EE 5200 - Lecture 5 Tuesday Sep 9, 2003

Topics for Today:

- Announcements
  - Everyone have a book now? Confirm.
  - Software: Matlab? Will begin using as early as next week.
  - Room B45 is open from 9am onward.
  - Office hrs: 1:30-2:30pm, Mon, Wed, Fri
  - Office: EERC 623. Phone: 906.487.2857
  - Ch.1 Solutions posted on web page, with corrections.
  - Exercises posted on web page, check e-mail for details.

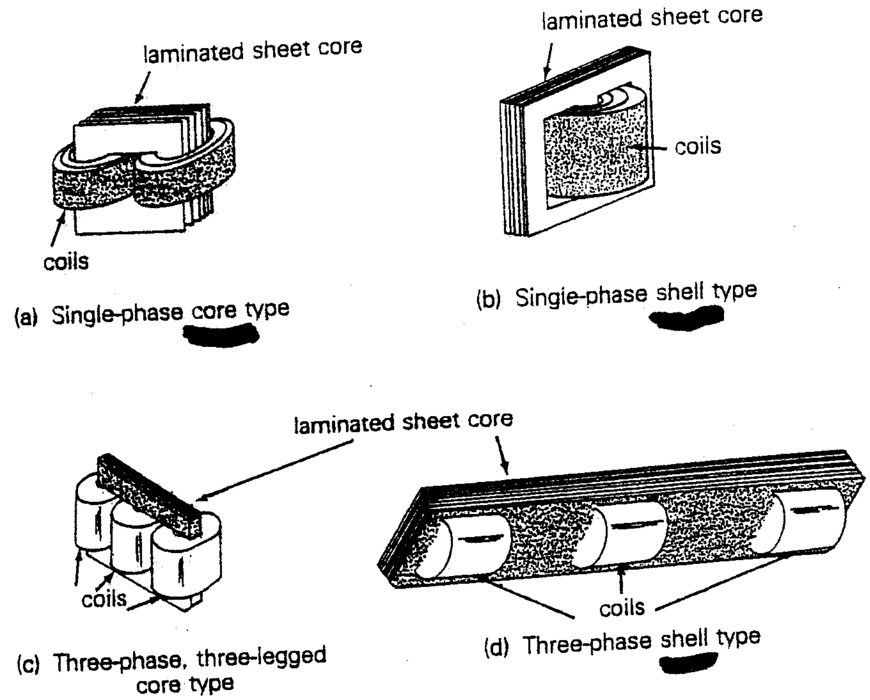
- Comments on Chapter 1 / Review:
  - Sequence networks - correction to last Thursday's notes.

- Chapter 2 - Transformers and circuits w/transformers
  - Single phase transformers
  - Basic structure: winding R and Leakage, Core losses and saturation
  - 3-phase transformer banks and phase shifts

- IEEE: Δ H1  X1
- IEC: Dyn1

Figure 4.15

Transformer core configurations



(a) Single-phase core type

(b) Single-phase shell type

(c) Three-phase, three-legged core type

(d) Three-phase shell type

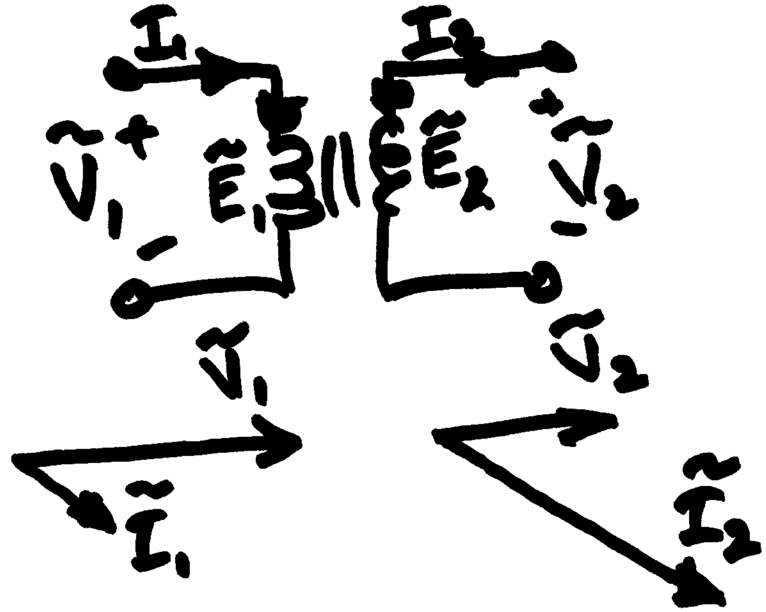
compared to replacement of only one phase of a three-phase bank. In either case, the equivalent circuits developed here and subsequent analyses are the same.*

SECTION 4.5

PER-UNIT SEQUENCE MODELS OF THREE-PHASE TWO-WINDING TRANSFORMERS

Figure 4.16(a) is a schematic representation of an ideal Y–Y transformer grounded through neutral impedances Z_N and Z_n. Figure 4.16(b–d) show the per-unit sequence networks of this ideal transformer. Throughout the remainder of this text per-unit quantities will be used unless otherwise indicated. Also, the subscript "p.u.," used to indicate a per-unit quantity, will be omitted in most cases.

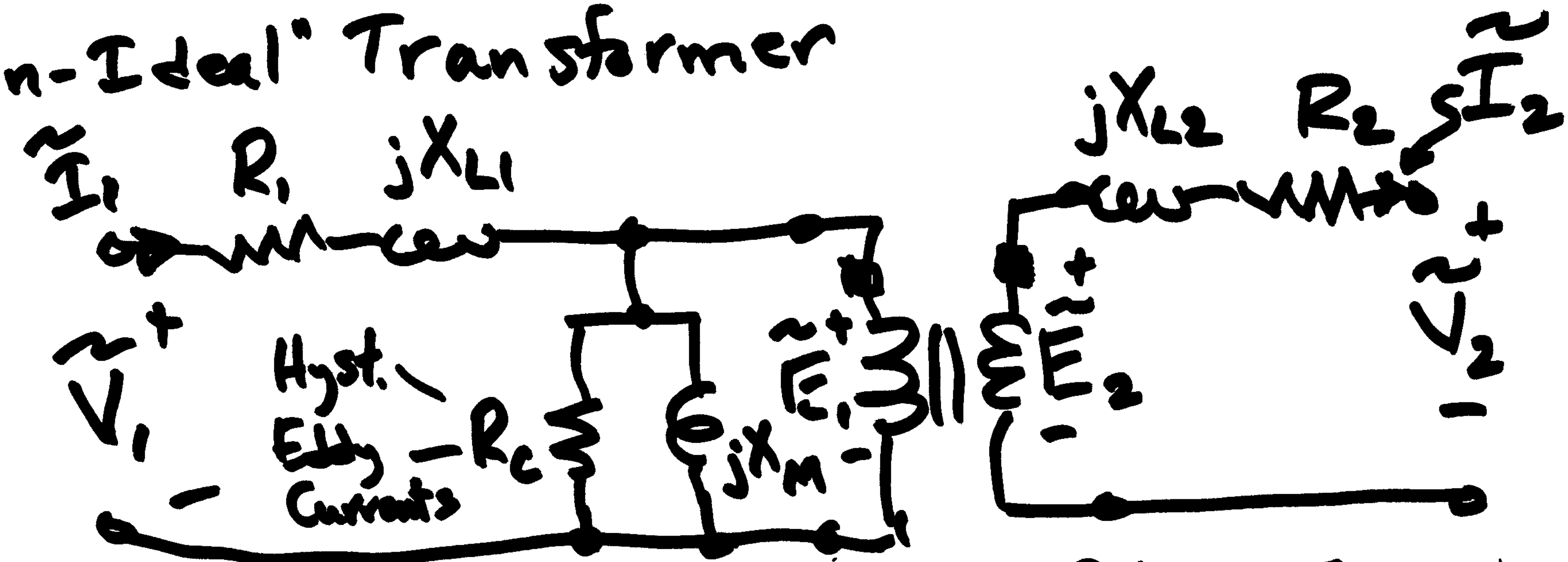
By convention, we adopt the following two rules for selecting base quantities:

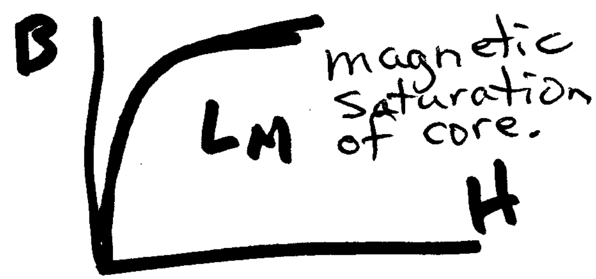


$R_{WINDING}$ R_1, R_2

R↑ as f↑
- skin effect
- proximity effect.

"Non-Ideal" Transformer

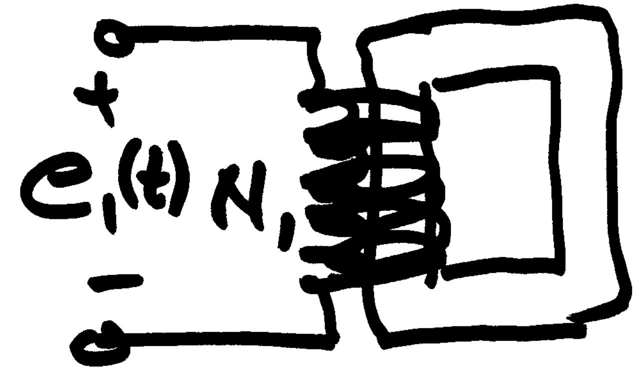




see fig 3.1

Faraday's Law:

$$e_1 = N_1 \frac{d\phi}{dt}$$



<u>Problem:</u> Faraday's Law does not handle polarity of induced voltage.

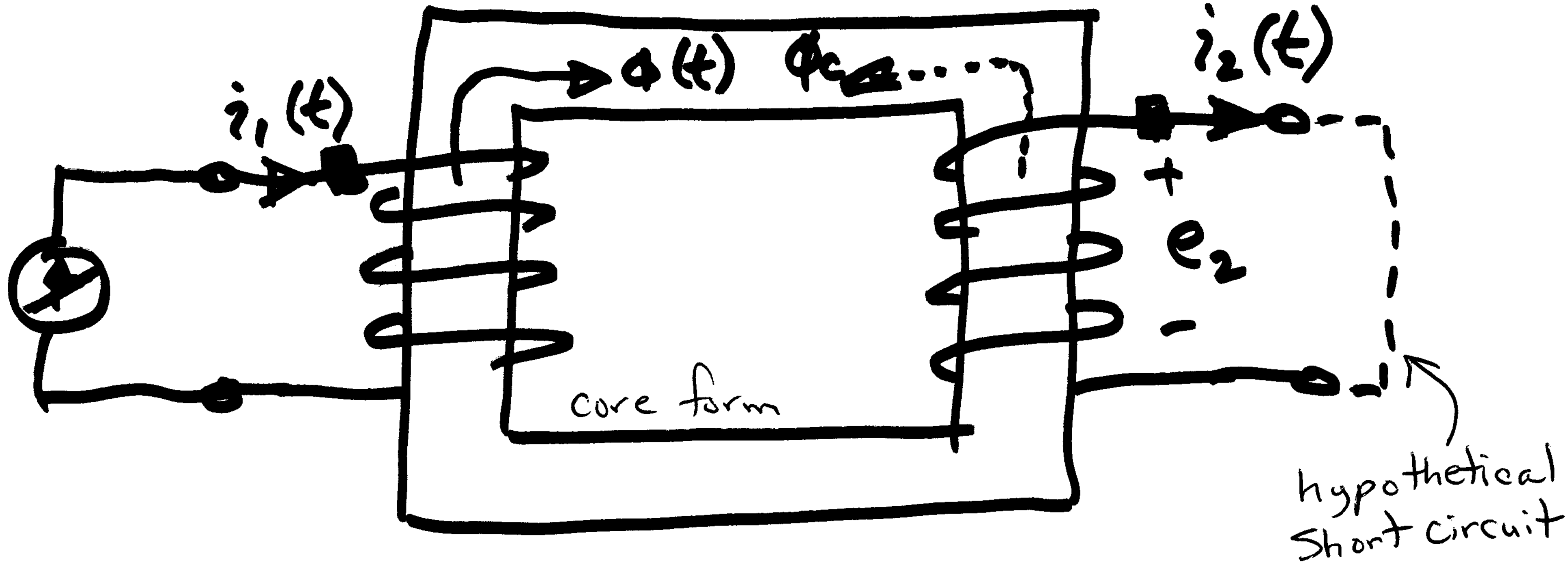
$\Longrightarrow$ Lenz's Law Does

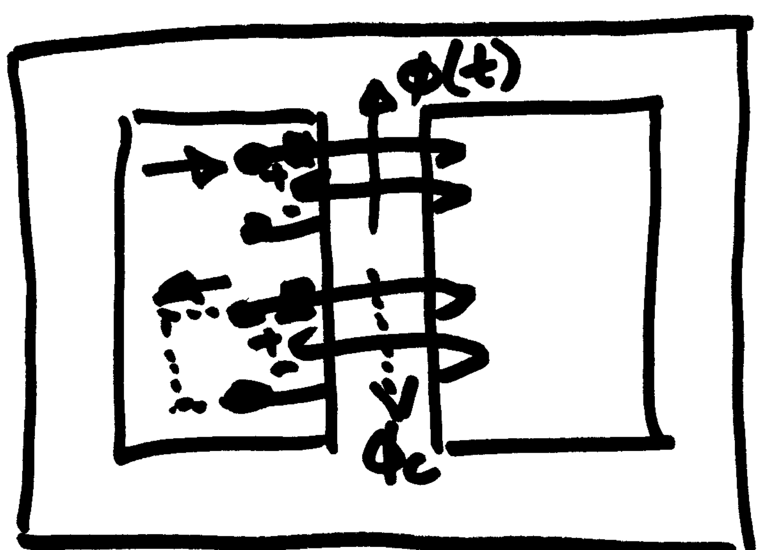
λ = flux linked $= N\phi$

$$e = N\frac{d\phi}{dt} = \frac{d\lambda}{dt}$$

(polarity explanation on pages 5-6)

5



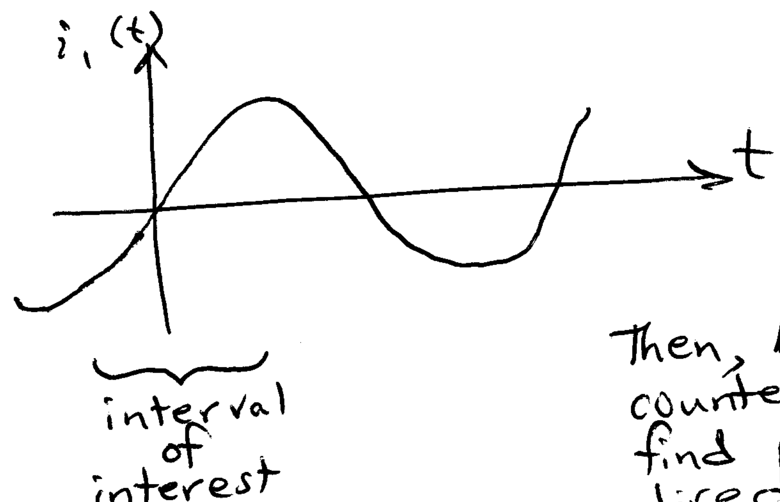


Shell form

Lenz's Law (refer to page 5)

The voltage induced has a polarity such that the resulting current flowing through a hypothetical short circuit would produce a counter flux Φ_c that opposes the change in flux $\frac{d\Phi}{dt}$ that induced the voltage in the first place.

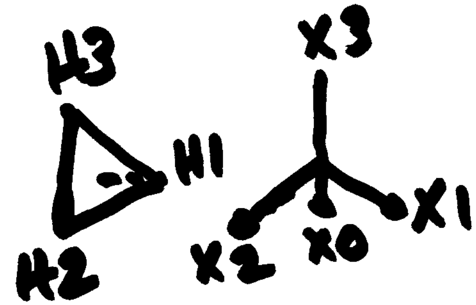
One simple way to apply this, as shown on page 5, is to consider an injected current, $i_1(t)$, which could be a sinusoid, which is increasing with time:

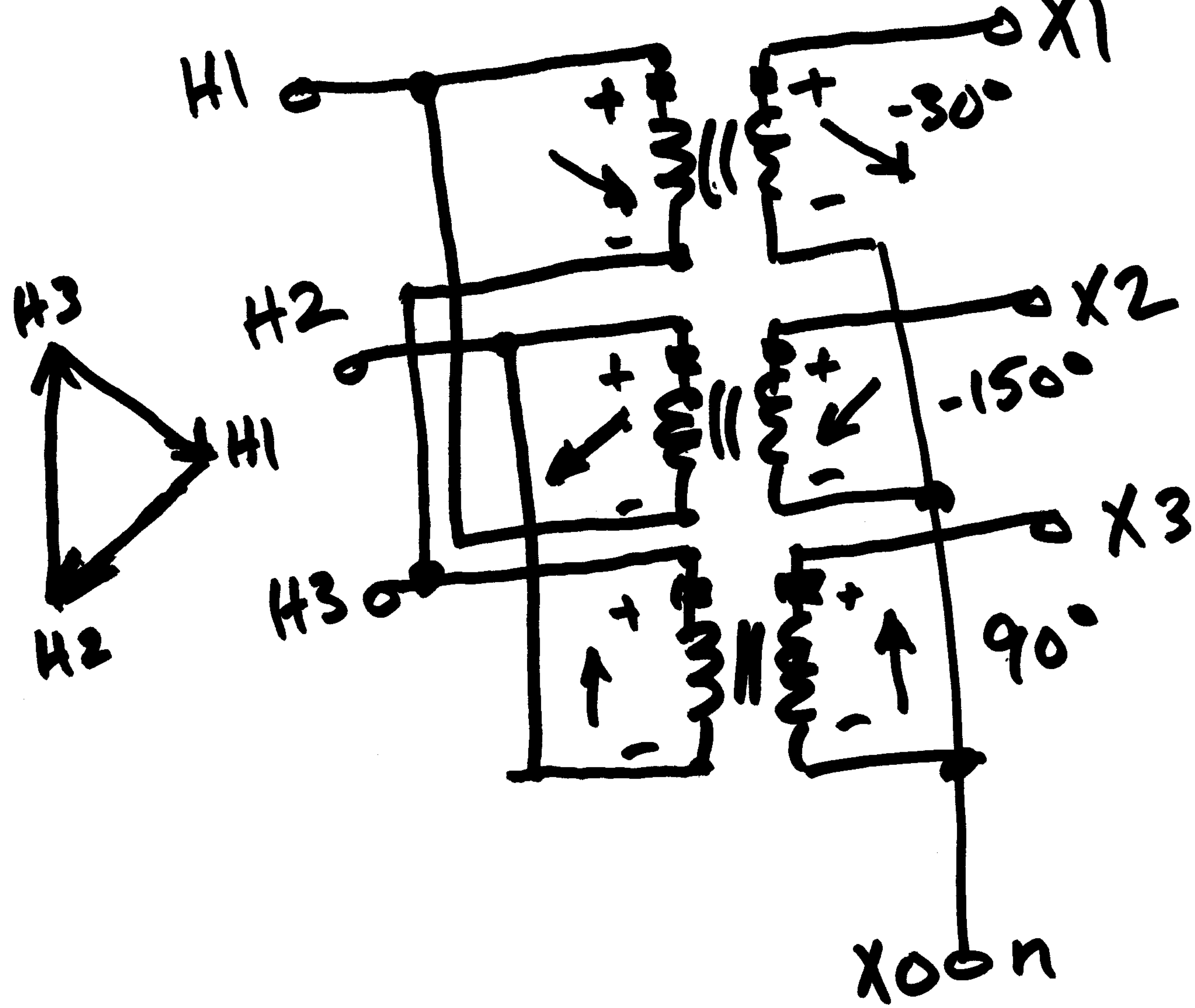


Then, based on required counter flux, we can find polarity of e_2 and direction of i_2 during that same interval, and properly define polarity marks

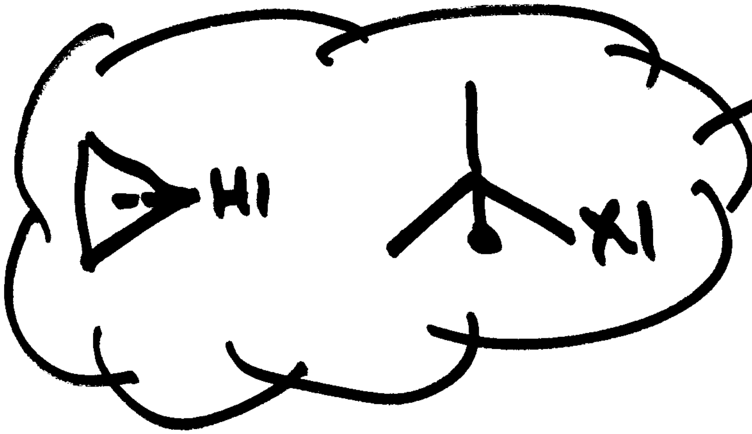
3-PHASE XFMR BANKS

Ex: Δ-Y (Dyn1)

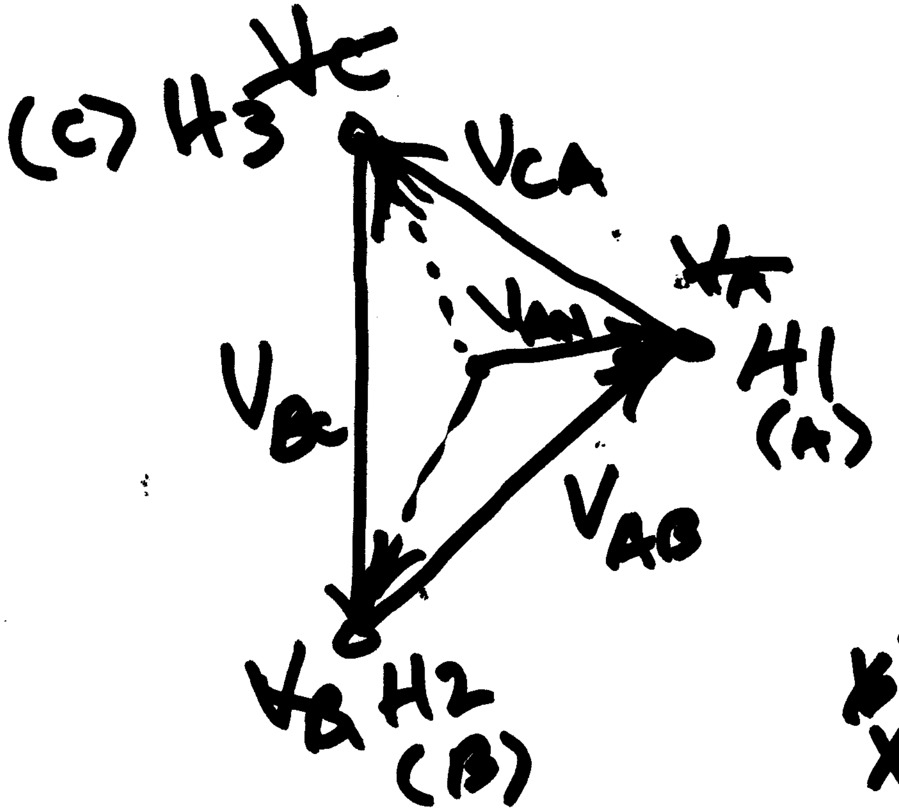


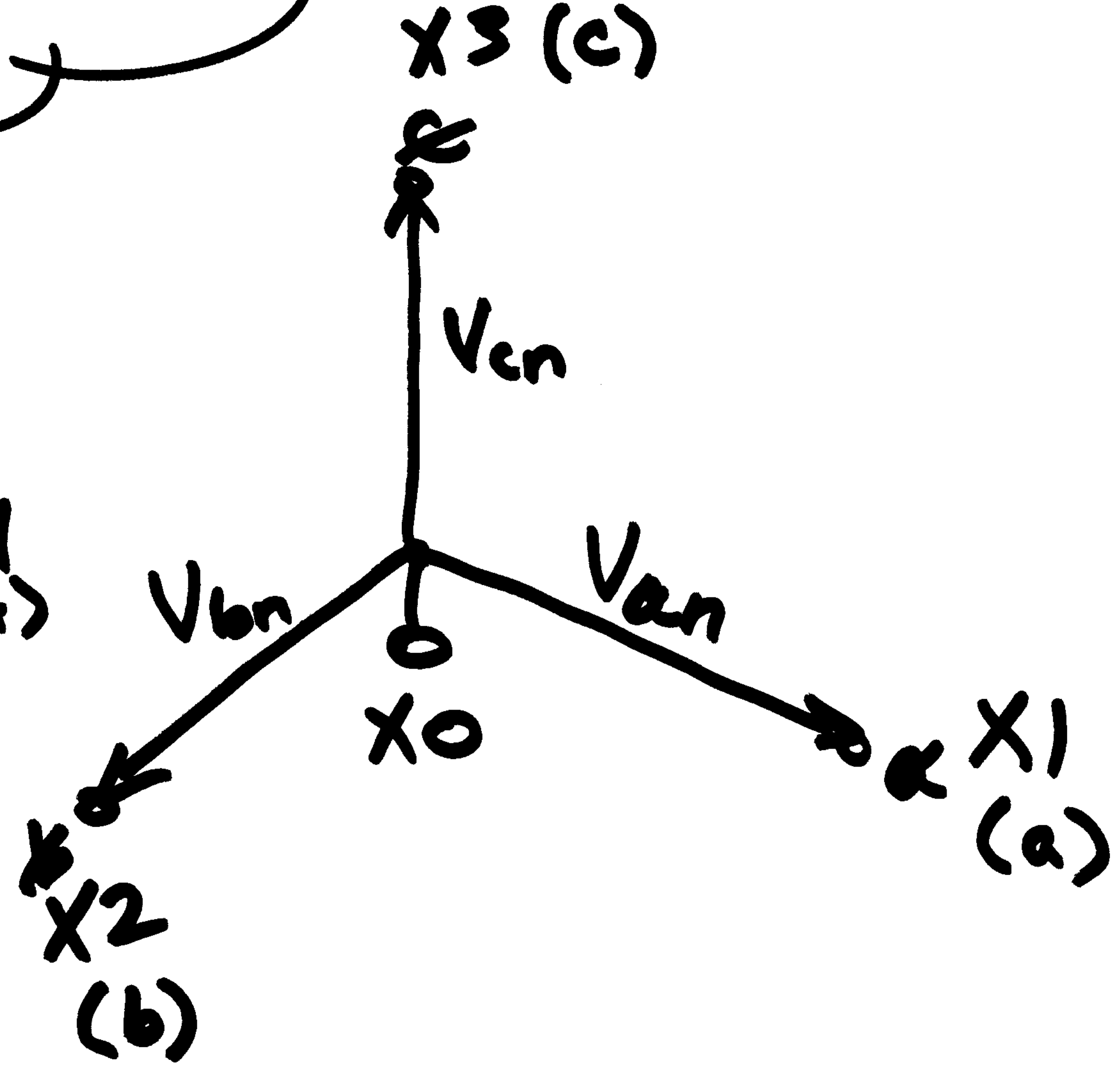


"ANSI" or IEEE STDS



POS SEQ PHASE SHIFT



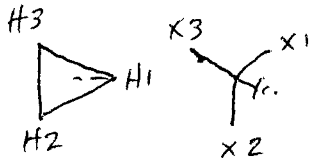


- Three-Phase Transformers

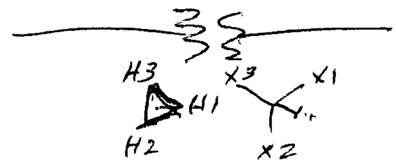
Mork

All of these can <u>and are</u> used to indicate the s~me winding connections:

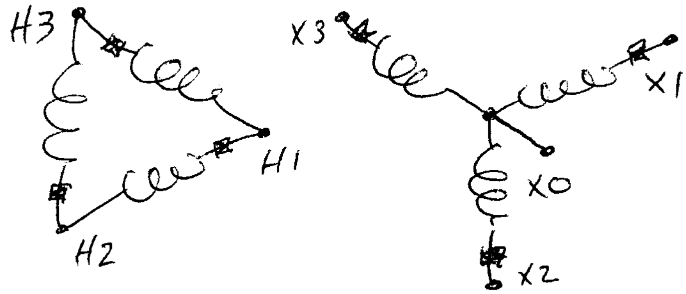
IEEE Stds:



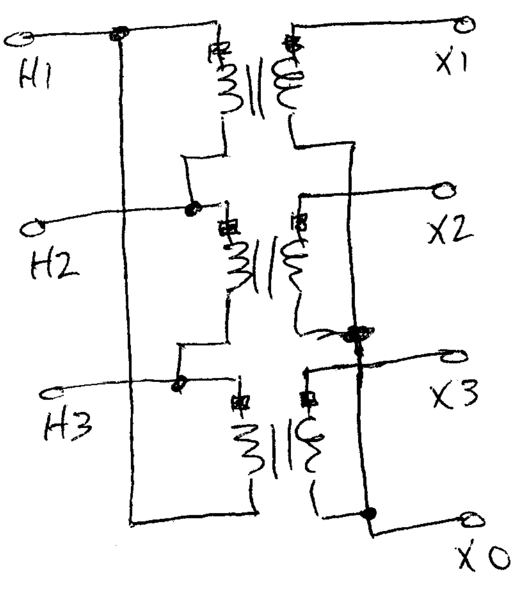
One-Line:



schematic

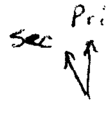


circuit 3-line diagram



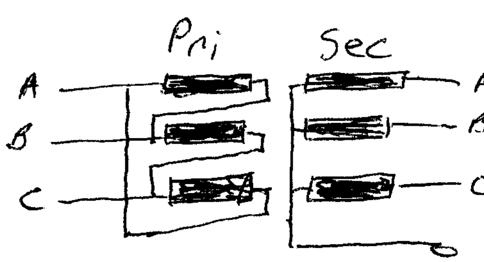
In Europe and much of the world:

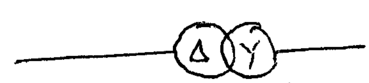
IEC Stds: Dyn11



One-Line:

"~ld-down" diagram





Dyn11