Ongoing List of Topics:

- URL: http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm
- Term Project - last few proj/teams being firmed up and getting moving.
  - Follow timeline, see posting on web page (posted in week 5)
  - Formal outline w/complete references complete, get/keep cranking...
- Homework set 10
  - Handout problem, Probs 4.2, 4.3 (a,b,c) - Complete today at 5pm
  - Problem 4.4 - complete by Tuesday 5pm. Use e-mail forum!
- Protection fundamentals for 87T, cont’d –
  - a) correct connection of CT secondaries to relays (Lecture 24)
  - b) relay settings, to compensate for pri voltage ratio and CT ratios.
  - c) Mismatch problems - due to being forced to use less than full CT ratio, and having Pri and Sec CTs with different accuracy levels. Differential slope of trip characteristic can be 10%, 15%, 25%, etc, to allow for mismatch. Refer to XFRM.pdf!
- Bus protection - 87B
  - Low Impedance relays
  - High-Impedance relays
  - Partial bus protection using 51 relay (distribution bus w/radial feeders)

- **CAP BANKS**
S.C. MVA = 600
@ 115-kV Bus

(Prob. 4.2)

\[ IF = \frac{600 \times 10^6}{\sqrt{3} (115,000)} \]

\[ X_{TH} = \frac{V_{TH}}{I_F} \]

\[ jX_{TH} \]
Figure 4.20  Example of fault calculation for an autotransformer.
Mathematical model is ok to calculate the currents flowing thru the transformer bushings, but breaks down for determining actual winding currents in xfrmr. (per unit system also breaks down).

Instead, convert the per unit current into actual amps flowing into the bushings. Then, trace thru the series, common, and delta windings.

EE 5210 - Power Systems Protection

Spring 2001
Ampere-turns Up = Ampere-turns Down
1702.7x1.1429 + 232.21x.1485 = 1980.4x1.0
1946.02 + 34.48 = 1980.4
1980.5 = 1980.4 Check.

Figure 4.22  Ampere-turn check to confirm or establish the direction of current flow in the tertiary. Also, recall that coil voltages are proportional to \( N_{S} \).

There can be a question about the direction of current in the tertiary. This can be checked by ampere-turns, as shown in Fig. 4.22. Arbitrarily, one per unit turn was assumed for the 161-kV winding, and the others were derived. Any winding or group could be used for the base, as convenient.

4.13 EXAMPLE: OPEN-PHASE CONDUCTOR

A blown fuse or broken conductor that opens one of the three phases represents a series unbalance covered in more detail in Blackburn (1993). As
Choosing reference direction of all winding currents to be into polarity mark...

\[ \sum \text{MMFs} = 0 \]

\[ I_H N_s + (I_H - I_n) N_c + \frac{I_H}{\sqrt{3}} N_\Delta = 0 \]

Basic Autotransformer

\[ I_H = I_n + I_c \]

\[ I_A = \frac{I_H}{\sqrt{3}} \]
Superposition:

- Linear System
- Total effect as sum of separate effects, i.e.
  modal analysis like 0,1,2 components.

Therefore, we can separately consider the effects of zero sequence currents, tracing them through the xfrmr windings.

Goal: What currents are flowing thru neutral and thru the phase-CTs of the delta? Must have correct phase angle and polarity!