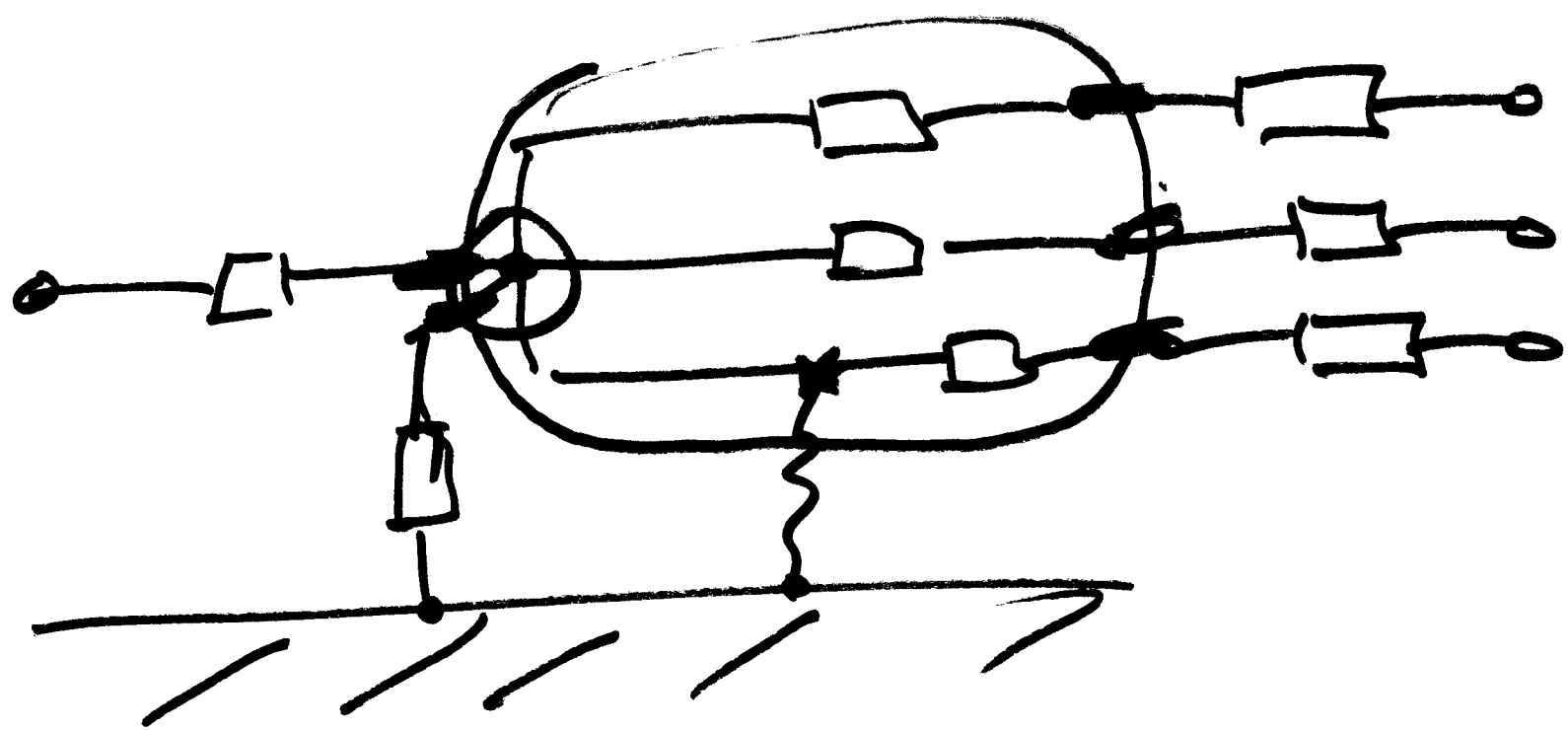


Ongoing List of Topics:

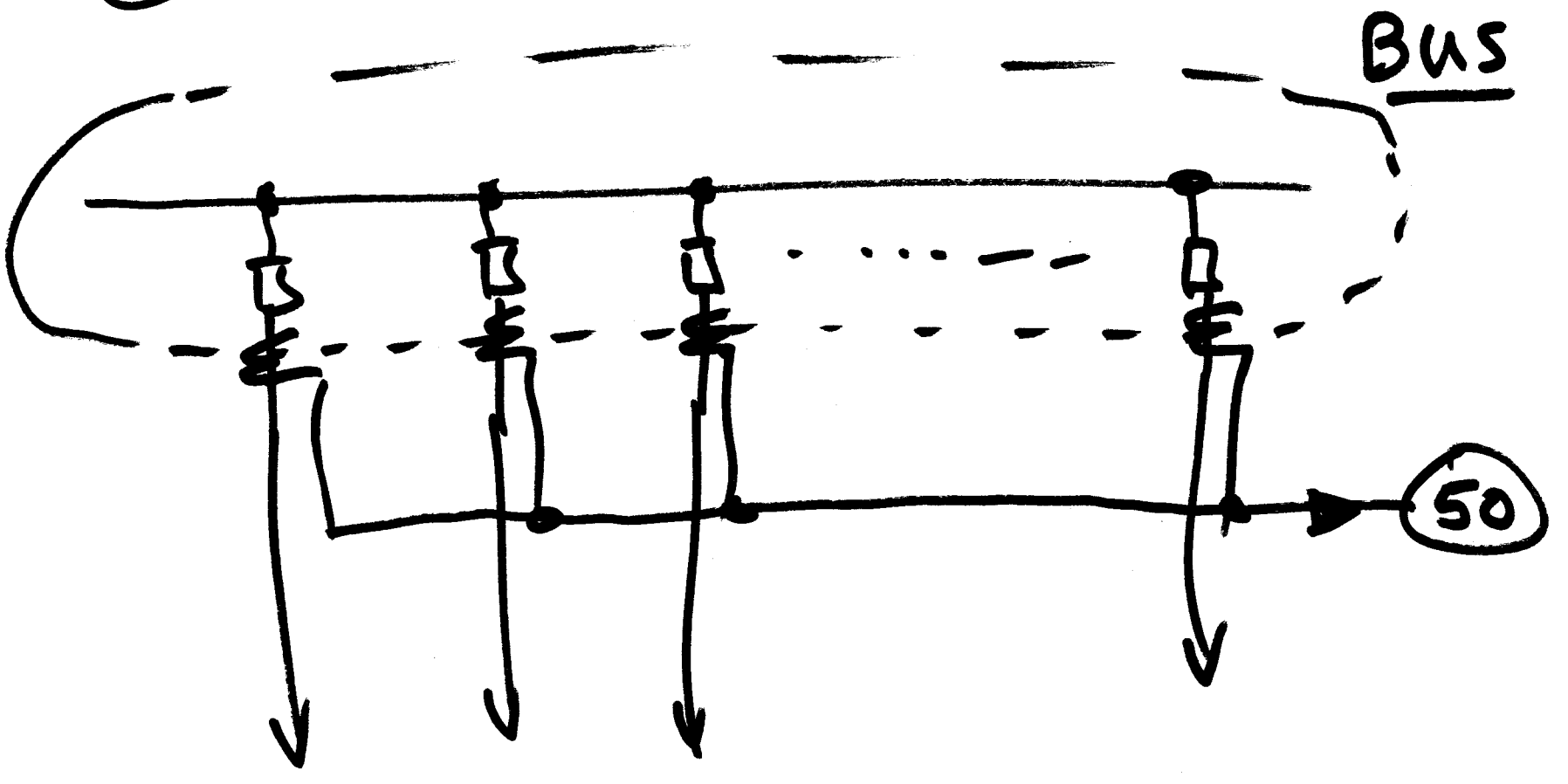
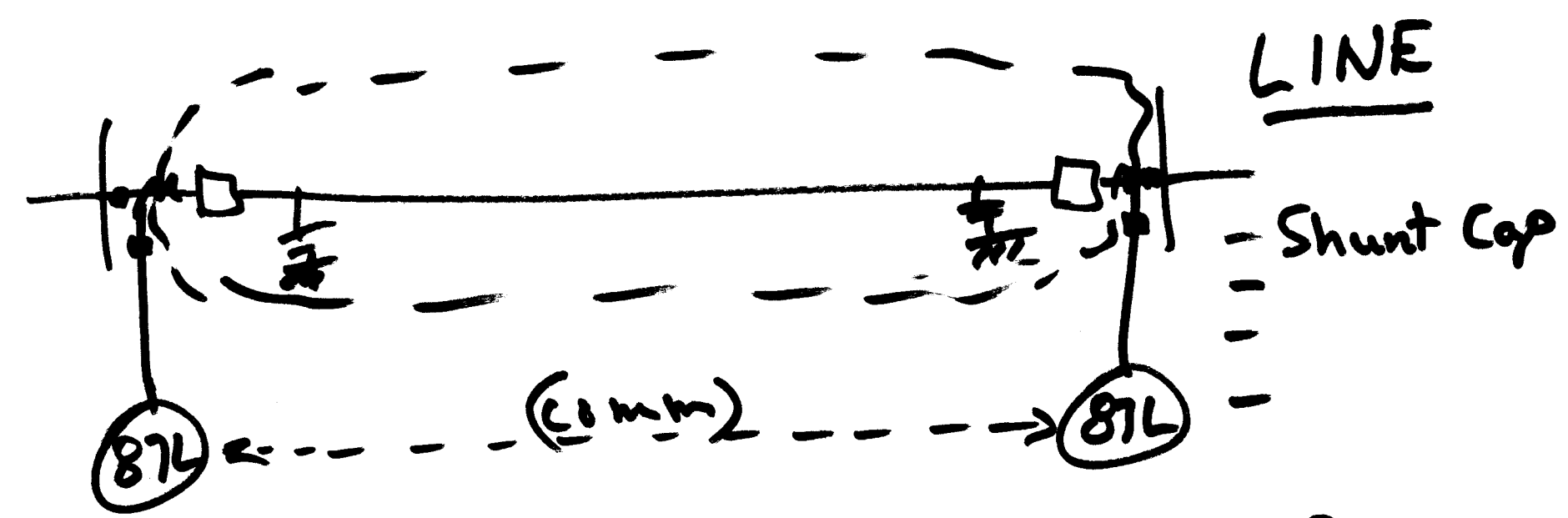
- URL: <https://pages.mtu.edu/~bamork/EE5223/>
- Term Project - most on track; a few proj/teams just getting moving.
 - Follow timeline, see posting on web page
 -
- Next homework set topics:
 - Probs 4.2, 4.3 (a,b,c), 4.4
 - Transformer differential relay application
- Protection fundamentals for 87T, 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 XFMR.pdf !
 - Transformer damage curves –
 - Inrush types: 1) energization; 2) recovery; 3) sympathetic. §9.3.

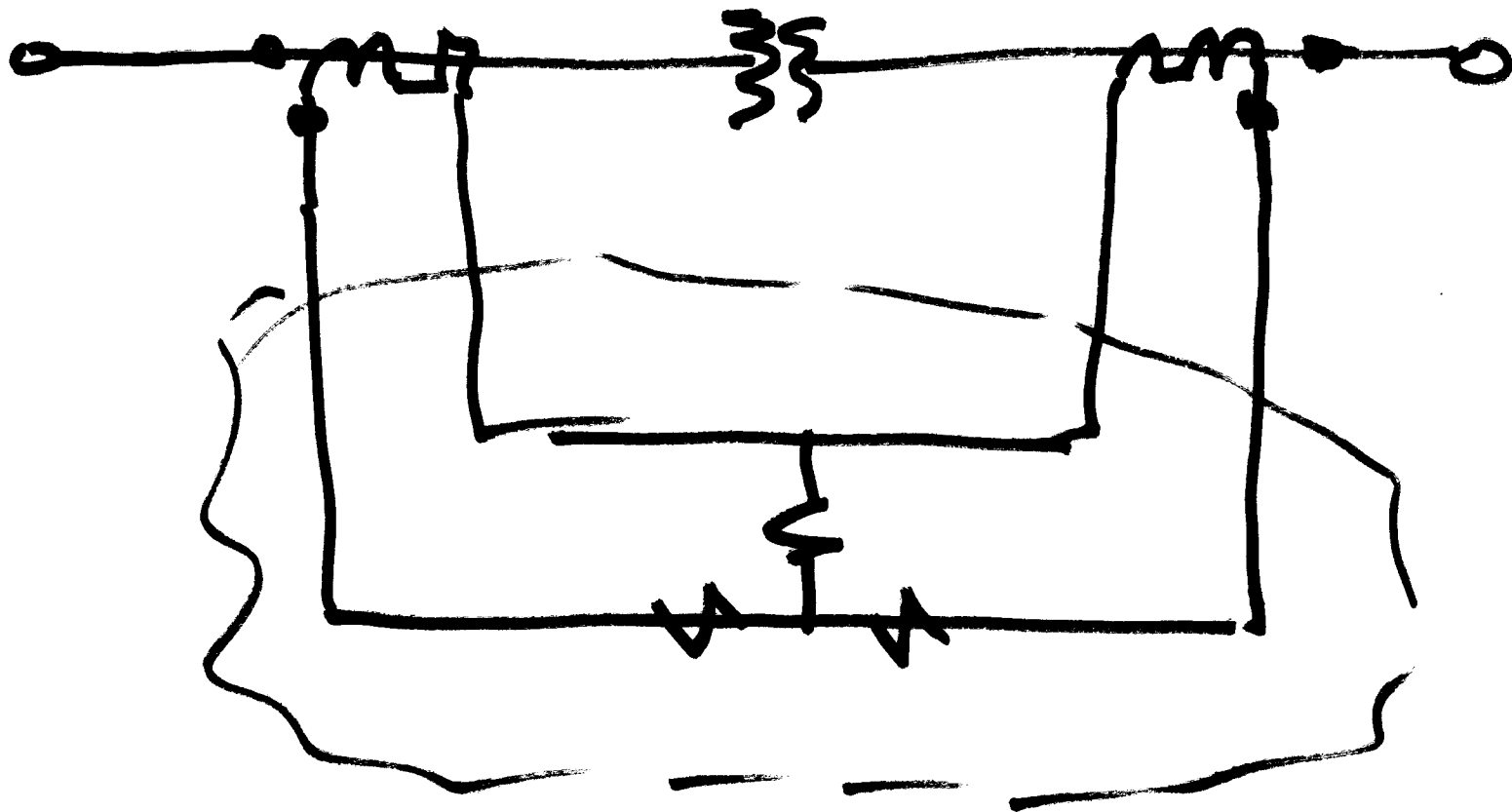
Protection fundamentals in preparation for next EE5224 relaying labs:

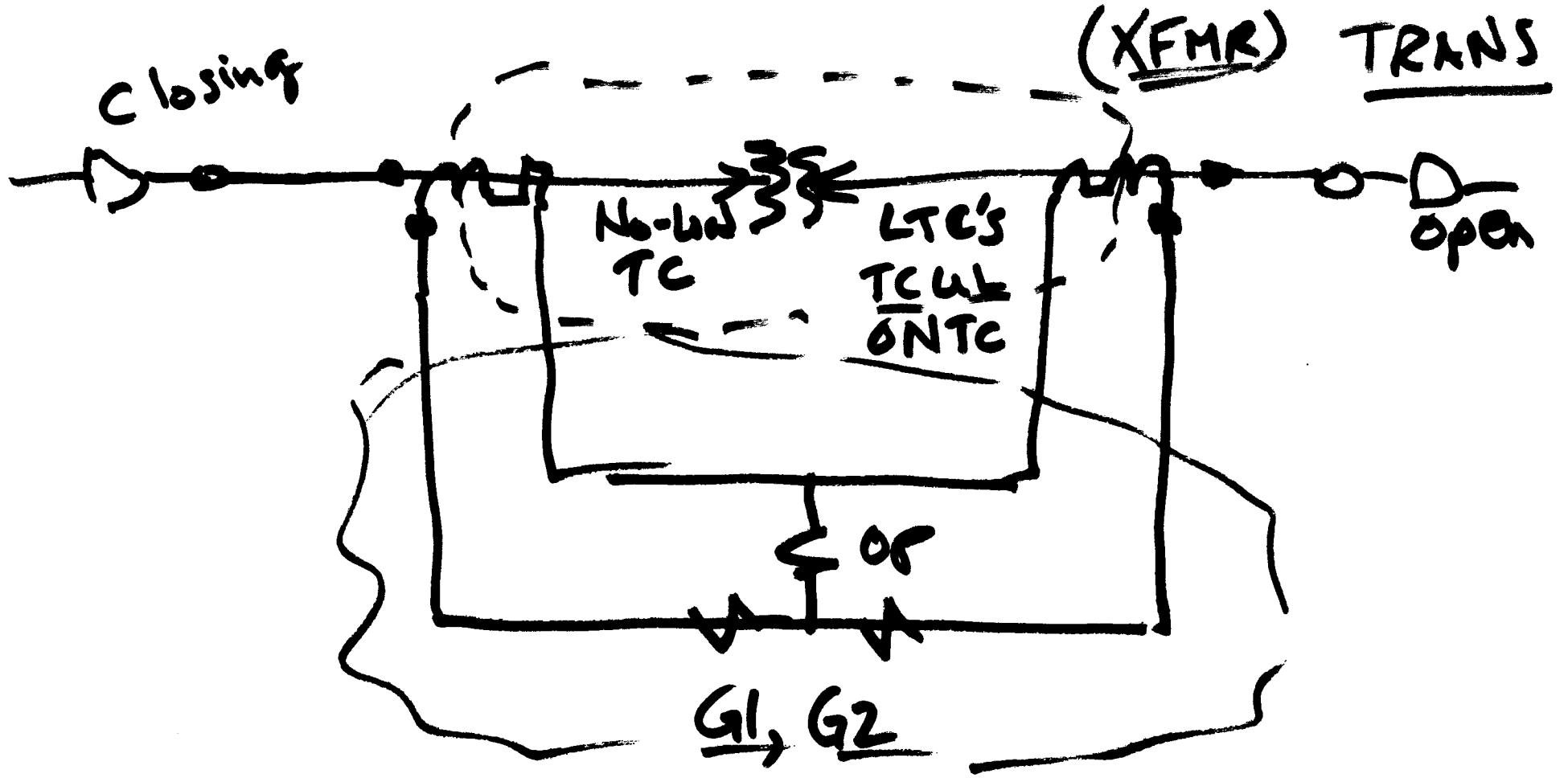
- Xfmr diff 87T -
 - must either connect CT secondaries to provide proper phase shift so that restraint currents flowing through restraint elements are in phase, or provide relay with phase shift and delta or wye info;
 - b) relay settings are used to compensate for pri voltage ratio and CT ratios. CT accuracy problems can be a big concern due to having 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% to allow for mismatch (measurement error) due to CT accuracy problems.
- In case of generator differential 87G - quite simple, connect CTs so current flows in “do-nothing” loop through Restraint elements (resulting in near-zero current through Operate element). Use equal (preferably full) ratio with all CTs. Differential slope of trip characteristic is rather flat compared to 87T below. Example shown of how not to connect CT secondaries.



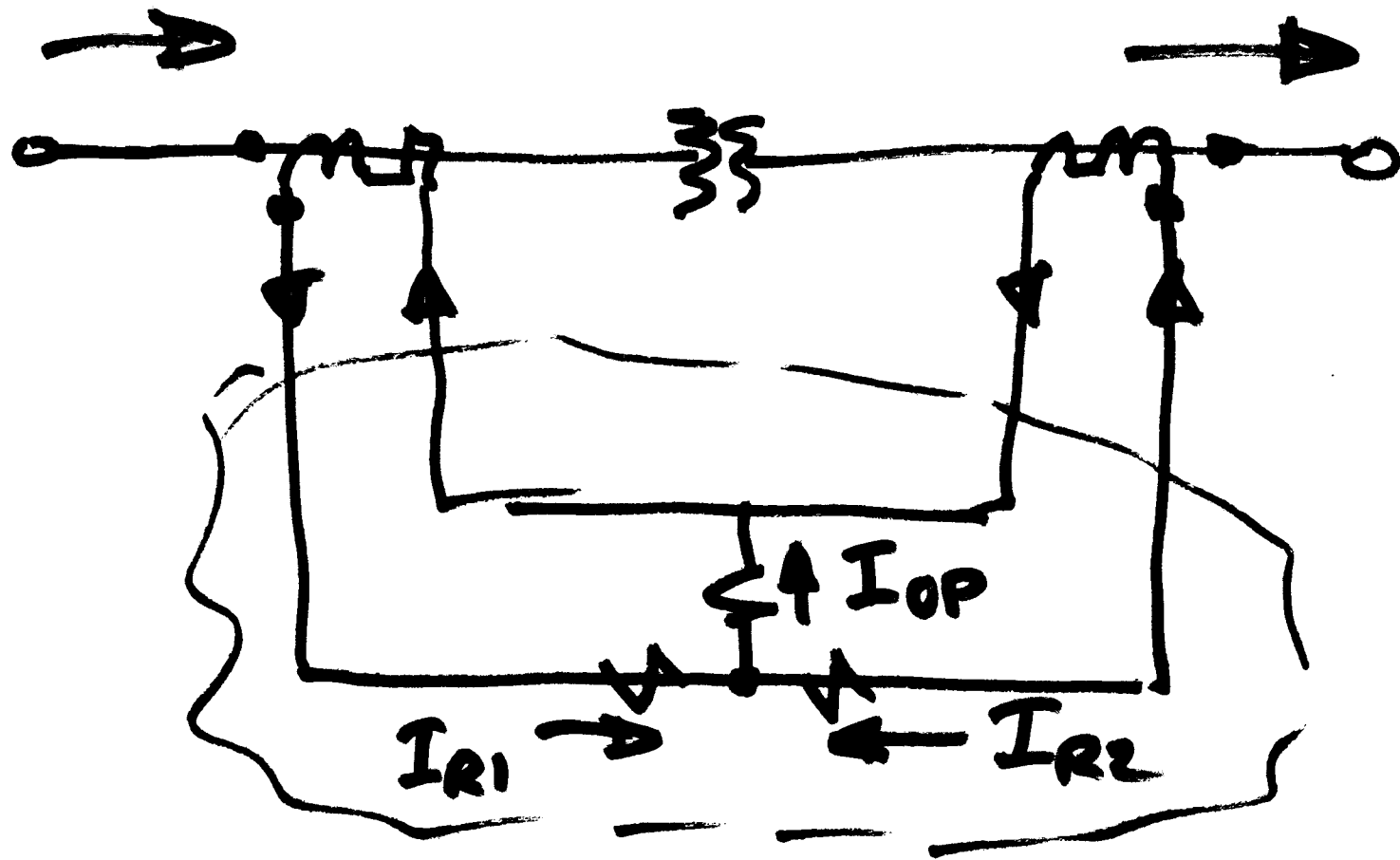
KCL: $\sum I's \text{ in} = 0$
 $\sum I's \text{ out} = 0$





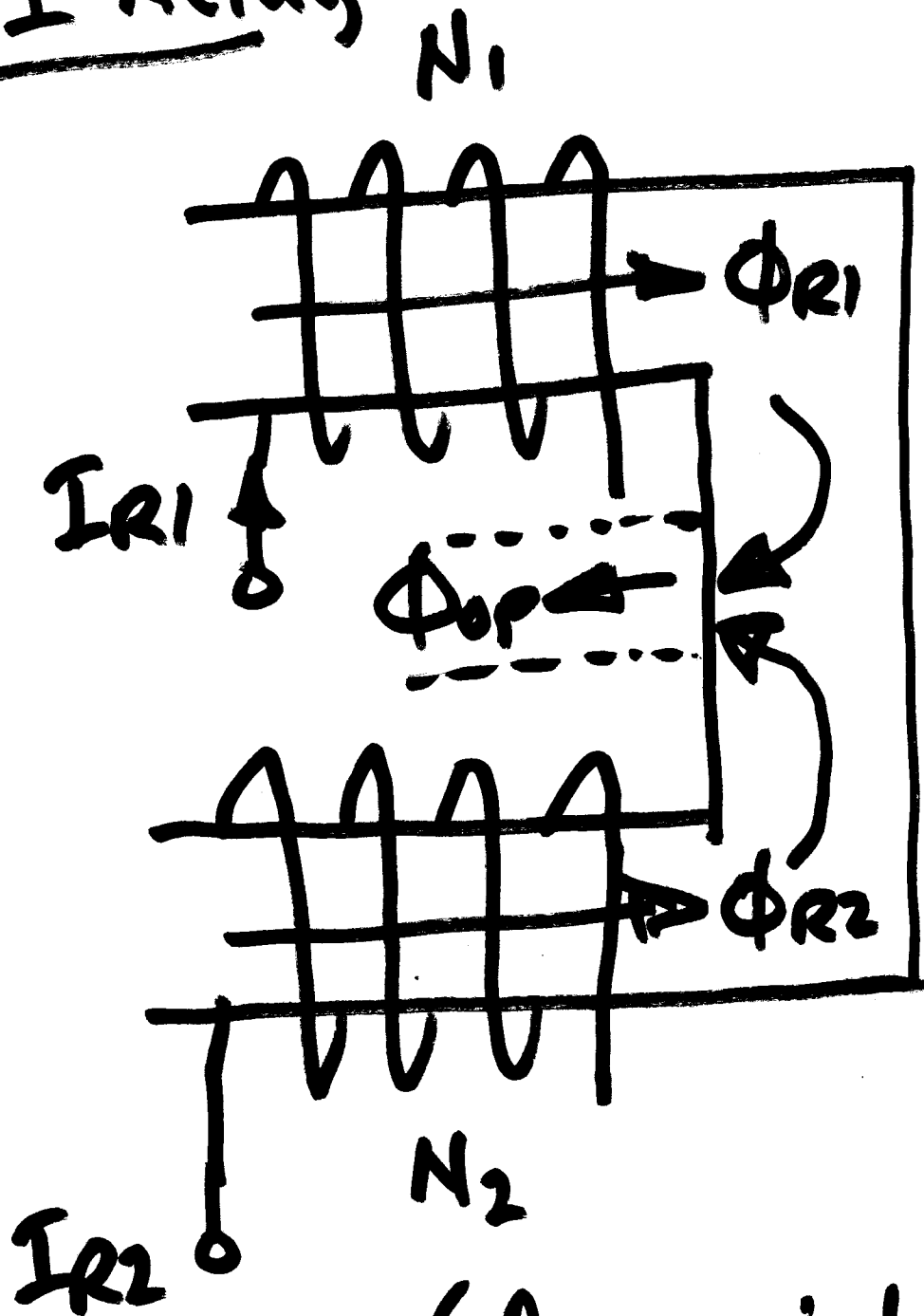


- CT ratios
- inrush
- Phase shifts - Δ s, Ys, Autos, Zig-Zag extended Δ s, Scott T, etc.
- LTCs...



- LTC, PS (Adjustable Turns Ratio, TTR)
- Δ 's, Y's, phase shifts \leftarrow
- CT secondary connections (G1, G2)
- Internal Settings - Phase Shift (G3)

GI Relay



Total MMFs

$$I_{R1}N_1 + I_{R2}N_2$$

Should add
to approx zero
to avoid relay
operation.

Note: tap

Setting determines
values of N_1 & N_2 .

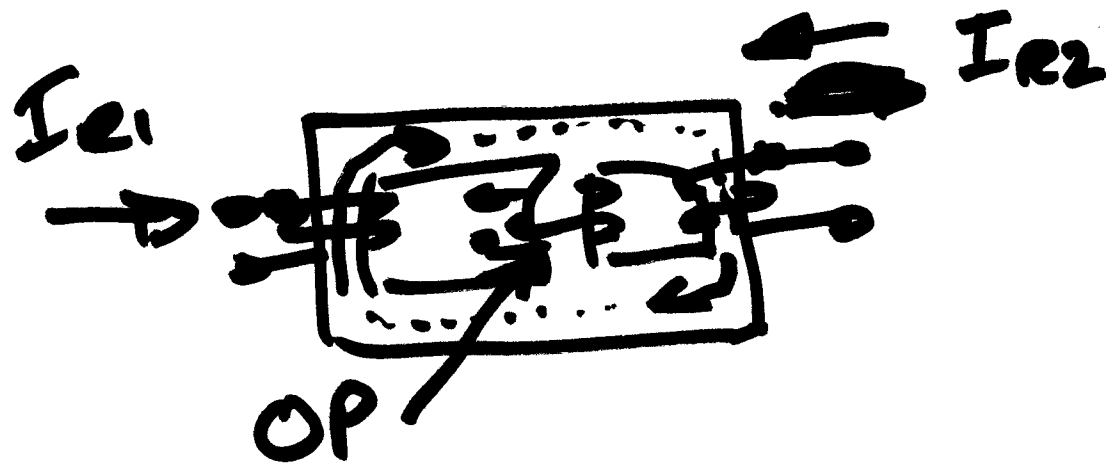
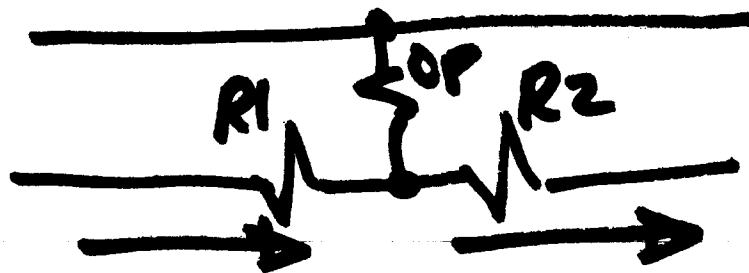
(Ampere's Law: $NI = R\Phi$)

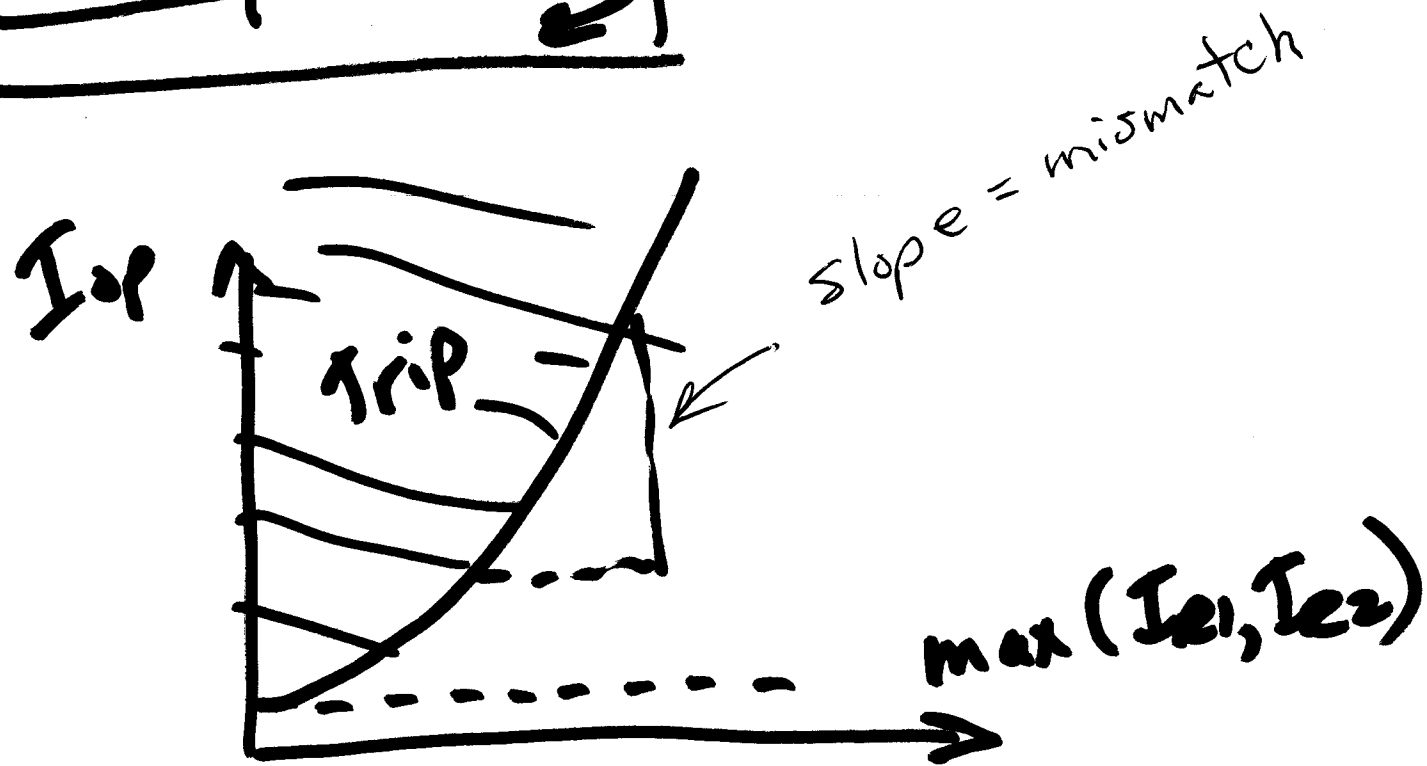
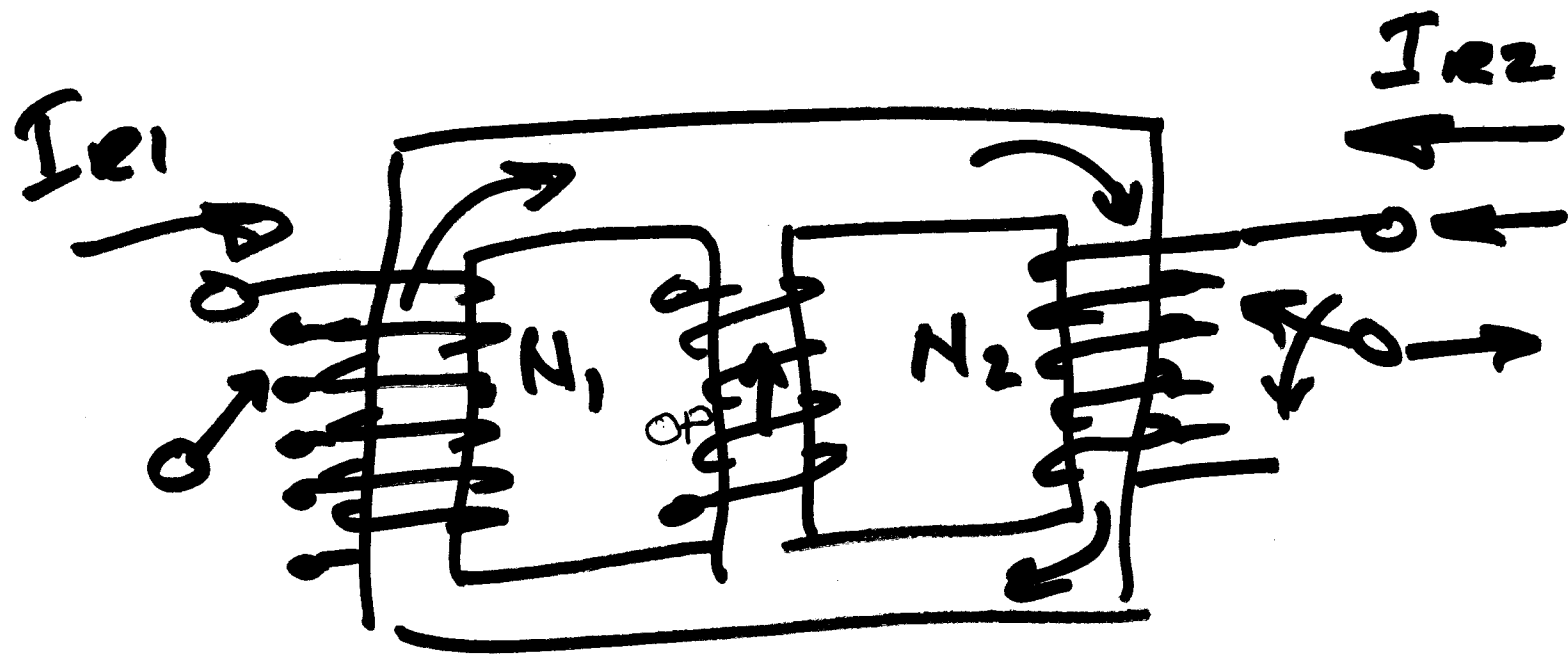
Fro

Mismatch - -Thru- Currents

- CT ratios
- Tap Settings

① HU - 87T





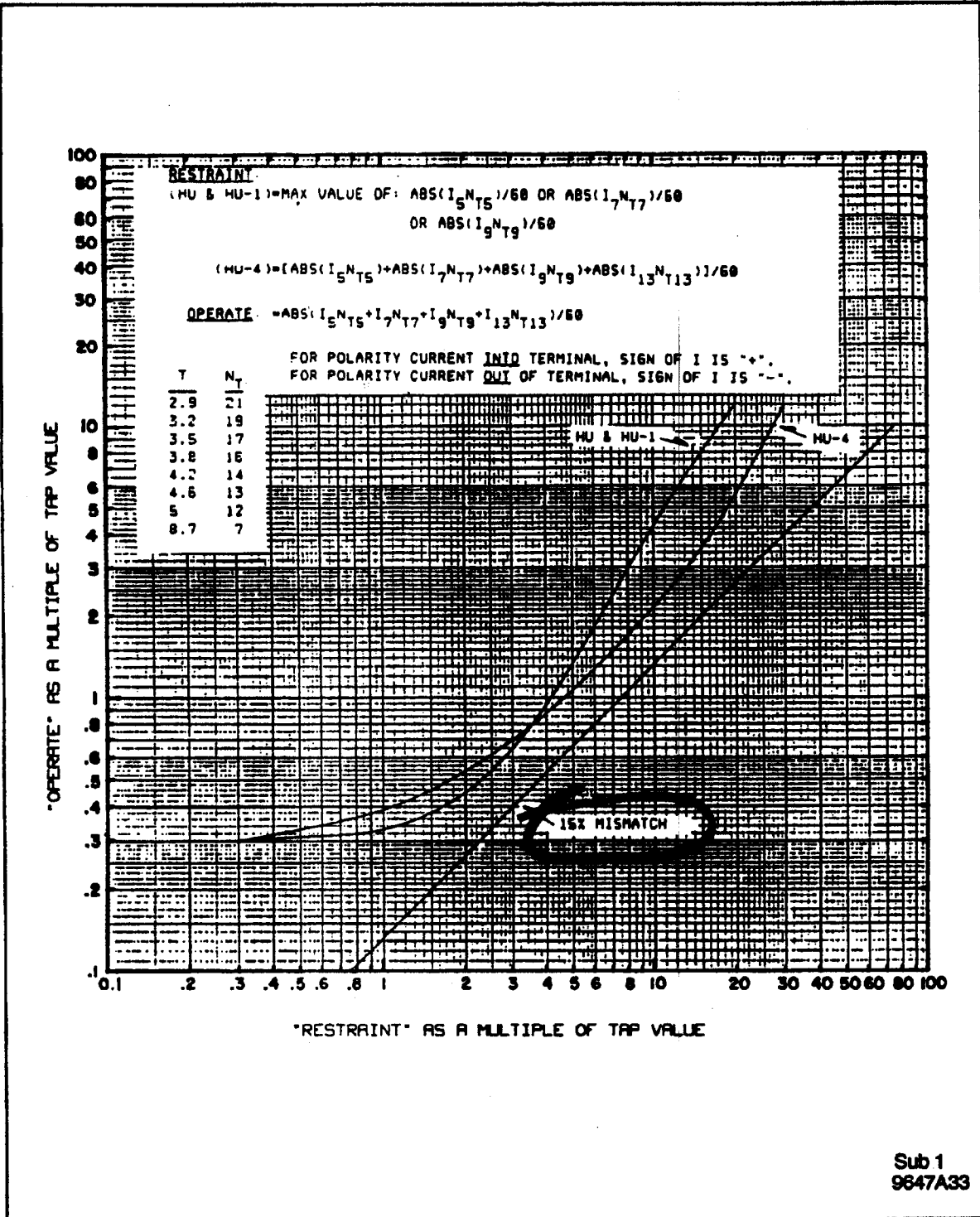
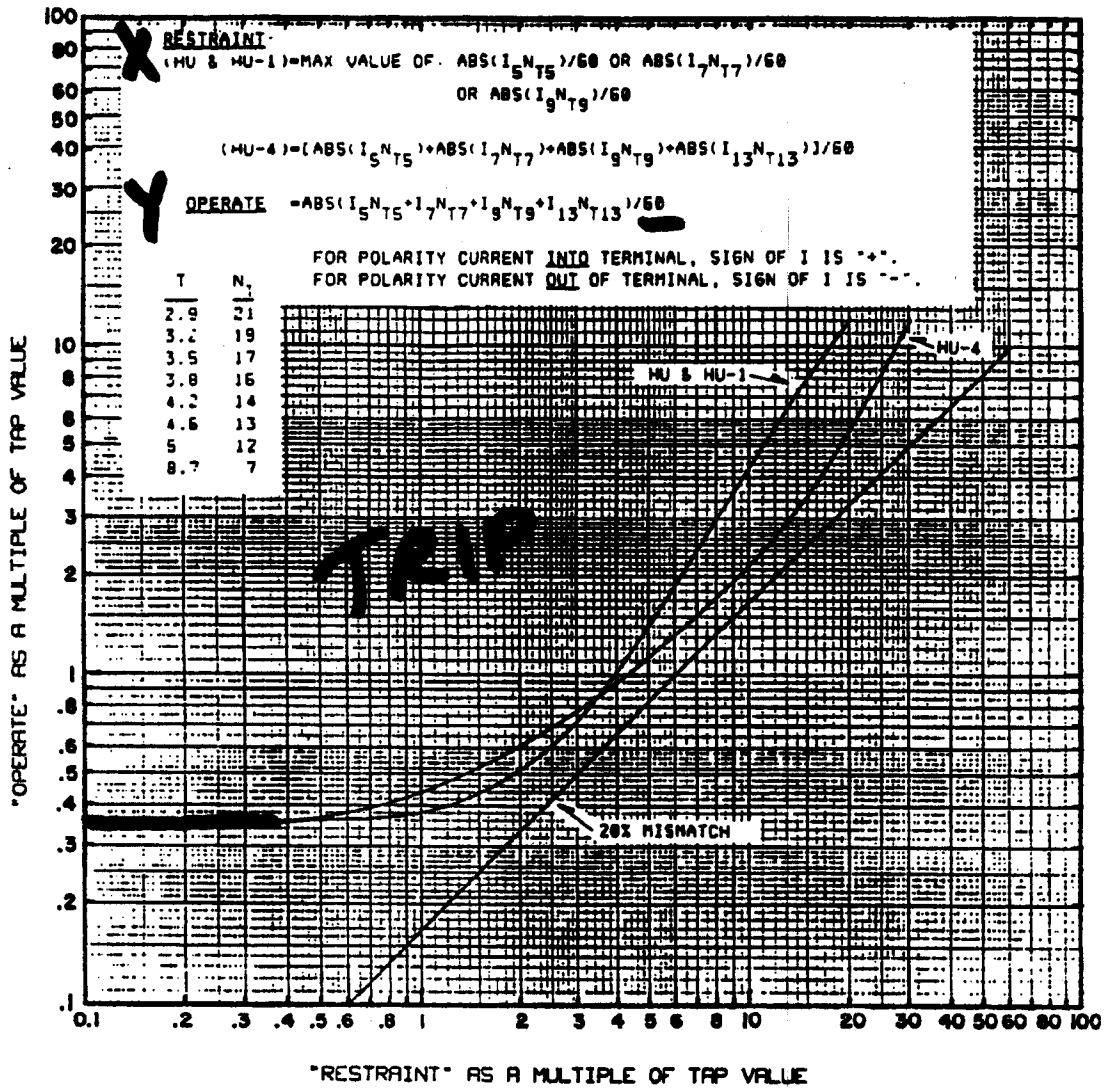


Figure 13. HU, HU-1 and HU-4 Differential Characteristics (30% Sensitivity).

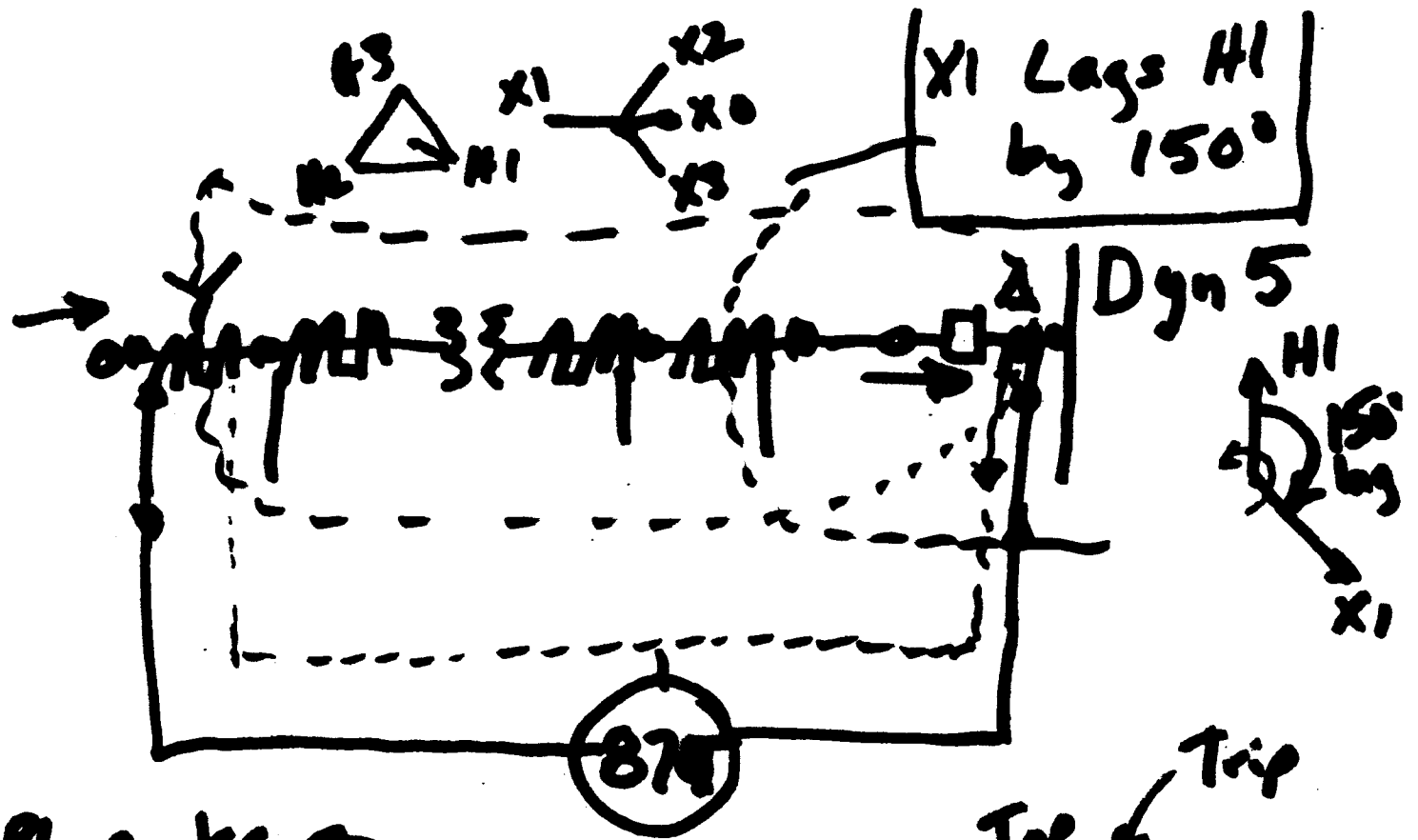


Hu



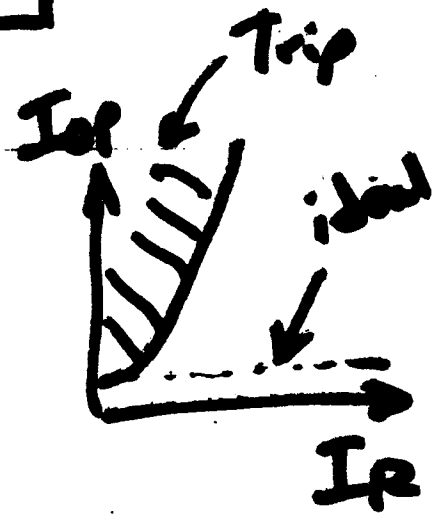
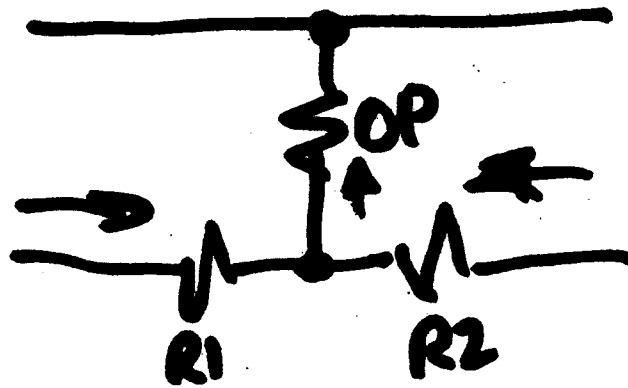
Sub 1
 9647A34

Figure 14. HU, HU-1 and HU-4 Differential Characteristics (35% Sensitivity).

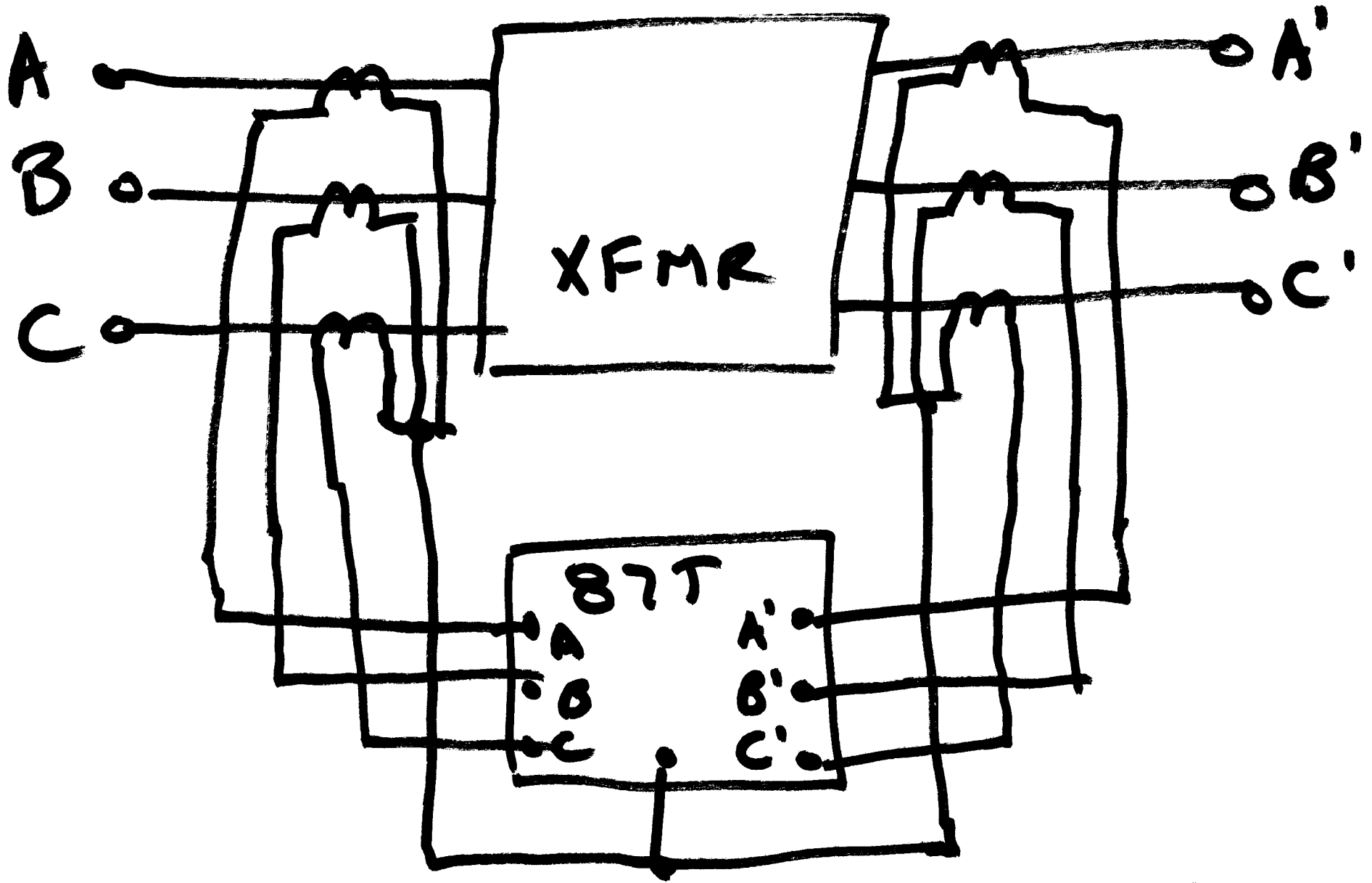


- Match Ph. angles ←

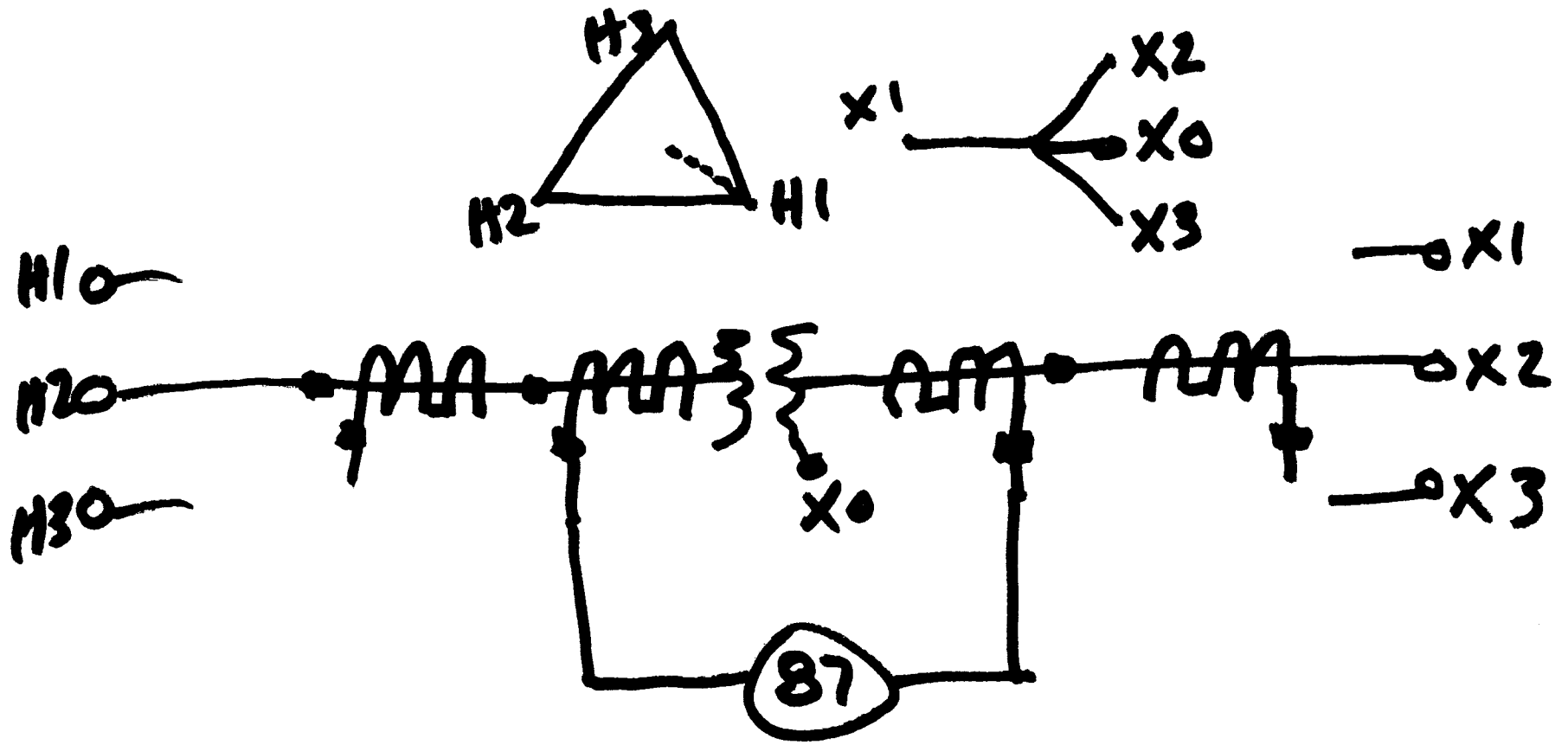
- Match Current magnitudes, approx.



"mismatch"



Ideally: for G3 relay, just connect line currents & provide settings.



"Reconcile" :

Mag ✓
Phase Ang ✓

Example 1: Sec lags Pri by 150° .

