EE 5223 - Lecture 14 Wed Feb 10, 2021

Ongoing List of Topics:

- URL: http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm
- Labs - EE5224 Lab 2 - begins on Wed Feb 10th
- Term Project - details posted. Must have one MS student/team!
- Exercises posted

Today:

- Reclosing - radial vs. grid system
- Short circuit protection in grid systems
  - Directional overcurrent
  - Impedance
- Voltage & Current relationships during faults, §3.5-3.10
  - X/R ratio, dc offset, decay of dc offset
  - Relative angles and magnitudes of all Vs & Is during fault
- Basic connections of directional overcurrent (67) relays.
  - Phase relays - each line current is polarized with V_{LL} from other phases.
  - Ground relay - residual current ($3I_{ao}$) polarized with $V_{\text{broken delta}}$ ($3V_{ao}$)
- Excellent Illustrations: figures 3.7 thru 3.10

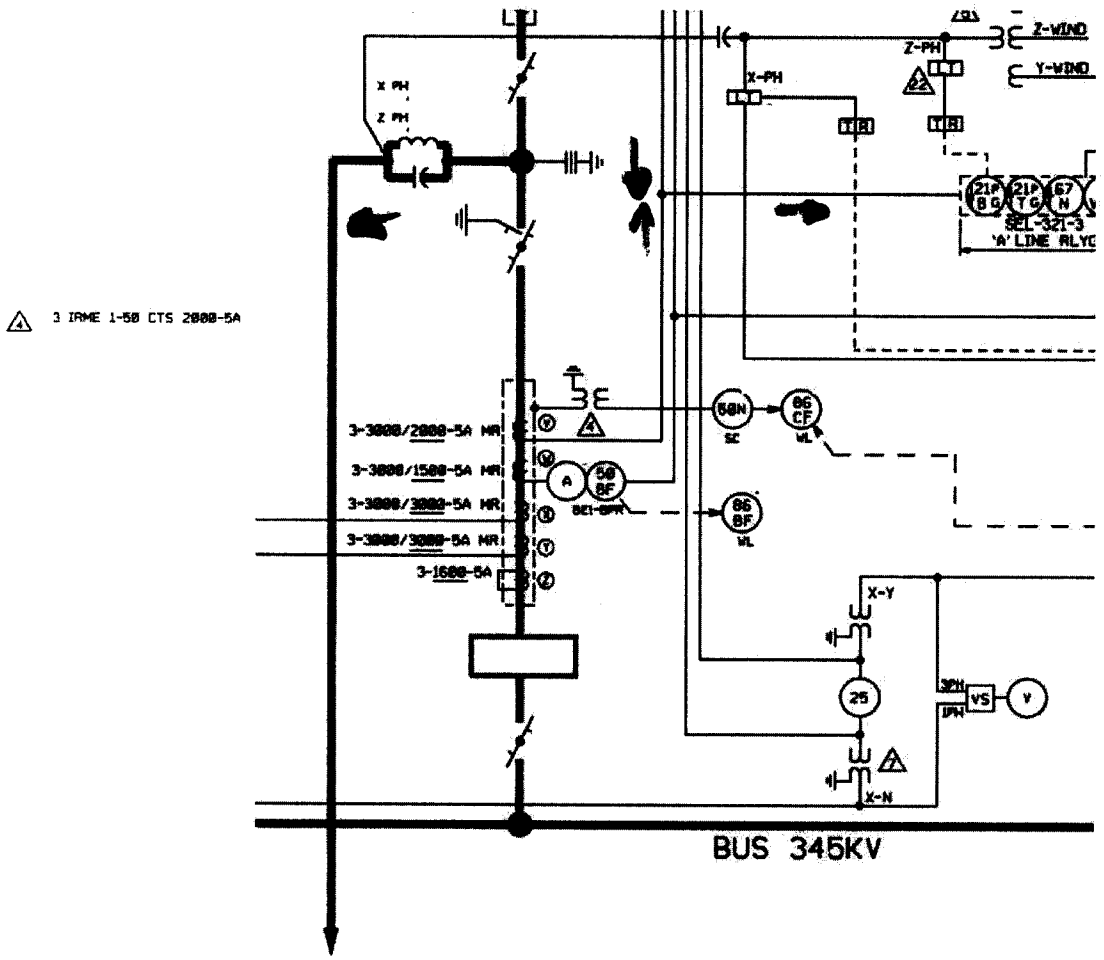
Some Term Project Ideas:

- Browse Table of Contents in your text book for ideas.
- Scope of project? Teams of 1, 2, or 3, scope appropriate.
- Ask online students/engineers for suggestions
  - New technologies to figure out, important problems to solve
  - Important concepts that need to be better understood (beyond tech level)
- Using ATP to model CT saturation and relay performance (actual waveforms)
  - CT saturation effects
  - Full 3-phase connection of CT, CT secondary cables, and relay burdens.
  - Build library of ATP components for this application.
- Application and testing of a protection scheme (many are possible)
  - Choose scheme and relay(s)
  - Design the protection scheme and provide settings
  - Test in relaying lab
- Substation automation (IEC 61850)
- Negative sequence polarization methods

Term Project Ideas (cont'd):

- Hardware vs. simulation, or both? EE5220 students - use ATP,Comtrade.
- Relay tester, lab tests of relays?
- Extend Matlab work? ASPEN? Make educational or engineering tools.
- Type of protection you're interested in?
  - Distribution (urban, rural, industrial)
  - Transformer (fixed tap, LTC, PS)

    - Generator
    - Bus
    - Cap Banks (Shunt or Series)
    - Transmission Lines, Cables
    - Motors (Induction, Synchronous)
- Examples of past projects can be looked at. Some topics I can suggest:
    - Capacitor Bank Protection
    - High-Impedance Faults
    - Negative sequence polarization
    - Substation Grounding, Grounding Issues
    - Small/medium gas-turbine gen protection.
    - Other ideas - see course web page and click on Useful Web Links.
    - New technologies - eg. optical VTs?
    - Out of step, load shedding, system separation.
    - Relay settings and system coordination.Pilot schemes.
    - Blocking, permissive, overreach, underreach.
    - End-to-end line relay testing (GPS coordination)
    - Multi-terminal line protection
    - IEC 61850 - use of high bandwidth intranet for peer-peer communications among relays.


3 IRME 1-50 CTS 2000-5A
X PH
Z PH
Z-PH
X-PH
Z-WIND
Y-WIND
SEL-321-3
3-3000/2000-5A MR
3-3000/1500-5A MR
3-3000/3000-5A MR
3-3000/3000-5A MR
3-1600-5A
50N
86 CF
50 BF
86 BF
X-Y
25
VS
X-N
BUS 345KV

Date: Tue, 10 Feb 2009 20:57:08 -0500
To: ee5223-l@mtu.edu
From: Bruce Mork <bamork@mtu.edu>
Subject: Fwd: Lecture 13
Sender: owner-ee5223-l@mtu.edu
Reply-To: Bruce Mork <bamork@mtu.edu>

Tom - Thanks for sharing, this helps alot to see what is going on. I'll show this to the class tomorrow.

The example shared by Consumers Energy in L13, with metering CTs on breaker-and-a-half metering scheme, drew some questions and possible criticism from me, mainly due to concerns over whether the relaying zones of protection overlapped or not (the metering looked ok).

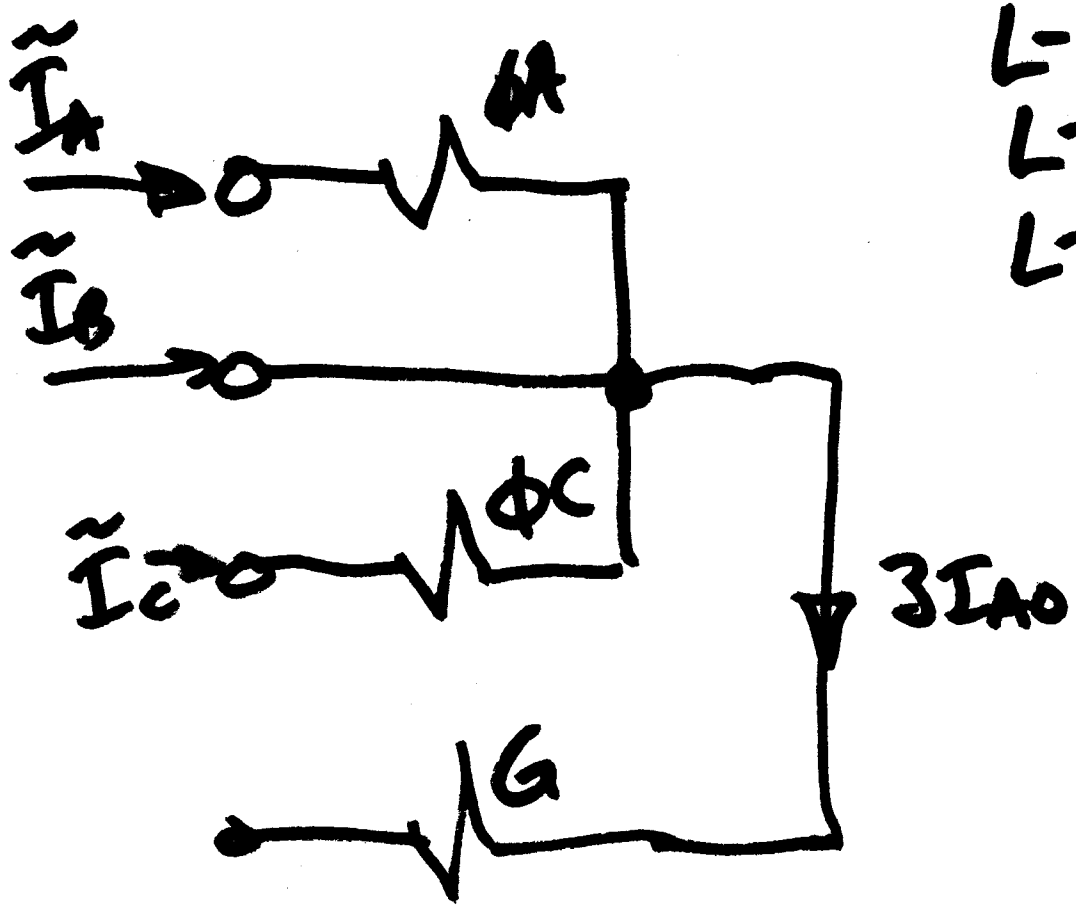
Tom shares a similar case from what appears to be a 345-kV breaker and a half case. The 5 CTs in one device turn out to be what I call a "pedestal" CT or what Tom calls a "stack type" CT. I'll show the pictures in class tomorrow. The pedestal CTs are necessary because the older type air-blast circuit breakers (60s and 70s vintage) do not have any CTs incorporated in their bushings so a separate external CT had to be designed into the system.

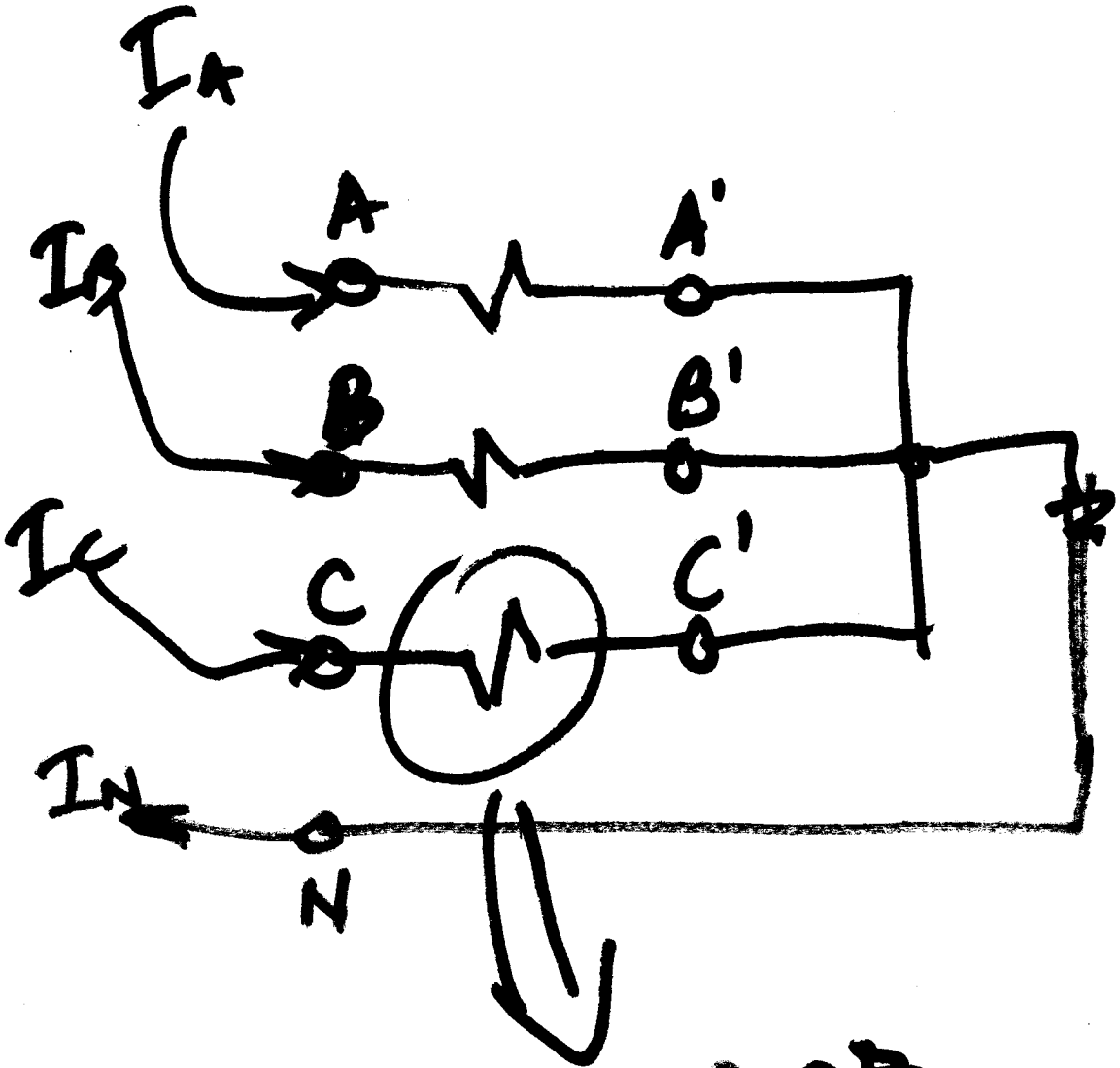
Tom also shares a picture of the airblast circuit breakers and some newer SF6 breakers with built-in CTs.

Dr. Mork

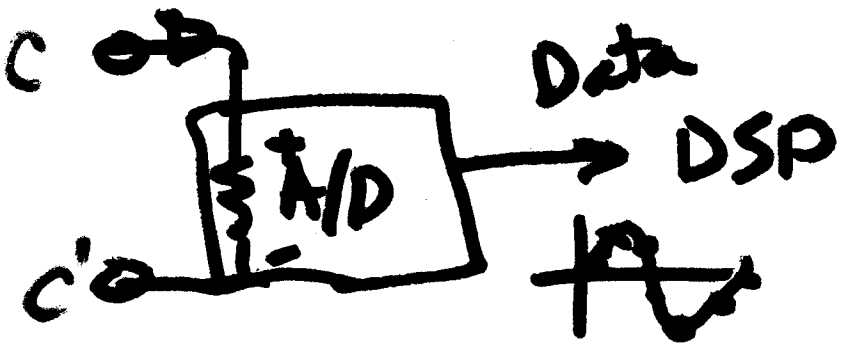
> From: "Miller, Thomas" <tommiller@ltctransco.com>
> To: "bamork@mtu.edu" <bamork@mtu.edu>
> Date: Tue, 10 Feb 2009 20:39:47 -0500
> Subject: Lecture 13
>
> Dr. Mork,
>
> In reference to lecture 13, looking at the CT protection on the one line diagram, I think the CT arrangement is possible because of an extra 'donut-type' CT. This CT may have been eliminated from the one line diagram shown in class.
>
> Attached is another one line diagram showing this donut-type CT, and an extra shorted CT with a different accuracy class usually used for metering purposes. This donut-type CT is used exclusively to protect the stack type CT configuration from an internal fault. Any current detected by the 50N/type SC relay will trip an 86CF/type WL to isolate the circuit breaker.
>
> I have also attached pictures of two different types of high voltage circuit breakers. The breaker with the stack type CT configuration has the donut-type CT at the base. The other breaker uses CTs on both sides of the main contacts, thus the main copper is always protected.
>
> Tom

3Φ –
L-L –
L-L-G
L-G

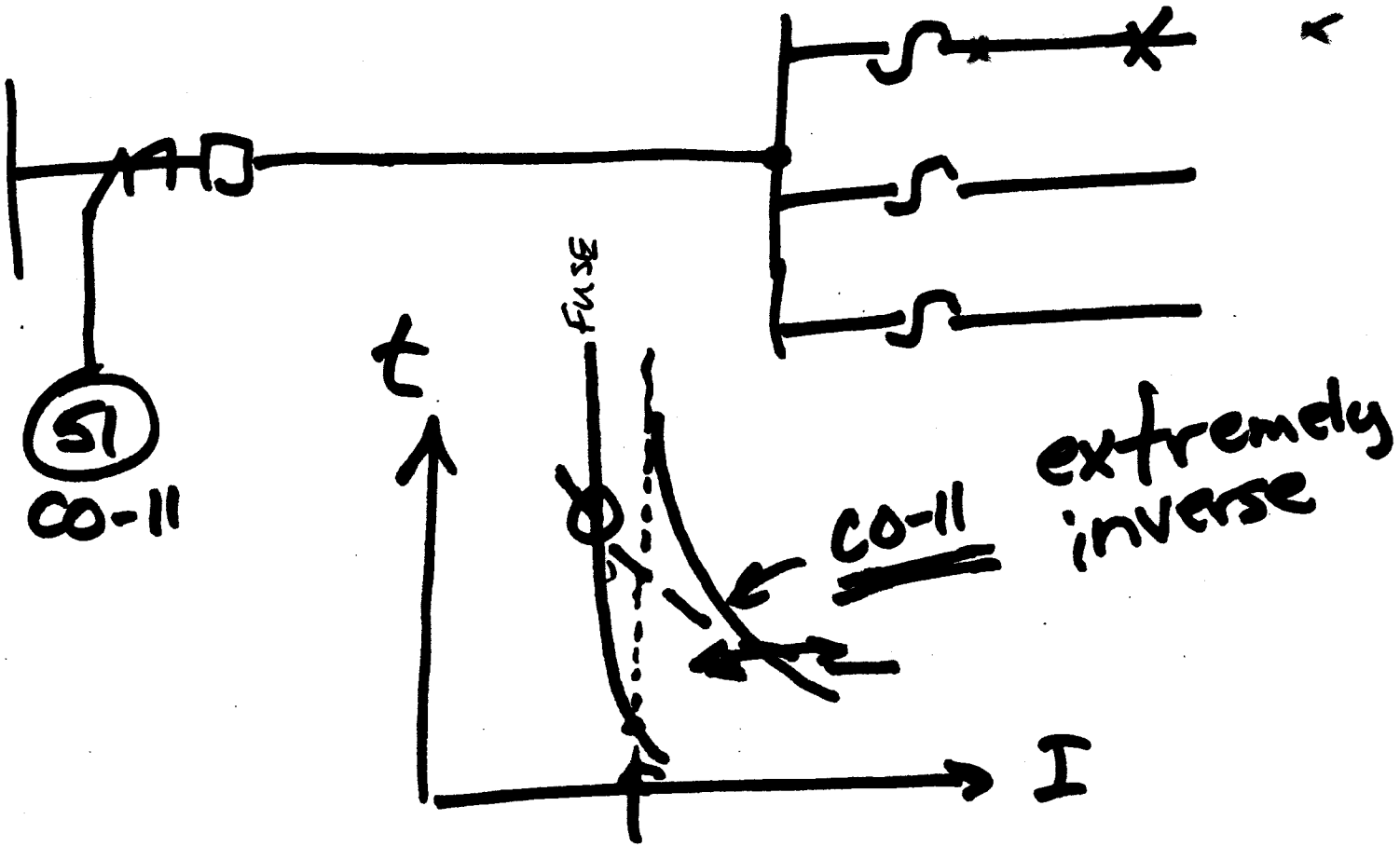


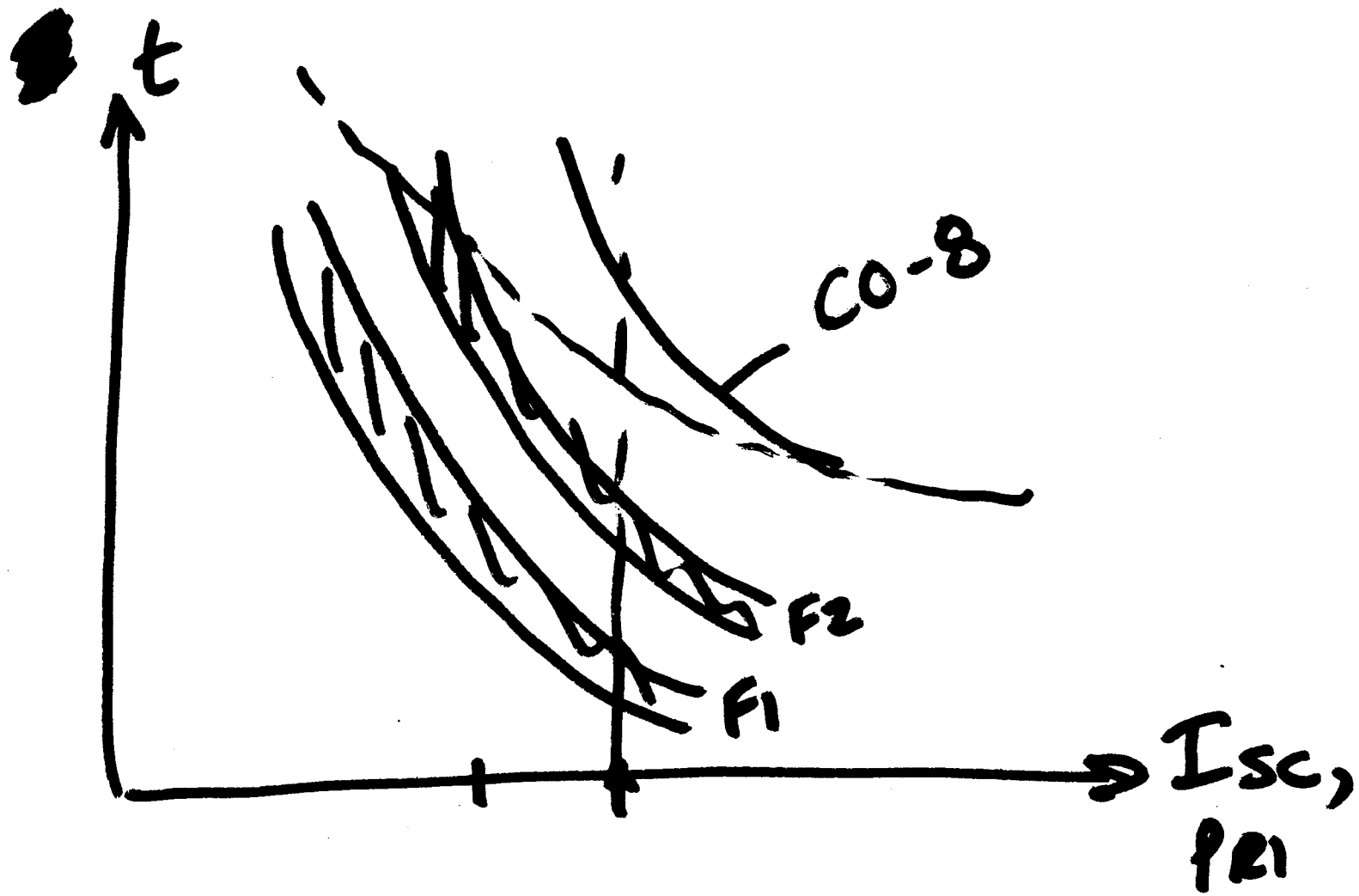


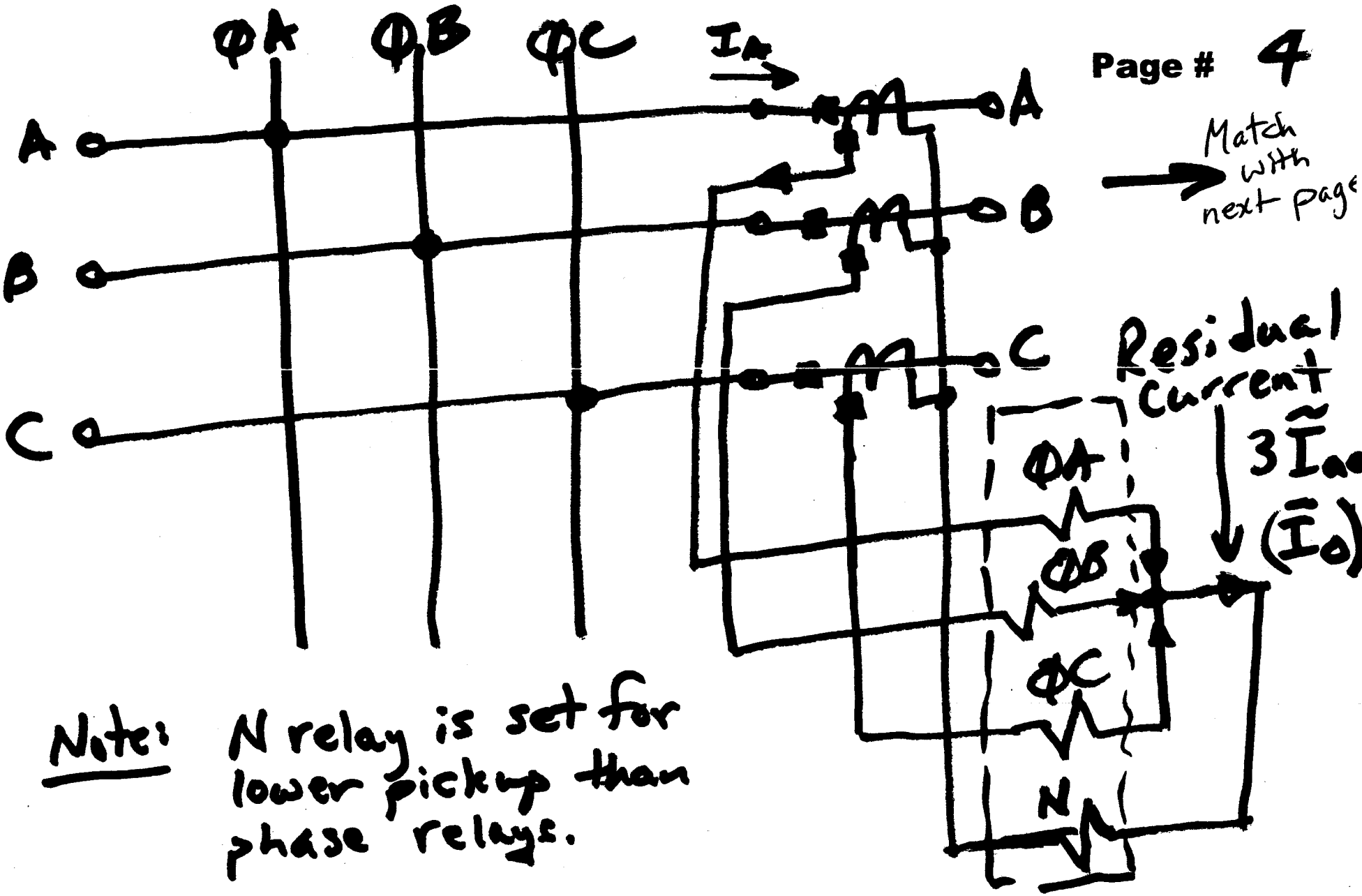
$$3\tilde{I}_{A0} = \tilde{I}_A + \tilde{I}_B + \tilde{I}_C$$



Coordination of Fuses w/relays




t
CO-8
F2
F1
Isc,
pA



Note: N relay is set for lower pickup than phase relays.

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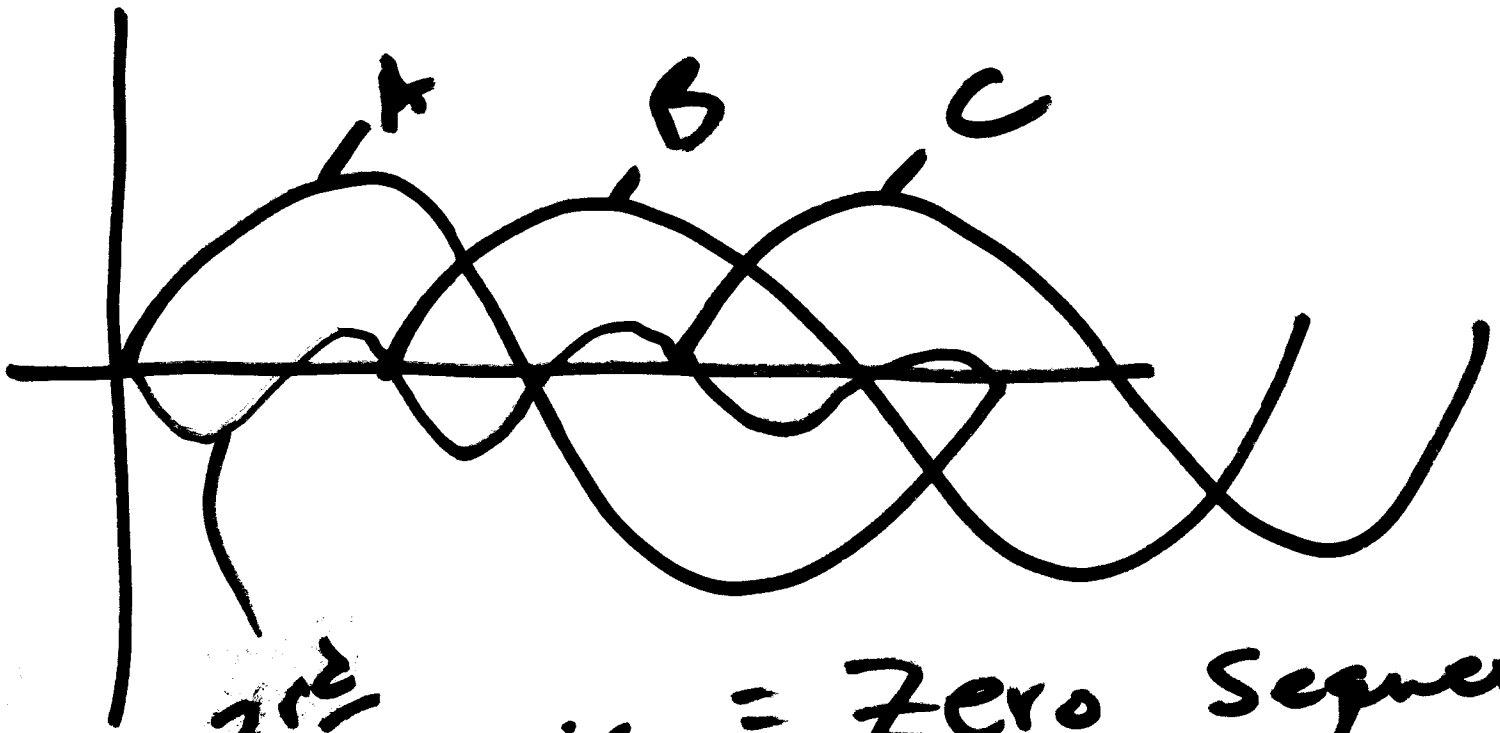
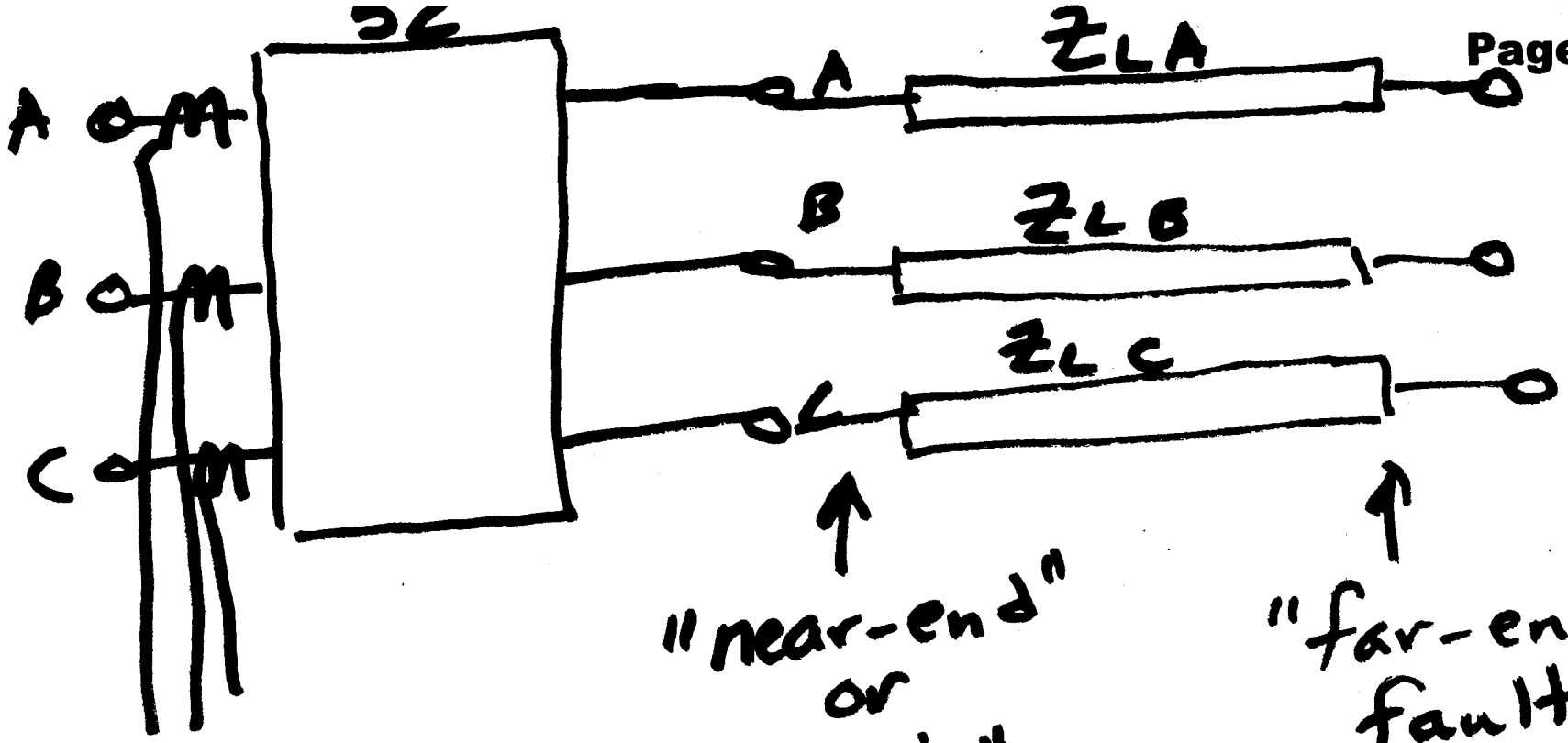


3rd Harmonic = Zero Sequence

Harm	POS	NEG	ZERO
3rd, 6, 9...			x ← "Tri-plen"
2, 5th, 7th		x	
1st, 4, 8	x		



Types of Faults -- 3-Phase, 3-Phase-G
- L-L
- L-L-G

(-LG) } ZF

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