Ongoing List of Topics:

- **URL:** [http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm](http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm)
- Labs - EE 5224 Labs ongoing. Key: do the prelab!
- Team formations - Homeworks 3A (done) and 3B (Feb 22nd)!
- Fri Feb 19th - Proposed project topic for term project. Propose 2 project ideas (about 3 sentences each: topic, what/how you will do, and deliverables).
- Today:
  - Show and tell - 67 relays
    - electromechanical IRD (from SB19)
    - electronic BE1-67N (from SB35)
    - uProc SEL-311 (From SB35)
  - Proposed term project idea/topic (2-3 sentences) submit by end of week!
- Misc Topics: insulators, BIL, NESC clearances, corona
- Symmetrical Components overview
  - Basic pos/neg/zero networks
  - Fault current is only first step of calc. Need fault contributions at relays!
  - transformer connections in zero seq, and phase shifts in pos/neg.
- Homework #8 - group assignment by project teams.
Grid Area 1 \rightarrow \text{Load} \rightarrow \text{Line} \rightarrow \text{Grid Area 2}

\[ P_{12} \Rightarrow \frac{V_1 V_2}{X} \sin (\alpha - \beta) \]

\[ \Rightarrow (\alpha - \beta) \text{ increases as } P_{12} \text{ increases} \]

- Tripping line increases \( \angle A - LB \)
- Reclosing may be problematic...

\[ \text{Set at } \leq 40^\circ \]
67 - Directional O.C.
(can also have inst. &
time delay versions).

**Key:** Polarizing input
determines the
directionality of
relay. Can use
either V or I to
polarize.

EE 5210 - Power Systems Protection Spring 2001
Types of Faults: 3-Phase, 3-Phase-G, L-L-L, L-L-G

"near-end" or "close-in" fault

"far-end" fault

EE 5210 - Power Systems Protection  Spring 2001
**Figure 4.34** Sequence voltages and the voltage at the fault point for the various fault types. Solid faults with $Z_1 = Z_2 = Z_0$ for simplicity. Magnitudes are not to scale.

<table>
<thead>
<tr>
<th>Fault Type</th>
<th>Positive Sequence</th>
<th>Negative Sequence</th>
<th>Zero Sequence</th>
<th>Fault Voltages</th>
</tr>
</thead>
<tbody>
<tr>
<td>a, b, c</td>
<td>$v_{c1}$</td>
<td>$v_{a1}$</td>
<td>$v_{b1}$</td>
<td>$v_a = v_b$</td>
</tr>
<tr>
<td>a, b</td>
<td>$v_{c1}$</td>
<td>$v_{a1}$</td>
<td>$v_{b2}$</td>
<td>$v_c = v_a$</td>
</tr>
<tr>
<td>b, c</td>
<td>$v_{c1}$</td>
<td>$v_{a1}$</td>
<td>$v_{b2}$</td>
<td>$v_b = v_c$</td>
</tr>
<tr>
<td>c, a</td>
<td>$v_{c1}$</td>
<td>$v_{a2}$</td>
<td>$v_{b2}$</td>
<td>$v_a = v_c$</td>
</tr>
<tr>
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</tbody>
</table>

**Figure 4.35** Sequence currents and the fault current for the various fault types. Solid faults with $Z_1 = Z_2 = Z_0$ for simplicity. Magnitudes are not to scale.
Key: Relay located at sending (near) end of line.

- Voltage at relay greatly reduced during fault, but will only be zero for close-in fault.
IF $Z_{TH}+Z_{LINE} < Z_{LOAD}$

$\Rightarrow Z_{LOAD}$ determines S.S. $\phi$-angle of I.

$\Rightarrow Z_{TH}+Z_{LINE}$ determines S.S. $\phi$-angle of I during fault!