Topics for Today:

- Introductions
- Startup
  - Book
  - Syllabus
  - Course Expectations, Grading
    - Attend all lectures
    - Come to class on time
    - Turn in work on time
    - Interview trips: not an excused absence
- Labs - EE4224/5224 - Begin in Week 2
- Term Project
- Software - Aspen
- Intro to system protection. Always be aware of:
  - Reliability: dependability vs. security
  - Selectivity
  - Speed
  - Simplicity, Economics
- Zones of protection
- Bus Configurations (Ch.10, sect 10.1 - 10.10)
- How to read a one-line
- Instrument transformers
- Study Chapter 1, review Chs. 2, & 3.


READING ASSIGNMENTS: The reading assignments and information to be reviewed will be posted on the course web page on an ongoing basis. Materials are to be read before the related lecture.

HOMEWORK: Homework assignments will be given on an ongoing basis and will be a combination of handouts and book problems. Use 8½ x 11 green engineering grid paper, one side only. Show all work, illustrate by schematic or a diagram, give equations before substitution, show all units and underline or circle all answers.

You are to work with a homework partner, and may have a different partner for each assignment. Take turns being lead partner. Blind copying of problems is not allowed, as this defeats the purpose of doing homework in the first place.

TESTS: Approximately 3 tests will be given. They will be take-home exams. As for all tests taken at MTU, the university's "Academic Integrity" policies shall be strictly enforced (this guide is available on-line and from the Dean of Student's office).

ABSENCES: Students are expected to be present for all class meetings. Note that interview trips are not an excused absence. Full credit may be possible for late work, provided there is a legitimate excuse. It is the student's responsibility to contact the instructor, explain the circumstances, and arrange for makeup (in advance if possible). Arrangement for late makeup of tests or the final exam is possible only in extremely exceptional circumstances. Makeup tests are graded half on written performance and half on interview/explanation of solution.

HELP FROM INSTRUCTOR: Questions are encouraged in class, as time permits. A classroom office hour will be scheduled, as will office hours in my office in EERC 623.

GRADING: Final averages will be based on the following distribution:

<table>
<thead>
<tr>
<th></th>
<th>EE 4223</th>
<th>EE5223</th>
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<tbody>
<tr>
<td>Tests (2-3):</td>
<td>45%</td>
<td>40%</td>
</tr>
<tr>
<td>Homework:</td>
<td>25%</td>
<td>15%</td>
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<tr>
<td>Applications Probs:</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Term Project:</td>
<td>20%</td>
<td>30%</td>
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Worst case grade cutoffs: A: above 90, AB: 85, B: 80, BC: 75, C: 70, CD: 65, D: 60. Cutoffs may be adjusted downward in some cases, as explained in class. Student grades-to-date and class standings will be updated following each test. It is your responsibility to verify that your grades have been correctly entered. Be aware of your standing so you know if you have to work harder to get the grade you want. Cutoffs for individual students may be adjusted 1-2 pts downward depending on attendance, participation, professional merit.
Protection - From What?
- Lightning
- Faults - S.C.S.
- Operational Errors (controls)
- Switching Surges (Overvoltages)

- Of What?
- Lines, Cables
- Transformers - 30-50 yr life.
- Generators - 30-40 yrs
- Buses
- Motors
- Cap Banks, Reactor Banks
- FACTS devices - 10-20 yrs.
Key Goals of Protection (p. 1a)

- Economics
- Reliable (always trip for problem)
- Fast ("time is damage")
- Selectivity (only trip what's needed) (Minimum)
- Simplicity
  - Fewer parts
  - Cheaper
  - Faster to troubleshoot/fix

EE 5210 - Power Systems Protection

Spring 2001
One-line Symbols:

- Control/termination cabinet, used for plan view drawings.
- Circuit Breaker (High Voltage)
- Air-Break Circuit Breaker (Low Voltage)
- Fused Disconnect Switch
- Fused cutout
- Disconnect Switch
- Air-Break Switch w/arc restrictor

Circuit Switcher:

- Vacuum interrupter trips first, then switch opens.
- Can't interrupt high fault currents like CB, but cheaper.
- Often used on HV side of transformer.
- Can close & open on full load current also, so provides function of load-break switch as well.
CHAPTER 11 - SYSTEM PROTECTION

Instrument transformers - used to "step down" primary voltages and currents to lower standard levels.

- Current: 0-5A - CT
- Voltage: X1-X3: 0-120V
  X2-X3: 0-69.3V
  VT
  X1-X3: 0-115V
  X2-X3: 0-66.4V
  CVT or CCVT

Ex:

Note that "PT" designation is obsolete - new designation is "VT". Economics usually point to use of CVT or CCVT for voltages above 69-KV, VTs for lower voltages.

Note that linear couplers, which produce a secondary voltage proportional to the primary current, were in vogue for a while in the 50's & 60's but never caught on. Used mainly in bus differential schemes. Requires special relays (voltage instead of current input) - this additional cost hobbled it. (See p. 353, Blackburn)
Zones of Protection

- Overlapping
- Preferably at CB

(Note: CT is actual boundary of Zone B)

-- Zone A to Zone B

EE 5210 - Power Systems Protection  Spring 2001
No CB?

Zone A

Zone B
a) Circle the zones of protection for the following power system.

b) State which CB's trip for a fault at:
   1) L1
   2) Bus III
   3) G2
   4) T4
   5) Bus II
   6) Load
   7) M1

c) For a fault on Bus I and CB3 fails which CB opens as backup.

d) Does CB2 need to operate for a Bus I fault?

e) For a fault on L4 which CB's back up CB11.

f) For a fault on L2 which CB's back up CB4.

g) CB6 & 9 trip → where was fault?

h) CB 6, 9, 8, 11 trip → where was fault

i) CB2 trips where was fault

j) CB1 trips where was fault

k) CB7 trips where was fault

l) For a fault on Bus III), which CB's
   1) Trip first
   2) If the ones which should trip first don't which ones should trip next.