University of Idaho

# ECE 525

# POWER SYSTEM PROTECTION AND RELAYING

## SESSION no. 1

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# ECE 525: Power Systems Protection and Relaying

## Fall 2018

**DESCRIPTION** Study of power system faults and application of relays for power system protection. Review of symmetrical components as applied fault currents. Introduction to digital filtering and microprocessor based relaying. Use computer simulation for application of relays.

**PREREQUISITES** Power Systems Analysis (UI ECE 422 or equivalent) or permission.

**INSTRUCTOR** Brian K. Johnson

**CLASS TIME** 3:30 – 4:45 pm T,Th, JEB 25

**CONTACT INFO**
Phone: 208-885-6902 (800-824-2889, ext. 6902)
Fax: 208-885-6165
e-mail: bjohnson@uidaho.edu

**OFFICE HOURS** M-F: 11:00-12:00
Or any time my door is open.

**COURSE WEB SITE** http://www.ece.uidaho.edu/ee/power/ECE525

**TEXT**
*Required:* J.C. Das: *Power System Protective Relaying*. CRC Press, 2017)

*Optional Reference:* J.L. Blackburn and T.J. Domin: *Protective Relaying: Principles and Applications, Fourth Edition.* CRC Press, 2014 (3rd edition of the book is ok as well).

GE Grid Solutions Network Protection and Automation Guide (available for free on the web, see links on course web page for access instructions).

**REFERENCES**
1. H.J. Altuve, E. O Schweitzer, III, *Modern Solutions for Protection, Control and Monitoring of Electric Power Systems*. Schweitzer Engineering Laboratories, Inc., 2010. Order through SEL: http://www.selinc.com
2. P.M. Anderson, *Analysis of Faulted Power Systems*, IEEE PRESS, 2000. **Note:** this book is available for free download for IEEE members from IEEEXplore (log in as yourself, go to Books, then select tab for Classics and search for the book title).
3. P.M. Anderson, *Power System Protection*. IEEE PRESS, 1998. **Note:** this book is also available for free download for IEEE members from IEEEXplore

**SOFTWARE**
- You will be required to use MathCAD for several projects during this course. I can provide you a link for ordering a student license at a reduced fee under a UI license. You can also access it through the university VLAB portal.
- You might want to use a commercial fault programs for performing short calculations at times. If you do not have access to a program, you can use the demo/educational version of Powerworld: http://www.powerworld.com
- I will do some relaying examples using relay models in transients programs. We will discuss access to those programs.

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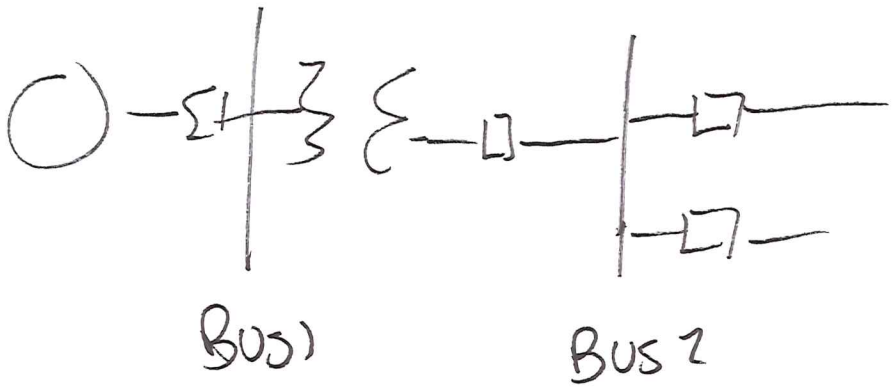

## GRADING:

| Item | Percent of Grade | A: 90-100 |
|---|---|---|
| Homework | 23% | B: 80-89 |
| Labs/Projects | 16% | C: 70-79 |
| Quizzes | 5% | D: 60-69 |
| Exam 1 | 28% | F: < 60 |
| Final Exam | 28% | |

## COURSE OUTLINE

| *Lecture Topic* |
|---|
| Introduction/Welcome |
| Protection Basics 1, 2, 3 |
| Instrument Transformers |
| Grounding schemes, fault detection and identification 7, notes |
| Brief Review of Symmetrical Components & fault calculations |
| Distribution Protection 6, 8<br>• Instantaneous overcurrent protection<br>• Time overcurrent protection<br>• Directional protection<br>• Coordination<br>• Arc flash |
| Fundamentals for software tools and labs<br>• Introduction to transient simulation tools<br>• Introduction to MathCAD<br>• Signal processing and digital filtering –in MathCAD<br>• Distribution Relay in MathCAD<br>• Introduction to AMPS<br>• **Lab 1/project 1:**<br>• **Lab 2/project 2:** |
| Bus protection<br>• Differential Protection<br>• Bus configurations<br>• Common bus protection schemes<br>• Impacts of CT saturation - Breaker failure protection<br>• **Lab 3/project 3:** |
| Reactor/Capacitor Bank Protection |
| Transformer Protection<br>• **Lab 4/project 4** |

1. Exams may given as "take homes"
2. Note: homework assignments and projects will require software tools, especially MathCAD.

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## GENERAL GUIDELINES:

**On-Campus Students**:

1. Assignments handed in after the due date will be worth a maximum of 50%. However, we will allow extensions if you consult with us in advance and if you have a major schedule conflict.
2. Feel free to contact us by phone or e-mail if you have questions and can't make it to our offices easily.
3. We will be scheduling lab sessions using the model power system and RTDS outside of the normal class time. We will try to set times that don't cause problems with your work schedules or the schedules for your other classes.

**Outreach Students**:

1. This is not a self-paced class. Engineering Outreach students are expected to finish the course at the same time as the on campus students.
2. Due dates for homework and projects will generally be specified the same as the due date for on-campus students. This is the date when your assignment reaches Moscow. Assignments will be worth a maximum of 50% after the due date. However, we will allow extensions if you consult with us in advance and if you have a major schedule conflict.
3. Returned homework and projects may not reach you prior to exams. Please make copies of any assignments that you believe may be useful before you submit them.
4. Please put your name and the course number on top of the first page of each exam and homework, especially if submitting e-mail or fax. It would be best if your name was in the header of each page. E-mail submission of assignments is ok, as long as compatible file formats are used.

   Allowable formats for electronic submission are Adobe Portable Document Format (PDF), Microsoft Word (*.doc or *.docx), Rich Text Format (*.rtf) or MathCAD 15 (or earlier) or Prime 4.0. Limit to one or two attached files. I don't want a large number of files with no documentation on what order to use them. Please copy Ahmed Momen (mome4109@vandals.uidaho.edu) on e-mail submissions of homework and labs (not exams).
5. Make sure you number your pages as: 1/4, 2/4, etc., so I know whether or not I have a complete set. Also make sure writing is dark and clear on the scan.
6. Phone calls or the use of e-mail for asking questions is encouraged. You are welcome to call outside of office hours. The Engineering Outreach 800 line is available 24 hours a day so you can reach us outside of their hours.
7. Library Resources: As a UI student, you not only have access to valuable print and electronic resources from the university's library, such as access to IEEEXplore, but you also have the access to personalized assistance from the librarians. If you have assignments or research questions and aren't sure how to make the most of library resources from off campus, you can visit the Off-Campus Access information page on the library's website at: http://www.lib.uidaho.edu/help/offcampus.html

   As a UI student you can also download a VPN client from the ITS Help Desk: https://support.uidaho.edu/TDClient/KB/ArticleDet?ID=231

   You will need to log in using your UI student account.

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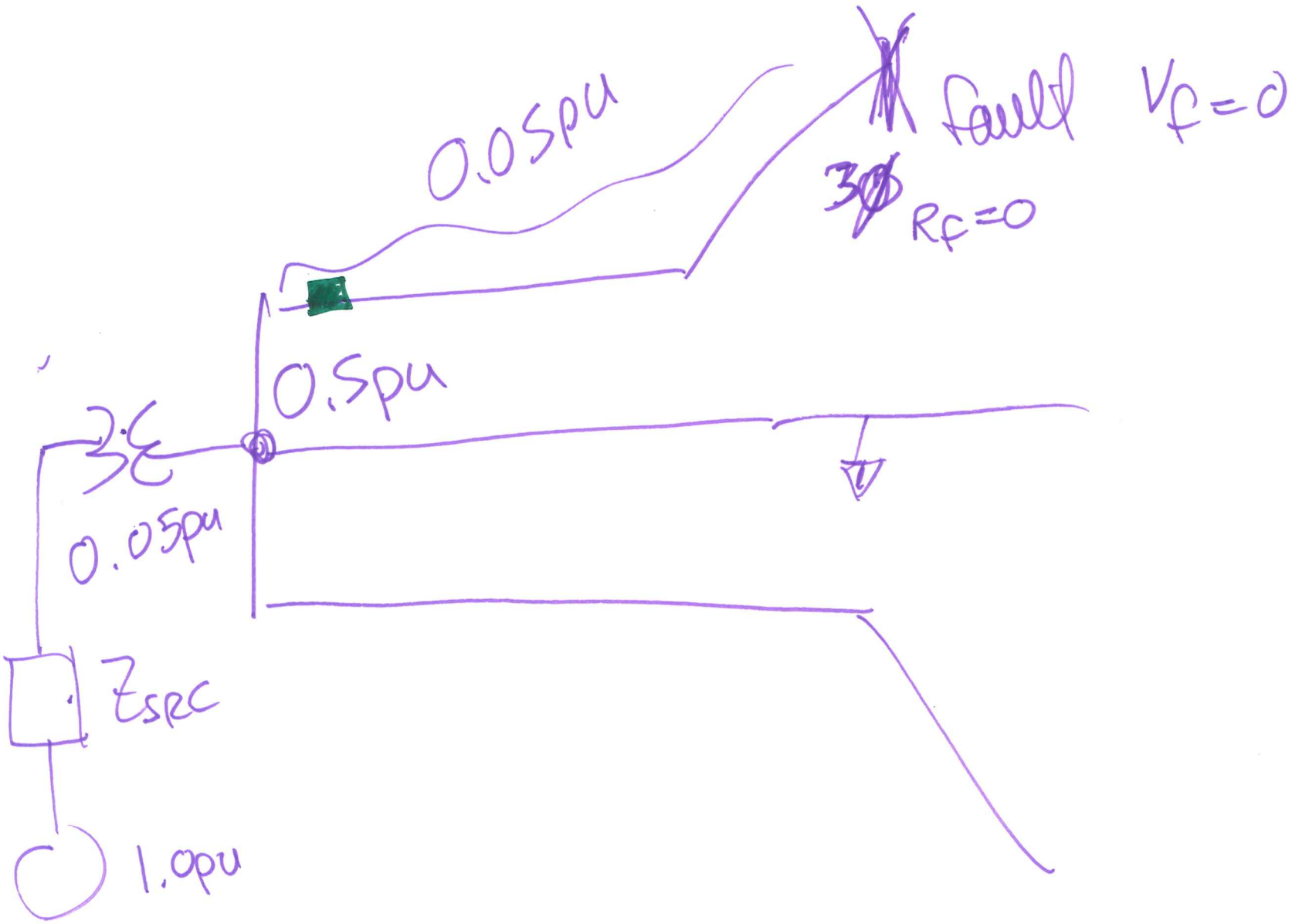
0.05pu
fault
$V_f = 0$
$R_f = 0$
0.5pu
3Ø
0.05pu
$Z_{src}$
1.0pu

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## Power Systems Protection

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- What exactly are we protecting?
  - » A Equipment - generators transformers lines etc
  - » B people
  - » C system stability
  - » D power quality
  - » E
  - » F



## Impacts on the Power System

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- Local protection
  - » Protection of immediate equipment
  - » Minimize disruption of loads
    - – Duration or interruption or abnormal condition
- Larger system issues?
  - » Impacts on stability of larger system
  - » Potential for distant impact
- Power Quality

## Expensive Consequences for Protection Failure

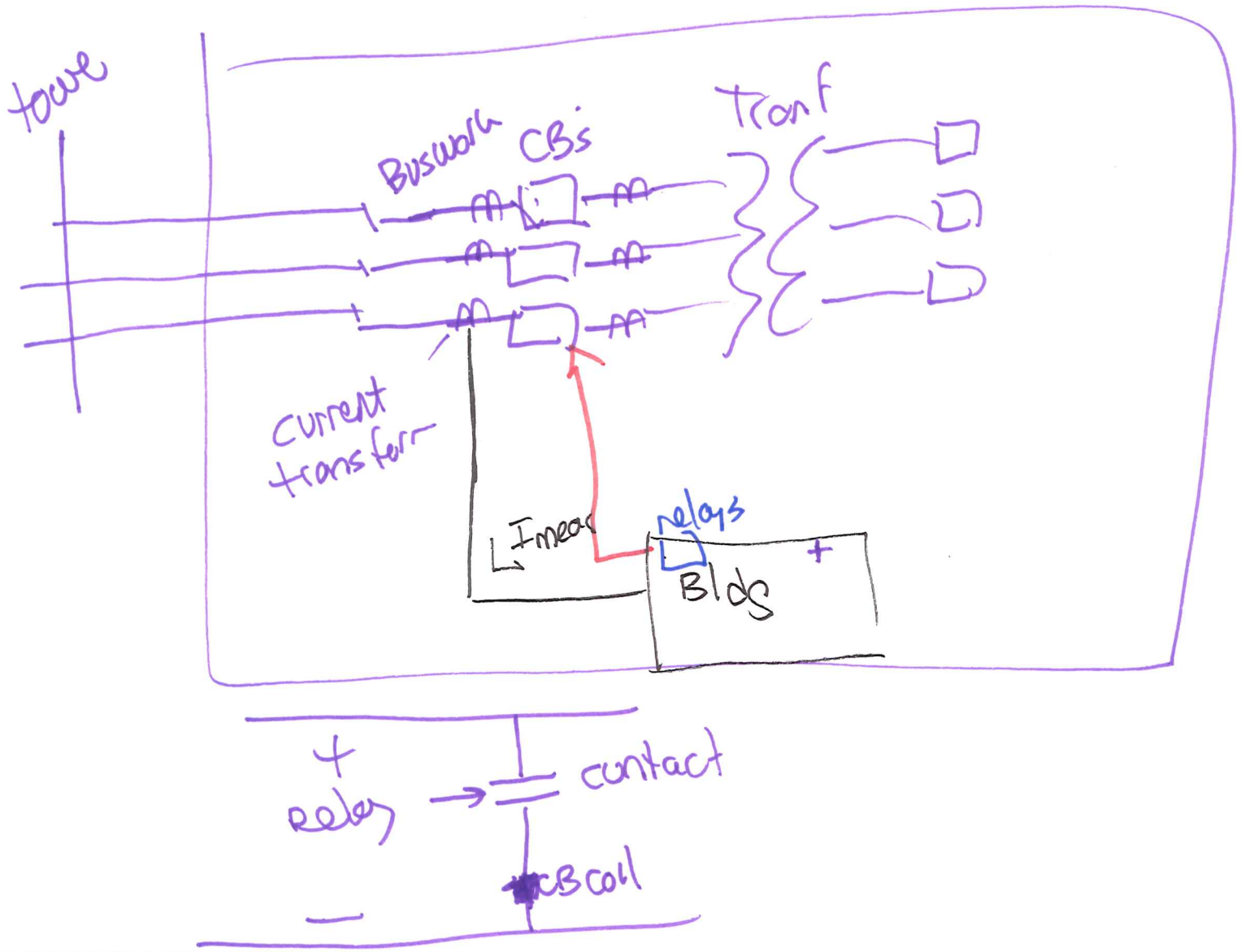




## What Events Require Protective Actions



- Faults (shunt)
  - SLG - 80-85%
  - 3Ø - rare
  - LL - } 15%
  - DLG - }
- Abnormal operation
  - Earthquake, hurricanes
  - Breaker failure
  - power swings


tower
Busbars
CBs
Tranf
current transfer
Imeas
relays
Blds
+
+
relay
contact
CB coil
–

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## What Actions Taken?

- 1 - open breakers (trip breakers) (local)
- 2 - open remote breakers
- 3 - ~~Rete~~ reclose
  - Block tripping
  - Delay tripping
  - Alarm
    - ↳ simple indicate
    - ↳ Record volt/current, etc = Event Record





## What is a Protection System?

- Current and voltage transformers
- Relay
- Circuit breaker
- Control wiring or substation network
- Communication system
- Coordinate with: Other relays, fuses, active controls