

**Topics for Today:**

- Announcements
- Detailed Term Project outline (in format of report [Table of Contents](#)) + complete list of references.
- Software: online students - apply for ATP/ATPDraw license, verify licensing when you receive it by e-mail, and we will mail you the install CD.
- ASPEN software - run off of MTU server via internet, see e-mail instructions.
- Office: EERC 614. Phone: 906.487.2857
- Recommended problems & all solutions: Ch.9, 13 solns now posted.
- Chapter 9 - Load Flow wrapup
- Corrective Actions for low or high bus voltage
- Line Loading concerns
- Contingencies
- System Security - Operation, Protection, Cyber-security

**Next: Chapter 13 - Power system operation, AGC, economic dispatch**

- Paralleling of Generators, droop characteristics
- Optimization methods - LaGrange multipliers

A term **project** shall be done in lieu of a final exam. The project you choose:

- must be of topical interest, and relate to course material of EE5200.
- must be new work (not copied from your previous course or a past student's project).
- must demonstrate a graduate student level of mastery and **application** of the related concepts and theories. [Note: this is not a term paper.]
- is sufficiently researched (referenced) and documented, and also includes the in-depth analysis and evaluation of the concepts of the most key journal paper related to this work.
- length of body of report: approximately 10 pages of text (not including figures, tables, or equations). All writing is your own original writing. Plagiarism is strictly prohibited!

Time line and required submissions are as follows, all deliverables contribute to the grade of your term project, i.e. 15% of your course grade. Approximate schedule is:

- Week 6 (Friday): submit short e-mail with idea(s) requesting instructor feedback.
- Week 7 (Friday): submit formal outline of project and list of key references.
- Week 9: submit expanded outline of project and complete reference list.
- Week 12: journal paper analysis and presentation (also counts as "mini-lecture")
- Week 12: Submit rough draft of project report before leaving for Thanksgiving break.
- Week 14: Submit final report/deliverable.
- Finals week: present/demonstrate project during final exam time-slot.

#### Report Outline:

##### ***Front Matter:***

- Title Page
- Executive Summary (not needed for initial draft)
- Table of Contents (use as "working outline")

##### ***Body of report:***

- Introduction (brief overview of project: problem area, motivation, overview of project)
- Background
  - literature search, most important references
  - Presentation of key concepts connected with project
  - Identification of existing voids or weaknesses, and resulting opportunity
- Proposed Approach
  - Overview of basic idea that you will develop and implement
  - Development and implementation details
- Implementation (may not be complete in draft versions)
- Results (Expected Results in draft versions)
- Conclusion
- Recommendations for Continued Work

##### ***Supplemental Information:***

- Reference List (number references [1], [2], etc, in order of first author's last name)
- Appendices as required to document details

#### Suggested layout:

- Font: 11-pt CG Times w/1.25-1.5 line spacing; or 10-pt comic or ariel w/1.0-1.25 line space
- Page layout: 1" margins, include page numbering within margin area.
- Use equation editor, number equations and references, call out references by number [1].

## Journal Paper Review

The purpose of this assignment is to get practice in library searches and in reading, understanding, analyzing, explaining, and critiquing a journal paper. It is likely that as a professional you will be called upon to review journal papers or conference papers for IEEE and other professional societies, so this is a useful skill to develop.

You are to find a recent journal paper whose subject is key to your term project. If you like, you can ask your instructor to approve the paper you've chosen. Typically, overview papers or papers that provide a qualitative synopsis are not acceptable. Preferably, you should find a paper that goes into the details of some type of analytical method of analysis. Some typical sources for papers are (also - many links are given at end of EE5200 web page, including IEEE Xplore):

- IEEE Transactions on Power Systems, Power Delivery, etc.
- IEEE Power & Energy Magazine
- Proceedings of IEE (Part B)
- Electric Power Research Journal
- Electric Machines and Power Systems Research Journal

You are to write a technical analysis and interpretation of the paper (not an outline!). *An analysis is an examination, evaluation, and interpretation of the paper. Is what the author doing correct? Has it been done before? Is it presented clearly? Is it worth writing about? Is the method new, an improvement on existing methods, or does it replicate something already done?* Go through the mathematical development of the paper, follow and understand the derivations, and explain how it works. To answer these questions, you may have to educate yourself on the topic of the paper. That may require reading other papers on the subject (given as references in the paper you're reviewing) and finding background material in books.

Deadlines:

Friday of Week 11 (Nov 13th): complete a rough draft of review/analysis notes of the paper. This should be your own intermediate deadline, we won't collect this.

Submit a formal review /writeup by end of Week 12 (Nov 20<sup>th</sup> )

On-campus students give short 8-10 min ppt "mini-lecture" by end of Week 13 (Dec 4<sup>th</sup> ).  
Off-campus students submit your ppt by e-mail attachment. It's possible to embed audio.

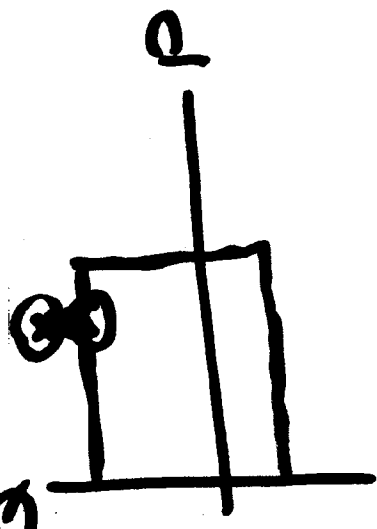
For on-campus student presentations, the written analyses are to be distributed to everyone in the class and read prior to your oral presentations. Everyone is encouraged to ask questions during the presentation.

# Load Flow

- How set up, i.e. parameter input. ✓
- What to do w/ output? Typical Probs:
  - Bus voltage too high/low
  - Line loading exceeded.
  - Transformers overloaded.
    - LOL concerns
    - Age concerns
- A limits of Gen's exceeded.

Load-flow software:

- Change Bus to PQ bus.

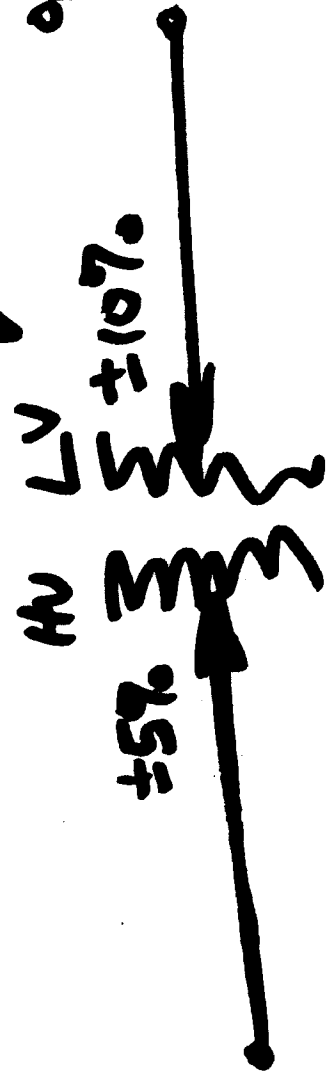


# Transformer Taps:

2

High Maintenance

100,000 -  
500,000  
operations.



- o — +5%
- o — +8.5%
- o — Nominal
- o — -2.5%
- o — -5%

HV: No-load taps: 5 taps  $\pm 5\%$

LV: LTC - Load Tap Changer  $\pm 10\%$ , 5/8% steps

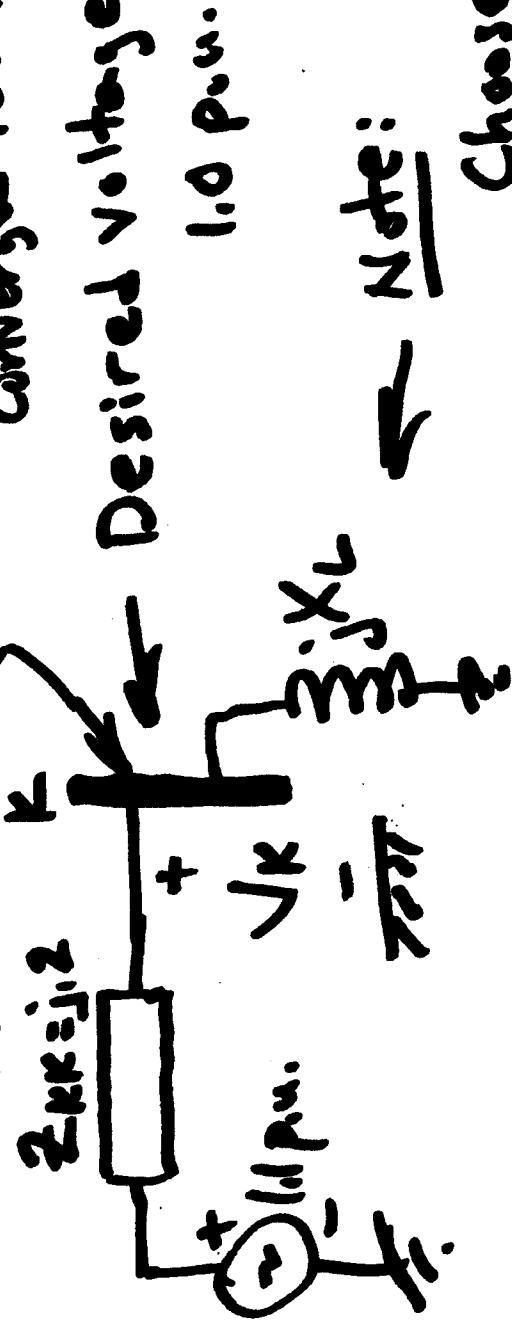
- o — 16H
- o — Nominal
- o — 16L

Bus voltage high/low.

3

Too high:

$V = 1.10 \text{ p.u.}$  from  
converged loadflow



Desired voltage:  
1.0 p.u.

Note:

Choose  $X_L$   
with smallest  
current draw.

$$V_k = 1.0 = 1.1 \frac{jX_L}{j1.2 + jX_L}$$

$$.2 + X_L = 1.1 X_L$$

$$.2 = .1 X_L$$

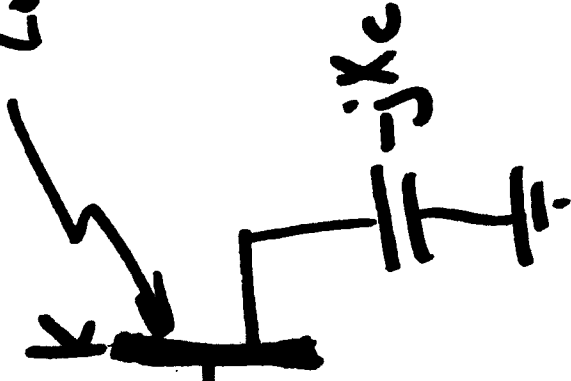
$$X_L = 2 \text{ p.u.}$$

4

Load flow: 0.91 p.u.

Two Loads:

$2 + j2$



$$X_c = \frac{1}{\omega C}$$

$$1.0 = \underline{0.91} \frac{-jX_c}{j.2 - jX_c}$$

Solving:  $X_c = \underline{2.22 \text{ p.u.}}$

$$Q = \frac{V^2}{X_c} = V^2 B_c \quad B_c = \omega C$$

What if  $Z_{kk}$  includes R?

$$1.0 = 0.91 \left| \frac{-jx_c}{(0.05 + j2) - jx_c} \right|$$

✓ must take  
abs.  
value.

square both sides,  
 $\Rightarrow$  gives quadratic,

2 solns for  $x_c$ .

$$x_c = \frac{1}{\omega C}$$

which  $x_c$  is "correct" to spec.

Case 1:  $x_{c1}$  is pos,  $x_{c2}$  is neg.  
(Reed.)

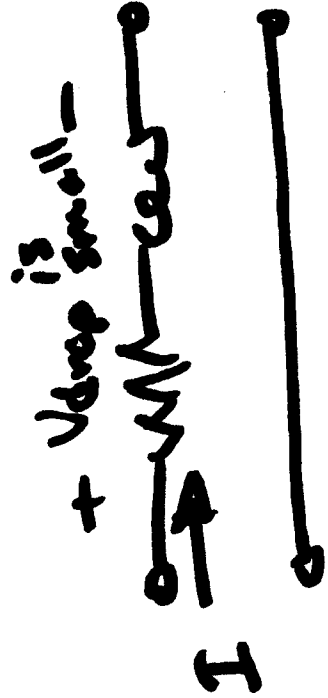
Case 2:  $x_{c1}$  is pos,  $x_{c2}$  is pos.  
 $x_{c1} > x_{c2}$ .

## Line Loading:

6

Short Line:

- usually no probs w/ Voltage drop

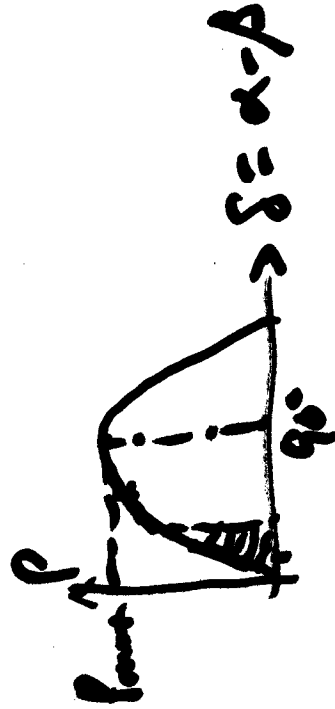
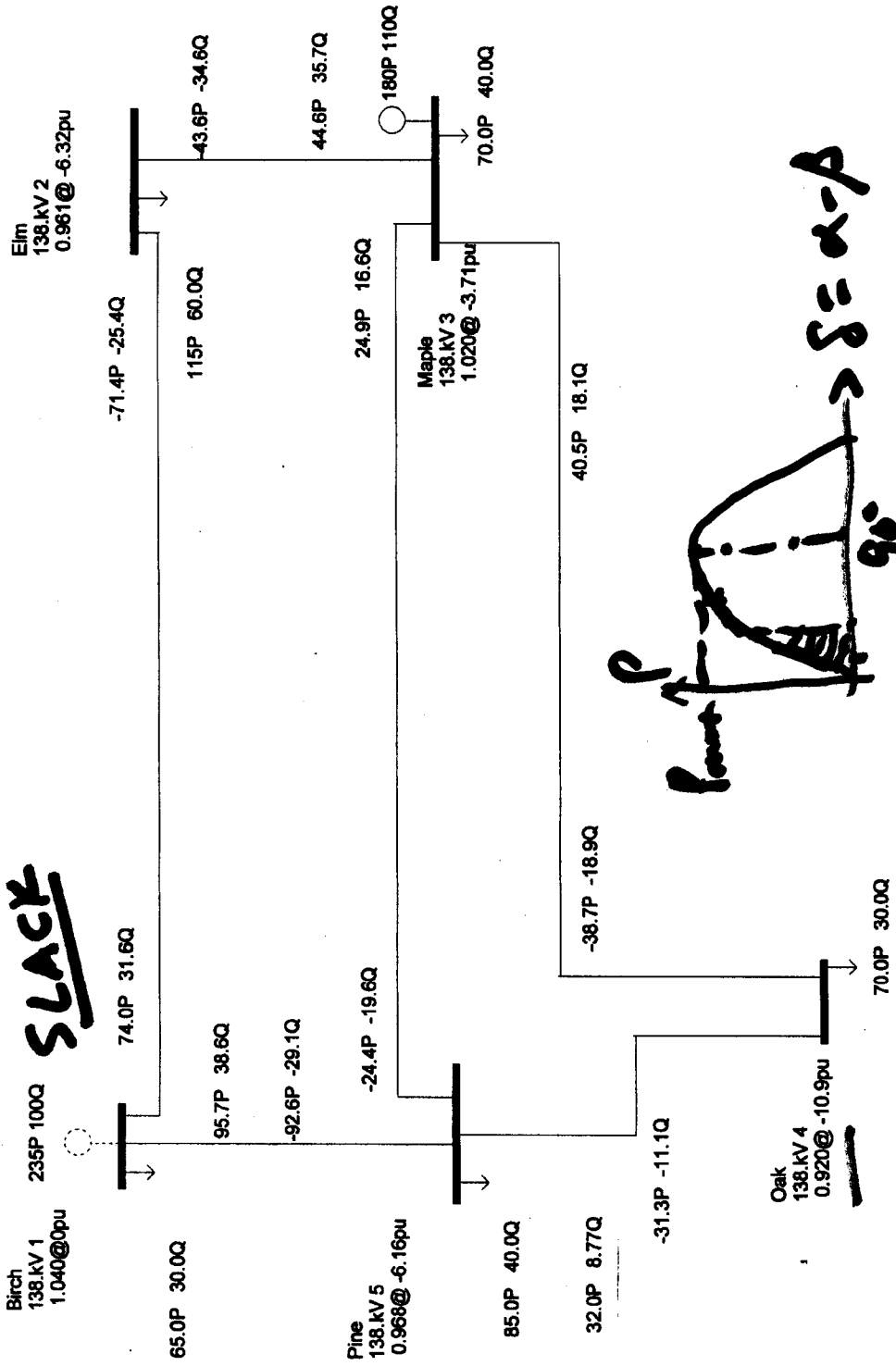


- Ampacity of line (I<sup>2</sup>R heating)

- ⇒ higher R
- ⇒ more sag.
- NESC.

- ACSR
- Composite - 3M.

# 5-Bus System



- ① - Ampacity
- ② - Voltage Drop:

(R+jX)

IR voltage drop results in low bus voltages.

- ③ - Power Transfer Limits



For typical operation,

$\alpha - \beta$  should be limited below 35-40°.

- ④ - Stability Limits

$$P_{max} = \frac{V_1 V_2}{X} \sin \delta$$

$$= \frac{V_1 V_2}{X} \sin(\alpha - \beta)$$



Contingencies - Major "event" that impacts system ability to maintain operation within limits.

Planning / design typically for "N-1"

N-1's implies loss of most critical component.

NERC, regional reliability councils, also TO's need to be involved.

- Survive N-1, but not N-2.
- System is very vulnerable in N-1 state, must restore system to secure state of operation ASAP.

Security: at least 3 uses/meanings 9

① - "System Operation" - "Secure  
operation"

② - Cyber-security - keep hackers  
from getting in, to servers.

- Relays
- Imbedded Processors.

③ - Security: power system protection.

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