EE 521/ECE 582 – Analysis of Power systems

Class #1 – August 23, 2022

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Outline

- Introductions
  - Professor
  - Class participants
- Syllabus Discussions
  - University Policies
  - Class Policies
  - Assignments
- Why do we care about analysis of power systems?

My Family

My parents

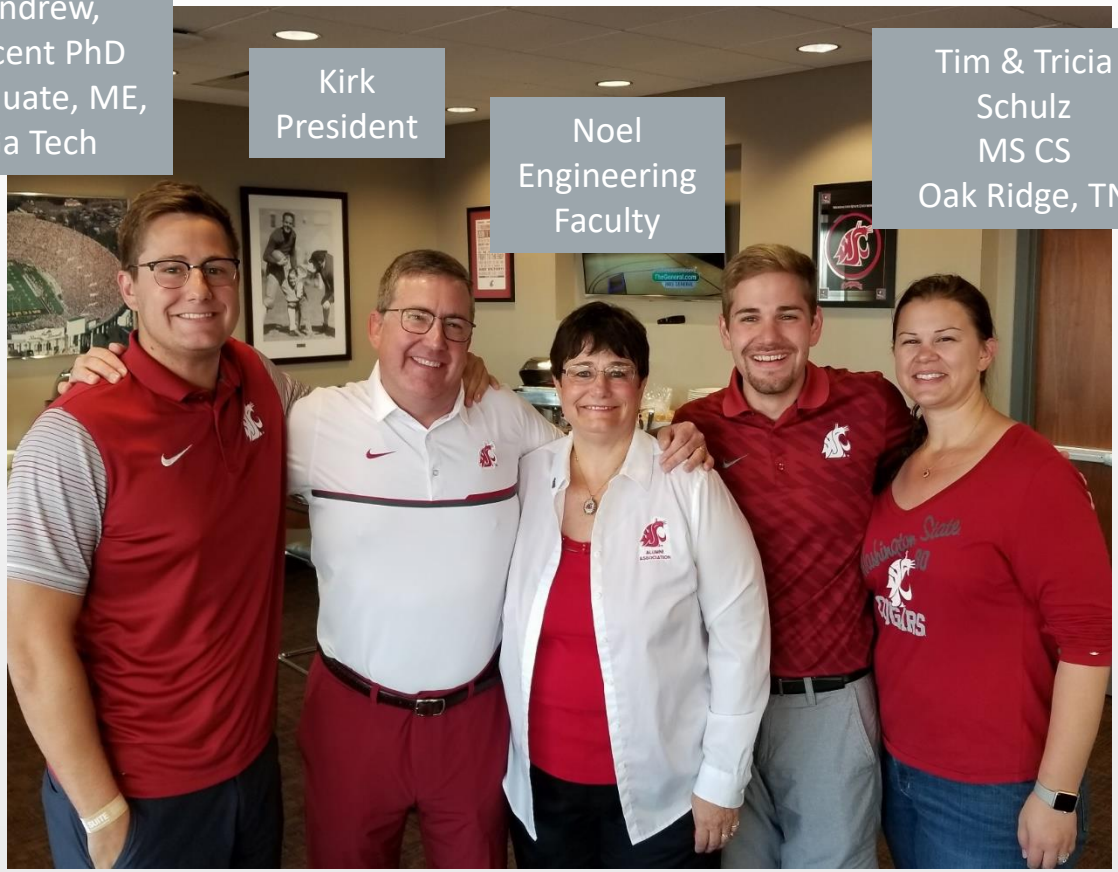
Dad – EE Professor
Mom – Elementary School Teacher

Andrew, Recent PhD Graduate, ME, Ga Tech

Kirk President

Noel Engineering Faculty

Tim & Tricia Schulz MS CS Oak Ridge, TN



Career Timelines – Dual Career Advancement

Asst Prof UND

Asst Prof MTU

Assoc Prof Dept. Chair MTU

Professor Dept. Head MSU

Dean MSU

VPR MSU

President K-State

President WSU

BS

PhD

1985

90

95

2000

05

10

15

Met

Married

Timothy

Andrew

Empty Nest

BS

MS

Instructor

PhD

PhD Student, Minnesota

Asst Prof MTU

Assoc Prof MSU

TVA Professorship

Prof MSU

Sabbatical F'08

Prof K-State

Assoc. Dean

Prof WSU

Schweitzer Chair

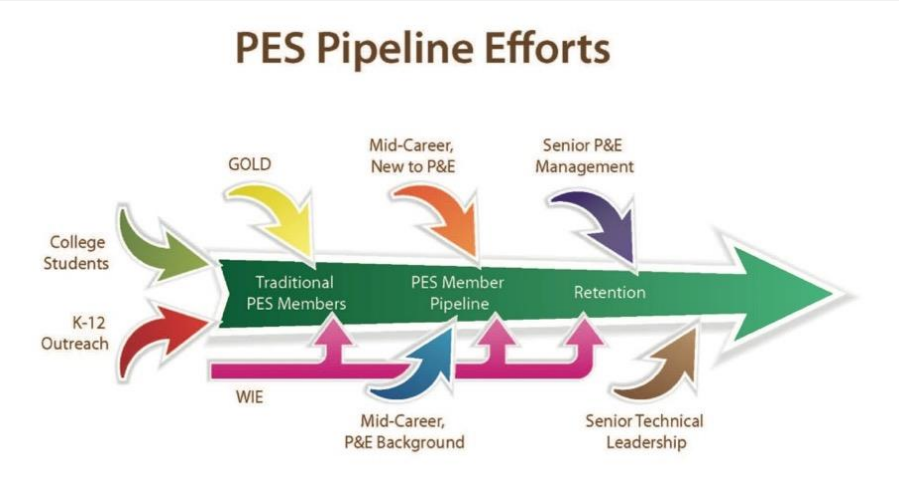
IEEE PES Pres ('12-'13)

Dr. Schulz's Research Areas

- Integration of DER into distribution systems including storage and electric vehicles
- Intelligent system applications in power system design, contol and operation
- Outage and Storm Management including smart metering and resilience efforts
- Rural electrification and Microgrids
- Shipboard Power Systems

IEEE Power & Energy Society
President Experiences -2012-2013

- Technical Society within IEEE (over 450,000 members worldwide)
- Over 37,000 members worldwide
- Traveled over 240k air miles over 2 years including 6 continents, interacting with students and engineering professionals from all around the world
- Two initiatives – pipeline support and women in power



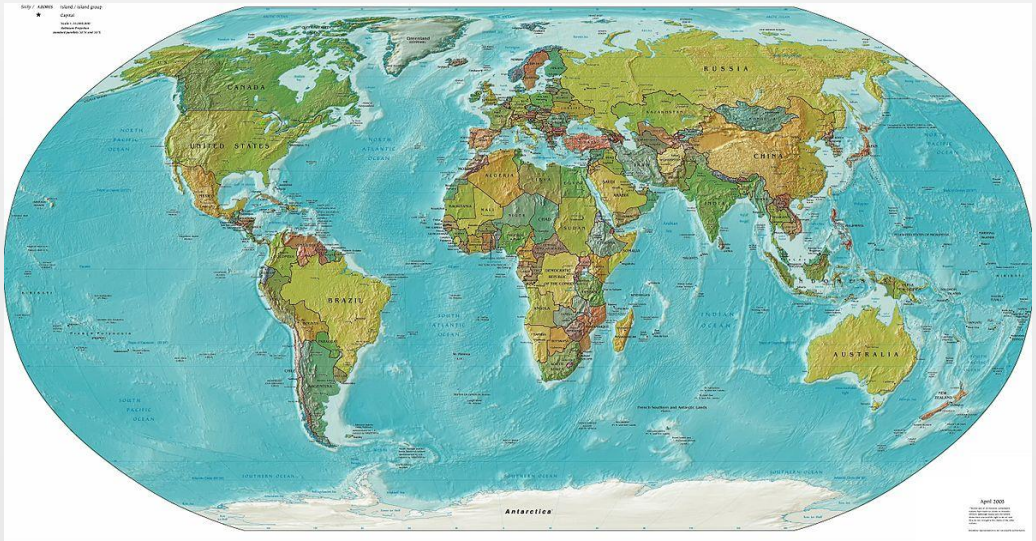
Women in Power

ISGT Asia 2013 – Bangalore

Africon 2015 – Addis Ababa

Learning through Travel

- In United States
  - Traveled within 48 states
  - Lived in seven states
- Traveled across seven continents
  - Sabbatical in Wales 2008 – 4 months
  - Visited 37 countries outside of US
- Spent 4 weeks in India in 2019



Introduce yourself

- Name
- Campus Location
- Program (MS or PhD)
- Research Area if known
- Fun thing you did this summer

Longer introduction on Canvas discussion

Syllabus Information

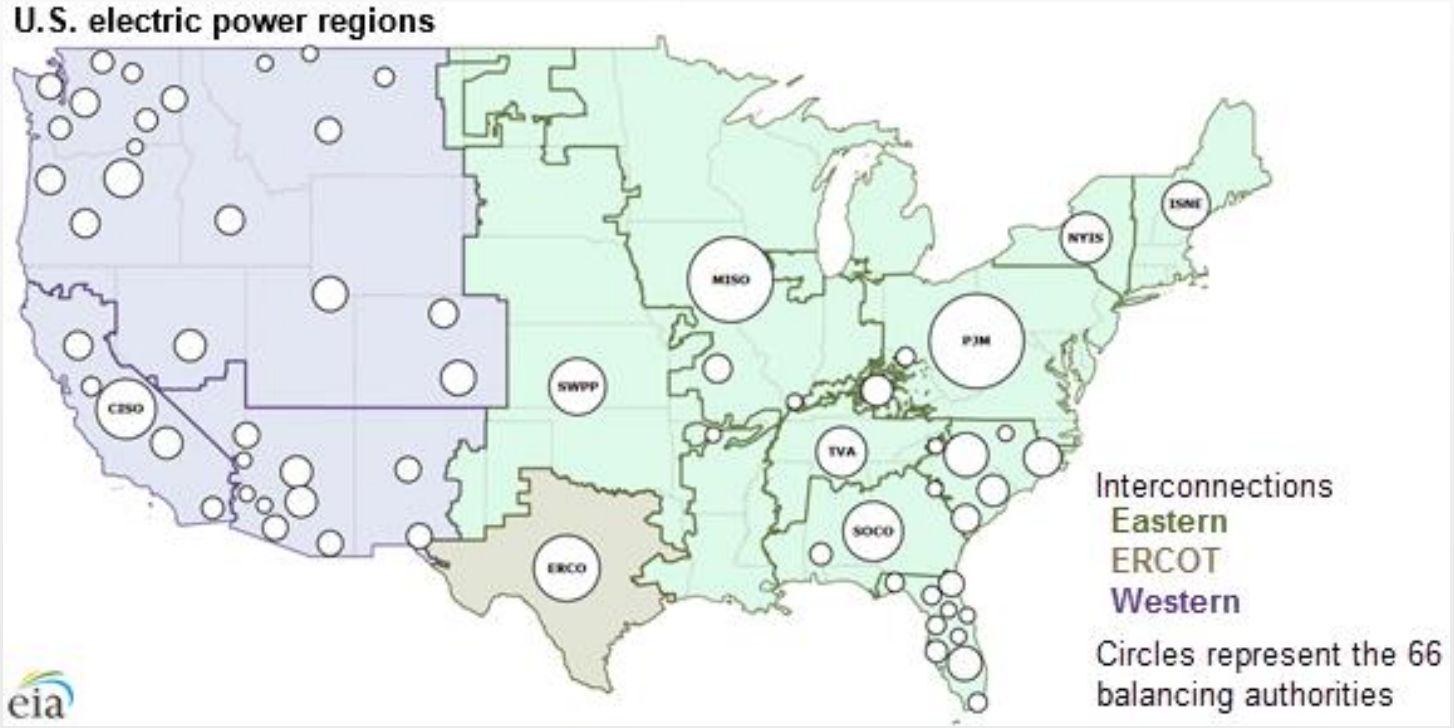
Canvas

Power Systems Analysis

- 2000 – National Academies of Engineering (NAE) called “Electrification- Vast networks of electricity provide power for the developed world.” to engineering achievement of 1900s link
- Generation often located away from loads
- Interconnection of the Power Grid – Electrical Highways – Transmission
- Substation to customers – Distribution

Power Systems Analysis

- According to the U.S. Energy Information Administration (EIA) EPA WEBSITE, the U.S. power grid is made up of over 7,300 power plants, nearly 160,000 miles of high-voltage power lines, and millions of miles of low-voltage power lines and distribution transformers, connecting 145 million customers throughout the country (EIA, 2016).



Power Systems Analysis – Lots of Questions

Make sure no overloads on the equipment

How do I restore after a fault?

How do I protect the power system?

How do I run system to minimize costs?

How do I run the system to minimize environmental impact?

Which generation plants should be on?

When to turn on which generator?

What happens if a certain switch is opened?

How do I create a model of power systems and answer some of these questions?

Converting Physical System into Computer Models

Questions to ask

- How do I model different parts of the system?
- How do I convert that into equations that can be used to find answers to questions?
- How much accuracy do I need?
- How long does it take to solve the equations?
- Can I get quick results for operations?

Converting Physical System into Computer Models

Matrices

$$\begin{bmatrix} 1 & 3 & 4 & 8 \\ 2 & 1 & 2 & 3 \\ 4 & 3 & 5 & 8 \\ 9 & 2 & 7 & 4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

$V=IR$

$P=I^2R = V^2/R$

$[Y]\,[V] = [I]$

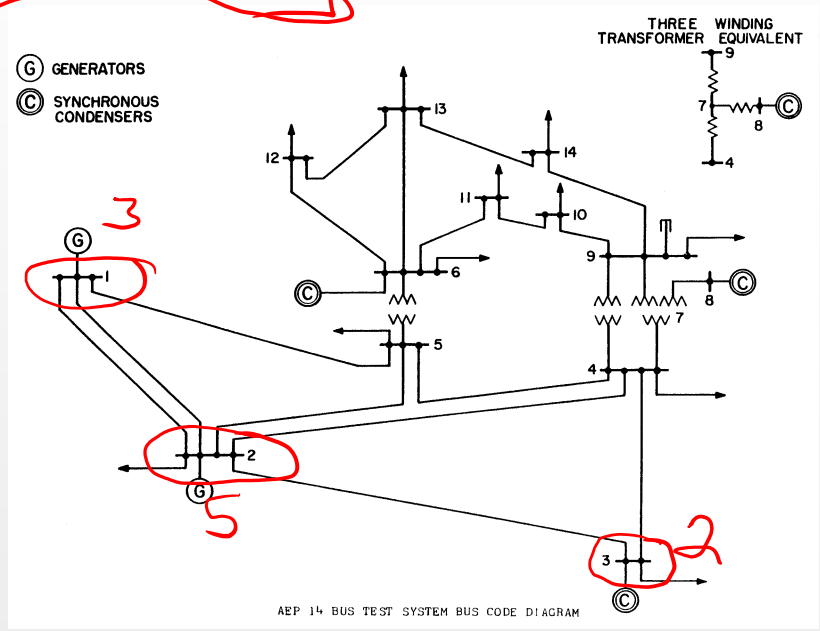
Challenges:

- Complex Numbers – many early programs in Fortran
- Large matrices where you need to take the inverse of the matrix
- Took lots of computational time to get results
- Changes to system, change the matrix so have to redo all the calculations

Utilities were one of the largest users of computers before the personal computer – mainframes.

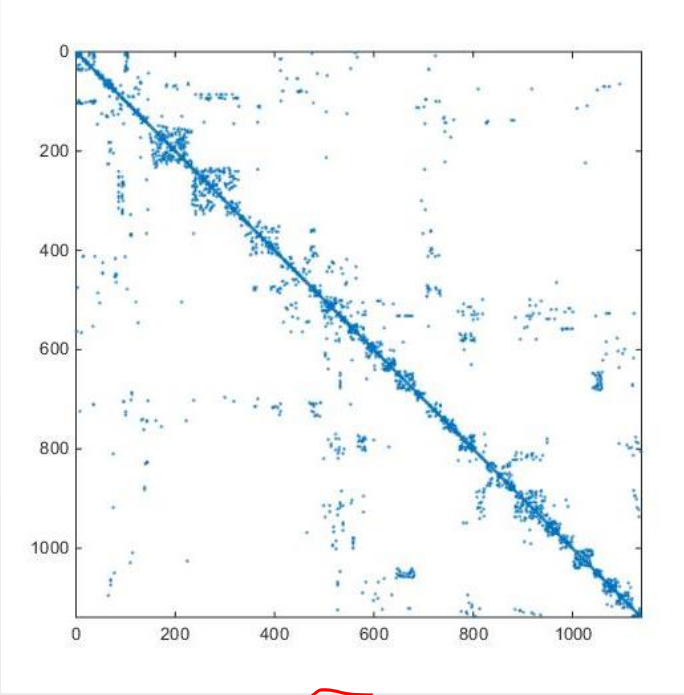
Converting Physical System into Computer Models

Unique Features of Power Systems



New techniques to do computations faster with sparse matrices

Sparse Matrices

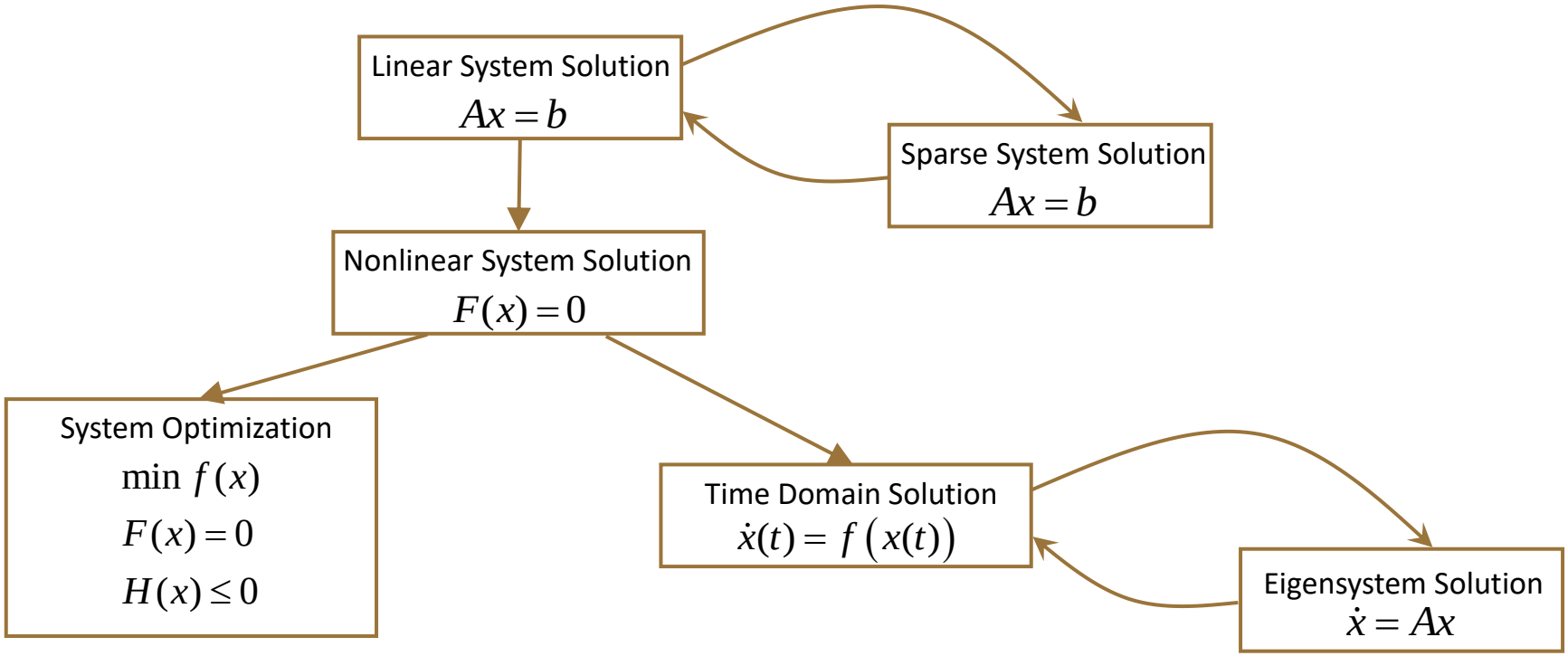


1138 x 1138 and has 4058 non-zero elements in 1295044 elements

Analysis of Power Systems Class

- Understand the mathematical principles behind the different algorithms used for power systems analysis for transmission systems
- Think about the algorithms that are used and how to make them faster using different techniques such as sparsity, simplifications and assumptions
- Write programs to implement these algorithms to better understand the fundamental models and equations.

Organization of Course



Announcements

Office hours this week upon request

- No face to face class on Thursday – I will post a video for your review

AGI Day 2021 – August 31 – In-person and virtual

- Remember to do introduction on Canvas discussion
- Read Chapter 1 and start on Chapter 2 (through at least 2.3)
- Pull out your power systems book and review power flow modeling