ECE 461(3Credits) /462(1Credit) Power Systems
Fall 2019 Schedule and Grading
Tuesday, August 27th to Thursday, Dec 12th
SEE http://www.calendar.colostate.edu/
12:30 1:45 PM T R Engineering B 105

Please forgive this 21-page syllabus, schedule and grading missive, but with lectures and a 462 lab there are lots of issues to cover. To keep it all clear and fresh, I will send out a weekly memo usually a week in advance the prior Friday detailing:

1. **Last week's efforts**
2. **This week's efforts and what's due the coming week (e.g. Pop Quiz)**
3. **Next week's efforts and due dates for all new assignments**

NO CLASS Thursday, November 21, 2019 before thanksgiving break

Instructors teaching philosophy

- **ECE Students are the most important people at CSU.**
- **Not dependent on faculty.**
- **Faculty is dependent on them.**
- **Not an interruption of our work.**
- **They are the purpose of being at CSU.**
- **Students are doing us a favor when they come to our office.**
- **We are not doing them a favor by serving them.**
- **Students are part of our business, not outsiders.**
- **Not just a CSU ID number.**
- **They are flesh and blood human beings with feelings and emotions.**
- **Students come to us with their needs and wants.**
- **It is our job to address them with courteous and attentive treatment.**
- **Students are the life blood of this and every university.**
- **Without them we would close our doors.**
- **DON'T EVER FORGET THIS**

Disclaimer Notice:

Use this syllabus to guide you through the semester but realize that up to date in class announcements always supersede this preliminary guide.

Thank you for reading though this 22 page, "err on the side of covering everything missive". If you have further questions ask me in class so everybody benefits.

Class Time: Tuesday and Thursday 12:30 – 1:45 PM in D102 (Physics wing).

Instructor: Prof. George Collins, **Email**: gcollins@engr.colostate.edu

Divide yourselves into groups for doing HW, PSSE Labs, Pop Quizzes and Talks # 1 and #2. Do this ASAP and give the list of group members to both the grader and me. Send REVISED PPT slides for BOTH class talks to Prof Collins, again for both Talks.

TA: to be announced

Send all HW sets, Pop Quizzes, PSSE exercises, 462 motor labs and WORD Papers for both group in-class talks to the grader.

Send REVISED PPT slides of talks 1 and 2 to Prof. Collins only.

Here are few guidelines regarding HW and POP QUIZ submissions-

1) Preferably write your solutions in MS Powerpoint. Number of slides may vary depending upon the solution.
2) Please use the file name format as- "ECE xyz_HW/POP QUIZ#_Group#".
3) Only group leader will submit the final ppt of HW/POPQUIZ.
4) Please cc all the group members when submitting the final ppt for HW/POPQUIZ.

Decide your group members and leader of the group among yourselves. Elected group leaders will send the list of confirmed group members. Also please try to maintain equal number of members in each group before sending the list of confirmed group members.

Note: If you are entertaining a job in Power here is a website for you with an 18-minute video from IEEE that provides an overview of power engineering: Happy Viewing! http//www.ieee.org/portal/ieeetv/viewer.html?progID=70345

Text Book: Electrical Machines, Drives and Power Systems, Theodore Wildi

Class website: http://www.engr.colostate.edu/ECE461

COURSE OBJECTIVES

This course will teach basic power generation, transmission and distribution, with the perspective of INCREASED energy efficiency in both generation and consumption of electrical energy. As motors consume >60 % of grid power more efficient motor designs and motor drives will be addressed. As well we will cover as the increased role of emerging alternative sources of electrical energies and the challenges to grid stability and load cycle problems these create. A move to all

electric cars or even hybrid vehicles would save significant energy, due to the inefficiency of internal combustion engines, but only if we optimize car electric motors .car batteries and motor drives. These are all problematic. This course will discuss all these emerging issues and more. SEE http://www.teslamotors.com/display_data/twentyfirstcenturycar.pdf

The materials in this class each year are 1/4 new, hence, you need to come to class. A lot of changes are occurring in the power industry and I want to inform you so you can get a better job.

The class notes are password protected and user name and password are:

Username: Student
Password: Power!

462 Motor Labs: Hours to be arranged for each Student Group

GROUP EFFORT is key to 462. Form groups of up to 4-8 students

462 Motor Lab Teaching Assistant (TA): **To be announced**

There will be 5 Motor Labs (**Tentative**). Tentative due dates are as follows.

Motor Lab # 1 Due Thursday, September 13, 2019

Motor Lab #2 Due Thursday, October 4, 2019

Motor Lab #3 Due Thursday, October 18, 2019

Motor Lab #4 Due Thursday, November 1, 2019

Motor Lab #5 Due Thursday, November 15, 2019

TA will assign motor labs after you form lab groups. Lab times/hours for each group to do the lab will be decided as well as respective due dates. Form your 462 motor lab groups ASAP to get desired lab times. Lab report for each experiment should be submitted to the TA within the deadline. ECE 462 Motor Labs are set up in the electronics lab of C wing.

SEE: http://www.engr.colostate.edu/ECE462/course_info.shtml

*If you are experiencing difficult situations that are affecting, or could potentially affect, your academic success, please contact **Student Case Management** as soon as possible (http://www.studentcasemanagement.colostate.edu/ E203 Newsom Hall, 970-491-8051). Difficult situations can include issues such as medical, mental health, personal or family crisis, illness, or injury. If students request extensions or considerations due to difficult situations, I typically require documentation from Student Case Management. In addition, I urge students to contact me in advance of deadlines about such issues.*

For making referrals, their contact information is:

Student Case Management
E203 Newsom Hall
970-491-8051
vpsa_student_case_management@colostate.edu
http://www.studentcasemanagement.colostate.edu/

END OF BRIEF 462 Motor Laboratories INFO.

Below is 461 information

GROUP EFFORT is key to ECE 461. Form groups of up to 4-8 students to complete:

1. HW assignments
2. Pop Quizzes
3. PSSE exercises
4. 462 Motor Labs are both managed and graded separately for the lab grade for the 1 credit lab course.
5. Two PPT based group talks and two WORD based papers, where you identify your portion clearly. IN SHORT you actually need to do only a fraction of the 461/462 work listed above as a group member, however be sure to understand the other portions done by your colleagues to pass job interviews in the power area.

   Talk # 1 is on SCADA but for Talk # 2 start reading **H. Narain and L. Gyugyi "Understanding FACTS AC Transmission Systems" IEEE press 2000**

   GRADE BREAKDOWN is given below:

461 Grading Summary:

1. **HW Assignments: 11 %**
2. **Talk / Paper # 1: 20% or x/ 20 ALL group talks #1 are on SCADA and individuals cover different portions**
3. **Talk / Paper #2: 40 % or x / 40 ALL group talks #2 are on a sub-topic in "Flexible AC Transmission (FACTS) unless you are also registered in ECE 562 where a talk on** DC to AC inverters **@ fixed 60 Hz but variable amplitude and phase is accepted**
4. **Pop Quizzes: 20%**
5. **PSSE Exercises: 9 %**

   WARNING TO STUDENT USERS OF CANVAS

Canvas gives grades even for partial assignments completed. Look in Canvas. Note that the grading group subtotals do display at the bottom right, so if students are sharp they will know that this reflects their scores for only say 40% of their grade not 100% for example. If not careful to look, they may see misread CANVAS attempts to give grades dynamically during the semister.

TOTAL 100 points and is the basis of the normal 461 grade. However, I provide up to 10 EXTRA CREDIT assignments throughout the semester as well as up to 10 points ex. cr. for class participation.

Practice makes perfect

Kaizen is a Japanese word for "continual improvement" and is common in manufacturing as pioneered by Toyota.

Presentation skills too can be honed through repetition, listening to talks and critique of your own talks. My goal is to get you ready for a job in industry where communication skills are crucial. So go to ALL talks to learn.

Disclaimer Notice:

Remember, all homework, pop quizzes, and PSSE labs are group efforts.. We will emphasize group efforts with teams of students handing in weekly HW sets and take home POP quizzes as well as two talks and two papers. PLEASE FORM a GROUP for HW, POP QUIZZES and for talks/ presentations/ papers, described below, ASAP in the first week of the semester.

A more detailed explanation of all the assignments related to ECE461 is given below:

1. HW Assignments:

(11% of final grade) Eight group Homework assignments @ 10 pts each will comprise 16 % of the final grade. Send homework to the grader (TA) within the deadline.

2. Talk / Paper #1: ALL talks are on different aspects of SCADA (20 points of final grade: 15 for PPT talk and 5 for WORD paper both of which you send to COLLINS by email attachment as a group with individual parts one week after talk in class to revise errors/improve. Each student in each group will present and final version of PPT and group WORD will be handed in one week after they talk. In short the talk grade x/ 15 is broken down as FOLLOWS:

1. TECHNICAL ACCURACY 9/15
2. Slide ORGANIZATION 3/15
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE 1/15
4. PROPER SPELLING GRAMMAR REFERENCES 1/15
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 1/15

And send Revised PPT slides and final WORD to Collins only by email attachment

WORD PAPER GRADE OUT OF 5 AS FOLLOWS:
1. TECHNICAL ACCURACY 2/5
2. PAPER ORGANIZATION 1/5
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE 1/5
4. PROPER SPELLING GRAMMAR REFERENCES .5/5
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED .5/5

After talk # 1 TENTITIVELY on Tuesday, October 9, Collins returns to lecture on Chapter 10 of our text.

3. Talk / Paper #2 : (40 points of final grade: 35 on PPT Talk and 5 on WORD paper)

Talk and PPT both which you send to COLLINS by email attachment as a group with individual parts. Each student in each group will present and final version of PPT and group WORD will be handed in one week after they talk to revise errors/improve.

Revised PPT and WORD send both to Collins only by email attachment. Each student in each group will present and final version of PPT and group WORD will be handed in one week after they talk. In short the talk time is for a critique.

In short the talk # 2 is on various sub-topics **in "Flexible AC Transmission (FACTS) unless you are also registered in ECE 562 where a talk on** DC to AC inverters **@ fixed 60 Hz but variable amplitude and phase is accepted**

grade x/ 40 is AS FOLLOWS:

6. **TALK #2 (35 % of grade: 30 PPT talk and 5 WORD PAPER) Again unless you are also registered in ECE 562 where a talk on** DC to AC inverters **@ fixed 60 Hz but variable amplitude and phase is accepted**

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PPT Presentation is grades as follows out of 30:
1. TECHNICAL ACCURACY 21/30
2. PPT Slide ORGANIZATION 6/30
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW COVERAGE 1/30
4. PROPER SPELLING GRAMMAR REFERENCES 1/30
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 1/20

WORD PAPER GRADE OUT OF 5 AS FOLLOWS:

- **1. TECHNICAL ACCURACY 2/5**
- **2. PAPER ORGANIZATION 1/5**
- **3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE 1/5**
- **4. PROPER SPELLING GRAMMAR REFERENCES .5/5**
- **5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED .5/5**

FACTS GROUP TALK #2

a. (20 % of talk #2 grade) 3 Phase inverters/converters and how power electronic drives allow independent control of amplitude and phase to provide desired compensation. Show how Voltage Source Converters (VSC) provide grid frequency AC voltage injection, in either series or shunt, with both variable amplitude and phase using a DC source and switches (SCR's or IGBT's).

b. (20% of talk #2 grade) Static Synchronous Series Compensators (SSSC), which have as the key building block a VSC, covered in part b.

c. (20 % of talk #2 grade) Shunt Compensation, which also has as a key building block a VSC.

d. (40 % of talk #2 grade) Explain in detail how a UPFC combines a VSC driven series compensation (SSSC) and a VSC driven shunt compensator (STATCOM) to form a UPFC, which is able to:

- Independently control simultaneously either active or reactive power injected to the line.
- Act as a shunt compensation and phase shifting device simultaneously.

Grades for 2 and 3 were talks 1 and 2 so next is part 4 and 5 of 461 grades

4. Pop Quizzes:

(20% of final grade) I count 20% for eight weekly 461 class pop quizzes **@ 100 point**s each, to be done as a group. Pop Quizzes will be assigned every week and due on Thursdays of the following week. **Send Pop Quizzes to TA via CANVAS as a group**

5. PSSE Labs:

(9% of final grade) **Four PSSE laboratory experiments @ 10 points each will comprise 9% of the final grade. All four PSSE lab reports will be due during the two weeks of Talk 1, TENTATIVLY Tues. September 24 to Thur. October 3 2019 (Week 6 & 7). Send PSSE labs to TA through Canvas.**

GRADE DISTRIBUTION

Our final grading approach will be more traditional with both + and - letter grades to achieve a sliding curve and a distribution of grades. In an ideal statistical world we would seek in a class grade distribution as follows.Grading will be curved with students above one standard deviation above median receiving an "A", students below the median and above one standard deviation below the median receiving a "C". 2 standard deviations below the median will receive a "D", 3 standard deviations below will receive a "F", and anything lower will receive an "F".

A-F GRADING SUMMARY with plus minus fine tuning for 461

Letter grades for ECE 461 are on an F to A scale with plus minus fine tuning on all letter grades.

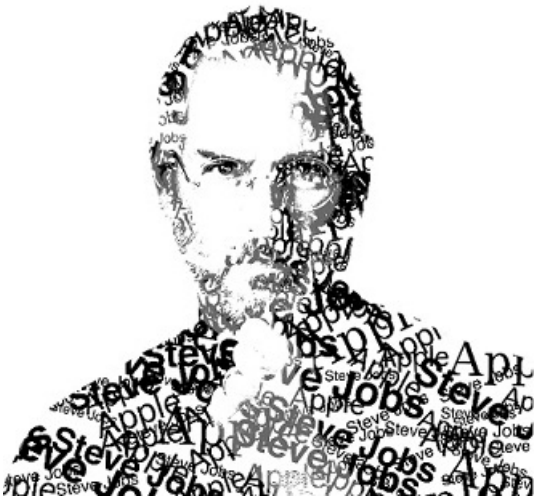
Score (X)	Letter Grade
X > 100	A+
X > 96	A
X > 93	A-
X > 91	B+
X > 86	B
X > 83	B-
X > 81	C+
X > 59	C
X < 59	F

No C minus grades allowed in ECE

I hope by the end of the required talks/papers in 461 or even sooner, all students appreciate the old saw*"to read without reflecting is like eating without digesting"*. Or for the simple fools like me the shorter version *"knowing the facts versus knowing the truth"*. Beware that both talk # 1 on SCADA/ Smart Grid as well as talk # 2 on "FACTS" need you to start background preparations for this ASAP. For groups that choose "Variable frequency Motor Drives" you can split your efforts into both Talk # 1 (basics) and talk # 2 (details). Note that the two talks and associated papers accounts for 55% of the final 461 grade. You can earn extra points as outlined in class, and as some students need a better 461 grade for various reasons—here is a chance to earn it, by doing what is explained below.

Positive Class Participation up to a possible 10 % of final grade. Up to an additional 10 extra points on the final grade are available, for special projects, related to variable frequency MOTOR drives or DC to AC inverters at 60 Hz only. An example would be the company inverter product line from “Enphase” which on an IC sense/command and control chip with few additional external pieces, can convert the output of a DC solar cell array to single phase AC at grid frequencies. This allows one to purchase a solar panel and plug it directly into the homes AC wiring.

PPT Presentations Advice Steve Jobs Style



When you give a presentation, you face at least two hurdles.

First, you need to sell yourself as a credible spokesperson on your topic. Audiences need to believe in you-and that's hard enough.

Second, you need to sell your ideas so that people come away inspired, persuaded and enlightened.

Steve Jobs did both-with incredible skill. Widely considered one of the most gifted presenters ever, Jobs understood how to deliver memorable speeches in a seemingly effortless, engaging manner. His conversational tone, simple yet compelling word choice and masterful use of slides and other props helped reinforce his message in winning ways.

You’ll learn how to develop key skills, including how to:

- **Integrate Aristotle's "Big Three"-logos/ethos/pathos-to win over audiences.** Learn how to blend logic, credibility and emotion to enliven your remarks.
- **Convey big ideas or central themes via multiple channels.** From audience giveaways to props to slides, apply the Steve Jobs approach and align all available tools to drive home key points so that people cannot help but remember them-and buy into them.
- **Think in threes.** To explain complex processes (from chemical reactions to financial formulas), learn to cluster your main points in threes. Your audiences will thank you.

- **Use bluntness and directness.** Rather than drop hints or dance around controversial positions, follow Steve Jobs' example and state your case boldly and succinctly.

- **Embrace simple language.** If you need to explain complex ideas, you must speak in complex terms. Right? Well, Steve Jobs was a master at communicating complicated concepts in unmistakably clear words. Develop tools to translate your speech into plain English that's compelling and hard for anyone-of any background or educational level-to ignore.

- **Start staff meetings with an edge.** Steve Jobs did not begin staff meetings with touchy-feely happy talk. Instead, he often provoked people or expressed disappointment in some aspect of the team's performance. But by the end of the meeting, everyone left in a positive frame of mind-inspired and validated. Find out how Jobs pulled that off.

All students are advised to be present in class and learn from others' talks. For details on the format and contents of the paper, refer to the "Talk Paper Guidelines" document available on the ECE461 course website: http://www.engr.colostate.edu/ECE461/FA14/ECE461%20Talk%20Paper%20Guidelines.pdf

Positive Class Participation up to a possible 10 % of final grade. Up to an additional 10 extra points on the final grade are available, for special projects, related to variable frequency drives only. An example would be the company inverter product line from "Enphase" which on an IC sense/command and control chip with few additional external pieces, can convert the output of a DC solar cell array to single phase AC at grid frequencies. This allows one to purchase a solar panel and plug it directly into the homes AC wiring.

GROUP EFFORTS

Notice that group/team efforts are required in both these courses. Power companies value communication skills (oral and written) HIGHLY so ECE461 will help prepare you for the real world. You will all have two talks and two papers during the semester done as group efforts. Your technical presentations will be GROUP efforts to simulate your next environment —industry. This group effort is purposeful to get students familiar with the team efforts that they will SOON encounter in industry. This is to encourage team efforts and to better understand the dynamics of team work, as you will soon work in teams in industry. The team's tasks include HW assignments, the two in class talks and two written papers as well as weekly POP quizzes. The goal is to better appreciate how to act in teams, as will the case incidentally when you join industry. You will get a team grade for all of the above. Still each student will have their portion highlighted for extra credit when merited, as for example when giving class talks or in papers if properly documented.

If you are interested in "Smart Grid", sometimes referred to as "The Enernet", I suggest you may be left **wondering isn't SCADA already smart — and what does smart grid really mean?** Is it just politics selling/justifying more spending on the grid for the benefit of all (or just a few)? Is the need to do this "Smart Grid" all at once really necessary or imagined? In this regard I judge renewable/green energy claims beyond 20-30 % total energy generation are starting to be more "pixie dust" than reality UNLESS grid level battery storage is cost effective. For starters realize that "capacity factors" for wind and solar are typically <25%, meaning take KW rating and multiply by 6/24. Why? Because, the sun shines only for a part of the day and the wind blows intermittently. You and your group can dispute that. But you make your own determinations.

ACADEMIC INTEGRITY

This course will adhere to Academic Integrity Policy of CSU General Catalog and Student Conduct code. It is expected in this course that all students will not give, receive or use any unauthorized or undocumented assistance in their group efforts as well as individual efforts. All appropriate sources need to be referenced and it's best to do in IEEE format for references/sources. For details go to: http://catalog.colostate.edu/general-catalog/policies/students-responsibilities/#academic-integrity All problems will be handled according to CSU policies. See: http://tilt.colostate.edu/integrity/faqs/howShouldI.cfm

PREAMBLE ON SEVERAL WEB SITES FOR BACKGROUND ON ELECTRIC POWER

Some Web videos on energy and power engineering are given below for your pleasure. This is optional and not required. http://www.youtube.com/watch?v=vqgNrj6oEdc

A fun demonstration of the enormous POWER behind the grid as shown by switch opening on a 500,000 volt line when air breakdown is 30kV/ cm, causing a meter long arc (a flash over) in open air that ignites the air with plasma. Workman/lineman have been seriously burned or blinded by these meter long arcs. Respect high voltage. When trees come close to power lines this also causes flash over events. Tree trimming near power lines is required by the federal government

Here is an 18-minute video that provides an overview of power engineering: http//www.ieee.org/portal/ieeetv/viewer.html?progID=70345

Here is a website dedicated to the "smart grid" a term of some ambiguity: http://www.smartgridnews.com/artman/publish/index.html.

See another website: http://antwrp.gsfc.nasa.gov/apod/image/0011/earthlights_dmsp_big.jpg to grasp the energy use situation on earth any given evening. Just increasing transformer operating efficiency in transmission and distribution by 1% would save trillions of dollars per year in energy costs, reduce green house gas and CO_2 emissions, and reduce the need to build new power plants. That is 1% of 3 TW= 30 GW or 30 GW power plants that would not have to be operating.

Moreover surprising to some, inefficient energy use is becoming ILLEGAL, such as use of incandescent light bulbs in 2012. See for example: http://www.energy.ca.gov/commissioners/rosenfeld_docs/index.html and http://www.efficientpowersupplies.org/efficiency_news.asp

EPA, CEC (California energy commission) and DOE energy star programs are but several examples, as are the federal laws that require the states to get 7.5 % of electricity needs by 2013, peaking at 20% from renewable sources. Some wags say, as renewables are still requiring subsidies, long term overuse of renewables is a form of "green energy suicide". Finally, if you want get Cambridge University professor's skeptical /realistic but cold air attitude on the LIMITATIONS of "Green Energy" see: http://www.withouthotair.com/.

Finally a website for all that describes energy in a cosmic perspective: http://www.evworld.com/library/energy_numbers.pdf

COST – "the four letter word' plays a key role in this course. Cost is just an economic word for the common good. So all energy sources must be cost competitive and all "improvements" to the grid must have a discussion about cost/ benefit tradeoffs.

WHEW! If you visited all the background sites you are ready to engage with the real 461 academic course. Part of that reality is grades!

ECE461 Homework Assignments

Refer to the our WILDI textbook for detailed statement of HW problems.

HW #	**Problem #**
1	Chapter 3 - #22, 24, 26 Chapter 5 - #19, 20, 21, 22, 23
2	Chapter 7 - #26, 27, 28, 29
3	Chapter 8 - #28, 30, 34, 35
4	Chapter 9 - #7, 8, 9, 10
5	Chapter 10 - #34, 35, 36, 37
6	Chapter 11 - #12, 13, 14, 15
7	Chapter 12 - #11, 12, 13, 15
8	Chapter 27 - #6, 9, 13, 19

Pop quizzes will be sent to all students every week to all students via email. So, make sure your email is active and up to date. PSSE laboratory documents are available on the ECE461 course website. Get started on the PSSE labs, ask all your doubts to the TA, since all of them are due in a span of two weeks' time.

IN CLASS TALKS AND COMPANION PAPERS together account for 60% of the grade

Prof. Collins will deliver one detailed lecture on SCADA and a few smart Grid highlights, prior to your Student Group Talk # 1. This primes your pumps on SCADA an "OLD (40 years of experience) sense-command and control GRID SYSTEM and also sets the stage for smart grid dicsussions by realizing the grid is already very smart and automated too. SCADA has wide use in industry process control, outside the power industry as well.

I again will deliver an overview INTRODUCTORY lecture on "FACTS" prior to TALK # 2 that will cover:

i. Chapter 21 of our text, especially sections 21.15 to 21.34. Read and study this material carefully. See also H. Narain and L. Gyugyi "Understanding FACTS AC Transmission Systems" IEEE press 2000

ii. Thyristor switching to achieve either Three Phase AC to DC rectification as well as DC to Sinusoidal AC grid frequency conversion with arbitrary amplitude and phase control of the AC at the fixed grid frequency only. By injecting this AC in either series or shunt on a transmission line we can control the flow of AC power as well as voltage levels at various nodes.

iii. Two types of power flow optimization will be covered:

   a. AC Source to AC Source power flows

   b. AC source to passive loads power flow

   c. A breakdown of the two types of compensation:

      - Series Compensation
      - Shunt compensation

A "Facts" overview is then already given so your groups can focus on topics below in your talks.

NOW for what your group MUST include in Talk # 2 "FACTS", which provides real time dynamic compensation of AC transmission lines for increased power flow, better voltage control and improved grid stability.

Smart grid trends and promises but seldom delivers in a cost effective manner than the old SCADA which offers both lower cost and a more reliable grid so far in 2019. Key here is to cover Phase Measurement Units (PMU), which are the only true new addition to the "smarter grid" as compared to SCADA. Separate promises from actual working Smart Grid Systems by examples. As an illustration the old serial port interfaces were RS or TIA 232 and 485, which are still legacy serial ports with great noise immunity (e. g 232 has 6 volt noise region between one and a zero bit

allowing operation in a utility environment), however bit transfer speeds are low. In your paper/talk include the NEW I^2C serial interface used in the smart grid, and discuss its application to utility environments.

Special Talk # 2 opportunity for students taking credit in BOTH 461 and 562
TALK /PAPER CHOICE # 2: Fixed 60 Hz Inverters for Solar and wind power as well as VARIABLE FREQUENCY motor drives. Each group chooses 2 types of inverters either fixed or variable frequency inverters to present.

Motors and **VARIABLE FREQUENCY motor drives** are key technologies for a variety of reasons. First >60% of grid energy goes to motors. Moreover, improvements in efficiency from input AC power to Torque- RPM mechanical energy at loads is an on-going green revolution as it creates "Negawatts" of saved energy that need not be generated. Electric cars will also be more competitive with these "variable frequency" motor drive improvements. In short the goal of the new power electronics technologies is increased efficiency motor operation, smaller size and lighter weight electric motors and eliminating the need for mechanical gear trains to meet the applications specific $T_{OUT} - N_{OUT}$ mechanical load requirements by variable frequency drive electrical means alone.
So a special opportunity is offered to students in both 461 and 562 courses to do talk # 2 on motors/motor drives. An emphasis list of items to cover is given below for 461 presentations and a different list of items for 562 student presentations. Students MUST add to this according to their group's interests.
For those students who will give the same talk in both classes both emphasis lists must be covered in the presentation that will give twice once in each class.
Moreover students enrolled in BOTH 461 and 562 can use the same talk in both classes IF SEE BELOW.

461 VARIABLE FREQUENCY motor drives Presentations Require the following high Points:

1. Describe the $Z_{IN,}$ V_{IN} and I_{IN} seen by the power electronics drives (e.g. the motor's electrical input characteristics) versus the varying $T_{OUT} – N_{OUT}$ curves of the mechanical load for:
    a. Brushless DC Motor (BDCM)
    b. Synchronous motor
    c. Permanent magnet Synchronous motor (PMSM)
    d. Induction motors

    In short review the T_{OUT}-N_{OUT} vs V_{IN} - I_{IN} curves for the four most used motors.
2. Provide web links to manufacturers spec and application notes and their major arguments to justify the separate claims that "PMSM" technology is the best versus "BDCM" technology is best versus Synchronous or induction motors. This is easily resolved by

distinguishing what mechanical loads each technology is best suited for. Do this for the four the chosen motors at the three mechanical load levels of :

a. Low HP < 1 HP
b. Medium HP < 10HP
c. High HP > 100 HP

3. Commercial motor control systems consist of: sensors, command and control chips and power train drives.
    a. Describe in detail spatial location, type and output levels from the sensors for rotor position and other motor parameters needed for control decisions.
    b. Give three commercial motor control chips or board level hardware control systems.
    c. Compare and contrast the advantages and limitations as well as cost of high power switch hardware in the drive train employing :
        a. Thyristors
        b. IGBT's
        c. IGCT's and it's varients of MOS control

        Go to manufacturer's websites and get specs for the high power switches as well as application sheets for motor drive applications with these same switches and their control drive electronics.
        d. Provide two examples of commercial power train electronics from switch drives to variable 3 phase output V(f) from power switches.

562 VARIABLE FREQUENCY motor drives Presentations Require following high Points:

1. Explain the cost and reliability considerations for the motor centric items listed in 461 point #1 as well as the best of the breed for applications at the three HP levels for the four motor varieties:
    a. Brushless DC Motor (BDCM)
    b. Synchronous motor
    c. Permanent magnet Synchronous motor (PMSM)
    d. Induction motors

2. Explain in detail the differences and advantages as well as disadvantages of DSP vs FPGA vs microprocessor control methodologies and switch algorithm flexibility as well as cost.
3. Discuss the R-L-C components both within and external to motors as regards their maximum operating voltages, currents and frequencies.

Again if the same talk is given in both classes all of both high points at minimum must be covered as well as the student group's own topics. SEE the end of this memo to get more details on the special terms and conditions for students enrolled in both 461 and 562 doing the talks on variable frequency drives.

NOTE: For group efforts Microsoft has versions of Word and Power Point that reside on servers at Microsoft Office Live —moreover this allows MULTIPLE users to log on and work on the SAME document together. I strongly recommend Microsoft SkyDrive for student cooperative projects/talks/papers that many students in a group can share edit as they occur. It is deeply integrated with Microsoft Office on both Windows and Macs.

NO CLASS THUR. 21 NOV just before fall break

We do have alternative Talk/ paper # 2 opportunities, which can be used in both 461 and 562 classes if you are taking both and are explained below.

VARIABLE FREQUENCY DRIVES FOR AC AND DC MOTORS: TALK # 2

Special Requirements for Special Talk # 2 on "Variable Frequency Motor Drives" for those students registered in BOTH 461 and 562. Yes you can give the same talk in both classes and for both required talks. The first talk should be basic concepts and the second detailed coverage of one or more applications.
Motors and motor drives are key technologies for a variety of reasons. First >60% of grid energy goes to motors. Moreover, improvements in efficiency from grid power to Torque - RPM mechanical energy at loads is an on-going green revolution as it creates "Negawatts" of saved energy that need not be generated. Electric cars will also be more competitive with these motor/ motor drive improvements.

In short the goal of the new technologies is increased efficiency motor operation, smaller size and lighter weight electric motors and eliminating the need for mechanical gear trains to meet the applications specific $T_{OUT} - N_{OUT}$ mechanical load requirements by electrical means alone.
So a special opportunity is offered to students in both 461 and 562 courses to do talk # 2 on motors/motor drives. An emphasis list of items to cover is given below for 461 presentations and a different list of items for 562 student presentations. Students MUST add to this according to their group's interests. For those students who will give the same talk in both classes both emphasis lists must be covered in the presentation that will given twice once in each class.

BELOW I list the points that must be covered later in the semester in talk # 2, for those groups that choose variable frequency motor drives 461.

Motor Drive Presentations Required High Points: Again this talk can be given in both 461 and 562 if you are registered in both and follow directions I outlined.

1. Describe the $Z_{IN,}$ V_{IN} and I_{IN} seen by the power electronics drives (e.g. the motor's electrical input characteristics) versus the varying T_{OUT} –N_{OUT} curves of the mechanical load for:
    e. Brushless DC Motor (BDCM)
    f. Synchronous motor
    g. Permanent magnet Synchronous motor (PMSM)
    h. Induction motors

In short review the T_{OUT}-N_{OUT} vs. V_{IN} - I_{IN} curves for the four most used motors.

2. Provide web links to manufacturers spec and application notes and their major arguments to justify the separate claims that "PMSM" technology is the best motor technology versus "BDCM" technology is best versus Synchronous or induction motors. This is easily resolved by distinguishing what mechanical loads each technology is best suited for. Do this for the four the chosen motors at the three mechanical load levels of:
    d. Low HP < 1 HP
    e. Medium HP < 10HP
    f. High HP > 100 HP

3. Commercial motor control systems consist of: sensors, command and control IC chips and power train drives.
    d. Describe in detail spatial location, type and output levels from the sensors for rotor position and other motor parameters needed for control decisions on motors.
    e. Give three commercial motor control chips or board level hardware control systems.
    f. Compare and contrast the advantages and limitations as well as cost of high power switch hardware in the drive train employing:
        a. Thyristors and Triacs
        b. IGBT's
        c. IGCT's and it's variants of MOS gate control of a switch

Go to manufacturer's websites and get specs for the high power switches as well as application sheets for motor drive applications with these same switches and their control drive electronics.
    g. Provide two examples of commercial power train electronics from switch drives to variable 3-phase output V (f) from power switches.

Again if the same talk is given in both classes all of both high points at minimum must be covered as well as the student group's own topics.

SCHEDULE AND DUE DATES SUMMARY

Talk #1 Dates (Week 6 & 7) assuming four student groups

Tuesday, September 24, 2019

Thursday, September 26, 2019

Tuesday, October 1, 2019

Thursday, October 3, 2019

Talk #2 Dates (Week 12 &13) assuming four student groups

Tues. November 5, 2019

Thur November 7, 2019

Tues Nov 12 2019

Thursday 14 Nov. 2019 , **NO CLASS 21 Nov Thur but group that talked 14 Nov must submit revised Talk # 2**

Note: *Talk papers and revised PPT slides are due one week after your group presents. So, each group has a difference submission date for talk papers and slides. Submit the talk papers to the TA and ONLY revised PPT slides to me via email gcollins@engr.colostate.edu*

HW Due Dates

HW #1 - Thursday, August 29, 2019

HW #2 - Thursday, September 5, 2019

HW #3 - Thursday, September 12, 2019

HW #4 - Thursday, September 19, 2019

HW #5 - Thursday, October 10, 2019

HW #6 - Thursday, October 17, 2019

HW #7 - Thursday, October 24, 2019

HW #8 -Thursday, October 31, 2019

Pop Quiz Due Dates

Pop Quiz #1 - Tuesday, September 3, 2019

Pop Quiz #2 - Tuesday, September 10, 2019

Pop Quiz #3 - Tuesday, September 17, 2019

Pop Quiz #4 - Tuesday, September 24, 2019

Pop Quiz #5 - Tuesday, October 15, 2019

Pop Quiz #6 - Tuesday, October 22, 2019

Pop Quiz #7 - Tuesday, October 29, 2019

Pop Quiz #8 - Tuesday, November 5, 2019

PSSE Lab Due Dates

Lab #1 - Tuesday, September 24, 2019

Lab #2 - Thursday, September 26, 2019

Lab #3 - Tuesday, October 1, 2019

Lab #4 - Thursday, October 3, 2019

ECE462 Motor Lab Due Dates

Motor Lab # 1 Due Thursday, September 12, 2019

Motor Lab #2 Due Thursday, October 3, 2019

Motor Lab #3 Due Thursday, October 17, 2019

Motor Lab #4 Due Thursday, October 31, 2019

Motor Lab #5 Due Thursday, November 14, 2019

LAST DAY OF CSU CLASSES Thur.12 December 2019.

ECE462: Power Systems Laboratory
Lab times TBA Depending on lab groups

Look at some motor animations on this site:
http://www.ece.umn.edu/users/riaz/animations/listanimations.html
A particulary good one is:
A good one is:

9. Sinusoidally distributed windings and fields in a 3-phase ac machine

Course Info:
A series of 9 laboratory experiments (6 require one week each and three require three weeks each to complete. The experiments cover DSP based control of DC PMDC and synchronous motors. A Simulink model (*.mdl) of a DC switch-mode power converter will be built. After verifying the stimulation results with Simulink model, the model will be modified to control the output of the power converter in real-time. A DC-motor will be connected to the output of the power converter. With this arrangement, a variable voltage can be applied to the terminals of the DC-motor to observe open-loop speed control of a DC motor; two, calculate the motor back-emf constant kE as well as a the electrical parameters (Ra and La) of the motor using the blocked rotor test. In addition the mechanical characteristics B and J will be determined. The torque speed characteristics will be verified. Students implement a close-loop speed control of a DC-

motor drive for which the parameters were calculated. Once the parameters are tuned, the model of the DC-motor will be replaced with the real motor. The tuned controllers will be implemented in real-time on DS1104 to perform the close-loop speed control of the DC-motor. The magnetizing inductance (Lm>>Lls) will be calculated by running the induction motor at synchronous speed, at rated voltage and rated frequency. The rotor circuit parameters i.e. Llr and R' will be calculated by blocked-rotor test while injecting slip frequency at the stator terminals. Finally, the torque speed characteristics of a three phase induction motor are measured and students observe the induction motor in generation mode (super synchronous speed) and motoring mode (sub synchronous speed)

461 Lecture Notes 462 Appendix

462 TA WILL meet with all 462 groups to set laboratory schedule coupled with 461 and acceptable to each groups schedule

http://www.engr.colostate.edu/ECE462/course_info.shtml

Laboratories

- Experiment #1
- Experiment #2
- Experiment #3
- Experiment #4
- Experiment #5
- Experiment #6
- **Necessary 462 Files**

- Lab 1
- Lab 2
- Lab 3
- Lab 4
- Lab 5
- Lab 6

Ddisclaimer Notice:

Use this syllabus to guide you through the semester but realize that up to date in class announcements always supersede this preliminary guide.

Thank you for reading though this 21 page covering everything missive. If you have further questions ask me in class so everybody benefits.