

**ECE 461(3Credits) /462(1Credit) Power Systems  
Fall 2017 Schedule and Grading**

**Tuesday, August 22<sup>nd</sup> to Thursday, Dec 9<sup>th</sup>**

SEE <http://www.calendar.colostate.edu/>

12:30 1:45 PM T R Engineering D 102

**Please forgive this 21-page syllabus, schedule and grading missive, but with lectures and a 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**

**461 Grading Summary:**

- 1. HW Assignments: 5 %**
- 2. Talk / Paper # 1: 20 %**
- 3. Talk / Paper #2: 40%**
- 4. Pop Quizzes: 20%**
- 5. Exam # 1: 15 %**

**Extra credit up to 7%**

**Class participation: 3 %**

**Details of 1-5 are within.**

**Thursday, NO CLASS November 16, before thanksgiving break**

**Instructors teaching philosophy**

- **ECE Students are the most important people at CSU.**
- **Students are Not dependent on faculty, rather faculty are dependent on them.**
- **Student visits to our offices are not an interruption of our work.**
- **Students 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**

GRADING SUMMARY is on page 4

Electric power generation may contribute to global warming. SEE:  
<https://youtu.be/SXxHfb66ZqM>

Goals of the 461, More Grade details and Expectations for Talks are described on pages 5-10

ADVICE FOR SUCCESS IN 461 is on page 11-14

Synopsis of Weekly HW Questions and Weekly Topics are on pages 15-18

Table form of weekly schedule and Due Dates is on pages 19-22

***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](mailto: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

**461 grader /462 TA Syed Azam**

[smahdiaz@rams.colostate.edu](mailto:smahdiaz@rams.colostate.edu)

Send all HW sets, Pop Quizzes, PSSE exercises, 462 motor labs to the grader by email or by CANVAS.

Send REVISED PPT slides of talks and WORD Papers for both group in-class talks 1 and 2 to me only not to the grader by email attachment. **Do NOT send to CANVAS**

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. NUMBER EACH SLIDE
- 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](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): Syed Azam <smahdiaz@rams.colostate.edu

There will be 5 Motor Labs (Tentative). **Tentative due dates** only due to unknown student group availability are as follows.

Motor Lab # 1 Due **Tuesday, September 12,**

Motor Lab #2 Due **Tuesday, October 3,**

Motor Lab #3 Due **Tuesday, October 17,**

Motor Lab #4 Due **Tuesday, Oct 31**

Motor Lab #5 Due **Tuesday, November 14,**

**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](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

<http://www.studentcasemanagement.colostate.edu/>

END OF BRIEF 462 Motor Laboratories INFO.

Below is 461 information

GROUP EFFORT is key to 461. Form **groups of up to 6-8 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, however be sure to understand the other portions done by your colleagues to pass job interviews in the power area. For Talk # 2 start reading **H. Narain and L. Gyugyi “Understanding FACTS AC Transmission Systems” IEEE press 2000**

## **ECE 461 GRADING CRITERIA**

*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.*

### **REPEAT OF 461 Grading Summary:**

6. HW Assignments: 5 %
7. Talk / Paper # 1: 20 %
8. Talk / Paper #2: 40%
9. Pop Quizzes: 20%
10. PSSE Labs: 15 %

**Extra credit up to 7%**

**Class participation: 3 %**

Same breakdown as in CANVAS. 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 semester.

**TOTAL 100 points and is the basis of the normal 461 grade. However, I provide up to 10 EXTRA CREDIT assignments throughout the semester. 7 for extra credit assignments and 3 for class participation( not class attendance)**

**Disclaimer Notice:**

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

Remember, all homework, pop quizzes, and PSSE labs are group efforts. So, individual work is much less. 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 detailed explanation of all the assignments related to ECE461 is given below:

**1. HW Assignments:**

(5% 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:**

**Talk/paper # 1: (20 points of final grade: 15 for talk and 5 for paper both of which you send to COLLINS by email attachment**

**PPT Talk:**

- 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 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**

send WORD paper ONLY to **Syed Azam**

[smahdiaz@rams.colostate.edu](mailto:smahdiaz@rams.colostate.edu) by email attachment

**Talk #1 Dates assuming four student groups**

**Tuesday, September 26**

**Thursday, September 28,**

**Tuesday, October 3**

**Thursday, October 5,**

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

**Revised PPT to Collins only by email attachment.** One suggested topic is IoT applied to the SCADA monitoring of the grid.

**Talk #2 Dates assuming four student groups**

**Thursday, November 2,**

**Tuesday, November 7,**

**Thur Nov 9**

**Tues Nov 14**

**Thursday, NO CLASS November 16, before thanksgiving break**

I want you to learn skills for jobs, especially new jobs. "Nowadays students got the BS, MS and PhD but what they don't got is a JOB."

Here is an alternative talk # 2 in the emerging internet of things, which will be your generation's technical playground for industrial devices/sensors/tools. Explain how this is incorporated into SCADA via IOT concepts.

Four players here are a mix of hardware, sensors, communication and software in the cloud that link design, production, control and maintenance in factories or lighting in high rises:

Siemens AG (Germany) for hardware and sensors with the product "MindSphere". Sensors operations collect data and send data to the cloud. The cloud with taking all sensor data into account sends back control instructions.

SAP (Germany) software provider of business software with the product "HANA" product works with both GE and Siemens.

GE Co (USA) with the product "Predix" melded to hardware and sensors. Sensors operations collect data and send data to the cloud. The cloud with taking all sensor data into account sends back control instructions.

Microsoft (USA) and their software product "Azure cloud platform" ,which works with both GE and Siemens MindSphere with SAP products.

These IoT systems require an assembly of "Co-petitors". Each is unique to each application. Try your hand in talk #2 with:

1. Outlining the capabilities of GE vs Siemens and their sensor vendors, such as Analog Devices.
2. Listing capabilities of SAP vs Microsoft
3. Unique combinations and requirements suited for the power grid versus the internet of manufacturing
4. Focusing on manufacturing or the power grid as a subset of IoT

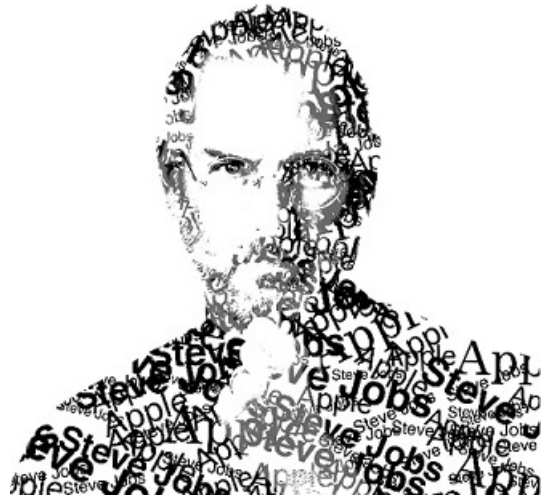
## Presentations Advice Steve Jobs Style

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.
- **TALK #2 (40 % of grade: 35 PPT talk and 5 WORD PAPER)**

**Talk # 2PPT Presentation is grades as follows out of 35:**

- 1. TECHNICAL ACCURACY 20/35**
- 2. PPT Slide ORGANIZATION 7/35**
- 3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH  
COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW COVERAGE  
4/35**
- 4. PROPER SPELLING GRAMMAR REFERENCES 2/35**
- 5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 2/35**

**Talk #2 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. SPELLING? REDERENCES 0.5**
  - 5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 0.5/5**
- **Talk #2 Dates assuming four student groups**
  - **Thursday, November 2,**
  - **Tuesday, November 7,**
  - **Thur Nov 9**
  - **Tues Nov 14**
  - **Thursday, NO CLASS November 16, before thanksgiving break**

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>

### **3. Pop Quizzes:**

(20% of final grade) I count 20% for eight weekly 461 class pop quizzes @ **100 points** 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**

### **5. PSSE Labs:**

(15 % 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, Tues. September 26 to Thur. October 8 2016 (Week 6 & 7). Send PSSE labs to TA**

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 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.

In your TALK # 2. “Flexible AC Transmission (FACTS) or prior in talk # 1 ”SCADA versus the smart grid technologies (SG)”.

If you are interested in “Smart Grid”, sometimes referred to as “The Enernet”, I suggest you download the white paper “Top Design Considerations for Low Power Metering Applications” from [www.silabs.com/meteringWP](http://www.silabs.com/meteringWP). A minimum 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. 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/fags/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=vqgNrx6oEdc>

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](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<sub>2</sub> 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](http://www.energy.ca.gov/commissioners/rosenfeld_docs/index.html) and [http://www.efficientpowersupplies.org/efficiency\\_news.asp](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](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 textbook for detailed statement of HW problems.

<u>HW #</u>	<u>Problem #</u>
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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

**TALK/PAPER CHOICE # 1 SCADA (<20%) AND SMART GRID (>80%) GRID IN TWO PARTS:**

**Part one:** “OLD (40 years of experience) SCADA SYSTEM (<20% of Talk # 1 grade) to set the stage for smart grid 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.

**Part Two:** Smart grid trends and promises (>80 % of Talk # 1 grade). Show how the smart grid does more than the old SCADA at lower cost and faster, if you can. 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<sup>2</sup> C serial interface** used in the smart grid, and discuss its application to utility environments.

**Special Talk # 2 opportunity for students in BOTH 461 and 562**

**TALK /PAPER CHOICE # 2: VARIABLE FREQUENCY MOTOR DRIVES**

Alternatively groups for talk # 2 may present on “Variable Frequency Motor Drives”. Moreover, if group members are in 562 Power Electronics they can use the same talk in both courses. Each week we will hear from two groups for a total of four group talks/week. Due the importance of variable frequency motor drives student groups can choose this topic for both Talk/paper # 1 and

later in the semester talk/paper # 2. Moreover students enrolled in BOTH 461 and 562 can use the same talk in both classes.

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 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.

#### **461 Presentations Required 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 variants 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 Presentations Required 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.

Due the importance of variable frequency motor drives student groups can choose this topic for both Talk/paper # 1 and later in the semester talk/paper # 2. Moreover students enrolled in BOTH 461 and 562 can use the same talk in both classes.

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.

**I will deliver an overview INTRODUCTORY lecture on “FACTS” around **Thur. October 31** , prior to group talks **2-14 Nov** 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.

### **FACTS GROUP TALK #2**

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 re-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 but with different emphasis.**

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 as well as IGBT's
  - b. 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.

### **PRESENTATIONS REQUIRED 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:
  - e. Brushless DC Motor (BDCM)
  - f. Synchronous motor
  - g. Permanent magnet Synchronous motor (PMSM)
  - h. 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.

### **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.

<u>Score (X)</u>	<u>Letter Grade</u>
X > 100	A+
X > 96	A
X > 93	A-
X > 91	B+
X > 86	B
X > 83	B-
X > 81	C+
X > 76	C
X < 59	F

No C minus grades in ECE allowed

**Full SCHEDULE AND DUE DATES SUMMARY**

**Talk #1 Dates assuming four student groups**

**Tuesday, September 26**

**Thursday, September 28,**

**Tuesday, October 3**

**Thursday, October 5,**

**Talk #2 Dates assuming four student groups**

**Thursday, November 2,**

**Tuesday, November 7,**

**Thur Nov 9**

**Tues Nov 14**

**Thursday, NO CLASS November 16, before thanksgiving break**

***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](mailto:gcollins@engr.colostate.edu)*

**HW Due Dates**

HW #1 - Thursday, Aug 31,

HW #2 - Thursday, September 7,

HW #3 - Thursday, September 14,

HW #4 - Thursday, September 21,

HW #5 - Thursday, October 5

HW #6 - Thursday, October 12

HW #7 - Thursday, October 19

HW #8 - Thursday, November 6

**Pop Quiz Due Dates**

Pop Quiz #1 - Tuesday, September 5,

Pop Quiz #2 - Tuesday, September 12

Pop Quiz #3 - Tuesday, September 19

Pop Quiz #4 - Tuesday, September 26

Pop Quiz #5 - Tuesday, October 17,

Pop Quiz #6 - Tuesday, October 24,

Pop Quiz #7 - Tuesday, October 31

Pop Quiz #8 - Tuesday, November 7

**PSSE Lab Due Dates**

Lab #1 - Tuesday, September 28

Lab #2 - Thursday, October 5,

Lab #3 - Tuesday, October 12,

Lab #4 - Thursday, October 19,

**TENTATIVE ECE462 Motor Lab Due Dates**

Motor Lab # 1 Due **Tuesday, September 14,**

Motor Lab #2 Due **Tuesday, October 3,**

Motor Lab #3 Due **Tuesday, October 17**

Motor Lab #4 Due **Tuesday, October 31**

Motor Lab #5 Due **Tuesday, November 7**

LAST DAY OF CSU CLASSES **8 December**

*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 particularly 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  $k_E$  as well as the electrical parameters ( $R_a$  and  $L_a$ ) 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 ( $L_m \gg L_l$ ) will be calculated by running the induction motor at synchronous speed, at rated voltage and rated frequency. The rotor circuit parameters i.e.  $L_r$  and  $R_r$  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)

**Lecture Notes**

462 [Appendix](#)

[http://www.engr.colostate.edu/ECE462/course\\_info.shtml](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](#)

### ***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.*