CTE 2020 Workshop

Research Paralleled with Teaching

1/9/2020, 1:40-2:25pm, DeMoss Hall 4020

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Intro-

- *Objectives:*
  - ✓ Is it possible to make a meaning progress in student-involved research with a student who doesn't have taken research-related course yet?
  - ✓ If so, how to make it possible?

- *Limitation*
  - ✓ Identify limitation in detail (student knowledge, limitation in time and resources)
  - ✓ Setup a plan to overcome the limitation to make a successful progress

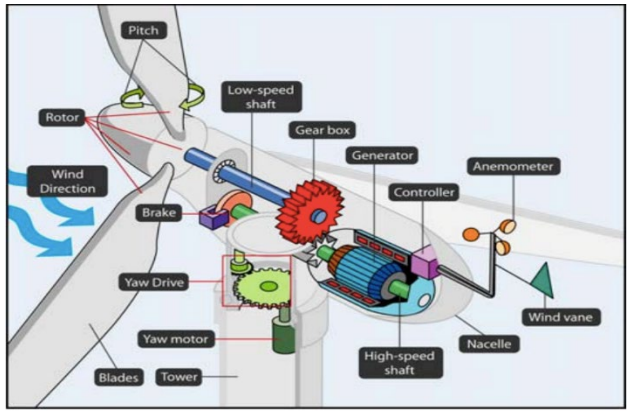
- *Approach*
  - ✓ Set up research timeline which is in parallel with the topic sequence in related course
  - ✓ Use the paralleled research sequence as opportunities of reinforcement of classroom learning

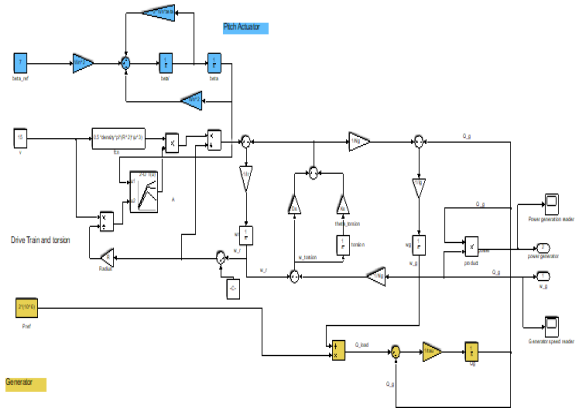
- *Solution*
  - ✓ Progress the research activity based on the class topic sequence and use it as another reinforcement opportunities of class materials
  - ✓ Evaluate the result of research by applying the concept of paralleling approach

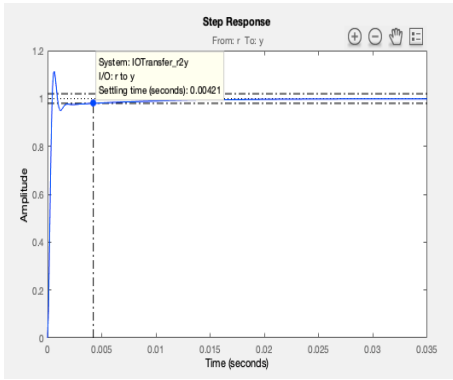
- *Outcomes*
  - ✓ Student's confidence about the research report
  - ✓ One publication: in-preparation for NCUR conference in March, 2020
  - ✓ One research report

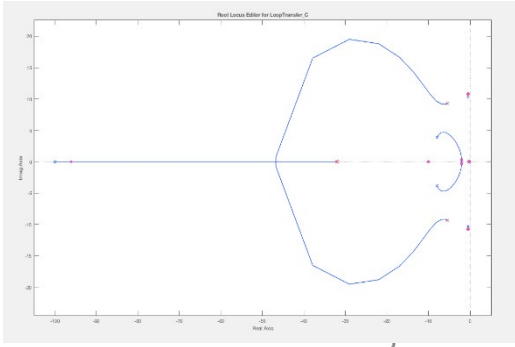
Background

- *Details of research*
  - ✓ Topic: Efficient Wind Power Generation Using Control Technology - Part 2
  - ✓ Required knowledge: Control (various controller design), Software skills for simulation
- *Details of necessary knowledge:*
  - ✓ Nyquist stability theorem for stability analysis
  - ✓ Frequency domain controller design technique
  - ✓ Software simulation skills: Linearization, Control Design toolbox
- *Deficiency of involved-student:*
  - ✓ No understanding about: stability, frequency domain controller design
  - ✓ Lack of skills with minimum understanding of Matlab/Simulink









Limitations

- Major limitation: Student Qualification:
  - Not taken Control class but, Is taking the class at the same semester with the research being conducted
  - Limited skills for simulation software

- Minor limitation: Senior-standing student
  - Simultaneously taking Senior Capstone Design
  - Limited time to spend on research as senior: finding job, finishing remaining coursework, etc.

Approach

- Paralleling the research sequence with that of class topics (course: ENGE 411 Control):
  - ✓ Mapping between research schedule with class topics (see next page):
    - ➢ Apply classroom knowledge to research items such as various controller design for wind turbines
    - ➢ Apply simulation skills from lab assignment to acquire simulation data for wind turbines modeling
    - ➢ Apply stability analysis skills from classroom to the stability analysis of wind turbines system
  - ✓ Using research activity as an reinforcement-learning moment by directly applying the classroom knowledge to research
    - ➢ Apply the classroom understanding to real world application in wind turbines controller design

Class sequence

W/O paralleling

Wk	Date	Topic	Textbook	Assignment
1	8/20	Laplace transform, Transfer function	2.2, 2.3	HW1
1	8/22	Transfer function of electromechanical systems	2.4 – 2.9, 3.3	
2	8/27	Lab 1 (Finding Transfer function)		
2	8/29	State space representation Conversion between transfer function and state space	3.3, 3.5-3.6	HW2
3	9/3	Pole, zero, and system response	4.2	
3	9/5	First order, second order system response	4.3 – 4.5	HW3
4	9/10	Lab 2 (System identification)		
4	9/12	Laplace transform solution and time domain solution	4.10, 4.11	
5	9/17	Signal flow graph (Mason Rule) Signal flow graph of state equations	5.4 – 5.6	HW4
5	9/19	Exam 1		
6	9/24	Routh-Hurwitz stability criteria	6.2 – 6.4	
6	9/26	Lab 3 (Stability analysis)		HW5
7	10/1	Stability in state space, Steady state error	6.5, 7.2	
7	10/3	Fall Break		
8	10/8	Steady state error in state space	7.8	HW6
8	10/10	Properties of Root Locus techniques	8.1 – 8.3	
9	10/15	Sketching the Root Locus	8.4 – 8.6	
9	10/17	Design via Root Locus	9.1 – 9.2	HW7
10	10/22	Physical realization of compensator (PID controller)	9.6	
10	10/24	Lab 4 (Controller design with Root Locus technique, PID controller design)		
11	10/29	Stability, GM, PM using Nyquist Criteria	10.1 - 10.3	HW8
11	10/31	Stability, GM, PM using Bode plots	10.4 - 10.7	
12	11/5	Exam 2		
12	11/7	Frequency-domain controller design using Bode diagram: Closed-loop frequency response characteristics	10.2 10.8 - 10.11	HW9
13	11/12	Lag compensator design	11.1 – 11.3	
13	11/14	Lead compensator design	11.4	HW10
14	11/19	Lab 5 (Lead-Lag compensator design)	11.5	
14	11/21	Controllability/Observability	12.3, 12.6	
15	11/26	Thanksgiving break		
15	11/28	Thanksgiving break		
16	12/3	Integral Control, Observer design	12.5, 12.8	
16		Final Exam: TBA		

Research sequence

Academic Week	Day	Task	Deliverable
1	8/19	Reviewing background materials and updating proposal	Updated proposal including details of deliverables.
2	8/26	Proposal Finalized	Research Proposal Finalized (Draft Proposal must be submitted to the Department Chair by the end of the term prior to the term student intends to perform directed research).
3	9/2	Wind turbine modeling using Matlab and Simulink	Wind Turbine Model
4	9/9	Wind turbine modeling using Matlab and Simulink	Wind Turbine Model
5	9/16	Wind turbine modeling using Matlab and Simulink	Wind Turbine Model
6	9/23	Designing PID controller in Matlab	PID Controller
7	9/30	Designing PID controller in Matlab	PID Controller
8	10/7	Designing PID controller in Multisim	PID Controller
9	10/14	Designing PID controller in Multisim	PID Controller
10	10/21	Designing PID controller on Breadboard	PID Controller
11	10/28	Designing PID controller on Breadboard	PID Controller
12	11/4	Designing PID controller on Breadboard	PID Controller
13	11/11	Running tests once complete system is built	Performance Review: Prototype 1
14	11/18	Running tests once complete system is built	Performance Review: Prototype 2
15	11/25	Thanksgiving break	
16	12/2	Research defense	Final prototype and PowerPoint ready

Needs adjustment to parallel research sequence with class one

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Stability analysis

Lag controller design

Frequency analysis

Outcomes

- Results of this approach:
  - ✓ *Increased student's confidence*: All the reporting work was done by student in great confidence (He voluntarily approached to faculty to show interest in presenting the results at conference)
  - ✓ *More controller design technique could have been applied*: Lead/Lag compensator and Bode frequency method compared to initial proposition for only designing PID controller
  - ✓ *Increased confidence of the involved faculty*: decreased reluctance to involve disqualified students
  - ✓ *One publication* is in-preparation: NCUR conference in March/2020
  - ✓ Some *mindset change* of instructor: instead of directly rejecting student who doesn't have prequalified knowledge, isn't there any ways to overcome some obstacles, i.e., paralleling research with teaching schedule?

- Question?