COURSE OUTLINE

Academic Year	AY2019/2020		**Semester**	2
Course Coordinator	Foo Yi Shyh Eddy (Dr)			
Course Code	EE4530			
Course Title	POWER SYSTEM ANALYSIS AND CONTROL			
Pre-requisites	Before AY2021-22 Sem2:	EE3010 Electrical Devices & Machines and EE3015 Power Systems & Conversion		
	AY2021-22 Sem2 and onwards:	EE3010 Electrical Devices & Machines and EE3015 Power Systems & Conversion or EE2005 Electrical Devices & Machines and EE3015 Power Systems & Conversion		
No of AUs	3			
Contact Hours	Lectures: 26 hours, Tutorials: 12 hours			
Proposal Date	5 March 2020 (REF#ACC-CN-2020/06_ITN-02)			

Course Aims

This course is designed to provide students with

1. Apply fundamental concepts of analysis and control of power systems,
2. Identify the problems commonly encountered in power system engineering practice,
3. Employ modelling, analysis and control techniques to solve some practical problems in power systems.
4. Discover career opportunities as power engineers, system planning engineers and system control engineers in the utility industry.

Intended Learning Outcomes (ILO)

By the end of the course, you should be:

1) Employ various solving techniques to solve power flow problems in practical power systems.
2) Relate concepts and apply the techniques of load frequency control, economic dispatch, power electronics-based active power control devices and their applications.
3) Describe basic concepts on recent development and system operation in a deregulated electricity market environment.
4) Explain and apply practical control methods of regulating voltage and reactive power in transmission and distribution systems using reactive compensating devices.
5) Explain the concepts of angle stability and voltage stability in power systems. In particular the concept of transient stability is well illustrated through the equal area criterion.
6) Describe and give examples of methods for stability assessment and improvement under steady state, dynamic and transient conditions.

Course Content

Power Flows. Active Power And Frequency Control. Reactive Power And Voltage Control. Power System Stability.

Course Outline

S/N	Topic	Lecture Hours	Tutorial Hours
1	Power flows System components modelling. Formulation of power flow equations. Methods of power flow solution. Case studies.	4	2
2	Active power and frequency control Governor control systems. Area control errors and load frequency control. Energy offers. Transmission losses, penalty factors and loss coefficients. Economic dispatch. Automatic generation control. Electricity markets. Active power control devices.	8	4
3	Reactive Power and Voltage Control Production and absorption of reactive power. Methods of voltage control. Reactive power and voltage control devices. Application to transmission and distribution systems.	6	3
4	Power System Stability Steady-state, dynamic and transient stability. Swing equations. Power-angle equations. Equal-area criterion of stability. Multi-machine stability studies. Methods for stability assessment. Factors affecting transient stability. Methods of improving transient stability. Voltage Stability.	8	3
	Total hours	26	12

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. CA1 – Quiz #1	1	EAB SLO* a, c	10%	Individual	
2. CA2 – Quiz #2	4	EAB SLO* a, c	10%	Individual	
3. CA3 – Homework Assignment #1	2,3	EAB SLO* a, c	10%	Individual	
4. CA4 – Homework Assignment #2	5,6	EAB SLO* a, c	10%	Individual	
5. Final Examination	1,2,3,4,5,6	EAB SLO* a, c	60%	Individual	
Total			**100%**		
* Please refer to Appendix 2 on the EAB accreditation SLOs					

Mapping of Course SLOs to EAB Graduate Attributes

Course Student Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)

EE4530 Power System Analysis and Control	Technical Elective	●		●									

1. Employ various solving techniques to solve power flow problems in practical power systems.	EAB SLO* a, c
2. Relate concepts and apply the techniques of load frequency control, economic dispatch, power electronics-based active power control devices and their applications.	EAB SLO* a, c
3. Describe basic concepts on recent development and system operation in a deregulated electricity market environment.	EAB SLO* a, c
4. Explain and apply practical control methods of regulating voltage and reactive power in transmission and distribution systems using reactive compensating devices.	EAB SLO* a, c
5. Explain the concepts of angle stability and voltage stability in power systems. In particular the concept of transient stability is well illustrated through the equal area criterion.	EAB SLO* a, c
6. Describe and give examples of methods for stability assessment and improvement under steady state, dynamic and transient conditions.	EAB SLO* a, c

Legend: ● Fully consistent (contributes to more than 75% of Student Learning Outcomes)
◐ Partially consistent (contributes to about 50% of Student Learning Outcomes)
○ Weakly consistent (contributes to about 25% of Student Learning Outcomes)
Blank Not related to Student Learning Outcomes

Formative feedback

These are the forms of feedback that you can expect in the course:

Your exercises in tutorial classes;
Examination results;
Markers' report on overall examination performance;
Quizzes scores and answers / solutions / explanations provided in tutorial/lecture classes;
Assignment scores uploaded on course site.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
LECTURE	Lectures and lecture materials cover all topics
TUTORIAL	Classroom discussions on tutorial questions and related topics

Reading and References

TEXTBOOK

1. Saadat Hadi, Power System Analysis, 3rd Edition, McGraw-Hill, 2010. (TK1001.S111 2010)

REFERENCES

1. Weedy Birron Mathew and Cory Brian John, Electric Power Systems, 5th Edition, John Wiley, 2012. (TK1001.W394 2012)
2. Grainger John J and Stevenson William D, Power System Analysis, McGraw-Hill, 1994. (TK3001.G743)

Course Policies and Student Responsibilities

General:
You are expected to complete all tutorial questions and take-home assignment by due dates. You are expected to take all quizzes. You are expected to take responsibility to follow up with course notes, assignments and course related announcements. You are expected to actively participate in class discussions.

Continuous assessments:
You are required to attend all continuous assessments.

Absenteeism:
Continuous assessments make up a significant portion of your course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect your overall course grade.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Dr. Foo Yi Shyh Eddy	S1-B1C-89	6790 4519	eddyfoo@ntu.edu.sg
Prof Wang Youyi	S2-B2B-47	6790 4537	eyywang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction to power flow study and Gauss Seidel method for PQ buses	1	2 lectures
2	Gauss Seidel method for PV buses and Newton Raphson method	1	2 lectures + 1 tutorial

3	Introduction to active power and frequency control. Basic generator control loops will be discussed	2	2 lectures + 1 tutorial
4	Discussion on load frequency control with worked examples	2	2 lectures + 1 tutorial + Homework Assignment #1
5	Economic dispatch - heat rate, cost rate curves and lossless thermal dispatch	3	2 lectures + 1 tutorial + Quiz #1
6	Economic dispatch – including generator limits and thermal dispatch with losses	3	2 lectures + 1 tutorial
7	Reactive Power and Voltage Control	4	2 lectures + 1 tutorial
Recess	Recess Week		
8	Reactive Power and Voltage Control	4	2 lectures + 1 tutorial
9	Reactive Power and Voltage Control	4	2 lectures + 1 tutorial
10	Power System Dynamics and Stability	5,6	2 lectures + 1 tutorial + Quiz #2
11	Rotor Dynamics and Swing Equations	5,6	2 lectures + 1 tutorial + Homework Assignment #2
12	Power-Angle Equation and Equal-Area Criterion	5,6	2 lectures + 1 tutorial
13	Equal-Area Criterion of Stability	5,6	2 lectures + 1 tutorial

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.