



52. Course Specification of Substations Design

-	I. Course Identification and General Information:						
1.	Course Title:	Substation	Substations Design				
2.	Course Code & Number:	PME428	3				
			С.Н				
3.	Credit hours:	Th.	Tu.	Pr.	Tr.	Total	
		2	2	-	-	3	
4.	Study level/ semester at which this course is offered:	Fifth Year- First Semester					
5.	Pre –requisite (if any):	Power System Analysis 1 (PME332)					
6.	Co –requisite (if any):	None					
7.	Program (s) in which the course is offered:	BSc. Electrical Power and Machines Engineering					
8.	Language of teaching the course:	English					
9.	Location of teaching the course:	Electrical Engineering Department/Faculty of Engineering			/Faculty		
10.	Prepared By:	Prof. Dr. Eng. Omar H. Al-Sakaf					
11.	Date of Approval		-	-		_	

II. Course Description:

This course introduces students to the function of high voltage substations at all levels of the power grid, with an introduction to typical substation components included. It familiarizes students with the position and function of substations in power systems, high voltages and currents, elements of high voltage substations, especially switchgear, their basic characteristics, choice method and necessary calculations, basic and auxiliary schemes, grounding and electric accident prevention, substation reliability, measuring, control and signalization, as well as influences of substations on the environment. Students learn features, drawbacks and application of the different designs of high voltage substations and their realization as outdoor, indoor and gas-insulated substations.

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	III. Course Intended learning outcomes (CILOs) of the course	Referenced PILOs
a1	Describe the methodologies and principles of design, techniques and operation of high voltage switchgear in high voltage substations.	A1, A2, A3, A4
a2	Describe the classifications of high voltage substations layouts, their characteristics and features.	A1, A2, A3, A4
b1	Analyze engineering decisions considering balanced costs, benefits, safety, quality, reliability, and environmental impact.	B1, B2, B3, B4
b2	Identify and formulate engineering issues to solve problems in the field of high voltage substations.	B1, B2, B3, B4
c1	Apply modern techniques, skills and engineering tools to high voltage substation equipment design and selection.	C1, C2, C3, C4
c2	Develop technical specifications including testing and evaluation of components and equipment related to high voltage substations.	C1, C2, C3, C4
d1	Create systematic and methodic approaches when dealing with new and advancing technology.	D2, D3, D5
d2	Acquire problem solving and design skills and use computer applications and internet to extract information related to field of study and to prepare and present design reports.	D2, D3, D5

	(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:			
Course Intended Learning Outcomes		Teaching strategies	Assessment Strategies	
	a1 Describe the methodologies and principles of design, techniques	• Lectures,	■ Assignments,	

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and	operation	of high	voltage	■ Demonstrations,	■ Oral Presentations,
switch	igear in	high	voltage	Interactive class	Quizzes,
substa	tions.			discussion,	■ Tests,
a2	2 Describe the classifications of		■ Tutorials	■ Written Exams	
high	voltage	substations	layouts,		
their	characteris	tics and featu	ıres.		

(B) Alignment Course Intended Learni Strategies and Assessment Strategies:	ing Outcomes of Intellectual	Skills to Teaching
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1 Analyze engineering decisions considering balanced costs, benefits, safety, quality, reliability, and environmental impact. b2 Identify and formulate engineering issues to solve problems in the field of high voltage	Lectures,Demonstrations,Interactive class discussion	 Assignments, Oral Presentations, Quizzes, Tests, Exams
substations.		

` '	(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:			
Course Intended Learning Outcomes		Teaching strategies	Assessment Strategies	
c1	Apply modern techniques, skills and engineering tools to high voltage substation equipment design and selection.	Lectures,Demonstrations,Interactive class discussion.	Assignments,Oral Presentations,	
c2 of relate	Develop technical specifications including testing and evaluation components and equipment d to high voltage substations.		 Quizzes, Tests, Written Exams.	

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(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:				
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies		
d1 Create systematic and methodic approaches when dealing with new and advancing technology.	■ Demonstrations,			
d2 Acquire problem solving and design skills and use computer applications and internet to extract information related to field of study and to prepare and present design reports.	 Demonstrations, Interactive class discussion. 	Assignments,Oral Presentations.		

IV. Course Content:

A – Theoretical Aspects:

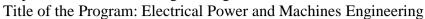
Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
1.	General Introduction	a1, a2, b1, b2, c1, c2, d1, d2	 Classification of Substations Substation Siting Substation Design Considerations 	1	2
2.	Switchgear	a1, a2, b1, b2, c1, c2, d1, d2	 Switching - Basic Principles The Process of Current Interruption Technical Realization Low Voltage Switchgear High Voltage Switchgear High Voltage Circuit Breakers Arc Quenching Media Sulphur Hexafluoride Vacuum 	4	8

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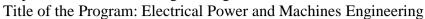
			 Oil Air Selection of Circuit Breakers Switches and Disconnectors Operating Mechanisms 		
3.	Substations Alternative Layouts	a1, a2, b1, b2, c1, c2, d1, d2	 Substations with Busbars Single Busbar Arrangement Double Busbar Arrangement Substations without Busbars Simplified High Voltage Substations Layouts 	4	8
4.	Conventional Designs of Outdoor Air- Insulated High Voltage Substations	a1, a2, b1, b2,c1, c2, d1,d2	 Safety Clearances Conventional Designs Parallel-Transverse Layout Series-Longitudinal Layout Series-Transverse Design Diagonal Design 1½ - Breaker Layout 	1	2
5.	Gas Insulated Switchgear for Substations	a1, a2, b1, b2,c1, c2, d1,d2	 Advantages of GIS GIS Construction Technical Realization Hybrid Substations Containerized GIS Substations Service Life and GIS Advancements 	2	
6.	Substation Auxiliary Power Supplies and	a1, a2, b1, b2,c1, c2, d1,d2	 Substation Auxiliary Power Supplies Substation Building Services Substation Fire Safety 	1	2

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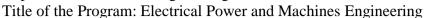


Number of Weeks /and Units Per Semester					28
7.	Substation Automation Basics	a1, a2, b1, b2, c1, c2, d1,d2	 Substation Automation Systems Instrument Transformers Substation Control Supervisory Control and Data Acquisition SCADA System 	1	2
	Building Services				

B – Tu	B – Tutorial:							
Order	Tasks	Number of Weeks	Contact Hours	Learning Outcomes				
1.	Analysis of high voltage substations design considerations.	2	4	b1, b2, c1, c2, d1, d2				
2.	Problems to determine the best substation site; closest to the load center.	1	2	b1, b2, c1, c2, d1, d2				
3.	Illustrating via flowcharting steps involved in establishing a new substation.	1	2	b1, b2, c1, c2, d1, d2				
4.	Selecting and specifying substation main components and equipment.	2	4	b1, b2, c1, c2, d1, d2				
5.	Reading and analyzing substation drawings and diagrams.	1	2	b1, b2, c1, c2, d1, d2				
6.	Analyzing, comparing and assessing different substation layouts.	2	4	b1, b2, c1, c2, d1, d2				
7.	Role-play exercises to determine the correct switching sequence.	2	4	b1, b2, c1, c2, d1, d2				
8.	What-If scenarios to determine number of circuits lost due to faults on different substation main components and incoming/outgoing feeders.	3	6	b1, b2, c1, c2, d1, d2				
Numbe	r of Weeks and Units Per Semester	14	28					

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Teaching Strategies of the Course: V.

- Lectures
- Interactive class discussion
- Demonstration Technical Video Clips
- Field Visits

VI	VI. Schedule of Assessment Tasks for Students During the Semester:							
No.	Assessment Week Due Mark Proportion of Final Assessment Learning Outcom							
1.	Mini Projects	1-14	20	20%				
2.	Mid-Term Exam	8	20	20%	L1 L2 -1 -2 -1 -12			
3.	Final Exam	16	60	60%	b1, b2, c1, c2, d1, d2			
	Total		100	100%				

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VII. Learning Resources:

1- Required Textbook(s)

 Omar Al-Sakaf, 'Introduction to High Voltage Substations Design', Second Edition, 2019, Sana'a, Yemen.

2- Essential References.

- Colin Bayliss and Brian Hardy, 'Transmission and Distribution Electrical Engineering', Third edition 2007.
- Electric Power Substation Engineering, John McDonald, ed. Boca Raton, FL: CRC Press, 2nd Edition, 2007.
- Design Guide for Rural Substations, United States Department of Agriculture, 2001, www.usda.gov/rus/electric.
- Siemens Power Engineering Guide, 6th Edition, www.ev.siemens.de, www.energy.siemens.com.
- ABB Switchgear Handbook, 11th Edition, www.abb.com.

3- Electronic Materials and Web Sites etc.

- Course Power Point.
- Video clips.
- Links to information resources.

7	VIII. Course Policies:
	Class Attendance: A student should attend not less than 75 % of total hours of the subject; otherwise he will
1.	not be able to take the exam and will be considered as exam failure. If the student is
	absent due to illness, he/she should bring an approved statement from university Clinic
	Tardy:
2.	For late in attending the class, the student will be initially notified. If he repeated lateness
	in attending class he will be considered as absent.
	Exam Attendance/Punctuality:
3.	A student should attend the exam on time. He is Permitted to attend an exam half one
3.	hour from exam beginning, after that he/she will not be permitted to take the exam and
	he/she will be considered as absent in exam-
	Assignments & Projects:
4.	The assignment is given to the students after each chapter; the student has to submit all
	the assignments for checking on time-

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	Cheating:
5.	For cheating in exam, a student will be considered as failure. In case the cheating is
	repeated three times during his/her study the student will be disengaged from the Faculty-
	Plagiarism:
	Plagiarism is the attending of a student the exam of a course instead of another student.
6.	If the examination committee proved a plagiarism of a student, he will be disengaged
	from the Faculty. The final disengagement of the student from the Faculty should be
	confirmed from the Student Council Affair of the university.
	Other policies:
	- Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise
7.	the student will be asked to leave the lecture room
	- Mobile phones are not allowed in class during the examination.
	Lecture notes and assignments my given directly to students using soft or hard copy

Reviewed	Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek
By	A. Barakat
	President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi
	Name of Reviewer from the Department: Asst. Prof. Dr. Adel Ahmed Al-Shakiri
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa
	Assoc. Prof. Dr. Ahmed Mujahed
	Asst. Prof. Dr. Munasar Alsubri

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52. Course Plan of Substations Design

I. Information about Faculty Member Responsible for the Course:								
Name of Faculty Member	Prof. Dr. Eng. Omar H. Al- Sakaf			Office	Hours			
Location& Telephone No.	Faculty of Engineering Mobile: 733772328/773332328	SAT	SUN	MON	TUE	WED	THU	
E-mail	oalsakaf@gmail.com oalsakaf@yahoo.com		08:00 - 12:00					

-	II. Course Identification and General Information:								
1.	Course Title:	Substati	ons Desig	gn					
2.	Course Number & Code:	PME42	8						
			C	.H		Total			
3.	Credit hours:	Th.	Tu.	Pr.	Tr.	Total			
		2	2	-	ı	3			
4.	Study level/year at which this course is offered:	Fifth year- First Semester							
5.	Pre –requisite:	Power System Analysis 1 (PME332)							
6.	Co –requisite (if any):	None							
7.	Program (s) in which the course is offered	BSc. Electrical Power and Machines Engineering							
8.	Language of teaching the course:	English							
9.	System of Study:	Regular							
10.	Mode of delivery:	Face-to-Face							
11.	Location of teaching the course:	Electrication of Engineering	_	ering Dep	artment/F	aculty			

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III. Course Description:

This course introduces students to the function of high voltage substations at all levels of the power grid, with an introduction to typical substation components included. It familiarizes students with the position and function of substations in power systems, high voltages and currents, elements of high voltage substations, especially switchgear, their basic characteristics, choice method and necessary calculations, basic and auxiliary schemes, grounding and electric accident prevention, substation reliability, measuring, control and signalization, as well as influences of substations on the environment. Students learn features, drawbacks and application of the different designs of high voltage substations and their realization as outdoor, indoor and gas-insulated substations.

IV.Intended Learning Outcomes (ILOs) of the Course:

- 1. Describe the methodologies and principles of design, techniques and operation of high voltage switchgear in high voltage substations.
- **2.** Describe the classifications of high voltage substations layouts, their characteristics and features.
- **3.** Analyze engineering decisions considering balanced costs, benefits, safety, quality, reliability, and environmental impact.
- **4.** Identify and formulate engineering issues to solve problems in the field of high voltage substations.
- **5.** Apply modern techniques, skills and engineering tools to high voltage substation equipment design and selection.
- **6.** Develop technical specifications including testing and evaluation of components and equipment related to high voltage substations.
- **7.** Create systematic and methodic approaches when dealing with new and advancing technology.
 - Acquire problem solving and design skills and use computer applications and internet to extract information related to field of study and to prepare and present design reports.

Title of the Program: Electrical Power and Machines Engineering









V. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1.	General Introduction	 Classification of Substations Substation Siting Substation Design Considerations 	1 st	2
2.	Switchgear	 Switching - Basic Principles The Process of Current Interruption Technical Realization Low Voltage Switchgear High Voltage Switchgear High Voltage Circuit Breakers Arc Quenching Media Sulphur Hexafluoride Vacuum Oil Air Selection of Circuit Breakers Switches and Disconnectors Operating Mechanisms 	2 nd ,3 rd ,4 th ,5 th	8
3.	Substations Alternative Layouts	 Substations with Busbars Single Busbar Arrangement Double Busbar Arrangement Substations without Busbars Simplified High Voltage Substations Layouts 	6 th ,7 th	4
4.	Midterm Exam		8 th	2
5.	Substations Alternative Layouts	 Substations with Busbars Single Busbar Arrangement Double Busbar Arrangement Substations without Busbars 	9 th ,10 th	4

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		Simplified High Voltage		
		Substations Layouts		
6.	Conventional Designs of Outdoor Air- Insulated High Voltage Substations	 Safety Clearances Conventional Designs Parallel-Transverse Layout Series-Longitudinal Layout Series-Transverse Design Diagonal Design 1½ - Breaker Layout 	11 th	2
7.	Gas Insulated Switchgear for Substations	 Advantages of GIS GIS Construction Technical Realization Hybrid Substations Containerized GIS Substations Service Life and GIS Advancements 		4
8.	Substation Auxiliary Power Supplies and Building Services Substation Auxiliary Power Supplies Substation Building Services Substation Fire Safety		14 th	2
9.	Substation Automation Basics	 Substation Automation Systems Instrument Transformers Substation Control Supervisory Control and Data Acquisition SCADA System 		2
10.	Final Exam		16 th	2
Numbe	Number of Weeks /and Units Per Semester			32

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B – Tutorial:					
Order	Tasks	Number of Weeks	Contact Hours		
1.	Analysis of high voltage substations design considerations.	1 st ,2 nd	4		
2.	Problems to determine the best substation site; closest to the load center.	3 rd	2		
3.	Illustrating via flowcharting steps involved in establishing a new substation.	4 th	2		
4.	Selecting and specifying substation main components and equipment.	5 th ,6 th	4		
5.	Reading and analyzing substation drawings and diagrams.	7 th	2		
6.	Analyzing, comparing and assessing different substation layouts. 8 th ,9 th 4		4		
7.	Role-play exercises to determine the correct switching sequence. 10 th ,11 th		4		
8.	What-If scenarios to determine number of circuits lost due to faults on different substation main components and incoming/outgoing feeders.	12 th ,13 th ,14 th	6		
Number	Number of Weeks and Units Per Semester 14 28				

VI. Teaching Strategies of the Course:

- Lectures
- Interactive class discussion
- Demonstration Technical Video Clips
- Field Visits

VII. Schedule of Assessment Tasks for Students During the Semester:					
No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course

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					Learning Outcomes
1.	Mini Projects	1-14	20	20%	
2.	Mid-Term Exam	8	20	20%	L1 L2 -1 -2 -11 -12
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