

Program Name : Electrical Engineering Program Group
Program Code : EE/EP/EU
Semester : Sixth
Course Title : Electrical Substation Practices (Elective-II)
Course Code : 22633

1. RATIONALE

The electrical power for many industries is made available through their own substations. This course will empower the students with the necessary knowledge of operations and maintenance of substation equipment. This course will also be useful for students to observe the safety while working in substations as well as to improve the quality of power system. In this course new type of substation like Gas Insulated substation is also included.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the safe working of different types of electrical substations.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following *industry oriented* COs associated with the above mentioned competency:

- Follow safety rules for Substation.
- Maintain substation earthing and neutral grounding.
- Maintain the Sub-station Equipment and Bus bar layout
- Interpret single line diagram of substation.
- Maintain Gas insulated Substation

4. TEACHING AND EXAMINATION SCHEME

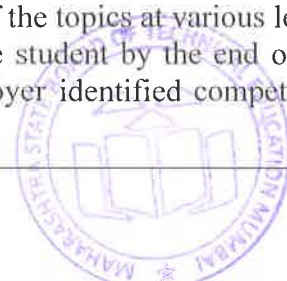
Teaching Scheme			Credit (L+T+P)	Examination Scheme												
L	T	P		Theory						Practical						
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
			Max		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment

5. COURSE MAP (with sample COs, PrOs,UOs,ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.



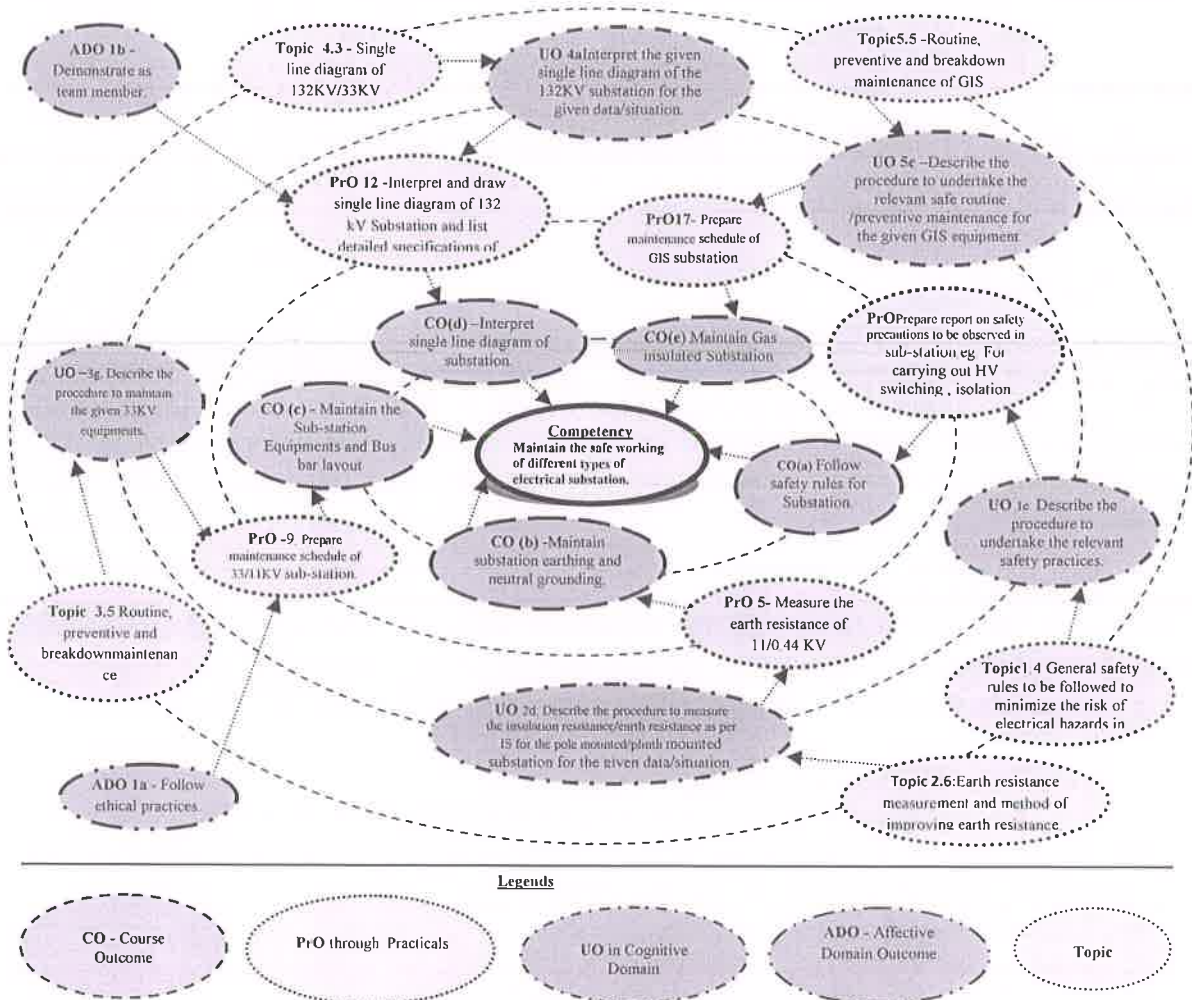


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare report on safety precautions to be observed in sub-station.eg. For carrying out HV switching , isolation from other feeding points etc.	I to V	02*
2	Draw layout and prepare report of 11 KV pole mounted substation earthing after seeing the relevant video clip.	II	02*
3	Draw layout and prepare report of 11 KV plinth mounted substation earthing.	II	02
4	Interpret and draw single line diagram of 11 kV Substation and list detailed specifications of equipment used.	II	02
5	Measure the earth resistance of 11/0.44 KV substation. Compare with standard values and prepare report for improvement of earth resistance.	II	04*
6	Prepare Visit report of 33/11KV sub-station and draw the layout diagram.	III	04*
7	Interpret and draw single line diagram of 33 kV Substation and list detailed specifications of equipment used.	III	04

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Measure the earth resistance and insulation resistance of 33/11KV substation	III	04
9	Prepare maintenance schedule of 33/11KV sub-station.	III	02*
10	Perform BDV (break down voltage) test on power transformer oil	III	04
11	Perform specific gravity test and measure battery voltage and prepare maintenance schedule of Battery	III,IV	02
12	Interpret and draw single line diagram of 132 kV Substation and list detailed specifications of equipment used.	IV	04*
13	Locate and record the hot spot(s) in substation equipment, terminals, conductor joints by using non contact type thermal sensor.	IV	04
14	Prepare a report on maintenance of SF6 circuit breakers in sub station	IV	02
15	Use the given firefighting equipment used in 11KV, 33KV and 132KV substation.	IV	02*
16	Interpret and draw single line diagram of 33 KV Gas Insulated sub-station.	V	02*
17	Prepare maintenance schedule of GIS substation.	V	02
Total			48

Note

- i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicious mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory and any 04 from remaining, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.
- ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		100

The above PrOs also comprise of the following social skills/attitudes which are Affective The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

- a) Follow safety practices.
- b) Practice good housekeeping.
- c) Practice energy conservation.
- d) Work as a leader/a team member.
- e) Follow ethical Practices.



The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

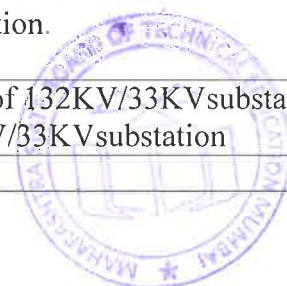
S. No.	Equipment Name with Broad Specifications	PrO.No.
1	Multimeter, clip on meter , voltmeters, ammeters	1 to 17
2	Digital Earth tester	05 , 08
3	Motorized megger (1000 V)	8
4	Hygrometer	11
5	Non contact type thermometer / thermal sensor for locating hot spots	13
6	Oil testing kit (0-60) kv	10

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Overview of Sub- stations.	1a. Select the site for the substation for the given data/situation with justification. 1b. Classify the substation based on the given data/situation. 1c. Interpret of symbols used in the given single line diagram. 1d. Describe the procedure to maintain the earth resistance as per IE rules for the given data/situation. 1e. Describe the procedure to undertake the relevant safety practices in substation for the given data/situation.	1.1 Need of electrical substation. Factors governing the selection of the site of the substation, Classification of sub-station based on voltage level, Indoor and Outdoor, configuration, application, various symbols used in single line diagram. 1.2 Conductor used in main bus and auxiliary bus for 11KV, 33KV, 132KV substation. 1.3 Typical earth resistance values of various substation and structures as per IE rules:- 11KV,33KV,132KV substation and double pole structure, transmission tower(tower foot resistance) 1.4 General safety rules to be followed to minimize the risk of electrical hazards in substation.
Unit – II 11KV substation	2a. Draw the layout diagram for the pole mounted/plinth mounted substation for the given	2.1 Need for pole mounted and plinth mounted substation. 2.2 11KV/440V Pole mounted

	<p>data/situation.</p> <p>2b. Interpret the given single line diagram of the pole mounted/plinth mounted substation for the given data/situation.</p> <p>2c. Select the relevant equipment and accessories required for the 11KV pole mounted substation for the givendata/situation with justification.</p> <p>2d. Describe the procedure to measure the insulation resistance/earth resistance as per IS for the pole mounted/plinth mounted substation for the given data/situation.</p> <p>2e. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the specified11KV substation equipment.</p> <p>2f. Describe the procedure to maintain the given 11KV equipment.</p>	<p>substation Equipment and accessories: Functions and rating of: Three phase distribution transformer, Lightning arrester(LA), Metering Current transformer (CT), Metering voltage transformer PT, Air break switch (AB switch),Drop out (DO) fuse, insulators and Distribution box.</p> <p>2.3 Layout and Single line diagram of pole mounted substation.</p> <p>2.4 Insulation resistance measurement.</p> <p>2.5 Earthing: Equipment earthing and System earthing.</p> <p>2.6 Earth resistance measurement and method of improving earth resistance.</p> <p>2.7 Routine, preventive and breakdown maintenance.</p> <p>2.8 Safety practices followed during routine, preventive and breakdown maintenance.</p>
<p>Unit – III 33KV substation</p>	<p>3a. Draw the layout diagram for the 33KV substation for the given data/situation.</p> <p>3b. Interpret the given single line diagram of the 33KV substation for the given data/situation.</p> <p>3c. Select the relevant equipment and accessories required for the 33KV substation for the given data/situation with justification.</p> <p>3d. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given 33KV substation equipment.</p> <p>3e. Describe the procedure to undertake the measurement of BDV of the transformer oil for the given data/situation.</p> <p>3f. Describe the procedure to use therelevant fire-fighting equipment for the given situation.</p> <p>3g. Describe the procedure to maintain the given 33KV equipment.</p>	<p>3.1 Need of 33KV/11KVsubstation.</p> <p>3.2 33KV/11KVsubstation Equipment and accessories: Functions and rating of:Power transformer, Lightning arrester(LA), Instrument Transformer-Current transformer (CT) and Potential transformer (PT), HT fuses, Isolating switches (Isolator), Insulators, control and relay panel, station transformer, capacitor bank, battery and charger and circuit breaker.</p> <p>3.3 Layout and Single line diagram of 33KV substation.</p> <p>3.4 Earthing: Equipment earthing and System earthing</p> <p>3.5 Routine, preventive and breakdown maintenance.</p> <p>3.6 BDV (break down voltage) test on power transformer oil.</p> <p>3.7 Safety practices followed during routine, preventive and breakdown maintenance.</p> <p>3.8 Fire-fighting equipment for the different situations in the substation.</p>
<p>Unit – IV 132 KV</p>	<p>4a. Interpret the given single line diagram of the 132KV substation</p>	<p>4.1 Need of 132KV/33KVsubstation.</p> <p>4.2 132KV/33KVsubstation</p>



substation	<p>for the given data/situation.</p> <p>4b. Select the relevant equipment and accessories required for the 132KV/33KV substation for the given data/situation with justification.</p> <p>4c. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given 132KV substation equipment.</p> <p>4d. Describe the procedure to use the relevant fire-fighting equipment for the given situation.</p> <p>4e. Describe the procedure to maintain the given component(s) of the 132KV substation.</p> <p>4f. Describe the procedure to locate and record the hot spot(s) in 132KV substation.</p>	<p>Equipment and accessories: Functions and rating of: Power transformer, Lightning arrester (LA), Instrument Transformer- Current transformer (CT) and Potential transformer (PT), Capacitor voltage transformer (CVT), HT fuses, Isolating switches (Isolator), Insulators, control and relay panel, station transformer, capacitor bank, battery and charger, wave trap/wave drum, Power line carrier communication (PLCC) and circuit breaker.</p> <p>4.3 Single line diagram of 132KV/33KV substation.</p> <p>4.4 Earthing: Equipment earthing and System earthing.</p> <p>4.5 Step potential, touch potential, mesh potential, transferred potential, earth mat or grid.</p> <p>4.6 Routine, preventive and breakdown maintenance; Safety practices followed during routine, preventive and breakdown maintenance.</p> <p>4.7 Fire-fighting equipment for the different situations in the substation.</p> <p>4.8 Non-contact type thermal sensor to locate and record hot spot(s) in a substation.</p>
Unit– V Gas Insulated sub-station	<p>5a. Interpret the single line diagram of the GIS for the given data/situation.</p> <p>5b. Describe the function of the given part(s) of the GIS.</p> <p>5c. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given GIS equipment.</p> <p>5d. Describe the procedure to use the relevant fire-fighting equipment for the given situation.</p> <p>5e. Describe the procedure to maintain the given GIS equipment.</p>	<p>5.1 Need of gas insulated substation (GIS).</p> <p>5.2 Essential parts of GIS, advantages of GIS, drawbacks of GIS.</p> <p>5.3 Single line diagrams of GIS.</p> <p>5.4 Partial discharge monitoring.</p> <p>5.5 Routine, preventive and breakdown maintenance of GIS.</p> <p>5.6 Safety practices followed during routine, preventive and breakdown maintenance.</p> <p>5.7 Firefighting equipment used in GIS.</p>

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.



9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Overview of Sub-stations	06	00	04	02	06
II	11 KV substation	12	04	04	10	18
III	33 KV substation	12	02	04	12	18
IV	132 KV substation	10	04	04	08	16
V	Gas Insulated sub-station	08	02	04	06	12
Total		48	12	20	38	70

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- Prepare report on market survey of various three phase power and distribution transformers(specification, manufacturer, application, cost)
- Prepare model of pole mounted distribution transformer.
- Prepare power point presentation related to substation equipment.
- Prepare power point presentation related to maintenance of substation.
- Prepare a single line diagram of substation.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- '**L**' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
- About **15-20% of the topics/sub-topics** which is relatively simpler or descriptive in nature is to be given to the students for **self-directed learning** and assess the development of the COs through classroom presentations (see implementation guideline for details).
- With respect to item No.10, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- Use Flash/Animations to explain various theorems in circuit analysis
- Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be **individually** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

- Power / distribution transformer:** Prepare chart showing three phase power / distribution transformer.
- Neutral grounding:** Collect specification from different manufacturers and prepare report.
- Sub-station equipment:** Collect specification from different manufacturers and prepare report.
- Gas Insulated Substation:** Collect photographs with details of Gas Insulated Substation and identify different parts (specification, application, cost, features, manufacturer)
- Single line diagram of sub-station:** Prepare Single line diagram of sub-station

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Generation Of Electrical Energy	Gupta, B.R.	Eurasia Publishing House (Pvt.) Ltd, , 1996. ISBN :81-219-0102-2
2	Principles Of Power System	Mehta, V.K.	S.Chand&Co.Ltd, New Delhi 2011. ISBN :81-219-0594-X
3	A Course in Electrical Power	Soni, M. L. Gupta, P.V. U.S. Bhatnagar,	Dhanpat Rai & Co. (P) Ltd., New Delhi 2016, ISBN: 9788177000207
4	Switchgear Protection and Power Systems	Sunil S. Rao	Khanna Publisher, New Delhi, 2008 ISBN: 978-8174092328
5	Elements of Electrical Power Station Design	Deshpande, M.V.	PHI Learning Pvt Limited, New Delhi, 2009, ISBN: 978-8120336476
6	Power Plant Engineering	Nagpal, G.R. S.C. Sharma,	Khanna Publishers-Delhi, 2012 ISBN :978-8174093097

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

- <http://nptel.iitm.ac.in>
- <http://iitm.vlab.co.in/?sub=46&brch=144&sim=1056&cnt=4>
- <http://www.edumedia-sciences.com>
- <http://www.engineeringtv.com/video/Texas-Instruments>
- SEQUEL (open source)
- PSIM
- PSCAD

