Program Name : **Electrical Engineering Program Group**

Program Code : **EE/EP/EU**

Semester : **Third**

Course Title : **Electrical Circuits**

Course Code : **22324**

1. RATIONALE

To maintain electrical equipments, knowledge of electrical circuits is very important. Understanding electrical circuits lays the foundation to maintain electrical and electronic devices, machines and equipment. This course will help the students to use the principles of circuit and analyze the same to diagnose and rectify the electrical circuits related problems in the industries and power utilities.

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 electrical systems applying AC and DC circuit fundamentals.**

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:

a. Troubleshoot problems related to single phase A.C series circuits.
b. Troubleshoot problems related to single phase A.C parallel circuits.
c. Troubleshoot problems related to three phase circuit.
d. Use principles of circuit analysis to troubleshoot problems related to electric circuits.
e. Apply network theorems to troubleshoot problems related to electric circuits.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	2	8	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.

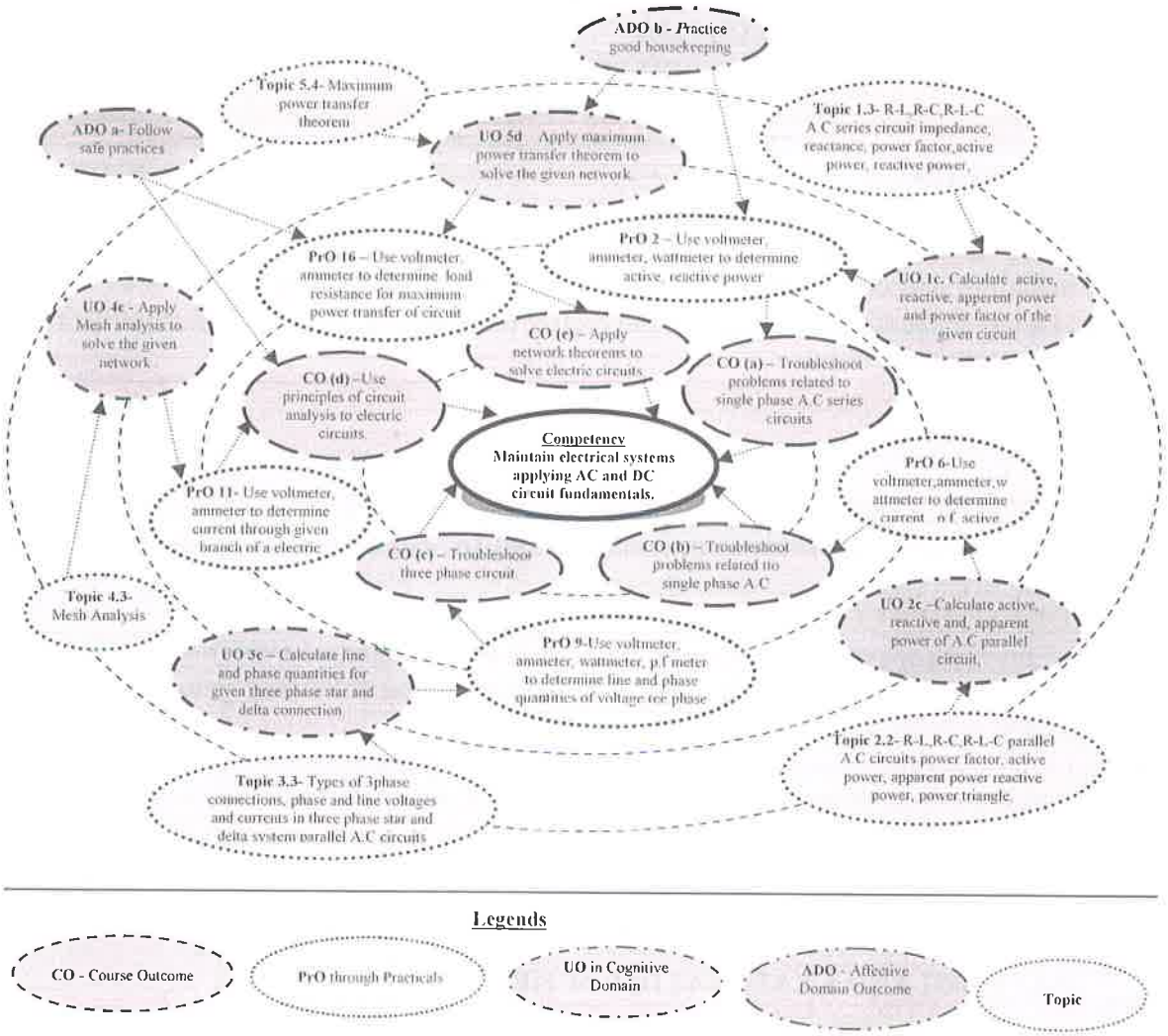

Figure 1 - Course Map

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	Use dual trace oscilloscope to determine A.C voltage and current response in given R,L,C circuit.	I	02*
2	Use voltmeter, ammeter, wattmeter to determine active, reactive and apparent power consumed in given R-L series circuit. Draw phasor diagram.	I	02
3	Use voltmeter, ammeter to determine active, reactive and apparent power consumed in given R-C series circuit. Draw phasor diagram.	I	02
4	Use voltmeter, ammeter, wattmeter to determine active, reactive	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	and apparent power consumed in given R-L-C series circuit. Draw phasor digram.		
5	Use variable frequency supply to create resonance in given series R-L-C circuit or by using variable inductor or variable capacitor.	I	02
6	Use voltmeter, ammeter, wattmeter to determine current, p.f, active, reactive and apparent power in R-C parallel A.C. circuit.	II	02
7	Use voltmeter, ammeter, wattmeter, p.f meter to determine current, p.f., active, reactive and apparent power for given R-L-C parallel circuit with series connection of resistor and inductor in parallel with capacitor.	II	02*
8	Use variable frequency supply create resonance in given parallel R-L-C circuit or by using variable inductor or capacitor .	II	02
9	Use voltmeter, ammeter, wattmeter, p.f meter to determine line and phase quantities of voltage and current for balanced three phase star and delta connected load and calculate active, reactive, and apparent power. Draw phasor diagram.	III	02
10	Use voltmeter, ammeter, wattmeter, p.f meter to determine line and phase quantities of voltage and current for unbalanced three phase star and delta connected load and calculate active, reactive, and apparent power. Draw phasor diagram.	III	02*
11	Use voltmeter, ammeter to determine current through the given branch of a electric network by applying mesh analysis.	IV	02*
12	Use voltmeter, ammeter to determine current through the given branch of a electric network by applying node analysis.	IV	02
13	Use voltmeter, ammeter to determine current through the given branch and voltage across the given element of circuit by applying superposition theorem .	V	02
14	Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Thevenin's theorem	V	02*
15	Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Norton's theorem	V	02
16	Use voltmeter, ammeter to determine load resistance for maximum power transfer for a given circuit by applying maximum power transfer theorem .	V	02
	Total		**32**

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 judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, 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 %
a.	Preparation of experimental set up	20

S.No.	Performance Indicators	Weightage in %
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

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. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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
- 'Organising Level' in 2nd year
- 'Characterising 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 authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Digital storage oscilloscope: Dual trace 50Mhz	1
2	Ammeters MI Type: AC/DC, 0-5-10Amp,0-1.5 Amp,0-2.5Amp,0-0.5-1Amp	2 to 12
3	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V,0-75/150V	2 to 12
4	Wattmeter: Single phase 2.5/5Amp, 200/400V, Single phase 5/10Amp, 250/500V	2 to 12
5	Low power factor wattmeter : Single phase, 5/10Amp, 250/500V	2 to 12
6	Wattmeter : Dynamometer type, single phase, 0-750 watts,10Amp, 300-600V	9 to 10
7	Wattmeter: Dynamometer type, single phase, 5Amp, 250V	2 to 12
8	Dimmer: 1-phase,1kva,230V	2 to 12
9	Dimmer: 3-phase, 5kva	9 to 10
10	Three phase Power factor meters: AC, 415V, 50 Hz , 5-10 Amp	9 to 10
11	Load bank: Resistive, 3-phase, 5Kw, 415V	9 to 10
12	Trainer kit for all theorems	13to 16
13	Ammeters PMMC Type: DC, 0-1.5/3Amp, 0-2.5/5 Amp, 0-5/10Amp	13to 16
14	Voltmeter PMMC Type: DC, 0-150/300V, 0-250/500V,0-75/150V	13to 16

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 (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Single Phase A.C series circuits	1a. Calculate impedance of the given A.C series circuit. 1b. Determine the current, voltage in the given A.C series circuit. 1c. Find active power, reactive power, apparent power and power factor of the given A.C series circuit to draw the vector diagram. 1d. Find voltage magnification and Q-factor of the given A.C series circuit for resonance condition. 1e. Describe the procedure to determine active, reactive and apparent power consumed in the given A.C series circuit using, voltmeter, ammeter, wattmeter.	1.1 Generation of alternating voltage, Phasor representation of sinusoidal quantities 1.2 R,L,C circuit elements its voltage and current response 1.3 R-L, R-C, R-L-C combination of A.C series circuit, impedance, reactance, impedance triangle, Power factor, active power, reactive power, apparent power, power triangle and vector diagram 1.4 Resonance, Bandwidth, Quality factor and voltage magnification in series R-L, R-C, R-L-C circuit
Unit– II Single Phase A.C parallel circuits	2a. Find the Impedance for the given A.C parallel circuits 2b. Determine the current, voltage, for the given A.C parallel circuit. 2c. Find the active power, reactive power, apparent power and power factor of the given A.C parallel circuit, with vector diagram. 2d. Apply the principles of resonance to the given A.C parallel circuit and calculate current magnification and Q-factor of the given A.C series circuit. 2e. Describe the procedure to determine active, reactive and apparent power consumed in the given A.C parallel circuit using, voltmeter, ammeter, wattmeter.	2.1 R-L, R-C and R-L-C parallel combination of A.C. circuits. Impedance, reactance, phasor diagram, impedance triangle 2.2 R-L,R-C,R-L-C parallel A.C. circuits power factor, active power, apparent power , reactive power, power triangle 2.3 Resonance in parallel R-L,R-C, R-L-C circuit, Bandwidth, Quality factor and voltage magnification
Unit-III Three phase circuits	3a. Explain the given three phase circuit diagram with justification. 3b. Comment regarding the balance of the given circuit with justification. 3c. Calculate line and phase quantities for given three phase star and delta connection. 3d. Determine the three phase power for the given star and delta connection.	3.1 Phasor and complex representation of three phase supply 3.2 Phase sequence and polarity 3.3 Types of three-phase connections, Phase and line quantities in three phase star and delta system 3.4 Balanced and unbalanced

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	3e. Describe the procedure to determine active, reactive and apparent power consumed in the given three phase circuit using, voltmeter, ammeter, wattmeter.	load, neutral shift in unbalanced load 3.5 Three phase power, active, reactive and apparent power in star and delta system
Unit –IV Network Reduction and principles of DC circuit analysis	4a. Apply source transformation techniques for the given network. 4b. Reduce the given network by applying Star/delta and delta/star delta transformation. 4c. Apply Mesh analysis to solve the given network. 4d. Apply Node analysis to solve the given network. 4e. Describe the procedure to determine the current and voltage in the given branch of the given network applying Mesh and Node analysis.	4.1 Source transformation 4.2 Star/delta and delta/star transformation 4.3 Mesh Analysis 4.4 Node Analysis
Unit-V Network Theorems	5a. Apply superposition theorem to solve the given circuit. 5b. Apply Thevenin's theorem to solve the given circuit. 5c. Apply Norton's theorem to solve the given circuit. 5d. Apply maximum power transfer theorem to solve the given network. 5e. Describe the procedure to solve the given electric circuit by applying network theorems.	5.1 Superposition theorem . 5.2 Thevenin's theorem. 5.3 Norton's theorem 5.4 Maximum power transfer theorem 5.5 Reciprocity theorem 5.6 Duality in electric circuits

***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 QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Single phase A.C series circuits	12	03	05	07	15
II	Single phase A.C parallel circuits	12	03	04	06	13
III	Three phase circuits	10	03	04	06	13
IV	Network Reduction and Principles of circuit analysis	14	03	04	06	13
V	Network Theorems	16	04	04	08	16
Total		**64**	**16**	**21**	**33**	**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:

a. Visit any 33/11kv substation nearby to your house and take the help of sub-station in-charge to know the three phase circuits and occurrences of fault.
b. Write report on accidental power off/shut down problem in hostel/ room/building.
c. Read the safety precautions of various electric equipment in residence and transformer repair shop.
d. Do internet survey and use various meters to test electrical equipment and machines in market.
e. Guide student(s) in undertaking micro-projects.
f. Library / Internet survey of electrical circuits and network
g. Prepare power point presentation or animation for understanding different circuits behavior.
h. Analyse circuit response to diagnose faults in the electric/electronic circuits.
i. Practice Pspice/matlab to analyse circuit response.

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:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'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.
c. 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).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with power system utility and electrical equipements.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various theorems in circuit analysis.
i. Use Pspice/Matlab models to explain different concepts of electric circuit.

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 is given here. Similar micro-projects could be added by the concerned faculty:

a. **Single Phase A.C. series and parallel Circuits:** Prepare series and parallel LED lamp/load(R,L,C) circuit. Measure the response and draw vector diagram. Calculate power factor for the circuit.
b. **Three phase balanced circuits:** Prepare three phase network of balanced load at 230volts and determine phase and line quantities and also calculate active and reactive power for the given load.
   i. Star connection
   ii. Delta connection
c. **Three phase unbalanced circuits:** Prepare three phase network of unbalanced load and determine phase and line quantities and also calculate active and reactive power for the given load.
   i. Star connection
   ii. Delta connection
d. **Principles of circuit analysis and Network theorem:** Prepare power point presentation on source transformation, star delta transformation, mesh and nodal analysis, Network theorems for the given network.
e. Solve the given Electric circuit problems using PSpice/Matlab software.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of Electrical Networks	Gupta, B.R ; Singhal, Vandana	S.Chand and Co., New Delhi, 2005 ISBN : 978-81-219-2318-7
2	Fundamentals of Electrical Engineering	Saxena, S.B lal ; Dasgupta, K.	Cambridge university press pvt. Ltd., New Delhi, 2016, ISBN : 978-11-0746-435-3
3	A Text Book of Electrical Technology Vol-I	Theraja, B. L. ; Theraja, A. K.	S. Chand & Co. Ramnagar, New Delhi, 2012; ISBN : 9788121924405
4	Circuit and network	Sudhakar, A. ; Shyammohan, S.palli	McGraw Hill Education, New Delhi, 2015, ISBN : 978-93-3921-960-4
5	Electric Circuits	Bell, David A.	Oxford University Press New Delhi, 2009; ISBN : 978-01-954-2524-6
6	Schaum online series-Theory & problems of electric circuits	Edminister.	McGraw Hill Education, Newyork, 2013, ISBN: 978-00-701-8999
7	Introductory circuit	Boylested, R.L.	Wheeler, New Delhi , 2013

S. No.	Title of Book	Author	Publication
	Analysis.		ISBN: 978-00-231-3161-5
8	Basic Electrical Engineering	Mittle, V.N. ; Mittle, Arvind	McGraw Hill Education, Noida, 2005 ISBN: 978-00-705-9357-2
9	Electric Circuit Analysis	Sivanandam, S.N.	Vikas publishing house pvt. Ltd, Noida, 2002; ISBN:978-81259-1364-1
10	Circuit theory	Salivahanan, S.; Pravin kumar, S.	Vikas publishing house pvt. Ltd, Noida, 2014; ISBN:978-93259-7418-0

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.cesim.com/simulations
b. www.scilab.org/scilab
c. www.ni.com/multisim
d. www.youtube.com /electric circuits
e. www.dreamtechpress.com /ebooks
f. www.nptelvideos.in/electrical engineering/ circuit theory
g. www.learnerstv.com/free-engineering
h. www.orcad.com/resources/orcad-downloads