GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-II

Course Title: A. C. Circuits
(Course Code: 4320901)

Diploma programmer in which this course is offered	Semester in which offered
Electrical Engineering	Second

1. RATIONALE

Most of electrical power generation, transmission, distribution and utilization are in the form of alternating current. Therefore it is essential for students of diploma electrical engineering to know fundamental concepts and principles of AC circuits to solve electrical circuits. This course is not only a prerequisite to learn the advanced electrical courses but also diploma students undertaking this course are expected to apply the principle of ac circuits to troubleshoot electrical circuits in industries/power system. This is one of the most important core engineering courses for electrical technocrats and hence students should try to develop mastery over fundamental concepts and principle of AC Circuits for effective working as an electrical engineer.

2. COMPETENCY

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

- **Apply the principles of AC circuits to maintain electrical system.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- ***a)*** Interpret various terminologies, waveform and vector representation of alternating quantities.
- ***b)*** Apply principles of A.C. series circuits to solve electrical circuits.
- ***c)*** Apply principles of A.C. parallel circuits to solve electrical circuits.
- ***d)*** Apply principles of three phase circuits to solve electrical circuits.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	1	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be

taken during the semester for the assessing the attainment 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, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Demonstrate waveforms of alternating quantities using CRO and function generator.	I	2
2	Use CRO to measure Peak value, RMS value, Time period and frequency of alternating quantity.	I	2*
3	Measure voltage, current, and power through pure resistor.	II	2
4	Measure inductance and internal resistance of choke coil.	II	2
5	Measure voltage, current, power and power factor in an RL A.C. series circuit.	II	4*
6	Measure voltage, current, power and power factor in an RC A.C. series circuit.	II	2*
7	Measure voltage, current, power and power factor in an RLC A.C. series circuit.	II	4
8	Measure resonance frequency and resonant impedance in RLC series circuit.	II	2
9	Measure voltage, current, power and power factor in an RL A.C. parallel circuit.	III	4*
10	Measure voltage, current, power and power factor in an RC A.C. parallel circuit.	III	2*
11	Measure voltage, current, power and power factor in an RLC A.C. parallel circuit.	III	4
12	Verify line & phase voltage and line & phase current relation for three phase star connection.	IV	2*
13	Verify line & phase voltage and line & phase current relation for three phase delta connection.	IV	2*
14	Test relation between power consumption in three phase star and delta connected load.	IV	2
	Minimum 10 Practical Exercises		28

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*
ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises**of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices.	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	Single phase variac: 10A, Output 0-270V AC for Input of 230V 50Hz AC	3 to 11
2	Single phase choke coil :230V, 50Hz, 2KVAR	4,5,7,9,11
3	Single phase capacitor bank: 230V, 50Hz, 2KVAR	6,7,10,11
4	Three phase variac : 20A, Output 0-415V for Input of 415V 50Hz AC	12 to 14
4	Single phase resistive load bank : 230V, 2KWOR Lamp loads	3 to 11
5.	Three phase lamp loads suitable for making three phase star and delta connection	12, 13
6.	CRO	1,2
7.	Function Generator	1,2
8.	Ammeter:0-1A/0-5A/0-10A	3 to 14
9.	Voltmeter:0-50V/0-150V/0-300V/0-500V	3 to 14

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
10.	Wattmeter:0-1000W(5/10A,300/600V)	3,5,6,7 9,10,11,14

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member(while doing a micro-project)
b) Follow safety practices while using AC supply and electrical equipments.
c) Work as a group member (while performing experiments and taking readings)
d) Practice environmental friendly methods and processes. (Environmentrelated)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit 1 A C Fundamentals	1a.Explain generation of alternating EMF. 1b.Define various terms regarding alternating quantity. 1c.Derive equation for RMS and average value of sinusoidal waveform. 1d.Interpret phase difference between ac quantities with necessary wave-forms 1e.Explain the vector representation and mathematical operations of alternating vector quantities	1.1 Principle of generation of alternating voltage 1.2Cycle, Time period, Frequency, Amplitude, Instantaneous value, Average value, R.M.S. value, Form factor, Peak Factor Phase and Phase difference 1.3 Vector representation of alternating quantities 1.4Addition,subtraction, multiplication and division of alternating quantity 1.5Numerical based on AC fundamentals

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	1f. Solve numerical based on AC fundamentals	
Unit-II Single Phase AC Series Circuits	2a Compare the behavior of AC voltage, current, power and power factor through pure resistance, pure inductance and pure capacitance with waveforms and vector diagrams. 2b.Compare behavior of AC voltage, current, power and power factor through RL, RC and RLC series circuit with waveforms and vector diagrams. 2c.Explain resonance in RLC series circuit with graphical representation 2d.Explain the concept of active power, reactive power and power factor with power triangle 2e.Explain the concept of Lagging, leading and unity power factor with waveform and vector diagram 2f.Explain Causes & disadvantages of low power factor and advantages of improving power factor. 2g. Solve numerical based on single phase AC series and circuits and series resonance.	2.1 Waveform, vector diagram and expression of voltage, current and power in pure: Resistance, Inductance, Capacitance 2.2 AC through RL, RC, RLC series circuits. 2.3 Resonant condition and frequency in RLC series circuit 2.4 Active, reactive and apparent power with examples. 2.5 lagging, leading and unity power factor 2.6 Causes & disadvantages of low power factor and advantages of improvement in power factor 2.7 Numerical based on AC series circuits and series resonance
Unit-III Single Phase AC Parallel Circuits	3a.Decribe various methods of solving AC parallel circuits. 3b.Explain resonance in RLC parallel circuit. 3c.Solve numerical based on single phase AC parallel circuits and parallel resonance	3.1 Phasor (Vector) method for solving AC parallel circuits. 3.2 Admittance method for solving AC parallel circuits. 3.3 Complex algebra method for solving AC parallel circuits. 3.3 Resonant frequency and resonance condition in parallel AC circuits 3.4 Numerical based on AC parallel

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		circuits and parallel resonance.
Unit-IV Three Phase Circuits	4a.Differentiate between single and three phase circuits. 4b.Explain generation of three phase alternating voltage. 4c.Distinguish between line and phase voltage, line and phase currents in 3- phase AC circuits 4d.Describe three phase star and delta connection with phasor diagrams 4e.Solve numerical based on three phase AC circuits	4.1 Comparison between Single and three phase systems 4.2 Principle of generation of three phase alternating voltage. 4.3 Line and phase voltage, line and phase current 4.4 Three-phase star connection 4.5 Three phase delta connection 4.6 Numerical based on three phase circuits

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	A C Fundamentals	12	6	6	6	18
II	Single phase AC Series Circuits	14	8	8	8	24
III	Single phase AC Parallel Circuits	08	4	6	4	14
IV	Three Phase Circuits	08	4	5	5	14
Total		42	22	25	23	70

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

Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly 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 perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Present seminar on various topics from course content
b) Solve numerical given in tutorials.

The tutorials can be given unit wise. The Student should be encouraged to get their tutorial assessed by the concerned teacher progressively during the term and at the end of the term the whole work should be submitted to the concerned teacher.

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) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) Show animation/ video related to course content.
e) Tutorial hours should be used to develop the ability in students to solve numerical related to AC fundamentals and AC circuits.
f) Co-relating the importance of content of this course with other courses/ practical applications. (e.g. importance of a content in course or whole course related to A.C. Machines, Transmission and Distribution of Electrical Power, Energy Conservation Switchgear and Protection etc. and in practical industrial &/ domestic applications.
g) Students learn Engineering Mathematics as a separate course in 2nd Semester and knowledge of some topics /concepts of this course is necessary and extremely helpful to learn various topics of A.C. Circuits. So, students should be encouraged at the beginning of the term and periodically during term by the concerned faculties of A.C. Circuits to learn Engineering Mathematics with more interest and also co-relate the content of AC Circuits with Mathematics and Engineering Mathematics.
h) Introduce E-waste recycling technology among the students.
i) Guide students on how to address issues on environment and sustainability

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-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students 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. This has to match the competency and the COs.Similar micro-projects could be added by the concerned course teacher:

a) Build model to demonstrate generation of alternating EMF.
b) Build model of various types of AC Series circuits.
c) Build model of various types AC Parallel circuits.
d) Build lamp loads in three phase star connection.
e) Build lamp Loads in three phase delta connection.

f) Prepare chart of generation of alternating voltage.
g) Prepare chart for phase difference between alternating quantities
h) Prepare chart of waveforms and vector diagram of voltage, current and power in purely resistive, inductive and capacitive circuits.
i) Prepare chart of graphical representation of series and parallel resonance
j) Prepare chart of waveforms and vector diagram of three phase voltage.
k) Prepare chart for three phase star and delta connection with current and voltage relations.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	A text book of Electrical Technology Volume-I (Basic Electrical Engineering)	B. L. Theraja & A.K. Theraja	S. Chand and Co., New Delhi, 23 edition or Latest edition (ISBN : 9788121924405)
2	Principles of Electrical Engineering	B. R. Gupta	S. K. Kataria & Sons, New Delhi, Latest edition (ISBN-9788121901031)
3	Fundamentals of Electrical Engineering	Tarlok Singh	S. K. Katariav & Sons, New Delhi, Latest edition(ISBN: 9789350140680)
4	Basic Electrical Engineering	K. Uma Rao and A. Jayalakshmi	Pearson Education, New Delhi Latest Edition(ISBN: 9789385909283)
5	Basic Electrical and Electronics Engineering	Ravish. R. Singh	Tata McGraw Hill EducationPvt.Ltd., New Delhi 2018 edition or Latest edition (ISBN-978007026092)
6	Fundamentals of Electrical Engineering and Electronics	S.K. Sahdev	Dhanpatrai & Co., New Delhi Latest edition(ISBN: 978877002027)
7	Principles of Electrical Engineering and Electronics	V.K. Mehta Rohit Mehta	S. Chand and Co., New Delhi (ISBN : 9789352837199)
8	Elements of Electrical Engineering	U.A. Patel	Atul Prakashan, Ahmedabad 2010 edition or latest edition

14. SOFTWARE/LEARNING WEBSITES

WEBSITES

- https://nptel.ac.in/courses/108/105/108105112/
- https://nptel.ac.in/courses/108/105/108105053/
- https://lectures.gtu.ac.in/(related to course content)
- https://circuitglobe.com/

- https://www.*electronics*-tutorials.ws/accircuits
- https://www.electrical4u.com/electrical-engineering-articles/basic-electrical/
- https://www.electricaltechnology.org/
- www.vlab.co.in
- www.khanacademy.org
- https://ndl.iitkgp.ac.

15. PO-COMPETENCY-CO MAPPING:

Semester I	A C Circuits (Course Code:4320901)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO4 Engineerig Tools, Experimen-tation&Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Apply the principles of AC circuits to maintain in electrical system.**						
Course Outcomes CO1 Interpret various terminologies, waveform and vector representation of alternating quantities.	3	3	-	2	-	-	-
CO2 Apply principles of A.C. series circuits to solve electrical circuits.	3	3	2	2	-	-	-
CO3 Apply principles of A.C. parallel circuits to solve electrical circuits	3	3	2	2	-	-	-
CO4 Apply principles of three phase circuits to solve electrical circuits.	3	3	2	2	-	-	-

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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