Chhattisgarh Swami Vivekanand Technical University, Bhilai

Diploma in Electrical Engineering **Semester -V**

A) Course Code : 2024571(024)

B) Course Title : Power Electronics

C) Pre-requisite Course Code and Title : Basic Electronics, Digital Electronics & Electrical Circuit

D) Rationale :

Power electronics is playing a vital role in supply and control of electrical power in several domestic and industrial applications. It is said that eighty percent of all electrical energy will be processed by power electronics by 2030. Professional advantages continue to grow for engineers who understand the fundamental principles and technical requirements of modern power conversion systems. The purpose of using power electronics device is to match the load requirements with the source. Nowadays the conventional relays in power system are replaced with power electronic devices. This course is designed to provide essential theoretical and practical skills to use power electronic devices and circuits for various power electronics applications.

E) Course Outcomes:

CO-1 Select power electronic devices for a given application.

CO-2 Maintain SCR commutation circuit and DC-DC converters.

CO-3 Maintain phase controlled rectifiers.

CO-3 Troubleshoot Inverters and Cyclo-converter circuit.

CO-4 Maintain AC controller, UPS and SMPS used in various domestic and commercial applications.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)				
				L	P	T	SL	Credit L+T+(P/2)
1.	Electrical Engineering	2024571 (024)	Power Electronics	3	-	1	1	4
2.	Electrical Engineering	2024562 (024)	Power Electronics (Lab)	-	2	-		1

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No	Board of Study	Course Code	Course Titles	Scheme of Examinations					
				Theory			Practical (PRA+PDA+Viva)		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Electrical Engineering	2024571 (024)	Power Electronics	70	20	30	-	-	120
2.	Electrical Engineering	2024562 (024)	Power Electronics (Lab)	-	-	-	40	50	90

Legend : PRA : Process Assessment, PDA : Product Assessment

Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical)

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select power electronic devices for a given application.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 1.1 Sketch ISI symbol of various Power electronic devices. SO 1.2 Explain the working principle of SCR, DIAC and TRIAC with the help of characteristic curve. SO 1.3 Explain various triggering methods of SCR. SO 1.4 Choose suitable power electronic device for a given switching application.	LE1.1 Test the performance of a given SCR and Plot the VI characteristics. LE1.2 Test the performance of a given MOSFET and plot the output characteristics. LE1.3 Test the performance of a given IGBT and plot the output characteristic. LE1.4 Test the performance of TRIAC for the given AC loadcontrol. LE1.5 Design the R and RC triggering circuit for triggering SCR.	**Unit 1.0Power electronic devices** 1.1 Silicon Controlled Rectifier (SCR): Construction, principle of operation, characteristic curve, two transistor analogy, Switching characteristics and triggering methods 1.2 Rating and Protection: over voltage, over current, snubber circuit 1.3 Series and parallel operation of SCRs: String efficiency 1.4 DIAC, TRIAC: Construction, Operation, characteristic curves and applications 1.5 Power BJT, MOSFET, IGBT: Construction, Operation, characteristic curves and applications	• Compare the construction of various power electronic devices • List the advantages and disadvantages of various power electronic devices

SW-1 Suggested Sessional Work (SW):

- **Assignments:**
  i. List various applications in our daily life where power electronic devices and circuits are used.
  ii. Collate the ratings of general purpose, fast recovery and Schottky diodes and state their applications. Also prepare a report on this.
- **Mini Project:**
  i. Design a circuit to test whether a given SCR is healthy or unhealthy.
  ii. Measure the latching current and holding current for a given SCR and compare with data sheet values.
  iii. Design a pulse triggering circuit for triggering SCR.
- **Other Activities (Specify):**
  i. Collect information on the rating of commercially available power semiconductor devices and prepare a report on it.
  ii. Design a triggering circuit for triggering a given TRIAC using DIAC.

CO-2 Maintain SCR commutation circuit and DC-DC converters.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 2.1 Explain how the natural commutation technique is used to turn off the SCR. SO 2.2 Explain the operation of the given forced commutation technique. SO 2.3 Explain the working of the given type of DC-DC converter. SO 2.4 Compare the salient features of different converter topology.	LE2.1 Test the performance of a buck converter at different duty cycle for a given resistive load. LE2.2 Test the performance of a buck converter at different duty cycle for a given resistive inductive load. LE2.3 Test the performance of a boost converter at different duty cycle for a given resistive load. LE2.4 Test the performance of a forced commutation circuit (A, B, C, D and E)	**Unit 2.0Commutation Techniques and DC-DC Converters** 2.1 Need for commutation in SCR 2.2 Principle of Natural and Forced commutations (class A, class B, class D and class E) 2.3 Working principle of buck, boost and buck boost converter 2.4 Simple numerical on Converters: duty ratio calculation, output voltage, current, input and output power, efficiency calculation for a buck converter, boost converter	• Compare the operations of natural commutation and forced commutation. • Summarize the applications of DC-DC converter.

SW-2 Suggested Sessional Work (SW):

- Assignments:
  i. Describe the process of commutation in SCR.
  ii. Classify various commutation techniques.

- **Mini Project:**
  i. Build and test a circuit for self commutation of a given SCR and for a given input voltage by estimating the values of commutating components L and C.
  ii. Build and test a control circuit to obtain constant and variable frequency output in a DC-DC converter.
  iii. Simulate a DC-DC step down converter feeding a motor load and observe the output voltage for different duty cycles.

- **Other Activities (Specify):**
  i. Collate information on various types of DC-DC converters available for solar power applications and prepare a report.
  ii. Prepare a chart to describe the working of a charge controller circuit.

CO-3 Maintain phase controlled rectifiers.

(Approx. Hrs: CI+ LI+SW+SL=14)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Determine the average output voltage for a single-phase half	LE3.1 Build and test a triggering circuit for a single phase full wave controlled	**Unit 3.0Phase Controlled Rectifier** 3.1 Single phase half wave controlled rectifier	• Explain the importance of various performance

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
wave controlled rectifier for a given load. SO3.2 Explain the working principle of full converter for a given load, with and without freewheel diode. SO3.3 Justify the need of freewheeling diode in converter. SO3.4 Describe the working of three phase half wave controlled converter with a neat sketch for a given load.	rectifier using SCR. LE3.2 Test the performance of a half wave controlled rectifier comprising of SCR for R load. LE3.3 Test the performance of a half wave controlled rectifier comprising of SCR for RL load. LE3.4 Test and analyze the performance of a half wave controlled rectifier comprising of SCR for RL load with freewheeling diode. LE3.5 Test the performance of a full wave controlled rectifier comprising of SCR for RL load and calculate the Ripple factor.	with R, RL and RLE load 3.2 Single phase full wave controlled rectifier (M-2 &B-2 connection) with R, RL and RLE load 3.3 Effect of free-wheel diode in single phase full converter 3.4 Effect of source inductance on converter performance 3.5 Three-phase half wave-controlled rectifier with R and RL load	parameters of controlled rectifier • Explain input supply power factor of a single phase full wave uncontrolled and controlled bridge rectifier circuit.

SW-3 Suggested Sessional Work (SW):

- **Assignments:**
  i. Prepare a report on the effect of freewheeling diode on the ac power input and switching device rating for a single phase half wave controlled rectifier feeding RL load.
  ii. Determine the average output voltage of a single phase full wave rectifier when one of the switching devices in any one leg gets open circuited during its operation.
  iii. Prepare a report on the effect of triggering angle on the output load current for a three phase half wave controlled rectifier feeding an R load.

- **Mini Project:**
  - Build and test a triggering circuit for a single phase full controlled rectifier using given SCR's with midpoint configuration and prepare a report on it.
  - Compare the output waveform of a single phase full wave controlled rectifier feeding a load with input AC current waveform and prepare a report on it.
  - Using any Simulation tool, analyze the load voltage and current of a half wave controlled and full wave controlled rectifier feeding a resistive inductive load.

- **Other Activities (Specify):**
  i. Compare the performance of a single phase full wave rectifier feeding a RL load with and without freewheeling diode with respect to input power factor and the active power drawn by the load and prepare a report on it.

CO-4 Troubleshoot Inverters and Cyclo-converter circuit.

(Approx. Hrs: CI+ LI+SW+SL=14)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Explain the working principle of inverter SO4.2 Classify inverter SO4.3 Describe the PWM techniques and their applications SO4.4 Explain the working principle of Cyclo-converter SO4.5 Compare the salient features of various cyclo-converter topologies	LE4.1 Test the performance of a single-phase half bridge VSI feeding R load. LE4.2 Test the performance of a single phase full bridge VSI feeding RL load. LE4.3 Measure the input to output frequency of a single phase to single phase step down cyclo-converter. LE4.4 Measure the input to output frequency of a single phase to single phase step up cyclo-converter.	**Unit 4.0Inverter and Cycloconverter** 4.1 Inverter: Working principle, types-Voltage Source Inverter, Current Source Inverter. 4.2 PWM Inverters: single phase Half bridge and full bridge with R and RL load 4.3 PWM techniques: single pulse, multi-pulse and SPWM (Uni-polar and bi-polar switching) 4.4 Concept of three phase VSI 4.5 Single phase Cyclo-converter: working principle of Midpoint and bridge Configuration with R load 4.6 Step up and step down single phase Cyclo-converter and its applications	• Differentiate between inverter and converter circuit comprising of thyristor. • Compare the rating of a converter and inverter grade thyristor.

SW-4 Suggested Sessional Work (SW):

- **Assignments:**
  i. List the applications and the merits and demerits of a VSI and CSI
  ii. Explain the effect on device ratings with uni-polar and bipolar switching PWM techniques for inverters.

- **Mini Project:**
  - Build and test inverter circuit for emergency lighting.
  - Test the performance parameters of a given inverter system using harmonic analyzer or power analyzer.

- **Other Activities (Specify):**
  i. Investigate the effect of nonlinear loads on the supply system of your institution and prepare a report on it.
  ii. Simulate a Single phase full bridge inverter circuit using unipolar and bipolar pulse width modulation techniques

CO-5 Maintain AC controller, UPS and SMPS used in various domestic and commercial applications.

(Approx. Hrs: CI+ LI+SW+SL=16)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Explain the working principle of On-Off control of AC voltage controllers SO5.2 Explain the working principle of phase angle control of AC voltage controllers SO5.3 Explain the working of off-line and online UPS. SO5.4 Explain the working of SMPS	LE5.1 Measure the output load voltage of a single phase AC voltage controller using On-off control LE5.2 Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive load. LE5.3 Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive inductive load.	**Unit 5.0AC Voltage Controller, UPS AND SMPS** 5.1 Single phase AC voltage controller: Working principle and its applications 5.2 Significance of UPS, Block diagram of UPS, function of each block, types: ON-line & Off-line UPS. 5.3 SMPS: Block diagram, principle of operation, advantages and disadvantages and applications of SMPS.	• List the various commercial applications of AC voltage controllers. • List the various devices and components used in a home UPS system. • Compare on line and off line UPS.

Legend:CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-5 Suggested Sessional Work (SW):

- **Assignments:**
  i. Compare the specification of online UPS system from major manufacturers for a given load requirement.
  ii. Describe the working of the offline UPS system with the help of a block diagram.
  iii. List the types of storage batteries used in UPS and the advantages and disadvantages for each type.

- **Mini Project:**
  - Build and test a light dimmer circuit.
  - Build and test a circuit used for a commercial ceiling fan voltage regulator.

- **Other Activities (Specify):**
  i. List the type of disturbances in a commercial AC supply.
  ii. Demonstrate the maintenance steps involved for a UPS system.

I) Suggested Specification Table (For ESA of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Power electronic devices	4	6	5	15
II	Commutation Techniques and DC-DC Converters	4	4	2	10
III	Phase Controlled Rectifier	4	6	5	15
IV	Inverter and Cyclo-converter	3	8	4	15
V	AC Voltage Controller, UPS and SMPS	3	8	4	15
Total		**18**	**32**	**20**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESA of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Test the performance of a given SCR and Plot the VI characteristics.	50	40	10
LE1.2	Test the performance of a given MOSFET and plot the output characteristics.	50	40	10
LE1.3	Test the performance of a given IGBT and plot the output characteristic.	50	40	10
LE1.4	Test the performance of TRIAC for the given AC loadcontrol.	50	40	10
LE1.5	Design the R and RC triggering circuit for triggering SCR.	50	40	10
LE2.1	Test the performance of a buck converter at different duty cycle for a given resistive load.	50	40	10
LE2.2	Test the performance of a buck converter at different duty cycle for a given resistive inductive load.	50	40	10
LE2.3	Test the performance of a boost converter at different duty cycle for a given resistive load.	50	40	10
LE2.4	Test the performance of a forced commutation circuit (A, B, C, D and E)	50	40	10
LE3.1	Build and test a triggering circuit for a single phase full wave controlled rectifier using SCR.	50	40	10
LE3.2	Test the performance of a half wave controlled rectifier comprising of SCR for R load.	50	40	10
LE3.3	Test the performance of a half wave controlled rectifier comprising of SCR for RL load.	50	40	10
LE3.4	Test and analyze the performance of a half wave controlled rectifier comprising of SCR for RL load with freewheeling diode.	50	40	10
LE3.5	Test the performance of a full wave controlled rectifier comprising of SCR for RL load and calculate the ripple factor.	50	40	10
LE4.1	Test the performance of a single phase half bridge VSI feeding R load.	50	40	10
LE4.2	Test the performance of a single phase full bridge VSI feeding RL load.	50	40	10

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE4.3	Measure the input to output frequency of a single phase to single phase step down cyclo-converter.	50	40	10
LE4.4	Measure the input to output frequency of a single phase to single phase step up cyclo-converter.	50	40	10
LE5.1	Measure the output load voltage of a single phase AC voltage controller using On-off control.	50	40	10
LE5.2	Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive load.	50	40	10
LE5.3	Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive inductive load.	50	40	10

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Industrial visits
4. Industrial Training
5. Field Trips
6. Demonstration
7. ICT Based Teaching Learning (Video Demonstration, Mobile)

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Power Electronics	Bimbhra, P. S.	Khanna Publication	5th Edition, 2012 ISBN: 978-8174092793
2.	Fundamentals of Power Electronics	Bhattacharya, S. K.	Vikas publishing House	1st Edition,2009 ISBN: 978-8125918530
3.	Power Electronics	Chitode, J.S.	Technical Publications	1st edition, May 2008 ISBN: 978-8184314182
4.	Power Electronics	Gupta, B.R. ; Singhal V.	Katson Books	6th Edition, 2010 ISBN: 978-8185749532
5.	Power Electronics	Singh, M.D.; Khanchandani, K.B.	McGraw Hill Education	2nd edition, 2017 978-0070583894
6.	*Power Electronics* Circuits Devices and Applications	*Rashid,* Muhammad H.	Pearson Education India	4th edition, ISBN: 978-8 131702468

(b) Open source software and website address:

1. Power electronics:http://nptel.ac.in/syllabus/108101038/
2. SCR: https://www.youtube.com/watch?v=CFonDZVRdAc
3. Cyclo-Converter: https://www.youtube.com/watch?v=FwtDWgKQaA4
4. Video lecturer: http://freevideolectures.com/Course/2351/Power-Electronics
5. http://en.wikipedia.org/wiki/Power_electronics.
6. https://www.tutorialspoint.com/power_electronics/index.htm
7. Online Magazine:http://www.powerelectronics.com/
8. Python Power electronics simulation software

(c) Others:

1. Learning Packages
2. Lab Manuals
3. Manufacturers' Manual

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Components/ Equipment	Broad Specifications	Relevant Experiment Number
1.	Transformer (1-phase)	230V/24V	LE3.1-LE3.5
2.	Transformer (1-phase)	Primary: 30V-25V-0-25V–30V, Secondary: 0-30V/2Amps.	LE3.1-LE3.5
3.	Power switches		
4.	SCR	12A,600V, Type TY616	LE1.1,
5.	Power diode	10 Amp,600V	LE 1.1-LE 1.4
6.	MOSFET	V_{DS} 650V, 35 Amp, Type SPW35N60C3	LE1.2
7.	IGBT	V_{CE} 600V, 33 amp, Type IRGP50B60PD	LE1.3
8.	Triac	BT136, 10A,600V	LE3.1, LE5.3
9.	Diac	DB32, Rated current: 2 A, Power: 0.15 W	LE3.1
10.	Passive components	Inductors, resistors, voltage and current sources, capacitors, and transformers	
11.	Resistor	I K ohm to 10 K ohm, 1 Watt	ALL
12.	Inductor	300milli H,2A,	LE2.2,LE3.3-LE3.5,LE4.2,LE5.3
13.	Variable inductor	10mH – 5mH – 0 – 5mH – 10mH/2 Amps	ALL
14.	Capacitors	6.8 micro Farad, 10 micro Farad, 100V	LE1.5
15.	Potentiometer	100K ohm	ALL
16.	Incandescent lamp	60 Watt	
17.	Digital multi-meter	4 1/2 digit, 19999 count TRMS	ALL
18.	True RMS multi-meter	1.0% + 3 (DC, 45 Hz to 500 Hz) 2.0% + 3 (500 Hz to 1 kHz)	ALL
19.	Digital CRO with two input isolated channel	30 MHZ Dual Trace	LE1.1-LE1.4 LE2.1-LE2.5 LE3.1-LE3.5 LE4.1-LE4.4 LE5.1-LE5.3
20.	Bread board	Cu thin film base	ALL

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Select power electronic devices for a given application.	3	3	3	3	1	1	3	3	2	3	3	3
CO-2 Maintain SCR commutation circuit and DC-DC converters.	2	3	3	3	1	1	3	3	2	3	3	3
CO-3 Maintain phase controlled rectifiers.	3	3	3	3	1	1	3	3	2	3	3	3
CO-4 Troubleshoot Inverters and Cyclo-converter circuit.	3	3	3	3	1	1	3	3	2	3	3	3
CO-5 Maintain AC controller, UPS and SMPS used in various domestic and commercial applications.	3	3	3	3	1	1	3	3	2	3	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-1 Select power electronic devices for a given application.	SO1.1 SO1.2 SO1.3 SO1.4	LE1.1, LE1.2 LE1.3, LE1.4 LE1.5	Unit 1.0 Power electronic devices 1.1, 1.2, 1.3, 1.4,1.5	As mentioned
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-2 Maintain SCR commutation circuit and DC-DC converters**.**	SO2.1 SO2.2 SO2.3 SO2.4	LE2.1, LE2.2 LE2.3, LE2.4	Unit 2.0 Commutation Techniques And DC-DC Converters 2.1,2.2,2.3,2.4	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-3 Maintain phase controlled rectifiers.	SO3.1 SO3.2 SO3.3 SO3.4	LE3.1, LE3.2 LE3.3, LE3.4 LE3.5	Unit 3.0 Phase Controlled Rectifier 3.1,3.2,3.3,3.4,3.5	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-4 Troubleshoot Inverters and Cyclo-converter circuit.	SO4.1, SO4.2 SO4.3, SO4.4 SO4.5	LE4.1, LE4.2 LE4.3, LE4.4	Unit 4.0 Inverter and Cyclo-converter 4.1,4.2,4.3,4.4,4.5 4.6	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-5 Maintain AC controller, UPS and SMPS used in various domestic and commercial applications.	SO5.1 SO5.2 SO5.3 SO5.4	LE5.1, LE5.2 LE5.3	Unit 5.0 AC voltage controller, UPS and SMPS 5.1, 5.2, 5.3	

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A) Course Code : 2024572(024)

B) Course Title : Power System Operation and Protection

C) Pre-requisite Course Code and Title : AC rotating Machines, Electrical Power Generation Transmission and Distribution

D) Rationale :

Electrical and Electrical & Electronics engineering diploma holders are expected be aware of power system components, power system stability andeconomic loaddispatch, active & reactive power control mechanisms and power system protection including automatic protective scheme comprising ofcircuit breakersandprotectiverelays.Itisessentialthatthediplomapassoutstudentsshoulddevelopskillsof operating various controls and switchgear in power system. They are also required to carryout remedial measures for faults in equipment in power system using appropriate diagnostic instrument/devices. This course attempts to develop these skillsin students and hence it is a core course for all electrical engineers.

E) Course Outcomes:

CO-1 Represent the power system components in p.u. system.

CO-2 Implement methods to regulate the power system stability.

CO-3 Apply various strategies for active and reactive power control.

CO-4 Identify elements of protection and circuit interrupting devices.

CO-5 Select suitable protective relays, circuit breakers for protection of alternators, transformers and motors.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)				
				L	P	T	SL	Credit L+T+(P/2)
1.	Electrical Engineering	2024572 (024)	Power System Operation and Protection	3	-	1	1	4
2.	Electrical Engineering	2024563 (024)	Power System Operation and Protection (Lab)	-	2	-	-	1

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning, C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

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				Theory			Practical (PRA+ PDA+ Viva)		
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Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI) Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Represent the power system components in PU system.

(Approx.Hrs:CI+ LI+SW+SL=10)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Represent an interconnected synchronous generator with sending end and receiving end transformers and end loads using single line diagram. SO1.2 Represent a given three phase balanced system by single phase equivalent network. SO1.3 Calculate the p.u. values of a power system parameter.	LE1.1 Determine per unit impedance of a given three phase system (Synchronous Machine) installed in your lab. LE1.2 Prepare the Single line diagram of your institute power supply system and mention the power system parameters in p.u. values LE1.3 Develop a simple programme to calculate the p.u. values of a given power system using MATLAB software.	**Unit-1.0 Representation of Power System** 1.1 Single line representation of a simple power system with standard symbols. 1.2 Single Phase representation of balanced three phase networks 1.3 Per unit (PU system) : Introduction, representation, change of base and simple numerical. 1.4 Complex power flow, Concept of torque or Load angle (δ) and Power factor angle (θ) 1.5 Simplified representation of Synchronous Machines 1.6 Power angle curve of a synchronous generator	• Interpret schematic single line diagram of a substation using standard symbols with p.u. values.

SW-1 Suggested Sessional Work (SW):

- **Assignments:**
  i. Sketch a single line diagram for a typical power system containing different components using standard symbols.
- **Mini Project:**
  i. Draw a schematic single line diagram of a 11/132/220 KV nearby substation using standard symbols (after visit).
- **Other Activities (Specify):**
  i. Seminar on representation of power system.
  ii. Arrange expert lecture by some engineers working at load dispatch centers/Power transmission companies.

CO-2 Implement methods to regulate the power system stability.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Differentiate symmetrical and unsymmetrical faults in Transmission lines. SO2.2 Analyze the transients under no load and load conditions of a synchronous machine. SO2.3 Explain the concept of symmetrical components. SO2.4 Explain the concept of positive sequence, Negative sequence and zero sequence components. SO2.5 Explain the concept of sequence impedance. SO2.6 Draw the sequence networks. SO2.7 Analyze the unsymmetrical faults (LG, LL & LLG) SO2.8 Explain the effect of load disturbance on alternator	LE2.1 Simulate 3 phase balanced system fault and unsymmetrical faults LE2.2 Demonstrate fault study with single line and double line in 3 phase system. LE2.3 Demonstrate the LLL, LLLG and LG, LL, LLG Faults LE2.4 Verify the theoretical calculations of the given power system faults and compare with practical results.	**Unit-2.0 Power System faults and Stability** 2.1 Symmetrical Faults: Definition of transients in a transmission lines, Sub-transient, transient and steady state period; reactance offered, LLL and LLLG faults 2.2 Definition: Short Circuit Capacity (SCC) of a bus, Simple Numerical 2.3 Unsymmetrical faults : LG, LL, LLG faults and their effects 2.4 Stability: Introduction, Steady state and transients stability, Stability limit 2.5 Steady State stability: static and dynamic stability 2.6 Transient stability : swing curve, Introduction to equal area criteria of stability and its applications 2.7 Methods of improving stability	• Simulation on available open source power system software. • Concepts of j & an operator. • Power and Torque Angle Curve of a Synchronous Machine • Turbine Speed Governing

SW-2 Suggested Sessional Work (SW):

- **Assignments:**
  i. Name and Sketch circuit diagram for various possible faults and explain in brief their results.
  ii. Illustrate any one example of grid failure due to power system stability.

- **Mini Project:**
  i. Prepare a report on generally occurring faults and stability problem in case of one alternator connected to infinite bus bar.

- **Other Activities (Specify):**
  i. Arrangevisit to a State Load Dispatch Centre

CO-3 Apply various strategies for active and reactive power control.

(Approx. Hrs: CI+ LI+SW+SL=16)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.2 Apply concept of real and reactive power transfer in transmission lines SO3.3 Explain the need to control transmission line voltages SO3.4 Distinguish the applicationof Series, shunt,series-shunt FACTcontrollers with its strengths and limitations.	LE3.1 Simulate real and reactive power control methods using AGC of long distance transmission line (using 'Power World' simulator (open source)). LE3.2 Simulate real and reactive power control methods using Synchronous machine Excitation Control of long distance transmission line. (Using 'Power World' simulator (open source)).	**Unit-3.0 Active and Reactive power control** 3.1 Introduction to active and reactive power in power system and their sources. Requirement of reactive power in power system. 3.2 Effect of DC excitation on lagging and leading operation of a synchronous machine, V curve of a synchronous machine. 3.3 Voltage control in power system: shunt reactor, synchronous phase modifier, shunt capacitors, series capacitors, static VAR system and related circuit diagram.	• Complex power • Energy storing elements • FACT controllers and its uses. • Standard capacitor banks specifications by any manufacturer • Deregulated power supply and ancillary services in electrical power supply

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-3 Suggested Sessional Work (SW):

- **Assignments:**
  i. Calculate the KVAR rating of a capacitor bank to improve p.f. of a given squirrel cage induction motor (say 10 HP) running at a lower power factor (say at 0.8) to a high power factor (say 0.9).
- **Mini Project:**
  - Prepare a report for Power consumption of a typical industry regarding installed capacity, units consumed and KVAR supplied etc. and analyze the effect of KVAR on units consumed and related electricity bill.
- **Other Activities (Specify):**
  i. Visit of a nearby local Supply system and also visit of any Ancillary Services Unit.

CO-4 Identify elements of protection and circuit interrupting devices.

(Approx. Hrs: CI+ LI+SW+SL=16)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Describe the functions of basic elements of a protective system.	LE4.1 Determine the fusing factor of a given fusing material.	**Unit-4.0 Elements of Protection and Circuit Interrupting Devices** 4.1 Basic elements of a	• Collection of data for various circuit breakers, from

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.2 Differentiate various types of faults and abnormalities occurring in a power system. SO4.3 Explain the use of CT and PT in protection system. SO4.4 Describe the working of current limiting reactors and their arrangements SO4.5 Select appropriate method of neutral Earthing for the given situation. SO4.6 Describe protective system showing different circuit interrupting devices using a line diagram. SO4.7 Explain the sequence of operation of an interlocking of interrupting devices. SO4.8 Distinguish the characteristics of fuse and circuit breakers. SO4.9 Explain arc formation and zero current interruption. SO4.10 Compare arc quenching in A.C. and D.C. circuit breaker. SO4.11 Explain the resistance switching for the given situation.	LE4.2 Identify various switchgear equipment available in the lab and write its specification and symbols. LE4.3 Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay.	protective system. 4.2 Types, causes and effects of various Faults. 4.3 Protection zones : Backup protection zones 4.4 CT and PT: Specifications and Connection diagram (single phase and 3 phase) 4.5 Current limiting reactors. 4.6 Neutral Earthing 4.7 Interrupting devices: Sequence of operation and interlocking 4.8 Isolators and Fuses: types, features, testing and applications 4.9 Construction, working and testing of circuit breakers: Air break, Air Blast, Sulphur Hexa Fluoride (SF6), vacuum and oil circuit breakers 4.10 Auto-reclosure, Arc phenomena and extinction 4.11 Resistance switching 4.12 Working principle of arc quenching in HVDC circuit breaker	Manufactures/ users or from their websites (such as SEIMENS, BHEL, GE,L&T, Crompton, Power Grid Corporation etc.)

SW-4 Suggested Sessional Work (SW):

- **Assignments:**

i. List different types of circuit breakers and collect literature from Manufactures/users and their websites (such as SEIMENS, BHEL, GE, L&T, Crompton, Power Grid Corporation etc.)

- **Mini Project:**
  i. Prepare a report on various Protecting devices used in a nearby substation.

- **Other Activities (Specify):**
  i. Visit of a nearby substation and observe the protective devices used.

CO-5 Select suitable protective relays, circuit breakers for protection of alternators, transformers and motors.

(Approx. Hrs: CI+ LI+SW+SL=16)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Describe need for different types of relays. SO5.2 Explain the terms related to relays. SO5.3 Explain the concept of over current and directional relays. SO5.4 Explain setting of relays. SO5.5 Carryout testing of given relays SO5.6 Explain the faults and abnormalities in alternator. SO5.7 Explain various faults occurring in motor and their protection schemes. SO5.8 Explain Differential protection of Bus bars. SO5.9 Explain various protection schemes for transformer. SO5.10 Describe the inrush current phenomenon in transformer SO5.11 Explain the protection offered by Buchholz Relay.	LE5.1 Identify parts of various circuit breakers and their specification. LE5.2 Dismantle a Vacuum circuit breaker. LE5.3 Identify the various components of SF6 circuit breaker. LE5.4 Test overload relay and plot Time-Current characteristic. LE5.5 Use Buchholz relay for transformer protection. LE5.6 Test thermal overload relay for protection of motor and set the relay properly. LE5.7 Test static relay for the protection of motor LE5.8 Interpret the protection scheme for an alternator in power station (from Blue print and visit). LE5.9 Interpret different protective scheme for transformer.	**Unit-5.0 Protective Relays and Circuit Breaker** 5.1 Protective relay: Principle of working, construction and operation of electromagnetic induction (shaded pole, watt-hour meter and induction cup), Settings 5.2 Relay Types: Thermal relay, Directional relay, Distance relay (impedance, reactance and mho), Negative phase sequence relay, Static relay, Microprocessor based relay: Principle and working of 5.3 Maintenance and testing of relays 5.4 Various faults and abnormal operating conditions in Alternator and its protection schemes 5.5 Various faults and abnormal occurring in the Motor and its protection schemes 5.6 Differential Protection of Bus bars	• Prepare a report on the application of MCB, MCCB, ELCB and ACB as protective device in typical distribution system. • Interpret various protective scheme used for transmission lines and feeders (from Blue print and visit).

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.12 Describe the protection scheme for transmission line. SO5.13 Explain working of Impedance relay. SO5.14 Explain need of carrier aided protection. SO5.15 Explain protection of given feeders and ring mains and Bus bar.		5.7 Over current, Percentage differential and restricted earth fault protection of Transformers 5.8 Inrush phenomenon and over fluxing phenomenon in Transformer 5.9 Buchholz Relay, analysis of trapped gases 5.10 Transmission line protection scheme 5.11 Protection scheme -Overload protection, Over-current and earth fault protection, Time graded and current graded protection, Current balance differential protection 5.12 Carrier aided protection, Carrier inter-tripping, acceleration and blocking scheme 5.13 Distance /Impedance protection**,** Auto reclosing 5.14 Protection of parallel feeders and Ring Mains	

SW-5 Suggested Sessional Work (SW):

- **Assignments:**
  i. Interpret the protection scheme for an alternator in power station (from Blue print and visit).

- **Mini Project:**
  i. Draw schematic diagram of protective schemes for 66 KV/ 132 KV/220 KV Substation nearby area. (after visit)

- **Other Activities (Specify):**
  i. Visit of a nearby Motor Control Centre and observe the various protective relays used.

I) Suggested Specification Table (For ESA of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Power System Components	4	4	2	10
II	Power System Faults and Stability	5	5	4	14
III	Strategies for Active and Reactive Power Control	4	6	4	14
IV	Elements of Protection and Circuit Interrupting Devices	5	5	6	16
V	Protective Relays, Circuit Breakers and Protection of Alternators, Transformers and Motors	4	6	6	16
Total		**22**	**26**	**22**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESA of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Determine per unit impedance of a given three phase system (Synchronous Machine) installed in your lab.	50	40	10
LE1.2	Prepare the Single line diagram of your institute power supply system and mention the power system parameters in p.u. values	50	40	10
LE1.3	Develop a simple programme to calculate the p.u. values of a given power system using MATLAB software.	50	40	10
LE2.1	Simulate 3 phase balanced system fault and unsymmetrical faults.	50	40	10
LE2.2	Demonstrate fault study with single line and double line in 3 phase system.	50	40	10
LE2.3	Demonstrate the LLL, LLLG and LG, LL, LLG faults.	50	40	10
LE2.4	Verify the theoretical calculations of power system faults and compare with practical results.	50	40	10
LE3.1	Simulate real and reactive power control methods using AGC of long distance transmission line (using 'Power World' simulator (open source)).	50	40	10
LE3.2	Simulate real and reactive power control methods using Synchronous machine Excitation Control of long distance transmission line. (Using 'Power World' simulator (open source)).	50	40	10
LE4.1	Determine the fusing factor of a given fusing material.	50	40	10
LE4.2	Identify various switchgear equipment available in the lab and write their specification and symbols.	50	40	10
LE4.3	Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay.	50	40	10
LE5.1	Identify parts of various circuit breakers and their specification.	50	40	10
LE5.2	Dismantle a Vacuum circuit breaker.	50	40	10
LE5.3	Identify the various components of SF6 circuit breaker.	50	40	10
LE5.4	Test overload relay and plot Time-Current characteristic.	50	40	10
LE5.5	Use Buchholz relay for transformer protection.	50	40	10
LE5.6	Test thermal overload relay for protection of motor and set the relay properly.	50	40	10

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE5.7	Test static relay for the protection of motor.	50	40	10
LE5.8	Interpret the protection scheme for an alternator in power station (from Blue print and visit).	50	40	10
LE5.9	Interpret different protective scheme for transformer.	50	40	10

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Demonstration
10. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
11. Brainstorming

L) Suggested Learning Resources:

(b) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1	Electrical Power Systems	Ashfaq Hussain	CBS Publishers & Distributors	Latest Edition ISBN 10:8123914482, ISBN 13: 9788123914480
2	Electrical Power System	Wadhwa C. L.	New Age Int. Pub. New Delhi	Latest Edition ISBN 10: 8122403026, ISBN 13: 9788122403022
3	Power System Protection and Switchgear	Ram B. and Vishwakarma D.N.	TMH, New Delhi, Latest edition	Latest Edition ISBN 10:007107774X ISBN 13:9780071077743
4	Generation and Economic considerations	Gupta J. B.	S.K. Kataria & Sons	Latest Edition ISBN: 9789350142752, 9350142759
5	Transmission and Distribution of Electrical Power	Gupta J. B.	S.K. Kataria & Sons	Latest Edition ISBN: 9789350143629, 9350143623
6	Electrical Power-I	Tarlok Singh	S.K. Kataria & Sons	Latest Edition ISBN-10: 9350143984 ISBN-13: 978-9350143988
7	Principles of Power System	Mehta V K Rohit Mehta	S.Chand Publishing	Latest Edition ISBN: 9788121924962,

				8121924960
8	A course in power systems	Gupta J. B.	S.K. Kataria & Sons	Latest Edition ISBN 10: 9350143739, ISBN13:9789350143735
9	Switchgear and Protection	Rao S.S.	Khanna Publications, New Delhi, Latest Edition	Latest Edition ISBN: 9788174092328, 8174092323
10	Fundamentals of Power System Protection	Paithankar Y.G. and Bhide S.R	PHI Learning, New Delhi, Latest Edition	Latest Edition ISBN-10: 8120341236 ISBN-13: 978-8120341234

(b) Open source software and website address:

1. www.nptel.iitm.ac.in
2. http://electrical-engineering-portal.com/download-center/electrical-software
3. http://electrical-engineering-portal.com/testing-commissioning-current-transformer#2
4. www.electricalnotes.wordpress.com
5. www.electricaleasy.com
6. www.electrical-engineering-portal.com
7. Representation of Power system
   https://www.youtube.com/watch?v=nqKpyip_23Y
8. Power system faults and stability
9. https://www.youtube.com/watch?v=dV9cppI-Prs
10. Strategies for Active and Reactive Power Control
    https://www.youtube.com/watch?v=9ZVu5nYpyrU
11. Elements of Protection and Circuit Interrupting Devices
12. https://www.youtube.com/watch?v=ggAR6...
    https://www.youtube.com/watch?v=5SIk1Mm_pjo
13. Protective Relays, Circuit Breakers and Protection of Alternators, Transformers and Motors
    https://www.youtube.com/watch?v=LAiBuu_nICI

(c) Others:

4. Learning Packages
5. Lab Manuals
6. Manufacturers' Manual
7. Users' Guide

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1.	Numerical relay panel with all protection	Time-Over current protection (definite-time/inverse-time/user- def.) , Sensitive earth-fault detection, Inrush restraint, Motor protection(Undercurrent monitoring, Starting time supervision, Locked rotor, Overload protection, Temperature monitoring, Load jam protection	
2.	Static earth fault relay	Ratings:5 A , 50 Hz, VA rating:3 VAtypical Setting ranges : Low-set: 0.1 A to 5.0	LE5.7

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		High-set : 0.1 A to 50 A	
3.	Vacuum Circuit Breaker with operation simulation panel	VCB along with variable earth leakage relay, Over voltage / under voltage relay, loading facility, over / under frequency relay, overload relay, to operate under various abnormal conditions.	LE5.2
4.	SF6 circuit breakerwith operation simulation panel		LE5.3
5.	Panel for Biased Differential protection of Transformer	Test setup is equipped with single-phase type staticrelay connected with single- phase auto transformer, provides facility to vary current using a variac and rheostats	LE5.9
6.	Current Transformer (Metering	LT Current transformers for metering -ring or windowtype 1. Class of Accuracy :0.5 2. Rated burden:5.00VA 3. Power frequency withstand voltage: 3kv 4. Highest system voltage:433 V 5. Nominal system voltage: 400V Frequency 50Hz supply system 3 ph. solidly grounded neutral system Transformation ratio specified from the following standard ratings as per requirement : **Ratio:**50/5;150/5;300/5;400/5; 1000/5	
7.	Current Transformer (protection)	System voltage:11 kV Insulation level voltage (ILV) : 12/28/75 kV Ratio: 200/1 - 1 - 0.577 A Core 1: 1A, metering, 15 VA/ class 1, ISF<10 Core 2: 1 A, protection, 15 VA/5P10 Core 3: 0.577 A, Class PS, KPV>= 150 V, magnetizing current at Vk/2 <=30 mA, RCT at 75 C<=2 ohms Short time rating:20 kA for 1 second	LE4.3
8.	Potential Transformer	Typical specification for a 11 kV Potential Transformer: System voltage: 11 kV Insulation level voltage (ILV) : 12 /28/75 kV Number of phases: Three Vector Group: Star / Star Ratio: 11 kV/ 110 V Burden: 100 VA Accuracy: Class 0.5 Voltage Factor: 1.2 continuous and 1.5 for 30 seconds With provision for fuse	LE4.3
9.	Buchholz Relay	Buchholz Relay set up consisting of following: - Digital AC Ammeter and Voltmeter -Gas actuated Buchholz Relay -Gas compressor for Relay -Duly wired built in control and protection unit -Built in power on indicator trip status indicator	LE5.5

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		-Terminals for all the relay and necessary patch chords	
10.	Power world simulator	open source	LE3.1, LE3.2
11.	Generator protection trainer kit	Generator protection trainer for the following: Protection against -over current ➢ Under and over voltage ➢ Over and under frequency ➢ earth fault using rotor earth fault relay ➢ negative sequence using negative sequence relay ➢ wrong synchronization using synchronization relay ➢ reverse power using reverse power relay	LE5.8
12.	Transformer fault simulator along with panel meters and motor-generator set (Advance level)	Transformer fault simulator to perform the following tests: Plot the characteristics of % bias differential relay Pick test for differential relay Transformer protection using differential relay for in-zone trip faults Transformer protection using differential relay for out-zone or non-trip faults	
13.	3 phase fault analyzer kit along with meters and motor-generator set (Advance level)	3 phase fault analyzer for short, medium and long transmission line for L-G,LL and LL-Gfaults	LE2.1,LE2.2, LE2.3, LE2.4
14.	MATLAB SIMULINK software Latest version	Sim Power Systems	LE1.3
15.	Over Load Relay		LE5.4
16.	Thermal Overload Relay		LE5.6

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Represent the power system components in p.u. system.	2	3	3	3	1	1	2	3	2	3	3	3
CO-2 Implement methods to regulate the power system stability.	2	3	3	3	1	1	2	3	2	3	3	3
CO-3 Apply various strategies for active and reactive power control.	3	3	3	3	1	1	3	3	2	3	3	3
CO-4 Identify elements of protection and circuit interrupting devices.	3	2	3	2	1	1	2	2	2	3	3	3
CO-5 Select suitable protective relays, circuit breakers for protection of alternators, transformers and motors.	2	2	2	3	1	1	2	2	2	3	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-1 Represent the power system components in p.u. system.	SO1.1 SO1.2 SO1.3	LE1.1 LE1.2	Unit-1.0 Representation of Power System 1.1 , 1.2, 1.3, 1.4,1.5,1.6	As mentioned
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-2 Implement methods to regulate the power system stability.	SO2.1 - SO2.8	LE2.1 LE2.2 LE2.3 LE2.4	Unit-2.0 Power System faults and Stability 2.1, 2.2,2.3,2.4,2.5,2.6	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-3 Apply various strategies for active and reactive power control.	SO3.1 SO3.2 SO3.3	LE3.1 LE3.2	Unit-3.0 Active and Reactive power control 3.1, 3.2, 3.3	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-4 Identify elements of protection and circuit interrupting devices.	SO4.1 - SO4.11	LE4.1 LE4.2 LE4.3	Unit-4.0 Elements of Protection and Circuit Interrupting Devices 4.1, 4.2, 4.3, 4.4,4.5.4.6,4.8,4.9, 4.10,4.11, 4.12	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-5 Select suitable protective relays, circuit breakers for protection of alternators, transformers and motors.	SO5.1 - SO5.15	LE5.1 - LE5.9	Unit-5.0 Protective Relays and Circuit Breaker 5.1, 5.2 ,5.3, 5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11, 5.12,5.13, 5.14	

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning.

A) Course Code : 2024573(025)

B) Course Title : Instrumentation and Process Control

C) Pre-requisite Course Code and Title : Electrical Circuit, Electrical and Electronic Measurements

D) Rationale :

In the era of industrial automation, it is very essential that a diploma engineer working in any industry particularly process industry needs the knowledge and skill set to maintain the instrumentation system, transducers used to measure the physical quantity, associated signal conditioning, data transmission and different types of controllers to control the smooth functioning of the process plant. This course attempts to develop these skills in students and hence it is a core course for all electrical, electrical and electronics diploma engineers.

E) Course Outcomes:

CO-1 Interpret building blocks of basic instrumentation system and its characteristics.

CO-2 Select a transducer for measurement of a given physical quantity.

CO-3 Interpret the function of signal conditioning and data transmission in process plants.

CO-4 Measure different types of non-electrical quantities.

CO-5 Interpret the stability of a given control system and various control actions.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)				
				L	P	T	SL	Credit L+T+(P/2)
1.	Electrical & Electronics Engineering	2024573 (025)	Instrumentation and Process Control	2	-	1	1	3
2.	Electrical & Electronics Engineering	2024564 (025)	Instrumentation and Process Control (Lab)	-	2	-	-	1

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning, C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No.	Board of Study	Course Code	Course Title	Scheme of Examinations					
				Theory			Practical (PRA+ PDA+ Viva)		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Electrical & Electronics Engineering	2024573 (025)	Instrumentation and Process Control	70	20	30	-	-	120
2.	Electrical & Electronics Engineering	2024564 (025)	Instrumentation and Process Control (Lab)	-	-	-	40	50	90

Legend : PRA : Process Assessment, PDA : Product Assessment

Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Interpret building blocks of basic instrumentation system and its characteristics.

(Approx.Hrs:CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Represent an instrumentation system using block diagram. SO1.2 Classify characteristics of transducers. SO1.3 Explain static and dynamic characteristics of the given transducers.	LE1.1 Determine accuracy of a given measuring instrument. LE1.2 Determine static characteristics of given instrumentation system. LE1.3 Determine dynamic characteristics of given instrumentation system.	**Unit-1.0 Basic Instrumentation System and characteristics** 1.1 Need of instrumentation. 1.2 Block diagram of a generalized instrumentation system and their functions– Measure, sensing, signal conditioning, data transmission, display and control aspect. 1.3 Characteristics of an instrumentation system : i. Static characteristics - Accuracy, precision, error, resolution, linearity, reproducibility, repeatability, threshold, dead- zone, sensitivity, drift, distortion. ii. Dynamic characteristics - Fidelity, bandwidth, response time, time constant, settling time, Overshoot, dynamic error.	• Function of various building blocks of the basic instrumentation systems and latest developments.

SW-1 Suggested Sessional Work (SW):

- **Assignments:**
  i. Sketch a block diagram of a typical instrumentation system.
  ii. Prepare a chart depicting static and dynamic characteristics of an instrument.
- **Mini Project:**
  i. Prepare a prototype model for a typical process plant control.
- **Other Activities (Specify):**
  i. Seminar on representation of Instrumentation system.

CO-2 Selecta transducer for measurement of a given physical quantity.

(Approx. Hrs: CI+LI+SW+SL=20)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Explain the concept of sensor and transducer in instrumentation system. SO2.2 Differentiate the given sensors and transducers. SO2.3 Classify transducer based on given criteria. SO2.4 Explain construction and basic working principle of given transducers. SO2.5 State the application of the given transducers.	LE2.1 Plot the displacement versus output voltage characteristic of LVDT. LE2.2 Measure pressure using Bourdon tube. LE2.3 Measure the strain using strain gauge. LE2.4 Measure the temperature of a hot body using (i) thermocouple (ii) RTD and (iii) Thermistor and interpret the results.	**Unit-2.0 Transducers** 2.1 Concepts, importance and characteristics 2.2 Sensors and transducers. 2.3 Classification of transducers based on: • Energy – Active and passive. • Technology – Mechanical, Electrical, Electronic. • Stages – Primary and secondary. • Pressure, displacement, Temperature. 2.4 Construction, fundamental working principle and applications of: • Bourdon tube • LVDT • Strain Gauge • Thermocouple, Resistance Temperature Detector(RTD), Thermistor • Piezoelectric • Resistive, Inductive and Capacitive • Proximity • Ultrasonic	• Latest developments in resistive, inductive and capacitive transducers and their applications. • Types of proximity and ultrasonic transducer and uses.

SW-2 Suggested Sessional Work (SW):

- **Assignments:**
  i. Make a chart of transducers indicating transduction methods, principle of operation.
  ii. List the name of transducers with maximum and minimum ratings along with advantages and disadvantages.

- **Mini Project:**
  ii. Prepare a simple working model of an instrumentation system having any one of the transducers studied in the above unit.
- **Other Activities (Specify):**
  i. Visit a nearby industry. Observe and briefly explain the instrumentation devices used in various processes.

CO-3 Interpret the function of signal conditioning and data transmission devices used in process plants.

(Approx. Hrs: CI+LI+SW+SL=16)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Explain the need of signal conditioning in an Instrumentation system. SO3.2 Investigate the working of operational amplifier circuit. SO3.3 Use analog to digital and digital to analog convertors in data transmission. SO3.4 Analyze the working of multiplexer and demultiplexer in data transmission.	LE3.1 Observe the output of an instrumentation amplifier. LE3.2 Observe the output waveform of A/D and D/A converter. LE3.3 Convert a given physical quantity into 4 bit Digital output usingADC.	**Unit-3.0 Signal conditioning and data transmission** 3.1 Signal conditioning- Purpose, Elements 3.2 Operational Amplifier, instrumentation Amplifier, Applications. 3.3 Sample and Hold of a signal, Shannon criteria, Quantization (discretization), Quantization error 3.4 Data transmission- Advantages and disadvantages of Digital Transmission over Analog. A/D and D/A conversion. Multiplexing (TDM & FDM), Demultiplexing.	• On - chip signal conditioners along with A/D converter (digital sensors). • Modern trends in the field of signal conditioning and data transmission.

SW-3 Suggested Sectional Work (SW):

- **Assignments:**
  i. Make a survey and prepare a report on different ICs for A/D and D/A converters available in market.
- **Mini Project:**
  i. Assemble an instrumentation amplifier on a breadboard and observe the output waveform using CRO.
  ii. Make a prototype model of logarithmic amplifier using operational amplifier.
- **Other Activities (Specify):**
  i. Visit in nearby local industry and analyze the function of ICs in control panel room.
  ii. Make a survey for commonly used multiplexer and de-multiplexer inplant/industry.

CO-4 Measure different types of non Electrical Quantities.

(Approx. Hrs: CI+LI+SW+SL=14)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Describe the procedural steps to measure the given non electrical quantities using relevant transducers. SO4.2 Select suitable	LE4.1 Measure the temperature of a water heating system using RTD. LE4.2 Calibrate the low pressure using Pirani gauge. LE4.3 Measure the liquid level using capacitive	**Unit-4.0 Measurement of Non-Electrical quantities** 4.1 Measurement of Temperature- using Thermocouple, RTD, Thermistor and Pyrometer. 4.2 Measurement of Pressure- using Pirani Gauge, LVDT,	• Advances in lproximity and ultrasonic transducers.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
transducer for the given application and justify the selection.	probe. LE4.4 Measure the frequency and observe the speed using tachometer. LE4.5 Measure the speed using stroboscope. LE4.6 Calibrate the humidity of an environment using Hygrometer. LE4.7 Measure the pH value of a given system using pH meter.	Strain Gauge, and Capacitive Transducer. 4.3 Measurement of speed – using Tachometer, Stroboscope 4.4 Measurement of Flow – using electromagnetic pick-up, turbine flow meter. 4.5 Measurement of liquid level – using capacitive transducer. 4.6 Material Analysis- Measurement of pH, Humidity, types of Hygrometer. 4.7 Measurement of position, object detection using proximity transducers 4.8 Measurement of distance, water level and obstacle detection using ultrasonic transducer.	

SW-4 Suggested Sectional Work (SW):

- **Assignments:**
  i. List the major specifications of various instruments for the pressure measurement.
  ii. Make a report on calibration of PH value of different material in instrumentation system.
- **Mini Project:**
  i. Make a prototype model of electromagnetic flow meter and observe the output.
- **Other Activities (Specify):**
  i. Visit an oil depot of Indian Oil or Bharat Petroleum and prepare a report on measurement of liquid level.
  ii. Visit a food industry and prepare a report on various transducers used in the plant.

CO-5 Interpret the stability of a given system and various control actions.

(Approx. Hrs: CI+LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Describe stable and unstable control system using pole zero configurations. SO5.2 Analyze plant behavior of an open loop system. SO5.3 Describe system stability of an	LE5.1 Plot time response of first order system using MATLAB/Scilab. LE5.2 Plot the time response of second order system and determine various parameters using MATLAB/Scilab. LE5.3 Plot unit step response of a given higher order	**Unit-5.0 Basic Control System** 5.1 Concept of System, representation in ‘‘s’’ domain, Laplace transform, transfer function, poles and zeroes. 5.2 Concept of system stability based on location of poles and zeroes, system transfer function.	• Plot the time response for a unit ramp and unit acceleration inputs for a second order system. • Different controllers

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
open and closed loop control system. SO5.4 Analyze the basic control actions used in system stability.	stable system using MATLAB/Scillab. LE5.4 Plot time response and measure various parameters for under damped, over damped and critically damped system using MATLAB/Scilab. LE5.5 Plot time response characteristic of a closed loop system using PID controllers and compare the system performance with respect to open loop system.	5.3 Unit step response of a system – Introduction, response for any stable and unstable system. 5.4 Open loop and closed loop control system: Block diagram representation. 5.5 Terminology used in feedback control system - plant output, feedback signal, reference input signal, error signal, controller, actuator (final control element), examples of commonly used actuators. 5.6 Basic control actions – Proportional (P), Integral (I) and Differential (D), PID Controller. 5.7 Use of sensors and transducers in feedback control system.	available for industrial applications.

Legend:CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-5 Suggested Sectional Work (SW):

- **Assignments:**
  i. Prepare a report on controllers used in industrial applications.
  ii. List and briefly describe various types of controllers for speed control of motors.

- **Mini Project:**
  i. Prepare a working model of on-off control for controlling water level in a water tank with alarming signal.
  ii. Visit a nearby industry and prepare a report on use of different controllers and control elements used.

- **Other Activities (Specify):**
  i. Make a prototype model to demonstrate a real time control system with feedback.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESA of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Basic Instrumentation System and characteristics	4	4	2	10
II	Transducers	5	5	5	15
III	Signal conditioning and data transmission	4	6	5	15
IV	Measurement of non-electrical quantities	4	6	5	15
V	Basic control system	4	6	5	15
Total		**21**	**27**	**22**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESA of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Determine accuracy of a given measuring instrument.	50	40	10
LE1.2	Determine static characteristics of given instrumentation system.	50	40	10
LE1.3	Determine dynamic characteristics of given instrumentation system.	50	40	10
LE2.1	Plot the displacement versus output voltage characteristic of LVDT.	50	40	10
LE2.2	Measure pressure using bourdon tube.	50	40	10
LE2.3	Measure the strain using strain gauge.	50	40	10
LE2.4	Measure the temperature of a hot body using thermocouple.	50	40	10
LE3.1	Observe the output of an instrumentation amplifier.	50	40	10
LE3.2	Observe the output waveform of A/D and D/A converter.	50	40	10
LE3.3	Convert a given physical quantity into 4-bit digital output usingADC.	50	40	10
LE4.1	Measure the temperature of a water heating system using RTD.	50	40	10
LE4.2	Calibrate the low pressure using pirani gauge.	50	40	10
LE4.3	Measure the liquid level using capacitive probe.	50	40	10
LE4.4	Measure the frequency and observe the speed using tachometer.	50	40	10
LE4.5	Measure the speed using stroboscope.	50	40	10
LE4.6	Calibrate the humidity of an environment using hygrometer.	50	40	10
LE4.7	Measure the pH value of a given system using pH meter.	50	40	10
LE5.1	Plot time response of first order system using MATLAB/Scilab.	50	40	10
LE5.2	Plot the time response of second order system and determine various parameters using MATLAB/Scilab.	50	40	10
LE5.3	Plot unit step response of any given higher order stable system using MATLAB/Scilab.	50	40	10

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE5.4	Plot time response and measure various parameters for under damped, over damped and critically damped system using MATLAB/ Scilab.	50	40	10
LE5.5	Plot time response characteristic of a closed loop system using PID controller and compare the system performance with respect to open loop system.	50	40	10

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Demonstration
10. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
11. Brainstorming

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Electrical & Electronic Measurement	A.K. Sawhney	Dhanpat Rai & Co.	Latest Edition Year-2015 *ISBN*-10: 8177001000; *ISBN*-13: 978-8177001006
2.	Transducers and Instrumentation	D.V.S.Murty	Prentice Hall of India,	Latest Edition Year-2008 *ISBN*-10: 8120335694
3.	Mechanical and Industrial Measurements	R.K.Jain	Khanna Publishers	Latest Edition ISBN 13; 9788174091918
4.	Instrumentation Devices and Systems	Rangan,Sharma and Mani	Tata McGraw Hill,	Latest Edition ISBN 10: 0074633503 ISBN13: 9780074633502
5.	Electronic Instrumentation	H.S.Kalsi	Tata McGraw Hill,	Latest Edition ISBN 1259084027 9781259084027
6.	Instrument Engineers' Handbook	B.G. Liptak	CRC press, Volume 1,2	Latest Edition ISBN-13: 978-1466571716 ISBN-10: 1466571713

S. No.	Titles	Author	Publisher	Edition & Year
7.	Control System Engineering	I.J.Nagrath and M.Gopal	Wiley Eastern Limited	Latest Edition ISBN 10: 1848290039 ISBN 13: 9781848290037
8.	Computer Based Industrial Control	Krishna Kant	Prentice Hall of India,	Latest Edition ISBN-10: 9788120339880 ISBN-13: 978-8120339880
9.	Linear Control System	B.S.Mankey	Khanna Publishers	Latest Edition ISBN: 9788174093103, 9788174093103
10.	Industrial Instrumentation and Control	S.K.Singh	Tata McGraw Hill,	Latest Edition ISBN: 9789351340102, 9789351340102

(b) Open source software and website address:

1. Flow meter, Electromagnetic flow meter and ultrasonic flow meter- www.instrumentationtoday.com/
2. Control value actuators and basic design-www.instrumentationtoolbox.com
3. Automatic process control , large integrated computer based system- https://www.electrical4u.com/transducer-automaticprocesscontrol/
4. Transducer and types of transducer - https://www.electrical4u.com/transducer-types-of-transducer/

(c) Others:

1. Learning Packages
2. Lab Manuals
3. Manufacturers' Manual
4. Users' Guide

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1.	Ammeter	Range 0-5 A, AC/DC	LE1.1
2.	Voltmeter	Range 0-250 V, AC/DC	LE1.1
3.	Instrumentation Trainer	±5V D.C. at 5mA	LE1.2
4.	CRO	Dual Trace, 25 MHz	LE1.2, LE3.1
5.	Linear variable differential transducer	±12V D.C. at 50mA	LE2.1
6.	Instrumentation Trainer using different Transducer	Should be equipped with different types of Transducer and display device	LE2.2. LE2.3, LE2.4
7.	Temperature Trainer	±5V D.C. at 5mA	LE2.4
8.	Instrumentation Amplifier	±5V D.C. at 5mA	LE3.1
9.	Simulation Software	MATLAB/ Scilab	LE3.2, LE5.1, LE5.2, LE5.3, LE5.4, LE5.5
10.	Multiplex/Demultiplexer Kit	4-Channel	LE3.3
11.	A/D and D/A converter Kit	8-bit	LE3.4, LE3.5
12.	Temperature Trainer	Equipped with RTD	LE4.1

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
13.	Pressure Transducer Trainer	Equipped with Pirani Gauge	LE4.2
14.	Liquid Level Measurement Trainer	Using capacitive probe	LE4.3
15.	Tachometer	Suitable for speed measurement of machines	LE4.4
16.	Stroboscope	Max limit 500 rpm	LE4.5
17.	Hygrometer	Max limit 100 milliliters per cubic centimeter	LE4.6
18.	pH meter	Multiple transducer kit: Inbuilt power supply, measurement facility, expansion facility and with latest features like computer interface etc.	LE4.7
19.	Strain gauge	$\pm$12V D.C. at 50 mA	LE2.3
20.	Thermistor	as per standard specification and latest configuration	LE2.4
21.	Thermo-couple	Types B, E, J, K, R, S, T and C thermocouples	LE2.4
22.	PID controller trainer	Type P , I , D , PID trainer.	LE5.5

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Interpret building blocks of a basicinstrumentation system and its characteristics.	2	3	3	2	-	-	2	3	2	3	2	2
CO-2 Select appropriate transducer for measurement of a given physical quantity.	2	3	3	3	3	-	2	3	2	3	2	2
CO-3 Interpret the function of signal conditioning and data transmission in process plants.	3	3	3	3	2	-	2	3	2	3	2	2
CO-4 Measure different types of non-electrical quantities.	3	2	3	2	2	-	2	3	3	3	2	2
CO-5 Interpret the stability of a given system and various control actions	2	2	2	3	2	-	2	2	2	3	3	2

Legend: 1 – Low, 2 – Medium, 3 – High

Use various tools to simulate, implement and test simple Electrical & Electronics Engineering related circuits and systems
PSO2Apply electrical & Electronics Engineering knowledge to maintain various Electrical & Electronics Engineering related systems.

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	LaboratoryInstruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2	CO-1 Interpret building blocks of a basic instrumentation system and its characteristics.	SO1.1,SO1.2	LE1.1,LE1.2	Unit-1. Basic Instrumentation System and characteristics 1.1 , 1.2, 1.3, 1.4	As mentioned
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2	CO-2 Select appropriate transducer for measurement of a given physical quantity.	SO.2.1,SO.2.2 SO2.3,SO2.4	LE2.1,LE2.2 LE2.3,LE2.4	Unit-2.0 Transducers 2.1, 2.2,2.3,2.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2	CO-3 Interpret the function of signal conditioning and data transmission in process plants.	SO.3.1,SO3.2 SO3.3,SO3.4	LE3.1,LE3.2 LE3.3,LE3.4 LE3.5	Unit-3.0 Signal conditioning and data transmission 3.1, 3.2, 3.3	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2	CO-4 Measure different types of non-electrical quantities.	SO4.1,SO4.2 SO4.3,SO4.4	LE4.1,LE4.2,LE4.3 LE4.4,LE4.5,LE4.6, LE4.7,LE4.8	Unit-4.0 0 Measurement of Non-Electrical quantities 4.1, 4.2, 4.3, 4.4,4.5,4.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2	CO-5 Interpret the stability of a given system and various control actions	SO5.1,SO5.2 SO5.3,SO5.4 SO5.5	LE5.1,LE5.2 LE5.3,LE5.4 LE5.5	Unit-5.0 Basic Control System 5.1, 5.2 ,5.3, 5.4,5.5,5.6	

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning.

A) Course Code : 2024574(024)

B) Course Title : Installation and Maintenance of Electrical Equipment

C) Pre-requisite Course Code and Title : Elements of Electrical Engineering, DC Machines and Transformers, AC Machines

D) Rationale :

Electrical engineering diploma holders are expected to carry out electrical installation, testing and maintenance of electrical equipment used in industries. Therefore, diploma pass outs should have a better understanding of the site activities to be carried out at each stage, namely, erection of electrical machines and equipment, installation, testing and commissioning procedures as per standard practice. The contents of this course are designed such that it develops all the above skills in the students.

E) Course Outcomes:

CO-1 Install electrical equipment and machines.

CO-2 Commission electrical equipment and machines.

CO-3 Maintain Earthing systems for electrical equipment and installations.

CO-4 Maintain electrical machines and installations.

CO-5 Follow standard practices and safety measures.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)				
				L	P	T	SL	Credit L+T+(P/2)
1.	Electrical Engineering	2024574 (024)	Installation and Maintenance of Electrical Equipment	2	-	1	1	3
2.	Electrical Engineering	2024565 (024)	Installation and Maintenance of Electrical Equipment (Lab)	-	2	-	-	1

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning, C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No	Board of Study	Course Code	Course Titles	Scheme of Examinations					
				Theory			Practical (PRA+ PDA+ Viva)		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Electrical Engineering	2024574 (024)	Installation and Maintenance of Electrical Equipment	70	20	30	-	-	120
2.	Electrical Engineering	2024565 (024)	Installation and Maintenance of Electrical Equipment (Lab)	-	-	-	40	50	90

Legend : PRA : Process Assessment, PDA : Product Assessment

Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI) Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Install electrical equipment and machines.

(Approx.Hrs:CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Identify given types of heavy electrical equipment. SO1.2 Describe the Installation procedure of the given static equipment. SO1.3 Describe the Installation procedure of the given rotating machine. SO1.4 Describe the Installation procedure of the given transformer.	LE1.1 Identify the different types of installation kits, tools, accessories and equipment. LE1.2 Make a report for installation of static machines. LE1.3 Make a report for installation of rotating machine. LE1.4 Make a report for installation of pole mounted transformer.	**Unit-1.0 Installation of Electrical equipment and machines** 1.1 Types of heavy electrical equipment 1.2 Unloading electrical equipment at site, Inspection of electrical equipment at site. 1.3 Installation procedures of small and large static equipment. 1.4 Installation procedures of small and large rotating type machine 1.5 Installation of pole mounted transformer	• Storage of equipment and accessories at site • Precautions to be taken duringhandling and installation of heavy electrical equipment

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies), SL: Self Learning

SW-1 Suggested Sessional Work (SW):

- **Assignments:**
  i. Prepare a foundation plan for installation of a given motor**.**
  ii. Prepare installation report of a given rotating electrical machine.

- **Mini Project:**
  i. Collect information on the installation procedures of a three phase transformer in an HV/EHV switchyard.

- **Other Activities (Specify):**
  i. Prepare a report on the foundation plan and installation procedures for an EHV tower carrying double circuit ACSR conductors.
  ii. Prepare report on the tools, tackles lifting equipment and accessories required for installation of a given diesel generator unit.

CO-2 Commission electrical equipment and machines.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Describe the testing procedure of the given static electrical equipment before commissioning SO2.2 Describe the different testing procedure of the given rotating machine before commissioning SO2.3 Describe the commissioning procedure to be adopted for commissioning the given type of equipment SO2.4 Describe the precautions to be followed for energizing the given transformer	LE2.1 Identify the different types of commissioning tools,accessories and instruments. LE2.2 Make a report for commissioning of given static machine. LE2.3 Make a report for commissioning of the given rotating machine LE2.4 Make a report for commissioning of pole mounted transformer.	**Unit-2.0 Commissioning of Electrical equipment and Machines** 2.1 Commissioning procedure to be adopted for commissioning the static equipment in respect of: Mechanical installation and alignment. 2.2 Commissioning procedure to be adopted for commissioning the static equipment in respect of: Electrical tests and safety precautions to be adopted before energization. 2.3 Commissioning procedure to be adopted for commissioning the rotating machine in respect of: Mechanical installation and alignment. 2.4 Commissioning procedure to be adopted for commissioning the rotating machine in respect of: Electrical tests and safety precautions to be adopted before energization. 2.5 Test report on commissioning and test certificate	• Special tests on electrical equipment • Transform oil properties • IS Code of power transformer

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies), SL: Self Learning

SW-2 Suggested Sessional Work (SW):

- **Assignments:**
  i. Identify the common troubles and the corresponding tests to be performed before commissioning of the following; 1. DC machine 2. Three phase Distribution transformer.
  ii. Prepare a commissioning report of installed electrical equipment.

- **Mini Project:**
  i. Identify the different routine test performed before commissioning a HV AC motor.
  ii. A three phase induction motor when switched into supply do not start but gives humming noise. Identify the reasons for it.

- **Other Activities (Specify):**
  i. Identify the necessary tools and perform the procedures of alignment of a motor coupled to a high pressure centrifugal pump set.
  ii. Identify the general symptoms of trouble for three phase induction motor and suggest methods of their repairs

CO-3 Maintain Earthing systems for electrical equipment and installations.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Identify the types of the given earthing systems. SO3.2 Describe the method of earthing for the given soil condition. SO3.3 Describe the given method(s) for measuring earth resistance. SO3.4 Describe the earthing procedure for the given type of electrical installations.	LE3.1 Prepare drawing of plate/pipe earthing. LE3.2 Measure earth resistance of any Electrical machine /premises. LE3.3 Measure earth resistance of a Electrical substation.	**Unit-3.0 Earthing systems**: SO3.1 Necessity of earthing. SO3.2 Different methods of earthing SO3.3 Permissible earth resistance value for different electrical installations. SO3.4 Factors affecting the earth resistance SO3.5 Methods for Improvement of earth resistance. SO3.6 Measurement of earth resistance	• IS code of earthing • Comparison between equipment earthing and system earthing.

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-3 Suggested Sessional Work (SW):

- **Assignments:**
  i. List the materials required for installing lightning arrester in your college.

- **Mini Project:**
  i. Record the procedures and obtain typical values of the earth resistance used for equipment earthing of a given installation. Comment on the result obtained as per IS.

- **Other Activities (Specify):**
  i. Prepare a report on the earthing procedures for Building and Industrial Electrical installation
  ii. Prepare a report on the effect of connected load due to failure of supply system neutral earthing.

CO-4 Maintain Electrical Machines and Installations.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Describe various internal and external faults that may occur in the given electrical equipment. SO4.2 Describe the procedure of preventive maintenance of the given electrical equipment and installations. SO4.3 Describe the preventive maintenance schedule of the given equipment and installations.	LE4.1 Perform insulation test of transformer oil. LE4.2 Prepare preventive maintenance report of distribution transformer installed in college premise. LE4.3 Prepare the standard operating procedure for Shut down and Re energizing of a given electrical equipment to be taken up for preventive maintenance. LE4.4 Prepare Preventive maintenance schedule of induction motors in industrial establishment. LE4.5 Prepare maintenance schedule of 33/11 kV O.H. Lines. LE4.6 Perform preventive maintenance check for LV Air circuit breaker and Vacuum circuit breaker. LE4.7 Measure insulation resistance of a given HV underground cable. LE4.8 Identify measurement tools available for conditioning monitoring of electrical equipment.	**Unit-4.0Maintenance of Electrical Machines and Installations** 4.1 Reason of failure of electrical equipment and machines. 4.2 Methods for drying insulation, Measurement of internal temperature of winding, Need of vacuum impregnation 4.3 Filtering process of insulating oil, Testing of insulating oil 4.4 Concepts of preventive maintenance, 4.5 maintenance schedule for induction motor, DC Motor, transformer, power Distribution line, Circuit breaker and underground cable 4.6 Tools for hot line maintenance	• Predictive maintenance • Maintenance of UPS • Maintenance of solar lighting system

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies), SL: Self Learning

SW-4 Suggested Sessional Work (SW):

- **Assignments:**
  i. Prepare a poster on the instrument used for detection of underground cable fault and label its major accessories.

ii. Prepare a report on the procedures of Cable jointing and the types of cable joints with their sketch

- **Mini Project:**
  i. Prepare a breakdown maintenance report for repair of a given domestic appliance.

- **Other Activities (Specify):**
  i. Prepare a report on the working principle and use of any three of following instruments available in market
     - Insulation tester
     - Earth tester
     - Phase sequence indicator
     - Clamp on meter
     - Growler
     - Power analyzer

CO-5 Follow standard practices and safety measures

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Describe Normal performance of the given equipment. SO5.2 Describe the Trouble shooting procedure of given type of fault(s). SO5.3 Select the relevant Instruments and accessories for trouble shoot the given equipment and justify your selection. SO5.4 Describe the causes of the identified electrical accidents. SO5.5 Describe the operation of the given type of fire extinguishers	LE5.1 Identify the types of firefighting equipment used for electrical fires LE5.2 Identify the tools and equipment used in installation and maintenance work LE5.3 Prepare Trouble shooting chart of the given equipment LE5.4 Undertake drill operation for using fire extinguishers for safety against fire. LE5.5 Prepare a report on action to be taken when a person gets attached to a live part.	**Unit-5.0Trouble shooting and safety measures** 5.1 Normal performance of equipment 5.2 Causes of Electrical accidents 5.3 Common faults in electrical equipment ; DC Machines, AC Machines, Transformers, Power cables and electrical Installations 5.4 Trouble shooting of internal and external faults; DC Machines, AC Machines, Transformers, Power cables and electrical Installations 5.5 Instruments and accessories for trouble shooting. 5.6 Trouble shooting charts; electrical iron, ceiling fan, wall fan, washing machine, air cooler. 5.7 Safety regulation and safety measures 5.8 Treatment of shock 5.9 Different types of Fire extinguishers	• Artificial respiration • Fire extinguishers • I.E. Rules

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-5 Suggested Sessional Work (SW):

- **Assignments:**
  i. Prepare the specification of the commonly used hand tools by electrician.
  ii. Prepare a chart on the procedures to be followed for artificial respiration of an electrocuted person.
- **Mini Project:**
  i. Prepare a project report on the safety precautions of Indoor and Outdoor Electrical Installation
- **Other Activities (Specify):**
  i. Prepare a report of the different types of fire fighting equipment's and their limitations.
  ii. Prepare a report on the equipment's required in loading and un loading of heavy electrical machines.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESA of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Installation of Electrical Equipment and Machines	4	5	5	14
II	Commissioning of Electrical Equipment and Machines	4	5	5	14
III	Earthing systems	4	4	4	12
IV	Maintenance of Electrical Machines and installations	5	5	6	16
V	Trouble shooting and Safety Measures	4	5	5	14
Total		**21**	**24**	**25**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESA of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Indentify the different types of Installation kits, tools, accessories and equipment.	50	40	10
LE1.2	Make a report for installation of static machines.	50	40	10
LE1.3	Make a report for installation of rotating machines.	50	40	10
LE1.4	Make a report for installation of pole mounted transformer.	50	40	10
LE2.1	Indentify the different types of commissioning tools, accessories and instruments.	50	40	10
LE2.2	Make a report for commissioning of the given static	50	40	10

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
	machine.			
LE2.3	Make a report for commissioning of the given rotating machine.	50	40	10
LE2.4	Make a report for commissioning of pole mounted transformer.	50	40	10
LE3.1	Prepare drawing of plate/pipe earthing.	50	40	10
LE3.2	Measure earth resistance of any electrical machine/ premise.	50	40	10
LE3.3	Measure earth resistance of an electrical substation.	50	40	10
LE4.1	Perform insulation test of transformer oil.	50	40	10
LE4.2	Prepare preventive Maintenance report of distribution transformer installed in college premise.	50	40	10
LE4.3	Prepare the standard operating procedure for shut down and re-energizing of a given electrical equipment to be taken up for preventive maintenance.	50	40	10
LE4.4	Prepare Preventive maintenance schedule of induction motors in industrial establishment.	50	40	10
LE4.5	Prepare maintenance schedule of 33/11 kV O.H. Lines	25	20	05
LE4.6	Perform preventive maintenance check for LV Air circuit breaker and Vacuum circuit breaker	25	20	05
LE4.7	Measure insulation resistance of a given HV underground cable	25	20	05
LE4.8	Identify the measurement tools available for conditioning monitoring of electrical equipment.	25	20	05
LE5.1	Identify the types of Firefighting equipment used for electrical fires.	25	20	05
LE5.2	Identify the tools and equipment used in installation and maintenance work.	25	20	05
LE5.3	Prepare Trouble shooting chart of the given equipment.	25	20	05
LE5.4	Undertake drill operation for using fire extinguishers for safety against fire.	25	20	05
LE5.5	Prepare a report on action to be taken when a person gets attached to a live part.	25	20	05

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

2. Improved Lecture Method
3. Industrial visits
4. Field Trips
5. Self Learning
6. Observation, Practice and Feedback
7. Classroom, Laboratory, Workshop, Field, Video, Live Demonstrations
8. ICT Based Teaching Learning (Video Demonstration)

L) Suggested Learning Resources: Books

S.No.	Titles	Author	Publisher	Edition & Year
1	Testing, commissioning operation and maintenance of electrical equipments	Rao, S.	Khanna Publication	6th Edition,2010
2	Installation, commissioning and maintenance of electrical equipments	Singh, Tarlok	S.K. Kataria and Sons	1st Edition, 2013
3	Installation, maintenance and repair of electrical machines and equipments	Gupta, Madhvi	S.K. Kataria and Sons	1st Edition, 2014
4	Preventive maintenance of Electrical apparatus	Sharoti, S.K.	Katson Publishing House	2ndEdition, latest
5	Electrical workshop: Safety, commissioning, maintenance and testing of Electrical equipment	Singh, R.P.	I K international Publishing house Pvt. Ltd.	3rd Edition 2012
6	IS Standards	Govt of India Bureau of Indian standards	Bharat Manak Sangralya, Bhopal	

(b) Open source software and website address:

1. Preventive and predictive maintenance - www.lce.com/pdfs/The-PMPdM-Program-124.pdf
2. Electricity supply act, 1948- cercind.gov.in/ElectSupplyAct1948.pdf
3. Fire extinguishers- www.iapa.ca/pdf/prevent.pdf
4. Principles of electrical grounding- www.pfeiffereng.com/Principals%20of%20Electrical%20Grounding.pdf
5. Preventive maintenance schedule of electrical equipment- https://www.usbr.gov/power/data/fist/fist4_1B/4-1B%20Maintenance%20Scheduling%20for%20Electrical%20Equipment%20(November%202005).pdf

(c) Others:

1. Learning Packages
2. Manufacturers' operating manual
3. Manufacturers' service manual

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1.	Voltmeter	Moving iron and Moving Coil type 0-500 V	LE2.1, LE2.2, LE2.3, LE2.4
2.	Ammeter	Moving iron and Moving Coil type 0-50 A	LE2.1, LE2.2, LE2.3, LE2.4
3.	Digital Earth tester	Connecting wires and spikes with provision for measuring soil resistivity	LE3.1, LE3.2, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
4.	Digital Multimeter	0-750V AC,0-1000V DC, 10 microamp-10-amp AC, DC, Resistance and continuity measurement	LE2.1, LE2.2, LE2.3, LE2.4, LE3.1, LE3.2, LE 3.3, LE3.4, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
5.	Phase sequence indicator	25-50 Hz, 50-500V	LE2.1, LE2.2, LE2.3, LE2.4, LE3.1, LE3.2, LE 3.3, LE3.4, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
6.	Insulation tester	Test voltage selector switch for selection of 500V,1000V,2500V and 5000V Measurement Insulation resistance up to Giga ohms with facility for measuring polarization index	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
7.	Single phase watt meters	Pressure coil 0-150-300V Current coil 0-2.5-5Amp	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
8.	Single phase watt meters	Pressure coil 0-150-300V Current coil 0-5-10Amp	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
9.	Single phase LPF wattmeter	Pressure coil 0-150-300V Current coil 0-2.5-5Amp	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
10.	Clip on meter	Voltage: 0-750VAC Current: up to 100 A	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
11.	Digital portable LCR meter	Inductance: 0.1 MH to 9999 H, Resolution 0.1 MH Capacitance: 0.1 pF to 9999 mF, Resolution 0.1 pF Resistance: 0.001 Ω to 1 M Ω, Resolution 0.001 W	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE4.6, LE4.7, LE5.4
12.	Soldering Iron	230V, 20watt	LE1.1 to LE5.4

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Install electrical equipment and machines.	3	3	3	2	2	1	1	2	2	2	3	3
CO-2 Commission electrical equipment and machines.	3	3	3	2	3	1	1	2	2	2	2	3
CO-3 Maintain Earthing systems for Electrical equipment and Installations.	3	3	3	2	3	2	2	2	2	2	2	3
CO-4 Maintain Electrical Machines and Installations.	3	3	3	3	3	2	2	2	2	2	3	3
CO-5 Follow standard practices and safety measures.	3	3	3	3	3	2	2	2	2	2	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-1 Install electrical equipment and machines.	SO1.1 SO1.2 SO1.3 SO1.4	LE1.1 LE1.2 LE1.3 LE1.4	Unit-1.0 Installation of Electrical equipment and machines 1.1,1.2,1.3,1.4,1.5	As mentioned
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-2 Commission electrical equipment and machines.	SO2.1 SO2.2 SO2.3 SO2.4	LE2.1 LE2.2 LE2.3 LE 2.4	Unit-2.0Commissioning of Electrical equipment and machines 2.1,2.2,2.3,2.4,2.5	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-3 Maintain Earthing systems for Electrical equipment and Installations.	SO3.1 SO3.2 SO3.3 SO3.4	LE3.1 LE3.2 LE3.3	Unit-3.0 Earthing Systems 3.1,3.2,.3.3,3.4,3.5,3.6	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-4 Maintain Electrical Machines and Installations.	SO4.1 SO4.2 SO4.3	LE4.1 - LE4.8	Unit-4.0Maintenance of Electrical Machines and Installations 4.1,4.2,4.3,4.4, 4.5, 4.6	
PO1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO-5 Follow standard practices and safety measures.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	LE5.1 LE5.2 LE5.3 LE5.4 LE5.5	Unit-5.0Trouble shooting and safety measure 5.1,5.2,5.3,5.4,5.5,5.6, 5.7, 5.8, 5.9	

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning.

A) Course Code : 2024561(025)

B) Course Title : Electrical & Electronics Simulation (Lab)

C) Pre-requisite Course Code and Title : Electrical Circuits, Basic Electronics, DC Machines and Transformer, Digital Electronics, AC rotating Machines, Power Systems

D) Rationale :

In the present industrial scenario and revolution in information and communication technology, diploma pass outs are required to work on the different simulation tools/software, Electronics Design and Automation (EDA) tools to simulate various electrical/electronic circuits, test, analyze and interpret the results and graphs. These simulation tools not only provide facilities to select and use a wide range of devices and components to test and analyze the performance of an Electrical/Electronic circuit prior to its physical implementation but also reduces the cost and time for hardware implementation by optimizing the circuit performance. The task of professionals in designing and analyzing circuits has become comparatively stress-free. Keeping this in mind, this practical course is developed to enable the students to become competent in using various EDA tools to simulate, hone analyzing and interpreting skills in the field of electrical and electronics engineering.

E) Course Outcomes:

CO-1 Install a given simulation tool/open source software and test its functionality on a simple electrical circuit.

CO-2 Use simulation tool to simulate the given electronic circuit.

CO-3 Use simulation tool to simulate the given digital electronic circuit.

CO-4 Use simulation tool to simulate the given electrical machine and power system circuit.

CO-5 Use C programming/open source software-SciLab to interface Arduino/open source board.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Credit L+T+(P/2)
1.	Electrical & Electronics Engineering	2024561 (025)	Electrical and Electronics Simulation (Lab)	-	4	2	2

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning, C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No.	Board of Study	Course Code	Course Title	Scheme of Examinations					
				Theory			Practical (PRA+ PDA+ Viva)		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Electrical & Electronics Engineering	2024561 (025)	Electrical and Electronics Simulation (Lab)	-	-	-	40*	50	90

Legend : PRA : Process Assessment, PDA : Product Assessment

Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select power electronic devices for a given application.

(Approx.Hrs:CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Describe the installation procedure of the given Simulation tool/open source software. SO1.2 Describe the procedure to simulate a given electrical circuit using Simulation tool /open source software, test by applying different mathematical, logical and relational operators, analyze and interpret the results .	LE1.1 Open the new Simulation file/project and script file and save at the given place. LE1.2 Copy the available code/file and make the changes in the circuit by changing component values. LE1.3 Connect one or more source and discrete components and complete the circuit in the circuit window. LE1.4 Connect the resistors in series and parallel combination and measure the current and voltages in the circuit using Simulation tool. LE1.5 Perform node and loop analysis of the given electrical network. LE1.6 Perform analysis of a given electrical circuit by coding a program file using operators and conditional statements.	**Unit 1.0: Introduction to Simulation tools** 1.1 Hardware and software requirements to install the specified free/ Licensed Simulation tool 1.2 Introduction to: Scilab, or any other open source software, 1.3 Open the basic interface of the Simulation tool and explore the various tabs and functions 1.4 Open demo files, help files and new project/file/code 1.5 Explore the following operations: file, Edit, save, open, run, test, simulate, export and import. 1.6 Connect sources, test, and measuring instruments with analog and digital components and complete the circuit 1.7 Create program files and apply different operators to perform mathematical or logical operations and use plot command	• Use different free LT Spiceor licensed like pSpice, Multisim, MATLAB, Simulation tools to simulate and test the given electric circuit. • Explore the different libraries available in SciLab.

SW-1 Suggested Sessional Work (SW):

- **Assignments:**
  i. Describe the advantages of simulation tool for circuit design.
  ii. List functions **of simulation** tools.

- **Mini Project:**
  i. Prepare a presentation to demonstrate the use of any one free simulation tools.

- **Other Activities (Specify):**
  i. Prepare a chart to compare the features of three free simulation tools.
  ii. Prepare a chart to represent the steps to simulate and test a given electrical circuit and compare the results obtained through practical experiments.

CO-2 Use Simulation tool to simulate the given Electronic circuit.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Explain the need for the virtual and real component. SO2.2 Describe the rules of component selection for the design of any circuit.	LE2.1 Simulate and test the integrator circuit. LE2.2 Simulate and test the differentiator circuit. LE2.3 Simulate and test the clipper and clamper circuit. LE2.4 Simulate and test the comparator circuit for two DC input signal. LE2.5 Simulate and test the half wave and full wave rectifier. LE2.6 Simulate and test the actable multivibrator circuit contain the timer IC. LE2.7 Simulate and test the bistable multivibrator circuit contain the timer IC. LE2.8 Simulate and test voltage regulator circuit contains 7805 IC.	**Unit 2.0 Basic Electronic Circuit Simulation** 2.1 Basic Components: Resistor, capacitor, inductor, diodes, transistors, relays, switches 2.2 Power sources, AC, DC, battery, ground, virtual ground, current and voltage sources 2.3 Miscellaneous components and ICs: - buzzer, lamps, LEDs, probes, OPAMP IC, Timer IC, voltage regulator IC	• Describe the working of the demo/example circuits available in the help folder of the simulation tool.

SW-2 Suggested Sessional Work (SW):

- **Assignments:**
  i. Simulate a clamper circuit, which clamps the given sinusoidal input to 10 volts above the zero level.
  ii. Simulate a bistable multivibrator circuit for given time duration.

- **Mini Project:**
  i. Develop a full wave rectifier circuit, analyze and interpret the output voltage ripple content using PI and T filter circuit
  ii. Carried out the DC analysis of the common emitter and common base amplifier.

- **Other Activities (Specify):**
  i. Simulate and test voltage regulator circuit using IC to obtain a regulated output voltage of ± 9V.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

CO-3 Use Simulation tool to simulate the given Digital Electronic circuit.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Explain the design rules for digital circuits. SO3.2 Describe the steps to test the functionality of digital circuits. SO3.3 Compare the characteristics of various types of digital inputs.	LE3.1 Test the functions of various logic gates. LE3.2 Test the functions of various FF. LE3.3 Simulate and test half adder circuit. LE3.4 Simulate and test full adder circuit. LE3.5 Simulate and test four-bit parallel adder circuit. LE3.6 Develop a 4-bit parity generator circuit. LE3.7 Simulate a Mod-10 up counter. LE3.8 Test the functions of shift register.	**Unit 3.0 Digital Circuit Simulation** 3.1 Functions of Logic of Gates : AND, OR, NOR, NAND, XOR, XNOR, NOT 3.2 Testing of Flip-Flop(FF) : RS, JK, D, T, Master slave FF operation 3.3 Truth table vérification, digital circuit design base on truth table, simplification of Boolean equations 3.4 Testing of following circuits: Adder, Subtractor, Multiplier, coder and decoder, Multiplexer and de-multiplexers, counters, clocks, shift register	• Compare different types of gates ICs specifications. • Calculate the delay produced by the various counters used in digital clock circuit.

Legend:CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-3 Suggested Sessional Work (SW):

- **Assignments:**
  i. Construct the truth table for a given problem and realize it using digital gates.
  ii. Develop a 1 to N (For a given N) decoder using gates and realize it 1-N line de-multiplexer IC.

- **Mini Project:**
  i. Develop a modulo- 10 UP/DOWN counter circuit.
  ii. Simulate a circuit to display two-digit numbers using seven segment display.

- **Other Activities (Specify):**
  i. Seminar on simple digital circuits used for various applications.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

CO-4 Use Simulation tool to simulate the given Electrical Machine and power system circuit.

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Describe the effect of core permeability on the inductance of a magnetic circuit. SO4.2 Analyze the effect on terminal voltage of a distribution transformer as the load power factor varies from leading to lagging. SO4.3 Explain the constant torque and constant power region of a DC motor. SO4.4 Analyze the effect of variation in rotor resistance on the electromagnetic torque developed for a three phase SRIM. SO4.5 Describe the effect of field current on a synchronous motor. SO4.6 Determine the symmetrical components of a three-phase power system circuit under fault conditions. SO4.7 Calculate regulation and efficiency for T and pie network.	LE4.1 Use program file to plot the inductance of a magnetic circuit as a function of the core permeability. LE4.2 Use program file to plot the efficiency of a given transformer as function of the load current. LE4.3 Use program file to plot the variation of speed of a given DC motor operating in constant i. Torque region ii. Power region. LE4.4 Use program file to plot the rotor speed of a three-phase slip ring induction motor with varying rotor resistance and constant load torque. LE4.5 Use program file to plot the armature current versus field current for a synchronous motor. LE4.6 Use program file to determine the fault current for given parameters of a three-phase power system. LE4.7 Calculate ABCD parameter for a given transmission line and find regulation and efficiency.	**Unit 4.0 Electrical Machine and Power system simulation** 4.1 Effect of core permeability on flux linkage and inductance for a magnetic circuit 4.2 Effect of load current and power factor on the voltage regulation and efficiency of a transformer. 4.3 Speed control of a DC motor under varying armature terminal voltage and varying field current. 4.4 Conventional speed control techniques for three phase IM. 4.5 Synchronous motor as synchronous condenser. 4.6 Different types of fault occurrence in power system network and calculation of fault current 4.7 Transmission line parameters and classification of transmission lines	• List the types of plot commands used in program files for simulation tools. • Survey about the commonly occurring faults in a 33/11 KV transmission line network

SW-4 Suggested Sessional Work (SW):

- **Assignments:**

i. Develop a program file to determine the equivalent circuit parameters of a transformer using open circuit and short circuit test parameters.
ii. Develop a program file to determine the terminal voltage of an alternator under varying load conditions.

- **Mini Project:**
  i. Develop a program file using symmetrical component theory to determine the overload and short circuit current rating of circuit breaker for a given power system circuit.

- **Other Activities (Specify):**
  i. Simulation studies on "Power Quality issues".

CO-5 Use C programming and open source software-SciLab to interface with Arduino/open source board

(Approx. Hrs: CI+ LI+SW+SL=12)

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Overview of open source hardware board (Arduino) SO5.2 Identify pins of Arduino board. SO5.3 Describe the features of open source tool used for programming on Arduino board. SO5.4 Write steps for interfacing Serial Port with Arduino board. SO5.5 Explain Interfacing of Digital I/O devices with program (Digital I/O Interfacing) SO5.6 Explain Interfacing of Analog I/O devices program (Analog I/O Interfacing). SO5.7 Overview of Graphical Interface unit of Scilab-Xcos	LE5.1 Write a program for blinking LED. LE5.2 Write a program to switch LED with respect to state of button. LE5.3 Write a program to print Binary Up/Down counter using LED's LE5.4 Write a program to control LED with computer command LE5.5 Write a program to print "HELLO WORLD" in LCD LE5.6 Interface LM35 temperature sensor with Arduino and monitor temp. on serial monitor LE5.7 Interface a light dependant resistor for controlling the intensity of light using Arduino and Xcos	**Unit 5.0 Arduino like open source board control using SciLab** **5.**1 Introduction to Arduino hardware i. Functions of each Pin of Arduino ii. Basic Circuit For Arduino 5.2 Introduction to Arduino software i. Programming of an Arduino (Arduino ISP) ii. Arduino Boot loader iii. Initialization of Serial Port using Functions 5.3 Interfacing of sensors with Arduino 5.4 Serial Communication between Arduino and SciLab	• Make a market on the different types of digital and analog sensors.

Legend:CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning

SW-5 Suggested Sessional Work (SW):

- **Assignments:**
  i. Design a system to show case zoom-in/zoom-out effect using LED's

ii. Design a system to print the string in LCD where input would be supplied by the computer on real time.

- **Mini Project:**

  i. Develop a project to switch ON a Light with respect to the existing ambient light of the room.
  ii. Develop a project to control room temperature with respect to provided set temperature

- **Other Activities (Specify):**

  i. Write a program to change LED pattern with respect to state of button.
  ii. Monitoring temperature of a room using Arduino with SciLab

I) Suggested Specification Table (For ESA of Classroom Instruction): Not Applicable

J) Suggested Specification Table (For ESA of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Open the new EDA file/project and save at the given place.	50	40	10
LE1.2	Copy the available code/file and make the changes in the circuit by changing component values.	50	40	10
LE1.3	Connect one or more source and discrete components and complete the circuit in the circuit window.	50	40	10
LE1.4	Connect the resistors in series and parallel combination and measure the current and voltages in the circuit using simulation tool.	50	40	10
LE1.5	Perform node and loop analysis of the given electrical network.	50	40	10
LE1.6	Perform analysis of a given electrical circuit by coding a program file using operators and conditional statements	50	40	10
LE2.1	Simulate and test the integrator circuit.	50	40	10
LE2.2	Simulate and test the differentiator circuit.	50	40	10
LE2.3	Simulate and test the clipper and clamper circuit.	50	40	10
LE2.4	Simulate and test the comparator circuit for two DC input signal.	50	40	10
LE2.5	Simulate and test the half wave and full wave rectifier.	50	40	10
LE2.6	Simulate and test the actable multivibrator circuit contain the timer IC.	50	40	10
LE2.7	Simulate and test the bistable multivibrator circuit contain the timer IC.	50	40	10
LE2.8	Simulate and test voltage regulator circuit contains 7805 IC.	50	40	10
LE3.1	Test the functions of various logic gates.	50	40	10
LE3.2	Test the functions of various FF.	50	40	10
LE3.3	Simulate and test half adder circuit.	50	40	10
LE3.4	Simulate and test full adder circuit.	50	40	10
LE3.5	Simulate and test four-bit parallel adder circuit.	50	40	10
LE3.6	Develop a 4-bit parity generator circuit.	50	40	10
LE3.7	Simulate a Mod-10 up counter.	50	40	10
LE3.8	Test the functions of shift register.	50	40	10
LE4.1	Use program file to plot the inductance of a magnetic circuit as a function of the core permeability	50	40	10
LE4.2	Use program file to plot the efficiency of a given transformer as function of the load current	50	40	10
LE4.3	Use program file to plot the variation of speed of a given DC	50	40	10

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (% Marks)		
		Performance		Viva-Voce
		PRA	PDA	
	motor operating in constant i. Torque region ii. Power region			
LE4.4	Use program file to plot the rotor speed of a three-phase slip ring induction motor with varying rotor resistance and constant load torque.	50	40	10
LE4.5	Use program file to plot the armature current versus field current for a synchronous motor.	25	20	05
LE4.6	Use program file to determine the fault current for given parameters of a three-phase power system network.	25	20	05
LE5.1	Develop a series R-L-C circuit and analyze the relationship of V and I waveform in under damped, critically damped and over damped condition	25	20	05
LE5.2	Develop a half wave controlled rectifier circuit with R load and analyze the voltage and current waveform across load.	25	20	05
LE5.3	Develop a half wave controlled rectifier circuit with R-L load and analyze the voltage and current waveform across load with and without freewheeling diode.	25	20	05
LE5.4	Develop a full wave controlled rectifier circuit with R-L load and analyze the voltage and current waveform across load.	25	20	05
LE5.5	Develop a type E chopper circuit and analyze output voltage and current waveform.	25	20	05
LE5.6	Simulate PWM circuit and observe the output for the different input modulating signals.	25	20	05

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
7	Modeling and Simulation using Matlab and Simulink	Jain, Shailendra	Wiley India	2011, 2nd edition ISBN: 9788126551972
8	Programming in Matlab, Aproblem solving approach	Mittal, Ankush Patel; R. N., Mittal	Pearson Education India	2014, 1st edition ISBN: 9789332524811
9	Microcontroller Experiments through Arduino Scilab & Xcos	Manas Ranjan Das	Shroff Publishers and Distributors	2017,1st Edition ISBN: 9789352130870
10	Electronics Devices and Circuit Theory	Boylestad, Robert L.	Pearson Publication, New Delhi	2015, 11th edition, ISBN: 9789332542600
11	Getting Started with Arduino: The Open Source Electronics Prototyping Platform	Banzi, Massimo ;Shiloh, Michael	Shroff/Maker Media	2014, 3rd edition, ISBN: 978-1449363338

(b) Open source software and website address:

1. https://en.wikipedia.org/wiki/Electronic_design_automation
2. https://www.oreilly.com/library/view/...design/.../0131828290_ch01lev1sec3.html
3. Open source EDA tool for circuit simulation: - www.esim.fossee.in
4. Tutorial for e-sim software: - esim.wikia.com/wiki/Tutorial_the_basics_of_e-sim
5. Scilab software: - www.scilab.org/download/latest
6. Scilab tutorial: -www.scilab.org/resources/documentation/tutorial
7. Tina software official website: - https://www.tina.com
8. Tina software tutorial: -https://www.tina.com/tutorials
9. LT spice software: -http://www.linear.com/designtools/software/#LTspice
10. Open source hard ware project: - http://www.electronics-lab.com/downloads/circutedesignsimulation/?page=5 /
11. Circuit Logix software: -https://www.circuitlogix.com/student_version.ph
12. Spectrum software: - www.spectrum-soft.com/
13. Free e-book: -www.talkingelectronics.com/projects/...1A/BasicElectronics-1A_Page1.html
14. https://www.arduino.cc
15. https://scilab-arduino.fossee.in

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Desktop computers	Processor: Intel Core i7-2600 Processor, 3.4GHz, 8 GB RAM. 8M Cache Operating system: Windows 7 Professional 64 - English, with latest service pack System Recovery DVD: Genuine Windows 7 Professional 64 - Recovery DVD, Video adapter, Integrated Video Intel Audio adapter: & Burner Software), Pointing device: Optical Mouse with Scroll Button, Speakers: Internal speaker Power cord: Line Cord – Monitor: 22 inches wide LCD monitor with Install-Ready	All

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		Security Cable Lock Hole Feature Security and Wi-Fi modem	
2	Laser printer	Print Speed: 33 ppm mono (A4) and above, Monochrome laser beam printing,Print Quality. Up to **1200** x **1200** dpi, Print Resolution. **600** x **600** dpi, Warm-up Time. Approx. 28 seconds or less from power on.Print Margins. 5 mm-top, bottom, left and right.	All
3	Modem/Wifi-modem	450Mbps and above wireless speed ideal for interruption sensitive applications like HD video streaming, three antennas increase the wireless robustness and stability, Easy wireless security encryption at a push of WPS button, IP based bandwidth control allows administrators to determine how much bandwidth is allotted to each PC	All
4	Internet connection	Broad band	All
5	Simulation tools like:	Multisim with floating license/SPICE/ /Matlab with floating license /Scilab	All
6	Projector and screen	Full HD resolution, White and colour light output at 2,500 lumens, Contrast ratio at 1,000,000:1, 4K enhancement technology, Ease of setup with motorised lens adjustment	All

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Install a given simulation tool/open source software and test its functionality on a simple electrical circuit.	2	2	3	3	1	2	2	3	2	3	3	3
C0.2 Use simulation tool to simulate the given electronic circuit.	1	3	3	3	1	1	1	3	2	3	3	3
CO-3 Use simulation tool to simulate the given digital electronic circuit.	1	3	3	3	1	1	1	3	2	3	3	3
CO-4 Use simulation tool to simulate the given electrical **machi**ne and power system circuit.	1	3	3	3	1	1	1	3	2	3	3	3
CO-5 Use C programming/open source software-SciLab to interface Arduino/open source board.	1	3	3	3	1	1	1	3	2	3	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO1 Install a given simulation tool/open source software and test its functionality on a simple electrical circuit.	SO1.1, SO1.2	LE1.1, LE1.2 LE1.3, LE1.4 LE1.5, LE1.6	Unit 1.0 Introduction to Simulation tool 1.1, 1.2, 1.3,1.4, 1.5,1.6	As mentioned
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO2 Use simulation tool to simulate the given electronic circuit.	SO2.1, SO2.2	LE 2.1, LE 2.2, LE 2.3, LE2.4, LE 2.5, LE 2.6 LE 2.7, LE2.8	Unit 2.0 Basic Electronic Circuit Simulation 2.1, 2.2, 2.3	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO3 Use simulation tool to simulate the given digital electronic circuit.	SO3.1 SO3.2 SO3.3	LE3.1, LE3.2, LE 3.3, LE3.4, LE3.5, LE3.6 LE 3.7, LE3.8	Unit 3.0 Digital Circuit Simulation 3.1, 3.2, 3.3, 3.4	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO4 Use simulation tool to simulate the given electrical machine and power system circuit.	SO4.1,SO4.2 SO4.3,SO4.4 SO4.5,SO4.6	LE4.1, LE4.2, LE4.3, LE4.4, LE4.5, LE.4.6	Unit 4.0 Electrical Machine and Power system simulation 4.1, 4.2, 4.3,4.4, 4.5,4.6	
PO 1,2,3,4,5,6, 7,8,9,10 PSO 1,2	CO5 Co-5 Use simulation tool to simulate the given power electronic circuit. Use C programming/open source software-SciLab to interface Arduino/open source board.	SO5.1 SO5.2 SO5.3	LE5.1, LE5.2, LE5.3, LE5.4, LE 5.5	Unit 5.0 Arduino/open source board control using SciLab 5.1, 5.2,5.3,5.4	

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in Laboratory, Workshop, field or other locations using different instructional strategies) SL: Self Learning.

A) Course Code : 2024566(024)

B) Course Title : Industrial Training

C) Pre- requisite Course Code and Title : Industrial Visit, Industrial Training and Internship

D) Rationale :

With the advancement in technology and industry, we need to prepare our young Indian technical talent to meet the present demand. Our diploma passouts are either supposed to work as supervisor in the industries or start their own enterprise, hence upon the completion of diploma programme, they need to be adequately equipped with knowledge, skills and attitude required by the world of work in their relevant field. To attain this, students need to be sent for industrial visit and industrial training during the course of study. With these provision of industrial exposures relevant practical and professional skills are developed in the students and as a result of this students are readily employed and widely accepted by cross section of the industries, even sometimes during such training itself.

Series of continues interactions with the industry personnel are required to be done for planning and arranging and also effectively implementing such exposures.

E) Course Outcomes: After undergoing the industrial visit, industrial training and internship the students will be able to -

CO-1 Appreciate the importance of industrial visit, industrial training and internship for gaining direct practical skills on their relevant domain area.

CO-2 Comprehend the comprehensive view of industry or world of work in terms of its layout, management, culture, hierarchy, discipline, safety norms, different department/sections, quality control/assurance in processes, services and products, demonstration and operation of specific equipment/machinery, rules and procedures etc.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)				
				L	P	T	SL	Credit L+T+(P/2)
1.	Electrical Engineering	2024566 (024)	Industrial Training	-	2	-	2	1

Legend: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others), LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) SW: Sessional Work (includes assignment, seminar, mini project etc.), SL: Self Learning, C:Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No	Board of Study	Course Code	Course Titles	Scheme of Examinations					
				Theory			Practical (PRA+ PDA+ Viva)		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Electrical Engineering	2024566 (024)	Industrial Training	-	-	-	30	40	70

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: i. Separate passing is must for Progressive and End Semester Assessment.
ii. Separate passing is must for Classroom Assessment (Theory) and Laboratory Assessment (Practical).

Guidelines to teachers for Industrial Visit, Industrial Training and Internship are given below:

H) Guidelines to Teachers for arranging Industrial Visit :

1. Rationale :

During implementation of the curriculum, industrial exposure in the form of industrial visit is very important for developing and reinforcing many concepts and principles and also to get an idea to understand the industrial environment, working culture and latest developments in relevant field and many other aspects of the industries, where diploma holders are going to be absorbed. Students also get exposed to the different kinds of problems which can be brought into the institutional laboratories or workshop. Planning before industrial visit and Industrial tour is essentially required to be done or effective implementation of the same.

2. Planning for industrial visit :

During industrial visit of students to develop certain expected outcomes, many dimensions or aspects of industries need to be understood. The major dimensions or aspects of industry's visit which may be taken care of during the industrial visit are as below –

- Layout of different Departments, Sections of Industry, stores, entry and exit etc.

S.N	Major Dimensions /Aspects of Industrial Visit
I.	Layout of different Departments, Sections of Industry, stores, entry and exit etc.
II.	Display of Quotations in the Industry
III.	Display of Charts on - • Systems of Industry • Procedures/Rules/standards • Hierarchy at Industries • Products & Services • Targets • Safety Precautions/Norms • Flow diagrams of different process • Other Aspects
IV.	Demonstration of Specific Equipment, not available in the Institute or Department or even the Demonstration of Performance of Specific Experiment.
V.	Demonstration of latest Engineering Tools or Techniques or Software's or Procedures

Assessment rubric may be prepared by the implementing teachers in advance for assessing the students on various dimensions of industrial visit.

3. Major outcomes expected to be attained and assessed :

Outcomes expected from the industrial visit should be clearly defined and briefed to the students. Evaluation criteria for assessing students need to be prepared for different outcomes set, during the planning stage. The list of major outcomes expected to be attained are –

- Development and reinforcement of Basic knowledge
- Development and reinforcement of Engineering knowledge through reinforcement of concepts or principles
- Outcome attainment through content beyond syllabus
- Engineering and Society

- Environment & Sustainability
- Communication ability
- Industrial System and its development
- Safety Awareness
- Systematic Operations and Productions
- Quality control
- Management of work place and work force
- Development of positive attitude
- Work culture/Quality Culture
- Development of Professional Ethics
- Industrial Management
- Systematic planning, Implementation & Evaluation
- Use of engineering tools, techniques, softwares and Procedures
- Development of Lifelong learning skills

It is important to note that outcomes attained during industrial visit are at the awareness level only.

I) Guidelines to Teachers for arranging Industrial Training :

1. Rationale :

Apart from arranging industrial visit, organizing industrial training of students is essentially required to be done during implementation of the curriculum to improve the quality of our young diploma engineering students and to enhance the prospects of employability, After undergoing industrial training, students get the direct exposure to the world of work in their relevant field. They get hands on experience in the industries. The need to be given opportunity to undergo training in relevant industry for minimum two weeks and it is recommended that it should be mandatory for all the programmes running in the institute. The industrial training period may vary from 2 weeks to 6 months depending upon the requirement of that programme. The programmes, where there is provision of industrial training during the semester are termed as sandwich programmes. Many of the programmes have industrial training at the end of last semester or sometimes a full semester is dedicated for industrial training.

2. Planning for Industrial Training :

Following points need to be planned and briefed by the teachers to the students before proceeding for industrial training. Student should take into consideration these points and carry the relevant format/data/log book with them.

- Objectives /Purposes of the industrial training
- Outcomes targeted before proceeding to industrial training.
- Pre-requisite knowledge or skills required to be developed in the students in the form of demonstration or classroom sessions.
- Identification and planning for demonstration of any equipment or experiments, concepts, under the content beyond syllabus.
- Preparation of database of nearby relevant industries.
- Good rapport need to be developed and maintained with the industries by the teachers, so that the students are ultimately benefitted by the industrial training.
- Industrial policy of the state also need to be taken care of while planning of industrial training
- For assessing the students on various dimensions of industrial training, assessment rubric may be prepared by the implementing teachers in advance.

- Following formats need to be developed by the teachers and briefed to the students before proceeding to industrial training –
  - Formats of observations on layout, ambience, and work culture to be developed, and briefed to the students.
  - Formats of outcome attainment, related to observation on relevant technical area also need to be developed by the teachers and briefed to the students.
  - Formats and contents of report writing and presentation.
  - Formats and contents on assessment of industrial training.
  - Continuous observation formats on many points such as behavioral aspects related to soft skills development such as initiativeness, observation, notes taking skills, inquisitiveness, obedience, sincerity, follow the instructions, positive attitude and many other aspects.
  - Formats of Assessment Rubric on different parameters of both behavioral aspects and technical aspects of the programme.

3. Actions to be taken by the Students and Teachers :

Students are sent to Industrial training after briefing on various aspects. During industrial training, observational skills in students are required to a great extent -

- Students need to be alert, meticulous and record the data, as briefed to them before the industrial training.
- Record of observations on safety precaution to be followed, any special point during performance and handling of equipment, performance on technical aspects and other related aspects need to be taken care of.
- Continuous observation, monitoring and assessment on various behavioral and performance of technical aspects of each student need to be critically observed and recorded by the teachers using different assessment tools.

4. Post Training Assessment :

The students need to be assessed on report writing, presentation and interpretation of data recorded, on various dimensions, planned and performed, after the industrial training. The actions are required to be taken for assessment during report writing, analysis, interpretation, presentation of data and its assessment.

5. Major outcomes expected to be attained and assessed :

The following learning outcomes are expected to be developed during the industrial training. This will lead to attainment of COs, POS and PSOs.

- Development and Reinforcement of Basic Knowledge/concepts
- Development and Reinforcement & Engineering Knowledge i.e operations, performance, maintenance, demonstrations of specific skills relevant to the content of the programme.
- Experiment and practice – Development of experimental practical skills and technical skills relevant to the course programme.
- Development of learning to learn skills and life long teaching skills for latest advancement in technology.
- Development of positive attitude, professional ethics and etiquettes.
- Development of skills for individual and team work during performance and otherwise.
- Maintaining Business Secrecy
- Development of Communication Skills
- Ability to follow the instructions
- Ability to follow the safety precautions
- Ability to supervise the task

- Ability to coordinate with subordinates and higher ups
- Development of Interpersonal skills
- Environmental Consciousness and Sustainability
- Development of Observational Skills
- Time Management
- Self discipline
- Integrity
- Development of generic skills such as pro-activeness, commitment
- Development of Problem Solving abilities
- Achievement of target

J) Guidelines to Teachers for arranging Internship :

1. Rationale :

The concepts of internship is the need for the development of outcomes based in the students. It encourages on the job-training, practice, feedback and reinforcement of concepts and principles. During internship students are exposed to variety of task/problems/assignments which enhances the exposure of students to cross section of different real situations. Continuous feedback on the job helps in sharpening of the outcomes to be attained in the relevant field.

2. Planning for Internship :

The advantages of providing internshala platform to the students are enormous. Some of these are :

- Free access to 4^{th} Lakhs internships (both part-time and full time).
- A chance to earn a certificate and a stipend.
- Additional 10% discount on all Internshala training to students.
- The T&P official of every college will who receive a monthly performance report of their students on Internshala.
- Once the institutions are registered with the Internshala. Registration is done through the website internshala.com/i/register-rgpv. Details of students (name, e-mail & phone no.) are uploaded in an excel sheet. Internshala will create an account for all the students so that they can apply for internship. The registration is free of cost.

For assessing the students on various dimensions of internship, assessment rubric may be prepared by the implementing teachers in advance

3. Major outcomes expected to be attained and assessed :

The following learning outcomes/skills are expected to be developed through internship. This will lead to attainment of COs, POS and PSOS.

- Development and Reinforcement of Basic Knowledge/concepts
- Development and Reinforcement & Engineering Knowledge i.e operations, performance, maintenance, demonstrations of specific skills relevant to the content of the programme.
- Experiment and practice – Development of experimental practical skills and technical skills relevant to the course programme.

- Development of learning to learn skills and lifelong teaching skills for latest advancement in technology.
- Development of positive attitude ethics values and etiquettes.
- Development of skills for Individual and Team work during performance and otherwise.
- Maintaining Business Secrecy
- Development of Communication Skills
- Ability to follow the instructions
- Ability to follow the safety precaution
- Ability to supervise the task
- Ability to coordinate with subordinates and higher ups
- Development of Interpersonal skills
- Environmental Consciousness and Sustainability
- Development of Observational Skills
- Time Management
- Self discipline
- Integrity
- Development of generic skills such as pro-activeness, commitment
- Development of Problem Solving abilities
- Achievement of target

K) Initiatives by Govt. of India and other Agencies :

1. Initiatives by Govt. of India, GOI

a. Initiatives by Ministry of Skills Development and Entrepreneurship

Many efforts are initiated by different agencies in this direction as per our Prime Minister's Skills Development Mission. Make in India, Skills India etc are such initiatives taken by ministry for the benefit of the students.

b. Initiatives by Ministry of HRD, Govt. of India

I. Ministry of HRD, Government of India is providing students a platform to inculcate a culture of product innovation and a mindset of problem solving to solve some of pressing problems solving to solve some of pressing problems we face in our daily lives through Smart India Hackathon (SIH) 2019.

In SIH-2019, the students would also have the opportunity to work on challenges faced within the private sector organizations and create world class solutions for some of the top companies in the world, thus helping the private sector hire the best minds from across the nation. The team size for participation in one team will be 8 (6 Students + 2 Mentors). 50 Teams will be selected for the final Hackathon. The prize will be a cash prize for each rank with following distribution criteria for the top three teams ranging from Rs. 50,000 to 1,00,000/-.

II. **Internshala :** Internshala is India's largest internship and training platform where more than 80,000 companies look for interns in various profiles (Engineering, management, media, arts etc.) AICTE has also partnered with Internshala for providing internship opportunities to every students in AICTE approved colleges. This facility is created to provide a platform for hands on experience to the our future technicians on the

relevant industries. With this experience, they are updated with the latest advances in their field of work.

Government of India through, AICTE is engaged in promoting the concept of industrial training through its various scheme, such as Internshala. The teachers now have the responsibility to understand in depth and implement such schemes in the institution for the benefit of students. At institute level also, there is need to develop policy for sending the students for industrial training.

c. Initiatives by Ministry of Labour and Employment, Govt. of India

Ministry of Labour and Employment, Government of India launched a National ICT based job portal known as National Career Service (NCS) portal to connect the opportunities with the aspirations of youth. This portal facilitates registration of job seekers, job providers, skill providers. Career counselors, etc. The portal provides job matching services in a highly transparent and user friendly manner. These facilities along with career counseling content are delivered by the portal through multiple channels like career centres, mobile devices, CSCs, etc.

The portal provides information on over 3000 career options from 53 key industry sectors. Job seekers also have access to industry trends in a user friendly way. The NCS portal links job-seekers, employers, counselors and training providers all through Aadhaar-based authentication. Registration to NCS portal is online and free of charge. The salient feature of NCS portal includes the following :

- Career counseling and Guidance
- Enabling Skill Development
- Empowering Job seekers to find the right Job
- Enabling employers to pick the right talent
- Enhancing capabilities of students through training

Information's related to Job Fairs/Placements

d. Initiatives by Telecom Sector Skill Council (TSSC)

TSSC has taken a step towards fulfilling the emerging requirements of the industry by partnering with key stakeholders in order to bring the latest content to the forefront. TSSC have got into partnership with All India Council for Technical Education (AICTE) for summer internship programme and various other MNCs to impart Skilling in new emerging technologies. Some of the prime courses in new emerging technologies being offered by TSSC in addition to TSSC Qualification packs are as under :

- Artificial Intelligence & Data Science
- Cyber Security
- Internet of Things
- Android
- AR/VR

In addition to this certain courses on life skills/soft skills, employability related skills are also planned for the students such as

- Problem solving and analytic
- Communication skills
- Lifelong learning
- Behavioral Skills
- Professional Behavioral etc.

The main objectives of TSSC are as follows

- Bridge the gap and enhance employability of our students
- Training young minds towards 21st Century skills assisting industry cross-sector
- Meet the needs of school leavers and graduates, employers, government educational institutions and society.

- Address the need for quality, skill training for human resources to complement the large goal of accomplishing the include growth.
- Address the limited capacity of skills development facilities in India
- To develop extensive placement linkages with employers in all sectors to provide gainful entry-level employment opportunities to youth undergoing the skill training.
- Industry participation in developing the skill training solutions to address critical skill gaps by standardization of training content, delivery and assessment process o improve overall competitiveness of the industry.

2. Initiatives by other agencies

a. Initiatives by Engineering Council of India (ECI)

(ECI has also taken initiatives to organize series of interactive workshops to update and apprise the students about the products and services being offered by respective corporate house. This interaction will definitely bring the institute and industry closer and help in planning for effective implementation of industrial training.

b. Others

Many public sector and private organizations are also contributing to the course of quality improvement in technical education system by way of arranging industrial visit of providing industrial training to the students as a part of their corporate social responsibility and also for the growth of technical education system of the country.

L) Initiatives to be taken by State Technical University/Board/Institutions.

- State Technical University/Board have to sign MOU with Internshala, partner of AICTE, with the aim of providing students with professional experience in the form of internship. For registration of students at college level for Internshala platform, visit of website address internshala.com/i/register-rgpv is suggested for uploading the details (Name, e-mail address &phone number compulsory) in an excel sheet. Internshala will create an account for all the students so that they can apply for internship. The registration is free of cost.
- Programme wise Industries Bank of nearby industries at state level and national level need to be created for useful interaction with details of content e-mail addresses phone numbers and areas of expertise.
- Institute may take initiative to facilitate the registration of students at National Career service (www.ncs.gov.in) portal and ensure the compliance of above directive in your institute.
- Institute should encourage and facilitate the registration of team of students for Smart India Hackathon-2019 at www.sih.gov.in portal and other similar websites.
- After careful curriculum analysis and also identifying the learning gaps, an action plan for effective implementation of the course need to be prepared based on the area of industries. This would help the teachers to decide the particular industry to be visited for exposing to specific content area or specific outcomes to be attained.
- Frequent Industry – Institute meet may be arranged on different topics for mutual benefit.
- List of a directory of industrial experts may be prepared for inviting them for seeking their expertise.
- Guidelines/policy for sending students to industrial training/internship must be prepared by the university for effective implementation of the industrial training/internship.
- TOT programmes on orientation of arranging industrial visit, training should be arranged for teachers implementing the same.

- MOU between University and Industry need to be signed for -
  - Industry collaboration for student/faculty empowerment
  - Partnership with industry on curriculum implementation.
  - Demonstrating and performing practical performances to students.
  - Providing technical work force for industrial production.
  - Corporate support to Academia through various resources.
- Establishment of training and placement cell at each institute level.
- Employability Enhancement initiatives need to be taken by CSVTU for arranging campus placement at CSVTU level/institute level or through open campus.

M) References:

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