GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: WIRING ESTIMATING, COSTING AND CONTRACTING
(COURSE CODE: 3350901)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Electrical wiring plays a major role in distributing the electrical energy from electric utilities to consumer. Electrical diploma holders have to work as Technicians and Supervisors for planning, installing and testing various electrical wiring Installations such as residential, commercial and Industrial electrification schemes. They should be able to prepare costing and estimates for these schemes with a thorough understanding of the methods/procedure of estimating, tendering/ contracting is desired. Knowledge of IE rules for different types of electrical Installation, their planning considerations equips the students with the capability to plan and prepare different Installation projects. Essential efforts are made in this course to develop above skills in the students.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Carry out wiring estimating, costing and contract of various types of installations.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Prepare an estimate of quantity and cost of the material for a electrical project following IE Act-2003.
ii. Prepare detail estimate and costing of Residential and commercial Electrical Installations following IE Act-2003.
iii. Test Residential, commercial and Industrial Electrical Installation following IE Act-2003.
iv. Prepare detail estimate and costing of a transmission line/Overhead and underground distribution project following IE Act-2003.
v. Prepare estimates for repairs and maintenance of electrical devices and equipment.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (outcomes in Cognitive Domain)	Topics and Sub-topics
Unit – I Electrical Wiring and IE Rules	1a. Differentiate between different types of wiring system 1b. List the applications of different types of wiring tools 1c. Troubleshoot different types of wiring circuits 1d. Explain the IE rules of wiring	1.1 Types of wires, wiring system. 1.2 Specifications of Different types of wiring materials, Accessories 1.3 Wiring tools. 1.4 Wiring circuits. 1.5 Domestic and industrial panel wiring. 1.6 I.E. rules for wiring, IE Act-2003.
Unit– II Estimating, Costing and Contracting	2a Classify types of estimation and estimation tools 2b Describe Purchase procedure 2c Explain the types of contracts and contractors. 2d Explain the concept of contracts and Tenders 2e Explain the procedure for submission and opening of tenders. 2f Explain the principles of Execution of works 2g Explain the procedure for Billing of executed work	2.1 Estimation and estimation tools. 2.2 Electrical Schedule of rates, catalogues, Survey and source selection, Recording estimates 2.3 Quantity and cost of material required. 2.4 Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills 2.5 Types of contract system. 2.6 Tendering procedure and preparation of simple tender, Earnest Money Deposit, Security Deposit 2.7 Schedule of rates (S.O.R.)
Unit– III Estimating and Costing of Domestic and Industrial Wiring	3a. Prepare Layout and wiring diagram for domestic wiring. 3b. Calculate the Load, quantity and cost of material required for domestic wiring.	3.1 Layout for domestic Wiring, 3.2 Load calculation 3.3 Cable selection 3.4 Earthing 3.5 Selection of switchgear. 3.6 Overall Estimating and costing

Unit	Major Learning Outcomes (outcomes in Cognitive Domain)	Topics and Sub-topics
	3c. Prepare Layout and wiring diagram for industrial wiring. 3d. Calculate the Load, quantity and cost of material required for industrial wiring.	3.7 Layout for domestic Wiring, 3.8 Load calculation 3.9 Cable selection 3.10 Earthing 3.11 Selection of switchgear. 3.12 Overall Estimating and costing
Unit– IV Estimation of Overhead Transmission Line, and Underground Distribution System	4a. Sketch layout of transmission line with specifications 4b. Prepare plan of transmission line project work. 4c. Determine main components and specification of transmission line. 4d. Estimate quantity of material and cost required for a transmission line project work.	4.1 Transmission lines, Line supports, Factors governing height of pole, 4.2 Conductor materials, size of conductor for overhead 4.3 Transmission line: cross arms, pole brackets and clamps, guys and stays, conductors configuration spacing and clearances, span lengths, overhead line insulators, insulator materials lightning arrestors, erection of supports, setting of stays, 4.4 Earthing of lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between supports conductors, 4.5 I.E. rules pertaining to LV Transmission lines
	4e. Draw layout of overhead distribution line. 4f. Prepare plan of overhead distribution project work. 4g. Determine main components and specification of overhead distribution system. 4h. Estimate quantity of material and cost required for a overhead distribution project work. 4i. List Types of service connections	4.6 Describe Method of installation of service connection(1-phase and 3-phase), observing I.E. rules 4.7 Overhead distribution system. 4.8 Materials and accessories required for the overhead distribution system. 4.9 Estimate for 440 V, 3-phase, 4 wires or 3 wires overhead distribution system. 4.10 Types of service connections 4.11 Method of installation of service connection(1-phase and 3-phase), 4.12 I.E. rules pertaining to overhead lines and service connection
	4j. Draw layout of underground distribution system. 4k. Prepare plan of underground distribution project work. 4l. Determine main components and specification	4.13 Underground distribution system. 4.14 Materials and accessories required for underground distribution system. 4.15 Estimate for 440 V, 3-phase, 4 wires or 3 wires underground distribution system. 4.16 I.E. rules pertaining to underground system and service

Unit	Major Learning Outcomes (outcomes in Cognitive Domain)	Topics and Sub-topics
	of underground distribution system. 4m. Estimate quantity of material and cost required for a overhead distribution project work.	connection.
Unit-V Estimating and Costing of Repairs and Maintenance of Electrical Devices and Equipment	5a Survey market for cost of products and parts. 5b Prepare drawing of products 5c Prepare cost table for new product 5d Prepare cost table for repair and maintenance of electric fan, automatic electric iron, single phase transformer, mixer grinder, D.O.L. Starter. 5e List Tools used for repairs & maintenance work	5.1 D.O.L. starter, small motor, mono block pump, automatic electric iron, table/ceiling fan, ICDP/ICTP Switch, etc. 5.2 Preparation of detailed drawing work of the product. 5.3 Preparation of material quantity sheet for the product. 5.4 Materials and cost required for maintenance work. 5.5 Estimation of repairing cost and overall cost. 5.6 Tools used for repairs & maintenance work Preparation of cost schedule for repair and maintenance of electric fan, automatic electric iron, single phase transformer, mixer grinder, D.O.L. Starter.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Electrical Wiring	6	04	04	02	10
II	Elements of Estimating and concepts of contracting.	6	04	04	02	10
III	Estimating and Costing of Domestic and Industrial Wiring	8	04	05	06	15
IV	Estimation of Transmission line, Overhead and Underground Distribution System	14	05	10	10	25
V	Estimating and Costing of Repairs and Maintenance of Electrical Devices and Equipment	8	02	04	04	10
	Total	**42**	**19**	**27**	**24**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	**Unit No.**	**Practical/Exercises** (outcomes in psychomotor domain)	**Approx. Hrs.**
1	I	Undertake following wirings a. Tube light wiring b. Stair case wiring c. Go down wiring d. Parallel loop wiring.	4
2	I	Select appropriate wiring and list materials and accessories for given project	2
3	II	Prepare a tender notice for given project work	2
4	III	Prepare cost estimate of a domestic installation cost (Residential building, laboratory room or Drawing hall etc).	4
5	III	Prepare cost estimate of an industrial installation. (workshop, agriculture, flour mill, etc.)	4
6	IV	Prepare cost estimate of an overhead service connection. (single phase and three phase).	4
7	IV	Prepare cost estimate of an underground service connection (single phase and three phase).	4
8	IV	Estimate of material and specifications required for 220kV/110kV Transmission line.	4
9	IV	Estimate of material and specifications required for overhead, 440 V, 3-phase, 4 wire or 3 wire distribution line.	4
10	V	Estimate of material and specifications of any one Electrical Product	4
11	V	Estimate of material and specifications of repairs and maintenance of any one domestic appliance	4
Total Hours (perform any practical worth 28 hours from above depending upon the availability of resources so that most units are covered)			**40**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on solving numericals
iii. Reads drawing of electrical installation and calculates quantity of material required for various electric installation and power projects
iv. Writes specifications and selection of the material required for various electric projects.
v. Checks bills of contractor (s) for payment by referring schedule of rates described by electricity authorities.
vi. Survey and collect rates for various items of works.
vii. Gather Electrical work tender notices from news paper and read and interpret it.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Field / industrial visit

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Electrical Design, estimating & Costing	Raina, K. B. and Bhattacharya,S.K.	New Age International (p) Limited, New Delhi
2.	Electrical Estimating & costing	Uppal, S L	New Age International (p) Limited, New Delhi
3.	Electrical Installation Estimating & Costing	Gupta, J.B.	S. K. Kataria & Sons, New Delhi
4.	Relevant IS Code for-service line connection, laying of cable, wiring installation	NBC	National Building Code-Vol. IV
5.	I.E. rules for wiring, Electricity supply act-1948.	Bureau of Indian Standards	Electricity supply act-1948.

B) List of Major Equipment/ Instrument with Broad Specifications

i. Different wiring Tools and wiring material – 1 Set
ii. DOL starter – 1 No.
iii. Star delta starter – 1 No.
iv. Auto transformer starter – 1 No.
v. Monoblock pump – 1 No.
vi. Automatic electric iron – 1 No.
vii. Table/ceiling fan – 1 No.
viii. ICDP/ICTP – 1 No.
ix. Automatic electric iron, – 1 No.
x. Single phase transformer – 1 No.
xi. Mixer grinder – 1 No.

C) List of Software/Learning Websites

i. www.vlab.com
ii. www.nptel.iitm.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. V. R. Kotdawala,** Lecturer in Electrical Engineering, Government Polytechnic, Himatnagar
- **Prof. A. A. Amin**, Lecturer in Electrical Engineering, Government Polytechnic, Vadnagar.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. Walkey, A.S** Associate Professor, Department of Electrical and Electronics Engineering,
- **Dr. Joshua Earnest,** Professor, Department of Electrical and Electronics Engineering,

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ENERGY CONSERVATION & AUDIT
(COURSE CODE: 3350902)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

The consumption of energy is increasing day by day. One way to cope up with the increase in energy demand is to increase the production of energy which demands more investment and the other way is to conserve the energy because energy conserved/saved is energy generated. Energy conservation means reduction in energy consumption but not compromising with the quality or quantity of energy production. Essential theoretical and practical knowledge about the concept of energy conservation, energy management, different approaches of energy conservation in industries, economic aspects of energy conservation project and energy audit and measuring instruments in commercial and industrial sector will be achieved by this course.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Plan and supervise for conservation of electrical energy**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify the demand supply gap of energy in Indian scenario.
ii. Carry out energy audit of an industry/Organization.
iii. Draw the energy flow diagram of an industry and identify the energy wasted or a waste stream.
iv. Select appropriate energy conservation method to reduce the wastage of energy
v. Evaluate the techno economic feasibility of the energy conservation technique adopted.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	70	30	20	30	150

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (out comes in cognitive)	Topics and Sub-topics
Unit – I Elements of Energy Conservation and Management	1a. Explain general energy problem in India 1b. Identify the scope for energy conservation 1c. Explain the Concept of energy conservation and its benefits	1.1 General energy problem, Sector wise Energy consumption, demand supply gap, Scope for energy conservation and its benefits 1.2 Energy conservation Principle – Maximum energy efficiency, Maximum cost effectiveness
	1d. Explain Energy conservation act 2001 and with its Mandatory provisions and features	1.3 Mandatory provisions of EC act 1.4 Features of EC act-Standards and labeling, designated consumers, Energy Conservation Building Codes (ECBC)
	1e. Explain the concept of energy management and its objectives 1f. Describe the initialization and organizing energy management program	1.5 Energy management concept and objectives 1.6 Initializing Planning, Leading, Controlling, Promoting, Monitoring and Reporting. energy management programmes
Unit– II Energy Conservation Approaches In Industries	2a. Identify energy conservation opportunities in various electrical systems in industries 2b. List the energy saving opportunities in electric motors 2c. Explain conservation of energy achieved by improving pf and harmonics	2.1 energy saving opportunities in electric motors 2a. Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc., 2b. Effects of harmonics on – Motors, and remedies leading to energy conservation
	2d. Explain benefits of the listed methods and techniques aiding to conserve energy in lighting systems, heating and Cooling	2.3 Energy conservation by VSD 2.4 Methods and techniques of energy conservation in ventilation and air conditioners

Unit	Major Learning Outcomes (out comes in cognitive)	Topics and Sub-topics
	systems, Variable speed drive (VSD) ? 2e. State the energy conservation strategies in furnaces, ovens and boilers	- compressors pumps, fans and blowers - Area Sealing, Insulating the Heating / cooling fluid pipes , automatic door closing- Air curtain, Thermostat / Control 2.4 Energy conservation in electric furnaces, ovens and boilers
	2f. State the energy conservation strategies in electric lighting	2.5 lighting techniques – Natural , CFL, LED lighting sources and fittings
Unit– III Techno-economic Evaluation of Energy Conservation Option	3a. Describe circumstances that need capital investments for energy conservation in any plan 3b. Calculate the cost of energy conservation project 3c. Calculate the depreciation cost using sinking fund method 3d. Calculate the payback period for a given energy conservation equipment 3e. Evaluate a energy conservation project based on risk analysis	3.1 New equipment, technology, staffing, training 3.2 Calculation and costing of energy conservation project. 3.3 Depreciation cost, sinking fund method. 3.4 Cost evaluation by Return On Investment(ROI) and pay back method etc. 3.5 Risk analysis 3.6 Case study.
Unit– IV Energy Conservation in Power Generation, Transmission and Distribution:	4a. Identify scope of energy conservation in Generation 4b. Explain Demand side management and its significance in energy conservation Explain Energy conservation measures to optimize Transmission and distribution losses	4.1 Performance improvement of existing power plant: co-generation , small hydro ,DG Set 4.2 .Demand side management 4.3 Load response programmes 4.4 Types of tariff and restructuring of electric tariff Technical measures to optimize T and D losses
Unit– V Energy Audit	5a. Explain the concept of energy audit and its benefits 5b. Draw energy flow diagram to identify waste stream and energy wastage 5c. State the types of energy audits 5d. Describe the methodology for preliminary & detailed energy audit 5e. Describe energy audit report with a simple example 5f. Enlist the Measurements and	5.1 Energy audit and its benefits, 5.2 Energy flow diagram 5.3 Preliminary, Detailed energy audit. 5.4 Methodology of -preliminary energy audit and Detailed energy audit – Phase I, Pre audit, Phase II- Audit and Phase III- Post audit 5.5 Energy audit report. 5.6 Electrical Measuring Instruments - Power Analyser,

Unit	Major Learning Outcomes (out comes in cognitive)	Topics and Sub-topics
	measuring instruments used in energy audit 5g. Describe IE rules and regulations for energy audit Describe Electricity act 2003	Combustion analyzer, fuel efficiency monitor, thermometer-contact, infrared, pitot tube and manometer, water flowmeter, leak detector, tachometer and luxmeter 5.7 IE rules and regulations for energy audit Electricity act(Numerical)

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Elements of Energy Conservation And Management	08	02	03	03	08
II	Energy Conservation Approaches In Industries	16	06	08	04	18
III	Technoeconomic Evaluation of Energy Conservation Option	12	05	05	06	16
IV	Energy Conservation In Power Generation, Transmission And Distribution	10	04	06	04	14
V	Energy Audit	10	06	02	06	14
	Total	**56**	**23**	**24**	**23**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The tutorial/practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills **(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this program. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain*

Following is the list of experiments for guidance.

S. No.	Unit No.	Practical Exercises (Major Outcomes in psychomotor domain)	Hrs. required
1	I	List various energy management systems prevailing in a particular industry/Organization	2
2	I	Identify the energy management skills and strategies in the energy management system	2
3	I	Organize a energy management programme in a given industry	4
4	II	List the various energy conservation methods useful in a particular industry	2
5	II	Identify the critical areas where energy conservation is required	4
6	II	Select appropriate energy conservation method for the critical area identified	4
7	III	List the various energy conservation methods useful in power generation, transmission and distribution	2
8	IV	Find out the payback period for a given energy conservation equipment	4
9	IV	Determine depreciation cost of a given energy conservation project/equipment	4
10	V	Draw the energy flow diagram for a industry/shop floor division	4
11	V	Identify various measuring instruments used for energy audit	4
12	V	Use various measuring instruments for carrying out energy audit	4
13	V	Prepare a sample energy audit questionnaire	2
14	V	Prepare a energy audit report	2
15		Prepare a technical report on energy conservation act 2003	2
16		Prepare a technical report on ECBC	2
Total (perform any practical worth 28 hours from above depending upon the availability of resources so that most units are covered)			**48**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities:

i. Assignments on solving simple numericals

ii. Prepare a report based on a survey of at least two nearby industries on energy conservation measures adopted by them using questionnaire

iii. Carry out a survey on internet and prepare a report on energy conservation act and ECBC

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Carry out detailed energy audit of your Institute or any other official building.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Electric Energy Generation, Utilisation and Conservation	Sivaganaraju, S	Pearson, New Delhi, 2012
2.	Electrical Power	V. K. Mehta	Khanna and Khanna Publishers, New Dehli
3.	Electrical Power	S. L. Uppal	Khanna and Khanna Publishers, New Dehli
4.	Art and Science of utilization of Electrical Energy	H. Partab	Dhanapat Rai and Sons, New Dehli
5.	Prasanna Chandra	Project Management	Tata Mcgraw Hill, New Delhi
6.	Prasanna Chandra	Financial Management	Tata Mcgraw Hill, New Delh
7.	Wayne C. Turner	Energy Management Handbook	-
8.	Paul O Callaghan	Energy management	Mcgraw Hill, New Delhi
9.	www.bee-india.com	Fundamentals of electrical system	Bureau of Energy Efficiency

B) List of Major Equipment/ Instrument with Broad Specifications

Sl. No.	Measuring instruments
1.	Anemometer
2.	Lux Meter
3.	Power Analyzer
4.	Turbine Flow Meter
5.	Thermometer (Contact / Non-contact type)
6.	Tachometer (Contact / Non-contact type)
7.	Pressure Gauges
8.	Ammeter (AC / DC)
9.	Voltmeter (AC / DC) Mandatory
10.	Power Factor meter
11.	Tong Tester
12.	Earth Tester
13.	Energy meter
14.	Tri-vector meter
15.	Stroboscope

16. Multimeter
17. Pitot tube and manometer
18. Water Flow Meter
19. Leak Detector

C) List of Software/Learning Websites

i. www.bee. com
ii. www.nptel.iitm.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S. V. Jagani**, Lecturer in Electrical Engineering, Govt. Polytechnic, Dahod
- **Prof. T. A. Patel,** Lecturer in Electrical Engineering, Govt. Polytechnic, Dahod
- **Prof. H C Chawda**, Lecturer in Electrical Engineering, R C Technical Institute, Ahmedabad

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- **Dr (Mrs.) C. S. Rajeshwari,** Professor, Department of Electrical and Electronics Engineering,
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GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POWER ELECTRONICS
(COURSE CODE: 3350903)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Nowadays all the modern electrical machines are controlled by power electronics devices and methods. The function of power electronics is to process and control the electric power by supplying voltage and current in a form that is optimally suited to the load. With the advancement of power electronics devices the conventional control and relays are now replaced by electronic control and relays, employing solid state power semiconductor devices. This course is therefore designed so that the diploma engineers will be able to use power electronics for controlling AC and DC power in various applications. Essential theoretical and practical knowledge to use power electronics to control electrical machines in commercial and industrial sector will be achieved by this course.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Use power electronics for controlling AC and DC Power in various applications.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Use power semiconductor devices in different applications.
ii. Maintain SCR Protection and Commutating Circuits**.**
iii. Troubleshoot chopper circuits.
iv. Maintain inverters and cyclo-converter circuits.
v. Maintain power electronic circuits used in various domestic and industrial applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	70	30	20	30	150

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Power Semi Conductor Devices and Controlled Rectifier**	1a. Classify Thyristor family. 1b. Explain the working of various power electronics devices with sketches 1c. Explain various polyphase uncontrolled rectifiers with sketches and waveforms 1d. Explain the Effects of transformer reactance 1e. Compare the difference in working of the single phase half wave, full wave controlled rectifiers using SCR, UJT and Phase shift circuits 1f. Explain the working Principle of A.C. load control & of pulse transformer	1.1 Classification of Thyristor family. 1.2 Working, of SCR, IGBT ,GTO, MCT, DIAC and TRIAC 1.3 Three phase half wave, full wave or bridge rectifier and Six phase half wave rectifier. 1.4 Effect of transformer reactance. 1.5 Single phase half wave and full wave controlled rectifiers using SCR, UJT & phase shift circuits. 1.6 Working of pulse transformer. 1.7 Principle of A.C. load control.
Unit– II **SCR Protection and Commutating Circuits**	2a. Justify the need of SCR protections. 2b. Describe working of snubber circuit, freewheeling diode, thermistor and heat sink for SCR. 2c. State the need to turn off SCR. 2d. Differentiate various types of commutation methods with sketches 2e. Use SCR datasheets for the given parameters	2.1 Need of SCR protections : Over voltage and over current protection. 2.2 Snubber circuit, freewheeling diode, Thermistor, heat sink. 2.3 Turn off (commutation) method and types-Natural commutation, Forced commutation, Series resonance/ current commutation, Voltage commutation. 2.4 Auxiliary SCR for commutation. 2.5 External pulse commutation. 2.6 Specifications of SCR: Voltage, current, Power, temperature, dv/dt and di/dt

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit– III **Choppers**	3a. Explain the working principle of Chopper and its applications 3b. Compare the salient features of different types of choppers 3c. With sketches compare the working of Jone's Chopper and Morgan's chopper	3.1 Function and working of choppers 3.2 Types of chopper circuits: A type to E-type 3.3 Jone's chopper circuit 3.4 Morgan's chopper
Unit– IV **Inverters and Cycloconverter**	4a. Explain basic working principle of inverter 4b. Classify inverters 4c. With sketches, explain the working of inverter circuit using transistors and SCR. 4d. Distinguish the working of series and parallel inverters using SCR. 4e. Describe pulse width modulation technique and its techniques	4.1 Working principle of inverter 4.2 Classification of inverter- • phase and 3-phase inverters, • Line commutated and forced commutated inverters • Series, Parallel and bridge inverter 4.3 Series and parallel inverter using SCR 4.4 PWM method and PWM inverter 4.5 Single pulse width, Multiple pulse width and Sinusoidal pulse width modulation
	4f. Explain the working principle of cyclo-converter. 4g. Compare the salient features of various types of cyclo-converters.	4.6 Operating principle of cyclo converter. 4.7 types of cyclo-converters : Single phase to single phase cyclo converter, Single phase to bridge cyclo converter.
Unit-V **Other Industrial Applications of Power Electronic Devices**	5a. With sketches, explain the speed control of - a DC series motor using SCR chopper circuit & D.C. Motor using armature voltage control, D.C. drive using PLL method. 5b. With sketches, describe the use of power electronics for speed control of universal motor. 5.1 With sketches, describe the use of power electronics for speed control methods of induction motor such as stator voltage control, frequency control, Power factor control method. AC drives. 5c. With sketches, describe the use of power electronics devices in heating resistance welding static circuit breaker and time-delay circuit applications.	5.2 Speed control of D.C. Motor using armature voltage control. 5.3 Speed control of D.C. Motor using SCR chopper circuit. 5.4 Speed control of D.C. drive using PLL method. 5.5 Speed control of universal motor. 5.6 Different types of speed control methods for induction motor such as stator voltage control, frequency control, Power factor control method. 5.7 Heating control, resistance welding, static circuit breaker and time delay circuits.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Semi conductor devices and Controlled Rectifier	12	8	3	3	14
II	SCR Protection and Commutating circuits	16	12	4	4	20
III	Choppers	6	4	2	2	8
IV	Inverters and Cyclo converter	14	10	4	4	18
V	Other Industrial applications of Power Electronic Devices	8	2	2	6	10
	Total	**56**	**36**	**15**	**19**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours.
1	I	Wire the three phase half wave rectifier & test the performance.	2
2	I	Wire the three phase full wave rectifier & test the performance.	2
3	I	Wire the Bridge rectifier & test the performance.	2
4	I	Check the performance of six phase half wave rectifier.	2
5	I	Analyze poly phase rectifier circuit performance through simulation	2
6	I	Test the performance of IGBT	2

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours.
7	I	Test the performance of GTO	2
8	I	Test the performance of MCT	2
9	I	Compare the ratings and packages of IGBT, GTO, MCT using data sheet.	2
10	I	Test the performance of TRIAC for AC load control	2
11	I	Use R-C phase shift net work for firing angle Control of single phase controlled rectifier.	2
12	II	Troubleshoot Snubber circuits	2
13	II	Troubleshoot SCR commutating circuits.	2
14	III	Troubleshoot chopper circuits with load.	2
15	III	Perform test the DC motor for speed control using appropriate chopper circuit	2
16	III	Simulate chopper circuit, observe and print the various wave forms.	2
17	IV	Build/test parallel inverter using two SCRs.	2
18	IV	Test IC TL494 for PWM.	2
19	IV	Test 1-φ Cyclo-converter for different output frequencies.	2
20	V	Build Time delay relay circuit using UJT and SCR.	2
21	V	Test the Speed control of universal motor using SCR-UJT circuit.	2
22	V	Test the Speed control of DC motor using chopper circuits.	2
23	V	Test the Speed control of 3 phase induction motor using solid state devices.	2
24	V	Test the Speed control of motor using PLL method.	2
Total Hours (perform any practical worth 28 hours from above depending upon the availability of resources so that most units are covered)			**48**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare journals based on practical performed in laboratory.
ii. Prepare a report on various types of drives used in nearby industries.
iii. Assignments on solving numerical
iv. Prepare chart displaying various Power semiconductor devices and their symbols
v. Simulate various circuits in syllabus and take print out of various wave forms.
vi. Make a market survey for various types of thyristors available in market.
vii. Present a dynamic animations prepared or collected from the internet to illustrate the following:

- Working principle of inverter
- Working principle of PWM inverter
- Working principle of chopper

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Visit nearby industries to see the industrial applications of Power semiconductor devices and circuits

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Power Electronics	Rashid, Muhammad H.	PHI Learning, New Delhi latest edition
2.	Power Electronics	Gupta, B. R., Singhal V.,	S.K. Kataria and sons, New Delhi
3.	Power Electronics	Singh,M. D. K. Khanchandani, B.	Tata Mc. Graw Hill, New Delhi
4.	Power Electronics	Bimbhra, P.S.	Khanna Publisher, New Delhi latest edition
5.	Industries and power Electronics	Rai, H.C.	Umesh Publications. New Delhi latest edition
6.	Fundamentals of electric drives	Dubey, G. K.	Narosa Publishing house New Delhi latest edition
7.	Electric drives-concepts and applications	Subramanyan, V.	Tata McGraw-Hill, New Delhi latest edition

B) List of Major Equipment/Instrument with Broad Specifications

S. No.	Item and Specifications
1	DIAC, TRAIC, SCR, IGBT, GTO and MCT - 5 Nos. each of current rating at least 20 amps or above
2	Trainer Kits for testing the V-I characteristics of the following - 2 Nos. each: a) DIAC b) TRAIC c) SCR d) Power transistor e) Power MOSFET f) IGBT g) GTO h) MCT
3	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) 3-phase uncontrolled half wave rectifier b) 3-phase uncontrolled full wave rectifier
4	Trainer kit to check the performance using R, RL and RLC Load of the following - 2 Nos. each:

S. No.	Item and Specifications
	a) Fully controlled three phase half wave converter **b)** Fully controlled three phase Full wave converter
5	Trainer kit to check the performance of Three-phase semi-converter using R, RL and RLC Load of the following - 2 Nos.
6	Chopper Trainer kit to check the performance of the following for different types of loads - 2 Nos. each: a) IGBT Based Chopper Circuit b) Jones Chopper Trainer Circuit c) Morgan Chopper Trainer Circuit
7	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) Offline inverter b) Online inverter
8	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) Class A Load Commutation b) Class B Resonant Pulse Commutation c) Class C Complementary Commutation d) Class D Impulse or Auxiliary SCR commutation e) Class F Line or natural Commutation
9	Electric DC Drive Trainer consisting of the following controlling schemes - set: a) Speed control of dc DC shunt motor using single phase fully controlled converter b) Speed control of DC shunt motor using three phase fully controlled converter c) Armature and field control of DC shunt motor d) Speed control of DC shunt motor using SCR dual converter e) Thyristor chopper for DC motor drive f) DC series motor controller using jones chopper
10	Experimental set up to perform Speed control of a 3 phase WRIM using Kramer drive - 1 set
11	Experimental set up to perform Speed control of a 3 phase induction motor using v/f method - 1 set
12	Experimental set up to perform speed control of a DC shunt motor using open loop and PID control system through computer interfacing - 1 set
13	3 Phase Power Analyzer 3 Nos. with the following specifications: • 3 phase/1 phase measurement- • True RMS Voltage 600/1200 V • True RMS Current 80 A, • Power measurement (Active, reactive and apparent power), • Power factor measurement, • Frequency Measurement, • RS-232 serial communication, • LCD display

C) List of Software/Learning Websites

i. www.nptel.iitm.ac.in
ii. www.youtube (lectures on Power electronics)
iii. www.howstuffworks.com
iv. www.alldatasheet.com
v. MATLAB/SIMULINK
vi. Psim
vii. Electronics Work bench

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H. C. Chawda**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad.
- **Prof. R.D. Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Dr. A.S. Pandya**, HOD in Electrical Engineering**,** G.P. Rajkot.
- **Prof. K. K. Kansara**, Lecturer in Electrical Engg., NMGPI Ranpur

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr (Mrs.) C. S. Rajeshwari** Professor and Head, Department of Electrical and Electronics Engineering,
- **Prof. Joshua Earnest,** Professor, Department of Electrical and Electronics Engineering,

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MICROPROCESSOR AND CONTROLLER APPLICATIONS (COURSE CODE: 3350904)

Diploma Programme in which this course is offered	Semester in which offered
ELECTRICAL ENGINEERING	5th Semester

1. RATIONALE

In modern process industries and power stations use of microprocessor, microcontroller, PLC is very common in order to control, monitor and process various parameters and data. Microprocessor and Microcontroller is specialized and essential field where the industries need highly skilled manpower. Hence this course is designed to develop skills to maintain microprocessor based system and the programming practices will develop the skills to indigenous real time applications.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following competency:

- **Maintain Microprocessor, Microcontroller, PLC and SCADA-based electrical systems**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Distinguish Micro processors, microcontrollers and PLC based control systems.
ii. Maintain microprocessor-based systems.
iii. Maintain microcontroller-based systems.
iv. Maintain PLC-based systems.
v. Maintain SCADA-based systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	70	30	20	30	150

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

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (outcomes in Cognitive Domain)	Topics and Sub-topics
UNIT – I Control Systems Components	1a. Describe basic control actions 1b. Differentiate open and closed loop of control systems	1.1 Role of control system in instrumentation 1.2 Open and close loop control system, types and Block diagram
	1c. Explain servomechanism and regulator circuits	1.3 Servomechanism and regulators with suitable examples
	1d. Define the following: Derivative, Integral control, Proportional derivative (PD), Proportional integral (PI), P Proportional integral and Derivative (PID) control	1.4 Basic control actions - On-off, Proportional, Derivative, Integral control, Proportional derivative (PD), Proportional integral (PI), P Proportional integral and Derivative (PID) control
	1e. Explain working principle & application of basic control system components	1.5 Basic control system components –AC/ DC Servo motor, AC/ DC Tacho generator, Stepper motor and Synchro
Unit– II Basics of Microprocessor	2a. Describe functions of each block of generalize microprocessors 2b. List Advantages and disadvantages of microprocessor control	2.1 Introduction to microprocessor 2.2 Advantages and disadvantages of microprocessor control
	2c. Explicate microprocessor architecture with the help of suitable block diagram 2d. Describe memory organization of 8085 microprocessor. 2e. Explain importance of timing and control section	2.3 Structure of micro processor, Generalized architecture of microprocessor, Functions of each block 2.4 Functional block diagram of 8085 microprocessor with pin diagram, logical block diagram of 8085 microprocessor-Registers, ALU, memory organization, decoder, serial control section, interrupt section, timing and control section
	2f. Classify instruction set of 8085 microprocessor 2g. Develop Basic assembly language program using basic instruction for the given application. 2h. Explain following with the help of timing diagram : machine cycle, T-state	2.5 Assembly language Programming of 8085, Addressing Modes, Instruction classification, Instruction formats 2.6 Basic Assembly Language programming (only simple arithmetic operations-addition,

Unit	Major Learning Outcomes (outcomes in Cognitive Domain)	Topics and Sub-topics
		subtraction)
Unit– III Basics of Microcontroller 8051	3a. Compare microcontrollers and microprocessors 3b. Explain 8051 architecture with block diagram 3c. Describe the function of each pins of 8051 chip 3d. Explain registers and their functions of 8051	3.1 Microcontrollers and microprocessors 3.2 Pin diagram of 8051 microcontroller 3.3 Internal RAM, ROM and Special function Registers in 8051chip
	3e. Program the I/O ports for data transfer 3f. Program the timer and counter for required time delay generation. 3g. Program the I/O ports for interfacing external memory	3.4 I/O ports 3.5 Counters and Timers 3.6 Interfacing with external memory
Unit–IV Microprocessor and Microcontroller Applications	4a. Compare various types of semiconductor memories 4b. Explain interfacing of microprocessor with memory 4c. Describe function of 8255 with the help of suitable block diagram	4.1 Different types of memories: ROM, RAM, PROM, EPROM, EEPROM 4.2 Schematic diagram of memory chips decoder, memory interfacing. 4.3 Memory I/O data transfer scheme for 8255.
	4d. Describe use of microprocessor/microcontroller for switch and LEDs control. 4e. Describe use of microprocessor/microcontroller for temperature control of furnace 4f. Describe use of microprocessor/microcontroller for Traffic light controller 4g. Describe use of microprocessor for SCR firing angle control 4h. Draw block diagram explaining Data acquisition system	4.4 Interfacing of switches and LEDs 4.5 Simple applications of microprocessor and Microcontroller for temperature control of furnace, Traffic light control and SCR firing angle control using micro processor, Data acquisition system.
Unit-V Programmable Logic Controller And SCADA	5a. Explain working of each module of PLC 5b. State the criteria for the selection of PLC for the given application	5.1 PLC:CPU, I/O modules, bus system, power supplies and remote I/Os, counter, timer 5.2 Different PLC's available in market 5.3 Selection of a PLC
	5c. Describe SCADA functions	5.4 SCADA- Concept and Application

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Control Systems components	10	04	04	04	12
II	Basics of Microprocessor	12	03	04	08	15
III	Basics of Microcontroller 8051	12	03	06	06	15
IV	Microprocessor and Microcontroller Applications	12	02	07	06	15
V	Programmable Logic Controller and SCADA	10	04	03	06	13
Total		**56**	**16**	**24**	**30**	**70**

Legends: R = Remember U = Understand; A = Apply and above levels (Bloom's Revised Taxonomy)
Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	Control angular displacement using Synchro.	2
2	I	Regulate speed of DC motor using tacho generator.	2
3	II	Develop assembly language program for arithmetic addition	2

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
		of two numbers using µP 8085 kit.	
4	II	Develop assembly language program for arithmetic subtraction of two numbers using µP 8085 kit.	2
5	II	Develop assembly language program for arithmetic multiplication of two numbers using µP 8085 kit.	2
6	III	Interface seven segment LED display with 8051 kit.	
7	III	Interface LCD display with 8051 kit.	
8	III	Control speed of stepper motor using 8051 kit.	
9	IV	Interface programmable device like 8255 with µP 8085	2
10	IV	Interface switches and LEDs using µP 8085	2
11	IV	Control temperature using the 8085 application module	2
12	IV	Use µP 8085 for SCR firing angle control.	2
13	IV	Control Traffic light system using µP 8085	2
14	V	Use arithmetic function of PLC for a typical application.	2
15	V	Use timer function of PLC for a typical application(introduce delay).	2
Total			**30**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Build various trainer kits for control system applications.
ii. Interface microprocessor and microcontroller with external devices for developing mini project.
iii. Prepare flow chart and assembly language programming for basic arithmetic operations.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Industrial visit to process industries.
ii. Programming practice on 8051, 8085 simulators

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Microprocessor Architecture, Programming and Applications with 8085	Gaonkar, Ramesh S.	Penram International Publishing (India)Pvt.Ltd. New Delhi (5th Edition)
2.	Fundamentals of Microprocessors and Microcontrollers	Ram, B.	Dhanpat Rai Publications, New Delhi
3.	Microprocessors and Interfacing Programming and Hardware	Hall, Douglass V.	TMH publication, New Delhi, (latest Edition)
4.	The 8051 Microcontroller Architecture, Programming and Applications	Ayala, Kenneth J.	Penram International Publishing (I) Pvt. Ltd. New Delhi

S. No.	Title of Book	Author	Publication
5.	The 8051 Microcontroller and Embedded Systems using Assembly and C	Ali, Muhamad Mazidi, Janice Mazidi Gillispie, Rolin D. Mckinleay	PHI Learning, New Delhi, (latest Edition)
6.	Programmable Logic Controllers And Applications	Webb, John W Ronald Reis. A.	Prentice Hall of India, New Delhi, (latest Edition)
7.	Control Systems Engineering	Nagarath I. J., Gopal M.	New Age Publishers, New Delhi, (latest Edition)

B) List of Major Equipment/ Instrument with Broad Specifications

i. Trainer kit of speed control and speed regulation of DC motor using Techo Generator.
ii. Trainer kit of Synchro transmitter and receiver.
iii. Microprocessor 8085 kit with necessary accessories.
iv. 8255 interfacing kit.
v. Microcontroller 8051 kit with necessary accessories.
vi. Kit for add on cards for performing different applications of PLC.
vii. Add on cards for interfacing different types of inputs and out puts.
viii. Power supply for above kits and applications

C) List of Software/Learning Websites

i. www.keil.com/
ii. www.allaboutcircuits.com
iii. www.nmbtc.com
iv. http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/microcontrollers/micro/ui/Course_home1_1.htm

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. J C Gadani,** Lecturer in Electrical Engineering, C U Shah Polytechnic, Surendranagar.
- **Prof. B R Shrotriya,** Lecturer in Electrical Engineering, Government Polytechnic, Ahmedabad
- **Prof. H. I. Joshi**, Lecturer in Electrical Engineering, Government Polytechnic, Ahmedabad.
- **Prof. K. K. Kansara,** Lecturer in Electrical Engineering, NMGPI Ranpur.

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr.(Mrs.) Anjali Potnis**, Assistant Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: WIND AND SOLAR ENERGY SYSTEMS
(COURSE CODE: 3350905)

Diploma Programmers in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Gujarat is one of the several states in India where a large number of wind and solar grid connected electric power installations, and competent technicians to maintain these vital renewable energy power plants is a dire need of the industry. It is to fulfill this need, that this curriculum has been designed so that the diploma engineer would be able to maintain the installations thereby minimizing the downtime. It is presumed that the students have studied

2. LIST OF COMPETENCY

The course should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain various types of wind power plants and solar power plants.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Maintain constant speed wind power plants.
ii. Maintain variable speed wind power plants.
iii. Maintain concentrated solar power (CSP) and solar photovoltaic (PV) wind power plants,
iv. Check the grid compatibility of the power from wind and solar power plants.
v. Resolve the grid integration issues of wind and solar power plants

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (Major outcomes in Cognitive Domain)	Topics and Sub-topics
Unit – I Constant Speed Wind Power Plants	1a. Explain the working principle of Type-A WPP 1b. Describe the starting methods of stall and pitch controlled Type-A WPPs.	1.1 Type-A WPP(Wind Power Plants): • Working Principle • Different topologies • Starting methods • Maintenance procedure
	1c. Explain the working principle of Type-B WPP. 1d. Compare the major differences in the maintenance of Type-A and Type-B WPPs.	1.2 Type-B WPP: • Working Principle • Different Types • Maintenance procedure
Unit – II Variable Speed Wind Power Plants	2a. Explain the working principle of Type-C WPP 2b. Describe the working principle of a back-to-back power electronic controller used in Type-C WPPs	2.1 Type-C WPP: • Working principle • Working Principle Back-to-Back control • Maintenance procedure of Type-C WPPs
	2c. Explain the working principle of Type-D geared WPP. 2d. Explain the need for direct drive WPPs 2e. Explain the working principle of a Type-D direct-drive WPP.	2.2 Type-D Geared WPP: • Working principle • Maintenance procedure of Type-D Geared WPPs 2.3 Type-D direct-drive WPP: • Working principle • Maintenance procedure of Type-D Geared WPPs
Unit – III Solar Power Plant Performance	3a. Explain the concept and construction of solar thermal power plants. 3b. Describe the performance of a typical CSP plant 3c. Describe the maintenance procedure of a typical CSP plant	3.1. Solar Thermal Power Plants: Working of a typical Concentrated Solar Power (CSP) plant 3.2. Maintenance procedure of CSP systems
	3d. Explain the concept and construction of solar PV power plants. 3e. Describe the performance of a typical solar PV power plant. 3f. List the types of batteries 3g. Describe the features required of a battery for solar PV system 3h. Explain the significance of solar PV tracking. 3i. Describe Installation , testing & the maintenance procedure of a typical solar PV power plant.	3.3. Solar photovoltaic (PV) Power Plants: Working of a typical Solar PV Power plant. 3.4. Types of Batteries for solar PV system. 3.5. Maintenance procedure of typical Solar PV Power plant

Unit	Major Learning Outcomes (Major outcomes in Cognitive Domain)	Topics and Sub-topics
Unit – IV Wind and Solar Power Quality	4a. Describe the phenomenon of local impact of wind power on the grid 4b. Suggest ways to handle these local impacts safely	4.1. Local impact of wind power on the grid.
	4c. Explain the phenomenon of system wide impact of wind power 4d. Suggest ways to handle these system wide impacts safely	4.2. System wide impact of wind power on the grid. 4.3. Power Quality of solar PV systems
	4e. Differentiate the features of the power obtained from the solar PV and CSP power plant.	4.4. Power quality of CSP solar plant. 4.5. Power quality of solar PV power plant
Unit –V Grid Connection of Wind and Solar Power Plants	5a. State the grid interface issues of wind power and methods to resolve them. 5b. State the grid operational issues of wind power and methods to resolve them.	5.1. Grid interface issues of wind power. 5.2. Grid operational issues of wind power.
	5c. State the method(s) of integrating into the grid the power obtained from a CSP plants with sketches. 5d. State the method(s) of integrating into the grid the power obtained from solar PV power plants with sketches. 5e. Describe with sketches and labels the concept of a grid connected wind solar hybrid system. 5f. Describe the maintenance procedure of a typical grid connected wind-solar PV hybrid system.	5.3. Grid connection of CSP plants. 5.4. Grid connection of solar PV power plants 5.5. Wind- solar hybrid systems 5.6. Maintenance of solar PV and wind solar Hybrid system

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Constant Speed Wind Power Plants	12	04	12	04	20
II	Variable Speed Wind Power Plants	12	04	12	04	20
III	Solar Power Plant Performance	08	04	06	02	12
IV	Wind and Solar Power Quality	06	02	06	04	12
V	Grid Connection of Wind and Solar Power Plants	04	02	04	00	06
	Total	**42**	**16**	**40**	**14**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Hours Required
1	I	Dismantle a small planetary gearbox used in Type-A WPPs	02
2	I	Assemble a small planetary gearbox used in Type-A WPPs	02
3	I	Identify the various parts of a squirrel cage induction generator (SCIG) commonly used in Type-A WPPs	02
4	I	After viewing the video of Type-A WPP and identify the parts which require preventive maintenance	02
5	I	Identify the various parts of a Type-B WPP.	02
6	I	After viewing the video of Type-B WPP and identify the parts which require preventive maintenance	02
7	II	Identify the various parts of a Type-C WPP	02
8	II	After viewing the video of Type-C WPP and identify the parts which require preventive maintenance	02
9	II	Identify the various parts of a Type-D geared WPPs	02
10	I1	After viewing the video of Type-D geared WPP identify the parts which require preventive maintenance	02
11	I1	After viewing the video of Type-D direct-drive WPP identify the parts which require preventive maintenance	02
12	III	Assemble a CSP system	02
13	III	Dismantle a CSP system	02
14	III	Assemble a solar PV cell, module, array system with and	02

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Hours Required
		without battery connection	
15	III	Dismantle a solar PV cell, module, array system with and without battery connection	02
16	III	Install & Test the performance of a solar PV cell, module, array system with and without battery connection	02
17	III	Connect the solar PV modules in series and parallel	02
18	III	Test the solar PV tracking system	02
19	III	Test the effect of Light and temperature intensity on the solar PV system	02
20	IV	Software simulation/animation in some appropriate software/video programme	02
21	V	Assemble a wind-solar PV hybrid system	02
22	V	Dismantle a wind-solar PV hybrid system	02
23	V	Test the performance of a wind-solar PV hybrid system	02
TOTAL (perform any practical worth 28 hours from above depending upon the availability of resources so that most units are covered)			**46**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following are the list of proposed student activities such as:

i. A 'portfolio' of information on a renewable energy topic/technology will be developed by each student.
ii. Install and bring down a hydraulically operated tubular tilt-up/tilt-down tower of a wind solar hybrid system in the polytechnic campus
iii. Prepare journals based on experiments performed in laboratory

9. SPECIAL INSTRUCTIONAL STRATEGIES

i. Visit to wind farms
ii. Visit to solar power plants
iii. Visit to wind solar hybrid systems
iv. Use Video films/animation films on working of various types of wind power plants.
v. Use Video films/animation films on working of various types of solar power plants.
vi. Mini project.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Wind Power Technology	Earnest , Joshua	PHI Learning, New Delhi, 2014
2.	Solar Photovoltaic: A Lab Training Module	Solanki, Chetan Singh, Arora, Brij M., Vasi Juzer, Patil, Mahesh B.	Cambridge University Press, New Delhi, 2009
3.	Solar Photovoltaic: Fundamentals, Technologies and Application	Solanki, Chetan Singh	PHI Learning, New Delhi, 2009
4.	Wind Power Plants and Project Development	Earnest , Joshua and Wizelius, Tore	PHI Learning, New Delhi, 2011
5.	Solar Energy	S.P. Sukhatme, J.K.Nayak.	Tata McGraw, New Delhi, 2010.
6.	Introduction to Photovoltaics	John R. Balfour, Michael L. Shaw, Sharlave Jarosek	Jones & Bartlett Publishers, Burlington, 2011
7.	Concentrator Photovoltaic	Luque A. L. and Andreev V.M.	Springer, 2007
8.	Solar Cells and Their Applications	Partain L.D., Fraas L.M.	Wiley, 2nd Ed., New Delhi, 2010

B) Major Equipment/Instruments with Broad Specifications

i. Planetary Gearbox: Matching with 30/50/100/ 250 kW wind turbine second hand or new: 5 Nos.
ii. GFRP Wind Turbine blades: suitable for 10kW Wind turbines: 12 Nos.
iii. 3-bladed Geared Wind Turbine: 5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market - 1 No.
iv. Concentrated Solar Power (CSP) system - 5/10/20/30 kW or whichever lowest rating that is available in the market
v. Polycrystalline solar PV module: 10/20/30/30 or 50 W module or whichever lowest rating that is available in the market - 5 Nos. or whichever lowest rating that is available in the market - 5 Nos.
vi. Monocrystalline solar PV module: 10/20/30/30 or 50 W module or whichever lowest rating that is available in the market - 5 Nos.
vii. Wind (1kW) - Solar PV (1kW) Hybrid System complete in all aspects - 1 set
viii. Non-motorised solar PV tracking systems - 200/300 or 500 W - 1 set
ix. Solar Photovoltaic Training Kit from Electrical Engineering Dept. IIT, Mumbai - 10 kits

C) List of Software/Learning Websites

i. Wind Power

- http://www.awea.org/Resources/Content.aspx?ItemNumber=900
- http://www.windpowerwiki.dk/
- http://learn.kidwind.org/teach

ii. Solar Power

- http://www.fao.org/docrep/010/ah810e/AH810E11.htm
- http://www.renewables-made-in-germany.com/en/renewables-made-in-germany-start/solar-energy/solar-thermal-energy/overview.html
- http://www.renewables-made-in-germany.com/en/renewables-made-in-germany-start/solar-energy/solar-thermal-power-plants/overview.html
- http://www.eai.in/ref/ae/sol/technology_options.html

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. J.K. Rathod**, Hod (Electrical Engg.), Tolani F.G. Polytechnic, Adipur
- **Prof. R.D. Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. J C Gadani,** Lecturer in Electrical Engineering, C U Shah Polytechnic, Surendranagar

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- **Prof. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering
- **Prof N. P. Patidar,** Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: SPECIAL ELECTRICAL MACHINES
(COURSE CODE: 3350906)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Due to research and development the specialized electrical machines have been developed for specialized applications. They play an important role in industries such as production, processing, fabrications and renewable energy applications, etc. Some special electrical machines have higher efficiency, small size and useful for specific applications. This course refers to such machines which have not been considered in the earlier semesters. The most significant development in recent years in the allied area of motor control also plays an important role. Essential efforts are made in this course to familiarize the students with advanced technology in such machines which is a necessary to maintain them.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Maintain different types of special electric machines.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Use different types of transformers efficiently for various applications.
ii. Maintain different types induction machines for different applications
iii. Maintain different types synchronous machines for different applications
iv. Maintain different types of fractional horsepower motors
v. Maintain various types of Small specialised electric machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (outcomes in cognitive domain)	Topics and Sub-topics
Unit – I Special Transformer Types	1a. Explain with sketches the various connection diagrams a power and distribution transformer 1b. Describe the features of a welding transformer 1c. Differentiate between a audio transformer, isolation transformers and microphone transformers	1.1 Different types of connections of power and distribution transformers 1.2 Welding transformers 1.3 Isolation transformer 1.4 Pulse transformer 1.5 Audio transformers and microphone transformers
	1d. Distinguish between current and potential transformers 1e. Distinguish between constant current and constant voltage transformers 1f. Describe the test & maintenance procedure of all the above mentioned special transformers	1.6 Instrument transformers : current transformers and potential transformers 1.7 Constant Voltage Transformer (CVT) and Constant Current Transformer (CCT) 1.8 Maintenance procedure
Unit– II Special Induction Machines	2a. Explain the working principle of dual winding squirrel cage induction generator with sketches 2b. Describe the phenomenon of cogging and crawling in induction machines. 3a. Explain working principle of soft starters with sketches 2c. Justify the need for reactive power compensation for squirrel cage induction generators.	2.1 Dual winding Squirrel cage induction generator 2.2 Soft starters 2.3 Reactive power compensation
	2d. Explain the working principle of wound rotor induction generator with sketches 2e. Explain the working principle of doubly fed induction generator with sketches 2f. Explain the working principle of brushless doubly fed induction generator 2g. Describe the maintenance procedure of all the above mentioned special induction machines	2.4 Wound rotor induction generator (WRIG) 2.5 Doubly fed induction generator (DFIG) 2.6 Brushless doubly fed induction generator (BDFIG) 2.7 Maintenance procedure
Unit– III Special Synchronous Machines	3a. Explain the working of wound rotor synchronous generator used in renewable energy applications with sketches. 3b. Explain the working of wound rotor synchronous generator used in direct-drive wind turbines with sketches.	3.1 Wound rotor synchronous generators for renewable energy applications 3.2 Wound rotor synchronous generators in large and small direct-drive wind turbines.

Unit	Major Learning Outcomes (outcomes in cognitive domain)	Topics and Sub-topics
	3c. Explain the working of permanent magnet synchronous generators used in direct drive large wind turbines with sketches 3d. Explain the working of permanent magnet synchronous generators used in direct drive small wind turbines with sketches 3e. Describe the test & maintenance procedure of all the above mentioned special synchronous machines	3.3 Permanent magnet synchronous generators in large and small direct-drive wind turbines 3.4 Maintenance procedure
Unit–IV Fractional Horse Power Motors	4a. Describe the concept of FHP motor sand their applications 4b. Explain the working of hysteresis motor with sketches and application 4c. Explain the working of permanent magnet motors and their applications 4d. Differentiate the working principles of Reluctance motor and Switched reluctance motor with sketches and application. 4e. Describe the test & maintenance procedure of all the above mentioned fractional horse power motors	4.1 Fractional horse power (FHP) motor 4.2 Hysteresis motor 4.3 Permanent magnet motor 4.4 Reluctance motor 4.5 Switched reluctance motor 4.6 Maintenance procedure
Unit-V Other Special Motors	5a. Explain the working principle of different types of stepper motors 5b. Explain working principle of Brushless DC Motor and their applications 5c. Explain working principle of a Servomotor with sketches and application 5d. Explain working principle of synchros with sketches and application 5e. Explain working principle of resolvers with sketches and application. 5f. Describe the test & maintenance procedure of all the above mentioned special motors	5.1 Stepper motor and its types. 5.2 Brushless DC motors 5.3 Servomotors 5.4 Synchros 5.5 Resolvers 5.6 Maintenance procedure

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Special Transformer Types	08	00	06	04	10
II	Special Induction Machines	06	00	08	02	10
III	Special Synchronous Machines	06	00	08	08	16
IV	FHP motors	08	04	04	08	16
V	Other Special Motors	14	04	06	08	18
Total		**42**	**08**	**38**	**24**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Approx Hours Required
1	II	Identify the various parts of a squirrel cage induction generator (SCIG)	02
2	II	Dismantle a small SCIG.	02
3	II	Test & Assemble a small SCIG.	02
4	II	Operate the squirrel cage induction motor as a SCIG to test the performance.	02
5	II	Identify the various parts of a wound rotor induction generator (WRIG).	02
6	II	Dismantle a small WRIG.	02
7	II	Test & Assemble a small WRIG.	02
8	II	Operate the wound rotor induction motor as a WRIG to test the performance.	02

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Approx Hours Required
9	II	Identify the various parts of a doubly-fed induction generator (DFIG).	02
10	II	Dismantle a small DFIG.	02
11	II	Test & Assemble a small DFIG.	02
12	II	Operate the DFIG to test the performance.	02
13	III	Identify the various parts of a wound rotor synchronous generator (WRSG)	02
14	III	Dismantle a WRSG.	02
15	III	Test & Assemble a WRSG.	02
16	I1I	Operate the WRSG to test the performance.	02
17	III	Identify the various parts of a permanent magnet synchronous generator (PMSG)	02
18	III	Dismantle a PMSG.	02
19	III	Test & Assemble a PMSG.	02
20	III	Operate the PMSG to test the performance.	02
21	IV	Dismantle/assemble/test a Hysteresis motor	02
22	IV	Dismantle/assemble/test a Permanent magnet motor	02
23	IV	Dismantle/assemble/test a Reluctance motor	02
24	IV	Dismantle/assemble/test a Switched reluctance motor	02
25	V	Dismantle/assemble/test a Stepper motor and its types.	02
26	V	Dismantle/assemble/test a Brushless DC motors	02
27	V	Dismantle/assemble/test a Synchros	02
28	V	Dismantle/assemble/test a Resolvers	02
29	V	Dismantle/assemble/test a Servomotors	02
TOTAL (perform any practical worth 28 hours from above depending upon the availability of resources so that most units are covered)			**58**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare journals based on practical performed in laboratory.

ii. Prepare/Download a dynamic animation to illustrate the following:
- Working of double cage induction generator
- Working wound rotor induction generator
- Working doubly fed induction generator
- Working synchronous generators used in direct drive wind turbines

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Visit transformer and induction motor manufacturer/testing facilities

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Electrical Technology Vol. II	Theraja ,B. L.	S Chand and Co., New Delhi
2.	Wind Power Technology	Earnest , Joshua	PHI Learning, New Delhi, 2014
3.	Fundamentals of Electrical Engg.	Mehta, V.K.	S Chand and Co., New Delhi
4.	Electrical Machines	Ghosh, Smarajit	Pearson Learning, New Delhi
5.	Electrical Machinery	Fitzgerald,,A.E. Charles Kingsley, Jr., Stephen D. Umans	Mc. Graw Hill, New Delhi
6.	Theory and performance of Electrical Machines	Gupta, J.B.	S.K. Kataria and sons, New Delhi
7.	Electrical Machines	Hussain, Ashfaq	Dhanpat Rai and Company, New Delhi

B) List of Major Equipment/ Instrument with Broad Specifications

i. Squirrel Cage Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
ii. Wound Rotor Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
iii. Doubly fed Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. -- 2 Nos
iv. Wound Rotor Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
v. Permanent Magnet Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
vi. Welding transformers - 1 No.
vii. Isolation transformer - 1 No.
viii. Pulse transformer - 1 No.
ix. Audio transformers - 1 No.
x. Microphone transformers - 1 No.
xi. Hysteresis motor - 1 No.
xii. Permanent magnet motor - 1 No.
xiii. Reluctance motor - 1 No.
xiv. Switched reluctance motor - 1 No.
xv. Stepper motors of different types - 1 No.
xvi. Brushless DC motors - 1 No.
xvii. Servomotors - 1 No.
xviii. Synchros - 1 No.
xix. Resolvers - 1 No.

C) List of Software/Learning Websites

i. http://www.learnabout-electronics.org/ac_theory/transformers04.php
ii. http://www.tpub.com/celec/5.htm
iii. http://www.wisegeek.com/what-is-a-fractional-horsepower-motor.htm
iv. www.sskphdmm.com
v. www.nptel.iitm.ac.in
vi. www.electricalandelectronics.org
vii. www.allaboutcircuits.com
viii. www.nmbtc.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

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Coordinator and Faculty Members from NITTTR Bhopal

- **Dr (Mrs.) C. S. Rajeshwari**, Professor and Head, Department of Electrical and Electronics Engineering
- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ELECTRIC TRACTION AND CONTROL
(COURSE CODE: 3350907)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

The country is leading towards the railway electrification and also moving towards metro, monorail system. The diploma student is required to know about the electric traction scheme and its latest trends. This subject is offered as one of the elective, highlighting the current and future trends in traction systems, auxiliary equipment, electric locomotives, control of traction motors and future-trends. The Diploma pass student with this elective will be able to maintain the traction systems, auxiliary equipment, electric locomotives and traction motors.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain traction systems, auxiliary equipment, electric locomotives and traction motors.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Distinguish different traction systems and latest trends in traction systems.
ii. Differentiate services of traction system based on speed time curve.
iii. Control different types of traction motors
iv. Use various traction system auxiliaries.
v. Explain the distribution system of a traction system.

vi. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

4. COURSE DETAILS

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
UNIT – I Traction Systems and Latest Trends	1a. Explain the present scenario of Indian Railways- High speed traction, Metro 1b. Detail the latest trends in traction. 1c. Explain types of traction systems and their significance. 1d. Explain the general arrangement of different types of Electric traction systems and their significance. 1e. Select a traction system for a given application.	1.1 Present scenario of Indian Railways – High speed traction, Metro 1.2 Latest trends in traction- Metro, monorail, Magnetic levitation Vehicle 1.3 Steam, diesel, diesel-electric, Battery and electric traction systems 1.4 General arrangement of D.C.,A.C.singlephase,3phase hase,Composite systems 1.5 Choice of traction system - Diesel- Electric or Electric
UNIT– II Mechanics of Train Movement	2a. Draw the speed time curve related to different traction system. 2b. Solve numerical based on speed time curve. 2c. Calculate specific energy consumption. 2d. State the factors affecting Specific energy consumption.	2.1 Analysis of speed time curves for main line, suburban and urban services 2.2 Simplified speed time curves. 2.3 Relationship between principal quantities in speed time curves 2.4 Requirement of tractive effort 2.5 Specific energy consumption and Factors affecting it.
UNIT– III Traction Motors and Their Control	3a. State the desirable features of traction motors. 3b. Explain Significance of D.C. series motor over D.C. Shunt motor. 3c. Explain working of various A.C. motors as traction motors. 3d. Compare different traction motors. 3e. Apply various control methods applied to traction motors. 3f. Explain different types of electric braking system.	3.1 Features of traction motors. 3.2 Significance of D.C. series motor as traction motor 3.3 A. C. Traction motors-single phase, Three phase, Linear Induction Motor 3.4 Comparison between different traction motors 3.5 Series-parallel control 3.6 Open circuit, Shunt and bridge transition 3.7 Pulse Width Modulation control of induction motors 3.8 Types of electric braking system.

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
UNIT-IV Electric Locomotives and Auxiliary Equipment	4a. Classify electric locomotive 4b. Describe the function of auxiliaries in traction system 4c. Describe the different current collecting methods in locomotives 4d. Explain different control and auxiliary equipment used in the locomotive 4e. Describe the Power conversion and transmission systems 4f. Explain Coach wiring and lighting devices	4.1 Important features of electric locomotives 4.2 Different types of locomotives 4.3 Current collecting equipment 4.4 Coach wiring and lighting devices 4.5 Power conversion and transmission systems 4.6 Control and auxiliary equipment.
UNIT-V Feeding and Distribution System.	5a. Explain the distribution & feeder system pertaining to traction 5b. Classify traction substations 5c. Describe different methods of feeding the traction sub- station	5.1 Distribution systems pertaining to traction (distributions and feeders) 5.2 Traction sub-station requirements and selection 5.3 Method of feeding the traction sub- station

5. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Traction Systems and Latest Trends	04	04	04	00	08
II	Mechanics of Train Movement	07	04	05	05	14
III	Traction Motors and Their Control	15	05	07	10	22
IV	Electric Locomotives and Auxiliary Equipment	12	06	06	06	18
V	Feeding and Distribution System	04	02	02	04	08
	Total	**42**	**21**	**24**	**25**	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

6. SUGGESTED LIST OF EXERCISES/PRACTICALS

The tutorial/practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills**(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development*

*of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain*

S. No.	Unit No.	Practical Exercises (Major outcomes in Psychomotor Domain)	Approx Hours. required
1	I	Investigate the various traction systems in Indian railways.	2
2	I	Investigate various latest trends in electric traction systems.	2
3	II	Solve numericals on speed time curves.	2
4	II	Solve numericals on specific energy consumption.	2
5	III	Calculate energy saving by series parallel control of D. C. Motor (for two and four motors).	2
6	III	Justify the use of D. C. Series motor as traction motor.	2
7	III	Investigate the energy recovered using regenerative braking.	2
8	IV	Describe the train lighting system.	2
9	IV	Draw sketch of the current collecting equipments.	2
10	IV	Study of layout of D. C. locomotive and diesel locomotive.	2
11	1V	Study of power diagram of A.C. locomotive and its equipment.	2
12	V	Study of major equipments in AC traction substations.	2
13	VI	Use electronic control of traction motor.	2
14	VI	Understand the working of high speed train.	2
		Total Hours	**28**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare a report on current collector of bow and pantograph type current collector, showing complete arrangements of Pantograph its location and electric wiring system with locomotive.

ii. Prepare a report on the following locomotives:
   a. D. C. locomotive
   b. A. C. / D. C. locomotive
   c. Diesel electric locomotive (Report to be written)

iii. Prepare a report after visiting a electric-traction substation

8. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Arrange visit to nearby locomotive workshops.

ii. Show video/animation films to explain functioning of traction motor.

iii. Have Group Discussion on various topics and get updated with latest trends in traction.

9. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Modern Electric Traction	H. Partab	Dhanpat Rai and Sons, New Delhi
2.	Electric Traction	J. Upadhyay S. N. Mahendra	Allied Publishers Ltd., Dhanpat Rai and Sons, New Delhi
3.	Electric Traction	A.T. Dover	Mac millan, Dhanpat Rai and Sons, New Delhi
4.	Electric Traction Hand Book	R. B. Brooks.	Sir Isaac Pitman and sons ltd. London.

B) List of Major Equipment/ Instrument with Broad Specifications

i. Models of different traction systems and equipment

C) List of Software/Learning Websites

i. www.irieen.com (Indian Railways Institute of Electrical Engineering, Nasik Road)
ii. www.wr.railnet.gov.in/bctweb/ELECTRICAL.htm
iii. www.scrailway.gov.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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