(4th – SEMESTER)

Electric Motors

Subject code -EEE401

1. Rationale:

Electric motors impact almost every aspect of modern living through the use of various Appliances. They are used at some point in the manufacturing process of nearly every conceivable product that is produced in modern factories and has nearly unlimited number of applications. An Electrical Technician is expected to Analyse the performance and select a particular motor for an application followed by testing, troubleshooting and maintenance of the same.

2. Course Outcomes/Skill Sets:

On successful completion of the course, the students will be able to

CO-01	Conduct performance analysis of a given electrical motor, draw its characteristics and determine the right motor for a specific application.
CO-02	Select, Install and test the motor to be used for a specific application.
CO-03	Describe test parameters, testing procedures and demonstrate the troubleshooting of a given electric motor to ensure it performs optimally.
CO-04	Construct power circuit and control circuits using appropriate components /devices to control the given electric motor.

3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	1,4	1. **DC Motors:** Working principle, back emf & voltage equation- simple problems.	Refer Table1	**Follow Safety rules and Safe working practices (Demo)** 1. Identify the terminals, and test the field and armature windings of a DC machine for open circuit, short circuit and ground faults using test lamp /megger, check the insulation resistance, identify and locate the possible faults.
			2. Types of motor-circuit diagram with voltage equation. -meaning of Torque -torque developed by D.C motors, torque equation [no derivation] -torque- speed relationship		2. Control the Speed of the DC shunt motor by Armature voltage control. Plot the graph.
			3a. Characteristics of D.C. Motors -Torque – Speed, Speed – Load and Torque – Load Characteristics. 3b. Methods of speed control: – shunt field control –Armature or Rheostatic control		
			-Voltage control		

2	1	1,2,4	1. **Induction Motors**: Working principle of induction motor. Rotating magnetic field produced by polyphase supply.	Refer Table1	**Follow Safety rules and Safe working practices** 1a. Identify the parts of the 3- phase squirrel cage induction motor, test it for open circuit, short circuit and ground faults using a test lamp / megger, check the insulation resistance, identify and locate the possible faults. Suggest remedies. 1b. Connect forward & reverse a 3-phase squirrel cage induction motor.
			2. Construction of stator, squirrel cage rotor and phase wound rotor. Slip, frequency of rotor current. Problems.		2a. Identify the parts of 3 phase slip ring induction motor, test it for open circuit, short circuit and ground faults using test lamp/megger, check the insulation resistance, identify and locate the possible faults. Suggest remedies. **Ref.7(5)** 2b. Connect forward & reverse a 3-phase slip ring induction motor.
			3. Starting torques of squirrel cage and slip ring induction motor with expression. Condition for max starting torque. Effect of change in supply voltage on starting torque.		
3	1	1,4	1. Equation for torque under running conditions. -Draw torque – slip curves. -Relationship between full load torque and maximum torque, starting torque and maximum torque	Refer Table1	**Follow Safety rules and Safe working practices** 1. Plot the Speed-Torque (Slip Vs Torque) Characteristics of 3-Phase Induction motor by mechanical loading (Brake-drum apparatus). Use Power Quality Analyzer & Motor Analyzer to measure various parameters. **Ref.7(6)**
			2. Explain Equivalent circuit of an induction motor.		
			3. Relationship between rotor power input, rotor copper loss, and Mechanical power developed and slip. -Problems on the above.		2. Determine the efficiency of 3-phase squirrel cage induction motor by no load test/ blocked rotor test and brake test. Use Power Quality Analyzer & Motor Analyzer to measure various parameters.
4	1	1,4	1. **Starters:** Necessity of starters and list the various types of starters. Main criteria for the selection of the starting method.	Refer Table1	1a. Identify the parts of a DOL starter, test its parts, locate faults if any. Suggest remedies.
			2a. Construction, working and troubleshooting of D.O.L. Starter. 2b. Construction, working and troubleshooting of star-delta Starter.		1b. Connect, Start, Run and Reverse the direction of rotation of 3-phase Induction Motor using DOL starter. **Ref.7(7)**

			3a. Construction and working of Soft Starter. 3b. Maintain, service and troubleshoot the AC motor starter		**Follow Safety rules and Safe working practices.** 2a. Identify the parts of a Star- Delta starter, test its parts and locate faults if any. Suggest remedies Trace the start terminals and end terminals of three-phase windings and mark the terminals u1,v1,w1 and u2,v2,w2 Connect, Start, Run and Reverse the direction of rotation of 3-phase Induction Motor using star delta starter. 2b. Maintain, service and troubleshoot the AC motor starter
5	1,3	2,4	1. Speed Control of induction motor: - Change of applied voltage method. - Change of number of poles.	Refer Table1	**Follow Safety rules and Safe working practices.** 1. Speed control of IM using any one method, Use of Power Quality Analyzer & Motor Analyzer to measure various parameters.
			2. Speed Control of induction motor: - Change of frequency - Rheostat control method.		2a. Testing, troubleshooting and Servicing of three-phase Induction motors. 2b. Perform general preventive maintenance on 3-ph Induction motor. **Ref.7(8,9,10,11)**
			3. Testing and troubleshooting procedure of three-phase Induction motor. -General preventive maintenance procedure of three- phase Induction motors.		
6	1	1,4	1. **Synchronous Motors**: Working principle, construction, and method of starting of synchronous motor. -Compare the synchronous motor with the induction motor.	Refer Table1	**Follow Safety rules and Safe working practices** 1. Start, Run and Reverse the direction of rotation of the synchronous motor.
			2.Effect of increased load with constant excitation. - Effect of change in excitation at constant load.		2. Plot V and inverted V curves for synchronous motor, Use Power Quality Analyzer & Motor Analyzer.
			3. Effect of excitation on armature current & power factor.		
7	1	1,2,4	1. Effect of excitation on leading, lagging and zero power factor.	Refer Table1	1. Demonstrate troubleshooting of synchronous motors.
			2. Synchronous condenser and its application. **Ref.7(19).**		2. Case study of Synchronous condenser.
			3. Hunting and phase swinging, losses and methods of starting of synchronous motors.		

8	1,2	1,4	1. IEC/ NEMA motors, Enclosure protection classes available protection classes are IP23, IP44, IP54 -IEC 60034-4-1:2018 standard for synchronous motors.	Refer Table1	1. Demonstrate different protection classes.
			2. Synchronous reluctance motors. **Ref.7(22).**		2a. Demonstrate Installation of synchronous motor and Induction motor. 2b. Perform general preventive maintenance of sync motors. **Ref.7(20,21)**
			3. Procedure for Installation and Maintenance of sync motors and Induction motor.		
9	1	1,4	1. **Single-phase motors:** Working principle, construction and characteristics. **Ref.7(28).**	Refer Table1	1a. Identify and connect the starting winding, running winding, capacitor centrifugal switch terminals rotation of 1-ph capacitor start Induction Motor. 1b. Start, Run and Reverse the direction of rotation.
			2. Resistance Split phase motor -Capacitor Start Induction motor.		2. Perform general preventive maintenance of 1-ph Induction Motors.
			3. Working Principle & characteristics of Induction Generators and its applications.		
10	1	1,4	1. **Special Machines: Servo motor:** Working, construction and applications, types, speed-torque characteristics, specifications, control mechanism. **Ref.7(29).** Working, construction and applications of Stepper motor and Torque motor and spindle motor.	Refer Table1	1.Identify the parts of special machines: Servo motor, universal motor, stepper motor and brushless DC Motor, and test the coils and windings for its working condition.
			2. Working, construction and applications of Universal motor, Reluctance Motor, Permanent Magnet Synchronous Motor (PMSM).		2. Demonstrate applications of special machines.
			3. Working, construction and applications of Two phase Four Pole Permanent magnet motor, Brushless D.C. Motors, specification for EV motors. **Ref.7(31)**		
11	2,4	2,3	1. Industrial application of motors.	Refer Table1	1. Calculate the total system efficiency by combining the four key components of a motor
			-Select a motor for a given industrial application. **Ref.7(12,13,14)**		system: the motor, drive, transmission and load (e.g., pump, fan, compressor, etc.) by using a motor testing tool(software). **Ref.7(15,16,17,18)**

			2 Motor testing tool for energy efficiency. **Ref.7(25,26,27)**		2.Identify different types of push button switches- single element and two element ON/OFF switches, mushroom head emergency stop switch, illuminated type, key lock type, selector switches and limit switches.
			3. Draw the standard symbols of control components Different types of push button switches- single element and two element ON/OFF switches, mushroom head emergency stop switch, illuminated type, key lock type, selector switches and limit switches.		
12	4	3,4	1. Working principle of Bi-metallic Overload Relay, Time Delay Relays - Electronic timer and electro-mechanical Pneumatic timer and Single- Phase preventer. **Ref 7(32)**		1a. Identify Bi-metallic Over Load Relay, Time Delay Relays - Electronic timer and Electro-mechanical Pneumatic timer and Single-Phase preventer. 1b. Identify the parts of a contactor, number of NOs, NCs, nature of coil supply AC/DC, voltage ratings and current ratings. Note down the technical specifications and terminal identification number
			2.Parts of a contactor, number of NOs, NCs, nature of coil supply AC/DC, voltage ratings and current ratings.		2a. Rig up and test the following applications of logic gates using push button switches, contactor and indicators. a) Starting from two different locations (OR Function) b) Stopping from one position (NOT Function) c) Two hand operation (AND Function) d) Stopping from two different locations (NOT+OR or NOR Functions) e) Stopping if both signals are given (NOT+AND or NAND functions) f) Memory function (Signal is maintained or holding). h. XOR and XNOR operation. 2b. Rig up and test Direct On Line Starter. **Ref 7(33)**
			3.Draw a control circuit for DOL starter and control circuit for forward and reverse operation of a motor with interlocking function using auxiliary contact.		
13	4	3,4	1.Draw a control circuit for forward and reverse operation of a motor with interlocking function using combined auxiliary contact and push buttons.		1.Rig up and test the control circuit for forward and reverse operation of a motor with interlocking function using combined auxiliary contact and push buttons.
			2.Draw a control circuit for a semi-automatic star delta starter.		2.Rig up and test the control circuit for a fully automatic star delta starter. **Ref 7(34)**
			3.Draw a control circuit for a fully automatic star delta starter.		
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	Electrical Technology volume 2 - BL Theraja & A.K.Theraja S.Chand publication.
2	Principles of Electrical Machines by V.K.Mehtha.S.Chand publication.
3	Electrical machines - Theory and Practice by M.N. Bandyopadhyay PHI publication.
4	Electrical Machines by Bhattacharya. Tata McGraw Hill Co. 5. Electrical Machines - J.B.Guptha Kataria & Sons Publications
5	https://search.abb.com/library/Download.aspx?DocumentID=9AKK107991A3212&LanguageCode=en&DocumentPartId=&Action=Launch
6	https://search.abb.com/library/Download.aspx?DocumentID=B5.0205&DocumentPartID=&Action=Launch
7	https://new.abb.com/docs/librariesprovider53/about-downloads/low-voltage-motor-guide.pdf
8	https://assets.new.siemens.com/siemens/assets/api/uuid:8e9204f9-1860-4720-9d6b-2be548d915d0/version:1560800077/troubleshooting-induction-motors.pdf
9	https://www.youtube.com/watch?v=390nOrLHAaw&t=3176s
10	https://www.youtube.com/watch?v=BoFToRcfL0k
11	https://www.youtube.com/watch?v=VCtiehg2pZc
12	h https://motors-pumps.gainesvilleindustrial.com/category/all-categories-electric-motor
13	https://www.controleng.com/online-courses/how-to-specify-motors-for-more-efficient-hvac- systems/
14	https://www.controleng.com/articles/how-to-select-a-motor-for-an-industrial-application/#:~:text=There%20are%20many%20aspects%20to,or%20a%20servo%2Fstepper%20motor.&text=Requirements%20for%20controlling%20motor%20speed%20and%20position%20also%20need%20to%20be%20considered.
15	https://www.iea-4e.org/wp-content/uploads/publications/2015/09/1 emsa pb 20150917.pdf
16	https://www.iea-4e.org/emsa/our-work/emsa-tools/
17	https://www.iea-4e.org/wp-content/uploads/2020/11/quickguide-mst-tool 1.2.pdf
18	https://www.iea-4e.org/wp-content/uploads/2020/11/webinar-2-motor-systems- tool 20151015.pdf

19	https://search.abb.com/library/Download.aspx?DocumentID=9AKK107991A6324&LanguageCode=en&DocumentPartId=&Action=Launch
20	https://search.abb.com/library/Download.aspx?DocumentID=SM103&LanguageCode=en&DocumentPartId=&Action=Launch
21	https://search.abb.com/library/Download.aspx?DocumentID=3BSM900636&LanguageCode=en&DocumentPartId=&Action=Launch
22	https://library.e.abb.com/public/58b63ea623dddaf9c125786800278df5/56- 61%201m103 ENG 72dpi.pdf
23	https://www.youtube.com/watch?v=mgoZSL2u6Jw
24	https://www.se.com/in/en/work/solutions/motor-control-protection/
25	https://www.iea-4e.org/wp-content/uploads/2020/11/MST Example I - anno 2017.pdf
26	https://www.iea-4e.org/wp-content/uploads/2020/11/MST Example II - anno 2017.pdf
27	https://www.iea-4e.org/wp-content/uploads/2020/11/MST Example II - anno 2017 Solution.pdf
28	https://search.abb.com/library/Download.aspx?DocumentID=B5.0205&DocumentPartID=&Action=Launch
29	https://www.motioncontrolonline.org/blog-article.cfm/What-is-a-Brushless-DC-Motor-and-How- Does-It-Work/57
30	https://www.motioncontrolonline.org/blog-article.cfm/What-is-a-Brushless-DC-Motor-and-How- Does-It-Work/57
31	https://circuitdigest.com/article/different-types-of-motors-used-in-electric-vehicles-ev
32	https://www.youtube.com/watch?v=2hsHoMEuS-0
33	https://www.youtube.com/watch?v=AhJRHFfXkdg
34	https://www.youtube.com/watch?v=OtydNtCxYQI

Equipment/software list

Sl. No.	Particulars	Specification	Quantity
1.	Central distribution board with control gear and power supply panel for all M/C.		
2.	Static converter Input-3phase, 440V,50Hz. Output -15kW,0- 220V Continuously variable.		

3.	DC Shunt Motor with mechanical loading (a brake drum) apparatus		
4	3-Phase Squirrel Cage Induction motor with mechanical loading (a break drum) apparatus		
5	Synchronous motor		
6	1-phase Capacitor start Induction motor		
7.	F.HP-motors Universal/hysteresis stepper motor, brushless DC motor, stepper motor, spindle motor , Permanent magnet synchronous motor, Reluctance motor		
8	1-Phase Variacs	220V,5A	
9	3-Phase Variacs	440V,15A	
10	Single-phase IM Various types one in each type		
11	Voltmeters	0-300/600 VAC	
12	Ammeters	0-5/10a AC	
13	Power Quality Analyser and Motor analyser		
14	Motor Testing Tool free software (https://www.iea-4e.org/emsa/our-work/emsa-tools/)		
15	Contactor - 16A, 4POLE, Coil Voltage 220volts/50 hz AC With 2 NO + 2 NC		
16	Timer (Electronic) 10 NO		
17	Push button (ON) 2 element type (1 NO + 1 NC)		
18	Push button (OFF) 2 element type (1 NO + 1 NC)		
19	Different types of Push button Switches (key type, Illuminated type, Emergency trip mushroom head type		
20	Limit Switches		
21	Selector Switches		
22	Thermal Over load relays (0-16A,415V with 1NO+1NC)		
23	MCB 16A, 415V, 4pol		

Power Electronics

Subject code -EEE402

1. Rationale:

Power electronics is the application of solid-state electronics to the control and conversion of electric power. Power semiconductor devices are used to construct converters and inverters in the various applications such as power supplies, Electric drives, Flexible AC Transmission systems and Distribution systems, EV's, Energy storage devices. An Electrical Technician shall apply the knowledge of Power electronics to control and convert Electrical Power for an application.

2. Course Outcomes/Skill Sets: On successful completion of the course, the students will be able to

CO-01	Identify the power electronic devices using relevant datasheets and demonstrate its suitability to produce specified electrical and thermal characteristics.
CO-02	Build a power electronic circuit for a given application, demonstrate its working either in real or simulated environment.
CO-03	Test a given power electronic circuit, identify the problem and troubleshoot to obtain the desired result/output.

3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1,2	1,4	1. Concept of power electronics, Draw the layer structure of the power diode and explain it. V –I characteristics of power diode.	Refer Table 1	1a. Study and interpret the datasheet of given power diode and BJT. 1b. Test the given Diode and BJT for its working condition. 1c. Simulate VI characteristics of power diode.
			2. Types of power diodes and their applications		2. Simulate output characteristics of Power BJT
			3. Types of Power transistors, BJT output characteristics, BJT as a switch.		
2	1,2	1,4	1. Operation of N-channel enhancement power MOSFET, and its transfer characteristic curve, Application of MOSFET.	Refer Table 1	1a. Study and interpret the datasheet of power MOSFET and IGBT 1b. Identify various Power MOSFET by its number and test by using a multimeter 1c. Identify IGBTs by their numbers and test by using a multimeter.
			2. Structure of IGBT and its characteristics		

			3. Application of IGBT, Compare MOSFET, BJT and IGBT		2a. Simulate the transfer characteristics of power MOSFET and IGBT. 2b. Rig up the circuit of power MOSFET as a switch
3	1,2	1,4	1.Layer diagram of SCR and Concept of two transistor analogy of SCR.	Refer Table 1	1.Test the given SCR for its working condition.
			2. Static V-I characteristic curve of SCR, Enumerate Reverse blocking, Forward blocking, forward conduction mode.		2. Simulate VI characteristics of SCR, GTO and LASCR.
			3. GTO, principle of operation and list its application, layer structure of LASCR and explain its operation.		
4	1,2	1,4	1. Layer structure, operation and characteristics of TRIAC	Refer Table 1	1a. Test the given TRIAC and DIAC for its working condition. 1b. Simulate VI characteristics of TRIAC and DIAC.
			2. 4-Modes of turn on of TRIAC and state the preferred mode of turn-on.		2.Build and test a TRIAC- fan motor speed control circuit.
			3. Operation of DIAC and its V-I characteristic, curve, application of DIAC.		
5	1,2	3,4	1. **SCR Control Circuits:** Methods of turn on of SCR	Refer Table 1	1.Build R firing circuit and determine the maximum firing angle.
			2. General layout of firing circuit.		
			3. R firing circuit and R-C firing circuit with waveforms.		2. Build R – C firing circuit and determine the maximum firing angle.
6	1,2	3,4	1. Construction, operation and characteristics of UJT	Refer Table 1	1.Build and test UJT Relaxation oscillator.
			2. Synchronized UJT pulse trigger circuit with waveform.		
			3. Digital firing scheme with waveforms.		2. Build and Test time delay relay using SCR and UJT.
7	1,2	3,4	1. Commutation, line commutation, forced commutation and methods of forced commutation, Load commutation and complementary commutation.	Refer Table 1	1.Simulate Line commutation and forced commutation circuits and observe waveforms.
			2. Voltage and current ratings of SCR and Reliability of SCR, MTBF.		
			3. How SCR can be protected against overvoltage and over current, di/dt & dv/dt. Different types of mounting of SCR.		2. Construct a snubber circuit for protecting SCR use freewheeling diode to reduce back emf.
8	1,2	4	1. **CONVERTERS:** types of power electronic converters: Single -quadrant semi-converter, two- quadrant full- converter and dual converter.	Refer Table 1	1.Build single-phase full controlled bridge converter for resistive load. Trace the waveforms across SCR and load.
			2. Single-phase full converter RLE type with continuous load current		2. Simulate single-phase Dual

			3.single-phase dual converter and principle of operation.		converter and observe waveforms.
9	1,2	4	1. Gating pulse requirement of three-phase full converters. 2.Three-phase bridge converter and 180 conduction mode with waveforms.	Refer Table 1	1.Test three-phase bridge rectifier module (36MT160) 2. Simulate three-phase Bridge converter and observe waveforms.
10	1,2	4	1. DC Chopper- Step-down and Step-up chopper and its operation. 2. Different chopper configurations- (A, B, C, D and E). 3. Inverter- Types of inverters (VSI and CSI).	Refer Table 1	1.Simulate/Build step-down chopper and observe waveforms. 2. Simulate / Build step-up chopper and observe waveforms.
11	1,2	4	1. Half bridge and full-bridge inverter and its operation. 2. Cycloconverter- Draw the circuit of mid- point Step-down cyclo-converter and its operation with waveforms. 3. Cycloconverter- Draw the circuit of a mid- point step-up cycloconverter and its operation with waveforms.	Refer Table 1	1.Simulate Full-bridge Inverter and observe waveforms. 2.Build and test a inverter. **Ref.7(18)**
12	2,3	2,4	**DC-DC converters:** 1. Working principle of Buck converter (regulator). 2. Working principle of Boost converter (regulator). **Ref.7(9,10,11,12)** 3.Working principle of Buck-boost and flyback converter. **Ref.7(14,15,16,17)**		1a. Build & test IC based - DC –DC converter for different voltages. **Ref.7(8)** 1b. Test the monolithic synchronous buck regulator (MP2305). 2.Test and Troubleshoot regulators. **Ref.7(13)**
13	2,3	2,3,4	1. SMPS and its operation and application. 2. UPS, Battery size and required voltage for UPS 3a. Draw the block diagram of offline online UPS and its operation. 3b. List basic troubleshooting steps for UPS. **Ref.7(21,23)**		1a. Identify various input and output sockets/ connectors of the given SMPS. 1b. Identify major sections/ ICs/components of SMPS. 1c. Troubleshoot given SMPS. **Ref.7(19,20)** 2a. Identify front panel control & indicators of UPS. 2b. Connect battery & load to UPS & test on battery mode. 2c. Open top cover of UPS & identify isolator transformer & UPS transformer & additional circuit other than inverter.

					2d. Identify various circuit boards in UPS and monitor voltages at various test points. 2e. Test UPS under fault condition & rectify fault. **Ref**: **7(22,24)**
Total in hours			**39**	**13**	**52**

Reference:

Sl. No	Description
1	Power Electronics by Dr P S Bimbhra , Khanna Publishers, New Delhi
2	Industrial Electronics and Control Biswanath Paul PHI Publication Edition-II
3	Thyristorised power controllers GK Dubey
4	Power and industrial Electronics by Harish C Rai
5	Power electronics by Mohan Undeland & Robbins, Wiley Publications
6	Modern Power Electronics by P.C.Sen
7	Power Electronics – RaghunathRao
8	https://components101.com/ics/ncp3064-dc-dc-converter-ic
9	https://www.youtube.com/watch?v=4IQBN6Oy8Lg
10	https://www.youtube.com/watch?v=_Rf29oUGpwI
11	https://www.youtube.com/watch?v=vmNpsofY4-U
12	https://www.youtube.com/watch?v=yD7fMylYgXw
13	https://www.youtube.com/watch?v=-3tBw6WSZVM
14	https://www.youtube.com/watch?v=zNfbbPobtus
15	https://www.youtube.com/watch?v=ZiD_X-uo_TQ
16	https://www.youtube.com/watch?v=9--_jaxiXhE
17	https://www.youtube.com/watch?v=Fk-B6OO6GB8https
18	https://www.youtube.com/watch?v=6CsTIPjFZ48 www.youtube.com/watch?v=I8c5DLJgS3o
19	https://www.youtube.com/watch?v=PPLjXkca7eo
20	https://www.powersupplyrepairguide.com/previewsmpsebook.pdf
21	https://www.youtube.com/watch?v=C1BYo88HSU0
22	https://www.youtube.com/watch?v=3oq18dZmb3Q
23	https://www.apc.com/lr/en/faqs/FA279110/
24	https://www.youtube.com/watch?v=lkriUIUdflM https://www.youtube.com/watch?v=JHgKBDoQCyQ
25	https://inst.eecs.berkeley.edu/~ee100/su07/handouts/EE100-MultiSim-Tutorial.pdf
26	http://eceweb1.rutgers.edu/~psannuti/ece223/Manual-for-multisim.pdf
27	https://www.multisim.com/help/getting-started/

Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
1	DC Regulated power supply	(0-300V, 2A)	5
2	DC Regulated Dual power supply	(0-30V,2A)	5
3	Cathode Ray Oscilloscope	Dual trace, 25 MHz.	5
4	Digital Multimeter	31 /2"1-ph	5
5	1-ph Induction Motor	220v,1ph,	1
6	Battery	6 V/12 V 60 AH	2
7	SMPS		5
8	UPS 2kVA	2 kVA	1
Software			
1	GNU-Octave/MatLab/P-spice/Multisim		20 License

Fundamentals of Automation Technology

Subject code -EEE403

1. Rationale:

The aim of this course is to introduce students to the present Industrial Automation scenario in India. The broad knowledge of essential component of present industrial Automation Industry such as Programmable Logic Controller (PLC), Distributed Control System (DCS), Supervisory Control and Data Acquisition (SCADA), industrial drives, human machine interface will enable the students to maintain the above automation controls systems used in the present industry. Thus this course is very important for students who want to use their knowledge of electronic engineering for working in the industrial automation sector.

2. Course Outcomes/Skill Sets: On successful completion of the course, the students will be able to

CO-01	Select a suitable sensor and actuator for a given automation application and demonstrate its use in a specific application.
CO-02	Install, test & control the pneumatic actuators using various pneumatic valves.
CO-03	Develop ladder diagrams for a given application and explain its implementation process using PLC.
CO-04	Describe the concept of SCADA and DCS systems and list their various applications.

3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	2,3, 4	1. How do engineers work, technical drawings and parts lists, Circuit diagrams, Flow charts and programs. **Ref.7(1)**	Refer Table 1	Video demonstration on Automation technology
			2. Technical plans and schematic diagrams, Calculations and simulation		
			3. Automation technology as a part of engineering sciences, Key development milestones in the history of automation technology, Effects of automation on people.		
2	1	1,4	1. How a solenoid works- Structure of a solenoid, Applications of solenoids **Ref.7(1)**	Refer Table 1	1.Test a Linear Actuator Solenoid
			2. Solenoids as simple actuators.		2.Install, wire and test digital time delay relay -
			3.How switches work and their structure-Normally open contacts, normally closed contacts, Changeover switches.		
			Relays and contactors-Structure of a relay, Applications of relays, Time relays. **Ref.7(1)**		
3	1	1,4	**1.Sensors: operation, characteristics and application:** Inductive Proximity Sensors, Magnetic Proximity Sensor.	Refer	1a. Identify and test different sensors. 1b. Select a suitable proximity sensor for a given application and wire up the same. **Ref 7(2)**
			2. Capacitive proximity sensors, Optical proximity sensors, Ultrasonic proximity sensors		

			3. Linear Position sensors, Photoelectric sensors. Infrared sensors Limit Switches.	Table 1	2.Develop a relay-based motor control automation such that the motor reverses its direction when the limit switches are activated.
4	1	4	1. Inductive linear transducer, area sensors, flow sensors **Ref.7(1)**		1.Identify and test different sensors.
			2. Temperature sensors, colour sensors, Hall effect sensor		2. Simple Hall effect sensor Latching ON/OFF Relay switch Circuit.
			3a. Pressure sensors -Electronic pressure switches with binary output signal. 3b. Concept of Sensor latching. Latching Digital Hall effect sensor.		
5	2	1,4	1. **Fundamentals of pneumatics-** Individual components in a pneumatic control system and their functions. **Ref.7(1)**	Refer Table 1	1a. Controlling of single- acting cylinder by 3/2 push- button valve/ **solenoid valve** b. Controlling of double-acting cylinder by 5/2 push-button valve/S**olenoid valve** c. Identify industrial applications of Single acting and Double acting cylinder. **Ref 7(3,4)**
			2. Functions and features of actuators (pneumatic cylinders)- Single-acting cylinder, Double-acting cylinders, Speed regulation with single-acting cylinders, Speed regulation with double-acting cylinders.		2 a. Speed control of single-acting cylinders by flow control valve b. Speed control of double-acting cylinders by flow control valve
			3. Functions and features of pneumatic valves- Pneumatic valve designations and symbols, Pneumatic valve actuation types, controlling a single-acting cylinder, Controlling a double-acting cylinder		
6	2	1,4	1. Functions and features of pneumatic drives- Guided cylinders, rodless linear drives and rotary drives. **Ref.7(1)**	Refer Table 1	1. Demonstrate the use of Pneumatic drives (used in small robots)
			2. Pneumatic grippers.		2. Demonstrate the use of Pneumatic grippers.
			3. Pneumatic control system represented in a circuit diagram- Symbol designations in circuit diagrams.		
7	1	1,4	1. **Electric drives:** Physical/technical fundamentals of the DC motor.	Refer Table 1	1. Activate the DC motor using 2 relays to run the motor forward and backward direction.
			2. Activating DC motors		
			3. Working principle of Variable frequency drive.		2. Install and control speed of 3-ph motor using VFD.

8	3	1,4	1. **Fundamentals of control technology**: Meaning of control system, open loop and closed system with examples. Different types of controllers (PLC, CNC, Hard-wired programmed control systems, robot controllers)	Refer Table 1	1.Demonstrate open loop and closed systems observed in everyday life.
			2. How programmable logic controllers (PLCs) work and their structure. Advantages and Disadvantages of PLC. Mathematical fundamentals – basic logic functions-Identity (YES function), Negation (NOT function), Conjunction (AND function), Disjunction (OR function), XNOR and XOR.		
			3. Examples of controller structure.		2. Demonstrate Industrial applications of PLC
9	3	1,4	1. **Programmable logic controllers-** Internal architecture and functional structure. Input/output modules.	Refer Table 1	1.a. Identify Components of PLC b. Identify different types of PLC c. Identify different input and output devices of PLC d. Identify the wiring mode of PLC- sourcing and sinking modes
			2a. List input / output devices of PLC. -List types of PLC. 2b. Functions of Programming equipment (Programmer/monitor)		2.Identify and Install Programming Software and communication driver.
			3a. Explain PLC Programming Languages –Ladder diagram/ Functional Block Diagram /Instruction List/structured text. 3b. Explain scope of f IEC standard for PLC: IEC 61131		
10	3	2,3, 4	1a. **Operation cycle of PLC**: Input scan, Program scan and Output scan. **1b. Operation modes of PLC**: program, run and test modes. Data files and program files.		1.Develop and test the ladder programs for the following motor controls: a) Starting from two different locations (OR Function) b) Stopping from one position (NOT Function)
			2.Configuration of I/Os and Addressing I/Os, study of PLC symbols.		
			3. Procedure for drawing ladder diagram, connection of inputs and outputs to input and output module and entering ladder program into PLC (CPU). Draw the ladder diagram for a simple example of one-contact, one-coil circuit and connection diagram showing how inputs are connected to the input and output module of PLC.		c) Two hand operation (AND Function) d) Stopping from two different locations (NOT+OR or NOR Functions) e) Stopping if both signals are given (NOT+AND or NAND functions) f) Memory function (Signal is maintained or holding) g) Interlocking protection (XNOR/XOR)

					2. Develop and test the ladder program for interlocking two motors, using **PLC simulation software.**
11	3	2,3, 4	1.Most commonly used PLC programming instructions and their applications: XIC, XIO, OTE. Latch, Unlatch		1a. Develop and test ladder program for switching ON motor 1, motor 2 and motor 3 in sequence with some time delay, using **PLC simulation software.** 1b. Develop and test the ladder program of the Alarm system for the following conditions: If one input is ON- nothing happens, if any two inputs are ON- a red light turns ON, If any three inputs are ON- a Hooter/Alarm turns ON, using PLC simulation software.
			2.Describe Timer instructions and their application: Describe Timer On Delay (TON), Timer Off Delay (TOF), Retentive Timer On (RTO)		
			3.Describe counter instructions and their application: COUNT UP, COUNTDOWN, UP/DOWN COUNTER Examples of use of counter and timer instructions.		2a. Develop and test ladder Program for fully Automatic Star-Delta starter, using **PLC simulation software.** 2b. Develop and test ladder Program to control automatic washing machine, using **PLC simulation software.**
12	3	2,3, 4	Wiring sensors to PLC 1. Wiring push button to PLC, and selector switch to PLC		1. Develop and run simple Ladder programs to read sensor status and to control various output. **LED is turned ON when a (proximity sensor) sensor is activated.** i. Draw the ladder diagram ii. Draw PLC wiring diagram. iii. Wire push buttons to input module and LED to output module. iv. Enter the ladder program into the PLC simulator and execute.
					v. If the program is error free, Upload the program into PLC and execute. vi. observe the output

			2.Wiring NPN sensor to PLC		2. Double acting cylinder is used to perform machining operations. Pneumatic cylinder is advanced by pressing two push buttons simultaneously. If any one of the push button is released, cylinder comes back to start position. Draw the pneumatic circuit, PLC wiring diagram and ladder diagram to implement this task.
			3.Wiring PNP sensor to PLC		
13	4	2,3, 4	1.Meaning of SCADA -Functions of each component of SCADA system, -Describe SCADA Hardware and software -Applications of SCADA.		Demonstrate application of SCADA/HMI/DCS
			2.Meaning of HMI and its applications. -Need & types of HMI. -Advantages of HMI. -Various software's used for Programming HMI. -Interfacing HMI and PLC- General block diagram.		
			3. Concept of DCS -Hierarchy of DCS. -Functions of each level of DCS.		
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	https://dlb.sa.edu.au/rehsmoodle/file.php/441/Teachware/563060 Fundamentals of automat ion technology.pdf
2	https://www.festo-didactic.com/ov3/media/customers/1100/566920 leseprobe en 2.pdf
3	https://www.youtube.com/watch?v=ZXANgP-q6b4
4	https://www.festo-didactic.com/ov3/media/customers/1100/566910 leseprobe.pdf
5	https://www.youtube.com/watch?v=GhS1qpHoSX0
6	https://www.youtube.com/watch?v=O-hbGD HsYk
7	**Control of Machines- S.K. Bhattacharya & Brijinder Singh, New Age International Publishers**
8	**Programmable Logic Controllers: John W.Webb, Ronald A.Reis, PHI**
9	**Introduction to PLC by Gary Dunning, Cengage Learning.**
10	**Mechatronics: W.Bolton**
11	https://nptel.ac.in/content/storage2/courses/112106175/downloads/Module%204/SELF%20 EVALAUTION/SE-Lecture%2041.pdf
12	https://accautomation.ca/wiring-push-buttons-and-selector-switch-to-click-plc/
13	https://realpars.com/discrete-sensors-part-1/
14	https://www.automationdirect.com/adc/overview/catalog/sensors -z- encoders
15	https://www.rtautomation.com/technologies/control-iec-61131-3/
16	https://davidrojasticsplc.files.wordpress.com/2009/01/libro-en-espanol.pdf

Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
1	Small compressor	4 bar, 1.5 HP,0-4 bar pressure, 0-10 litres	
2	Linear Actuator Solenoid 12V		
3	Inductive. Proximity Sensors. Magnetic Proximity Sensor, Limit Switches		
4	Capacitive proximity sensors, Optical proximity sensors Ultrasonic proximity sensors		
5	Infrared sensors, Pressure Sensor and Switch		
6	Inductive linear transducer , Area sensors, Flow sensors, Temperature sensors, colour sensors		
7	single-acting cylinder, double-acting cylinder		
8	3/2 and 5/2 push-button valve		
9	3/2 and 5/2 solenoid valve		
10	Flow control valves		
11	Digital time delay relay		
12	Direction control Valve, Double Acting Solenoid		
13	Pneumatic Grippers		
14	FRL (filter, regulator and lubricator) unit		
15	PLC Systems with digital I/P, O/P modules and software	12/24v Dc/relay, 8 Digital Inputs, 4 Digital Outputs, ethernet card standard micro SD card, integrated webserver	
16	Variable frequency drive	3-phase, 1HP, VFD	
17	1 HP induction motor with DOL starter	1 HP	
18	SCADA Software		

Computer Aided Electrical Drafting (CAED)

Subject code -EEE404

1. Rationale:

All equipment, installations, circuits and other electrical and electronic systems in the power and industrial sector need drawings for their manufacturing, installation, operation and maintenance. A technician working in design, shop floor and field area must possess the skill of reading, interpreting different drawings and to use Computer Aided Drawing (CAD) software to draw 2D & 3D Electrical drawings.

2. Course Outcomes/Skill Sets: *On successful completion of the course, the students will be able to*

CO-01	Study a given drawing and list all the electrical elements.
CO-02	Draw a single line diagram and control panel board wiring drawing for a given specification.
CO-03	Draw a winding and assembly drawing for a given machine and translate the assembly 2D drawing into a 3D drawing using CAD software.
CO-04	Draw a simple PLC module drawing for a given requirement using standard symbols.

3. Course Content:

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	1,4	1. INTRODUCTION to CAD commands. Practice essential commands like – line types, line weight, scale, unit,	Tutorial hours shall be used to practice drawings.	Practice the basic CAD commands. **Ref .7(1,2,3,4,5)**
			2. Layer, block, insert, explode, purge, table, attribute, quick select		
			3. view, multi-view, break, join, filter, find, pan, list match properties and related commands		
2	1,2	1,4	Single line diagram of 110 KV/11KV MUSS	Tutorial hours shall be used to practice drawings.	1. Single line diagram of 110 KV/11KV MUSS. **Ref .7(10,11)**
			Single line diagram 11KV of Substation		2. Single line diagram of 11KV Substation. **Ref .7(12,13,14)**
3	1,2	1,4	1. Draw and Create BOM (Bill of Material): Electrical wiring of a residential/Hospital building	Tutorial hours shall be used to practice drawings.	1. Draw the wiring layout of residential building/Hospital and generate BOM for a given plan with AEH. **Ref .7(7,8,9)**
			2.Draw and Create BOM (Bill of Material): Electrical wiring of a small workshop		2. Draw a wiring layout of a small workshop with 3 lathes, 1 drilling machine, 1 welding machine, 1

					grinding machine and generate BOM (Bill of Material).
4	1,2	1,4	Motor control Panel board Wiring.	Tutorial hours shall be used to practice drawings.	Draw MCC (Motor Control Centre) Panel board Wiring and create BOM. **Ref .7(15)**
5	1,2	1,4	Design a GA LT panel wiring drawing.	Tutorial hours shall be used to practice drawings.	Design an Electrical General Assembly of LT panel wiring. **Ref .7(16)**
6	1,2	1,4	Developed Winding Diagrams of 3-ph A.C. Machines: Single Layer Double Layer	Tutorial hours shall be used to practice drawings.	1.Develop a winding diagram- A.C. windings-Single Layer **Ref.7(6)** 2.Develop a winding diagram- A.C. windings- Double Layer
7	1,2	1,4	Developed Winding diagram of 1-ph, AC Induction Motor	Tutorial hours shall be used to practice drawings.	Develop a winding diagram for a 1-ph, Induction Motor, make terminal connections for Running & Starting Winding.
8	1,3	1,4	Transformer Assembly-Three-phase	Tutorial hours shall be used to practice drawings.	Three-phase core type 200KVA 33KV/400V transformer front elevation full in section, plan in full section. **Ref .7(18)**
9	1,3	1,4	Assembly drawing- Squirrel cage Induction motor.	Tutorial hours shall be used to practice drawings.	Draw the half end view and half sectional front elevation and half sectional end view for a 3HP 400V 50HZ 3PH 1440 RPM - Squirrel cage Induction motor. **Ref .7(19)**
10	1,3	1,4	Assembly drawing- Rotor of a 15KVA Alternator	Tutorial hours shall be used to practice drawings.	Draw the half sectional end view top half in section and half sectional front elevation for a Rotor of a 15KVA Alternator for a given sketch. **Ref .7(20)**
11	1,3	1,4	Assembly drawing – 4 Pole 25 KVA synchronous motor	Tutorial hours shall be used to practice drawings.	Draw half size half sectional elevation and half sectional end view. **Ref .7(21,22)**
12	3	1,4	3D Drawing- Squirrel cage Induction motor.	Tutorial hours shall be used to practice drawings.	3D view showing different parts. **Ref .7(23)**
13	1,4	1,4	PLC Module	Tutorial hours shall be used to practice drawings.	Design a Simple PLC Module showing I/O points. **Ref .7(24,25)**
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	Computer Aided Electrical Drawing - YOGESH, NAGARAJA,NANDAN PHI Publication
2	Electrical Drafting - S.F. DEVALAPUR
3	https://www.youtube.com/watch?v=pvKVy-eMDYc
4	https://www.youtube.com/watch?v=2ni0AWbloQA
5	https://www.youtube.com/watch?v=wIN61lmZByw
6	https://www.youtube.com/watch?v=OONCU5QbDpU
7	https://www.youtube.com/watch?v=asVQ3ncmqhY
8	https://www.youtube.com/watch?v=X1MsYDEkHpU
9	https://www.youtube.com/watch?v=8DEap6exAB0
10	https://www.youtube.com/watch?v=YXLhvA7dMb4
11	https://www.youtube.com/watch?v=ZRXlWoT-FRU
12	https://www.youtube.com/watch?v=Bk8YOLr0KFM
13	https://www.youtube.com/watch?v=Fa5gYiapD1E
14	https://www.youtube.com/watch?v=cKKvLXaV1g8
15	https://www.google.com/imgres?imgurl=https://5.imimg.com/data5/GZ/CR/MG/SELLER-40839587/capture7-500x500.PNG&imgrefurl=https://www.indiamart.com/proddetail/electrical- ga-general-assembly-design-22445785697.html&docid=t83B C9sNcBtnM&tbnid=nqa2KujeGdTYhM&vet=1&w=500&h=339&hl=en-US&source=sh/x/im#imgrc=nqa2KujeGdTYhM&imgdii=pQlfLt4RiUOsdM
16	https://www.google.com/imgres?imgurl=https://5.imimg.com/data5/GZ/CR/MG/SELLER-40839587/capture7-500x500.PNG&imgrefurl=https://www.indiamart.com/proddetail/electrical-ga-general-assembly-design-22445785697.html&docid=t83B C9sNcBtnM&tbnid=nqa2KujeGdTYhM&vet=1&w=500&h=339&hl=en-US&source=sh/x/im
17	https://www.youtube.com/watch?v=XsKbtm6OtAw
18	https://www.youtube.com/watch?v=fXOwgNYT0hg
19	https://www.youtube.com/results?search_query=Squirrel+cage+Induction+motor++assembly+cad+drawing
20	https://www.youtube.com/watch?v=nk_hmXUtiPk
21	https://www.youtube.com/watch?v=nk_hmXUtiPk
22	https://www.youtube.com/watch?v=rgP0aMth7LM
23	https://www.youtube.com/watch?v=fAN9jxydoMA&t=144s
24	https://www.youtube.com/watch?v=fTjd86ui5iM
25	https://www.youtube.com/watch?v=_0b2YDYFgZA
26	https://bescom.karnataka.gov.in/page/Departments+of+Corporate+Office/Quality%20Standards%20and%20Safety/Drawings/en
27	https://www.electricaltechnology.org/2012/02/star-delta-3-phase-motor-starting.html

Equipment/software list

Sl. No.	Particulars	Specification	Quantity
1	**Personal Computer**	● Operating **System**: 64-bit Microsoft Windows 10. ● Processor: 2.5 GHz (3+ GHz recommended) ● Memory: 8 GB (16GB recommended) ● Disk space: 1TB. ● Display: 1920 x 1080 resolution with True Color.	
2	**Electrical Computer Aided Drafting Software/ AutoCAD Electrical 2021**	**Student edition**	