Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bengaluru.

Course Title	:MOTOR CONTROLAND PLC LAB	Course Code	:15EE64P
Semester	:VI	Course Group	: Core
Teaching Scheme (L:T:P)	: 0:2:4 (in Hours)	Credits	: 3 Credits
Type of course	: Tutorial + Practical	Total Contact Hours : 78	
CIE	: 25 Marks	SEE	: 50 Marks
Programme: ELECTRICAL AND ELECTRONICS ENGINEERING.			

Pre-requisites	: Knowledge about–Analog and Digital Electronics, Concepts of power circuit and control circuits, working principle of electric motors and their applications.
Course Objectives	: To provide systematic training on electric motor controls that would develop technical skills in the students to design, construct and test various motor control circuits using relay logics as well as Programmable Logic Controllers.

Course Outcomes:

On successful completion of the Course, the student will be able to:

1. *Design various relay logic circuits to operate the motors.*
2. *Construct power circuit and control circuits using appropriate components /devices.*
3. *Develop, rectify errors and download the ladder programs to control the motors using PLC.*
4. *Interface PLC with the controlled device.*

LIST OF GRADED EXERCISES:

PART A

ELECTRIC MOTOR CONTROLS USING RELAY LOGIC CIRCUITS

Sl. No.	LIST OF GRADED EXERCISES	Hours
01	Draw the standard symbols of control components.	03
02	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. Note down the technical specifications.	03
03	Identify Bi-metallic Over Load Relay, Time Delay Relays - Electronic timer and Electro-mechanical Pneumatic timer and Single Phase preventer. Note down the technical specifications and terminal identification numbers.	03
04	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 numbers.	03
05	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)	03
06	DOL Starter: (a) Rig up and test Direct On Line Starter. (b) Rig up and test Direct On Line Starter with local and remote start stop. (c) Rig up and test Direct On Line Starter with inching operation.	03
07	Rig up and test the control circuit for forward and reverse operation of a motor with interlocking function using auxiliary contact.	03
08	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.	03
09	Rig up and test the control circuit for semi-automatic star delta starter.	03
10	Rig up and test the control circuit for fully automatic star delta starter.	03

Sl. No.		Hours
11	Rig up and test the control circuit for sequence operation of two motors. (The second motor cannot be started unless the first motor starts)	03
12	Rig up and test the control circuit for automatic change over of supply from EB to DG set when the EB supply fails.	03
	Total Hrs	**36**

PART B

PROGRAMABLE LOGIC CONTROLLERS

Sl. No.	LIST OF GRADED EXERCISES	Hours
13	Identify the following devices: INPUT DEVICES and THEIR APPLICATIONS. Push button switches, Thermal /Temperature sensors/ switches, Pressure switches, Float switches, Magnetic or reed switches, Limit switches, Proximity sensors-capacitive and inductive types, Optical sensors, Encoders, Relay, Contactor, Solenoid valve. OUTPUT DEVICES and THEIR APPLICATIONS. Contactors, Motors, Indicators and Hooters/Alarms.	03
14	Identify the type of PLC – Digital and Analog types. Identify the wiring mode of PLC- sourcing and sinking modes. Identify and Install Programming Software and communication driver.	03
15	Identify the PLC Programming Method used in the laboratory–Ladder program/ Functional Block Diagram /Instruction List/structured text. Connecting PLC, communication cable and programming device. Configure and establish communication between them. Identify protocols used for communication.	03
16	Understand - The Operation modes of PLC - program, run and test modes. Data files and program files, Configuration of I/Os and Addressing I/Os.	03
17	Identify the most commonly used PLC programming instructions and their applications: XIC, XIO, OTE, Latch, Unlatch, Timer and Counter Instructions.	03

18	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) 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)	**03**	
19	Develop and test the ladder program of 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.	**03**	
20	Develop and test the ladder program for DOL starter. Develop and test the ladder program for DOL starter with local and remote controls.	**03**	
21	Develop and test the ladder program for interlocking two motors.	**03**	
22	Develop a ladder programs to study ON delay. Application: Develop and test ladder program for switching ON motor1, motor 2 and motor 3 in sequence with some time delay.	**03**	
23	Develop and test ladder Program for Automatic fully Star-Delta starter.	**03**	
24	Develop and test ladder program for water level controller using latch and unlatch instructions.	**03**	
25	Interface and test PLC based DOL starter and run the motor.	**03**	
26	Interface and test PLC based Star-Delta starter and run the motor.	**03**	
	Total Hrs	**42**	

Reference books:

PART A: ELECTRIC MOTOR CONTROL

1. Control of electrical machines by S.K.Bhattacharya Birjindersingh, New Age International.
2. Electrical Design Estimation and costing by K.B.Raina &K.Battacharya.Khanna Publications.
3. Electrical Estimating and costing by Surjit Singh, DhanpatRai Company.

PART B: PROGRAMMABLE LOGIC CONTROLLERS

4. Robotics and Industrial Automation by R.K. Rajput , S. CHAND PUBLISHING.
5. Introduction to PLC by Gary Dunning ,Cengage Learning.
6. PLC, Principles and Applications by John W. Webb and Ronald A. Reis
7. NITTTR PLC STTP Course Materials.

e-Resources:

1. www.controlmanuals.com- Search for PLC and related topics.
2. https://books.google.co.in/books/about/Control_Of_Electrical_Machines.html?id= 1SHK6AJemEIC
3. http://booksite.elsevier.com/9781856176217/appendices/01~Ch11.pdf
4. electrical-engineering-portal.com › Resources

Composition of Educational Components:

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)
1	Remembering	20
2	Understanding	20
3	Application/ Analysis	60
Total		**100**

Mapping Course Outcomes with Program Outcomes:(Course Outcome linkage to Cognitive Level)

		Experiment linked	PO Mapped	Cognitive Level	Lab Sessions
CO1	*Design various relay logic circuits to operate the motors.*	5,6	2, 3, 8, 9, 10	R/A/C	6
CO2	*Construct power circuit and control circuits using appropriate components /devices.*	7,8,9,10,11,12	2, 3, 8, 9, 10	U/A	18
CO3	*Develop, rectify errors and download the ladder programs to control the motors using PLC.*	18,19,20,21,22,23,24	2, 3,4, 8, 9, 10	U/A/C/E	21
CO4	*Interface PLC with the controlled device*	25,26	2, 3,4, 8, 9, 10	A/C	6

U-Understanding; A-application/ Analysis; App-Application

Course-PO Attainment Matrix

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
EMC & PLC LAB		3	3	3				3	3	3

LEVEL 3- HIGHLY ADDRESSED, LEVEL 2-MODERATELY ADDRESSED, LEVEL 1-LOW ADDRESSED.

METHOD IS TO RELATE THE LEVEL OF PO WITH THE NUMBER OF HOURS DEVOTED TO THE COS WHICH ADDRESS THE GIVEN PO.

IF ≥40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 3

IF 25 TO 40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 2

IF 5 TO 25% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 1

If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

Course Delivery:

The laboratory Course will be delivered through Tutorial, laboratory interaction, group discussion, practical exercises, instructions, assignments and viva voice.

Tutorial - 1Hr:

Staff-in-charge will;

1. Explain the concept and working of experiment to be conducted.
2. Ask the students to draw the circuit diagram /ladder program, tabular column and truth table if any.
3. Guide the students to select appropriate components/ devices/ meters /equipments/ suitable accessories for the experiment to be conducted.
4. Give clear instructions about safety precautions to be followed while conducting the experiment.

Conduction/ Execution- 2 Hr:

Student group (3 to 5) will rig up the control circuits / develop ladder programs and conduct the experiment individually under the supervision of the staff-in-charge.

Course Assessment and Evaluation:

		What	To Whom	Frequency	Practical	Evidence Collected	Course Outcomes
Direct Assessment Method	**CIE** (Continuous Internal Evaluation)	I A Tests	Students	Two IA tests for Practical (Average marks of both the tests)	10	Blue Books	1 to 6
		Record Writing		Record Writing (Average of Marks allotted for each experiment.)	10	Lab Record	1 to 6
				Student Activity	05	3 pages Report	1 to 6
				TOTAL	**25**		
	SEE (Semester End Examination)	End Exam	Students	End of the Course	50	Answer Scripts	1 to 6
Indirect Assessment Method		Student Feedback on course	Students	Middle of The Course	Feed Back Forms		1 to 6
		End of Course Survey		End of The Course	Questionnaire		1 to 6

*CIE – Continuous Internal Evaluation   ***SEE** – Semester End Examination

Note:

1. I.A. test shall be conducted as per SEE scheme of valuation. However obtained marks shall be reduced to 10 marks. Average marks of two tests shall be rounded off to the next higher digit.
2. Rubrics to be devised appropriately by the concerned faculty to assess Student activities.

Suggested Student Activity (any one to be submitted with 3 pages report):

01. Prepare a report on applications of PLC in the Industries.
02. Prepare a report on different types/models of PLC used in the industries.
03. Prepare a report on various input and output devices used with PLCs.
04. Prepare a report on Protocols used for communication with PLCs in industries.
05. Prepare a report on different makes and models of contactors used in industries and their applications.

OR

Develop ladder programs for any one of the following PLC based applications:

01. Automatic Traffic signal control.
02. Two signal lights flashing alternately at some time interval.
03. Automatic conveyor system- Example: when the ON button is pressed, the conveyor system starts running provided the object is sensed (when an object /load is placed on it) and reverses it direction after few counts of objects and continues to run in forward and reverse directions until OFF button is pressed or when objects are not loaded / sensed for, say10 secs.
04. Go Down lighting:- when one switch is pressed, the light in that section will be ON. When a switch is pressed in the next section , the light will be ON in that section and the light in the previous section will be OFF.
05. Stair case lighting for two or more floors:- Ground floor and top floor have one way switches and in between floors has two way switches.

MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY (Course Coordinator)

Dimen sion	Scale					Students score (Group of five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	3				
2	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2				
3	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	5				
4	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	4				
Note: Concerned faculty (Course coordinator) must devise appropriate rubrics/criteria for assessing Student activity for 5 marks One activity on any one CO (course outcome) may be given to a group of FIVE students **Grand Average/Total**						14/4 =3.5 ≈4				

Example only: MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY-
Task given- Industrial visit and report writing

Dimension	Scale					Students score (Five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1.Organisation	Has not included relevant info	Has included few relevant info	Has included some relevant info	Has included many relevant info	Has included all relevant info needed	3				
2. Fulfill team's roles & duties	Does not perform any duties assigned	Performs very little duties	Performs partial duties	Performs nearly all duties	Performs all duties of assigned team roles	2				
3.Conclusion	Poor	Less Effective	Partially effective	Summarises but not exact.	Most Effective	5				
4.Convensions	Frequent Error	More Error	Some Error	Occasional Error	No Error	4				
					Total marks	14/4=3.5 ≈4				

Scheme of Valuation for SEE(Semester End Examination):

Note: The SEE Question paper should be set in such a way that Questions in the Question paper should have equal nos. of Questions from Part A and Part B.

Sl. No.	Particulars	Marks
1.	Writing Power circuit and control circuit diagrams / Ladder Programs.	15
2.	Conduction /Execution.	20
3.	Results	05
4.	Viva-voce	10
	Total	**50**

Model Question Bank:

Course Title: Motor Control and PLC Lab	Course Code: 15EE64P

PART A

1. Rig up relay logic circuits for the following logic functions:
   - i. OR Function
   - ii. NOT Function
   - iii. AND Function
   - iv. NOR Function
   - v. NAND Function
   - vi. Memory Function

2. Rig up control circuit of a DOL starter using relay logic.
3. Rig up control circuit of a DOL starter using relay logic with local and remote start /stop.
4. Rig up control circuit for Direct On Line Starter for inching operation using relay logic.
5. Rig up control circuit for forward and reverse operation of a motor with interlocking function using relay logic.
6. Rig up control circuit for semi-automatic star delta starter using relay logic.
7. Rig up control circuit for fully automatic star delta starter using relay logic.
8. Rig up control circuit for sequence operation of two motors (The second motor cannot be started unless the first motor starts) using relay logic.
9. Rig up control circuit for automatic changeover of supply from EB to DG set when the EB supply fails using relay logic.

PART B

1. Develop and test the ladder programs for the following logic functions:
   - i. OR Function
   - ii. NOT Function
   - iii. AND Function
   - iv. NOR Function
   - v. NAND Function
   - vi. Memory Function
2. Develop and test the ladder program of 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.
3. Develop and test the ladder programs to run DOL starter
4. Develop and test the ladder programs to run DOL starter with local and remote controls.
5. Develop and test the ladder program for interlocking two motors

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6. Develop and test ladder program for switching ON motor1, motor 2 and motor 3 in sequence with time delay.
7. Develop and test ladder Program for Automatic fully Star-Delta starter.
8. Develop and test ladder program for water level controller using latch and unlatch instructions.
9. Interface and test PLC based DOL starter to run the motor.
10. Interface and test PLC based Star-Delta starter to run the motor.

Motor Control and PLC Lab Equipment's Requirement:

Students Intake   :   60

Students per Batch   :   20

Sl. No.	Name of Equipment and Specification	Quantity Required
1	Contactor - 16A, 4POLE, Coil Voltage 220volts/50 hz AC With 2 NO + 2 NC	25 NOs.
2	Timer (Electronic)	10 NOs.
3	Pneumatic Timer	5 NOs.
4	Push button (ON) 2 element type(1 NO + 1 NC)	25 NOs.
5	Push button (OFF) 2 element type(1 NO + 1 NC)	25 NOs.
6	Terminals Knobs brass material with PVC top	100 NOs.
7	Different types of Push button Switches(key type, Illuminated type, Emergency trip mushroom head type)	6 NOs. Each types
8	Limit Switches	12 NOs.
9	Selector Switches	6 NOs.
10	Thermal Over load relays(0-16A,415V with 1NO+1NC)	12 NOs.
11	PLC TRAINER KIT digital type with minimum 10 I/O's with Communication cable	10 Sets
12	SENSORS(types-optical, Inductive, Capactive and through beam)	02 NOs. each type
13	Magnetic Float switch(Reed type)	02 NOs.
14	Industrial Hooter/Alarm(220V, Single Phase AC)	01 NOs.
15	Patch Cords 4mm cords banana pin type	100 NOs.
16	MCB 16A, 415V, 4pole	12NOs.
17	5A Supply Cords(2Pin/3Pin)	20 NOs.

Sl. No.	Name of Equipment and Specification	Quantity Required
18	Single Phase Preventer 415V 3phase	06 NOs.
19	LED Indicators 18mm dia, 220V AC RYB colors	50 NOs.
20	Interfacing Models **(INDUCTION MOTORS AVALIABLE IN ELECTRICAL LABS MAY BE USED)**	
	DOL STARTER WITH **MOTOR**	01 NOs.
	STAR-DELTA STARTER WITH **MOTOR**	01 NOs.
	SEQUENCE CONTROL OF **MOTORS**	01 NOs.
21	24V DC Single change over Single/Two pole Relays(Four channel)	06 NOs.

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