Course Title	: **Industrial Automation**	Course Code	: **15EC61T**
Semester	:6	Course Group	: **Core**
Teaching Scheme in Hrs (L:T:P)	: **4:0:0**	Credits	: **4**
Type of course	: **Lecture + activity**	Total Contact Hours	: **52**
CIE	: **25 Marks**	SEE	: **100 Marks**

Prerequisites

Basics concepts of semiconductor devices, analog and digital Electronics.

Course Objectives

1. Understand the working principle and applications of different power electronic devices
2. Appreciate need for Industrial electronic circuits in the controlled applications.
3. Develop PLC program and appreciate importance of SCADA in DCS in industrial applications.

Course Outcomes

On completion of the course, students will be able to
1. Understand characteristics, and working principle of different types of Power electronic devices and their applications.
2. Analyse the various Triggering and Commutation methods of Thyristors.
3. Describe the working of Choppers, Inverters and cycloconverter circuits and their applications.
4. Select Thyristors circuits for various industrial/controlled applications.
5. Understand basic concepts of PLC and develop application programs.
6. Identify and interpret the functionality of DCS and various elements of SCADA.

	Course Outcome	CL	Linked PO	Teaching Hrs
CO1	Understand the construction, characteristics, and working principle of different types of Power electronic devices and their applications.	*R/U/A*	1,2,5,6,7,10	**10**
CO2	Analyse the various triggering and commutation methods of Thyristor.	*R/U/A /E*	1,2,10	**8**
CO3	Describe the working of Choppers, Inverters and cycloconverter circuits and their applications.	*R/U/A*	1,2,3,10	**10**
CO4	Make use of various applications circuits of thyristors.	*U/A/E*	1,2,3,10	**6**
CO5	Understand basic concepts of PLC and develop its programming and applications.	*R/U/A /C*	1,2,3,4,10	**10**
CO6	Identify and interpret the functionality of DCS and various elements of SCADA	*R/U/A*	1,2,3,4,10	**8**
			Total sessions	**52**

Legends: PO-Program Outcome, CO-Course Outcome, CL-Cognitive Level, R-Remember, U-Understand, A-Apply, E-Evaluate, C-Create

Mapping Course Outcomes with Program Outcomes

Course Outcomes	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	*	*	--	--	*	*	*	--	--	*
CO2	*	*	--	--	--	--	--	--	--	*
CO3	*	*	*	--	--	--	--	--	--	*
CO4	*	*	*	--	--	--	--	--	--	*
CO5	*	*	*	*	--	--	--	--	--	*
CO6	*	*	*	*	--	--	--	--	--	*

*Legend: * Linked, -- No link*

Course-PO Attainment Matrix

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
Industrial Automation	3	3	3	2	1	1	1	--	--	3

Legend: Addressing levels: 1-Slight, 2-Moderate, 3-Substantial, -- Not addressed

Quantification Method: This 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% , Level 2; if 5 to 25%, Level 1; and if < 5%, not addressed.

Course content and pattern of marks for SEE

Unit No	Unit Name	Hour	Questions to be set For SEE					Marks Weightage	Weightage (%)
			R	U	A	E	C		
1	Power Electronic Devices	10	05	10	10	05	--	30	20
2	Triggering and commutation of SCR	8	05	05	10	--	--	20	15
3	Choppers, Inverters and Cycloconverters	10	05	10	10	05	--	30	19
4	Applications of Thyristors	6	--	05	15	--	--	20	12
5	Programmable Logic Controllers	10	05	05	10	--	05	25	19

6	DCS and SCADA System	8	05	05	10	--	--	20	15
	Total	**52**	**25**	**40**	**65**	**10**	**05**	**145**	**100**

Legend: R- Remember, U-Understand A-Application,E-Evaluate, C-Create

Course Content

Unit 1: Power Electronic Devices	Duration:10Hrs

Power Electronics-Introduction, need for power devices, features of Power diode, Power BJT, IGBT and MOSFET. SCR- Symbol, constructional features, two-transistor analogy, V-I Characteristics, specifications and ratings. Compare SCR with DIAC and TRIAC. **Controlled rectifiers-** Single phase half-wave controlled rectifier, single phase full-wave bridge controlled rectifier (only resistive load), importance of freewheeling diode. Discuss feasibility of Germanium Controlled Rectifier controlled applications.

Unit 2: Switching of SCR	Duration:08Hrs

Triggering- Definition and need, triggering circuits: R-Triggering, RC–triggering, Pulse triggering using UJT relaxation oscillators. **Commutation:** Need, discussion of natural and forced commutation of SCR. Discussion of resonant commutation, auxiliary commutation and complementary commutation. Protection of SCR-Snubber circuit.

Unit 3: Choppers, Inverters and Cycloconverters	Duration:10Hrs

Chopper-Definition**,** working principle, duty cycle, chopper control schemes, step-up and step-down chopper, chopper classifications - first quadrant, second quadrant, two quadrant and four quadrant choppers and applications. **Inverters**- Definition, working principle and types. Half-bridge inverter, full-bridge inverter, series inverter, variable dc link inverter, voltage source and current source inverters. PWM techniques used in inverters and applications. **Cycloconverters**-definition, classification, working of single phase to single phase midpoint cycloconverter, applications (for resistive load only).

Unit 4: Applications of Thyristors	Duration:06Hrs

Photo-electric Control of SCR, Light Dimmer circuit using DIAC and TRIAC, Burglar alarm circuit. Need for electronic control of motors, armature voltage control and field control method for speed control of DC shunt motor. Speed control of DC motors using dual converters, speed control of Induction motor.

Unit 5: Programmable Logic Controllers	Duration:10Hrs

Introduction to PLC**,** block diagram of overall PLC system, PLC scanning. **PLC Programming-**Ladder diagram, programming relation to digital logic gates, Boolean algebra–simple examples, PLC register basics. PLC timer-retentive and delay timer functions. PLC counter-up/down counters with examples. Basic number comparison functions. PID control of continues process with respect to PLC-PID.

Unit 6: DCS and SCADA System	Duration:08Hrs

Data Control System-Introduction, features, hierarchical architecture, advantages and applications. Introduction to HMI/MMI. SCADA-Introduction, background, definition, features, typical SCADA system. SCADA architecture-first to fourth generation. Introduction to SCADA hardware & software, interfacing PLC with SCADA, applications of SCADA. Comparison of PLC and SCADA.

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Suggested List of Student Activities   **Duration: 4hrs**

Note:The following activities or similar activities for assessing CIE (IA) for 5 marks (Any one)

Institutional Activities

Sl. No.	Activity
1	Organize Seminar, workshop or Lecture from experts on the modern trends in Industrial Automation.
2	Organize Seminar, workshop or Lecture from experts onPLC, SCADA or DCS.

Course Delivery

The course will be delivered through lectures, presentations and support of modern tools.

Course Assessment and Evaluation Scheme

Assessment Method	What		To Whom	Assessment mode /Frequency /timing	Max. Marks	Evidence Collected	Course Outcomes
Direct assessment	CIE	IA	Students	Three tests$^+$	20	Blue Books	1 to 6
				Activity*	05	Activity Sheets	1 to 6
	SEE	End exam		End of the course	100	Answer Scripts at BTE	1 to 6
				Total	125		
Indirect assessment	Student feedback on course		Students	Middle of the Course	Nil	Feedback Forms	1 to 3& Delivery of course
	End of course survey			End of the Course	Nil	Question-naires	1 to 6, Effectiveness of delivery instructions & assessment methods

Legends: CIE-Continuous Internal Evaluation, SEE- Semester End-exam Evaluation

$^+$ Every I.A. test shall be conducted for 20 marks. Average of three tests, by rounding off any fractional part thereof to next higher integer, shall be considered for IA.

*Students should do activity as per the list of suggested activities/ similar activities with prior approval of the teacher. Activity process must be initiated well in advance so that it can be completed well before the end of the term and assessed through appropriate Rubrics.

Questions for CIE and SEE will be designed to evaluate the various CLs as per the weightage shown in the following table.

Sl. No.	Cognitive Levels (CL)	Weightage (%)
1	Remembering	20
2	Understanding	30
3	Applying	40
4	Evaluate	06
5	Create	04
	Total	**100**

Continuous Internal Evaluation (CIE) pattern

(i) Student Activity (5 marks)

The following student activities or similar activities can be assigned for assessing CIE (IA) marks

Sl. No.	Activity
	1. Collect data sheets for various power electronic devices. 2. Make a hand-written report on industrial applications of PLC with logic diagram and their working. 3. Prepare a report and deliver presentation on SCADA systems. **Execution Mode** 1. Maximum of 4 students in each batch for student activity. 2. All the above activities need to be distributed evenly to the students. 3. Write qualitative report of 4-6 pages; one report per batch. 4. Activities can be carried out off-class or in the laboratory as the case may be. 5. Assessment shall be made based on quality of activity/presentation/demonstration and report.

Dimension	Scale					Marks (Example)
	1 Unsatisfactory	**2 Developing**	**3 Satisfactory**	**4 Good**	**5 Exemplary**	
1. Information search and documentation	Does not collect information relate to topic	Collects very limited information, some relate to topic	Collects basic information, most refer to the topic	Collects more information, most refer to the topic	Collects a great deals of information, all refer to the topic	3
2. Full-fills team roles and duties	Does not perform any duties assigned to the team role	Performs very little duties	Performs nearly all duties	Performs almost all duties	Performs all duties of assigned team roles	2
3. Shares work equality	Always relies on others to do the work	Rarely does the assigned work, often needs reminding	Usually does the assigned work, rarely needs reminding	Always does the assigned work, rarely needs reminding.	Always does the assigned work, without needing reminding	5
4. Listening skills	Is always talking, never allows anyone to else to speak	Usually does most of the talking, rarely allows others to speak	Listens, but sometimes talk too much,	Listens and talks a little more than needed.	Listens and talks a fare amount	3
					Total marks	ceil(13/4) = 4

(ii) Model of rubrics for assessing student activity

(iii) CIE/IA Tests (20 Marks)

Three tests have to be conducted in accordance with the test pattern given below and average marks of them are considered for CIE/IA with specified schedule.

(iv) Format of CIE/IA test question paper

CIE Question Paper					
Institution Name and Code					
Course Co-ordinator/Teacher					
Program Name		***Test No.***		*Units*	
Class/Sem		*Date*		*CL*	
Course Name		*Time*		*COs*	
Course Code		*Max. Marks*		*POs*	
Note to students: Answer all questions					

Question No.	Question	Marks	CL	CO	PO
1					
2					
3					
4					

Legends: PO-Program Outcome, CO-Course outcome, CL-Cognitive Level, R-Remember, U-Understand, A-Apply
Note: Internal choice may be given in each CO at the same cognitive level (CL).

(v) Model question paper for CIE

CIE Question Paper					
Institution Name and Code					
Course Co-ordinator/Teacher					
Program Name	Electronics & Communication	***Test No.***	1	*Units*	1 & 2
Class/Sem	6thSem	*Date*	1/1/2017	*CL*	R/U/A
Course Name	Industrial Automation	*Time*	10-11AM	*COs*	1 & 2
Course Code	15EC61T	*Max. Marks*	20	*POs*	1, 2 & 3
Note to students: Answer all questions					

No.	Question	Marks	CL	CO	PO
1	Explain the working principle of SCR.　　　OR Explain the working principle of TRIAC.	05	U/A	1	1,2,5,6,7,10
2	Define power Electronics. Mention its applications.	05	R	1	1,2,5,6,7,10
3	List the turn ON methods of SCR. Explain any two.OR Explain RC-triggering method to turn ON SCR.	05	R/U/A	2	1,2,10
4	Sketchand Explain Resonant commutation.	05	U/A	2	1,2,10

Semester End-exam Evaluation (SEE)

(i) End-exam question-paper pattern

.Unit No.	Unit Name	Study Duration (Hrs.)	No. Questions for End-exam	
			5 marks Part - a	10 marks Part - b
I	Power Electronic Devices	10	1	2
II	Triggering and commutation of SCR	8	1	2
III	Choppers, Inverters and Cycloconverters	10	2	2
IV	Applications of Thyristors	6	2	1
V	Programmable Logic Controllers	10	1	2
VI	DCS and SCADA System	8	2	1
	Total	**52**	**09 (45 Marks)**	**10 (100 Marks)**

(ii) Model question paper

Course Title **: Industrial Automation**

Course Code **: 15EC61T** Time **: 3 Hrs**

Semester **: 6** Max. Marks**: 100**

Instructions**:** *1. Answer any **SIX** question from **Part A** (5x6=30 Marks)*

*2. Answer any **SEVEN** full questions from **Part B** (7x10=70 Marks)*

Part A
1. Define power Electronics. Mention its applications.
2. Mention the different methods for protection of SCR
3. Define Cycloconverters. Explain its working principle.
4. Explain Two Quadrant chopper.
5. Discuss the importance of freewheeling diode
6. Write the circuit diagram for Light Dimmer circuit using DIAC and TRIAC.
7. Discuss Process Scanning of PLC.
8. Explain the concept of SCADA hardware.
9. Mention the features of SCADA.

Part B
1. Explain two transistor analogy of SCR with circuit diagram.
2. Sketch the V-I characteristics of TRIACand explain its working.
3. Explain RC-triggering method to turn ON SCR with circuit diagram.
4. Sketch and Explain Complementary commutation.
5. Sketch and explain Single phase to single phase midpoint cycloconverter.
6. Explain Four Quadrant chopper with circuit diagram.
7. Sketch the block diagram for Speed control of DC motors using Dual converters.
8. a) List and explain PLC Registers.

   b) Describe Retentive and Delay timer functions.
9. a) Define ladder diagram? Write and label its parts.

   b) Explain jump functions with example.
10. Sketch and explain typical SCADA system.

Course Title : **Industrial Automation**	Course Code: **15EC61T**

UNIT-1.Power Electronic Devices

05 Marks

Remember
1. What is the relevance of power electronics? Mention its applications.
2. Define holding and Latching current in SCR
3. List the features of power diode
4. What is the function of SCR? List its applications
5. List the applications of SCR and define holding current.
6. List the applications of IGBT and power BJT.
7. How does SCR switch differ from diode switch?

Understand
1. Distinguish between SCR and TRIAC
2. Classify the types of power semiconductor devices.
3. Explain the working of SCR.
4. Explain the characteristics of power diode.
5. Explain the characteristics of IGBT.
6. Discuss the structure of power MOSFET.
7. Discuss the structure of power BJT.
8. Discuss the structure/construction of IGBT.
9. Explain the characteristics of power BJT.
10. Explain the characteristics of MOSFET
11. Explain the structure of SCR.
12. Explain two transistor analogy of SCR.
13. Compare DIAC and TRIAC.
14. Compare SCR and TRIAC.
15. Discuss the importance of freewheeling diode.
16. ExplainFull wave mid-point controlled rectifier

Applying
1. Draw switching times characteristics of BJT and explain.
2. Write the V-I characteristics of SCR.
3. Sketch the circuit of Single Phase half wave controlled rectifier
4. Sketch the circuit of Full wave mid-point controlled rectifier
5. Sketch the circuit of Full wave bridge controlled rectifier
6. Sketch the circuit of Half wave bridge controlled rectifier

Evaluate
1. Compare IGBT and MOSFET.
2. Compare BJT and MOSFET.
3. Evaluate the expression for anode current of SCR.
4. Chose the suitable circuit for mid-point controlled rectification and explain.
5. Summarise the applications of Thyristors.
6. Evaluate the expression for two transistor analogy of SCR.

10 Marks

Remember

1. Define power electronics. Mention any 8 applications of power electronics.
2. Name any 5 applications of SCR and IGBT each.

Understand
1. Explain the characteristics and working principle of power BJT.
2. Explain the characteristics and working principle of MOSFET.
3. Differentiate BJT, IGBT and MOSFET.
4. Differentiate SCR, TRIAC and DIAC.
5. Explain two transistor analogy of SCR with circuit diagram.

Applying
1. Sketch the V-I characteristics of SCRand explain its working.
2. Sketch and explain the characteristics of IGBT.
3. Sketch and explain the Single Phase half wave controlled rectifier
4. Sketch and explain the Full wave mid-point controlled rectifier
5. Sketch and explain the Full wave bridge controlled rectifier
6. Sketch and explain the Half wave bridge controlled rectifier

UNIT-2.Triggering and commutation of SCR
05 Marks

Remember
1. Define Triggering and Commutation of SCR.
2. List the turn ON methods of SCR. Explain any two.
3. Define natural and forced commutation. List the types.
4. Mention the different methods for protection of SCR.
5. List the types of Commutation methods.

Understand
1. Explain briefly the turn ON methods of SCR.
2. Compare Natural and forced commutation.
3. Briefly explain Naturalcommutation, forcedcommutation and resonant commutation.
4. Explain snubber circuit to protect SCR.
5. Explain over voltage and over current protection of SCR.
6. Explain dv/dt protection of SCR.
7. Explain Gate protection of SCR.

Applying
1. Sketch and Explain Resonant commutation
2. Sketch the circuit forAuxiliary commutation
3. Sketch the circuit forComplementary commutation
4. Write the neat circuit diagram of SCR being triggered by UJT.
5. Sketch the circuit for RC-triggering method to turn ON SCR.
6. Sketch and explain R-triggering method to turn ON SCR.

10 Marks

Remember
1. List the types of Commutation methods. Explain any two methods.
2. List the different triggering methods of SCR and explain.

Understand
1. Explain the different methods for protecting the SCR.
2. Explain RC-triggering method to turn ON SCR with circuit diagram.

Applying
1. Sketch and explain pulse triggering using UJT relaxation oscillator to turn ON SCR.

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2. Sketch and Explain Auxiliary commutation
3. Sketch and Explain Complementary commutation

UNIT-3 Choppers, Inverters and Cycloconverters
05 Marks

Remember
1. Define Chopper. Mention its applications.
2. Define Inverter. Mention its applications.
3. Define Cycloconverter. Mention its applications.
4. Define Step-up and step-down chopper.
5. Define Cycloconverters. Explain its working principle.

Understand
1. Explain the basic principle of chopper operation
2. Explain different Chopper control Schemes
3. Explain the working principle of Step-up chopper
4. Explain the working principle of step-down chopper
5. Classify the chopper. Explain First Quadrant chopper.
6. Explain Second Quadrant chopper.
7. Explain Two Quadrant chopper.
8. Explain Four Quadrant chopper.
9. Write a short note on Inverters.
10. Classify the inverters based on commutation and explain.

Applying
1. Write a short note on Voltage source inverter
2. Write a short note on current source inverter
3. Sketch and explain the working principle of Series Inverter
4. Sketch and explain the working principle of Full Bridge Inverter
5. Write the circuit diagram of Single phase to single phase midpoint cycloconverter.
6. Sketch and explain the working principle of Half Bridge Inverter

Evaluate
1. Compare Voltage source inverter and current source inverter
2. Summarise the applications of Cycloconverter.
3. Summarise the applications of Inverters.
4. Predict and sketch the waveform of PWM techniques used in inverters.
5. Evaluate the expression for duty cycle of chopper and explain.

10 Marks

Understand
1. Explain Four Quadrant chopper with circuit diagram.
2. Explain PWM techniques used in inverters

Applying
1. Sketch and explain Single phase to single phase midpoint cycloconverter.
2. Sketch and explain the working principle of Variable DC linkinverter.

UNIT-4 Applications of Thyristors
05 Marks

Understand
1. Explain over voltage protection of motors.
2. Discuss over current protection of motors.
3. Explain Light Dimmer circuit using DIAC and TRIAC
4. Explain Burglar Alarm circuit using SCR

Applying

1. Sketch the block diagram for Speed control of DC motors using Dual converters
2. Sketch the block diagram for speed control of single phase Induction motor
3. Sketch the block diagram for speed control of three phase Induction motor
4. Write the circuit diagram for Photo Electric Control of SCR
5. Write the circuit diagram for Light Dimmer circuit using DIAC and TRIAC.
6. Sketch the circuit of Burglar Alarm circuit using SCR.
7. Sketch the block diagram for Armature voltage control method for speed control of DC shunt motor
8. Sketch the block diagram for Armature Field control method for speed control of DC shunt motor

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10 Marks

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Understand

1. Explain thePhoto Electric Control of SCR with circuit diagram.
2. Explain Light, Dimmer circuit using DIAC and TRIAC with circuit diagram.
3. Sketch and explain the Burglar Alarm circuit

Applying

1. Sketch and explain the Armature voltage control method for speed control of DC shunt motor
2. Sketch and explain the Armature Field control method for speed control of DC shunt motor
3. Sketch and explain the Speed control of DC motors using Dual converters
4. Sketch and explain the speed control of single phase Induction motor
5. Sketch and explain the speed control of three phase Induction motor

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UNIT-5 Programmable Logic Controllers
05 Marks

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Remember

1. Define PLC. Explain its advantages.
2. List the hardware components of PLC.
3. Define ladder diagram? Write and label its parts.
4. List the any 5 symbols used in ladder diagrams.
5. List and explain PLC Registers.
6. List and explain PLC timers with examples.

Understand

1. Explain overall PLC system.
2. Discuss Process Scanning of PLC.
3. Explain the significance of Ladder diagram in PLC programming.
4. Describe General characteristics of Registers
5. Explain Up/down Counter with examples
6. Explain Holding Registers, and Input & Output Registers

Applying

1. Write the ladder diagram, truth table for basic logic gates.
2. Write the ladder diagram and truth table for the expression Y=(A and B) or C
3. Describe Retentive and Delay timer functions.
4. Write short note on PLC up/down counter.
5. Differentiate between relay logic panel & PLC based control panel.

Create

1. Design ladder diagram for Demorgan's theorem expressions.

2. Construct ladder diagram for the Boolean expression $Y=(AB+\bar{B}C+\overline{CD})$
3. Write the block diagram of PID module.
4. Prepare the list of functional features of Ladder diagram.
5. Prepare the list of functional features of PLC.

10 Marks

Remember
1. a) Define PLC. Explain its advantages
   b)List and explain PLC Registers
2. a)Define ladder diagram? Write and label its parts
   b) List any five symbols used in ladder diagrams

Understand
1. Define PID? Explain its control process with respect to PLC.
2. Explain PLC timers with diagram.
3. Explain jump with return and non return functions

Applying
1. Write the block diagram of overall PLC system and explain.
2. Write the ladder diagram, truth table for basic logic gates and explain.
3. Write the ladder diagram and truth table for the following expressions:
   (i)Y1=(A and B) or C, (ii) Y2= (A or B) and C.

UNIT-6 DCS and SCADA System
05 Marks

Remember
1. Define SCADA. List its features.
2. Define DCS. Mention its features.
3. Mention the features of SCADA.
4. List the applications of SCADA.
5. List the Advantages of DCS.

Understand
1. Explain concept of HMI and MMI.
2. Explain the significance of SCADA.
3. Explain working of HMI with sketch
4. Explain working of MMI with sketch
5. Explain the concept of SCADA hardware.
6. Explain the concept of SCADA software.
7. Explain the method of interfacing SCADA with PLC.
8. Compare SCADA and PLC
9. Explain first(monolithic) generation architecture of SCADA.
10. Explain Second (distributed) generation architecture of SCADA.
11. Explain third (Networked) generation architecture of SCADA.

Application
1. Justify the interfacing of SCADA with PLC.
2. Describe SCADA hardware.
3. Describe SCADA software.
4. Write the block diagram of fourth generation SCADA architecture.
5. Write the block diagram of hierarchical architecture of DCS.

10 Marks

Understand
1. Describe SCADA hardware and software.
2. Explain the block diagram of DCS system.
3. Explain fourth (Internet) generation architecture of SCADA.
4. Explain the concept of SCADA hardware and software.

Application
1. Sketch and explain elements of SCADA System.
2. Sketch the block diagram for second and third generation SCADAarchitectureand explain.

End