Chhattisgarh Swami Vivekanand Technical University, Bhilai

Diploma in Electronics and Telecommunication Engineering **Semester-IV**

A) Course Code : 2028471(028)

B) Course Title : Microcontroller and its application

C) Pre- requisite Course Code and Title : Digital electronics

D) Rationale

Microcontroller is used in almost all the domestic, industrial, consumer goods and other high-end products. Automation is used in every field of engineering and microcontroller is inbuilt element of these systems and devices. Diploma engineers have to deal with various microcontroller-based systems and maintain them. This course is intended to develop the skills to maintain and solve the application problems related to microcontrollers.

E) Course Outcomes:

CO-1 Analyze architecture of microcontroller ICs.

CO-2 Develop program for 8051 in assembly language for the specified operations.

CO-3 Develop program by using timer, interrupt and serial ports /parallel ports.

CO-4 Interface the memory and I/O devices to 8051 microcontroller.

CO-5 Use microcontroller for the given application.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credit L+T+(P/2)
1	E&TC Engineering	2028471(028)	Microcontroller and its Application	3	-	-	3
2	E&TC Engineering	2028461(028)	Microcontroller and its Application (Lab)	-	2	-	1

Legend: L-Lecture, P- Practical, T- Tutorial

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	E&TC Engineering	2028471(028)	Microcontroller and its Application	70	20	30	-	-	120
2.	E&TC Engineering	2028461(028)	Microcontroller and its Application (Lab)	-	-	-	30	50	80

Legend: ESE- End semester Exam, CT- Class test, TA- Teacher Assessment

H) Course-Curriculum Detailing:

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

CO-1 Analyze architecture of microcontroller ICs.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Compare the parameters microprocessor, microcontroller and microcomputer. SO1.2 Explain different type of microcontroller architectures with neat block diagram. SO1.3 Describe with neat sketch memory organization of 8051 microcontroller. SO1.4 Compare the given derivatives of 8051 microcontroller.	LE1.1 Identify various blocks of 8051 microcontroller.	**Unit-1.0 Basics of microprocessor and 8051 Microcontroller** 1.1 Microprocessor, microcomputers, and microcontrollers (basic introduction and comparison) 1.2 Types of buses, address bus, data bus and control bus 1.3 Harvard and Von-Neuman architecture 1.4 8051 microcontroller: Architecture, Pin configuration, stack,memory organization 1.5 Comparison between derivatives of 8051 (8951, 8952, 8031, 8751).	• List basic difference between microprocessor, microcomputer and microcontroller. • Boolean processor, power saving options - idle and power down mode.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Explain the architecture of 8051 microcontroller with neat sketch.

b. Mini Project:

i. Prepare a chart of various features using data sheets of 8051 microcontroller and its derivatives.

c. Other Activities (Specify) :

i. Seminar on importance of 8051 microcontroller.

CO-2 Develop program for 8051 in assembly language for the specified operations.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Identify addressing mode of the given Instruction. SO2.2 Describe data transfer instructions with suitable examples. SO2.3 Write an assemble Language Program(ALP)to perform stack operation	LE2.1 Develop an assembly language program (ALP) to perform following arithmetic operations on 8-bit	**Unit-2.08051 Instruction set and programming** 2.1 Addressing modes. 2.2 Instruction set (Data transfer,	• Discuss the RAM and ROM space allocation in 8051. • Assembler Directives: ORG,DB,EQU,END,CODE,DATA

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.4 Explain the function of assembler, compiler and linker.	data:- addition, subtraction, multiplication and division. LE2.2 Develop an ALP to perform following arithmetic operations on 16-bit data:- addition, subtraction. LE2.3 Develop an ALP to transfer data from source to destination location of internal data memory. LE2.4 Develop an ALP to transfer data from source to destination location of external data memory LE2.5 Write an ALP to exchange data from source to destination memory location. LE2.6 Write ALP to find smallest/largest number from the given data bytes stored in internal data	Logical, Arithmetic, Branching, Machine control, Stack operation, Boolean) 2.3 Assembly language programming (ALP) 2.4 Software development cycle: editor, assembler, cross-compiler, linker, locator, compiler	

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
	memory locations. LE2.7 Write ALP to find smallest/largest number from the given data bytes stored in external data memory locations. LE2.8 Write ALP for arranging numbers in ascending /descending order stored in external memory locations. LE2.9 Write an ALP to generate delay, using register.		

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. Explain the types of addressing modes with examples.
ii. Explain the different steps for Stack implementation in 8051.

b. Mini Project:

i. Write an Assembly language program in 8051 to generate Fibonacci series.

CO-3 Develop program by using timer, interrupt and serial ports /parallel ports.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Write an ALP to generate a delay for the specified crystal frequency and mode. SO3.2 Explain with sketch the operation of the different mode for timer and	LE3.1 Write an ALP to generate delay, using Timer. LE3.2 Write an ALP to transfer 8-bit data serially on serial port. LE3.3 Write an ALP to turn LED ON when microcontroller gets interrupted.	**Unit 3.08051 Timers, Interrupts, serial and parallel communication** 3.1 Timer/Counters: SFRs: TMOD, TCON, Timer / Counter - Logic and modes, Simple programs on timer to generate time delay 3.2 Interrupts-SFRs: - IE, IP, Simple programs on	• Describe the purpose of interrupt/timers in a microcontroller.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
counter SO3.3 Explain with sketch the operation of the given mode for serial communication. SO3.4 Generate the waveforms by using the given mode of timer. SO3.5 Write an ALP to generate the specified waveform for the given port.	LE3.4 Develop an ALP to generate pulse and square wave by using Timer delay. LE3.5 Write an ALP to turn ON and OFF all 8 LED s at given port.	interrupts 3.3 Serial communication- SFRs: - SCON,SBUF,PCON, Modes of serial communication, Simpleprograms on serial communication 3.4 I/O port structure and configuration-P0,P1,P2,P3	

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Describe the I/O port structure and configuration of 8051.
ii. Write an ALP to generate 1ms delay using 8051 timer.

b. Mini Project:

i. Build a circuit using 8051 microcontroller to blink LED.
ii. Build a circuit using 8051 microcontroller to blink LED in ring fashion.

CO-4 Interface the memory and I/O devices to 8051 microcontroller.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Describe with sketch the interfacing of the given external Memory. SO4.2 Explain with Sketch the interfacing of the given external I/O device. SO4.3 Write an Assembly Language program to operate the given I/O device. SO4.4 Draw the Interfacing Diagram of ADC/DAC – 0808/09	LE4.1 Interface LED with 8051 to turn on the LED LE4.2 Interface 7-segment display to display the decimal number from 0 to 9. LE4.3 Write an ALP to turn the relay ON and OFF. LE4.4 Interface the given keyboard with 8051and display the key pressed. LE4.5 Interface LCD with 8051Microcontroller to display the alphabets and Decimal Numbers. LE4.6 Interface ADC with	**Unit 4.08051 Memory and I/O device Interfacing** 4.1 Memory interfacing: - Program and data memory. 4.2 I/O Interfacing: -LED, relays, keyboard, LCD, seven segment display, Stepper motor. 4.3 Interfacing DAC - 0808 with 8051 and its simple programming. 4.4 Interfacing ADC - 0808/09 with 8051 and its simple programming	• Summarize the basic concept of stepper motor, DAC, LED, LCD and seven segment display.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
	8051Microcontroller for analog to digital conversion. LE4.7 Interface DAC with 8051microcontroller to observe Waveforms.		

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. Prepare a chart of various types of LCDs to display its features, pin functions and steps of operations using data sheets.

ii. Prepare a chart of various types of seven segment displays, keyboard to display its features and steps for its operations using data sheets.

b. Mini Project:

i. Build a circuit using 8051 microcontroller to blink LED in ring fashion.

CO-5 Use microcontroller for the given application.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Write different steps for generating square wave form Using port pin of 8051. SO5.2 Control the given parameter using8051. SO5.3 Write different steps for interfacing stepper motor with microco-ntroller. SO5.4 Program 8051 for the given application	LE5.1 Write ALP to Interface stepper Motor with Microcontroller And rotate Stepper motor in Clockwise and anti-clock wise direction at given Angles.	**Unit-5.0Applications of 8051 Microcontroller** 5.1 Square wave generation using port pins of 8051. 5.2 Water level controller. 5.3 Temperature controller using ADC (0808/09). 5.4 Stepper motor control for clock wise, anti- clock wise rotation 5.5 Traffic light controller	• List the applications of 8051 microcontroller according to its use in various industries. • Square and triangular Waveform generation using DAC.

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

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Describe the working of Temperature controller using ADC (0808/09.

b. Mini Project:

i. Build a water level controller for given parameters.
ii. Build traffic light controller for specified delay.
iii. Build a room temperature measurement circuit using microcontroller.

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

I) Suggested Specification Table (For ESA of Classroom Instruction CI+SW+SL):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Basics of Microprocessor and 8051 Microcontroller	4	4	6	14
II	8051 Instruction set and programming	2	6	6	14
III	8051 Timers, Interrupts, serial and parallel communication	2	6	6	14
IV	8051 Memory and I/O Interfacing	4	4	6	14
V	Applications of 8051 Microcontroller	2	6	6	14
	Total	**14**	**26**	**30**	**70**

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

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

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Identify various blocks of 8051 microcontroller.	15	10	5
LE2.1	Develop an assembly language program (ALP) to perform following arithmetic operations on 8-bit data:-addition, subtraction, multiplication and division.	15	10	5
LE2.2	Develop an ALP to perform following arithmetic operations on 16-bit data:-addition, subtraction.	15	10	5
LE2.3	Develop an ALP to transfer data from source to destination location of internal data memory.	15	10	5
LE2.4	Develop an ALP to transfer data from source to destination location of external data memory	15	10	5
LE2.5	Write an ALP to exchange data from source to destination memory location.	15	10	5
LE2.6	Write ALP to find smallest/largest number from the given data bytes stored in internal data memory locations.	15	10	5
LE2.7	Write ALP to find smallest/largest number from the given data bytes stored in external data memory locations.	15	10	5
LE2.8	Write ALP for arranging numbers in ascending /descending order stored in external memory locations.	15	10	5
LE2.9	Write an ALP to generate delay, using register.	15	10	5
LE3.1	Write an ALP to generate delay, using Timer.	15	10	5
LE3.2	Write an ALP to transfer 8 bit data serially on serial port.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE3.3	Write an ALP to turn LED ON when microcontroller gets interrupted.	15	10	5
LE3.4	Develop an ALP to generate pulse and square wave by using Timer delay.	15	10	5
LE3.5	Write an ALP to turn ON and OFF all 8 LED s at given port.	15	10	5
LE4.1	Interface LED with 8051 to turn on the LED	15	10	5
LE4.2	Interface 7-segment display to display the decimal number from 0 to 9.	15	10	5
LE4.3	Write an ALP to turn the relay ON and OFF.	15	10	5
LE4.4	Interface the given keyboard with 8051and display the key pressed.	15	10	5
LE4.5	Interface LCD with 8051 Microcontroller to display the alphabets and Decimal Numbers.	15	10	5
LE4.6	Interface ADC with 8051 Microcontroller for analog to digital conversion.	15	10	5
LE4.7	Interface DAC with 8051 microcontroller to observe Waveforms.	15	10	5
LE5.1	Write ALP to Interface stepper Motor with Microcontroller And rotate Stepper motor in Clockwise and anti-clockwise direction at given Angles.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the cou3rse wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals

Legend : PRA: Process Assessment, PDA : Product Assessment

Note : Only one experiment has to performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

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

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1	8051 Microcontroller Architecture Programming and Application	Kenneth, Ayala	EEE/Prentice Hall of India,	2nd edition, New Delhi,1 July 2004, ISBN-13: 978-1401861582
2	The 8051 Microcontroller and Embedded system	Mazidi, Mohmad Ali; Mazidi, Janice Gelispe; McKinley Roline D.	Pearson /Prentice Hall,	2nd edition, Delhi,2008, ISBN 978-8177589030
3	Microcontroller Principle and Application	Pal, Ajit	Prentice Hall	India, New Delhi,2014, ISBN13: 978-81-203-4392-4
4	Microcontroller Theory and Application	Deshmukh, Ajay	Tata McGraw Hill pvt. Ltd.,	New Delhi,2011, ISBN- 9780070585959
5	Microcontroller Architecture Programming, Interfacing and System Design	Kamal, Raj	Pearson Education India,	Delhi,2012, ISBN 13:9788131759905
6	Microprocessors and Microcontrollers	Mathur; Panda	PHI Learning Private Limited	2016 or Latest edition

(b) Open source software and website address :

1. Simulation software:-www.keil.com.
2. Microcontroller:-www.faqs.org/microcontroller.
3. Memory:- www.slideshare.net/aismahesh/memory-8051
4. 8051 microcontroller:- www.intorobotics.com/8051-microcontroller-programming-tutorials- simulators-compilers-and-programmers/
5. Microcontroller instructions: www.electrofriends.com/ articles/electronics/ microcontroller-electronics-articles/8051-8951/80518951-microcontroller instruction-set/
6. Microcontroller:- www.ikalogic.com/part-1-introduction-to-8051-microcontrollers
7. Microcontroller:- www.binaryupdates.com/switch-with-8051-microcontroller/
8. Software:-www.edsim51.com
9. Microcontroller:- www.mikroe.com/chapters/view/64/chapter-1-introduction-to-microcontrollers/
10. Microcontroller project:- www.8051projects.net/download-c4-8051-projects.html
11. Microcontroller:- www.nptel.ac.in/courses/Webcourse- contents/ IITKANPUR/microcontrollers/micro/ui /Course_home2_5.htm

(c) Others

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

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Microcontroller Trainer kit	Single board systems with 8K RAM,ROM memory with battery back up, 16X4,16 X2, LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply.	All
2	PC	Desktop PC with microcontroller simulation software	All
3	CRO	Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe	All
4	Stepper Motor	50/100 RPM	LE 5.1
5	Trainer board	Keyboard 4*4trainer board	LE4.1 to LE 4.4
6	7- segment LED Display	7-segment LED Display:- 0.56 in 1-digit, common anode/common cathode	LE 4.2
7	Trainer board	ADC (0808)trainer board	LE 4.6
8	Trainer board	DAC (0808)trainer board	LE 4.7
9	Trainer board	LCD trainer board	LE 4.5

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Analyze architecture of microcontroller ICs.	2	3	3	3	1	1	1	2	1	1	2	2
CO-2 Develop program for 8051 in assembly language for the specified operations.	2	3	3	3	1	1	1	2	1	1	2	2
CO-3 Develop program by using timer, interrupt and serial ports /parallel ports.	2	3	3	3	1	1	1	2	1	1	2	2
CO-4 Interface the memory and I/O devices to 8051 microcontroller.	2	3	3	3	1	1	1	2	1	1	2	2
CO-5 Use microcontroller for the given application.	2	3	3	3	1	1	1	2	1	1	2	2

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-1 Analyze architecture of microcontroller ICs.	SO1.1,SO1.2 SO1.3,SO1.4	LE1.1	**Unit 1.0 Basics of Microprocessor and 8051 Microcontroller** 1.1,1.2,1.3,1.4,1.5,1.6	As mentioned in relevant page numbers
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-2 Develop program for 8051 in Assembly language for the specified operations.	SO2.1, SO2.2 SO2.3, SO2.4 SO2.5	LE2.1 - LE2.9	**Unit2.0 8051 Instruction Set and programming** 2.1,2.2,2.3,2.4,2.5	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-3 Develop program by using timer, interrupt and serial ports /parallel ports.	SO3.1, SO3.2 SO3.3, SO3.4 SO3.5	LE3.1 - LE3.5	**Unit3.0 8051 Timers, interrupts, serial and parallel communication** 3.1,3.2,3.3,3.4	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-4 Interface the memory and I/O devices to 8051 microcontroller.	SO4.1, SO4.2 SO4.3, SO4.4	LE4.1 - LE4.7	**Unit 4.0 8051 Memory and I/O device Interfacing** 4.1,4.2,4.3,4.4	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-5 Use microcontroller for the given application.	SO5.1, SO5.2 SO5.3, SO5.4	LE5.1	**Unit 5.0 Applications of 8051 Microcontroller** 5.1,5.2,5.3,5.4,5.5,5.6	

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A) Course Code : 2028472(028)
B) Course Title : Communication System-I
C) Pre- requisite Course Code and Title : Basic Electronics, Digital Electronics
D) Rationale:

Modern Society and Industry both are fully dependent on the telecommunication systems, not only for the communications but for all the other services provided by the communication networks. Various modes of communication like Radio and Microwave links, satellite, mobile, RADAR, telephony, telegraphy, optical and other types of cable communication etc. are commonly used for the different applications. This course will help the students to analyze and maintain components of basic communication system. After completing this course students will develop the skills to maintain the common Communication systems.

E) Course Outcomes:

CO-1 Identify basic elements of communication system.

CO-2 Analyze different types of signal used in the communication systems.

CO-3 Analyze the affect of different types of noise produced by the various sources, on the communication system.

CO-4 Analyze Analog Modulated and Demodulated signal.

CO-5 Maintain simple communication transmitters and receivers.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credit L+T+(P/2)
1	E&TC Engineering	2028472(028)	Communication System-I	3	-	-	3
2	E&TC Engineering	2028462(028)	Communication System-I (Lab)	-	2	-	1

Legend: L-Lecture, P- Practical, T- Tutorial

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	E&TC Engineering	2028472(028)	Communication System-I	70	20	30	-	-	120
2	E&TC Engineering	2028462(028)	Communication System-I (Lab)	-	-	-	30	50	80

Legend: ESE- End semester Exam, CT- Class test, TA- Teacher Assessment

H) Course-Curriculum Detailing:

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

CO-1 Identify basic elements of communication system.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
SO1.1 Classify frequency bands used for the various communication systems. SO1.2 Sketch the labeled diagram of electromagnetic waves spectrum and suggest the applications of each band. SO1.3 Classify various communication channel with example. SO1.4 Identify the frequency band for the given type of communication. SO1.5 List the examples of the simplex, half duplex and full duplex mode of communication.	LE1.1 Identify different block of communication systems available in your lab. LE1.2 Measure the frequency band of communication receiver available in your lab.	**Unit-1.0 Introduction to Communication System** 1.1 Basic building blocks of communication system: Transmitter, receiver, channel, antenna, multiplexer, and demultiplexer, encoder, decoder 1.2 Difference between Analog and Digital communication system 1.3 Modes of communication: Simplex, Half duplex and full duplex 1.4 Electromagnetic spectrum, different frequency bands and their applications, Concept of bandwidth 1.5 Examples of wired and wireless channels (basic idea only):- telephone channel, coaxial cable, optical fiber cable, wireless broadcast channel,	• Discussed Fundamental limitations of Analog communication system. • List various types of practical communication system. • Compare characteristics of analog and digital communication system. • Differentiate between wired and wireless communication.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Prepare a chart of electromagnetic spectrum used for the various communication system.
ii. List advantage and disadvantage of analog communication system.

b. Mini Project:

i. Prepare circuit to demonstrate the simplex and duplex communication mode.

c. Other Activities (Specify) :

i. Prepare PPT on wired and wireless communication channel used for different applications.

CO-2 Analyze different types of signal in the communication systems.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Sketch the given type of signals and perform the given operation on them. SO2.2 Classify the given signals with example. SO2.3 Differentiate the characteristics of the given type of signal. SO2.4 Calculate the periodicity of the given signal. SO2.5 Use the properties of Fourier series and Fourier Transform to analyze the given type of signal.	LE2.1 Generate sinusoidal, square, pulse, triangular signal of the given amplitude and frequency (with the help of simulation software). LE2.2 Determine the Fourier transform of the given function using any software. LE2.3 Plot the amplitude and phase spectrum of the given pulse wave. LE2.4 Measure the bandwidth of the given periodic signals. LE2.5 Sample the given signal and reconstruct it applying sampling theorem concept.	**Unit 2.0 Introduction to Signals and Sampling** 2.1 Representation of test signals like: pulse, sine, cosine, gate pulses, sawtooth, triangular and other periodic and non-periodic signals 2.2 Basic Operations on Signals: Time shifting, Time scaling, Amplitude scaling 2.3 Classification of Signals: Continuous and Discrete signals, Deterministic and Random signals, Periodic and non-Periodic signals, Energy and Power signals, causal and non-causal signals, Even and Odd signals (For both Continuous and Discrete signals) 2.4 Use of Fourier series and Fourier transform to analyze the basic signals.	• Summarize applications of Fourier series and Fourier transform used for analysis of signal.

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. Generate various signals using Simulation software and take the printout of the output waveform.

ii. Perform basic operations on signals using simulation software and take the printout of the waveform.

b. Mini Project:

i. Generate noise signal and plot the amplitude and phase plot of it using any simulation software.

c. Other Activities (Specify):

i. Present seminar on application of Fourier series and Fourier transform in communication system.

CO-3 Analyze the affect of different types of noise produced by various sources, on the communication system.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Identify different sources of noise present in the communication system. SO3.2 Classify different types of noise. SO3.3 Explain noise parameters with justification. SO3.4 Analyze the effect of white noise on the given communication system. SO3.5 Define figure of merit of the given type of communication system.	LE3.1 Measure noise parameterof the given communication system. LE3.2 Generate noise signal using random function. LE3.3 Calculate Noise figure of the Amplifiers connected in cascade using simulation software.	**Unit-3.0 Noise** 3.1 Introduction: - sources of noise 3.2 Classification of noise: - shot noise, Partition Noise, Flicker Noise, High frequency noise Thermal Noise, Relation between noise power and bandwidth, White Gaussian noise 3.3 Noise bandwidth, signal to noise ratio, Figure of merit, Noise factor, Noise figure, Noise temperature, Noise factor and equivalent noise temperature of amplifiers connected in cascade.	• Power spectral density of white noise. • Discus Importance of white Gaussian noise in communication system.

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Sketch equivalent circuit for thermal noise and explain it.
ii. Write short notes on noise produced by internal sources of communication system.

b. Mini Project:

i. Prepare a report on the natural and manmade noise affecting the radio communication system.

c. Other Activities (Specify):

i. Prepare PPT on different types of internal and external types of noise.

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

CO-4 Analyze Analog Modulated and Demodulated signal.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 4.1 Explain the need for the modulation. SO 4.2 Calculate the bandwidth, power and modulation index for a given AM signal. SO 4.3 Analyze carrier power and sideband power of the AM waveform. SO 4.4 Compare performance of AM and FM.	LE4.1 Measure modulation index of the AM wave using CRO. LE4.2 Calculate modulation index and efficiency of the DSB-SC signal. LE4.3 Calculate modulation index and efficiency of the SSB-SC signal. LE4.4 Demodulate AM, DSB-SC, SSB-SC using coherent detector. LE4.5 Calculate the modulation index of the FM signal. LE4.6 Test the frequency response of Pre-emphasis & De-emphasis Circuits used in FM receiver . LE4.7 Test the performance of FM Demodulation circuit. LE4.8 Test the performance of phase modulated circuit.	**Unit-4.0 Analog Modulation** 4.1 Concept and necessity of modulation 4.2 Amplitude modulation: mathematical representation of AM, DSB,SSB, efficiency and percentage of modulation ,bandwidth and power requirement in AM,DSB,SSB generation and detection of AM(Basic idea only) introduction to VSB 4.3 Basic idea of low level and high level AM modulation. 4.4 Angle Modulation: Representation of FM signal and PM signal, Bandwidth and Power requirement in FM & PM, Principles of operation of frequency modulation using Varactor diode and VCO.	• Discusses significance of modulation index. • Explain the importance of VSB transmission in Broadcast Television. • Describe advantages and disadvantages of FM over AM.

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. Sketch the waveform of AM signal for the given modulation index.
ii. Sketch the waveform of AM, FM and PM signal and analyze it.
iii. List the advantages and disadvantages of AM signal.
iv. List the advantages and disadvantages of FM signal.
v. List the applications (any five) of AM and FM.

b. Mini Project:

i. Simulate an AM signal for the given modulation index using any simulation software.
ii. Simulate a FM signal of a given modulation index and frequency deviation using any simulation software.

c. Other Activities (Specify):

i. Prepare presentation to show comparison of different analog modulation scheme.

CO-5 Maintain simple communication transmitters and receivers.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
SO5.1 Describe the functions of basic building blocks of AM and FM transmitter. SO5.2 Describe the functions of basic building blocks of AM and FM receiver. SO5.3 Explain the working of super heterodyne receiver with the help of block diagram. SO5.4 Describe the characteristics of the given type of general communication transmitter and receiver.	LE5.1 Measure selectivity, sensitivity and fidelity of the given super heterodyne AM receiver. LE5.2 Test the performance of A.G.C. circuit used in the receiver. LE5.3 Test the performance of AM receiver. LE5.4 Test the functions of FM receiver.	**Unit-5.0 Transmitters and Receivers** 5.1 Block diagram and functions of different stages of AM and FM Transmitter 5.2 Block diagram and function of different blocks of AM and FM receiver 5.3 Tuned Radio frequency (TRF) receiver 5.4 Super heterodyne Analog AM/FM receivers: Block diagram and principle of operation of super heterodyne receiver – IF amplifier and choice of IF – Mixer and converter 5.5 Receiver characteristics & Testing –sensitivity, selectivity and fidelity 5.6 Pre-emphasis and de-emphasis circuits	• Describe the functions of Tuned radio frequency receiver. • Describe the requirements of pre-emphasis and de-emphasis circuit in FM transmitter and receiver.

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Describe the functions of various controls of radio receiver.
ii. List the advantages (any four) of super heterodyning receiver.

b. Mini Project:

i. Build and test a FM receiver circuit for local FM reception.
ii. Build and test an AM receiver circuit for local AM reception.

c. Other Activities (Specify):

i. Prepare a chart to demonstrate the basic block diagram of transmitter and receiver and explain the concept of heterodyne principle.

I) Suggested Specification Table (For ESA of Classroom Instruction CI+SW+SL):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Introduction to Communication System	3	4	5	12
II	Introduction to Signals and Sampling	2	7	8	17
III	Noise	2	5	5	12
IV	Analog Modulation	3	5	8	16
V	Transmitters and Receivers	4	4	5	13
Total		**14**	**25**	**31**	**70**

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

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

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Identify different block of communication systems available in your lab.	15	10	5
LE1.2	Measure the frequency band of communication receiver available in your lab.	15	10	5
LE2.1	Generate sinusoidal, square, pulse, triangular signal of the given amplitude and frequency (with the help of simulation software).	15	10	5
LE2.2	Determine the Fourier transform of the given function using any software.	15	10	5
LE2.3	Plot the amplitude and phase spectrum of the given pulse wave.	15	10	5
LE2.4	Measure the bandwidth of the given periodic signals.	15	10	5
LE2.5	Sample the given signal and reconstruct it applying sampling theorem concept.	15	10	5
LE3.1	Measure noise parameter for given communication system.	15	10	5
LE3.2	Generate noise signal using random function.	15	10	5
LE3.3	Calculate Noise figure of the Amplifiers connected in cascade using simulation software.	15	10	5
LE4.1	Measure modulation index of the AM wave using CRO.	15	10	5
LE4.2	Calculate modulation index and efficiency of the DSB-SC signal.	15	10	5
LE4.3	Calculate modulation index and efficiency of the SSB-SC signal.	15	10	5
LE4.4	Demodulate AM, DSB-SC, SSB-SC using coherent detector.	15	10	5
LE4.5	Calculate the modulation index of the FM waveform.	15	10	5
LE4.6	Test the frequency response of Pre-emphasis & De-emphasis Circuits used in FM receiver .	15	10	5
LE4.7	Test the performance of FM Demodulation circuit.	15	10	5
LE4.8	Test the performance of phase modulated circuit.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE5.1	Measure selectivity, sensitivity and fidelity of a super heterodyne AM receiver.	15	10	5
LE5.2	Test the performance of A.G.C. circuit used in the receiver.	15	10	5
LE5.3	Test the performance of AM receiver.	15	10	5
LE5.4	Test the functions of FM receiver.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the cou3rse wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals

Legend : PRA: Process Assessment, PDA : Product Assessment

Note : Only one experiment has to performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

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

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1	Electronic communication systems	Kennedy, George Davis, Bernard	TMH com. Ltd. New Delhi	29th Edition 2013 ISBN:- 0-07-463682-0
2	Communication systems (Analog and Digital)	Singh,R.P.; Sapre,S.D.	Tata McGraw Hill com.ltd., New Delhi	2nd edition 2010 ISBN:- 978-0-07-063454-1
3	Communication systems (Analog and Digital)	Sharma, Sanjay	S.K. Kataria& Sons, New Delhi	6th revised edition 2012 ISBN:-978-93-5014-359-9
4	Modern Digital and Analog Communication Systems	Lathi,B.P and ZhiDing	Oxford University press, New Delhi	4thedition 2011 ISBN**:** 978-0198073802
5	Principals of Communication System	Herbert Taub, Donald Schilling, GoutamSaha	Tata McGraw Hill com.ltd., New Delhi	3rdEdition,2007,or latest edition ISBN:978-0070648111

(b) Open source software and website address :

1. Communication System:https://en.wikipedia.org/wiki/Communications_system
2. NPTEL:- https://onlinecourses.nptel.ac.in/noc18_ee03/preview
3. AM-Transmitter:-https://www.daenotes.com/electronics/communication-system/am-transmitter
4. http://www.brats-qth.org/training/advanced/trandrec1.htm
5. https://electronicsforu.com/electronics-projects/simple-fm-receiver (for Fm receiver)
6. http://www.electroschematics.com/9043/am-receiver-circuit/ (for Am receiver circuit)
7. https://www.electronicshub.org/modulation-and-different-types-of-modulation/
8. https://en.wikipedia.org/wiki/Noise_(electronics)
9. https://fleximize.com/articles/000556/background-noise-affects-communication
10. https://study.com/.../semantic-noise-in-communication-definition-examples-quiz.html
11. https://en.wikipedia.org/wiki/Noise_temperature
12. https://en.wikipedia.org/wiki/Effective_input_noise_temperature

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Signal Sampling &Reconstruction trainer kit	Signal Sampling & Reconstruction trainer kit with over, under and aliasing condition testing function.	LE2.5
2	CRO	Cathode Ray Oscilloscope Duel Trace 20Mhz, 1MegaΩ Input Impedance	LE1.2,LE2.3,LE2.4, LE4.1,LE4.2,LE4.3,LE4.5
3	Functiongenerator/RF generator	RF signal generator with Wide frequency range 100 KHz to 150 MHz Fine frequency adjustment by calibrated dial Built in audio frequency generator	LE1.2,LE2.3,LE2.4, LE4.1,LE4.2,LE4.3
4	Power supply	Regulated power supply: DC Supply Voltages Dual DC : 2 x 0 - 30V;0-2 A Automatic Overload (Current Protection) Constant Voltage & Constant Current Operation	All
5	Multimeter	Digital Multimeter : 3 1/2 digit display, 9999 counts digital multimeter measures: V_{ac}, V_{dc} (1000V max) , A_{dc}, A_{ac} (10 amp max) , Resistance (0 - 100 MΩ) , Capacitance and Temperature measurement.	All
6	Amplitude Modulation & Demodulation trainer kit	AM trainer kit for generation and detection of DSB/SSB AM modulation and demodulation .	LE4.1, LE4.2. LE4.3,LE4.4
7	Amplitude modulation/Demodulation	Amplitude modulation/Démodulation trainer Kit.	LE4.1,LE4.2,LE4.3
8	Frequency Modulation/Demodulation	FM trainer kit for FM modulation and demodulation.	LE4.6,LE4.7,
9	Frequency Transmitter/ Receiver Kit	Frequency Transmitter/ Receiver trainer Kit with testing facility at all the points.	LE5.3,LE5.4

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Identify basic elements of communication system.	1	2	2	2	1	1	1	2	1	1	3	3
CO-2 Analyze different types of signal and systems.	1	2	2	2	1	1	1	2	1	1	3	3
CO-3 Analyze the affect of different types of noise produced by various sources, on the communication system.	1	2	2	2	1	1	1	2	1	1	3	3
CO-4 Analyze Analog Modulated and Demodulated signal.	1	2	2	2	1	1	1	2	1	1	3	3
CO-5 Maintain simple communication transmitters and receivers.	1	2	2	2	1	1	1	2	1	1	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-1 Identify basic elements of communication system.	SO1.1 - SO1.5	LE1.1 LE1.2	**Unit 1.0 Introduction to Communication System** 1.1, 1.2, 1.3, 1.4, 1.5	As mentioned in relevant page numbers
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-2 Analyze different types of signal and systems.	SO2.1 - SO2.6	LE2.1 - LE2.5	**Unit 2.0 Introduction to Signals and System** 2.1, 2.2, 2.3, 2.4, 2.5	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-3 Analyze the affect of different types of noise produced by various sources, on the communication system.	SO3.1 - SO3.5	LE3.1 LE3.2 LE3.3	**Unit 3.0 Noise** 3.1, 3.2, 3.3	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-4 Analyze Analog Modulated and Demodulated signal.	SO4.1, SO4.2 SO4.3 , SO4.4	LE4.1 - LE4.8	**Unit 4.0 Analog Modulation** 4.1, 4.2, 4.3, 4.4	
PO-1,2,3,4, 5,6,7,8,9,10 PSO-1,2	CO-5 Maintain simple communication transmitters and receivers.	SO5.1,SO5.2, SO5.3 , SO5.4,	LE5.1, LE5.2 LE5.3, LE5.4	**Unit-5.0 Transmitters and Receivers** 5.1, 5.2, 5.3, 5.4, 5.5,5.6	

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

A) Course Code : 2028473(024)
B) Course Title : Power Electronics
C) Pre- requisite Course Code and Title : Basic Electronics, Digital Electronics & Electrical Circuit

D) Rationale :

In the recent era, power electronics is playing a vital role in supply and control of electrical power in several domestic, industrial applications and power system. The objective of power electronics device is to match the load requirements with the source. Nowadays the conventional relays in power system are replaced with power electronics devices. This course is designed to provide essential theoretical and practical skills to use power electronics devices and circuits for not only converting DC to AC power and vice versa but also to control DC and AC power as per the requirement of various commercial industrial sectorand power system applications.

E) Course Outcomes:

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

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

CO-3 Maintain phase controlled rectifiers.

CO-4 Troubleshoot Inverters and Cyclo-converter circuit.

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

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credit L+T+(P/2)
1	Electrical Engineering	2028473(024)	Power Electronics	2	-	1	3
2	Electrical Engineering	2028463(024)	Power Electronics (Lab)	-	2	-	1

Legend: L-Lecture, P- Practical, T- Tutorial

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Electrical Engineering	2028473(024)	Power Electronics	70	20	30	-	-	120
2	Electrical Engineering	2028463(024)	Power Electronics (Lab)	-	-	-	30	50	80

Legend: ESE- End semester Exam, CT- Class test, TA- Teacher Assessment

H) Course-Curriculum Detailing:

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

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

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Sketch ISI symbol of various Power Electronics devices. SO1.2 Explain the working principle of SCR, DIAC and TRIAC with the help of characteristic curve. SO1.3 Explain various triggering methods of SCR. SO1.4 Choose suitable Power electronic device for a given switching application.	LE1.1 Test the performance of a given SCR and Plot the VI characteristics. LE1.2 Test the performance of a given DIAC and Plot the VI characteristics. LE1.3 Test the performance of a given TRIAC and Plot the VI characteristics. LE1.4 Design the R and RC triggering circuit for triggering SCR.	**Unit-1.0Power Electronics Devices** 1.1 Silicon Controlled Rectifier (SCR): Construction, principle of operation, characteristic curve, two transistor analogy, Switching characteristics and triggering methods 1.2 Rating and Protection: over voltage, over current, snubber circuit 1.3 Series and parallel operation of SCRs: String efficiency 1.4 DIAC, TRIAC – Construction, Operation, characteristic curves and applications	• Compare the construction of various power electronic devices • List the advantages and disadvantages of various power electronic devices

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. List various applications in our daily life where power electronics devices and circuits are used.

ii. Collate the ratings of General purpose, fast recovery and Schottky diodes and state their applications. Also prepare a report on this.

b. Mini Project:

i. Design a circuit to test whether a given SCR is healthy or unhealthy.

ii. Measure the latching current and holding current for a given SCR and compare with data sheet values.

iii. Design a pulse triggering circuit for triggering SCR.

c. Other Activities (Specify) :

i. Collect information on the rating of commercially available power semiconductor devices and prepare a report on it.

ii. Design a triggering circuit for triggering a given TRIAC using DIAC.

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

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Explain how the natural commutation technique is used to turn off the SCR. SO2.2 Explain the operation of the given forced commutation technique. SO2.3 Explain the working of the given type of DC-DC converter. SO2.4 Compare the salient features of different converter topology.	LE2.1 Test the performance of a buck converter at different duty cycle for a given resistive load. LE2.2 Test the performance of a buck converter at different duty cycle for a given resistive inductive load. LE2.3 Test the performance of a boost converter at different duty cycle for a given resistive load. LE2.4 Test the performance of a forced commutation circuit(A,B,C,D and E)	**Unit 2.0Commutation Techniques and DC-DC Converters** 2.1 Need for commutation in SCR 2.2 Principle of Natural and Forced commutations (class A, class B, Class C, class D and class E) 2.3 Working principle of buck, boost and buck boost converter	• Compare the operations of natural commutation and forced commutation. • Summarize the applications of DC-DC converter.

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. Describe the process of commutation in SCR.

ii. Classify various commutation techniques.

b. Mini Project:

i. Build and test a circuit for self commutation of a given SCR and for a given input voltage by estimating the values of commutating components L and C.

ii. Build and test a control circuit to obtain constant and variable frequency output in a DC-DC converter.

c. Other Activities (Specify):

i. Collate information on various types of DC-DC converters available for solar power applications and prepare a report.

ii. Prepare a chart to describe the working of a charge controller circuit.

CO-3 Maintain phase controlled rectifiers.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Determine the average output voltage for a single-phase half wave-phase controlled rectifier for a given load. SO3.2 Explain the working principle of full converter for a given load, with and without freewheel diode. SO3.3 Justify the need of freewheeling diode in converter. SO3.4 Describe the working of three phase half wave and full wave phase controlled rectifier with a neat sketch for a given load.	LE3.1 Test the performance of a half wave- phase controlled rectifier comprising of SCR for R load. LE3.2 Test the performance of single phase full wave phase controlled rectifier with R load. LE3.3 Test the performance of a half wave phase controlled rectifier comprising of SCR for RL load. LE3.4 Test and analyze the performance of a half wave phase controlled rectifier comprising of SCR for RL load with freewheeling diode. LE3.5 Test the performance of a full wave phase controlled rectifier comprising of SCR for RL load and calculate the Ripple factor.	**Unit 3.0Phase Controlled Rectifier** 3.1 Single phase half wave-phase controlled rectifier with R and RL load. 3.2 Single phase full wave-phase controlled rectifier (M-2&B-2 connection) with Rand RL load. 3.3 Effect of free-wheel diode in single phase full converter 3.4 Three-phase half wave and full wave phase controlled rectifier with Resistive load.	• Explain the importance of various performance parameters of phase controlled rectifier • Explain input supply power factor of a single phase full wave uncontrolled and phase controlled bridge rectifier circuit.

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Prepare a report on the effect of freewheeling diode on the ac power input and switching device rating for a single phase half wave phase controlled rectifier feeding RL load.

ii. Determine the average output voltage of a single phase full wave rectifier when one of the switching devices in any one leg gets open circuited during its operation.

iii. Prepare a report on the effect of triggering angle on the output load current for a three phase half wave phase controlled rectifier feeding an R load.

b. Mini Project:

i. Build and test a triggering circuit for a single phase full wave phase controlled rectifier using given SCR's with midpoint configuration and prepare a report on it.

ii. Compare the output waveform of a single phase full wave phase controlled rectifier feeding a load with input AC current waveform and prepare a report on it.

c. Other Activities (Specify):

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

CO-4 Troubleshoot Inverters and Cyclo-converter circuit

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Explain the working principle of inverter SO4.2 Classify inverter SO4.3 Explain the working principle of Cyclo-converter SO4.4 Compare the salient features of various cyclo-converter topologies	LE4.1 Test the performance of a single-phase half bridgeInverter feeding R load. LE4.2 Test the performance of a single phase full bridge Inverter feeding R load. LE4.3 Measure the input to output frequency of a single phase to single phase step down cyclo-converter. LE4.4 Measure the input to output frequency of a single phase to single phase step up cyclo-converter.	**Unit-4.0 Inverter and Cycloconverter** 4.1 Inverter: Working principle, types-Voltage Source Inverter, Current Source Inverter. 4.2 Single phase series inverter and single phase parallel inverter. 4.3 Single phase Half bridge and full bridge inverter with Resistive load 4.4 Single phase Cyclo-converter: working principle of Midpoint and bridge Configuration with R load 4.5 Step up and step down single phase Cyclo-converter and its applications	• Differentiate between inverter and converter circuit comprising of thyristor. • Compare the rating of a converter and inverter grade Thyristor.

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. List the applications and the merits and demerits of a VSI and CSI.

ii. Explain the effect on device ratings with uni-polar and bipolar switching PWM techniques for inverters.

b. Mini Project:

i. Build and test inverter circuit for emergency lighting.

ii. Test the performance parameters of a given inverter system using harmonic analyzer or power analyzer.

c. Other Activities (Specify):

i. Investigate the effect of nonlinear loads on the supply system of your institution and prepare a report on it.

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

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

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

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Compare the specification of online UPS system from major manufacturers for a given load requirement.
ii. Describe the working of the offline UPS system with the help of a block diagram.
iii. List the storage batteries used in UPS.

b. Mini Project:

i. Build and test a light dimmer circuit.
ii. Build and test a circuit used for a commercial ceiling fan voltage regulator.

c. Other Activities (Specify):

i. List the type of disturbances in a commercial AC supply.
ii. Demonstrate the maintenance steps involved for a UPS system.

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

I) Suggested Specification Table (For ESA of Classroom Instruction CI+SW+SL):

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

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

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

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Test the performance of a given SCR and Plot the VI characteristics.	15	10	05
LE1.2	Test the performance of a given DIAC and Plot the VI characteristics.	15	10	05
LE1.3	Test the performance of a given TRIAC and Plot the VI characteristics.	15	10	05
LE1.4	Design the R and RC triggering circuit for triggering SCR.	15	10	05
LE2.1	Test the performance of a buck converter at different duty cycle for a given resistive load.	15	10	05
LE2.2	Test the performance of a buck converter at different duty cycle for a given resistive inductive load.	15	10	05
LE2.3	Test the performance of a boost converter at different duty cycle for a given resistive load.	15	10	05
LE2.4	Test the performance of a forced commutation circuit(A,B,C,D and E)	15	10	05
LE3.1	Test the performance of a half wave- phase controlled rectifier comprising of SCR for R load.	15	10	05
LE3.2	Test the performance of single phase full wave phase controlled rectifier with R load.	15	10	05
LE3.3	Test the performance of a half wave phase controlled rectifier comprising of SCR for RL load.	15	10	05
LE3.4	Test and analyze the performance of a half wave phase controlled rectifier comprising of SCR for RL load with freewheeling diode.	15	10	05
LE3.5	Test the performance of a full wave phase controlled rectifier comprising of SCR for RL load and calculate the Ripple factor.	15	10	05
LE4.1	Test the performance of a single-phase half bridge Inverter feeding R load.	15	10	05
LE4.2	Test the performance of a single phase full bridge Inverter feeding R load.	15	10	05

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE4.3	Measure the input to output frequency of a single phase to single phase step down cyclo-converter.	15	10	05
LE4.4	Measure the input to output frequency of a single phase to single phase step up cyclo-converter	15	10	05
LE5.1	Measure the output load voltage of a single phase AC voltage controller using On-off control.	15	10	05
LE5.2	Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive load.	15	10	05
LE5.3	Measure the output load voltage of a single phase AC voltage controller using phase angle control for a resistive inductive load.	15	10	05

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

Legend : PRA: Process Assessment, PDA : Product Assessment

Note : Only one experiment has to performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

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

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Power Electronics	P. S. Bimbhra	Khanna Publication	3rd Edition, 2004
2.	Fundamentals of Power Electronics	S. K. Bhattacharya	Vikas publishing house	1st Edition
3.	Power Electronics	J.S. Chitore	Technical publications	1st edition, May 2008
4.	Power Electronics	Dr. B.R. Gupta, V.Singhal	Katson Books	6th Edition, 2010
5.	Power Electronics	M.D. Singh, K.B. Khanchandani	Tata McGraw Hill publishing	7th edition, 2002
6.	Power Electronics Circuits Devices and Applications	Muhammad H Rashid	Pearson Education India ISBN-10: 8131702464 ISBN-13: 978-8131702468	4th edition

(b) Open source software and website address :

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

(c) Others:

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

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Transformer (1-phase)	230V/24V	LE3.1 LE3.5,LE5.1-LE5.3
2	Transformer (1-phase)	Primary: 30V-25V-0-25V–30V, Secondary: 0-30V/2Amps.	LE3.1 LE3.5,LE5.1-LE5.3
3	Power switches		
A	SCR	12A,600V, Type TY616	LE1.1
B	Power diode	10 Amp,600V	LE3.4
C	Triac	BT136, 10A,600V	LE1.3
D	Diac		LE1.2
4	Passive components		
A	Resistor	I K ohm to 10 K ohm, 1 Watt	ALL

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
B	Inductor	300milli H,2A,	LE2.2,LE2.4 LE3.3,LE3.4 LE3.5,LE5.3
C	Variable inductor	10mH – 5mH – 0 – 5mH – 10mH/2 Amps	ALL
D	Capacitors	6.8 micro Farad, 10 micro Farad, 100V	LE1.4
E	Potentiometer	100K ohm	ALL
5	Incandescent lamp	60 Watt	
6	Digital multi-meter	Make Rishabh 13S	ALL
7	True RMS multi-meter	1.0% + 3 (DC, 45 Hz to 500 Hz) 2.0% + 3 (500 Hz to 1 kHz)	ALL
8	Digital CRO with two input isolated channel	30 MHZ Dual Trace	LE1.1-LE1.4 LE2.1-LE2.4 LE3.1-LE3.5 LE4.1-LE4.4 LE5.1-LE5.3
9	Bread board	Cu thin film base	ALL

N) Mapping of POs & PSOs with COs:

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

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

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

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

A) Course Code : 2028474(028)
B) Course Title : Analog Electronic Circuit-II
C) Pre- requisite Course Code and Title : Analog Electronic Circuit-I
D) Rationale:

Industrial control circuits, consumer electronics goods and communication systems all contain the analog and digital circuits. This course deals with the analog components, ICs and analog circuits work on analog signals. After going through this course, the students will be able to develop skills to maintain various analog electronic circuits.

E) Course Outcomes:

CO 1 Test the parameters of an Operational Amplifier (OP-AMP) IC.

CO 2 Use OP-AMP for various linear and non-linear applications.

CO 3 Maintain OP-AMP based active filters and oscillators used in electronic circuits.

CO 4 Use OP-AMP based Comparators and Converters for various practical applications.

CO 5 Use Timer, PLL and Voltage regulator ICs to develop various applications.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credit L+T+(P/2)
1	E&TC Engineering	2028474(028)	Analog Electronic Circuit-II	2	-	1	3
2	E&TC Engineering	2028464(028)	Analog Electronic Circuit-II (Lab)	-	2	-	1

Legend: L-Lecture, P- Practical, T- Tutorial

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	E&TC Engineering	2028474(028)	Analog Electronic Circuit-II	70	20	30	-	-	120
2	E&TC Engineering	2028464(028)	Analog Electronic Circuit-II (Lab)	-	-	-	30	50	80

Legend: ESE- End semester Exam, CT- Class test, TA- Teacher Assessment

H) Course-Curriculum Detailing:

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

CO-1 Test the parameters of an Operational Amplifier (OP-AMP) IC.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Explain the importance of differential amplifier to analyze the working of OP-AMP operation. SO1.2 Sketch the block diagram of OP-AMP and describe the functions of the given block. SO1.3 Calculate CMRR and slew rate of the given OP-AMP IC. SO1.4 Sketch pin configuration of Op-AMP IC and describe the function of each pin.	LE1.1 Test various pins of OP-AMP ICs. LE1.2 Measure the input and output impedance of the given OP-AMP IC. LE1.3 Measure voltage gain of the given OP-AMP IC. LE1.4 Determine CMRR, slew rate, input offset voltage, input offset currents and bandwidth of the given OP-AMP IC. LE1.5 Test the performance of the given OP-AMP IC.	**Unit-1.0Fundamentals of Operational Amplifier(OP-AMP)** 1.1 Working principle and characteristics of basic differential amplifier 1.2 Block diagram of OP-AMP and functions of each block,ideal characteristics of OP-AMP, equivalent circuit of practical OP-AMP, virtual ground concept 1.3 OP-AMP IC configuration and various IC packages of OP-AMP,pin configuration of OP-AMP ICs and features of data sheet, 1.4 Electrical parameters of OP-AMP: voltage gain, input resistance, output resistance, CMRR, slew rate, input offset voltage, input offset currents and bandwidth.	• Summarize the advantages of differential amplifier and linear integrated circuits. • List the applications of differential amplifier.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Determine the output voltage of a differential amplifier for the input voltage of 300 µV. The differential gain of the amplifier is 5000 and the value of the CMRR is 100.

ii. Explain difference between ideal and practical characteristics of an OP-AMP.

b. Mini Project:

i. Prepare internet based report on the technical specification of OP-AMP ICs.(LM741, LM324, LM158,LM258,LM358, LM 339,LM392,LM611 and other LM series ICs)

c. Other Activities (Specify) :

i. Demonstration on the testing if OP-AMP IC.

CO-2 Use OP-AMP for various linear and non-linear applications.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Determine the gain of inverting and non inverting OP-AMP. SO2.2 Explain how OP-AMP work as a voltage follower. SO2.3 Describe with sketch working of the given type of Sample/hold circuit using OP-AMP. SO2.4 Describe the functions of the given Integrator and Differentiator circuits consist of OP-AMP. SO2.5 Explain the working principal of the given Log amplifier.	LE2.1 Test the AC and DC characteristics of inverting OP-AMP. LE2.2 Test the AC and DC characteristics of Non-inverting OP-AMP. LE2.3 Test the function of adder circuit consist of OP-AMP and other discrete components. LE2.4 Test the function of Subtractor circuit consist of OP-AMP and other discrete components. LE2.5 Test the function of integrator consist of OP-AMP and other discrete components. LE2.6 Test the function of Differentiator circuit consist of OP-AMP and other discrete components. LE2.7 Test the function of Sample/hold circuit consist of OP-AMP and other discrete components. LE2.8 Test the performance of the precision rectifier circuit consist of OP-AMP and other discrete components.	**Unit-2.0 Basic OP-AMP Applications** 2.1 Inverting and Non-inverting amplifiers using OP-AMP 2.2 OP-AMP as voltage follower, scaling amplifiers, adder, subtractor, integrator and differentiator, Log amplifier 2.3 Instrumentation amplifier-:circuit diagram and its working 2.4 Sample/hold circuit-working principle 2.5 Precision rectifiers: Circuit diagram Working ,function	• Compare gain of inverting and non inverting amplifier. • List the advantages of Sample/hold circuit consist of OP-AMP. • Differentiate between basic rectifier and precision rectifier. • AC and DC analysis of Inverting OP-AMP.

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. Show that the output of a Subtractor is proportional to the difference between the two input voltages.

ii. Summarize requirements of a good instrumentation amplifier?

b. Mini Project:

i. Develop simple application circuits using OP-AMP IC. (Light detector, Audio amplifier, two way intercom circuit, Air flow detector, FM receiver, audio mixer)

c. Other Activities (Specify):

i. Presentation on various applications of OP-AMP.

CO-3 Maintain OP-AMP based active filters and oscillators used in electronic circuits.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Sketch frequency response of the given type of active filter and explain its characteristics. SO3.2 Describe working principle of the given type of Oscillators using OP-AMP with circuit diagram. SO3.3 Calculate working frequency of the given type of Phase shift oscillator using OP-AMP with the help of circuit diagram.	LE3.1 Test the frequency response of the given type of active filters. LE3.2 Measure the frequency generated by Wein bridge oscillator circuit using OP-AMP and other discrete components. LE3.3 Measure the frequency generated by phase shift oscillator circuit using OP-AMP and other discrete components.	**Unit-3.0 Active Filters and Oscillators using OP-AMP** 3.1 Active Filter: Advantages and frequency response characteristics of active filters, parameters of filters: stop band ,pass band, attenuation in stop and pass band, frequency, phase and amplitude response 3.2 General idea about types: Low pass, High pass, Band pass, Band stop, notch and orders of active filters: First, second and higher order 3.3 Wein bridge Oscillators using OP-AMP, circuit diagram, working and frequency of oscillation 3.4 Phase shift oscillator using OP-AMP, circuit diagram, working and frequency of oscillation.	• List the advantages of active filter over passive filter. • Explain the basic principle of working of a oscillator circuit based on OP-AMP.

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Classify the types of active filter.
ii. Describe the given parameters of active filter.

b. Mini Project:

i. Develop a low pass filter for the given frequency band using OP-AMP.
ii. Develop OP-AMP based Phase shift oscillator for the given resonant frequency.

c. Other Activities (Specify):

i. Group discussion on advantages of active filters.

CO-4 Use OP-AMP based Comparators and Converters for various practical applications.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Explain the working principle of OP-AMP based Inverting and non-inverting comparator. SO4.2 Explain the working principle of OP-AMP based Schmitt trigger with circuit diagram. SO4.3 Explain the working principle of OP-AMP based Voltage to frequency converter with circuit diagram.	LE4.1 Test the output waveforms of OP-AMP based Inverting and non-inverting comparator. LE4.2 Design and test OP-AMP based Zero crossing detector circuit using OP-AMP. LE4.3 Design and test OP-AMP based Schmitt trigger circuit using OP-AMP and measure threshold voltage. LE4.4 Test the output of OP-AMP based Voltage to frequency converter circuit using op-amp. LE4.5 Test the output of OP-AMP based voltage to time converter circuit using OP-AMP.	**Unit-4.0 Comparators and Converters using OP-AMP** 4.1 OP-AMP based Comparators- types and characteristics 4.2 OP-AMP based Zero crossing detectors 4.3 OP-AMP based Schmitt trigger- types and characteristics 4.4 OP-AMP based Voltage to frequency converter, basic principle and circuit diagram 4.5 OP-AMP based Voltage to time converter; basic principle and it's circuit diagram	• Compare inverting and non-inverting comparator. • List the characteristics of comparator.

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. Explain the working of an OP-AMP based Inverting and Non-invertingSchmitt trigger with hysteresis curve and input-output waveforms.

ii. Summarize the applications of Comparator circuit.

b. Mini Project:

i. Build an OP-AMP based comparator circuit to compare the two sine waves of different amplitude.

CO-5 Use Timer, PLL and Voltage regulator ICs to develop various applications.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Describe the operational modes of IC 555 timer. SO5.2 Sketch the block diagram of PLL and explain working of each block.	LE5.1 Generate square waveform using IC 555 timer in as table mode and measure its frequency. LE5.2 Generate waveform using IC 555 timer in	**Unit 5.0 Common Linear ICs and it's Applications** 5.1 IC 555 timer- functional block diagram, pin configuration, Monostablemultivibrator and its applications like: frequency divider, PWM and PPM,	• List the applications of monostablemultivibrator consist of IC 555 and other discrete components. • Describe the applications related to communication

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.3 Explain working of basic low and high voltage regulators designed using IC 723. SO5.4 Design a voltage regulator circuit for the given output voltage using three terminal voltage regulator.	bistable stable mode and measure its frequency. LE5.3 Test the performance of voltage regulator IC 723. LE5.4 Test the output voltage and load regulation of voltage regulator IC 7805 and IC 7905. LE5.5 Test the performance of IC565.	Astablemultivibrator and its applications like: square wave generator and VCO 5.2 PLL- block diagram, basic operation, parameters, transfer characteristics, pin configuration of IC 565 5.3 Three terminal voltage regulator IC: 78XX and 79XX, block diagram, performance parameters, pin configuration and typical connection of IC 7805, pin configuration and functional block diagram of IC 723, basic low and high voltage regulators application of IC 723.	circuits of IC 565 PLL. • List (at least 10)applications of IC 555.

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

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Determine the output pulse width of the monostablemultivibrator using IC 555 if R = 12kΩ and C= 0.1μF.

ii. Give the typical electrical parameters for 565 PLL.

b. Mini Project:

i. Develop any one practical application circuit using Timer 555 ICs.

c. Other Activities (Specify):

i. Prepare a presentation on any one application of Linear IC(like Instrumentation amplifier, Precision rectifier, Comparator, Integrator etc.).

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

I) Suggested Specification Table (For ESA of Classroom Instruction CI+SW+SL):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Fundamentals of Operational Amplifier(OP-AMP)	2	5	7	14
II	Basic OP-AMP Applications	2	6	6	14
III	Active Filters and Oscillators using OP-AMP	2	6	6	14
IV	Comparators and Converters using OP-AMP	2	6	6	14
V	Common Linear ICs and it's Applications	2	6	6	14
	Total	**10**	**29**	**31**	**70**

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

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

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Test various pins of Op-AMP ICs.	15	10	5
LE1.2	Measure the input and output impedance of the given OP-AMP IC.	15	10	5
LE1.3	Measure voltage gain of the given OP-AMP IC.	15	10	5
LE1.4	Determine CMRR, slew rate, input offset voltage, input offset currents and bandwidth of the given OP-AMP IC.	15	10	5
LE1.5	Test the performance of the given OP-AMP IC.	15	10	5
LE2.1	Test the AC and DC characteristics of inverting OP-AMP.	15	10	5
LE2.2	Test the AC and DC characteristics of Non-inverting OP-AMP.	15	10	5
LE2.3	Test the function of adder circuit consist of OP-AMP and other discrete components.	15	10	5
LE2.4	Test the function of Subtractor circuit consist of OP-AMP and other discrete components.	15	10	5
LE2.5	Test the function of integrator consist of OP-AMP and other discrete components.	15	10	5
LE2.6	Test the function of Differentiator circuit consist of OP-AMP and other discrete components.	15	10	5
LE2.7	Test the function of Sample/hold circuit consist of OP-AMP and other discrete components.	15	10	5
LE2.8	Test the performance of the precision rectifier circuit consist of OP-AMP and other discrete components.	15	10	5
LE3.1	Test the frequency response of the given type of active filters.	15	10	5
LE3.2	Measure the frequency generated by Wein bridge oscillator circuit using OP-AMP and other discrete components.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE3.3	Measure the frequency generated by phase shift oscillator circuit using OP-AMP and other discrete components.	15	10	5
LE4.1	Test the output waveforms of OP-AMP based Inverting and non-inverting comparator.	15	10	5
LE4.2	Design and test OP-AMP based Zero crossing detector circuit using OP-AMP.	15	10	5
LE4.3	Design and test OP-AMP based Schmitt trigger circuit using OP-AMP and measure threshold voltage.	15	10	5
LE4.4	Test the output of OP-AMP based Voltage to frequency converter circuit using op-amp.	15	10	5
LE4.5	Test the output of OP-AMP based voltage to time converter circuit using OP-AMP.	15	10	5
LE5.1	Generate square waveform using IC 555 timer in astable mode and measure its frequency.	15	10	5
LE5.2	Generate waveform using IC 555 timer in bistable stable mode mode and measure its frequency.	15	10	5
LE5.3	Test the performance of voltage regulator IC 723.	15	10	5
LE5.4	Test the output voltage and load regulation of voltage regulator IC 7805 and IC 7905.	15	10	5
LE5.5	Test the performance of IC565.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the cou3rse wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals

Legend : PRA: Process Assessment, PDA : Product Assessment

Note : Only one experiment has to performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

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

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1	Linear Integrated Circuits and Application	U.A. Bakshi, A.P. Godse	Technical Publications Pune	Fourth edition, 2014, **ISBN-13:** 978-9350996980
2	Op-amps and Linear Integrated Circuits	Ramakant A. Gayakwad	Pearson eduction, NewDelhi, India	4th Edition, 2015, **ISBN-13:** 978-9332549913
3	Integrated Circuits	K.R. Botkar	KhannaPublishers, NewDelhi, India	2008, ISBN-13 : 9788174092083
4	Principles of Electronics	V.K. Mehta, Rohit Mehta	S. Chand Publishing, NewDelhi, India	23rd Edition, 2016, ISBN13:9788121924504

(b) Open source software and website address :

1. OP-AMP Comparator: https://www.electronics-tutorials.ws/opamp/op-amp-comparator.html
2. Operational Amplifier Basics: https://www.electronics-tutorials.ws/opamp/opamp_1.html
3. Operational amplifier ,Comparator (Tutorial): http://rohmfs.rohm.com/en/products/databook/applinote/ic/amp_linear/common/opamp_comparator_tutorial_appli-e.pdf

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Multimeter	Analog and Digital AC voltage:0-400 V,DC Voltage:0-24V AC Current:0-20A,DC Current:0-20 A	All
2	CRO	60 MHz, Dual Channel, Dual Trace With Component Tester	All
3	Function generator	0 -2 MHz with Sine, Square, Triangular wave output With Variable Frequency and output	All
4	Variable DC supply	0 to 30 V DC dual power supply	All
5	Digital Multimeter	3 and ½ digit with component Tester	All
6	Analog/Digital IC tester	Up to 40pins digital and upt18 pins analog IC testing facility	All

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)		Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
		PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1	Test the parameters of an Operational Amplifier (OP-AMP) IC.	1	2	3	2	1	1	1	2	1	1	2	3
CO-2	Use OP-AMP for various linear and non-linear applications.	1	2	3	2	2	1	1	2	1	1	2	3
CO-3	Maintain OP-AMP based active filters and oscillators used in electronic circuits.	1	2	3	3	1	1	1	2	1	1	3	3
CO-4	Use OP-AMP based Comparators and Converters for various practical applications.	1	2	3	3	1	1	1	2	1	1	3	3
CO-5	Use Timer, PLL and Voltage regulator ICs to develop various applications.	1	2	3	3	1	1	1	2	1	1	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO-1,2,3,4, 5,7,8,9,10 PSO-1,2	CO-1 Test the parameters of an Operational Amplifier (OP-AMP) IC.	SO1.1, SO1.2 SO1.3, SO1.4	LE1.1, LE1.2, LE1.3 LE1.4, LE1.5	Unit 1.0 Fundamentals of Op-Amp 1.1 , 1.2, 1.3, 1.4	As mentioned in relevant page numbers
PO-1,2,3,4, 5,7,8,9,10 PSO-1,2	CO-2 Use OP-AMP for various linear and non-linear applications.	SO2.1, SO2.2, SO2.3, SO2.4 SO2.5	LE2.1, LE2.2, LE2.3, LE2.4, LE2.5, LE2.6, LE2.7, LE2.8	Unit 2.0 Basic Op-amp Applications 2.1, 2.2, 2.3, 2.4, 2.5	
PO-1,2,3,4, 5,7,8,9,10 PSO-1,2	CO-3 Maintain OP-AMP based active filters and oscillators used in electronic circuits.	SO3.1 SO3.2 SO3.3	LE3.1 LE 3.2 LE3.3	Unit 3.0 Active Filters and Oscillators 3.1, 3.2, 3.3, 3.4	
PO-1,2,3,4, 5,7,8,9,10 PSO-1,2	CO-4 Use OP-AMP based Comparators and Converters for various practical applications.	SO4.1 SO4.2 SO4.3	LE4.1, LE4.2, LE4.3 LE4.4, LE4.5	Unit 4.0 Comparators and Converters 4.1, 4.2, 4.3, 4.4, 4.5	
PO-1,2,3,4, 5,7,8,9,10 PSO-1,2	CO-5 Use Timer, PLL and Voltage regulator ICs to develop various applications.	SO5.1, SO5.2 SO5.3, SO5.4	LE5.1, LE5.2, LE5.3 LE5.4, LE5.5	Unit 5.0 Specialized IC Applications 5.1, 5.2, 5.3	

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

A) Course Code : 2028475(028)

B) Course Title : Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA)

C) Pre- requisite Course Code and Title : Basic Electronics, Digital Electronics and Basic Programming Skills

D) Rationale:

The aim of this course is to introduce students with 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 (SCDA) will enable the students to maintain the automation controls systems used in the present industry.

E) Course Outcomes:

CO-1 Test the various functions of PLC.

CO-2 Test the output of ladder logic programs.

CO-3 Test advance functions of PLC.

CO-4 Maintain PLC based system.

CO-5 Identify various components of Distributed control system and SCADA system.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credit L+T+(P/2)
1.	E&TC Engineering	2028475(028)	Programmable Logic controller (PLC) and Supervisory control and Data Acquisition system (SCADA)	3	-	-	3
2.	E&TC Engineering	2028465(028)	Programmable Logic controller (PLC) and Supervisory control and Data Acquisition system (SCADA) (Lab)	-	2	-	1

Legend: L-Lecture, P- Practical, T- Tutorial

G) Scheme of Assessment:

S. No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1.	E&TC Engineering	2028475(028)	Programmable Logic controller (PLC) and Supervisory control and Data Acquisition system (SCADA)	70	20	30	-	-	120
2.	E&TC Engineering	2028465(028)	Programmable Logic controller (PLC) and Supervisory control and Data Acquisition system (SCADA) (Lab)	-	-	-	30	50	80

Legend: ESE- End semester Exam, CT- Class test, TA- Teacher Assessment

H) Course-Curriculum Detailing:

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

CO-1 Test the various functions of PLC.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Define the given terms related to programmable logic controller. SO1.2 Describe the function of the given block of the PLC. SO1.3 Describe the steps to interface the input analog and digital devices to PLC. SO1.4 Describe the steps to interface the output analog and digital devices to PLC.	LE1.1 Identify the various parts of the given PLC. LE1.2 Test the analog input and output lines of the given PLC. LE1.3 Test the digital input and output lines of the given PLC.	**Unit-1.0 Introduction to PLC**: 1.1 Definition, Block diagram 1.2 Parts of PLC, Principles of Operation, functions of various blocks 1.3 I/O modules: analog & digital, I/O Specifications 1.4 Advantages & Applications of PLC.	• List advantages that PLCs offer over conventional relay-based control systems. • List four criteria on the basis of that PLCs are categorized

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Compare the PLC and PC with regard to:
   a. Physical hardware differences
   b. Operating environment
   c. Method of programming
   d. Execution of program

ii. Compare discrete and analog I/O modules with respect to the type of input or output devices withwhich they can be used.

b. Mini Project:

i. Develop a simulation to connect analog and digital input to the PLC.

c. Other Activities (Specify) :

i. Present the seminar on the types of PLC available in the market.

CO-2 Test the output of ladder logic programs.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Explain the if close and open concept with example. SO2.2 Describe the PLC program scan sequence. SO2.3 Analyze PLC counter ladder logic programs for the given application. SO2.4 Develop a ladder logic programs for the specified application using arithmetic instructions.	LE2.1 Check the Addition and Subtraction Function using actual PLC. LE2.2 Develop/Execute ladder diagram of AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate. LE2.3 Develop/Execute ladder diagram for different Arithmetic operations. LE2.4 Develop/Execute ladder diagram for logical operations along with truth table.	**Unit 2.0 Basics of PLC Programming:** 2.1 Programming basics, Processor Memory Organization , Program Scan, port addressing 2.2 PLC Programming languages, ladder rung, Programming execution, If Closed and If Open Instructions, normally open and close operation 2.3 Ladder logic and diagram, relay logic and 2.4 Arithmetic instructions: addition, subtraction, multiplication 2.5 Logical operations: AND, OR,NOR, NAND,EX-OR,EX_NOR	• Develop a flow chart to write the ladder logic program. • Describe two common applications for counters

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. State three advantages of using programmed PLC timers over mechanical timing relays.

ii. It is required to have a pilot light glow when all of the following circuit requirements are to be meet:
   a. All four circuit pressure switches must be closed.
   b. At least two out of three circuit limit switches must be closed.
   c. The reset switch must not be closed.
   Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem.

b. Mini Project:

i. The following binary PLC coded information is to be programmed using the hexadecimal code. Convert each piece of binary information to the appropriate hexadecimal code for entry into the PLC from the keyboard.
   a. 0001 1111
   b. 0010 0101
   c. 0100 1110
   d. 0011 1001

c. Other Activities (Specify):

CO-3 Test advance functions of PLC.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Analyze PLC timer ladder logic programs for the given application. SO3.2 Develop an application programme using master control reset Instruction. SO3.3 Develop an application programme using jump instruction for the given PLC.	LE3.1 Develop ladder logic to test the functionally of D flip-flop. LE3.2 Develop ladder logic to test the functionally of RS flip-flop. LE3.3 Develop ladder logic to test the functionally of JK flip-flop. LE3.4 Check the UP/DOWN COUNTER operation of the given PLC. LE3.5 Simulate Industrial application on Delay timer of PLC. LE3.6 Check the delay timer operation of the given PLC. LE3.7 Simulate Bottle filing process on PLC simulator. Verify operation of the same process using actual PLC. Draw connection details for the same process. LE3.8 Develop ladder diagram for a temperature, level, flow control system.	**Unit-3.0 Advance PLC Functions and Applications:** 3.1 Programming Timer &Counter 3.2 SKIP Function, Master Control Relay Function, Jump Functions 3.3 Application : Bottling filling plant, Switching ON-OFF Light, Liquid Level Control	• Write function and operation of PLC counter. • Develop Ladder diagram using counter

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Describe the advantage of the jump instruction with the help of suitable example.

b. Mini Project:

i. Develop a liquid level control using PLC and prepare report on it.

c. Other Activities (Specify):

CO-4 Maintain PLC based system.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Explain requirements for a PLC enclosure. SO4.2 Describe proper grounding procedure and preventive maintenance steps associated with PLC systems. SO4.3 Describe the common procedure to interface the PLC with other hardware.	LE4.1 Test the ground connections of the given PLC. LE4.2 Interface the given PLC with LAPTOP.	**Unit-4.0 PLC Installation. and Troubleshooting** 4.1 PLC enclosures, electrical noise, Leaky inputs and outputs, grounding, voltage variations and surges 4.2 Common Preventive Maintenance procedure and Troubleshooting steps of PLC 4.3 Interfacing of Programmable Logic Controller with other hardware	• Identify the requirements to interface the given electronic hardware with PLC.

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. Summarize the basic grounding requirements for a PLC system.
ii. State two ways in which electrical noise may be coupled into a PLC control system.
iii. List five preventive maintenance tasks that should be carried out on the PLC installation regularly.

b. Mini Project:

c. Other Activities (Specify):

i. When line voltage variations to the PLC power supply are excessive, what can be done to solve the problem?

CO-5 Identify various components of Distributed Control System (DCS) and SCADA system.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 List and describe functions of each level of DCS. SO5.2 Summarize functions of each component of SCADA system. SO5.3 Describe how PLC can interfacing with SCADA	LE5.1 Test the given parameters of DCS. LE5.2 Test the given parameters of SCADA. LE5.3 Identify various level of distributed control system. LE5.4 Set up a SCADA configuration.	**Unit-5.0 DCS and SCADA:** 5.1 DCS: Block Diagram of DCS, advantages, limitations and application. 5.2 SCADA: Architecture, Block diagram of SCADA, applications of SCADA systems, advantages of SCADA System 5.3 Difference between PLC and DCS(Distributed control system).	• SCADA architecture • Communication protocols used for SCADA

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

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Compare suitability of PLC, DCS and SCADA for the given application.
ii. List (at least) practical applications of SCADA system.

b. Mini Project:

i. Develop PLC and SCADA based simple application and prepare the report.
ii. Prepare the internet based survey report on the various types of PLC.

c. Other Activities (Specify):

i. Arrange seminar on the DCS.
ii. Arrange seminar on the SCADA system.

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

I) Suggested Specification Table (For ESA of Classroom Instruction CI+SW+SL):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Introduction to PLC	4	6	4	14
II	Basics of PLC Programming	2	6	8	16
III	Advance PLC Functionsand Applications	2	4	8	14
IV	PLC Installation and Troubleshooting	2	4	6	12
V	DCS and SCADA	4	5	5	14
	Total	**14**	**25**	**31**	**70**

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

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

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Identify the various parts of the given PLC.	15	10	5
LE1.2	Test the analog input and output lines of the given PLC.	15	10	5
LE1.3	Test the analog input and output lines of the given PLC.	15	10	5
LE2.1	Check the Addition and Subtraction Function using actual PLC.	15	10	5
LE2.2	Develop/Execute ladder diagram of AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate .	15	10	5
LE2.3	Develop/Execute ladder diagram for different Arithmetic operations.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE2.4	Develop/Execute ladder diagram for logical operations along with truth table.	15	10	5
LE3.1	Develop ladder logic to test the functionally of D flip-flop.	15	10	5
LE3.2	Develop ladder logic to test the functionally of RS flip-flop.	15	10	5
LE3.3	Develop ladder logic to test the functionally of JK flip-flop.	15	10	5
LE3.4	Check the UP/DOWN COUNTER operation of the given PLC.	15	10	5
LE3.5	Simulate Industrial application on Delay timer of PLC.	15	10	5
LE3.6	Check the delay timer operation of the given PLC.	15	10	5
LE3.7	Simulate Bottle filing process on PLC simulator. Verify operation of the same process using actual PLC. Draw connection details for the same process.	15	10	5
LE3.8	Develop ladder diagram for a temperature, level, flow control system.	15	10	5
LE4.1	Test the ground connections of the given PLC.	15	10	5
LE4.2	Interface the given PLC with LAPTOP.	15	10	5
LE5.1	Test the given parameters of DCS.	15	10	5
LE5.2	Test the given parameters of SCADA.	15	10	5
LE5.3	Identify various level of distributed control system.	15	10	5
LE5.4	Set up a SCADA configuration.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the cou3rse wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals

Legend : PRA: Process Assessment, PDA : Product Assessment

Note : Only one experiment has to performed at the end semester examination of **30** Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

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

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1	Programmable Logic Controllers	Frank D. Petruzella	Tata McGrawHillpublications,New Delhi	5th edition, 2017
2	PLCs & SCADA: Theory and Practice	Rajesh Mehra and Vikrant Vij	Laxmi Publications, New Delhi	Latest edition
3	Programmable Logic Controllers	W. Bolton	Elsevier	6th Edition,
4	Programmable Logic Controllers Principles and applications 2.	Webb John W. and Reis A. Ronald	PHI ,New Delhi,	Latest edition,
5	Programmable Logic Controllers	John R Hackworth,	Pearson education, New Delhi	Latest edition,
6	Programmable Logic Controllers and Industrial Automation an Introduction	Mitra, Madhuchanda; Gupta, SamarjitSen	Param International Publising (India) Pvt. Ltd., New Delhi,	Latest edition
7	Programmable logic controllers: principles and applications	Webb, John W.; Reis, Ronald A.	PHI Learning Pvt. Ltd. New Delhi,	Latest edition.

(b) Open source software and website address :

1. www.control.com
2. www.plcs.net
3. www.pacontrol.com
4. En.wikipedia.org
5. www.seimens.com
6. www.ab.rockwellautomation.com › Allen-Bradley
7. www.abb.co.in
8. www.triplc.com
9. http://plc-training-rslogix-simulator.soft32.com/free-download/
10. www.youtube.com
11. www.ourinstrumentationgroup.com
12. www.plcsimulator.net/
13. http://scada.winsite.com Industrial Automation Course Code: 3361107 GTU/ NITTTR Bhopal/14-15 Gujarat State 6
14. http://sourceforge.net/projects/scadabr/files/latest/download?source=directory

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	PLC trainer	Power supply : 24V/2A,10Nos. of logic input,10 Nos. of Logic output,4 Nos. Relay for PLC output, Serial communication cable for easy to download the programs from PC to kit, LED indicator, Input : 230V AC, **Onboard user interface,**7 segment LED display, Stepper motor,16SPDT slider switches, 13DPDT	LE1.1.LE1.2,LE1.3, LE2.1,LE4.1,LE4.2

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		slider switches, 29 Tact switches, 174 LEDs available onboard , and higher specifications ,compatible software to interface the PLC with computer and programme it	
2	DCS Trainer	True industrial universal hybrid controller configuration using function blocks modbus/TCP and modbus RTU for HMI clients SCADA (HMI) Package,Panel for input simulation Easy interfacing with existing process plants 4 Relays of 230 VAC for Digital output, Inbuilt powering for all AI, DI & DO, Technical and user manual.	LE5.2
3	PLC and SCADA trainer	PLC with 20 digital inputs, 12 relay outputs, 4 analogue inputs and 2 analogue outputs. PLC Type: Allen-Bradley, Siemens, Mitsubishi and Modiconetc.,All inputs/outputs are on board with 4mm shrouded connectors. All inputs/outputs are expandable. Input bank with 16 Nos. standard selector switches with 4mm shrouded connector for apply the PLC inputs. Output bank with 16 Nos. standard 24V LAMP with 4m shrouded connector to show the PLC outputs. Analog Input source 2 potentiometer for 0-10V or 4-20mA. Analog output source 2 DPM with 4mm shrouded connectors. The PLC panel is fitted on trolley type alunimium based profile table with caster wheel. Total combine system is in the modular form for easy assemble and transportation along with Technical and user manual. SCADA software: 50 tags, Powerful SCRIPT, Recipe Managemant, 256 Levels of Security, Alarms and report management, Variety of graphics and Animations, Extensive Data and Event Logging, Realtime and Historical Trending, Wizards for Screen development, Communication—Multidrop, One to One, Modem, Ethernet, TCP/IP, Extensive Tags and Database Management, Script based Excel Report generation, Advance Component Library, Open Data Based Connectivity, OLE for Process Control (OPC Client)	LE1.1.LE1.2,LE1.3,LE2.1,LE.3.4,LE3.5,LE4.1,LE4.2LE4.4,LE5.2, LE5.3,LE5.4

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Test the various functions of PLC.	1	3	3	2	1	1	1	2	1	1	3	3
CO-2 Test the output of ladder logic programs.	1	2	3	2	1	1	1	2	1	1	3	3
CO-3 Test advance functions of PLC.	1	3	3	2	1	1	1	1	1	1	3	3
CO-4 Maintain PLC based system.	1	3	3	2	1	1	1	2	1	1	3	3
CO-5 Identify various components of Distributed control system and SCADA system.	1	2	3	2	1	1	1	2	1	1	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO-1,2,3,4,5,6,7,8,9,10 PSO-1,2	CO-1 Test the various functions of PLC.	SO1.1, SO1.2, SO1.3, SO1.4	LE1.1 LE1.2 LE1.3	**Unit-1.0 Introduction to PLC**: 1.1, 1.2, 1.3, 1.4	As mentioned in relevant page numbers
PO-,2,3,4,5,6,7,8,9,10, PSO-1,2	CO-2 Test the output of ladder logic programs.	SO2.1, SO2.2 SO2.3, SO2.4	LE2.1 LE2.2 LE2.3 LE2.4	**Unit 2.0 Basics of PLC Programming:** 2.1, 2.2, 2.3, 2.4, 2.5	
PO-1,2,3,4,5,6,7,8,9,10, PSO-1,2	CO-3 Test advance functions of PLC.	SO3.1 SO3.2 SO3.3	LE3.1, LE3.2 LE3.3, LE3.4, LE3.5, LE3.6 LE3.7, LE3.8	**Unit-3.0 Advance PLC Functionsand Applications:** 3.1, 3.2, 3.3	
PO-1,2,3,4,5,6,7,8,9,10, PSO-1,2	CO-4 Maintain PLC based system.	SO4.1 SO4.2 SO4.3	LE4.1 LE4.2	**Unit-4.0 PLC Installation. and Troubleshooting:** 4.1, 4.2, 4.3	
PO-1,2,3,4,5,6,7,8,9,10, PSO-1,2	CO-5 Identify various components of Distributed control system and SCADA system.	SO5.1 SO5.2 SO5.3	LE5.1, LE5.2, LE5.3, LE5.4	**Unit-5.0 DCS and SCADA:** 5.1, 5.2, 5.3	

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