NO	Course Information (2019-2020)	
1	Unite name	Industrial Electronics and Control I
2	Code	EcE-41031
3	Classification:	Engineering Subject
4	Credit value	3 (2-0-2)
5	Semester/ Year Offered	1/4
6	Pre-requisite:	Fundamental of Electronic Circuits, Electronic Engineering Circuits, Microelectronics, Integrated Electronics
7	Method of Delivery	Lecture, Discussion, demonstration
8	Assessment System and Breakdown of Marks:	Tutorial, Assignment, Lab report
	Tutorial and Assignment	10%
	Lab Report	20%
	Mid-term Examination	70%
9	Academic Staff: teaching unit:	Department of Electronic Engineering
10	Course outcome of unit: After completion of this course, students will be able to: 1. describe basic operation and compare performance of various semiconductor devices, passive components and switching circuits 2. determine the power circuit configuration needed to fulfill the required power conversion with applicable constraints 3. design and analyze power converter circuits by selecting the appropriate power semiconductor devices for the required application 4. design the control circuits and power circuits for a given power converter for the required application 5. perform the basic electronics troubleshooting by using tools/test equipment to analyze electronic components 6. develop skills to build and troubleshoot power electronics circuits	
	Synopsis of unit: The course covers the power electronics devices with their operation and applications. The course introduces to the students to the types of Thyristor, SCR, its terminology, turning ON and OFF of SCR, triggering SCR, forced commutation methods, characteristic and SCR operation, line commutation methods, Triacs, Diacs, Quadracs, Power diodes, Power transistor , Power MOSFET, IGBT, unijunction transistor. And heating and welding control, induction heating, dielectric heating and welding. And the next introduces to the students to the types of inverters, dual converters, choppers, cycloconverters, and motor control methods.	

12	Topic: 5. **Thyristors** 5.1 Introduction 5.2 Silicon Controlled Rectifier 5.2.1 Constructional features 5.2.2 Theory of operation of SCR with two transistor anology 5.2.3 Physical operation of SCR 5.3 SCR Terminology 5.3.1 Forward breakover voltage or forward breakdown voltage 5.3.2 Reverse breakdown voltage 5.3.3 ON – state voltage 5.3.4 Finger voltage 5.3.5 Average ON – state current 5.3.6 Holding current 5.3.7 Latching current 5.3.8 Forward current rating 5.3.9 Gate triggering current 5.3.11 Turn – on time 5.3.12 Turn – off time 5.4 Different Methods of Turning on of SCRs 5.4.1 Radiation triggering or light turn – on 5.4.2 Voltage triggering or breakover voltage turn – on 5.4.3 dv/dt turn – on 5.4.4 Gate turn – on or gate triggering 5.5 Different Methods of Turning off of SCRs 5.5.1 Natural commutation 5.5.2 Forced commutation 5.5.3 Gate turn – off 5.6 Different Methods of Triggering SCR Circuits 5.6.1 Pulse control by R – C network 5.6.2 Pulse triggering by saturable reactor 5.6.3 Composite triggering by PWM controller 5.6.4 Pulse triggering by discrete transistors 5.7 Different methods of Forced Commutation 5.7.1 Class A commutation (Series resonant commutation by an LC circuit) 5.7.2 Class B commutation (Parallel resonant commutation by an LC circuit) 5.7.3 Class C commutation (Complementary commutation or parallel capacitor turn – off) 5.7.4 Class D commutation (Auxiliary commutation) 5.7.5 Class E commutation (External pulse commutation) 5.7.6 Class F commutation (AC line commutation) 5.8 Comparison of SCRs and Transistors 5.9 Thermal Characteristics of SCRs 5.10 Causes of Damage to SCR 5.10.1 Preventing damage to SCRs 5.11 The SCR Crower or Overvoltage Protection Circuit 5.12 Series and Parallel Operation of SCRs 5.12.1 Series connected SCRs 5.12.2 Triggering of series connected SCRs 5.12.3 Parallel connection SCRs 5.12.4 Triggering of parallel connected SCRs 5.13 Line – commutated Converters or Rectifier Circuits

		5.13.1 Half – wave rectifier (inductive load) 5.13.2 Half – wave rectifier (resistive load) 5.13.3 Full – wave control circuit 5.13.4 Single – phase full – wave controlled rectifier using center – tap transformer (M – 2 connection) 5.13.5 Single – phase bridge rectifier 5.13.6 Single – phase full – wave full – controlled bridge rectifier (B – 2 connection) 5.13.7 Single – phase full – wave half – controlled bridge rectifier (B – 2 connection) 5.13.8 Three – phase full – wave rectifier (M – 6 connection or six – pulse double – star circuit) 5.13.9 Three – phase full – wave full – controlled bridge rectifier (B – 6 connection) 5.13.10 Three – phase full – wave half – controlled bridge rectifier (B – 6 connection) 5.13.11 Three – phase half – wave diode rectifier with resistive load 5.13.12 Differences between full – controlled bridge and half – controlled bridge rectifiers 5.14 TRIACS 5.14.1 Gate triggering modes of the Triac 5.14.2 Choice between triacs and SCRs 5.14.3 Comparison of triacs with antiparallel SCRs 5.15 DIACS 5.16 QUADRACS 5.17 Recovery Characteristic 5.18 First Recovery Diodes 5.19 Power Diodes 5.19.1 Current ratings of power diodes 5.19.2 Voltage rating of power diodes 5.19.3 Protection of the power diode (Snubber circuit) 5.20 Power Transistors or Power BJTs 5.20.1 Snubber circuit (Switching – aid circuit) of the power BJT 5.20.2 Switching characteristic of the power transistor 5.21 Power MOSFETS 5.21.1 Snubber circuit (Switching – aid circuit) of the power MOSFET 5.21.2 Switching characteristics of the power MOSFET 5.22 Insulated Gate Bipolar Transistor (IGBT) 5.23 Loss of Power in Semiconductor Devices 5.24 Comparison between Power MOSFET, Power Transistor, and Power IGBT 5.25 Unijunction Transistor 5.26 Electron Tubes 5.26.1 Gas – filled diode 5.26.2 Thyratrons 5.26.3 Ignitron (Mercury – pool tube)
	6	**Inverters, Dual Converters, Choppers and Cycloconverters** 6.1 Inverters 6.2 Line – commutated Inverters 6.2.1 Single – phase line – commutated full – controlled inverter 6.2.2 Three – phase line – commutated full – controlled inverter or six – pulse converter

6.3 Forced – commutated Inverters

- 6.3.1 Single – phase parallel – capacitor commutated inverter (Resistive load)
- 6.3.2 Single – phase parallel – inverter with feedback diodes
- 6.3.3 Single – phase series inverter

6.4 Voltage – source Inverter

6.5 Current – source Inverter

- 6.5.1 Differences between voltage – source and current – source inverters

6.6 Three – phase Forced – commutated Bridge Inverters

6.8 Dual Converters

- 6.8.1 The phase – controlled dual converter
- 6.8.2 Single – phase dual converter
- 6.8.3 Types of three – phase dual converters
- 6.8.4 Circulating current type dual converter (Mid – point configuration)
- 6.8.5 Circulating current type dual converter (Dual – bridge configuration)
- 6.8.6 The circulating current – free type or non – circulating type dual converter
- 6.8.7 Different configurations used for dual converters

6.9 Choppers

- 6.9.1 Principle of operation
- 6.9.2 Chopper control technique
- 6.9.3 Voltage step – down chopper
- 6.9.4 Voltage step – up chopper
- 6.9.5 Jones chopper
- 6.9.6 Two – quadrant chopper or reversible chopper
- 6.9.7 AC chopper

6.10 Cycloconverters

- 6.10.1 Types of cycloconverters
- 6.10.2 Single–phase/single–phase cycloconverter (Mid–point configuration)
- 6.10.3 Single–phase/single–phase cycloconverter (Bridge configuration)
- 6.10.4 Three – phase/single – phase cycloconverter
- 6.10.5 Types of three – phase/single – phase cycloconverters
- 6.10.6 Three – phase/single – phase cycloconverter (Circulating current type)
- 6.10.7 Three–phase/single–phase cycloconverter (Non – circulating current type)
- 6.10.8 Three – phase/three – phase cycloconverter

8 **Heating and Welding Control**

8.1 Introduction

- 8.1.1 Advantages of electrical heating

8.2 Induction Heating

- 8.2.1 Theory of induction heating
- 8.2.2 Principle of induction heating
- 8.2.3 Effects of supply frequency on induction heating
- 8.2.4 Effects of source voltage on induction heating
- 8.2.5 Choice of frequency for induction heating
- 8.2.6 Advantages of induction heating
- 8.2.7 Application of induction heating

	8.2.8 Surface hardening of steel or surface heating of a small cylindrical rod 8.2.9 Source of high frequency power supply for induction heating 8.3 Dielectric Heating 8.3.1 Electronic theory of dielectric heating 8.3.2 Principle of operation of dielectric heating 8.3.3 Dielectric heating in materials of irregular shapes 8.3.4 Limitations of the use of extremely high frequency for dielectric heating 8.3.5 Effect of vibration of voltage of the power supply on dielectric heating 8.3.6 Effect of vibration of frequency of the power supply on dielectric heating 8.3.7 Applications of dielectric heating 8.3.8 Source of high frequency power supply for dielectric heating 8.3.9 Differences between induction heating and dielectric heating 8.4 Welding 8.4.1 Theory of resistance welding 8.4.2 Classification of resistance welding 8.5 Scheme for AC Resistance Welding 8.6 Ignitron Contractor as Electronic Line Contractor 8.6.1 Heat control by the change of firing angles in ignitrons 8.6.2 Complete control in resistance welding by a sequence timer
13	**Main References:** Biswanath Paul, "Industrial Electronics and Control including Programmable Logic Controller," 3rd Edition, PHI learning Private Limited, Delhi-110092, 2014
14	**Additional references:**

Lab	Information on Practical (Industrial Electronics and control)
1	Topic: **Half wave rectifier (resistive load)** **Task**: • To **explian** the operation of an SCR connected as a gate-controlled ac rectifier • To **observe** the effects of varying gate current on the firing point of an

	SCR connected as an ac rectifier **Resources**: Multisim Software
2	**Topic**: **SINGLE PHASE FULL-WAVE CONVERTER** **Task**: • To **observe** the phase relations between the voltage waveforms in a single phase full-wave supply • To **observe** the load waveforms and their phase in a single phase full-wave rectifier with resistive load **Resources**: Multisim Software
3	**Topic**: **DC to DC Converter** **Task**: • To test DC to DC Converter Circuit **Resources**: Panel NO: P21 (Trainer)
4	**Topic**: **Light Dimmer Circuit using DIAC and SCR** **Task**: • To explain the operation of DIAC and SCR phase control • To control the lamp for arbitrary of light • To construct the **Light Dimmer Circuit using DIAC and SCR** **Resources:** Hardware • DIAC, SCR, Resistors, Capacitors, project Board, Printed circuit board, Connection wire, 9V Battery.
5	**Topic**: **DC motor control with SCR** **Task**: • To explain the operation of an SCR automatic-speed-control (ASC) circuit • To learn how the speed and direction of rotation of a dc motor may be controlled • To become familiar with some industrial control circuit schematic symbols and typical control circuits • To demonstrate the operation of a dc shunt motor **Resources:** Hardware • BT06 SCR, Resistors, Switch, project Board, Printed circuit board, Connection wire, 9V Battery and DC motor.