ANNEXURE – I

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Main Bawana Road, Delhi-42
(Academic-PG)

Scheme for Full Time M.Tech.(Control &Instrumentation) as per NEP-2020

SEMESTER I					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I501	System Theory	4	3-0-2	24	500-599*
C&I503	Non-Linear Control Theory	4	3-0-2		
C&I505	Analog and Digital Instrumentation	4	3-0-2		
C&I507	Control for Power Electronic Devices and Systems	4	3-0-2		
	Departmental Elective 1 (DEC1)				
C&I511	SCADA and Its Applications	4	3-1-0		
C&I513	Controller Design for Power Electronic Converters		3-0-2		
C&I515	Machine Learning		3-1-0		
C&I517	Soft Computing Techniques		3-1-0		
C&I519	Power Quality		3-1-0		
	Self-Study(SS)**				
C&I551	Seminar	2	------		
C&I553	MOOC		------		
	Skill Enhancement Course 1*(SEC1)**				
C&I541	PCB Design	2	0-0-4		
	Audit Course		2-0-0		
UEC501	English for Research Paper Writing	0	2-0-0		
UEC503	Disaster Management		2-0-0		
UEC505	Sanskrit for Technical Knowledge		2-0-0		
UEC507	Value Education		2-0-0		
UEC509	Constitution of India		2-0-0		
UEC511	Pedagogy Studies		2-0-0		
UEC513	Stress Management by Yoga		1-0-2		
UEC515	Personality Development through Life Enlightening Skills		2-0-0		

SEMESTER II					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I502	Intelligent Control	4	3-0-2	24	500-599*
C&I504	Process Control	4	3-0-2		
	Departmental Elective 2 (DEC2)				
C&I520	Control System for Electric Vehicles	4	3-0-2		
C&I522	Advanced Control System Design		3-1-0		
C&I524	Design of Fractional Order Systems		3-1-0		
C&I526	Robot Dynamics & Control		3-1-0		
C&I528	Random Process and Stochastic Control & Estimation		3-1-0		
	Departmental Elective 3 (DEC3)				
C&I530	Control for Photovoltaic and Wind Energy Systems	4	3-0-2		
C&I532	Electrical Energy Storage Systems		3-1-0		
C&I534	Analog Filter Design		3-1-0		
C&I536	Intelligent Instrumentation		3-0-2		
C&I538	VLSI Design in Electrical Systems		3-0-2		
UCC502	Research Methodology and IPR	4	3-1-0		
	Skill Enhancement Course 2*(SEC2)**				
C&I540	Industrial Training	4	0-0-8		
C&I542	Embedded Programming with Microcontroller		2-0-4		
C&I544	Implementation of Embedded Programming with Microcontroller		0-0-8		
C&I546	Professional Software		2-0-4		
C&I548	Real Time Simulation		0-0-8		
	NHEQF Level				6.5
SEMESTER III					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I601	Motion Control of Electrical Motors	4	3-0-2		600-699*
	Open Elective 1 (OEE)				

OEE601	Electric Vehicle Technology	4	3-1-0	16	
C&I603	Minor Project/Research Thesis/Patent	8	----		

SEMESTER IV

Code	Type	Cr	L-T-P	Total Credits	Level
C&I602	Major Project/Research Thesis/Patent	16	------	16	
	NHEQF Level				7.0

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Shahbad Daulatpur, Main Bawana Road, Delhi-42

(Academic-PG)

Scheme for Part Time M. TECH. (CONTROL & INSTRUMENTATION) as per NEP-2020

SEMESTER I					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I501	System Theory	4	3-0-2	12	500-599*
C&I503	Non-Linear Control Theory	4	3-0-2		
C&I505	Analog and Digital Instrumentation	4	3-0-2		
SEMESTER II					
	Type	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I502	Intelligent Control	4	3-0-2	12	500-599*
C&I504	Process Control	4	3-0-2		
	Departmental Elective 2 (DEC2)				
C&I520	Control System for Electric Vehicles	4	3-0-2		
C&I522	Advanced Control System Design		3-1-0		
C&I524	Design of Fractional Order Systems		3-1-0		
C&I526	Robot Dynamics & Control		3-1-0		
C&I528	Random Process and Stochastic Control & Estimation		3-1-0		
	NHEQF Level				6.5
SEMESTER III					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I507	Control for Power Electronic Devices and Systems	4	3-0-2	12	600-699*
	Departmental Elective 1(DEC1)				
C&I511	SCADA and Its Applications		3-1-0		
C&I513	Controller Design for Power Electronic Converters		3-0-2		

C&I515	Machine Learning	4	3-1-0		
C&I517	Soft Computing Techniques		3-1-0		
C&I519	Power Quality		3-1-0		
	Self-Study(SS)**				
C&I551	Seminar	2	------		
C&I553	MOOC		------		
	Skill Enhancement Course 1*(SEC1)**				
C&I541	PCB Design	2	0-0-4		
	Audit Course				
UEC501	English for Research Paper Writing	0	2-0-0		
UEC503	Disaster Management		2-0-0		
UEC505	Sanskrit for Technical Knowledge		2-0-0		
UEC507	Value Education		2-0-0		
UEC509	Constitution of India		2-0-0		
UEC511	Pedagogy Studies		2-0-0		
UEC513	Stress Management by Yoga		1-0-2		
UEC515	Personality Development through Life Enlightening Skills		2-0-0		

SEMESTER IV

Code	Type	Cr	L-T-P	Total Credits	Level
	Departmental Elective 3 (DEC3)			12	500-599*
C&I530	Control for Photovoltaic and Wind Energy Systems	4	3-0-2		
C&I532	Electrical Energy Storage Systems		3-1-0		
C&I534	Analog Filter Design		3-1-0		
C&I536	Intelligent Instrumentation		3-0-2		
C&I538	VLSI Design in Electrical Systems		3-0-2		
UCC502	Research Methodology and IPR	4	3-1-0		
	Skill Enhancement Course 2*(SEC2)**				
C&I540	Industrial Training	4	0-0-8		
C&I542	Embedded Programming with Microcontroller		2-0-4		

C&I544	Implementation of Embedded Programming with Microcontroller		0-0-8		
C&I546	Professional Software		2-0-4		
C&I548	Real Time Simulation		0-0-8		
	NHEQF Level				6.5
SEMESTER V					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I601	Motion Control of Electrical Motors	4	3-0-2	**16**	600-699*
	Open Elective 1 (OEE)				
OEE601	Electric Vehicle Technology	4	3-1-0		
C&I603	Minor Project/Research Thesis/Patent	8	-----		
SEMESTER VI					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
C&I602	Major Project/Research Thesis/Patent	16	------	16	------
	NHEQF Level				**7.0**

***Level**
Refer draft UGC Curriculum and credit framework for PG Programme

Self Study
Self-Study can be offered as Seminar or MOOC from online platform. In case of seminar, the respective required to collect seminar topic from the students in the beginning of first semester. The list of seminar topics must be approved by the department BOS within 15 days of the beginning of semester and submitted to Dean (Academics -PG).

***** Skill Enhancement Course 1 and 2**
Department must provide rich basket of Skill Enhancement Courses so that it can be changed in subsequent years.

******Audit Course**
As per AICTE Model Curriculum the audit courses are listed below. If department wants to offer any other audit course, then the respective department requires to get approval of the additional audit course from the Department BOS and submit BOS approved syllabus and scheme to Dean PG. Further, Dean PG will get it approved from the Academic Council in order to ensure smooth conduct of lecture and practical.

List of AICTE approved Audit Course

Code	Audit Course Name
UEC501	English for Research Paper Writing
UEC503	Disaster Management
UEC505	Sanskrit for Technical Knowledge
UEC507	Value Education
UEC509	Constitution of India
UEC511	Pedagogy Studies
UEC513	Stress Management by Yoga
UEC515	Personality Development through Life Enlightening Skills

Program Outcomes (POs):

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/document.
PO3: Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

ANNEXURE – II

Scheme of Evaluation for the course of all Programme

S. No.	Course Credits	Course Type			Examination		Relative Weightage				
		L	T	P/ST	TH	PR/ ST	CWS	PRS/ STS/ CMS	MTE	ETE/ EME	PRE/ STE
1.	2	1	1	0	Yes	No	25	-	25	50	-
2.	2	2	0	0							
3.	4	3	1	0							
4.	2	1	0	2	Yes	No	15	25	20	40	-
5.	4	3	0	2							
6.	4	2	1	2							
7.	4	2	0	4							
8.	4	1	0	6							
9.	4	0	1	6							
10.	2	0	0	4	No	Yes	-	50	-	-	50
11.	4	0	0	8							
12.	2/4	Self Study (Seminar)/ Industrial Training			No	Yes	-	40	-	-	60
13.	8/16	Minor Project/ Major Project/ Research Thesis/ Patent									

ANNEXURE III

	SEMESTER I													
	Teaching Scheme				**Contact Hours/Week**			**Exam Duration (Hrs)**		**Relative Weights (%)**				
S.No.	**Course Code**	**Course Name**	Type/ Area	**Cr**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	C&I501	System Theory	CORE	4	3	0	2	3	2	15	25	20	40	-
2	C&I503	Non-Linear Control Theory	CORE	4	3	0	2	3	2	15	25	20	40	-
3	C&I505	Analog and Digital Instrumentation	CORE	4	3	0	2	3	2	15	25	20	40	-
4	C&I507	Control for Power Electronic Devices and Systems	CORE	4	3	0	2	3	2	15	25	20	40	-
5	C&I511	SCADA and Its Applications	DEC1	4	3	1	0	3	0	25	-	25	50	-
	C&I513	Controller Design for Power Electronic Converters	DEC1	4	3	0	2	3	2	15	25	20	40	-
	C&I515	Machine Learning	DEC1	4	3	1	0	3	0	25	-	25	50	-
	C&I517	Soft Computing Techniques	DEC1	4	3	1	0	3	0	25	-	25	50	-
	C&I519	Power Quality	DEC1	4	3	1	0	3	0	25	-	25	50	-
6		Skill Enhancement Course 1												
	C&I541	PCB Design	SEC-1	2	0	0	4	0	2	-	50	-	-	50
7		Self-Study												
	C&I551	Seminar	SS	2	-	-	-	-	-	-	40	-	-	60
	C&I553	MOOC	SS	2	-	-	-	-	-	-	-	-	-	-
8		Audit Course												
	UEC501	English for Research Paper Writing	UEC501	0	2	0	0	-	-	25	-	25	50	-
	UEC503	Disaster Management	UEC503	0	2	0	0	-	-	25	-	25	50	-
	UEC505	Sanskrit for Technical Knowledge	UEC505	0	2	0	0	-	-	25	-	25	50	-

	UEC507	Value Education	UEC507	0	2	0	0	-	-	25	-	25	50	-
	UEC509	Constitution of India	UEC509	0	2	0	0	-	-	25	-	25	50	-
	UEC511	Pedagogy Studies	UEC511	0	2	0	0	-	-	25	-	25	50	-
	UEC513	Stress Management by Yoga	UEC513	0	1	0	2	-	-	15	25	20	40	-
	UEC515	Personality Development through Life Enlightening Skills	UEC515	0	2	0	0	-	-	25	-	25	50	-
Total Credits				**24**										

	SEMESTER II													
	Teaching Scheme				Contact Hours/Week			Exam Duration (Hrs)		Relative Weights (%)				
S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	Theory	Practica	CWS	PRS	MTE	ETE	PRE
1	C&I502	Intelligent Control	CORE	4	3	0	2	3	2	15	25	20	40	-
2	C&I504	Process Control	CORE	4	3	0	2	3	2	15	25	20	40	-
3	C&I520	Control System for Electric Vehicles	DEC2	4	3	0	2	3	2	15	25	20	40	
	C&I522	Advanced Control System Design	DEC2	4	3	1	0	3	0	25	-	25	50	
	C&I524	Design of Fractional Order Systems	DEC2	4	3	1	0	3	0	25	-	25	50	
	C&I526	Robot Dynamics & Control	DEC2	4	3	1	0	3	0	25	-	25	50	
	C&I528	Random Process and Stochastic Control & Estimation	DEC2	4	3	1	0	3	0	25	-	25	50	
4	C&I530	Control for Photovoltaic and Wind Energy Systems	DEC3	4	3	0	2	3	2	15	25	20	40	
	C&I532	Electrical Energy Storage Systems	DEC3	4	3	1	0	3	0	25	-	25	50	
	C&I534	Analog Filter Design	DEC3	4	3	1	0	3	0	25	-	25	50	
	C&I536	Intelligent Instrumentation	DEC3	4	3	0	2	3	2	15	25	20	40	
	C&I538	VLSI Design in Electrical Systems	DEC3	4	3	0	2	3	2	15	25	20	40	
5	UCC502	Research Methodology and IPR	UEC	4	3	1	0	3	0	25	-	25	50	-
6	C&I540	Industrial Training	SEC-2	4	0	0	8	0	2	-	50	-	-	50
	C&I542	Embedded Programming with Microcontroller	SEC-2	4	2	0	4	3	2	15	25	20	40	-
	C&I544	Implementation of Embedded Programming with Microcontroller	SEC-2	4	0	0	8	0	2	-	50	-	-	50
	C&I546	Professional Software	SEC-2	4	2	0	4	3	2	15	25	20	40	-
	C&I548	Real Time Simulation	SEC-2	4	0	0	8	0	2	-	50	-	-	50
Total Credits				24										

	SEMESTER III													
	Scheme Teaching				**Contact Hours/Week**			**Exam Duration (Hrs)**		**Relative Weights (%)**				
S. No.	**Course Code**	**Course Name**	Type/ Area	**Cr**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	C&I601	Motion Control of Electrical Motors	CORE	4	3	0	2	3	2	15	25	20	40	-
2	OEE601	Electric Vehicle Technology	OEE	4	3	1	0	3	0	25	-	25	50	-
3	C&I603	Minor Project/Research/Thesis/Patent	CORE	8	-	-	-	-	-	-	40	-	-	60
Total Credits				**24**										

	SEMESTER IV													
	Teaching Scheme				**Contact Hours/Week**			**Exam Duration (Hrs)**		**Relative Weights (%)**				
S. No.	**Course Code**	**Course Name**	Type/Area	**Cr**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	C&I 602	Major Project / Research / Thesis / Patent	CORE	16	-	-	-	-	-	-	-	-	-	100
Total Credits				**24**										

ANNEXURE – V

Important Note for AY 2024-2025:

Further, all the departments must provide the list of courses, existing subject codes, and new subject codes (as per updated format Annexure – III and Annexure –IV) that were offered in the AY 2024-2025 (for both 1st Year and 2nd Year). In order to maintain consistency with the course code in the result section, it is decided that a new course code must be provided by the department for the courses already offered in the August 2024 and January 2025 sessions. The required format is given below:

Semester I				
S. No.	**Existing Subject Code**	**Existing Subject Name**	**New Course Code**	**New Subject Name (Subject Name will remain same as of earlier)**
1	C&I501	System Theory	C&I501	System Theory
2	C&I505	Non-Linear Control Theory	C&I503	Non-Linear Control Theory
3	C&I507	Analog and Digital Electronics	C&I505	Analog and Digital Electronics (For batch 2024-25) Analog and Digital Instrumentation (For batch 2025-26 onwards)
4	C&I509	SCADA and EMS	C&I511	SCADA and EMS (For batch 2024-25) SCADA and Its Applications (For batch 2025-26 onwards)
5	C&I 5313	Soft Computing Techniques	C&I517	Soft Computing Techniques
6	C&I525	Self-Study	C&I551	Seminar
			C&I553	MOOC
7	C&I523	PCB Design	C&I541	PCB Design
8	UEC 501	Audit Course	UEC513	Stress Management by Yoga
Semester II				
S. No.	**Existing Subject Code**	**Existing Subject Name**	**New Course Code**	**New Subject Name (Subject Name will remain same as of earlier)**
1	C&I502	Intelligent Control	C&I502	Intelligent Control
2	C&I504	Process Control	C&I504	Process Control
3	C&I 5321	Advanced Control System Design	C&I522	Advanced Control System Design
4	C&I 5343	Electrical Energy Storage Systems	C&I532	Electrical Energy Storage Systems

5	UCC502	Research Methodology and IPR	UCC502	Research Methodology and IPR
6	C&I 546	Skill Enhancement Course 2	C&I546	Professional Software

Syllabus of Core Courses of M.Tech.(C&I)

Course Code	Course Name	Cr	L	T	P	PRE
C&I 501	System Theory	4	3	0	2	-

Course Objectives

To develop students with the knowledge and understanding of the behavior of electrical, mechanical, electromechanical systems etc in terms of state, state vectors and state models and to find solution of state equations for both continuous and discrete systems.

Course Outcomes

CO1 To understand concept of state, state variables and state vectors and its applications for modeling various physical systems, concept of controllability and observability.
CO2 To derive state space models of DC motor, Electrical circuits and Power Converters.
CO3 To analyze the Z and S domain stability and study relation between them.
CO4 To analyze the concept of state transition matrix and its application in continuous and digital control system.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**2**
CO2	**2**	**2**	**1**
CO3	**2**	**3**	**3**
CO4	**3**	**3**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Concept of state, state variable and state vectors and state models. Applications of state and state variables in modelling.	6
2.	State space modelling of Mass Spring Dashpot System, three mass systems, Armature and Field Controlled separately excited DC motors, Power Converters such as buck, boost and buck-boost, Cuk Converter, etc	10
3.	Sampler & Zero-order hold device, Discrete time response of sampled- data control systems, Z-Transform and its properties, Jury's stability test, stability via Z-plane and bi-linear transformation.	10
4.	Phase variable, canonical variable forms, evaluation of state transition matrix, properties of state transition matrix, solution of state equations of linear time invariant and time variant continuous and discrete time systems, Concepts of controllability and observability, controllability test, observability test, observer design, observer-based controller design.	14

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1	I.J, Nagrath and M.Gopal, "Control Systems Engineering", Seventh Edition, New Age Publisher.	2021
2	D.Roy Choudhary, "Modern Control Engineering", Prentice Hall of India Learning Private Limited	2015
3	M.Gopal, "Digital Control and State Variable Methods", McGraw Hill Education (India) Private Limited,	2015
4	Ned Mohan, Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons	2003
5	P.J. Antsaklis and Anthony N. Michel, "A Linear Systems Primer",	1997
6	R. W. Brockett, "Finite Dimensional Linear Systems", John Wiley and Sons	1970

Course Code	Course Name	Cr	L	T	P	PRE
C&I 503	Non-linear Control Theory	4	3	0	2	-

Course Objectives

To develop students with the knowledge and understanding for analyzing the nonlinear systems using phase plane and describing function methods. Student will be able to determine stability using Lyapunov's method, Popov's criterion etc. Also will be able to implement SMC and MPC methods on nonlinear systems.

Course Outcomes (COs)

CO1 To understand nonlinear systems and their behavior.
CO2 To analyze nonlinear systems using phase plane and describing functions methods.
CO3 To analyze lyapunov's stability methods and its applications.
CO4 To analyze the SMC and MPC method and their applications

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**1**
CO2	**2**	**3**	**3**
CO3	**2**	**2**	**2**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to non-linear systems and their behavior, multiple equilibrium points, limit cycles. nonlinear system analysis, phase-plane analysis, isoclines method and delta method. Concept of singular points and their analysis, existence of limit cycles.	8
2.	Describing function analysis, describing function of common non-linearities. Stability analysis of nonlinear system using describing function, dual input describing function, perturbation theory and perturbation dynamics.	10
3.	Lyapunov's methods, krasovski method, variable gradient method. advanced stability criterion, Lyapunov analysis of non-autonomous systems. Lyapunov's direct method of stability, absolute stability and Popov's criterion.	10
4.	Sliding Mode Control (SMC) and Model Predictive Control (MPC): Introduction, Mathematical Foundations of SMC, Differential Equations, Chattering Phenomenon, Non-Linear Control of DC-DC Converters such as Buck, Boost, Buck-Boost, Cuk converter etc. using SMC, Lyapunov and MPC.	12

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1.	D.P. Atherton, "Nonlinear control Engineering", First Edition, Van Nostrand Reinhold, 1975.	1975
2.	D.P. Atherton, "Stability of Nonlinear system", First Edition, John Wiley & Sons, 1981	1981
3.	W.J. Cunningham, "Introduction to Nonlinear Analysis", First Edition, McGraw-Hill, 1958.	1958
4.	W.J. Cunningham, "Introduction to Nonlinear Analysis", First Edition, McGraw-Hill, 1958.	1958
5.	J.E. Gibson, "Nonlinear, Automatic Control", First Edition, Tata McGraw-Hill 1963	1963
6.	W. Hahn, "Theory and Application of Lyapunov's Direct Method", First Edition, Prentice-Hall, Englewood Cliffs, 1963.	1963
7.	R.R. Mohler, "Nonlinear Systems: Dynamics and Control", Prentice-Hall, Englewood Cliffs, 1990.	1990
8.	Mark W. Spong, and M. Vidhyasagar, "Robotic Dynamics and Control", Prentice Hall, Englewood Cliffs, 2008.	2008
9.	Ned Mohan, Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons	2003
10.	M. Vidhyasagar, "Nonlinear System Analysis", Second Edition, Prentice-Hall, Englewood Cliffs, 2002.	2002

Course Code	Course Name	Cr	L	T	P	PRE
C&I 505	Analog and Digital Instrumentation	4	3	0	2	-

Course Objectives

To develop students with the knowledge and understanding to analyze the OPAMP with applications in instrumentation amplifier, Schmitt trigger, log/antilog amplifier etc. Further they will be able to analyze architecture and hardware description of Digital Signal Processor, and FPGA and CPLD.

Course Outcomes (COs)

CO1 To understand about the noninverting/inverting amplifiers, instrumentation amplifier etc.
CO2 To design differential amplifiers, Schmitt trigger and log/antilog amplifiers.
CO3 To analyze architecture and hardware configuration of digital signal processor.
CO4 To analyze the types of FPGA.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**2**	**1**
CO2	**2**	**1**	**1**
CO3	**3**	**2**	**2**
CO4	**2**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Linear circuits: Basic circuits using op-amps like non-inverting/inverting amplifiers, differential and instrumentation amplifiers, integrator, practical integrators, differentiator, current sources for floating and grounded loads, negative impedance converter, generalized impedance converter.	12
2.	Real op-amp performance parameters, static limitations, dynamic limitations, input-output swing limitations, compensation techniques. Applications in Non-linear circuits, Comparators, Schmitt trigger, precision rectifier. log/antilog amplifiers, analog multipliers, ADC and DAC circuits, Review of Latches, racing, master salve flip- flops, flip flops, characteristic equations, sequential circuits and combinational circuits.	16
3.	Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – types of FPGA, Xilinx XC3000 series , configurable logic blocks (CLB), input/output block (IOB) – programmable interconnect point (PIP) – Xilinx 4000 series – HDL programming –overview of Spartan 3E and Virtex II pro FPGA boards- case study	12

Suggested Readings

S.No	Name of Authors/ Books/Publishers	Year of Publication
1.	Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", Third Edition, Tata McGraw-Hill, 2017	2017
2.	George Clayton and Steve Winder, "Operational Amplifiers", Fifth Edition, EDN Series foe design Engineers, 2003.	2003
3.	John F. Wakerly, "Digital design", Fourth Edition, Prentice Hall, 2000.	2000
4.	Sedra and Smith, "Microelectronic circuits", Seventh Edition, Oxford Publication, 2017.	2017
5.	Donald A Neamen, "Electronic circuit analysis and design", Third Edition, Tata McGraw-Hill, 2006.	2006
6.	Donald A Neamen, "Electronic circuit analysis and design", Third Edition, Tata McGraw-Hill, 2006.	2006

Course Code	Course Name	Cr	L	T	P	PRE
C&I 507	Control for Power Electronic Devices and Systems	4	3	0	2	-

Course Objectives

To develop proficiency in analyzing, designing, and implementing Power semiconductor devices, AC-DC, DC-AC, AC-AC, and DC-DC power converters, focusing on efficiency, control techniques, and practical applications.

Course Outcomes (COs)

CO1 To analyze the characteristics of Power Semiconductor devices like Power diodes, power BJTs, Thyristors etc.

CO2 To design and analyze AC-DC converters, students will master single-phase and three-phase rectifiers, including semi and fully controlled converters, with a focus on power factor improvement and the impact of source inductance.

CO3 To implement and control DC to AC inverters, they will learn principles of operation, performance parameters, and voltage control methods for single and three-phase inverters, including SPWM and space vector modulation.

CO4 To analyze AC to AC converters and DC to DC converters, students will explore voltage controllers, and cycloconverters for phase control and reactive power management and advanced chopper circuits, including PWM techniques.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**3**	**3**	**1**
CO2	**2**	**1**	**2**
CO3	**2**	**2**	**2**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Review of Power Semiconductor Diodes, Power Transistors BJTs, Power MOSFETs: Basic structure, I-V and reverse recovery characteristics, Freewheeling diodes, steady power state and transfer characteristics of npn transistor, switching performance, IGBT turn-on and turn-off characteristics. Review of Thyristors, DIACS, TRIACS and GTOs: Basic structure, turn on methods: Gate triggering, dv/dt triggering, Switching characteristics during turn-on and turn -off process, thryistor Gate characteristics, Snubber circuit design, Natural and Resonant commutation, Heat Sink Design.	10
2.	AC-DC Converters: Single phase Semi converter & fully controlled converter, Design and analysis of single phase and three phase half controlled and full controlled rectifiers with R, RL and RLE loads -Effect of source inductance- input power factor and harmonic factor- dual converters, twelve pulse converters-power factor improvement schemes, –	8

	Gate drive and protection circuits. Pulse-Width Modulation (PWM) controlled rectifier circuits.	
3.	DC to AC Converters (Inverters): Single-phase and three-phase inverters, Principle of operation, Half bridge and full bridge single phase inverters, 120 and180 degree modes of operation, PWM techniques- sinusoidal PWM scheme for single and three phase inverter, Impact of harmonics-Harmonic elimination schemes- space vector modulation: Under and over modulation, Current source inverters,, Comparison between VSI & CSI , Multilevel Inverters (MLI).	8
4.	Single phase AC-AC voltage regulator-analysis of Half controlled and fully controlled AC regulators, three Phase AC Voltage Controller: operation, -integral cycle controller. Cycloconverters –types.	8
5.	DC-DC Converters: Principle of operation, analysis of step-down and step-up converters, classification of PWM choppers, Buck, Boost, Buck-Boost, Cúk and Sépic converters.	8

Suggested Books

S.No	**Name of Authors/ Books/Publishers**	**Year of Publication**
1.	Ned Mohan, Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons	2003
2.	G. Massobrio, P. Antognetti, Semiconductor Device Modeling with Spice, McGraw-Hill, 2nd Edition	2010
3.	B. Jayant Baliga, Power Semiconductor Devices, PWS Publication, 2nd Edition	2019
4.	V. Benda, J. Gowar, and D. A. Grant, “Discrete and Integrated Power Semiconductor Devices: Theory and Applications”, John Wiley & Sons, 2nd Edition	1999
5.	Barry W Williams, Power Electronics: Devices, Drivers, Applications, and Passive Components, McGraw Hill	1987

Skill Enhancement Course 1

Course Code	Course Name	Cr	L	T	P	PRE
C&I 541	PCB Design	2	0	0	4	-

Course Objectives
This course covers PCB design principles, fabrication, signal integrity considerations, and layout optimization for power supplies, mixed-signal circuits, and high-speed digital applications.

Course Outcomes (COs)
CO1 To develop skill in related technology of main course
CO2 To understand the professional tools
CO3 To design new concepts on professional tools
CO4 To analyze draft reports on professional tools

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**3**	**2**	**1**
CO2	**2**	**1**	**3**
CO3	**2**	**3**	**2**
CO4	**2**	**3**	**3**

Course Contents

S.No.	Content	Hrs
1.	Introduction to PCB design and CAD, PCB Fabrication, PCB cores and layer stack-up, PCB fabrication, Layer registration, Function of Layout in the PCB Design Process, Design Files Created by Layout, Layout format files, Postprocess (Gerber) files, PCB assembly layers and files.	4
2.	Introduction on layout drawing and importing the netlist, board outline, Design flow, Schematic design, part placement, wiring (connecting) the parts, Layout netlist, Designing the PCB with the parts, Auto-routing the board, Manual routing, Performing a design rule check, Postprocessing the board design for manufacturing, Introduction to PCB Assembly and Soldering Processes.	10
3.	Project Structures and Layout Tool set, Part libraries, Layout Environment and Tool Set, Board technology files, Design window, Control of the auto-router, Postprocessing and layer details, Introduction to Industry Standards, Classes and Types of PCBs, Fabrication types and assembly subclasses, Introduction to Standard Fabrication Allowances, tolerances, Breakout and annular ring control, PCB Dimensions and Tolerances, Tooling area	10

	allowances and effective panel usage, finished PCB thickness, Prepreg thickness, Copper thickness for PTHs and vias, Copper cladding/foil thickness, Copper Trace and Etching Tolerances, Hole Dimensions, Solder-mask Tolerance, Component Placement and Orientation Guide, Component Spacing for Through-hole Devices, Holes and jumper wires, Component Spacing for Surface-Mounted Devices(SMD), Land Patterns, Footprint and Padstack Design, Hole-to-lead ratio, PTH land dimension (annular ring width), Clearance between plane layers and PTHs, Soldermask and solder paste dimensions, Mounting holes, making and editing layout.	
4.	PCB design for signal integrity, Circuit Design Issues, Noise and Distortion, Frequency response, Electromagnetic Interference and Cross Talk, Magnetic fields and inductive coupling, Loop inductance, Electric fields and capacitive coupling, Ground Planes and Ground Bounce, Ground (return) planes, Ground bounce and rail collapse, guard traces, Split power and ground planes, PCB Electrical Characteristics impedance, Reflections, Ringing, length of traces, Transmission line terminations, Parts placement for electrical considerations, PCB layer stack-up, Bypass capacitors and fanout, Trace width for current carrying capability, for controlled impedance, for voltage withstanding, to minimize cross talk and Traces with acute and 90^{o} angles.	8
5.	PCB Design Examples: • Power Supply • Mixed Analog/Digital Design Using Split Power, Ground Planes • Multipage, Multipower, and Multiground Mixed A/D PCB Design • High-Speed Digital Design • Buck and Boost DC-DC converter • Full bridge isolated DC-DC Converter	10

Suggested Readings:

S.No	**Name of Authors/ Books/Publishers**	**Year of Publication**
1.	K. Mitzner, B. Doe, A. Akulin, A. Suponin and D. Müller, Complete PCB Design Using OrCAD Capture and PCB Editor, Academic Press	2007
2.	Tim Williams, The Circuit Designer's Companion, Butterworth-Heinmann	1991
3.	Majid Pakdel, Fast PCB Design with Altium Designer, Central West Publishing.	2021

Course Code	Course Name	Cr	L	T	P	PRE
C&I 502	Intelligent Control	4	3	0	2	-

Course Objectives

This course aims to provide comprehensive understanding of intelligent control system structure, norms and definite functions. It also develop students to implement fuzzy logic toolbox and neural network toolbox on nonlinear systems.

Course Outcomes

CO1 To understand the concept of norms of signals, vectors and matrices.
CO2 To implement fuzzy logic control using mamdani model.
CO3 To implement the fuzzy logic toolbox and neural network toolbox on nonlinear systems.
CO4 To design neural networks based control and applications of intelligent control on converters.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**2**
CO2	**2**	**2**	**3**
CO3	**3**	**2**	**3**
CO4	**3**	**3**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Intelligence, Johnson Picton model of Intelligent control system structure, review of work for intelligent control system. Norms of signals, vectors and matrices, Soft Computing and Hard Computing Techniques, Back Stepping control design, Definite functions, Nonlinear control strategies.	10
2.	Concept of Crisps & Fuzzy sets, examples, Fuzzy logic, Types of Membership function, Basic fuzzy set operation, Fuzzification, Defuzzification, Rule Base, & Fuzzy Inference System, Fuzzy logic control using Mamdani model. Implementation of fuzzy logic controller using Matlab, fuzzy-logic toolbox, Rule base editor, Rule Viewer, , Surface viewer, Membership function editor, Building systems with fuzzy logic toolbox, Stability analysis of fuzzy control systems, working with Simulink and Command line.	14
3.	Biological neuron, Artificial neuron, types of activation function, training of NN, Feedforward NN, Perceptron, Adaptive Network Fuzzy Inference System (ANFIS), Neural Networks in system identification and control.	8
4.	Applications of fuzzy logic and neural networks on benchmark systems, drives and power electronic converters such as DC-DC converters, Inverters etc.	8

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1.	B. Kosko, "Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence", First Edition, Prentice-Hall of India Pvt. Ltd	1991
2.	J.S.R Jang, C.T. Sun, E. Mizutani, "Neuro-fuzzy and soft Computing", First Edition, Pearson Education.	1997
3.	L. Behera, I. Kar, "Intelligent Systems and Control", Oxford Higher Education	2009
4.	Omid Omidvar and L. Elliott David, "Neural Systems for control", First Edition, Academic Press Limited.	1997
5.	C.T. Lin and C.S.G. Lee, "Neural Fuzzy Systems", First Edition, Prentice Hall PTR.	1996

Course Code	Course Name	Cr	L	T	P	PRE
C&I 504	Process Control	4	3	0	2	-

Course Objectives

This course aims to provide comprehensive understanding of the process control models, concept of proportional, proportional integral and proportional integral derivative control, concept of electronic controller and PLC.

Course Outcomes

CO1 To gain knowledge about the process control models like hydraulic tanks, fluid flow systems etc.

CO2 To analyze concept of proportional, proportional integral and proportional integral derivative control.

CO3 To analyze the concept of electronic controller, pneumatic controller and controller tuning.

CO4 To implement programming of PLC- Sequential and programmable controllers.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**2**
CO2	**1**	**2**	**2**
CO3	**2**	**2**	**2**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to process control, models of industrial process, hydraulic tanks, fluid flow systems, mixing process, chemical reactions, thermal systems-heat exchangers and distillation column	10
2.	Basic control action-on/off, P, P+I, P+I+D, floating control, pneumatic and electronic controllers, controller tuning, time response and frequency response methods , non-linear controllers, inverse time response of system, effect of pole and Zero on right hand side of s- plane, feed forward and multivariable control	12
3.	Evolution of PLC, sequential and programmable controllers, architecture, Programming of PLC, relay logic and ladder logic, functional blocks	10
4.	Communication networks for PLC, field bus such as profi-bus, mod-bus etc	8

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1.	Stephanopolus George, "Chemical Process control: An Introduction to Theory and Practice", First Edition, Prentice Hall India.	1983
2.	P. Harriot, "Process control", Tata McGraw-Hill.	2012
3.	Norman A Anderson, "Instrumentation for process measurement and control", Third Edition, CRC Press LLC.	1998
4.	Dale E. Seborg, Thomas F Edgar, Duncan A Mellichamp,"Process dynamics and control", Third Edition, Wiley John and Sons	2011
5.	T.E. Marlin, "Process control", Second edition, McGraw hill	2000
6.	M.P Lucas, "Distributed Control System", First Edition, Van Nostrand Reinhold Co.	1986
7.	Pertrezeulla, "Programmable Controllers", Fourth Edition, McGraw-Hill	2016

Skill Enhancement Course 2

Course Code	Course Name	Cr	L	T	P	PRE
C&I 540	Industrial Training	4	0	0	8	-
C&I 542	Embedded Programming with Microcontroller	4	2	0	4	-
C&I 544	Implementation of Embedded Programming with Microcontroller	4	0	0	8	-
C&I 546	Professional Software	4	2	0	4	-
C&I 548	Real Time Simulation	4	0	0	8	-

Course Objectives

To develop students with the knowledge and skills to understand the professional software and its applications in electrical engineering, to implement embedded programming with microcontroller in the applications of electrical engineering/ Industrial Training/ Real Time Simulation.

Course Outcomes (COs)

CO1 To develop related technology of main course
CO2 To analyze and get exposure to professional tools, embedded programming with microcontroller
CO3 To design new concepts on professional tools, embedded programming
CO4 To draft reports on professional tools, embedded programming, real time simulation etc

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**2**
CO2	**1**	**2**	**2**
CO3	**2**	**2**	**2**
CO4	**3**	**3**	**3**

Course Contents

S.no	Content
1	C&I 540: Industrial Training
2	C&I 542: Embedded Programming with Microcontroller Professional software : Lab practicals/course based on Microcontroller and Embedded Systems
3	C&I 544: Implementation of Embedded Programming with Microcontroller : Lab practicals/course based on Microcontroller and Embedded Systems

4	C&I 546: Professional Software (LabVIEW/Real Time Simulation/OrCad/ KiCad EDA etc)
5	C&I 548: Real time Simulation (OPAL-RT)

	C&I 542/544: Embedded Programming with Microcontroller/Implementation of Embedded Programming with Microcontroller	
S.No	**Contents**	**Hrs.**
1.	Embedded Control System, Key elements of a microcontroller, Programming microcontrollers, Scheme of a Power Electronics Control Problem, Embedded Development.	4
2.	Code Generation through MATLAB, Model-Based Design and Rapid Prototyping, Workflow for Automatic Code Generation, Generate Code for C2000 family Microcontrollers, TI C2000 Processors Block-set, Description of hardware kit, Power connectivity, Serial connectivity, PWM signals, GPIO signals, DC bus and phase voltage sensing, Low-side shunt-based current sensing, Code Composer Studio and Control SUITE, Embedded Coder for C2000 Processors.	8
3.	Designing a Closed-Loop Control System, Dynamical systems in electrical applications, Design a PI Controller in Continuous-Time Domain, Characterization of the closed-loop dynamics, Derive a PI Controller in Discrete-Time Domain, General properties of the discretization process, Characterization of the closed-loop dynamics F(z), PI-Based Current Control of an RL Load, Anti-Windup PI Controller Scheme. Fixed Point vs Floating Point Representation, Single vs Double Precision, Scaling in Fixed Point Representation, Conversion from Decimal Representation to Single Format	12
4.	Peripherals Settings, Serial Communication and Hardware Target, Execution in Simulink, MCUs and Real- Time Control with Simulink, Serial Communication Interface (SCI), Serial configuration, Time Variable Settings (Sample Rates), GPIO Peripheral—Digital Input/Output, Analog to Digital Converter Peripheral, Operating Principle, Sample & hold, Analog to digital converter, Hardware Details, Acquisition window and sample time, Synchronization between ADC modules, Pulse Width Modulator Peripheral, Operating Principle, Hardware Details, Generation of PWM signals, Counting modes, Setting of dead bands, DAC Peripheral, Filtered PWM, Synchronization between Multiple PWM Modules, Synchronization between ADC and PWM Modules, Events Execution within Sample Time, Encoder Peripheral and Operating Principle of Incremental Encoders, Hardware Details, Speed Computation, Debugging Tools, Processor- in-the-loop with Simulink	10
5	Advance Motion Control: Applications Case Studies: Basic Hardware and their configurations (Half Bridge, Full Bridge) and their control implementations, Modulation strategies (Unipolar and Bipolar voltage switching), Low-Side Shunt Current Sensing, Sensor Characterization. • Open Loop Control of a single phase/three phase Inverter feeding	8

	resistive load(s) with Unipolar and Bipolar SPWM modulations • Open Loop Control of a Permanent Magnet DC Motor, Linear Model of a PMDC Motor, System Simulations • Current Control of an RL and RLC Loads- Study on the transient response • Voltage and Current control of Non-isolated DC-DC converters	
	C&I 546: Professional Software (LabVIEW/Real Time Simulation/OrCAD/ /KiCad/Proteus etc)	
	C&I 548: Real Time simulation (OPAL-RT) Evolve from introductory to advanced model simulations using power electronics schematics (designed with MATLAB/Simulink®, PLECS®, PSIM® or NI MULTISIM®) in RT-LAB to run your most innovative HIL tests and validations. Battery management system and battery simulation, power electronics converters, electric motors, power grid connected HIL simulation, supervisory control and data acquisition systems, high-level control and low-level control for microgrid, renewable, sun, wind, battery, energy storage and other. OR other Professional Software.	

Suggested Readings:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication
1.	Hamid A. Toliyat and Steven Campbell, DSP-based electromechanical motion control, CRC press	2019
2.	M. Rossi, N. Toscani, M. Mauri and F. C. Dezza, Introduction to Microcontroller Programming for Power Electronics Control Applications: Coding with MATLAB and Simulink	2021
3.	Rulph Chassaing and Donald Reay, Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, John Wiley and Sons.	2010

Course Code	Course Name	Cr	L	T	P	PRE
C&I 601	Motion Control of Electrical Motors	4	3	0	2	-

Course Objectives

To equip students with in-depth knowledge of electric drive systems, their modeling, control strategies, and performance optimization using power electronic converters for various motor types

Course Outcomes

CO1 To Investigate dynamics of electrical drives, their nature and classification, applying concepts of steady-state stability

CO2 To Analyze chopper fed DC drive and to evaluate closed-loop control of dc motor drive

CO3 To Analyze induction motor equivalent circuit and torque-speed characteristics.

CO4 To Analyze PWM drives for induction motor.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**3**	**1**	**1**
CO2	**2**	**2**	**2**
CO3	**2**	**3**	**3**
CO4	**1**	**2**	**1**

Course Contents

S.No	Contents	Hrs.
1.	Introduction-Components of electrical Drives – electric machines, power converter, dynamics of electric drive - torque equation - equivalent values of drive parameters, four-quadrant operation of a motor – steady state stability.	6
2.	DC motor drives – dc motors & their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging –Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited & series motor with 1-phase and 3-phase converters – dual converter –analysis of chopper controlled dc drives – converter ratings and closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers and their response comparison.	12
3.	Induction motor drives – stator voltage control of induction motor – torque-slip characteristics – operation with different types of loads – operation with unbalanced source voltages and single phasing – analysis of induction motor fed from non-sinusoidal voltage supply – stator frequency control – variable frequency operation – V/F control, controlled current and controlled slip operation – effect of harmonics and control of harmonics.	10
4.	PWM inverter drives for Induction Motors – multi quadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque	8

	operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation	
5.	Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor.	4

Suggested Readings:

S.	**Name of Authors/ Books/Publishers**	**Year of Publication**
1	Ion Boldea I., S. A. Nasar, Electric Drives, CRC Press,	2006
2	G. K. Dubey, Fundamentals of Electrical Drives, CRC Press	2002
3	Ramu Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall	2001

Syllabus of Departmental Elective Courses

Course Code	Course Name	Cr	L	T	P	PRE
C&I 511	SCADA and Its Applications	4	3	1	0	-

Course Objectives

This course aims students to understand and analyze the SCADA, RTUs, IED, VDU, production control and training simulators.

Course Outcomes

CO1 To understand the concept of SCADA.

CO2 To analyze converters, RTUs, IED and VDU.

CO3 To describe structure of SCADA system.

CO4 To analyze production control and training simulators.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**2**	**2**
CO3	**2**	**3**	**3**
CO4	**3**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Evolution of SCADA, SCADA Architecture, SCADA components (MTU, RTU, Communication system, Field devices), Communication technologies, communication networks, Message format, IEEE C.37, Error detection and correction, Transmission media for SCADA	10
2.	RTU Components, Data Acquisition, Data Processing, Data Monitoring, Time Tagged Data, Alarms and Event Processing, Regulatory Functions, Intelligent Electronics Devices (IED), PLC, Transducers, Voltage to current/ current to voltage converters. Operator Interface, VDU Displays and its Uses, Alarms and their Treatment at MTU	10
3.	Process Configuration in MTU (Pipe line system, Transmission system etc) Master Station Performance, Reliability, Typical SCADA Configuration, Database Management System, Real Time Operational Requirements. OSI seven-layer model, TCP/IP model, Ethernet, CSMA/CD, SMTP, HTTP, Field bus protocol, DNP3, Modbus -ASCII/ RTU, Profibus-DP/AP, CAN, IEC- 61850, security aspects	10
4.	Overview of Power System, General hierarchical structure of power system. Generation, Transmission and Distribution Functions performed at the centralized management system, Regional Grid in India- overview, Real time network modeling, Security management, Production control, Training simulator	10

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1.	Stuart A. Boyer, "SCADA: Supervisory Control and Data Acquisition", ISA Publisher	2010
2.	Torsen Cegrell, "Power System Control Technology", Prentice- Hall	1986
3.	Behrouz A. Forouzan, "Data Communication and Networking", Mc- Graw Hill	2007
4.	Krishna Kant , "Computer based Industrial Control", PHI, 2004	2004
5.	George L. Kusic, "Computer Aided Power System Analysis", CRC Press	1986
6.	Mini S. Thomas, John D.McDonald, "Power System SCADA and Smart Grids",CRC Press	2015
7.	Terry Bartelt, "Industrial Control Electronics: Devices, Systems and Applications", Delmar, Thomson Learning	2002

Course ode	Course Name	Cr	L	T	P	PRE
C&I 513	Controller Design for Power Electronic Converters	4	3	0	2	-

Course Objectives

To develop expertise in modeling, analyzing, and designing control strategies for DC-DC converters, ensuring stability, efficiency, and performance in power electronics applications.

Course Outcomes (COs)

CO1 To understand the architecture and small-signal modeling of DC-DC converters, students will learn AC equivalent circuit modeling, perturbation, linearization techniques, and state-space averaging methods

CO2 To develop and analyze converter transfer functions, they will master circuit averaging, average circuit modeling, and the development of canonical circuit models, including modeling of pulse width modulators

CO3 To design compensators for voltage controllers in both non-isolated and isolated DC- DC converters, students will study stability analysis and PID control methods, considering converter types such as Buck, Boost, Buck-Boost, Cuk, Sepic, Flyback, Forward, and Full Bridge.

CO4 To design compensators for current controllers and implementation of digital control for Buck, Boost and Buck Boost converters

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**2**	**1**
CO3	**3**	**3**	**3**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Architecture of DC-DC Converters, Small Signal Modelling of basic electrical circuits, AC equivalent Circuit Modelling, Perturbation and Linearization, State Space Averaging techniques	6
2.	Circuit Averaging and Average Circuit Modelling, Modelling of Pulse Width Modulator. Converter Transfer Functions, Bode Plot of converter transfer functions	6
3.	Compensator Design for Voltage Controller for Non-Isolated DC-DC Converters (Buck, Boost, Cuk etc), Compensator Design for Voltage Controller for Isolated DC-DC Converters (Flyback, Forward and Full Bridge), Stability Analysis and PID Control.	10

4.	Compensator Design for Current Controller for Non-Isolated DC-DC Converters (Buck, Boost, Cuk etc), Compensator Design for Current Controller for Isolated DC-DC Converters (Flyback, Forward, Full Bridge), Stability Analysis and PID Control.	10
5.	Digital Control of Converters: Fixed and variable frequency digital control architectures, Digitization of Voltage mode control of Buck converter with feedback control Loop, Current Mode Controller for Buck , Boost DC- DC Converter, Design of Voltage Controllers, Implementation of Digital Control through DSPs and HIL.	8

Suggested Readings:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Robert W. Erickson, Dragan Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 1997.	1997
2.	Ned Mohan, Tore. M. Undeland, William. P. Robbins, Power Electronics – Converter, Application and Design, John Wiley & Sons, 2003.	2003
3.	M. K. Kazimierczuk, Pulse-Width Modulated DC-DC Power Converters, John Wiley & Sons. 2015.	2015
4.	Slotine J.J.E, W. Li, Applied Non-Linear Control, Prentice Hall Inc., 1991.	1991
5.	V. Ramanarayanan, Asif Sabanovich, Slobodan Cuk, Thesis- Sliding Mode Control of Power Converters, 1989.	1989

Course Code	Course Name	Cr	L	T	P	PRE
C&I 515	Machine Learning	4	3	1	0	-

Course Objectives

To develop students with the knowledge and understanding of optimization, decision tree learning, support vector machines and k means clustering algorithm in machine learning.

Course Outcomes (COs)

CO1 To study model selection, concept learning and inductive learning hypothesis for Machine Learning

CO2 To understand Performance Optimization for Machine Learning

CO3 To study Linear Classification, Decision tree learning ,Support Vector Machines techniques in Machine Learning

CO4 To study K-means clustering algorithm in machine learning

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**1**	**2**	**2**
CO3	**3**	**3**	**3**
CO4	**2**	**2**	**2**

Course Contents

S.No.	Contents	Contact hours
1.	Introduction: Well-posed learning problems, examples of machine learning applications, model selection and generalization, concept learning, inductive learning hypothesis, inductive bias. Information theory: entropy, mutual information, KL divergence	6
2.	Performance Optimization: Directional Derivatives, Minima, Necessary Conditions for Optimality, Convex function, Gradient Descent, Stable learning rates, Newtons Method, Conjugate gradient method, The Levenberg-Marquardt algorithm.	6
3.	Linear Classification: Linear classifier, Logistic Regression, Decision Boundary, Cost Function Optimization, Multi-class Classification, Bias and Variance, L1 and L2 Regularization, feature reduction, Principal Component Analysis, Singular Value Decomposition	6
4.	Decision tree learning: Decision tree representation, appropriate problems for decision tree learning, hypothesis space search in decision tree learning, inductive bias in tree learning, avoiding overfitting the data, alternative measures for selecting attribute values, ensemble	8

	methods, bagging, boosting, random forest	
5.	Support Vector Machines: Computational learning theory, probably approximately correct (PAC) learning, sample complexity and VC dimension, linear SVM, soft margin SVM, kernel functions, nonlinear SVM, Multiclass classification using SVM, Support vector regression.	8
6.	Instance based learning: K-nearest neighbor learning, distance weighted neighbor learning, locally weighted regression, adaptive nearest neighbor methods, The Concept of Unsupervised Learning, Competition networks, K-means clustering algorithm.	6

Course Contents

Suggested Readings:

S.No.	Name of Authors/Book/Publisher	Year of Publication
1.	T. Mitchell, Machine Learning, McGraw Hill	1997
2.	Christopher Bishop, Pattern Recognition and Machine Learning, Springer	2006
3.	K. Murphy. Machine Learning: A probabilistic perspective, MIT Press	2012
4.	Hastie, Tibshirani, Friedman, Elements of statistical learning, Springer	2011
5.	I. Goodfellow, Y. Bengio and A. Courville. Deep Learning. MIT Press	2016
6.	Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: AnIntroduction, MIT Press	2018

Course Code	Course Name	Cr	L	T	P	PRE
C&I 517	Soft Computing Techniques	4	3	1	0	-

Course Objectives

This course aims to provide comprehensive understanding of neural networks, basic concepts of GA, BFA, Jaya algorithm, support vector machine classifier and deep learning.

Course Outcomes (COs)

CO1 To understand the neural network and its various architectures.

CO2 To analyze the basic concept of genetic algorithm, BFA, Jaya algorithm etc. along with its typical control problem

CO3 To analyze the support vector machine classifier

CO4 To implement the deep learning, LSTM and recurrent neural networks.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**1**
CO2	**2**	**3**	**3**
CO3	**2**	**2**	**2**
CO4	**1**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to neural network, multilayer perceptron, radial basis function networks, self-organizing map, Elman networks, Jordan networks etc., Applications of neural network on control system benchmark systems/functions.	10
2.	Basic concept of Genetic algorithm and detailed algorithmic steps. Solution of typical control problems using genetic algorithm. Concept of some other search techniques like tabu search, ant-colony search, bacterial foraging algorithm (BFA), firefly Algorithm, jaya algorithm etc. Applications of these algorithms on control system benchmark systems/functions.	12
3.	Support Vector Machine, SVM Classifier, Objectives, function and characteristics of SVM. Advantages and Disadvantages of SVM	8
4.	Deep Learning, Convolutional Neural Network, Long Short Term Memory networks, Architecture & Recurrent Neural Network.	10

Suggested Readings:

1.	D.K Pratihar, "Soft Computing Techniques", First Edition, Alpha Publications	2013

2.	Jacek M. Zuarda, “Introduction to Artificial Neural Systems “, Jaico Publishing House	1997
3.	Sudarshan K. Valluru, T.N Rao, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, First Edition, Jaico Publishing House	2010
4.	G.J. Klir & T.A. Folger, “Fuzzy sets, uncertainty and information”, First Edition, Prentice-Hall of India	1988
5.	H.J. Zimmerman, “Fuzzy set theory-and its Applications”, Fourth Edition, Kluwer Academic Publishers	2001
6.	Driankov, Hellendron, “Introduction to Fuzzy Control”, Second Edition, Narosa Publishers	1996

Course Code	Course Name	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
C&I 519	Power Quality	4	3	1	0	25	-	25	50	-

Course Objectives

To develop students with the knowledge and understanding of nonlinear and unbalanced loads, non-sinusoidal conditions and DSTATCOM configuration for power quality improvement.

Course Outcomes (COs)

CO1 To classify power quality issues

CO2 To analyses Nonlinear and unbalanced loads, DC offset, noting, disturbance etc

CO3 To describe influence of non-sinusoidal conditions and analyse periodic steady state and time domain method

CO4 To study DSTATCOM configurations for power quality improvement

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**1**	**2**	**1**
CO3	**2**	**2**	**1**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Overview of Power Quality: Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves, Power quality problems, Poor load power factor, Non- linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage, power quality standards. Single phase static and rotating AC/DC converters, Three phase static AC-DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, Pulse modulated devices.	9
2.	Measurement and Analysis Methods: Voltage, Current, Power and Energy measurements, power factor measurement and definitions, event recorders, Measurement Error – Analysis, Analysis in the periodic steady state, Time domain method, Frequency domain methods: Laplace, Fourier and Hartley transform, The Walsh transform, Wavelet Transform.	9

3.	Analysis and Conventional Mitigation Methods: Analysis of Power outages, Analysis of unbalance: Symmetrical components of phasor quantities, instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion : On – line extraction of fundamental sequence components for measured samples, Harmonic indices, Analysis of voltage sag: Detorit Edition sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of Voltage flicker, Reduced duration, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.	12
4.	Power Quality Improvement: Utility- Customer interface-Harmonic filter: passive, Active and hybrid filter – Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC-Control strategies- Q theory, modified P-Q theory, Synchronous detection method–custom power park – status of an application of power devices.	9

Suggested Readings:

S.NO	Name of Authors/Books/Publishers	Year of Publication
1.	Arindam Ghosh, Power Quality Enhancement Using Custom Power Devices, Kluwer Acadamic Publishers	2002
2.	G. T. Heydt., Electric Power Quality, Stars in a Circle Publications, 2nd Edition	1994
3.	J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment, John Wiley & sons, New York	2000
4.	Math H. J. Bollen, Understanding Power quality problems, IEEE Press, New York	1999
5.	E. Acha, Manuel Madrigal, Power system Harmonics, John Wiley & sons, New York	2001
6.	Moreno – Murioz (Ed), Power Quality (Mitigation Technologies in Distribution Environment) Springer, 2007	2007

Course Code	Course Name	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
C&I 520	Control System for Electric Vehicles	4	3	0	2	15	25	20	40	-

Course Outcomes (COs)	
CO1	To understand control architecture and modeling in Electric vehicle
CO2	To analyze on board chargers
CO3	To design, model and control of drives for Electric Vehicle
CO4	To analyze Stability aspects of control systems for Electric Vehicles

CO-PO Articulation matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**2**	**2**
CO3	**2**	**3**	**3**
CO4	**3**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to System modelling: Importance of control system in Electrical vehicle, Study of control architecture in Electric vehicle, Systems models and their classifications, principles used in modelling of systems, Fundamental studies of Modelling of vehicle dynamics and control, Longitudinal Vehicle dynamics, Vertical Dynamics model and Lateral vehicle dynamics model, Integrated Vehicle Dynamics.	10
2	On-board Chargers: Review of semiconductor devices; turn-on and turn-off characteristics; loss computation in semiconductor devices; basics of nonisolated/isolated DC-DC and grid connected converters; classification of EV chargers; modelling and control of bi-directional DC-DC converters; discussions on V2X applications.	10
3	Induction Motor Drives: Basics of induction motor; open-loop v/f control; basics of DC-AC power converters; basic pulse width modulation techniques; vector control of IM drives; advanced control techniques, Basics of magnetic circuits and principle of reluctance; basics of switched reluctance motor; modelling and control of switched reluctance motor; modelling and control of PMSM drive.	10
4	Model based control approach for Electric Vehicle: Introduction to P, PI & PID Controller, and Internal Model Control (IMC) Design, Stability definition in the sense of Lyapunov, Vehicle stability analysis. Applications of control techniques in Traction control, Vehicle Control, Electric power steering control.	10

Suggested Readings:

S.NO	Name of Authors/Books/Publishers	Year of Publication
1.	Rajesh Rajamani, Vehicle Dynamics and Control, Springer, 2006	2006
2.	Uwe Kiencke and Lars Nielsen, Automotive Control Systems For Engine, Driveline, and Vehicle, Springer, 2005	2005
3.	Ali Emadi, Mehrdad Ehsani, John M. Miller, Vehicular Electric Power Systems: Land, Sea, Air and Space Vehicles, Marcel Dekker, 2004	2004
4.	Lino Guzzella, Antonio Sciarretta, Vehicle Propulsion Systems, Springer, 2007	2007

Course Code	Course Name	Cr	L	T	P	PRE
C&I 522	Advanced Control System Design	4	3	1	0	-

Course Objectives

This course aims to provide comprehensive understanding of reduced order observer, optimal control, robust control, slide mode control, model reference control and adaptive control .

Course Outcomes (COs)

CO1 To describe pulse transfer function.

CO2 To analyze processors, mechanization of control algorithms, PID control.

CO3 To derive solution of optimal control problem using Ricatti equation.

CO4 To analyze sliding mode control, robust control, model reference and adaptive control.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**1**	**1**
CO3	**3**	**2**	**3**
CO4	**3**	**3**	**3**

S.No	Contents	Hrs.
1.	Review of sample and hold devices, Reconstruction, Z transform – Properties – Pulse transfer function and state variable approach – Review of controllability and observability	10
2.	Pole placement design. Full order observer, Reduced order observer. Computer Based Control, Mechanization of control algorithms – PID control, tuning methods of PID controller	8
3.	Optimal Controller Design, Statement of optimal control problem- Solution using variational approach- Ricatti equation- -Infinite time problems, Linear regulator Problem, ARE equation, dynamic programming.	10
4.	Introduction to robust control, Slide mode control, H ∞ and H-2 control, Model reference control and Adaptive control, Applications in Robotic systems, Slide mode control, Model reference control and Adaptive control.	12

Suggested Readings:

1.	Gopal. M., "Digital control Engineering", Wiley Eastern Ltd	1988
2.	G.F. Franklin, J.David Powell, Michael Workman, "Digital control of Dynamic Systems", 3rd Edition, Addison Wesley	1998
3.	Paul Katz, "Digital control using Microprocessors", Prentice Hall	1981
4.	Forsytheand. W. Goodall. R.N., "Digital Control", McMillan	1991
5.	Nagrath I.J. and Gopal M., "Control Systems Engineering", New Age International Publisher	2007

Course Code	Course Name	Cr	L	T	P	PRE
C&I 524	Design of Fractional Order Systems	4	3	1	0	-

Course Objectives

To develop students with the knowledge of factional order control, analog circuit implementation, fractional order PID control and fractional order lead lag compensators.

Course Outcomes (COs)

CO1 To describe fundamentals of fractional order control.

CO2 To design analog circuit implementation of fractional order circuit elements.

CO3 To. Implement fractional order PID control on nonlinear systems.

CO4 To implement tuning of first order plus delay time plants and fractional order lead lag compensators.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**2**	**2**
CO3	**3**	**2**	**3**
CO4	**2**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Fundamentals of fractional order systems, different methods for approximating the fractional operator, analog circuit implementation of fractional order circuit elements. Fractional order analog circuits and filters of different types	12
2.	Fundamentals of fractional order control, fractional-order PID controllers	8
3.	Tuning of first-order plus delay time plants, fractional-order PD controller tuning for motion systems	8
4.	Tuning of fractional-order lead-lag compensators, Auto-tuning of Fractional-order Lead-lag Compensators. Applications of fractional order PID control on robotic systems and power electronic converters.	12

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Publication
1	C.A. Monje , Y. Chen, B.M. Vinagre, D. Xue, V. Feliu-Batlle, "Fractional-order Systems and Controls", Springer	2010
2	A. Tepljakov, "Fractional-order Modeling and Control of Dynamic Systems" Springer	2017
3	D.E. Kirk, "Optimal Control Theory: An Introduction", First Edition, Dover Publications Inc.	2004
4	M. Athans and P.L. Falb, "Optimal Control: An Introduction to the Theory and its Applications", Third Edition, McGraw-Hill.	2007
5	A.P. Sage, and C.C. White, III, "Optimum System Control", Second Edition, Prentice-Hall, Englewood Cliffs	2001

Course Code	Course Name	Cr	L	T	P	PRE
C&I 526	Robot Dynamics & Control	4	3	1	0	-

Course Objectives

To develop students with the understanding of robot arm direct, inverse kinematics and dynamics, implementation of path planning and nonlinear decoupled feedback control.

Course Outcomes (COs)

CO1 To describe robot arm direct and inverse kinematics.

CO2 To describe robot arm dynamics.

CO3 To implement path planning of Robot manipulators.

CO4 To analyse nonlinear decoupled feedback control.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**1**	**1**	**1**
CO3	**2**	**3**	**3**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Introduction, Geometric configuration of robots. Robot arm Kinematics: Direct and inverse kinematics – Rotation Matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configuration	12
2.	Robot Arm Dynamics, Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion equations – Generalised D'Alembert equations of motion	10
3.	Planning of Manipulator Trajectories, General consideration on trajectory planning joint interpolation & Cartesian path trajectories	8
4.	Control of Robot Manipulators, PID control computed torque technique – Near minimum time control – variable structure control – Non- linear decoupled feedback control – Resolved motion control and adaptive control	10

Suggested Readings:

S.No	Name of Authors/ Books/Publishers	Year of Pub.
1.	Fu, K.S. Gonazlez, R.C. and Lee, C.S.G., "Robotics (Control, Sensing, Vision and Intelligence)", First Edition, McGraw-Hill, 1987	1987

2.	Wesley, E. Snyder, "Industrial Robots: Computer interfacing and Control", First Edition, PHI, 1985	1985
3.	Asada and Slotine, "Robot Analysis and Control", First Edition, John Wiley and Son, 1986	1986
4.	Philippe Coiffet, "Robot Technology" Vol. II (Modelling and Control), First Edition, Prentice Hall INC, 1983	1983
5.	Groover M.P. Mitchell Wesis., "Industrial Robotics Technology Programming and Applications", First Edition,Tata McGraw-Hill, 1986	1986
6.	Groover M.P. Mitchell Wesis., "Industrial Robotics Technology Programming and Applications", First Edition,Tata McGraw-Hill, 1986	1986

Course Code	Course Name	Cr	L	T	P	PRE
C&I 528	Random Processes and Stochastic Control & Estimation	4	3	1	0	-

Course Objectives

To develop students with the knowledge and understanding of Weiner's theory, Gauss Markov model, Kalman filtering, power spectral density function and prediction problems.

Course Objectives

CO1 To describe random variable and processes along with estimation and applications of Weiner's theory.

CO2 To analyze the Gauss Markov model and Kalman filtering in non-linear systems.

CO3 To analyze correlation functions and describe power spectral density function.

CO4 To analyze filtering and prediction problems.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**1**
CO2	**2**	**2**	**3**
CO3	**2**	**3**	**3**
CO4	**3**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Random variables and processes, Weiner's theory of optimization. Basic concepts of estimation and various types of estimates, applications of Weiner's theory of compensator design for feedback control system	10
2.	Gauss-Markov model for vector random Processes, Kalman filtering, minimum variance Introduction, Statement of optimal control problem-Problem formulation and forms of optimal control-Selection of performance measures	12
3.	Stochastic Processes and their properties, Probability density functions. Moments Ergodic hypothesis and ensemble averages, correlation functions and power spectral density functions	10
4.	M.S.E. minimization, Filtering and prediction problems, Wiener-Hopf equation, Frequency domain system design	8

Suggested Readings:

S.No	Name of Authors/Books/Publishers	Year of Publication
1.	D.E. Kirk, "Optimal Control Theory: An Introduction", First Edition, Dover Publications Inc.	2004
2.	A.P. Sage, "Optimum System Control", Second Edition, Prentice Hall	1997
3.	BD.O. Anderson and J.B. Moore, "Optimal Filtering", Second Edition, Dover Publications	2005
4.	S.M. Bozic, "Digital and Kalman Filtering", First Edition, Edward Arnould, London	1979
5.	K.J. Astrom, "Introduction to Stochastic Control Theory", 56.52 Edition, Academic Press	2006

Course Code	Course Name	Cr	L	T	P	PRE
C&I 530	Control for Photovoltaic and Wind Energy Systems	4	3	0	2	-

Course Objectives

To develop a comprehensive understanding of photovoltaic (PV) and wind power systems , Wind electrical systems, MPPT, DC-DC converters for solar PV systems, PMSM and DFIG for wind generators.

Course Outcomes (COs)

CO1 To understand and analyze solar PV and Wind electrical systems.
CO2 To understand equivalent circuit of PV cell, MPPT and DC-DC converters for solar PV systems.
CO3 To analyze and implement wind energy systems, grid requirement for wind, PMSM and DFIG for wind generators.
CO4 To analyze Grid connected wind and solar energy conversion systems.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**3**	**3**	**3**
CO3	**2**	**3**	**3**
CO4	**2**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Introduction: Potential of renewable energies in India's future Power generation, Solar PV, wind electrical systems –control strategy , operating area, operating principles and characteristics.	**6**
2.	Solar Energy-Introduction to Solar Energy: Solar radiation, availability, measurement and estimation, Solar thermal conversion devices and storage, solar cells, solar cell interconnection, Solar cell characteristics and Photovoltaic Conversion, PV systems – analysis of PV systems- MPPT - Applications of PV Systems – solar energy collectors and storages, power electronics in solar energy utilization, DC-DC converters for solar PV systems, Grid requirement for PV, Control techniques, MPPT, Grid connected and Islanding mode, Grid synchronization, battery charging in PV systems.	**14**
3.	Wind Energy-Introduction – Basic principles of wind energy conversion system– Nature of wind – site selection consideration, basic components of wind electric conversion systems. Wind Turbine characteristics, Grid requirement for Wind, PMSM and DFIG for wind generators, Power electronic converters for PMSM and DFIG, Control techniques, MPPT, Grid connected and Islanding mode. Schemes for electric generations – generator control, load control, energy storage.	**12**
4.	Power Quality Improvement with Renewable Energy Resources: Load	**8**

	compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC-Control strategies- Q theory and modified P-Q theory.	

Text Books/Reference Books:

S.No	Name of Authors/Books/Publishers	Year of Publication
1.	Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, Power Conversion and Control of Wind Energy Systems,IEEE Press	2011
2.	Marian P. Kazmierkowski, R Krishnan and Frede Blaabjerg, Control in Power Electronics", Academic Press	2003
3.	William Shepherd and Li Zhang Power, Power Converter Circuits, Marcel Dekker	2004
4.	Fang Lin Luo, Hong Ye and Muhammad Rashid, Digital Power Electronics and Applications, Academic Press	2005

Course Code	Course Name	Cr	L	T	P	PRE
C&I 532	Electrical Energy Storage Systems	4	3	1	0	-

Course Objectives

To explore various energy storage systems, including batteries, ultracapacitors, fuel cells, and flywheels, along with power electronics for charging control and battery management in electrical vehicles.

Course Outcomes (COs)

CO1 To study and comprehend different types of Battery Technologies

CO2 To understand different types, components and advantages of Ultra-Capacitors and Super-Capacitors

CO3 To analyze different fuel cell technologies

CO4 To design Flywheels and study developments in SMES systems

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**2**	**1**	**1**
CO2	**2**	**2**	**2**
CO3	**2**	**2**	**3**
CO4	**3**	**3**	**3**

S.No	Contents	Hrs.
1.	Battery: Energy Storage Parameters; Lead–Acid Batteries-Constructional Features, Charge– Discharge Cycles, Operating Limits, Maintenance and Sizing, Types, Applications; storage density and safety issues in Lead-Acid, Nickel-Cadmium, Zinc Manganese dioxide batteries, Modern batteries as Zinc-Air, Nickel Hydride, Lithium Battery, Flow Batteries.	8
2.	Ultracapacitors/Supercapacitors: Double-Layer Ultracapacitors, High-Energy Ultracapacitors, Rating, Size & Applications, Supercapacitors - Basic components, Types of electrodes and electrolytes, Comparison with battery systems, applications in public transport vehicles, private vehicles, and consumer electronics; Aspects of energy density and price.	10
3.	Fuel Cell: Fuel cells for direct energy conversion, physical interpretation of the Carnot efficiency factor, electrochemical energy converters, power outputs, maximum intrinsic efficiency of an electrochemical converter. Types of fuel cells: Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, Alkaline fuel cell and Phosphoric fuel cell, Pumped Hydroelectric Energy Storage, Storage Capabilities of Pumped Systems, Compressed Air Energy Storage, Storage Heat.	10
4.	Flywheels: Advanced Performance of Flywheels, Applications of Flywheels, Design Strategies, Superconducting Magnetic Storage System, SMES System Capabilities, Developments in SMES Systems. Power Electronics	12

	For Charging Control -Basic operation and modeling of power electronic devices applied in power transmission and distribution systems for electrical vehicles, analysis and design of power converter circuits such as AC- DC, AC-AC, DC-DC and DC-AC converters; applications of power electronics circuit in electrical vehicles charging.	

Suggested Readings:

S	Name of Authors/Books/Publishers	Year
1.	M. Broussely and G. Pistoia, Eds, Industrial Applications of Batteries: From Cars to Aerospace and Energy Storage, Elsevier, Amsterdam	2007
2.	M. Broussely, G.A. Nazri and G. Pistoia,Eds., Lithium Batteries – Science and Technology, Kluwer Academic Publishers, Boston, USA.	2004
3.	Osaka T., Datta M. , "Energy Storage Systems in Electronics-New Trends in Electrochemical Technology" , CRC Press.	2000
4.	Nazri G. A. and Pistoia G., "Lithium Batteries – Science and Technology", Kluwer Academic Publishers.	2004
5.	Larminie J., Dicks A. and Wiley-Blackwell , "Fuel Cell Systems Explained", 2nd edition.	2003

Course Code	Course Name	Cr	L	T	P	PRE
C&I 534	Analog Filter Design	4	3	1	0	-

Course Objectives

This course aims to provide comprehensive understanding and designing of analog filters, current feedback amplifiers, second order active filters and ladder simulation.

Course Outcomes (COs)

CO1 To describe modern active building blocks of Analog filters.

CO2 To design current feedback amplifiers, OTRAS etc. and first order filters.

CO3 To describe second order active filters.

CO4 To Implement ladder simulation by element replacement.

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**3**	**2**	**2**
CO3	**2**	**2**	**2**
CO4	**3**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to modern active building blocks used in Analog Filters: Current Conveyors, Operational Transconductance Amplifiers, Current Feedback Amplifiers, OTRAs, CDBAs and other modern devices	10
2.	First order filters, Realization with passive elements, realization with active elements, cascaded design	8
3.	Second order active filters, design parameters, the 2nd order circuits, KHN, Bi quads, S & K Biquads, SAB biquads and GIC circuits. LP filters with maximally flat and equal ripple response, inverse chebyshev and cauer filter	10
4.	Frequency transformation: LP-HP, LP-BP, LP-BE, etc. LG, Ladder filters, Ladder Simulation by element replacement, GP embedding technique, FDNR technique, creation of negative components, Gm-C & switched capacitor filters, sensitivity considerations	12

Suggested Readings:

1.	R. Schaumann & M.E. Vanvalkenburg, “Design of Analog Filters”, First Edition, Oxford	2001
2.	Ramu Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall	2001

Course Code	Course Name	Cr	L	T	P	PRE
C&I 536	Intelligent Instrumentation	4	3	0	2	-

Course Objectives

This course aims to provide comprehensive understanding of transducers, Data Acquisition Systems, Microprocessor based instrumentation, Dalhin's method and virtual instrumentation.

Course Outcomes (COs)

CO1 To understand various Transducers and its applications
CO2 To analyse Data Acquisition systems and study Microprocessor Based Instrumentation
CO3 To analyze Dahlin's Method and standard algorithms
CO4 To design and analyze virtual instrumentation

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**2**	**3**	**2**
CO3	**3**	**3**	**3**
CO4	**2**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Transducers & its classifications, Fiber optics sensors, measurement of pressure, temperature, current, voltage, liquid level and strain. Laser for measurement of distance, length, velocity, acceleration, current, voltage, atmospheric effect. Telemetry: General telemetry system, land line & radio frequency telemetering system, transmission channels and media, receiver & transmitter	10
2.	Data Acquisition System: A/D and D/A converters, Analog data acquisition system, digital data acquisition system, modern digital data acquisition system and signal conditioning. Microprocessor Based Instrumentation, Hardware and firmware components of a microprocessor system – micro controllers – multiple processors, calibration and correction, computer interface, embedded programming issues	12
3.	Introduction to Digital Signal Processor (DSP), architecture of F28379D DSP, hardware configuration: analog to digital (ADC) resolution, device pins, digital-to-analog converter (DAC), enhanced pulse width modulator (ePWM) module, timers, ADC overview , operation of the ADC in the DSP , overview of the event manager (EV) , event manager interrupts , general purpose (GP) timers , compare units, capture units and quadrature enclosed pulse (QEP) circuitry , general event manager information.	

4.	Functional models of computer process control systems, RTOS, input-output systems, functions of the computer process control system, techniques for developing physical process models, Position, velocity, dead beat, ringing and Dahlin's algorithms, Optimization/Control of a distillation column	10
5.	Virtual Instrumentation, Block diagram and architecture of the virtual instrumentation. Smart sensors, smart transmitters, process instrumentation diagrams	8

Suggested Readings:

S.NO	**Name of Authors/Books/Publishers**	**Year of Publication**
1.	P W Chapman, "Smart sensors", First Edition, ISA Publications.	1996
2.	John F Ready, "Industrial applications of Lasers", Second Edition, Academic press.	1997
3.	Jasprit Singh, "Semiconductor optoelectronics: Physics and Technology", First Edition, McGraw Hill.	1995
4.	Clyde F. Coombs, "Electronic instrument handbook", Third Edition, McGraw Hill.	1994
5.	Lisa K.Wells & Jeffery Travis, "Lab view for every one", Third Edition, Prentice Hall.	2006
6.	Sokoloff, "Basic concepts of Lab view 4", First Edition, Prentice Hall.	1998
7.	A.K. Sawhney, "Advanced Measurements & Instrumentation", 4th Edition, Dhanpat Rai & Sons.	2010

Course Code	Course Name	Cr	L	T	P	PRE
C&I 538	VLSI Design in Electrical Systems	4	3	0	2	-

Course Objectives

To develop students with the understanding and designing of CMOS integrated circuits, MOSFET scaling, MOS circuits and VLSI design methodologies.

Course Outcomes (COs)

CO1 To learn basics of fabrication and Layout of CMOS integrated circuits
CO2 To understand MOSFET scaling and geometry effects
CO3 To analyze the various MOS circuits and their features
CO4 To design and analyze static and dynamic sequential logic circuit and evaluate timing parameters and implementation of VLSI design methodologies

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**1**	**1**	**1**
CO3	**3**	**3**	**3**
CO4	**2**	**2**	**2**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to VLSI, Manufacturing process of CMOS integrated circuits, CMOS n-well process design rules, packaging integrated circuits, trends in process technology. MOS transistor, Energy band diagram of MOS system, MOS under external bias, derivation of threshold voltage equation, secondary effects in MOSFETS	6
2.	MOSFET scaling and small geometry effects, MOSFET capacitances, Modeling of MOS transistors using SPICE, level I II and equations, capacitance models. The Wire: Interconnect parameters: capacitance, resistance and inductance. Electrical wire models: The ideal wire, the lumped model, the lumped RC model, the distributed RC model, the transmission line model, SPICE wire models.	6
3.	MOS inverters: Resistive load inverter, inverter with n-type MOSFET load, CMOS inverter: Switching Threshold, Noise Margin, Dynamic behavior of CMOS inverter, computing capacitances, propagation delay, Dynamic power consumption, static power consumption, energy, and energy delay product calculations, stick diagram, IC layout design and tools	8
4.	Designing Combinational Logic Gates in MOS and CMOS: MOS logic circuits with depletion MOS load. Static CMOS Design: Complementary CMOS, Ratioed logic, Pass transistor logic, BiCMOS logic, pseudo nMOS logic, Dynamic CMOS logic, clocked CMOS logic, CMOS domino logic, NP domino logic, speed and power dissipation of Dynamic logic, cascading dynamic gates	8
5	Designing sequential logic circuits: Timing matrices for sequential circuits, classification of memory elements, static latches and registers, the bistability principle, multiplexer based latches , Master slave Edge triggered register,	6

	static SR Flipflops, dynamic latches and register, dynamic transmission edge triggered register, the C2MOS register	
6	Pulse Registers, sense amplifier based registers, Pipelining, Latch verses Register based pipelines, NORA-CMOS. Two-phase logic structure; VLSI designing methodology –Introduction, VLSI designs flow, Computer aided design technology. Design Capture and verification tools, Design Hierarchy concept of regularity, Modularity & Locality, VLSI design style, Design quality	6

Suggested Readings:

S.NO	Name of Authors/Books/Publishers	Year of Publication
1.	Digital integrated circuits a design perspective by Jan M Rabaey, Anantha Chadrakasan Borivoje Nikolic, Pearson education	2011
2.	CMOS digital integrated circuits uits by Sung MO Kang Yusuf Leblebici, Tata McGraw Hill Publication	2002
3.	Principle of CMOS VLSI Design by Neil E Weste and Kamran Eshraghian, Pearson education.	2000

Syllabus of Open Elective Course of M.Tech.(C&I)

Course Code	Course Name	Cr	L	T	P	PRE
OEE 601	Electric Vehicle Technology	4	3	1	0	-

Course Objectives

To develop students with the understanding and designing of electric vehicle, simulation of mechanical and electrical systems and V2G and G2V modes and their charging infrastructure.

Course Outcomes (COs)

CO1 To understand control architecture and modeling in Electric vehicle

CO2 To analyze Simulation of Mechanical and Electrical Systems and validation for Electric Vehicle

CO3 To design Model based control approach for Electric Vehicle

CO4 To analyze and design power balance schemes in V2G and G2V modes and their charging infrastructure

CO-PO Articulation Matrix

	PO1	PO2	PO3
CO1	**1**	**1**	**1**
CO2	**1**	**2**	**3**
CO3	**3**	**3**	**2**
CO4	**2**	**3**	**3**

Course Contents

S.No	Contents	Hrs.
1.	Introduction to System modelling: Importance of control system in Electrical vehicle, Study of control architecture in Electric vehicle, Systems models and their classifications, principles used in modelling of systems, Fundamental studies of Modelling of vehicle dynamics and control, Longitudinal Vehicle dynamics, Vertical Dynamics model and Lateral vehicle dynamics model, Integrated Vehicle Dynamics.	10
2.	System simulation and validation: System simulation, advantages and disadvantage, steps in simulation study, Simulation of Mechanical and Electrical Systems, Introduction to modelling and Simulation for Software in loop (SIL) and Hardware in loop (HIL), Study of control architecture.	12
3.	Review of basic power electronics converters and their application in EV/HEV systems; Motor drive inverters, DC-DC converters; Design considerations for high-efficiency and high-power-density converters in vehicle applications. Model based control approach for Electric Vehicle: Introduction to P, PI & PID Controller, and Internal Model Control (IMC)	8

	Design, Introduction to Model based control system design for Electric Vehicle.	
4.	Energy Storage Systems for EVs and HEVs; Lithium-ion battery technology and its characteristics for vehicle propulsion; Battery management systems (BMS), Battery SOC and SOH Estimation, Battery Balancing-Passive and Active. Power Management for Vehicle-to-Grid (V2G) and Grid-to-vehicle (G2V) communication for grid integration and energy sharing Integration with renewable energy, Grid management and demand response and Charging Infrastructure.	10

Suggested Readings:

S.NO	Name of Authors/Books/Publishers	Year of Publication
1.	Rajesh Rajamani, Vehicle Dynamics and Control, Springer, 2006	2006
2.	Uwe Kiencke and Lars Nielsen, Automotive Control Systems For Engine, Driveline, and Vehicle, Springer, 2005	2005
3.	Ali Emadi, Mehrdad Ehsani, John M. Miller, Vehicular Electric Power Systems: Land, Sea, Air and Space Vehicles, Marcel Dekker, 2004	2004
4.	Lino Guzzella, Antonio Sciarretta, Vehicle Propulsion Systems, Springer, 2007	2007