DELHI TECHNOLOGICAL UNIVERSITY

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

Scheme for Full Time M.Tech. Power Electronics and Systems (PES) as per NEP-2020

SEMESTER I					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES501	Advanced Power Semiconductor Devices and Magnetics	4	3-0-2	24	500-599*
PES503	Power Electronics Converters	4	3-0-2		
PES505	Controller Design for Power Electronic Converters	4	3-0-2		
PES507	Electrical Drives and Systems	4	3-0-2		
	Departmental Elective-1 (DEC-1)	4			
PES511	Power Electronics for Photovoltaic and Wind Energy Systems		3-0-2		
PES513	Digital Signal Processing Application to Power Electronics and Systems		3-0-2		
PES515	Distributed Generation Systems		3-1-0		
PES517	Special Electromechanical Systems		3-1-0		
PES519	High/Medium Voltage DC Transmission Systems		3-1-0		
	Self-Study (SS)**	2	-		
PES551	Seminar				
PES553	MOOC#				
	Skill Enhancement Course-1 (SEC-1)***	2			
PES541	PCB Design		0-0-4		
	Audit Course****	0			
UEC501	English for Research Paper Writing		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		
#The subject name of the MOOC course will be printed on the marksheet 'MOOC (XXX).					

SEMESTER II

Code	Type	Cr	L-T-P	Total Credits	Level
PES502	Grid-Connected Power Converter and Systems	4	3-0-2	24	500-599*
PES504	Modulation Schemes for Power Electronics Systems	4	3-0-2		
	Departmental Elective-2 (DEC-2)				
PES520	Non-Linear Control of Power Electronic Converters	4	3-0-2		
PES522	Energy Storage Systems		3-0-2		
PES524	AC and DC Microgrids		3-1-0		
PES526	Modelling and Reliability Analysis of Electrical Energy Conversion Systems		3-1-0		
PES528	Smart Grid and Distribution Automation		3-1-0		
	Departmental Elective-3 (DEC-3)				
PES530	Advance Power Electronics Converters	4	3-0-2		
PES532	Multipulse and Multilevel Converters		3-0-2		
PES534	Wireless Power Transfer		3-0-2		
PES536	Pulse Power Electronics		3-1-0		
PES538	Power Quality		3-1-0		
UCC502	Research Methodology and IPR	4	3-1-0		
	Skill Enhancement Course-2 (SEC-2)*				
PES540	Industrial Training	4	0-0-8		
PES542	Embedded Programing with Microcontrollers for Power Electronics Systems		2-0-4		
PES544	Implementation of Embedded Programing with Microcontrollers for Power Electronics Systems		0-0-8		
NHEQF Level					6.5

SEMESTER III

Code	Type	Cr	L-T-P	Total Credits	Level
PES601	Vehicular Power Electronics	4	3-0-2	16	600-699*
	Open Elective*****				
OEE601	Electric Vehicle Technology	4	3-1-0		
PES603	Minor Project/ Research/Thesis/Patent	8	-		

SEMESTER IV					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES602	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**
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.

*******Open Elective**
Open Elective (OEC): Each department requires to offer one open elective course of interdisciplinary nature. The open elective course offered by the respective department act as an open elective for the students of other departments.

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Scheme for Part Time M.Tech. Power Electronics and Systems (PES) as per NEP-2020

SEMESTER I					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES501	Advanced Power Semiconductor Devices and Magnetics	4	3-0-2	12	500-599*
PES503	Power Electronics Converters	4	3-0-2		
PES505	Controller Design for Power Electronic Converters	4	3-0-2		
SEMESTER II					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES502	Grid-Connected Power Converter and Systems	4	3-0-2	12	500-599*
PES504	Modulation Schemes for Power Electronics Systems	4	3-0-2		
	Departmental Elective-2 (DEC-2)	4			
PES520	Non-Linear Control of Power Electronic Converters		3-0-2		
PES522	Energy Storage Systems		3-0-2		
PES524	AC and DC Microgrids		3-1-0		
PES526	Modelling and Reliability Analysis of Electrical Energy Conversion Systems		3-1-0		
PES528	Smart Grid and Distribution Automation		3-1-0		
NHEQF Level					**6.5**
SEMESTER III					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES507	Electrical Drives and Systems	4	3-0-2	12	500-599*
	Departmental Elective-1 (DEC-1)	4			
PES511	Power Electronics for Photovoltaic and Wind Energy Systems		3-0-2		
PES513	Digital Signal Processing Application to Power Electronics and Systems		3-0-2		
PES515	Distributed Generation Systems		3-1-0		
PES517	Special Electromechanical Systems		3-1-0		
PES519	High/Medium Voltage DC transmission Systems		3-1-0		
	Self-Study**	2	-		

PES551	Seminar				
PES553	MOOC#				
	Skill Enhancement Course-1 (SEC-1)* **	2			
PES541	PCB Design		0-0-4		
	Audit Course******	0			
UEC501	English for Research Paper Writing		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		

#The subject name of the MOOC course will be printed on the marksheet ‘MOOC (XXX).

SEMESTER IV

Code	Type	Cr	L-T-P	Total Credits	Level
	Departmental Elective-3 (DEC-3)			12	500-599*
PES530	Advance Power Electronics Converters	4	3-0-2		
PES532	Multipulse and Multilevel Converters		3-0-2		
PES534	Wireless Power Transfer		3-0-2		
PES536	Pulse Power Electronics		3-1-0		
PES538	Power Quality		3-1-0		
UCC502	Research Methodology and IPR	4	3-1-0		
	Skill Enhancement Course-2 (SEC-2)* **				
PES540	Industrial Training	4	0-0-8		
PES542	Embedded Programing with Microcontrollers for Power Electronics Systems		2-0-4		
PES544	Implementation of Embedded Programing with Microcontrollers for Power Electronics Systems		0-0-8		
	NHEQF Level				6.5

SEMESTER V

Code	Type	Cr	L-T-P	Total Credits	Level
PES601	Vehicular Power Electronics	4	3-0-2	16	600-699*
	Open Elective*******				
OEE601	Electric Vehicle Technology	4	3-1-0		
PES603	Minor Project/ Research/Thesis/Patent	8	-		

SEMESTER VI					
Code	**Type**	**Cr**	**L-T-P**	**Total Credits**	**Level**
PES602	Major Project/ Research Thesis/ Patent	16	-	16	-
NHEQF Level					7.0

***Level**
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****Self Study**
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***** Skill Enhancement Course**
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*******Open Elective**
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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	Minor Project / Research Thesis/ Patent									
14.	16	Major Project/ Research Thesis/ Patent			No	Yes	-	-	-	-	100

Teaching Scheme					**Contact Hours/ Week**			**Exam Duration (h)**		**Relative Weights (%)**				
Sl. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE**	**PRE**
SEMESTER I														
1.	PES501	Advanced Power Semiconductor Devices and Magnetics	CORE	4	3	0	2	3	2	15	25	20	40	-
2.	PES503	Power Electronics Converters	CORE	4	3	0	2	3	2	15	25	20	40	-
3.	PES505	Controller Design for Power Electronic Converters	CORE	4	3	0	2	3	2	15	25	20	40	-
4.	PES507	Electrical Drives and Systems	CORE	4	3	0	2	3	2	15	25	20	40	-
5.	PES511	Power Electronics for Photovoltaic and Wind Energy Systems	DEC-1	4	3	0	2	3	2	15	25	20	40	-
	PES513	Digital Signal Processing Application to Power Electronics and Systems	DEC-1	4	3	0	2	3	2	15	25	20	40	-
	PES515	Distributed Generation Systems	DEC-1	4	3	1	0	3	0	25	-	25	50	-
	PES517	Special Electromechanical Systems	DEC-1	4	3	1	0	3	0	25	-	25	50	-
	PES519	High/Medium Voltage DC transmission Systems	DEC-1	4	3	1	0	3	0	25	-	25	50	-
6.	PES551	Seminar	SS	2	-	-	-	0	2	0	40	-	-	60
	PES553	MOOC	SS	2	-	-	-	-	-	-	-	-	-	-
7.	PES541	PCB Design	SEC-1	2	0	0	4	0	2	-	50	-	-	50

8.	UEC501	English for Research Paper Writing	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC503	Disaster Management	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC505	Sanskrit for Technical Knowledge	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC507	Value Education	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC509	Constitution of India	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC511	Pedagogy Studies	UEC	0	2	0	0	-	-	25	-	25	50	-
	UEC513	Stress Management by Yoga	UEC	0	1	0	2	-	-	15	25	20	40	-
	UEC515	Personality Development through Life Enlightening Skills	UEC	0	2	0	0	-	-	25	-	25	50	-
Total Credits				**24**										

Teaching Scheme					**Contact Hours/ Week**			**Exam Duration (h)**		**Relative Weights (%)**				
Sl. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE**	**PRE**
SEMESTER II														
1.	PES502	Grid-Connected Power Converter and Systems	CORE	4	3	0	2	3	2	15	25	20	40	-
2.	PES504	Modulation Schemes for Power Electronics Systems	CORE	4	3	0	2	3	2	15	25	20	40	-
3.	PES520	Non-Linear Control of Power Electronic Converters	DEC-2	4	3	0	2	3	2	15	25	20	40	-

	PES522	Energy Storage Systems	DEC-2	4	3	0	2	3	2	15	25	20	40	-
	PES524	AC and DC Microgrids	DEC-2	4	3	1	0	3	0	25	-	25	50	-
	PES526	Modelling and Reliability Analysis of Electrical Energy Conversion Systems	DEC-2	4	3	1	0	3	0	25	-	25	50	-
	PES528	Smart Grid and Distribution Automation	DEC-2	4	3	1	0	3	0	25	-	25	50	-
4.	PES530	Advance Power Electronics Converters	DEC-3	4	3	0	2	3	2	15	25	20	40	-
	PES532	Multipulse and Multilevel Converters	DEC-3	4	3	0	2	3	2	15	25	20	40	-
	PES534	Wireless Power Transfer	DEC-3	4	3	0	2	3	2	15	25	20	40	-
	PES536	Pulse Power Electronics	DEC-3	4	3	1	0	3	0	25	-	25	50	-
	PES538	Power Quality	DEC-3	4	3	1	0	3	0	25	-	25	50	-
5.	**UCC502**	Research Methodology and IPR	UEC	4	3	1	0	3	0	25	-	25	50	-
6.	PES540	Industrial Training	SEC-2	4	0	0	8	0	2	-	50	-	-	50
	PES542	Embedded Programing with Microcontrollers for Power Electronics Systems	SEC-2	4	2	0	4	3	2	15	25	20	40	-
	PES544	Practical Implementation of Embedded Programing with Microcontrollers	SEC-2	4	0	0	8	0	2	-	50	-	-	50
Total Credits				**24**										

Teaching Scheme					Contact Hours/ Week			Exam Duration (h)		Relative Weights (%)				
Sl. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE**	**PRE**
SEMESTER III														
1.	PES601	Vehicular Power Electronics	CORE	4	3	0	2	3	2	15	25	20	40	-
2.	OEE601	Electric Vehicle Technology	OEC	4	3	1	0	3	0	25	0	25	50	-
3.	PES603	Minor Project/ Research/Thesis /Patent	CORE	8	-	-	-	-	-	-	40	-	-	60
Total Credits				**16**										

Teaching Scheme					Contact Hours/ Week			Exam Duration (h)		Relative Weights (%)				
Sl. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE**	**PRE**
SEMESTER IV														
1.	PES602	Major Project/ Research/Thesis /Patent	CORE	16	-	-	-	-	-	-	-	-	-	100
Total Credits				**16**										

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	PES501	Advanced Power Semiconductor Devices and Magnetics	PES501	Advanced Power Semiconductor Devices and Magnetics
2	PES505	Power Electronics Converters	PES503	Power Electronics Converters
3	PES507	Controller Design for Power Electronic Converters	PES505	Controller Design for Power Electronic Converters
4	PES509	Electrical Drives and Systems	PES507	Electrical Drives and Systems
5	PES5301	Power Electronics for Photovoltaic and Wind Energy Systems	PES511	Power Electronics for Photovoltaic and Wind Energy Systems
6	PES523	PCB Design	PES541	PCB Design
7	PES525	Self-Study/Seminar	PES551	Seminar
			PES553	MOOC
8	UEC501	English for Research Paper Writing	UEC501	English for Research Paper Writing
	UEC513	Stress Management by Yoga	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	PES502	Grid-Connected Power Converter and Systems	PES502	Grid-Connected Power Converter and Systems
2	PES504	Modulation Schemes for Power Electronics Systems	PES504	Modulation Schemes for Power Electronics Systems
3	PES5302	Non-Linear Control of Power Electronic Converter	PES520	Non-Linear Control of Power Electronic Converters
4	PES5310	Advance Power Electronics Converters	PES530	Advance Power Electronics Converters
5	UCC502	Research Methodology and IPR	UCC502	Research Methodology and IPR
6	PES546	Embedded Programming with Microcontroller for Power Electronics Systems	PES542	Embedded Programing with Microcontrollers for Power Electronics Systems

CORE-1

Advanced Power Semiconductor Devices and Magnetics (PES501)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Advanced Power Semiconductor Devices and Magnetics- PES501	**3**	**0**	**2**	Nil

Course Objective:

To provide a comprehensive understanding of power electronic devices, their switching characteristics, thermal management, and magnetic components, enabling efficient design and application in modern power electronics systems.

Course Outcomes (COs):

CO1: To understand the fundamental principles, switching characteristics, and thermal behavior of power electronic devices.
CO2: To apply the power semiconductor devices in designing efficient power converters and magnetic components.
CO3: To analyze the performance and efficiency of power electronic circuits considering switching losses and thermal constraints.
CO4: To design optimized power electronic circuits integrating appropriate devices, cooling techniques, and magnetics for practical applications.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	2	1	3
CO3	3	1	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction to Power Electronics Devices:** Power Diodes, Basic Structure, I-V and switching characteristics, Reverse Recovery Transients of Power Diodes and Schottky Diodes, Brief of Symmetric and Asymmetric Thyristors, Second Breakdown of Power BJT, Darlington Pair.	**6**
2.	**Power MOSFETs**: Basic Structure, HexFet structure, Punch Through and Non-Punch Through, Trench Gate MOSFET, OptiMOS and CoolMOS MOSFETs, V-I and switching characteristics, Resistive Switching Specifications, Clamped Inductive Switching	**7**

	Specifications, Transient Analysis, Switching Losses, Effect of Reverse Recovery Transients on Switching Stresses and Losses - di/dt and dv/dt limitations, Gating Requirements, FBSOA and RBSOA Curves, Snubber design.	
3.	**Transistors (IGBTs)**: Basic Structure and Operation, Parasitic Diode and Latch up, IGBT Switching Characteristics, Resistive Switching Specifications, Clamped Inductive Switching Specifications, Transient analysis, Current Tail, FBSOA and RBSOA Curves, Switching Losses, Overcurrent and Short Circuit Protection, Snubber Design.	**7**
4.	**Wide Bandgap Semiconductor Devices:** Introduction to wide bandgap materials (SiC, GaN), Advantages over silicon-based devices, SiC diodes and MOSFETs, GaN HEMTs, Applications in high-frequency and high-power scenarios, Gate driver circuit design.	**8**
5	**Thermal Design of Power Electronic Equipment's and Magnetics**: Heat transfer by conduction, transient thermal impedance, heat transfer by radiation and convection, Fin Efficiency, Optimum Fin Spacing, Multiple Fin Array, Thermal Resistance and Surface efficiency, Thermoelectric Effect- Seebeck Effect, Peltier Effect, Figure of Merit, Thermoelectric Generator (TEG), Thermoelectric Coolers (TEC), Heat Exchanger, Heat Sink Selection; **Magnetics:** Fundamentals of Magnetics, Types of Magnetic Materials, Magnetization Processes, Hysteresis Loop, Comparison and Applications of the Core Materials, Ferrite Core Losses with Non- Sinusoidal Voltage Waveforms, Steinmetz Equation, Insulation Requirements and Standards, Self- inductance and Mutual Inductance, Inductor Design, High frequency transformer design.	**14**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Ned Mohan, Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons, 2003.	2003
2.	G. Massobrio, P. Antognetti, Semiconductor Device Modeling with Spice, McGraw-Hill, 2nd Edition, 2010.	2010
3.	B. Jayant Baliga, Power Semiconductor Devices, PWS Publication, 2nd Edition, 2019.	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.	1999
5.	Barry W Williams, Power Electronics: Devices, Drivers, Applications, and Passive Components, McGraw Hill, 1987.	1987
6.	L Umanand and S R Bhat, Design of Magnetic Components for Switched Mode Power Converters, New Age International, 1st Edition, 1992	1992
7.	Ho Sung Lee, Thermal Design: Heat Sinks, Thermoelectrics, Heat Pipes, Compact Heat Exchangers, and Solar Cells, John Wiley & Sons Inc.	2010
8.	Allan D. Kraus, Design and Analysis of Heat Sinks, John Wiley & Sons Inc, 1995	1995

CORE-2

Power Electronics Converters (PES503)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Power Electronics Converters- PES503	**3**	**0**	**2**	Nil

Course Objective:

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

Course Outcomes (COs):

CO1: To understand the principles, operation, and control techniques of AC-DC, DC-AC, AC-AC, and DC-DC converters.
CO2: To analyze the performance, efficiency, and power quality aspects of various power electronic converters.
CO3: To design and implement power converter circuits considering modulation techniques, harmonic reduction, and power factor improvement.
CO4: To evaluate and compare different converter topologies for industrial, renewable energy, and advanced power electronics applications.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		1	-	3
CO2		3	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**AC-DC Converters**: Single phase diode rectifier with and without filter capacitor, Phase control, Single phase Semi converter & fully controlled converter, Three phase rectifier with and without capacitor filter, Three phase semi controlled & fully controlled converters with passive load impedance, twelve pulse converter, Power factor improvement methods, effect of source inductance, Pulse-Width Modulation (PWM) controlled rectifier circuits, design of converter circuits.	**10**
2.	**DC to AC Converters (Inverters):** Principle of operation, performance parameters, single phase half and full bridge inverters and Three-Phase naturally commutated controlled bridge inverter, Three-Phase step wave inverter circuits, Voltage control of single-phase inverters:	**10**

	single/multiple pulse/SPWM, Voltage control of three phase inverter, introduction to Space vector modulation, Harmonic reduction, Current source inverter, Comparison between VSI & CSI. Introduction to multilevel inverters, Diode clamped multilevel inverters; Neutral point clamped multilevel inverters, Flying capacitor multilevel inverters, Applications.	
3.	**AC to AC Converters:** Single and three phase AC voltage controllers, Thyristor controlled reactors (TCR), Static VAr compensator (SVC), Thyristor controlled series capacitor (TCSC), Phase- Controlled Cycloconverters, Matrix Converters.	**7**
4.	**Non-Isolated DC-DC Converters**: Principle of operation, analysis of step-down and step-up converters, classification of PWM choppers, Analysis of two and four quadrant PWM choppers, Cúk and Sépic converters.	**8**
5.	**Isolated DC-DC Converters**: Principle of operation, analysis of step-down and step-up converters, Flyback Converter, Forward Converter, Half Bridge and Full Bridge Converter.	**7**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Ned Mohan, Tore. M. Undeland and William. P Robbins, Power Electronics: Converters, Applications and Design, John Wiley and Sons, 2003.	2003
2.	Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education, 2011.	2011
3.	Marian P. Kazmierkowski, R. Krishnan and Frede Blaabjerg, Control in Power Electronics, Academic Press, 2002.	2002
4.	William Shepherd and Li Zhang Power, Power Converter Circuits, Marcel Dekker Inc., 2004.	2004
5.	Fang Lin Luo, Hong Ye and Muhammad H. Rashid, Digital Power Electronics and Applications, Elsevier (USA), 2005.	2005
6.	Robert W. Erickson, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2001.	2001
7.	Barry W Williams, Power Electronics: Devices, Drivers, Applications, and Passive Components, McGraw Hill.	1992
8.	Marian K. Kazimierczuk, Pulse-width Modulated DC–DC Power Converters, John Wiley & Sons.	2008
9.	Muhammad H. Rashid and Hasan M. Rashid, "SPICE for Power Electronics and Electric Power", CRC Press.	2005

CORE-3

Controller Design for Power Electronic Converters (PES505)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Controller Design for Power Electronic Converters-PES505	3	0	2	Nil

Course Objective:

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 small-signal modeling, state-space averaging, and AC equivalent circuit analysis of DC-DC converters.
CO2: To analyze converter transfer functions, canonical models, and Bode plots for stability assessment.
CO3: To design compensators for voltage and current control in non-isolated and isolated DC-DC converters.
CO4: To evaluate and implement advanced non-linear control techniques for enhanced converter performance.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		1	-	3
CO2		3	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Architecture of DC-DC Converters, Small Signal Modelling of basic electrical circuits, AC equivalent Circuit Modelling, Perturbation and Linearization, State Space Averaging techniques	**10**
2.	Circuit Averaging and Average Circuit Modelling, Development of Canonical Circuit Model, Modelling of Pulse Width Modulator.	**7**
3.	Converter Transfer Functions, Bode Plot of converter transfer functions.	**5**
4.	Compensator Design for Voltage Controller and Current Controller for Non-Isolated DC-DC Converters (Buck, Boost, Buck- Boost, Cuk, Sepic), Compensator Design for Voltage Controller and Current Controller for Isolated DC-DC Converters (Flyback, Forward, Full	**12**

	Bridge), Stability Analysis, PID Controller	
5.	Non-Linear Control of Non-Isolated Converter- Adaptive Control, Tracking Control, Sliding Mode Control.	**8**

Suggested Books:

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

CORE-4

Electrical Drives and Systems (PES507)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Electrical Drives and Systems- PES507	**3**	**0**	**2**	Nil

Course Objective:

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 (COs):

CO1: To understand the fundamentals of electric drives, load dynamics, and energy conversion principles.
CO2: To analyze the modeling, transient behavior, and control techniques of DC, induction, synchronous, and switched reluctance motor drives.
CO3: To design control strategies for speed, torque, and position regulation using power electronics and feedback techniques.
CO4: To evaluate and implement sensor-based and sensorless control techniques for high-performance motor drive applications.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction-** Energy Conversion in Electric Drives, Electric drives – an overview, Motor/mechanical load matching, Load dynamics and stability, Multi-quadrant operation, Electric drives configurations, Electric motors for drives; Power Electronic Converters for Drives.	**4**
2.	**DC Motor Drives:** Basic topologies, Performance equations- d-q model, Steady state motor characteristics, Transient operation for constant flux, P.M. brush motor transients, Transient operation for variable flux, Controlled Rectifier Fed D.C. Brush Motor Drives, Chopper-Controlled D.C. Brush Motor Drives, Closed Loop Motion Control in Electric Drives, Including Torque loop, Speed loop, Digital position control, State-space motion control,	**10**

	Torque perturbation observers.	
3.	**Induction Motor Drives:** The stator and its travelling field, the inductance matrix, phase coordinate model, space phasor model, space phasor diagram for electrical transients, Electrical transients with flux linkages as variables, Complex Eigen values for electrical transients, Electrical transients for constant rotor flux, Motoring, generating, braking, Speed control methods, Vector control -general flux orientation, General current decoupling, Parameter detuning effects in rotor flux orientation current decoupling, Direct versus indirect vector current decoupling, A.C. versus D.C. current controllers, Voltage decoupling, Voltage and current limitations for the torque and speed control range, Impressing voltage and currents through PWM, Switching state voltage vectors, Indirect vector A.C. current control, Flux observers for direct vector control with motion sensors, Indirect vector synchronous current control with speed sensor - a case study, Flux and speed observers in sensor less drives: Performance criteria, A classification of speed observers, Speed estimators, Rotor slots ripple speed estimators, Direct torque and flux control (DTFC), Feedback linearized control.	**12**
4.	**Synchronous Motor Drives:** Phase coordinate model, space phasor(d-q) model, PM-SM drives, Rectangular current control(Brushless D.C. motor drives), Rectangular current control system, Extending the torque - speed domain, Vector control, Optimum id-iq relationships, The indirect vector current control, Indirect voltage and current vector control, Fast response PM-SM drives, surface PM rotor motors with predictive control, Direct torque and flux control (DTFC) of PM-SMs, The stator flux and torque observer, Sensorless control of PM-SMs, Initial rotor position detection, Reluctance synchronous motor (RSM) drives.	**12**
5.	**Switched Reluctance Motor (SRM) Drives:** Construction and functional aspects, Average torque and energy conversion ratio, The peak kW/kVA ratio, commutation windings, SRM modelling, The flux- current-position curve fitting, SRM drives, Drive with position sensor, High grade (servo) drives, Sensor less SRM drives, the voltage -current model-based position - speed observer.	**4**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Ion Boldea I., S. A. Nasar, Electric Drives, CRC Press, 2006.	2006
2.	G. K. Dubey, Fundamentals of Electrical Drives, CRC Press, 2002.	2002
3.	Ramu Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, 2001	2001

CORE-5

Grid-Connected Power Converter and Systems (PES502)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Grid-Connected Power Converter and Systems- PES502	3	0	2	PES503

Course Objective:

To develop expertise in grid-connected converters, synchronization techniques, islanding detection, control strategies, and fault management for reliable renewable energy grid integration.

Course Outcomes (COs):

CO1: To understand grid-connected inverter structures, international grid codes, and synchronization techniques.
CO2: To analyze islanding detection methods, grid converter control, and power quality requirements.
CO3: To design control strategies for power, voltage, and frequency regulation in grid-tied converters.
CO4: To evaluate and implement advanced control techniques for grid-connected converters under fault conditions.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Grid Connected Converters**: The grid connected converter-key element in the grid integration of Wind Turbine (WT) and Photovoltaic (PV) system, Grid Connected Inverter Structures, Inverter structure derived from H-bridge topology, full bridge inverter, H5 inverter (SMA), HERIC inverter, REFU inverter, Inverter NPC Topology, neutral point clamped (NPC) half-bridge inverter, H-bridge based boost PV inverter with high frequency transformer, PV String Inverters, Three phase PV inverters.	6
2.	**Grid Connectivity Requirement and Synchronization :** International regulations, IEEE 1547, IEC 61727, VDC 0126-1-1, IEC 61000, EN 50160, voltage quality, Response to abnormal Grid condition and resynchronization, Power quality, current harmonics, average power factor; Anti-islanding requirements and standards: IEEE 1547/UL 1741, IEC 6211 and VED 0126-1-1; Grid synchronization techniques for single phase systems, Grid	8

	synchronization using Fourier Analysis, phase-locked loop, Phase Detection based on in-quadrature signals, signal generation, Adaptive filters, etc. Synchronous reference frame PLL under unbalanced grid conditions, Decoupled Double synchronous Reference Frame PLL(DDSRF-PLL), Double Second- order Generalized integration PLL(DSOGI-PLL) and structure of the DSOGI.	
3.	Islanding Detection, Non detection Zone, Passive islanding detection methods, OUF-OUV Detection, Phase jump detection(PJD), Harmonic detection (HD), Passive method evolution, Active islanding detection methods, Frequency Drift Methods, Voltage Drift Methods, Grid Impedance Estimation, PLL-Based Islanding Detention, Comparison of active Islanding Detection Methods,	**6**
4.	**Grid Converter Structures and Control:** Power configurations, Grid Power Converter Topologies, single- cell (VSC–CSC), Multicell, Grid control, Active power Control Under Normal Operation, Power curtailment, Frequency control, Reactive power control, Discussion of Harmonization of Grid Code, local voltage control, inertia emulation(IE), Power oscillation damping(POD), L- filter and LCL-filter inverter, AC and DC Voltage Control, DC Link Voltage Management, PQ Open-Loop control, synchronous frame and stationary frame VOC, Virtual flux based control, Direct Power Control, Linear current control, Modulation Techniques, single phase, Operating limits of controllers, Virtual Inertia, Virtual synchronous machines, Battery energy storage system, Bi-directional converters, storage system for inertia support.	**12**
5.	**Control of Grid Converters under Grid Fault:** Overview of Control Techniques for grid connected converter under Unbalance Grid voltage Conditions, Control structures for Unbalanced Current Injection, Power control under unbalanced grid conditions, instantaneous active reactive control (IARC), Positive and negative sequence control (PNSC), Average active-reactive control (AARC), balanced positive control (BPSC), Flexible positive and negative sequence control (FPNSC), Flexible Power control with current limitation, locus of the current vector under unbalanced grid conditions.	**10**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Frede Blaabjerg, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.	2011
2.	Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, John Wiley & Sons, 2010.	2010
3.	R. Strzelecki and G. Benysek, Power Electronics in Smart Electrical Energy Networks, Springer, 2008.	2008
4.	Amirnaser Yazdani and Reza Iravani, Voltage Source Converters in Power systems: Modeling, Control, and Applications, John Wiley and Sons, 2010.	2010

CORE-6

Modulation Schemes for Power Electronics Systems (PES504)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Modulation Schemes for Power Electronics Systems- PES504	**3**	**0**	**2**	PES503

Course Objective:

To develop expertise in power electronic converter modulation techniques, analyze PWM strategies, and design advanced modulation schemes for efficient and optimized converter operation.

Course Outcomes (COs):

CO1: To understand the fundamental principles of power electronic converters and pulse-width modulation (PWM) techniques.
CO2: To analyze modulation strategies for voltage source inverters, space vector modulation (SVM), and their impact on harmonic performance.
CO3: To design and implement modulation techniques for multilevel converters, including harmonic optimization and overmodulation strategies.
CO4: To evaluate advanced PWM techniques, including random PWM, SVM, and common-mode elimination, for improved converter performance.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction to Power Electronic Converters:** Basic Converter Topologies; Switch Constraints; Bidirectional Converters; Switching Function representation of Converters; Output Voltage Control and Phase Shift Modulation; Concept of a Space Vector Modulation; Multilevel Inverter Topologies; Hybrid Voltage Source Inverter. Fundamental Concepts of PWM; Evaluation of PWM Schemes; Double Fourier Integral Analysis of Two-Level Pulse Width Modulated Waveform; Sine-Triangle Modulation; PWM Analysis by Duty Cycle Variation; Sine-Sawtooth Modulation; Direct Modulation.	**10**

2.	**Modulation of Voltage Source Inverters:** Three-Level Modulation of a Single-Phase Inverter; Sideband Modulation; Switched Pulse Position; Continuous Modulation; Discontinuous PWM- Single-Phase Leg Switched; Two-Level Single-Phase PWM. Three-Phase Modulation with Sinusoidal References; Third-Harmonic Reference Injection; Optimum Injection Level; Analytical Solution for Third- Harmonic Injection; Harmonic Losses; Discontinuous Modulation Strategies; Triplen Carrier Ratios and Subharmonics.	**9**
3.	**Space Vector Placement Modulation Strategies and Overmodulation**: SVM Compared to Regular Sampled PWM; Phase Leg References for SVM; Naturally Sampled SVM; Harmonic Losses; Placement of the Zero Space Vector; Discontinuous Modulation: 120°, 60° & 30° Discontinuous Modulation; Phase Leg References for Discontinuous PWM; Comparison of Harmonic Performance, Overmodulation Region; Naturally Sampled Overmodulation of One Phase Leg of Inverter; Naturally Sampled Overmodulation of Single and Three-Phase Inverters	**9**
4.	**Modulation of Multilevel Converters:** Multilevel Converter Alternatives; PWM of Cascaded Single- Phase H-bridges; Overmodulation of Cascaded H-Bridges; PWM Alternatives for Diode- Clamped Multilevel Inverters; PD PWM, APOD or POD PWM for Three-Level Naturally Sampled; Overmodulation of Three-Level Inverters; PD PWM, APOD PWM, POD PWM for Higher Level Inverters.	**8**
5.	**Advance Topics in Modulation** Random Pulse Width Modulation; PWM Rectifier with Voltage Unbalance; Common Mode Elimination; Four Phase Leg Inverter Modulation; Effect of Minimum Pulse Width Modulation; PWM Dead-Time Compensation.	**6**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	D. Grahame Holmes and Thomas A. Lipo, Pulse Width Modulation for Power Converters, John Wiley & Sons. 2003.	2003
2.	Euzeli dos Santos and Edison R. da Silva, Advanced Power Electronics Converters: PWM Converters Processing AC Voltages, Wiley-IEEE Press 2014.	2014
3.	Eric Monmasson, Power Electronic Converters: PWM Strategies and Current Control Techniques, John Wiley & Sons, 2011.	2011
4.	Ned Mohan Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons., 2012.	2012
5.	Marian K. Kazimierczuk, Pulse-width Modulated DC–DC Power Converters, John Wiley & Sons	2008

CORE-7

Vehicular Power Electronics (PES601)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Vehicular Power Electronics– PES601	**3**	**0**	**2**	PES503

Course Objective:

To develop a comprehensive understanding of electric and hybrid vehicle architectures, vehicle dynamics, power electronics, energy storage systems, and charging infrastructure for efficient and sustainable transportation solutions.

Course Outcomes (COs):

CO1: To understand electric and hybrid vehicle architectures, their components, and operational characteristics.
CO2: To analyze vehicle dynamics, powertrain efficiency, and regenerative braking strategies.
CO3: To design power electronic converters and battery management systems for electric and hybrid vehicles.
CO4: To evaluate charging infrastructure, energy storage technologies, and vehicle-to-grid (V2G) integration.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction**: Electric and Hybrid Vehicles; Comparison of conventional vehicles with electric and hybrid vehicles; Overview of electric and hybrid vehicle architectures: Hybrid Electric Vehicle, Plug-In Hybrid, Series Hybrid, Parallel Hybrid, Series and Parallel Hybrid.	**4**
2.	**Vehicle Dynamics:** Longitudinal Vehicle Model, Longitudinal Resistance: Aerodynamic Drag, Grading Resistance, Rolling Resistance; Total Tractive Force; Maximum Tractive Effort and Powertrain Tractive Effort; Vehicle Performance: Maximum Speed of a Vehicle, Gradeability, Acceleration Performance; Braking Performance and Distribution: Braking Force, Braking Characteristics of a Two-Axle Vehicle; Vehicle Power Plant and Transmission Characteristics; Regenerative Braking, Time and Stopping Distance, Regenerative Braking Integrated with Conventional Hydraulic System.	**12**

3.	**Power Electronics Converters**: 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.	**6**
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, Capacity Estimation Based on SOC and Response Surface, Remaining Useful Life Prediction of Lithium-Ion Batteries, Battery Balancing-Passive and Active.	**10**
5.	**Charging Infrastructure and Power Management:** Charger Classification and Standards: AC Charging Systems, DC Charging Systems; Charger Requirements; Topology Selection for Level 1 and 2 AC Chargers; Topology Selection for Level 3 Chargers; Wireless Chargers: Inductive Charging, Resonant Inductive; EV Charging Protocols: Basic Concepts, Definitions and importance of protocols, SAE J1772, Combined Charging System (CCS), Specifications and variants (CCS1, CCS2), CHAdeMO, Tesla Supercharger. 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.	**10**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
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

DEPARTMENTAL ELECTIVE-1

Power Electronics for Photovoltaic and Wind Energy Systems (PES511)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Power Electronics for Photovoltaic and Wind Energy Systems- PES511	3	0	2	Nil

Course Objective:

To develop a comprehensive understanding of photovoltaic (PV) and wind power systems, power electronics interfaces, grid integration, energy management, and economic considerations for renewable energy applications.

Course Outcomes (COs):

CO1: To understand the fundamental principles, technologies, and performance characteristics of PV and wind power systems.
CO2: To analyze power electronics interfaces, grid synchronization, and power quality challenges in renewable energy integration.
CO3: To design standalone and grid-connected renewable energy systems with appropriate control strategies.
CO4: To evaluate energy management, storage solutions, and economic viability of renewable energy projects.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Photovoltaic (PV) Power:** PV Cell Technologies: Single-Crystalline Silicon, Polycrystalline and Semi- crystalline, Thin Films, Amorphous Silicon, Spheral, Organic, Concentrated Cells; Module and Array; Building Integrated PV Systems (BIPV); PV Energy Maps. Equivalent electrical circuit of PV cell and Array, Open Circuit Voltage and Short Circuit Current, i-v and p-v Curves, Sun Angle, Shadow Effect, Temperature Effect, Effect of Climate, Electrical Load Matching, Sun Tracking; Peak Power Point Operation, PV System Components.	12
2.	**Wind Power System:** System Components, Yaw Control, Speed Control, Turbine Rating, Electrical Load Matching, Variable-Speed Operation, System Design Features, Constant Tip-Speed Ratio and Peak Power Tracking Scheme for Maximum Power Operation, Variable-	8

	Speed Wind-Power System Based on Doubly- Fed Asynchronous Machines, DC-Bus Voltage Regulation by Controlled DC-Voltage Power, Environmental Aspects	
3.	**Power Electronics**: Voltage Source Converters (VSC), Voltage and Current control, PWM techniques, Parallel operation of VSCs, Grid Interface Controls - Voltage & Frequency Control, Battery Charge/Discharge Converters, Power Shunts, Voltage Current and Power Relations Component, Design for Maximum Efficiency, Static and Dynamic Bus Impedance, Voltage Regulation and Ripple, Harmonics, Power Quality and its problems, Renewable Capacity Limit, Systems Stiffness, Interfacing Standards.	**10**
4.	**Stand-Alone and Grid Connected PV and Wind Energy System**: Hybrid with Diesel and Fuel Cell, Mode Controller, Load Sharing, System Sizing, Grid-Connected System-Interface Requirements, Synchronizing with Grid, Inrush Current, Synchronous Operation, Load Transients, Safety, Operating Limit, Voltage Regulation, Stability Limit, Energy Storage and Load Scheduling, Utility Resource Planning, Wind Energy Converters (WEC) Types, Power Curves of WECs, Grid Integration, Reactive Power Management in Wind Parks, Power Quality on WECs, Offshore Wind Energy, Wind Park Design, Transmission Types,	**7**
5.	**Energy Management**, Storage and Communication, Grid-connected Applications, Plant Economy, Energy Delivery Factor, Initial Capital Cost, Availability and Maintenance, Energy Cost Estimates, Sensitivity Analysis, Effect of Wind Speed Variations, Effect of Tower Height, Profitability Index, Wind Farm Screening Chart, PV Park Screening Chart, Stand-Alone PV Versus Grid Line, Hybrid Economics.	**5**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
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

DEPARTMENTAL ELECTIVE-1

Digital Signal Processing Application to Power Electronics and Systems (PES513)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Digital Signal Processing Application to Power Electronics and Systems- PES513	3	0	2	Nil

Course Objective:

To equip students with expertise in digital control techniques for power electronics, covering signal processing, DSP-based control implementations, and real-time applications in power converters and motor drives.

Course Outcomes (COs):

CO1: To understand digital control circuits, signal conditioning, and discretization techniques for power electronics systems.
CO2: To analyze digital filtering techniques, DSP architectures, and real-time processing for power electronic applications.
CO3: To design and implement DSP-based control strategies for power converters and motor drives.
CO4: To evaluate DSP-based advanced control methods for efficient power electronics system operation.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	1	-	3
CO2	3	1	3
CO3	3	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Digital Control Circuits for Power Electronics Systems, Causal and Non-causal Digital Circuits, LTI Discrete-Time Circuits, Real-Time Control Systems, Sampling Rate, Simultaneous Sampling, Multirate Control Circuits, Signal Conditioning and Discretization.	**6**
2.	Analog Input, Galvanic Isolation, Common Mode, Isolation Amplifiers, Current Measurements and Sensing Techniques, Selected Parameters of Digital Control, Sampling of Analog Signal, Synchronization of Sampling Process, Maximum Signal Frequency Versus Signal Acquisition Time, Amplitude and Phase Errors of Sequential Sampling A/D Conversion, Signal Quantization, Dynamic Range of Signal, Propagation of Quantization Noise.	**6**

3.	Digital Filters and their Specifications, FIR Digital Filter, IIR Digital Filters, Design of Digital IIR Filters, Linear-Phase IIR Filters, Multirate Circuits, Signal Interpolation, Signal Decimation, DFT Filter Bank, Sliding DFT Algorithm, Sliding Goertzel Algorithm, Moving DFT Algorithm, Implementation of Digital Signal Processing Algorithms.	**8**
4.	Introduction to the DSP Controller and Peripherals, Types of Physical Memory, Software Tools, C2xx DSP CPU and Instruction Set, Core and Code Generation, Mapping External Devices to the C2xx Core and the Peripheral, System Configuration Registers, Memory, Memory Addressing Modes, brief on Assembly Programming Using the C2xx DSP Instruction Set. General Purpose Input/Output (GPIO) Functionality, Pin Multiplexing (MUX), Multiplexing and General Purpose I/O Control Registers, Using the General Purpose I/O Ports, Interrupts on the C2xx DSP, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software, Analog-to-Digital Converter (ADC), Event Managers (EVA, EVB), Event Manager Interrupts, General Purpose (GP) Timers, Compare Units, Capture Units and Quadrature Encoded Pulse (QEP) Circuitry, PWM Signal Generation.	**12**
5.	DSP-Based Implementation of DC-DC Buck-Boost Converters, Controlling the Buck-Boost Converter, Code Description, Interrupt Service Routine, The Regulation Code Sequences, DSP-Based Control of Stepper Motors, Subroutine of Speed Control Module, DSP-Based Control of Permanent Magnet Brushless DC Machines, BLDC Motor Control System, Implementation of the BLDC Motor Control, Clarke's and Park's Transformations, their implementation, Field Oriented Control (FOC) Transformations, Space Vector Pulse Width Modulation, Constant V/Hz Control for Induction Motor control, DSP-Based Control of Permanent Magnet Synchronous Machines, Implementation of Field-Oriented Speed Control of Induction Motor, Algorithm for Running SRM Drive using an Optical Encoder, DSP-Based Control of Matrix Converters using Venturini Algorithm.	**10**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Oppenheim and Schafer, Digital Signal Processing, Prentice Hall.	2010
2.	Hamid A. Toliyat and Steven Campbell, DSP-based electromechanical motion control, CRC press	2004
3.	M. Rossi, N. Toscani, M. Mauri and F. C. Dezza,, Introduction to Microcontroller Programming for Power Electronics Control Applications: Coding with MATLAB and Simulink	2022
4.	Rulph Chassaing and Donald Reay, Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, John Wiley and Sons.	2008
5.	Samuel Stearns, Digital Signal Processing with examples in MATLAB, CRC Press	2002

DEPARTMENTAL ELECTIVE-1

Distributed Generation Systems (PES515)

Course Title and Course Code	Course Structure			Prerequisite
	L	T	P	
Distributed Generation Systems- PES515	**3**	**1**	**0**	Nil

Course Objective:

To develop a comprehensive understanding of distributed generation, renewable energy sources, variable speed generators, and integration of alternative energy systems into the grid for sustainable power generation.

Course Outcomes (COs):

CO1: To understand the principles of distributed generation, energy planning, and economic aspects of renewable energy systems.
CO2: To analyze wind, photovoltaic, and fuel cell power generation systems, their characteristics, and performance.
CO3: To design and implement control strategies for variable speed generators and grid-connected renewable energy sources.
CO4: To evaluate the integration of multiple alternative energy sources and power converters for grid injection.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		1	-	3
CO2		3	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Distributed Generation:** Purpose of Distributed Generation, Sizing and Siting, Demand-Side Management, Optimal Location of Distributed Energy Sources; Alternative Sources of Energy, Planning and Development of Integrated Energy, Grid-Supplied Electricity, Load Distributed Generation, Calculation of Electricity Generation Costs, Sustainability, Modern Electronic Controls of Power Systems	**6**
2.	**Wind Power and Photovoltaic Plants:** Appropriate Location; Evaluation of Wind Intensity; General Classification of Wind Turbines; System TARP–WARP; Generators and Speed Control Used in Wind Power Energy; Photovoltaic Power: Electricity Generation by Photovoltaic Effect, Solar Cell Output Characteristics and equivalent model, Applications of	**14**

	Photovoltaic Solar Energy - Residential and Public, Economical Analysis of Solar Energy.	
3.	**Power Plants with Fuel Cell:** Fuel Cell Commercial Technologies and practical Issues for Generation of Electricity, Stacking Low- and High Temperature Fuel Cells, Constructional Features of various fuel cells: Proton Exchange Membrane Fuel Cells and Solid Oxide Fuel Cells, Advantages and Disadvantages, Equivalent Circuit of Fuel Cell, Aspects of Hydrogen as Fuel Future Perspectives; Fuel from Biomass, Factors Affecting Bio-digestion, Characteristics of Biodigesters, Construction of Biodigester, Generation of Electricity Using Biogas.	**9**
4.	**Variable Speed Generators:** Principles of Operation; Representation of Steady-Operation; Power and Losses Generated in Self-Excited Induction Generator; Frequency, Speed, and Voltage Controls; Load Control Versus Source Control for Induction Generators; The Danish Concept; Variable-Speed Grid Connection Control by the Load Versus Control by the Source, Economical Aspects.	**8**
5.	**Integration of Alternative Sources of Energy:** Principles of Power Injection Converting Technologies; Power Converters for Power Injection into the Grid; Active and Reactive Power Control Approach; Integration of Multiple Renewable Energy Sources; DG Control and Power Injection.	**5**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Gary L. Johnson, Wind Energy Systems, Prentice Hall, 1985.	1985
2.	Thomas Ackermann, Wind Power in Power Systems, John Wiley & Sons, Ltd, 2012.	2012
3.	Stefan C.W. Krauter, Solar Electric Power Generation, Photovoltaic Energy Systems, Springer, 2006.	2006
4.	Ion Boldea, Variable Speed Generators, CRC Press, 2nd Edition, 2015.	2015

DEPARTMENTAL ELECTIVE-1
Special Electromechanical Systems (PES517)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Special Electromechanical Systems-PES517	**3**	**1**	**0**	Nil

Course Objective:

To provide in-depth knowledge of various generator systems, including wound rotor, self-excited, switched reluctance, permanent magnet synchronous, and linear motion alternators, with a focus on modeling, control, and grid integration.

Course Outcomes (COs):

CO1: To understand the principles, modeling, and operation of different generator types, including wound rotor and self-excited induction generators.
CO2: To analyze the performance characteristics, control techniques, and power electronics interfaces of advanced alternator systems.
CO3: To design and implement control strategies for various generator topologies in standalone and grid-connected applications.
CO4: To evaluate the efficiency, stability, and integration challenges of modern generator technologies in real-world applications.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		1	-	3
CO2		3	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Wound Rotor and Self-Excited Induction Generators:** Equivalent Circuit, Phasor Diagrams, Operation at the Power Grid, Operation at Zero Slip, Autonomous Operation, Brushless Exciter Mode, Self-Excited Induction Generators**,** Steady-State Performance, Second-Order Slip Equation Methods, SEIGs with Series Capacitance Compensation, Performance Sensitivity Analysis, For Constant Speed and Unregulated Prime Movers, Pole Changing SEIGs, Unbalanced Operation of Three-Phase SEIGs, Transients, Parallel Connection, Stator Converter Controlled Induction Generators (SCIGs), Grid Connected SCIGs, Grid Connection and Four-Quadrant Operation of SCIGs, Stand-Alone Operation,	**12**

	Parallel Operation, Operation with DC Voltage Controlled Output, Dual Stator Winding for Grid.	
2.	**Induction Starter/Alternators (ISAs), Permanent-Magnet-Assisted Reluctance Synchronous Starter/Alternators (PM-RSM) for HeVs :** Essential Specifications, Topology Aspects, Space-Phasor Model and Characteristics, Vector Control, DTFC, Design Issues for Variable Speed, Measures for Wide Constant Power Range, PM-RSM, Topologies, Flux Distribution, d–q Model of PM-RSM, Steady-State Operation at No Load and Symmetric Short-Circuit Generator, Design Aspects for Wide Speed Range Constant Power Operation, Power Electronics for PM-RSM, Control of PM-RSM, State Observer for Motion Sensorless Control, Initial and Low Speed Rotor Position Tracking.	**8**
3.	**Switched Reluctance Generator System:** Practical Topologies and Principles of Operation, The kW/Peak kVA Ratio, SRG Modeling, The Flux/Current/Position Curves, Design Issues, Motor and Generator Specifications, Converters for SRGs, Control of SRG, Rotor Position and Speed Observers for Motion-Sensorless Control, Standstill Position Estimation,	**6**
4.	**Permanent Magnet Synchronous Generator System:** Practical Configurations and their Characterization, Distributed vs. Concentrated Windings, Airgap Field Distribution, The d–q Model of PMSG, Circuit Model of PMSG with Shunt Capacitors and AC Load, Utilization of Third Harmonic, Autonomous PMSGs with Controlled Constant Speed, Grid-Connected Variable-Speed PMSG System, The PM Genset with Multiple Outputs, Super-High-Speed PM Generators, Power Electronics Control Issues, Methods for Testing PMSGs, Medium-Power Vehicular Electric Generator Systems. Transverse Flux and Flux Reversal Permanent Magnet Generator Systems**,** Flux Reversal Generator (FRG) Control.	**8**
5.	**Linear Motion Alternators (LMAs):** Introduction, LMA Principle of Operation, The Motion Equation, PM-LMA with Coil Mover, Multipole LMA with Coil Plus Iron Mover, PM-Mover LMAs, The Tubular Homopolar PM Mover Single-Coil LMA, The Flux Reversal LMA with Mover PM Flux Concentration, PM-LMAs with Iron Mover, The Flux Reversal PM-LMA Tubular Configuration, The Analytical Model, Control of PM-LMAs, Electrical Control, The Spark-Ignited Gasoline Linear Engine Model, Note on Stirling Engine LMA Stability, Progressive-Motion LMAs for Maglevs with Active Guideway, Magneto hydrodynamic (MHD) Linear Generators, Super Conducting Machines.	**8**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Ion Boldea, Variable Speed Generators, CRC Press, 2nd Edition, 2015.	2015
2.	Fitzerald, Kinglay, Umans, Electrical Machniary, Tata Mc Graw Hill, 2004	2004
3.	Rakosh Das Begamudre, Electro Mechanical Energy Conversation with Dynamics of Machines, New Age International, 2003.	2003
4.	Hughes, A., Electric Motors and Drives, Newnes, 1994.	1994
5.	Leonhard, W., Control of Electrical Drives, Springer-Verlag, Berlin Heidelberg New York, Tokyo, 2 Edition, 1990.	1990

DEPARTMENTAL ELECTIVE-1

High/Medium Voltage DC Transmission Systems (PES519)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
High/Medium Voltage DC transmission Systems- PES519	**3**	**1**	**0**	Nil

Course Objective:

To explore flexible power grids, HVDC transmission technologies, converter control mechanisms, and advanced developments for efficient power transfer and system stability.

Course Outcomes (COs):

CO1: To explain the fundamentals of HVDC transmission and its comparison with AC transmission systems.
CO2: To analyze the operation and control strategies of Line-Commutated (CSC) and Voltage Source (VSC) converters.
CO3: To evaluate the impact of distributed generation and deregulation on HVDC system performance.
CO4: To design solutions for harmonic filtering, voltage regulation, and system stability in multi-terminal HVDC networks.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	3	1	2
CO2	1	3	2
CO3	2	2	3
CO4	3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction:** A more Flexible Power Grid, Power Electronics Control, Thyristor-Based CSC Transmission, VSC Transmission, Multi-terminal HVDC, Comparison of AC and DC Transmission Lines, The Impact of Distributed Generation, The Effect of Electricity Deregulation; HVDC Transmission Systems.	**8**
2.	**HVDC Conversion:** Basic CSC Operating Principles, Effect of Delaying the Firing Instant, The Commutation Process: Analysis of the Commutation Circuit, Power Factor and Reactive Power, Characteristic Harmonics, Multi-Pulse Conversion, DC Ripple Re-injection, Uncharacteristic Harmonics and Interharmonics, Control System Imperfections, Firing Asymmetry, Magnification of Low- Order Harmonics, Harmonic Reduction by Filters;	**12**

	Voltage Source Conversion, VSC Operating Principles, Converter Components, Comparison of LCC and VSC, Analysis of the CSC Waveforms, The Re-injection Concept with Self-Commutation, Application to VSC, Application to CSC.	
3.	**Line-Commutated CSC Transmission and their developments in Line Commutated HVDC schemes:** Line-Commutated CSC Transmission, The Line-Commutated HVDC Converter, Structure of the HVDC Link, DC System Configurations, Control and Operation, AC–DC System Interactions, Voltage Interaction, Dynamic Voltage Regulation, Dynamic Stabilisation of AC Systems, Controlled Damping of DC - Interconnected Systems, Damping of Sub-Synchronous Resonances, Active and Reactive Power Coordination, Transient Stabilisation of AC Systems, AC–DC–AC Frequency Interactions, DC Link Response to External Disturbances: Response to AC System Faults, Response to DC Line Faults, Reliability of LCC Transmission; Capacitor Commutated Conversion, Tuned AC Filters, Active DC Side Filters, STATCOM-Aided DC Transmission.	**10**
4.	**VSC Transmission, Multi-Level VSC and CSC Transmission:** VSC Transmission, Power Transfer Characteristics: Current Relationships, Structure of the VSC Link: VSC-HVDC Cable Technology, VSC DC System Control, Assistance During Grid Restoration, HVDC Light Technology, Potential for Multi- Terminal Sub-Transmission Systems.	**8**
5.	**Multi-Level VSC Transmission:** Power Flow Considerations, DC Link Control Characteristics, Independent Reactive Power Control, **Multi-Level CSC Transmission.**	**4**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Arrillaga J., Liu Y.H., Watson N.R., Flexible Power Transmission The HVDC Options, John Wiley & Sons, 2007.	2007
2.	Sood Vijay K., HVDC and FACTS Controllers Applications of Static Converters in Power Systems, Kluwer Academic Publishers, 2004.	2004
3.	Kimbark, E.W., Direct Current Transmission, Wiley Interscience, New York, 1971.	1971
4.	Padiyar, K. R., HVDC Power Transmission Systems – Technology and System Interactions, New Delhi-Eastern, 1990.	1990
5.	Adamson, C. and Hingorani, N.G., High Voltage Direct Current Power Transmission, Garraway, London, 1960.	1960

DEPARTMENTAL ELECTIVE-2

Non-Linear Control of Power Electronic Converters (PES520)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Non-Linear Control of Power Electronic Converters-PES520	3	0	2	Nil

Course Objective:

To study nonlinear control techniques for power electronics systems, focusing on sliding mode, model predictive, and adaptive control, with applications in power converters and stability analysis.

Course Outcomes (COs):

CO1: To understand the behavior of nonlinear systems and their dynamics.
CO2: To analyze various nonlinear control techniques, such as tracking control, feedback linearization, and sliding mode control, for power electronics systems.
CO3: To design advanced nonlinear controllers for power electronics applications, ensuring stability and optimal performance.
CO4: To evaluate the effectiveness of nonlinear control techniques in power converter systems and assess their real-time implementation challenges and performance.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Introduction to nonlinear systems and their behavior, Analysis of nonlinear systems using perturbation theory, phase plane trajectories, Describing functions, Lyapunov & Pupov's methods.	6
2.	Nonlinear control design techniques – tracking control, deadband control, passivity-based control, Feedback linearization, input-state and input-output linearization, design issues for MIMO nonlinear systems.	6
3.	Sliding Mode Control (SMC) for Power Electronics Systems: Introduction, Mathematical	8

	Foundations of SMC, Non-linear system behavior, Differential equations, State-space representation, Stability analysis, Lyapunov stability theory, Sliding Surfaces and Dynamics; Design of Sliding Mode Controllers, Integral sliding mode control, Chattering Phenomenon, Adaptive sliding mode control, Sliding Mode Control for Linear Systems, Sliding Mode Control for Non-Linear Systems, Applications of Sliding Mode Control, Digital implementation of SMC.	
4.	Model Predictive Control (MPC) for Power Electronics Systems: Principles of MPC, Formulation of the MPC problem; Constraints handling in MPC, Formulation and implementation of MPC for a Buck, Boost and Buck-Boost converter, Digital Implementation of MPC: Real-time implementation issues, Use of microcontrollers and DSPs for MPC	**10**
5.	Adaptive Control for Power Electronics Systems: Introduction, mathematical foundations, stability theory, Lyapunov stability, parameter estimation techniques such as gradient estimation and recursive least squares; Model Reference Adaptive Control (MRAC) and Self-Tuning Regulators (STR), direct and indirect approaches. Nonlinear control of basic power converters (buck, boost, buck – boost, cûk and sepic converter) like adaptive- (MRAC, self-tuning, gain scheduling control), adaline, tracking control.	**12**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Hassan. K. Khalil, Nonlinear systems, Prentice Hall Inc., 2002	2002
2.	Slotine J.J.E and W. Li, Applied nonlinear control, Prentice Hall Inc., 1991.	1991
3.	Mohler R.R., Nonlinear systems: Dynamics and Control, Prentice Hall Inc., 1991.	1991
4.	Adrian Ioinovici, Power Electronics and Energy Conversion Systems: Fundamentals and Hard- switching Converters, John Wiley & Sons Ltd., 2013.	2013
5.	Marian P. Kazmierkowski, R Krishnan and Frede Blaabjerg, Control in Power Electronics, Academic Press, 2002.	2002
6.	V. Ramanarayanan, Asif Sabanovich and Slobodan CûK, Thesis - Sliding Mode Control of Power Converters, 1989.	1989
7.	Shankar Sastry, Marc Bodson, Adaptive Control- Stability, Convergence and Robustness, Prentice Hall Inc., 2011	2011

DEPARTMENTAL ELECTIVE-2

Energy Storage Systems (PES522)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Energy Storage Systems- PES522	**3**	**0**	**2**	PES503

Course Objective:

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 understand the construction, operation, and performance characteristics of different energy storage systems, such as lead-acid, lithium-ion, and ultracapacitors.
CO2: To analyze the working principles, advantages, and limitations of fuel cells, flywheels, and other energy storage systems like pumped hydroelectric and compressed air storage.
CO3: To design power electronics circuits (AC-DC, DC-DC, etc.) for efficient charging control and battery management systems (BMS) in electric vehicles.
CO4: To evaluate the performance, degradation characteristics, and operational efficiency of different energy storage systems and BMS in electric vehicle applications.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		2	2	3
CO2		3	2	3
CO3		3	3	3
CO4		3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Battery:** Energy Storage Parameters; Lead–Acid Batteries-Constructional Features, Charge–Discharge Cycles, Operating Limits, Maintenance and Sizing, Types, Applications; Performance measurement, storage density, energy density, and safety issues in Lead-Acid, Nickel-Cadmium, Zinc Manganese dioxide batteries, Modern batteries as Zinc-Air, Nickel Hydride, Lithium Battery, Flow Batteries, Lithium-ion Battery:	**10**
2.	**Ultracapacitors/Supercapacitors:** Double-Layer Ultracapacitors, High-Energy Ultracapacitors, Rating, Size & Applications; Supercapacitors - Basic components, Types of electrodes and electrolytes, Advantages and Disadvantages, Comparison with battery	**8**

	systems, applications in public transport vehicles, private vehicles, and consumer electronics; Aspects of energy density, power density, price, and market.	
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; Advantages and Disadvantages	**6**
4.	**Flywheels and Other Storage Systems:** Advanced Performance of Flywheels, Applications of Flywheels, Design Strategies, Superconducting Magnetic Storage System, SMES System Capabilities, Developments in SMES Systems. **Other Storages:** Pumped Hydroelectric Energy Storage, Storage Capabilities of Pumped Systems, Compressed Air Energy Storage, Storage Heat, Energy Storage as an Economic Resource.	**6**
5.	**Power Electronics for Charging Control and Battery Management Systems: -**Basic operation and modeling of power electronic devices applied in power transmission and distribution systems for electrical vehicles, various types of power electronics circuits used in energy processing; 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; Battery Management System, Topology of the BMS, Battery Testing Standards, Electrical Performance Test, AC Impedance Test, Remaining Life Test, Temperature Characteristics, Performance Degradation Characteristics.	**12**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	M. Broussely and G. Pistoia, Eds, Industrial Applications of Batteries: From Cars to Aerospace and Energy Storage, Elsevier, Amsterdam, 2007.	2007
2.	M. Broussely, G.A. Nazri and G. Pistoia,Eds., Lithium Batteries – Science and Technology, Kluwer Academic Publishers, Boston, USA, 2004.	2004
3.	Rui Xiong and Weixiang Shen, Advanced Battery Management Technologies for Electric Vehicles, Wiley Inc	2019
4.	Sandeep Dhameja, Electric Vehicle Battery Systems, Elsevier Publications	2002

DEPARTMENTAL ELECTIVE-2

AC and DC Microgrids (PES524)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
AC and DC Microgrids- PES524	3	1	0	PES503

Course Objective:

To explore microgrid concepts, including AC and DC systems, control techniques, architectures, and market models, focusing on integration of distributed generation and real-world case studies.

Course Outcomes (COs):

CO1: To understand the concept of microgrids, types, and their applications in distributed generation.
CO2: To analyze the differences between AC and DC microgrids, including their advantages, disadvantages, and mathematical models.
CO3: To design architectures and converter topologies for AC microgrids, including power flow control, synchronization, and protection mechanisms.
CO4: To evaluate the control strategies for AC and DC microgrids, including supervisory control, virtual inertia control, and primary-secondary-tertiary control in grid-connected and islanding modes.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	2	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Microgrid Concept as a Means to Integrate Distributed Generation, Status Quo and Outlook of Microgrid Applications, Market Models for Microgrids, Case Study of Microgrid Projects in Europe and USA.	8
2.	Case Study: War of Currents, Types of Microgrids, Mathematical analysis of AC vs DC microgrid system, Advantages and Disadvantages of AC Microgrid, Advantages and Disadvantages of DC Microgrid, Applications of AC and DC Microgrids.	8
3.	Architecture of AC Microgrid, Converter Topologies and Modulation Strategies, AC Microgrid Protection.	8

4.	AC Microgrid Control Issues, Synchronization techniques and power flow control in grid connected mode, Control of VSC in islanding mode, Supervisory Control for AC Microgrid, Virtual Inertia Control.	**10**
5.	Concept of DC Microgrid, Architecture of DC Microgrid, Interfacing Converter for DC Microgrid, Primary-Secondary-Tertiary Control for DC Microgrid.	**8**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Nikos Hatziargyriou, Microgrids: Architectures and Control, IEEE Press, John Wiley & Sons, 2014.	2014
2.	Tomislav Dragicevic, Amjad Anvari - Moghaddam, Juan C. Vasquez, Josep M. Guerrero, DC distribution systems and microgrids, IET, 2018.	2018
3.	Suleiman M. Sharkh, Mohammad A. Abusara, Georgios I. Orfanoudakis, Babar Hussain, Power Electronic Converters for Microgrids, IEEE Press, John Wiley & Sons, 2014.	2014
4.	Rajeev Kumar Chauhan, Francisco Gonzalez-Longatt, Bharat Singh Rajpurohit, Sri Nivas Singh, DC microgrid in residential buildings, IET, 2018	2018

DEPARTMENTAL ELECTIVE-2

Modelling and Reliability Analysis of Electrical Energy Conversion Systems (PES526)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Modelling and Reliability Analysis of Electrical Energy Conversion Systems- PES526	**3**	**1**	**0**	PES503

Course Objective:

To study the modeling, analysis, and reliability of electrical machines, power converters, and power electronics systems, focusing on advanced reference frames, converter designs, and reliability in power electronics.

Course Outcomes (COs):

CO1: To understand the concept of reference frames, electrical network terminology, and their application in the modeling of electrical machines and generalized machine equations.
CO2: To analyze the behavior of three-phase induction and synchronous machines.
CO3: To design static power converters, considering various topologies for different applications.
CO4: To evaluate the reliability of power electronic systems, including power semiconductor modules.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	2	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Reference frames, Electrical network terminology, Mesh networks, Rotating machines in quasi holonomic and nonholonomic reference frame, Generalized machine, Generated voltage, Impedance matrix, Inductance and torque matrix, Flux linkage and flux density matrices, Rotation matrix, Electromagnetic torque, Elimination of axes, Analysis using revolving field theory, Transformation from the stationary to rotating reference frame and vice-versa; Electrical machines in rotating reference frames, voltage equation, torque and inductance matrix in nonholonomic and holonomic reference frames, Impedance matrix of second generalized machine, voltage and torque equation transformation from second generalized machine to first.	**8**
2.	Modelling of three phase Induction machine and synchronous machine in quasi-holonomic	**8**

	and holonomic frames, sequence impedances, Elimination of field and damper winding, torque in salient pole machine, determination of d-q axis reactances, under transients, with and without damper windings; State modelling of Electrical Machines, Voltage and torque equation under acceleration, Motional impedance matrix of generalized machine.	
3.	Analysis of Static Power converters, Modelling of AC-DC PFC and PWM converter, Isolated and Non-isolated DC-DC PWM Converters, Matrix converter and single and three phase PWM inverters (3 ph -3 wire and 3 ph - 4 wire).	**10**
4.	Concept of Reliability in Power Electronic System, Requirement of reliability for power electronic application, Reliability engineering in power electronics, Challenges and opportunities for research on power electronics reliability; Reliability of power electronic packaging, Modelling for the lifetime prediction of power semiconductor modules, Lifetime modelling and prediction of power devices, Reliability of DC-link capacitors in power electronic converters, Minimization of DC-link capacitance in power electronic converter systems.	**8**
5.	Reliability of power conversion systems in photovoltaic applications, Reliability of High-Power Converters, Reliability of power supplies, Faults in Microgrids, Protection Schemes in Microgrids.	**8**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Frede Blaabjerg, Henry Shu-hung Chung, Michael Pecht, Huai Wang, Reliability of Power Electronic Converter System, IET, 2015.	2015
2.	Antonio Carlos Zambroni de Souza, Miguel Castilla, Microgrids design and implementation, Springer, 2019.	2019
3.	A.K. Mukhopadhyay, Matrix Analysis of Electrical Machines, New Age International Pvt. Ltd, 1996.	1996
4.	Paul Krause, Oleg Wasynczuk, Scott Sudhoff and Steven Pekark, Analysis of Electric Machinery and Drive Systems, IEEE Press, John Wiley & Sons, 2013.	2013
5.	William H. Kersting, Distribution System Modeling and Analysis, CRC Press, 2001.	2001
6.	Charles V. Jones, Unified Theory of Electrical Machines, Plenum Press, 1968.	1968

DEPARTMENTAL ELECTIVE-2

Smart Grid and Distribution Automation (PES528)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Smart Grid and Distribution Automation - PES528	3	1	0	PES503

Course Objective:

To explore electrical power systems, microgrids, distributed generation, power quality, protection issues, power electronics interfaces, and communication systems, focusing on grid integration, control, and reliability.

Course Outcomes (COs):

CO1: To understand the structure, principles, and challenges of power systems, microgrids, and distributed generation.
CO2: To analyze the management, protection, and control issues for microgrids, including islanding and load shifting.
CO3: To design power electronic interfaces for microgrid integration, focusing on converters and grid synchronization.
CO4: To evaluate power quality, reliability issues, and control strategies in distributed generation systems.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	2	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction:** Structure and Fundamental Problems of Electrical Power Systems, Principles of Electrical Power Control, Classical Power Theory & Instantaneous Power Theory Power, Distributed Generation and Energy Storage Benefits to Grids, Damping of the System Oscillations, Fully Integrated Power System; Distributed Generation and Microgrid: Active distribution network, Configuration and Interconnection of Microgrids, Technical and economic advantages and challenges, Dynamic interactions of Microgrid, Ride through, Grid Synchronization, Distributed Energy Resources.	8
2.	**Management System and Protection issues for Microgrids:** Network management needs, Micro generation control, Energy storage, Regulation and load shifting, Source controller and	8

	EMS with protection, Demand-side Management; Different islanding scenarios, Protection issues of stand-alone Microgrid, Parallel operation issues and protection requirements, Distribution transformer protection, Under/overvoltage protection, Under/Over frequency protection, Unbalanced loading, Loss of mains protection, Rate of change of frequency.	
3.	**Power Electronic Interfaces:** Overview of Power converter and Controls, PWM Rectifiers, Two level and Multi-level Converters, Neutral Point Clamped Voltage Source Converter (VSC), Space Vector PWM, Z- source Converters, Grid-Imposed Frequency VSC System - Control in αβ & dq-frames, D- STATCOM, Integration and Interconnection Concerns, Voltage and Current Control of a 3-Phase 4 Wire distributed Interface Converters in Islanded Mode.	**8**
4.	**Power Quality and Reliability issues of Distributed Generation (DG):** Power quality disturbances, Existing power quality improvement technologies, Load compensation, Voltage regulation, Harmonic Filtration and Balancing of the Voltage in Three-wire Systems, Dynamic Voltage Restorer, Primary & Secondary DG system with power quality support, Soft grid-connected DG, DG with intermittent solar PV/wind generator, Controllers with Energy-storage Systems.	**10**
5.	**SCADA and Active Distribution Networks:** Existing Distributed Network operator (DNO) SCADA systems and its Control, Requirement of Communication in Microgrids, Distributed control system (DCS), Sub-station communication standardization, smart transformers, Online Condition monitoring, SCADA communication and architecture, Automated Meter Reading, Operational issues of Serial Communication, Broadband Powerline Communication, Optical & Wireless Communication.	**8**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Frede Blaabjerg, Henry Shu-hung Chung, Michael Pecht, Huai Wang, Reliability of Power Electronic Converter System, IET, 2015.	2015
2.	Antonio Carlos Zambroni de Souza, Miguel Castilla, Microgrids design and implementation, Springer, 2019.	2019
3.	A.K. Mukhopadhyay, Matrix Analysis of Electrical Machines, New Age International Pvt. Ltd, 1996.	1996
4.	Paul Krause, Oleg Wasynczuk, Scott Sudhoff and Steven Pekark, Analysis of Electric Machinery and Drive Systems, IEEE Press, John Wiley & Sons, 2013.	2013
5.	William H. Kersting, Distribution System Modeling and Analysis, CRC Press, 2001.	2001
6.	Charles V. Jones, Unified Theory of Electrical Machines, Plenum Press, 1968.	1968

DEPARTMENTAL ELECTIVE-3

Advanced Power Electronics Converters (PES530)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Advanced Power Electronics Converters– PES530	**3**	**0**	**2**	PES503

Course Objective:

This course covers advanced converter topologies, resonant and dual-active bridge converters, impedance source converters, and power electronics applications in high-performance systems.

Course Outcomes (COs):

CO1: To understand isolated and non-isolated converter topologies, resonant converters, and advanced DAB configurations.
CO2: To analyze converter modeling, impedance source converters, and control strategies for high-performance applications.
CO3: To design advanced power converters, including resonant and multilevel impedance source converters.
CO4: To evaluate converter efficiency, power flow control, and system performance under various operating conditions.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		2	1	3
CO2		2	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction:** Basics isolated and non-Isolated converter topologies, advantages and disadvantages, state- space and small signal modeling of the basic converter topology, Introduction to advanced converter topologies such as multilevel converter, resonant converter, dual active bridge, matrix converter, overview of power electronics converters application.	4
2.	**Higher Order Converters and Multiquadrant Operation -** Boost Circuit, Two- Stage, Three-Stage, Higher Stage Boost Circuit, Introduction to double and triple Boost Circuit; Circuit Description, Discontinuous Region, Switched Component Converters, Switched Capacitors DC/DC Converters, Switched Inductor Four-Quadrant DC/DC Converter, Continuous Mode, Discontinuous Mode.	8

3.	**Resonant Converter:** Introduction, need of Resonant Power Converter; Resonant Converter Applications; Overview of Resonant, Quasi-Resonant and Zero-Transition Converter Topologies; Design Considerations Rectifiers: Basics and types of Rectifiers; Current Rectifiers; Voltage Rectifiers; Series / Parallel Resonant Inverters: Introduction, Series Resonant Inverters, Parallel Resonant Inverters, Series-parallel Resonant Inverters; Resonant DC-DC Converters: Series Resonant Converters, Parallel Resonant Converters, Series-Parallel Resonant converters, LLC Converters, Bidirectional CLLC Converters.	**12**
4.	**Dual Active Bridge Converters:** Basic principles and configurations of Dual Active Bridge (DAB) converters; Comparison with other converter topologies; Converter Modeling and Analysis: Small-signal modeling of DAB converters, Analysis of steady-state and transient behavior, Power flow analysis and efficiency optimization techniques; Control Strategies for DAB Converters: Voltage and current control techniques, Phase-shift modulation and its implementation.	**10**
5.	**Impedance Source Converter:** Impedance Source Converter (ISC) Fundamentals: Definition and basic structure of ISCs, Z-source converter, Quasi Z-source converter, Series and parallel impedance source converters, Embedded and switched impedance source converters, Hybrid and Multilevel Impedance Source Converters, Hybrid topologies combining Z-source with other converter types, Multilevel impedance source converters for high power applications.	**8**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Fang Lin Luo & Hong Ye, Advanced DC/DC Converters, CRC Press, 2004.	2004
2.	Ned Mohan Tore. M. Undeland and William. P Robbins, Power Electronics converters, Applications and Design, John Wiley and Sons., 2012.	2012
3.	Robert W. Erickson, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2001.	2001
4.	Marian K. Kazimierczuk, Dariusz Czarkowski, Resonant Power Converters, 2nd Edition, John Wiley & Sons, 2011.	2011
5.	Ivo Barbi , Fabiana Pöttker, "Soft Commutation Isolated DC-DC Converters", Spinger-2019	2019
6.	Deshang Sha, Guo Xu, "High-Frequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain", Springer Nature Singapore, 2018	2018
7.	Guo Xu, Xiaoying Chen,"Topology Deduction and Control for Dual-Active-Bridge Converters", Springer Nature Singapore, 2024	2014

DEPARTMENTAL ELECTIVE-3

Multipulse and Multilevel Converters (PES532)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Multipulse and Multilevel Converters - PES532	3	0	2	PES503

Course Objective:

This course aims to develop a deep understanding of harmonic distortion, multi-pulse methods, transformers, multilevel inverters, and advanced modulation techniques for efficient power conversion.

Course Outcomes (COs):

CO1: To understand fundamental concepts of harmonic distortion, multi-pulse transformers, and modulation schemes.
CO2: To analyze multi-pulse circuit topologies and inverter configurations for performance and harmonic mitigation.
CO3: To design efficient power systems using advanced converters and modulation techniques for industrial applications.
CO4: To evaluate converter configurations and harmonic elimination strategies for optimal power system operation.

CO-PO Articulation Metrix:

Course Outcomes \ Program Outcomes	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	3	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction to Harmonics, Multipulse Methods & Transformer:** Voltage Distortion, Current distortion, Effects Of Negative Sequence Voltages, Effects of pre-existing harmonic Voltages, Different Circuit Topologies, Multipulse Methods, Multipulse Transformer Basics, Determining Phase Shift, Discussion of Vector representation; Doubly-Wound Multiphase transformers: Delta/Wye, Delta Zigzag/Fork, Delta /Polygon (Analysis, polygon Voltages and phase Shift, polygon Winding Currents), Delta/Delta/ Double Polygon, delta/Hexagon, Auto-Wound Transformer, Auto Connected Polygon (Design Analysis, Determination Of Line Input Current, Auto polygon Formulas, Auto-connected Fork, Differential Delta Connection,	8

	Differential fork connection, Delta/Wye With Center Tapped Delta, Transformer Primaries In Series	
2.	**Current-Control Transformer:** Interphase and Current control Transformer, Combining Two Or More Converters, Effects Of Interphase transformer Saturation, Paralleling by an Autotransformer**,** Current- Balancing Transformer (Zero Sequence Effects, ZSBT for 18 Pulses Operation), Harmonic Blocking Current Transformers, Multipulse Circuit Performance, Commutation Effects, AC line Reactance, 12 pulse with different type of Transformers, 18 Pulse with Fork Step – down Transformer, Eighteen- pulse converter, tests on other topologies, Field Test Results and their analysis.	**7**
3.	**Multilevel Voltage Source Converters:** PWM, Modulation Schemes, Space Vector Modulation, Dwell Time Calculation, Switching Sequence, Spectrum Analysis, Even-Order Harmonic Elimination, Discontinuous Space Vector Modulation, Cascaded H-Bridge Multilevel Inverters, Carrier Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes, Staircase Modulation.	**8**
4.	**Diode-Clamped Multilevel Inverters:** Converter Configurations, Switching State, Commutation, Space Vector Modulation, Switching Sequence Design, Inverter Output Waveforms and Harmonic Content, Neutral-Point Voltage Control, Effect of Motoring and Regenerative Operation, Feedback Control of Neutral-Point Voltage, High-Level Diode - Clamped Inverters, Carrier-Based PWM, NPC/H-Bridge Inverter.	**5**
5.	**Inverters:** Converter Configurations, Switching State, Commutation, Space Vector Modulation, Switching Sequence Design, Inverter Output Waveforms and Harmonic Content, Neutral-Point Voltage Control, Effect of Motoring and Regenerative Operation, Feedback Control of Neutral-Point Voltage, High-Level Diode - Clamped Inverters, Carrier-Based PWM, NPC/H-Bridge Inverter; PWM Current Source Inverter, Trapezoidal Modulation, Selective Harmonic Elimination, Space Vector Modulation, SVM Versus TPWM and SHE, Parallel Current Source Inverters (Inverter Topology, Space Vector Modulation for Parallel Inverters, Effect of Medium Vectors on dc Currents, dc Current Balance Control), PWM Current Source Rectifiers.	**14**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	Derek A. Paice, Power Electronic Converter Harmonics, Multipulse Method for Clear Power, IEEE Press.	1999
2.	Bin Wu, High Power Converters and AC Derives, IEEE Press, 2006.	2006
3.	N. Mohan, T. M. Undeland, et al., Power Electronics - Converters, Applications and Design, 3rd edition, John Wiley & Sons, New York, 2003.	2003
4.	GE Toshiba Automation Systems, A New Family of MV Drives for a New Century—DURA BILT 5i MV, Product Brochure, 50 pages, March 2003.	2003

DEPARTMENTAL ELECTIVE-3

Wireless Power Transfer (PES534)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Wireless Power Transfer– PES534	**3**	**0**	**2**	PES503

Course Objective:

This course explores the principles, design considerations, and control strategies for Wireless Power Transfer (WPT) systems, emphasizing efficient energy transmission and advanced converter topologies.

Course Outcomes (COs):

CO1: To understand the fundamentals of inductive and resonant wireless power transfer technologies and their applications.
CO2: To analyze different WPT topologies and resonant converters for performance optimization and design evaluation.
CO3: To design efficient WPT systems with advanced converter topologies for practical high-power applications.
CO4: To evaluate control strategies and optimization techniques for dynamic, high-efficiency WPT systems.

CO-PO Articulation Metrix:

Course Outcomes / Program Outcomes	PO1	PO2	PO3
CO1	2	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	**Introduction to Wireless Power Transfer (WPT), Overview of wireless power transfer:** history, applications, and future trends; Basic principles of electromagnetic induction and resonant coupling; Comparison of WPT with wired power transfer methods.	**6**
2.	**Inductive Coupling-Based WPT:** Principles and operation of inductive power transfer (IPT) systems; Coupled Coil Model, Gyrator Circuit Model, Magnetic Mirror Model, General Unified Dynamic Phasor, Analysis of basic IPT topologies: single-coil and multi-coil systems, Air Gap and Misalignment Characteristics, Design considerations, efficiency optimization, and practical implementations, Asymmetric Coils for Large Tolerance EV Chargers, DQ Coils, Capacitive Power Transfer for EV Chargers Coupler, Magnetic Shielding, Conductive	**10**

	Shielding, Active Shielding, Reactive Resonant Shielding, Compensation Networks, Magnetic Resonance Coupling, Introduction to Dynamic Charging.	
3.	**Resonant Coupling-Based WPT:** Introduction to resonant wireless power transfer (RWPT) systems; Series and parallel resonant coupling: operation and characteristics; Design and analysis of resonant WPT topologies: series-resonant, parallel-resonant, and hybrid systems; Resonant coupling circuits (N–N, N–S, S–N, S–S, S–P), Open-Circuit and Short-Circuit Type Coils, Resonant Converters for WPT, Analysis of resonant converter topologies: series-resonant, parallel-resonant, and hybrid configurations, Design considerations and optimization techniques for resonant WPT converters.	**8**
4.	**Advanced Converter Topologies for WPT:** Dual Active Bridge (DAB) converters and their applications in WPT systems; Full-Bridge and Half-Bridge converters for high-power WPT applications; Design challenges and practical considerations for advanced WPT converter topologies, Standards for EV Wireless Chargers.	**8**
5.	**Advanced Control Strategies for WPT:** Voltage and current regulation techniques in wireless power transfer systems; Closed-loop control methods for efficiency optimization and load adaptation; Controller Design of Dynamic Chargers, Adaptive and predictive control strategies for dynamic wireless power transfer environments.	**10**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	N. Mohan, T. M. Undeland, et al., Power Electronics - Converters, Applications and Design, 3rd edition, John Wiley & Sons, New York, 2003.	2003
2.	Fang Lin Luo & Hong Ye, Advanced DC/DC Converters, CRC Press, 2004.	2004
3.	Marian K. Kazimierczuk, Dariusz Czarkowski, Resonant Power Converters, 2nd Edition, John Wiley & Sons, 2011.	2011
4.	C. T. Rim and Chris Mi, Wireless Power Transfer for Electric Vehicles and Mobile Devices, John Wiley & Sons, 2017	2017
5.	A. T. Cabrera, J. M. González and José A. Aguado, Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach, Springer, 2019	2019

DEPARTMENTAL ELECTIVE-3

Pulsed Power Electronics (PES536)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
Pulsed Power Electronics– PES536	**3**	**1**	**0**	PES503

Course Objective:

This course explores nuclear physics fundamentals, reactor systems, pulsed power technologies, advanced semiconductor devices, and high-power radiation generation for energy and research applications.

Course Outcomes (COs):

CO1: To understand fundamentals of nuclear physics, reactor operations, and particle acceleration techniques.
CO2: To analyze thermal reactor processes, safety protocols, and energy transfer in pulsed power systems.
CO3: To design advanced semiconductor-based high-power pulse generators and electron beam devices.
CO4: To evaluate performance and safety of reactors, energy storage systems, and high-power radiation technologies.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		2	2	3
CO2		3	2	3
CO3		3	2	3
CO4		3	3	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Introduction to Nuclear Physics, Basics atomic structure, mass energy equivalence, Interaction of radiation with matter, fission and fusion, Energy released in reactions, Particle Accelerators, Electrical & Magnetic Forces, High Voltage Machines, Linear Accelerators, Cyclotron, Betatron, Synchrotron, Collider, Spallation, Separators, Mass Spectrograph, Separation of Deuterium, Detectors.	**7**
2.	Heat generation and heat removal from the reactor, steam-cycles, types of Thermal Reactors, Nuclear power plant layout, Type of Reactors, Isotope Production and Consumption, Breeding & Uranium resources, Fusion reactors, Comparison of Fusion reactors, Magnetic and Inertial confinement machines, Other Fusion concepts; Nuclear power station operation, Types of Pumps, Condensate booster, Feed water pump, Sodium Pump, Instrumentation and control, Irradiation effects, effects of temperature, Fuel cycles, instability, reactor control, start	**12**

	up and shunt down, reactor safety, reactor power level measurement, safety circuits, Radiation Shielding.	
3.	Pulse Discharge Capacitors, Types of Generators, Transformers, Transformers using long lines, Basic Pulsed-Power Energy Transfer Stage, Inductive Energy Storage, Power and Voltage Multiplication, Rotors and Homopolar Generators, Gas Switches, Magnetic switches, Summery, Mechanical Interrupters, Superconducting Opening Switches, Plasma Opening Switches, Voltage adding, cumulative Pulse Lines, KALIF, PBFA 2 and the Z- Machine, RHEPP.	**8**
4.	Semiconductor closing switches, Types of thyristors, Semiconductor Opening Switches(SOS), Operation of SOS diodes, SOS-diode-based nanosecond pulse devices, Pulse power generators in circuits with magnetic elements, Properties of magnetic elements in pulsed fields, Generation of nanosecond high- power pulses, Magnetic generators using SOS diodes, Long lines with nonlinear parameters, Formation of electromagnetic shock waves due to induction drag, Generation of nanosecond high-power pulses with the use of electromagnetic shock waves.	**8**
5.	LCSB, Cathodes, Explosive electron emission from a triple junction, Metal-dielectric cathode designs , Physical processes in LCSB diodes, Designs of LCSB accelerators, AEB, Principle of operation of diodes, Device of electron guns for MICD's The cathode plasma in a magnetic field, Formation of electron beams, Dense Electron Beam & their focusing, diode operation, Focusing of electron beams, High-power x-ray pulses, high-power pulsed gas lasers, generation of high-power pulsed microwaves, generation of ultrawideband radiation pulses.	**7**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Raymond Murray, Nuclear Energy: an introduction to the concepts, systems, & applications, Butterworth Heinmann, 2009.	2009
2.	Gennady A. Mesyats, Pulsed Power, Springer, 2005.	2005
3.	Samuel Glasstone & Alexander Sesonske, Nuclear Reactor Engineering: Reactor Systems Engineering, Chapman& Hall, 1994.	1994
4.	Ronald Allen Knief, Nuclear engineering: theory and technology of commercial nuclear power, Taylor & Francis, 1992.	1992
5.	J. Kenneth Shultis & Richard E. Faw, Fundamentals of Nuclear Science and Engineering, CRC Press, 2008.	2008
6.	Hansjoachim Bluhm, Pulsed Power Systems: Principles and Applications, Springer, 2006.	2006

DEPARTMENTAL ELECTIVE-3

Power Quality (PES538)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	**T**	**P**	
Power Quality- PES538	**3**	**1**	**0**	PES503

Course Objective:

To understand Power Quality issues in the power networks and their mitigation techniques.

Course Outcomes (COs):

CO1: To explain the power quality issues in distribution systems.
CO2: To measure and analyse the power quality problems.
CO3: To devise the operation and control strategies for mitigation of power quality issues.
CO4: To design solutions for harmonic filtering, variable reactive power compensation, current and voltage balancing and other power quality problem in distribution systems.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		2	1	3
CO2		2	1	3
CO3		3	2	3
CO4		3	2	3

Course Contents

Sl. No.	Content	Contact Hours
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.	**6**
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.	**6**

3.	Analysis and 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 from measured samples, Analysis of voltage sag, Voltage sag energy, Analysis of Voltage flicker, Reduced duration and customer impact of outgas, load balancing current balancing, Voltage sag reduction.	**10**
4.	Harmonic Compensation: Utility- Customer interface, Harmonic indices, Harmonic filter: passive, Active and hybrid filter, issues of resonances, resonance damping.	**6**
5.	Power Quality Improvement: 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. Power quality mitigation in Microgrids, voltage balancing of microgrids under high penetration of renewable energy sources	**14**

Suggested Books:

Sl. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, “Power Quality: Problems and Mitigation Techniques”, Wiley	2015
2.	Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Acadamic Publishers.	2002
3.	G.T. Heydt. “Electric Power Quality”, Elsevier Publications (2nd Edition).	2005
4.	J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment, John Wiley & sons, New York.	2000
5.	Math H.J. Bollen, Understanding Power quality problems, IEEE Press, New York	1999
6.	E. Acha, Manuel Madrigal, Power system Harmonics, John Wiley & sons, New York.	2001
7.	Moreno – Murioz (Ed), Power Quality (Mitigation Technologies in Distribution Environment, Springer, 2007	2007
8.	George J. Wakileh, “Power System Harmonics”, Springer	2001
9	Mahesh Kumar Mishra, “Power Quality in Power Distribution Systems: Concepts and Applications”, CRC Press	2023

SKILL ENHANCEMENT COURSE-1

PCB Design (PES541)

Course Title and Course Code	Course Structure			Pre-Requisite
	L	T	P	
PCB Design- PES541	**0**	**0**	**4**	Nil

Course Objective:

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 understand basics of PCB design, fabrication processes, and CAD tools for layout and assembly.
CO2: To analyze design constraints, signal integrity issues, and electrical characteristics in complex PCB designs.
CO3: To design high-performance PCBs for power supply, mixed-signal, and high-speed digital applications.
CO4: To evaluate PCB design quality through signal integrity assessment and compliance with manufacturing standards.

CO-PO Articulation Metrix:

Course Outcomes \ Program Outcomes	PO1	PO2	PO3
CO1	2	-	3
CO2	2	-	3
CO3	3	1	3
CO4	3	1	3

Course Contents

Sl. No.	Content	Contact Hours
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	**10**

	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 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 Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
1.	K. Mitzner, B. Doe, A. Akulin, A. Suponin and D. Müller, Complete PCB Design Using OrCAD Capture and PCB Editor, Academic Press	2019
2.	Tim Williams, The Circuit Designer’s Companion, Butterworth-Heinmann	2012
3.	Majid Pakdel, Fast PCB Design with Altium Designer, Central West Publishing.	2021

SKILL ENHANCEMENT COURSE-2

Embedded Programing with Microcontrollers for Power Electronics Systems (PES542)

Course Title and Course Code	Course Structure			Prerequisite
	L	**T**	**P**	
Embedded Programing with Microcontrollers for Power Electronics Systems– PES540	**2**	**0**	**4**	Nil

Course Objective:

This course focuses on embedded control systems, microcontroller programming, real-time control applications, and closed-loop control strategies in power electronics using advanced tools.

Course Outcomes (COs):

CO1: To understand key elements of embedded systems, microcontrollers, and real-time control techniques in power electronics.
CO2: To analyze closed-loop control systems, current control strategies, and signal processing in power electronics applications.
CO3: To design embedded control systems for power converters and motor drives with advanced modulation strategies.
CO4: To evaluate real-time control implementations and system performance through simulations and case studies.

CO-PO Articulation Metrix:

Course Outcomes	Program Outcomes	PO1	PO2	PO3
CO1		2	-	3
CO2		2	-	3
CO3		3	1	3
CO4		3	1	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Embedded Control System, Key elements of a microcontroller Programming microcontrollers, Scheme of a Power Electronics Control Problem, Embedded Development; 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	**12**

2.	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.	**8**
3.	Fixed Point vs Floating Point Representation, Single vs Double Precision, Scaling in Fixed Point Representation, Conversion from Decimal Representation to Single Format.	**5**
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.	**8**
5.	Real-Time Control in Power Electronics: 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 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	**9**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
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

SKILL ENHANCEMENT COURSE-2

Implementation of Embedded Programing with Microcontrollers for Power Electronics Systems (PES544)

Course Title and Course Code	Course Structure			Prerequisite
	L	**T**	**P**	
Practical Implementation of Embedded Programing with Microcontrollers – PES544	**0**	**0**	**8**	Nil

Course Objective:

This course focuses on embedded control systems, microcontroller programming, real-time control applications, and closed-loop control strategies in power electronics using advanced tools.

Course Outcomes (COs):

CO1: To understand key elements of embedded systems, microcontrollers, and real-time control techniques in power electronics.
CO2: To analyze closed-loop control systems, current control strategies, and signal processing in power electronics applications.
CO3: To design embedded control systems for power converters and motor drives with advanced modulation strategies.
CO4: To evaluate real-time control implementations and system performance through simulations and case studies.

CO-PO Articulation Metrix:

Course Outcomes \ Program Outcomes	PO1	PO2	PO3
CO1	2	-	3
CO2	2	-	3
CO3	3	1	3
CO4	3	1	3

Course Contents

Sl. No.	Content	Contact Hours
1.	Embedded Control System, Key elements of a microcontroller Programming microcontrollers, Scheme of a Power Electronics Control Problem, Embedded Development; 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	**12**

2.	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.	**8**
3.	Fixed Point vs Floating Point Representation, Single vs Double Precision, Scaling in Fixed Point Representation, Conversion from Decimal Representation to Single Format.	**5**
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.	**8**
5.	Real-Time Control in Power Electronics: 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 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	**9**

Suggested Books:

Sl. No.	**Name of Authors /Books / Publishers**	**Year of Publication/ Reprint**
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