

SRM VALLIAMMAI ENGINEERING COLLEGE

(Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK



VI SEMESTER

PEE603 - DESIGN AND MODELLING OF RENEWABLE ENERGY SYSTEMS

Regulation – 2023

Academic Year 2025-2026 EVEN

Prepared by

Ms. S.Vanila, Assistant Professor (Sel. G)



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SUBJECT & SUBJECT CODE: PEE603 - Design and Modelling of Renewable Energy Systems

SEM / YEAR: VI / III

UNIT-I: RENEWABLE ENERGY SYSTEMS: TECHNOLOGY OVERVIEW AND PERSPECTIVES				
Introduction-State of the Art- Examples of Recent Research and Development Challenges and Future Trends.				
PART-A				
Q. No	Questions	BT Level	Competence	CO
1.	Define Renewable Energy System.	1	Remembering	CO1
2.	List four major sources of renewable energy currently used for electricity generation.	1	Remembering	CO1
3.	Identify the current global leader in terms of installed renewable energy capacity.	1	Remembering	CO1
4.	Explain the difference between intermittent and dispatchable renewable energy sources.	2	Understanding	CO1
5.	State the primary driver for the increased adoption of renewable energy technologies worldwide.	1	Remembering	CO1
6.	Describe the current state of the art in solar PV efficiency for commercial modules.	2	Understanding	CO1
7.	What is Levelized Cost of Energy (LCOE)?	1	Remembering	CO1
8.	Explain why the LCOE for solar and wind power has dropped significantly in recent years.	2	Understanding	CO1
9.	List two examples of recent R&D advancements in wind power technology.	1	Remembering	CO1
10.	Explain the potential impact of ongoing research into Perovskite solar cells.	2	Understanding	CO1
11.	Describe the concept of a floating solar farm as a recent R&D example.	2	Understanding	CO1
12.	Identify ongoing research efforts related to improving	1	Remembering	CO1

	the efficiency of energy storage systems.				
13.	Explain the challenge posed by energy storage costs to the widespread adoption of 100% renewable grids.	2	Understanding	CO1	
14.	What is the primary policy challenge in transitioning from fossil fuels to renewable energy systems?	1	Remembering	CO1	
15.	Describe the concept of sector coupling as a future trend in energy systems.	2	Understanding	CO1	
16.	List two expected future trends in the renewable energy sector beyond 2030.	1	Remembering	CO1	
17.	Define the term grid modernization or Smart Grid.	1	Remembering	CO1	
18.	State the main technical challenge associated with integrating high levels of intermittent renewable energy into the existing grid infrastructure.	1	Remembering	CO1	
19.	Mention one challenge in integrating large-scale renewable energy into the grid.	1	Remembering	CO1	
20.	State one challenge faced by researchers in renewable energy development.	2	Understanding	CO1	
21.	Define microgrid.	1	Remembering	CO1	
22.	List any two environmental benefits of renewable energy.	2	Understanding	CO1	
23.	State two key research areas in renewable energy.	2	Understanding	CO1	
24.	Define energy forecasting.	2	Understanding	CO1	
PART-B					
1.	Explain the importance of renewable energy systems in the global energy scenario with suitable examples.	(16)	2	Understanding	CO1
2.	Describe the primary challenges faced when transitioning a traditional, centralized fossil-fuel-based grid towards a decentralized, renewable-dominated system.	(16)	1	Remembering	CO1
3.	Discuss the state-of-the-art renewable energy technologies used in modern power systems.	(16)	2	Understanding	CO1
4.	Describe the current status and trends in solar and wind energy technologies.	(16)	2	Understanding	CO1
5.	Assess the future trends in hybrid renewable energy systems and evaluate their role in providing consistent, reliable power compared to single-source systems.	(16)	4	Analyzing	CO1
6.	Illustrate how hybrid renewable energy systems	(16)	3	Applying	CO1

	can be applied to meet rural electrification needs.				
7.	Apply the concept of distributed generation to design a small renewable-based microgrid layout.	(16)	3	Applying	CO1
8.	Demonstrate with examples how advanced power electronics enhance the performance of renewable energy systems.	(16)	3	Applying	CO1
9.	Analyze the key challenges faced in integrating renewable energy sources into the existing power grid.	(16)	4	Analyzing	CO1
10.	Compare and analyze the technological developments in solar PV, wind, and bioenergy sectors.	(16)	4	Analyzing	CO1
11.	Analyze the impact of intermittency on the stability of power systems and the role of storage technologies.	(16)	4	Analyzing	CO1
12.	Evaluate the effectiveness of recent research advancements in renewable energy systems for improving efficiency and reliability.	(16)	5	Evaluating	CO1
13.	Critically evaluate policy and regulatory frameworks supporting renewable energy development.	(16)	5	Evaluating	CO1
14.	Assess the environmental and economic benefits of large-scale renewable energy deployment.	(16)	5	Evaluating	CO1
15.	Propose a future renewable energy system architecture integrating solar, wind, hydrogen, and storage technologies.	(16)	6	Creating	CO1
16.	Develop a comprehensive roadmap addressing the challenges and future trends in renewable energy technology development.	(16)	6	Creating	CO1
17.	Create a conceptual model for an integrated renewable energy park that combines solar, wind, biomass, and energy storage for 24/7 power supply.	(16)	6	Creating	CO1

UNIT-II: SINGLE-PHASE GRID-CONNECTED PHOTOVOLTAIC SYSTEMS

Introduction- Demands for Grid-Connected PV Systems-Power Converter Technology for Single-Phase PV Systems, Transformer less AC-Module Inverters (Module-Integrated PV Converters, Transformer less Single-Stage String Inverters, DC-Module Converters in Transformer less Double-Stage PV Systems

PART-A				
Q. No	Questions	BT Level	Competence	CO
1.	What is a grid-connected PV system?	1	Remembering	CO2
2.	Define a single-phase grid-connected PV system.	1	Remembering	CO2
3.	List two parameters used to evaluate the efficiency of a single-phase PV inverter.	1	Remembering	CO2
4.	Explain why galvanic isolation is removed in transformerless designs.	2	Understanding	CO2
5.	What is leakage current in transformerless PV systems?	1	Remembering	CO2
6.	Compare single-stage and double-stage PV systems.	2	Understanding	CO2
7.	What are the safety requirements for transformerless inverters?	1	Remembering	CO2
8.	Define double-stage PV architecture.	2	Understanding	CO2
9.	State any two challenges in grid-connected PV integration.	1	Remembering	CO2
10.	What is meant by double-stage PV converter topology?	1	Remembering	CO2
11.	What is a grid-tied inverter?	1	Remembering	CO2
12.	Define the term AC-module inverter.	1	Remembering	CO2
13.	What are the basic demands of grid-connected PV systems?	2	Understanding	CO2
14.	List any two advantages of transformerless PV inverters.	1	Remembering	CO2
15.	What is meant by module-integrated PV converters?	1	Remembering	CO2
16.	Explain the need for power converters in single-phase PV systems.	2	Understanding	CO2
17.	What is a string inverter in PV systems?	1	Remembering	CO2
18.	Differentiate between transformer-based and transformerless PV inverters.	2	Understanding	CO2
19.	What is meant by module-level MPPT?	1	Remembering	CO2
20.	Define partial shading effect in PV systems.	2	Understanding	CO2
21.	State any two demands that have increased the adoption of grid-connected PV systems.	2	Understanding	CO2
22.	Mention one example of a modulation technique used in single-phase PV inverters.	2	Understanding	CO2
23.	Write any two benefits of AC-module inverters.	1	Remembering	CO2
24.	State any two drawbacks of single stage transformerless PV systems.	1	Remembering	CO2
PART-B				

1.	Explain the architecture and components of a single-phase grid-connected PV system with neat diagrams.	(16)	1	Remembering	CO2
2.	Compare transformerless AC-modules, single-stage string inverters, and double-stage DC-module converters in terms of efficiency, safety, and cost.	(16)	4	Applying	CO2
3.	Explain the various power converter technology choices available for single-phase PV integration. Illustrate the typical power ratings and application scenarios for each type.	(16)	1	Remembering	CO2
4.	Describe the design considerations for selecting converter topologies in rooftop single-phase PV installations.	(16)	2	Understanding	CO2
5.	Analyse the challenges associated with galvanic isolation removal in transformerless PV systems.	(16)	4	Analyzing	CO2
6.	Illustrate the operation of transformerless single-stage string inverters with detailed power flow diagrams.	(16)	3	Applying	CO2
7.	Explain the grid-interface control requirements for single-phase PV inverters.	(16)	2	Understanding	CO2
8.	Evaluate the performance advantages and limitations of module-integrated PV converters.	(16)	5	Evaluating	CO2
9.	Develop the mathematical model of a DC-module converter used in double-stage transformerless PV systems.	(16)	3	Applying	CO2
10.	Discuss the working principle of transformerless AC-module inverters with suitable diagrams.	(16)	2	Understanding	CO2
11.	Analyse the requirements of transformerless operation in grid-connected PV inverters regarding leakage current and safety.	(16)	4	Analyzing	CO2
12.	Compare single-stage and double-stage single-phase PV converter topologies in detail.	(16)	4	Analyzing	CO2
13.	Derive the functional blocks and control flow of a single stage transformerless string inverter.	(16)	3	Applying	CO2
14.	Compare and analyse transformerless and transformer-based single-phase PV converter systems in terms of efficiency, safety, and cost.	(16)	4	Analyzing	CO2
15.	Explain the different power converter	(16)	2	Understanding	CO2

	technologies used in single-phase PV systems.				
16.	Develop the structure and operating principle of a module-integrated PV (AC-module) inverter.	(16)	3	Applying	CO2
17.	Show how module-integrated PV converters can be implemented in residential rooftop installations.	(16)	3	Applying	CO2

UNIT-III THREE-PHASE PHOTOVOLTAIC SYSTEMS: STRUCTURES, TOPOLOGIES

Introduction-PV Inverter Structures, Three-Phase PV Inverter Topologies-Control Building Blocks for PV Inverters, Modulation Strategies for Three-Phase PV Inverters, Implementation of the Modulation Strategies., Grid Synchronization, Implementation of the PLLs for Grid Synchronization, Current Control, Implementation of the Current Controllers, Maximum Power Point Tracking.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	What is a PV inverter?	1	Remembering	CO3
2.	Explain the importance of efficiency in MPPT operation.	2	Understanding	CO3
3.	Mention any two challenges in three-phase inverter control.	1	Remembering	CO3
4.	What are the advantages of space vector modulation?	2	Understanding	CO3
5.	What is the primary objective of current control in a grid-tied three-phase PV inverter?	2	Understanding	CO3
6.	What is field-oriented control (FOC) in the context of PV inverters?	1	Remembering	CO3
7.	Explain the purpose of implementing PLL in inverter control.	2	Understanding	CO3
8.	Define the term current limit in the context of inverter current control	1	Remembering	CO3
9.	What is meant by implementation of modulation strategies?	2	Understanding	CO3
10.	List the four primary functional blocks of a typical grid-connected three-phase PV system.	1	Remembering	CO3
11.	Differentiate between single-phase and three-phase PV inverter topologies.	2	Understanding	CO3
12.	What is sinusoidal PWM modulation?	1	Remembering	CO3
13.	Explain the role of a current controller in PV inverters.	2	Understanding	CO3
14.	Why is PLL used for grid synchronization?	2	Understanding	CO3

15.	What is the importance of current control in PV inverters?		2	Understanding	CO3
16.	Define maximum power point tracking (MPPT).		1	Remembering	CO3
17.	List any two MPPT techniques used in PV systems.		1	Remembering	CO3
18.	Define three-phase PV inverter topology.		1	Remembering	CO3
19.	Explain the need for modulation strategies in three-phase PV inverters.		2	Understanding	CO3
20.	State the purpose of the inner current control loop.		1	Remembering	CO3
21.	What is the purpose of control building blocks in PV inverters?		2	Understanding	CO3
22.	List any two types of PV inverter structures.		1	Remembering	CO3
23.	What is grid synchronization in PV systems?		1	Remembering	CO3
24.	Mention two functions of a Phase-Locked Loop (PLL).		1	Remembering	CO3

PART-B

1.	Explain the basic structure of a three-phase photovoltaic (PV) system with neat diagrams.	(16)	1	Remembering	CO3
2.	Evaluate the performance of three-phase PV inverter topologies under varying solar irradiance and grid conditions.	(16)	5	Evaluating	CO3
3.	Differentiate between single-phase and three-phase PV systems, discussing the advantages of three-phase systems for high-power applications and grid stability.	(16)	2	Understanding	CO3
4.	Develop a complete control strategy integrating MPPT, current control, and grid synchronization for a three-phase PV system.	(16)	5	Evaluating	CO3
5.	Explain in detail the Maximum Power Point Tracking (MPPT) algorithms used in PV systems.	(16)	2	Understanding	CO3
6.	Evaluate the performance of different MPPT algorithms in three-phase PV systems under rapidly changing irradiance.	(16)	5	Evaluating	CO3
7.	Illustrate the implementation of current controllers in three-phase PV inverter systems.	(16)	3	Applying	CO3
8.	Explain the need for current control in three-phase PV inverters and describe different current control techniques.	(16)	2	Understanding	CO3
9.	Describe the different types of PV inverter structures used in modern PV systems.	(16)	2	Understanding	CO3
10.	Demonstrate how MPPT algorithms are	(16)	3	Applying	CO3

	integrated into a three-phase PV inverter control loop.				
11.	Develop the control building blocks required for the operation of a three-phase PV inverter.	(16)	3	Applying	CO3
12.	Derive and explain the mathematical model of a three-phase PV inverter.	(16)	3	Applying	CO3
13.	Analyse different modulation strategies used in three-phase PV inverters.	(16)	4	Analyzing	CO3
14.	Evaluate different grid synchronization techniques used in modern PV systems.	(16)	5	Evaluating	CO3
15.	Discuss the implementation challenges of modulation strategies in three-phase PV power converters.	(16)	4	Analyzing	CO3
16.	Explain the importance of grid synchronization and the role of PLLs in three-phase PV systems.	(16)	2	Applying	CO3
17.	Create a comparative framework for analyzing multiple three-phase PV inverter structures and propose the best topology for a 5 kW residential system.	(16)	6	Creating	CO3

UNIT-IV BLDC MOTOR CONTROL

Introduction-Generator Selection for Small-Scale Wind Energy Systems- Turbine Selection for Wind Energy- Self-Excited Induction Generators for Small Wind Energy Applications- Permanent Magnet Synchronous Generators for Small Wind Power Applications- Grid-Tied Small Wind Turbine Systems-Magnus Turbine–Based Wind Energy System.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	What is meant by a small-scale wind energy system?	1	Remembering	CO4
2.	Define tip-speed ratio (TSR).	1	Remembering	CO4
3.	What is meant by power coefficient of a wind turbine?	1	Remembering	CO4
4.	Explain the significance of proper turbine–generator matching.	2	Understanding	CO4
5.	What are the challenges associated with grid integration of small wind turbines?	2	Understanding	CO4
6.	What is cut-in wind speed?	1	Remembering	CO4
7.	Explain the need for speed control in wind generators.	2	Understanding	CO4
8.	What is the purpose of capacitors in SEIG-based wind systems?	1	Remembering	CO4
9.	What are the main features of PMSG suitable for low-	2	Understanding	CO4

	speed wind turbines?			
10.	What is the role of power electronics in grid-tied small wind turbines?	2	Understanding	CO4
11.	List any two advantages of Magnus turbine-based wind energy systems.	1	Remembering	CO4
12.	Differentiate between horizontal-axis and vertical-axis wind turbines.	2	Understanding	CO4
13.	What is meant by grid-tied wind turbine operation?	1	Remembering	CO4
14.	Explain why SEIGs are used in standalone wind energy systems.	2	Understanding	CO4
15.	What is a Magnus turbine?	1	Remembering	CO4
16.	What are the main components of a small wind turbine system?	1	Remembering	CO4
17.	Explain the importance of generator characteristics in wind system design.	2	Understanding	CO4
18.	Define Magnus effect.	1	Remembering	CO4
19.	List two factors that influence generator selection for wind systems.	1	Remembering	CO4
20.	Define rated wind speed.	1	Remembering	CO4
21.	What is the purpose of turbine selection in wind systems?	2	Understanding	CO4
22.	What is the function of a permanent magnet synchronous generator (PMSG) in wind energy?	2	Understanding	CO4
23.	Define a self-excited induction generator (SEIG).	1	Remembering	CO4
24.	Mention two advantages of PMSG in small wind systems.	1	Remembering	CO4

PART-B

1.	Explain the characteristics and components of small-scale wind energy systems with neat diagrams.	(16)	1	Remembering	CO4
2.	Discuss the system integration, safety requirements, and protection schemes for small grid-tied wind turbine installations.	(16)	4	Analyzing	CO4
3.	Summarize the key factors involved in the initial selection of a generator for small-scale wind energy applications, explaining the trade-offs between different types.	(16)	2	Understanding	CO4
4.	Explain the dynamic behaviour and power control strategies of small wind turbines under	(16)	4	Analyzing	CO4

	fluctuating wind conditions.				
5.	Develop a detailed modelling approach for a Magnus turbine-based wind energy system.	(16)	3	Applying	CO4
6.	Compare and contrast the design, operational benefits, and limitations of a Magnus Turbine-Based Wind Energy System against a conventional blade-type wind turbine system.	(16)	4	Analyzing	CO4
7.	Justify the selection of a specific type of generator (e.g., PMSG vs. SEIG) for an off-grid, battery-charging small wind energy system, providing a detailed argument based on technical and practical merits.	(16)	5	Evaluating	CO4
8.	Explain the working principle of the Magnus turbine and analyse its aerodynamic advantages.	(16)	4	Analyzing	CO4
9.	Analyse the performance characteristics of a Permanent Magnet Synchronous Generator (PMSG) in small wind turbines.	(16)	4	Analyzing	CO4
10.	Explain the construction, operating principle, and control requirements of PMSG-based wind turbines.	(16)	2	Understanding	CO4
11.	Explain how a Brushless DC (BLDC) motor could be potentially adapted to function as a generator (BLDC generator) within a small wind energy system, focusing on the necessary control modifications.	(16)	3	Applying	CO4
12.	Develop a detailed technical specification sheet for a 5kW small wind turbine system suitable for residential use, including generator type, tower height, cut-in/cut-out speeds, and predicted annual energy output.	(16)	6	Creating	CO4
13.	Propose an innovative hybrid small-scale wind energy system that integrates a Magnus effect turbine with a conventional generator setup, outlining the potential advantages of this novel approach.	(16)	6	Creating	CO4
14.	Derive and explain the operating principle of a Self-Excited Induction Generator (SEIG) used in small wind systems.	(16)	3	Applying	CO4
15.	Develop the equivalent circuit and mathematical	(16)	3	Applying	CO4

	modelling of SEIG under variable wind-speed conditions.				
16.	Differentiate between Horizontal Axis Wind Turbines (HAWTs) and Vertical Axis Wind Turbines (VAWTs), discussing their respective advantages and disadvantages for small-scale applications.	(16)	2	Understanding	CO4
17.	Illustrate the power curve of a typical wind turbine and calculate the theoretical power output of a given turbine with a specified rotor diameter, wind speed, and air density (assuming a certain efficiency).	(16)	3	Applying	CO4

UNIT-V SRM MOTOR CONTROL

Introduction – modelling of induction machine in machine variable form and arbitrary reference frame, modelling of Doubly-fed Induction Generator.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Define an induction generator and state its primary principle of operation.	1	Remembering	CO5
2.	List two common applications for Doubly-Fed Induction Generators (DFIGs).	1	Understanding	CO5
3.	Differentiate between a synchronous machine and an induction generator in terms of excitation current source.	2	Understanding	CO5
4.	What is the main difference between a DFIG and a standard induction motor regarding rotor connections?	2	Understanding	CO5
5.	Explain the concept of "slip" in the context of an induction generator.	2	Understanding	CO5
6.	Write down the general voltage equations for a three-phase induction machine in the stationary machine variable form (a-b-c variables).	1	Remembering	CO5
7.	Identify the primary challenge associated with using the machine variable form (a-b-c) for induction machine control analysis.	2	Understanding	CO5
8.	List the assumptions generally made when developing the primitive machine model of an induction motor.	1	Remembering	CO5
9.	What do the self and mutual inductances depend on in	2	Understanding	CO5

	the machine variable model of an induction motor?			
10.	Define the arbitrary reference frame theory as applied to AC machines.	1	Remembering	CO5
11.	State the main advantage of transforming the induction machine equations to an arbitrary reference frame (d-q model).	2	Understanding	CO5
12.	Specify the transformation matrix used to convert a-b-c variables to d-q variables.	1	Remembering	CO5
13.	Draw a simple schematic representation of a DFIG system with its associated power converters.	2	Understanding	CO5
14.	What are the main advantages of DFIG-based wind turbines in terms of power control?	1	Remembering	CO5
15.	In DFIG operation, how does the power flow direction in the rotor change between subsynchronous and supersynchronous speeds?	2	Understanding	CO5
16.	What is the role of the rotor-side converter (RSC) and grid-side converter (GSC) in a DFIG system?	1	Remembering	CO5
17.	Write the fundamental voltage equations (stator and rotor) for a DFIG in the $d-q$ reference frame.	2	Understanding	CO5
18.	Mention the key parameters involved in the mechanical equations for a DFIG wind turbine model (e.g., inertia, wind speed, tip speed ratio).	2	Understanding	CO5
19.	What is the need for a rotor position sensor in a Switched Reluctance Motor (SRM) control system?	1	Remembering	CO5
20.	Define "holding torque" and "detent torque" with respect to stepper motors	1	Remembering	CO5
21.	Why are SR machines popular in adjustable speed drives?	2	Understanding	CO5
22.	List some position sensors used in SRMs.	1	Remembering	CO5
23.	What are the different modes of operation of an SRM?	1	Remembering	CO5
24.	Give the advantages of sensorless operation of an SRM.	1	Remembering	CO5

PART-B

1.	(i)	Explain the concept of an arbitrary reference frame and its application in simplifying the dynamic modelling of induction machines.	(8)	2	Understanding	CO5
	(ii)	Derive the voltage equations for a three-phase induction motor in the $d-q$ rotating reference frame.	(8)	2	Understanding	CO5

2.	(i)	Describe the principles of modelling a three-phase induction machine in its basic machine variable form (a-b-c) variables.	(8)	2	Understanding	CO5
	(ii)	Derive the relevant voltage and torque equations, clearly stating all assumptions.	(8)	2	Understanding	CO5
3.	(i)	Analyze the steady-state performance of an induction motor using the $d-q$ model equations in the synchronously rotating reference frame.	(8)	4	Analyzing	CO5
	(ii)	Discuss how parameters like torque, speed, and power factor are derived.	(8)	4	Analyzing	CO5
4.	Develop the complete mathematical model of a Doubly-Fed Induction Generator (DFIG) in the $d-q$ reference frame, considering both stator and rotor voltage equations. Clearly explain the significance of the slip ring connections.		(16)	3	Applying	CO5
5.	(i)	Evaluate the control strategies for a DFIG in a wind energy conversion system (WECS).	(8)	5	Evaluating	CO5
	(ii)	Discuss how the arbitrary reference frame model is used to achieve independent control of active and reactive power.	(8)	5	Evaluating	CO5
6.	A 40 kW, 3-phase DFIG has specific parameters. Using the derived $d-q$ model equations, calculate the rotor current and stator power for a given operating point (speed, voltage, frequency, and power factor). Assume necessary data if not provided.		(16)	3	Applying	CO5
7.	(i)	Compare and contrast the modelling of an induction machine in the stationary reference frame ($\alpha-\beta$) versus the synchronously rotating reference frame ($d-q$).	(11)	4	Analyzing	CO5
	(ii)	Highlight the advantages and disadvantages of each method for control system design.	(5)	4	Analyzing	CO5
8.	Formulate a simulation block diagram for the dynamic model of an induction motor using the arbitrary reference frame theory. Justify the selection of the reference frame for the simulation of transient conditions.		(16)	6	Creating	CO5

9.	Detail the steps involved in transforming the three-phase ($a-b-c$) variables of an induction machine to the two-phase ($d-q$) variables using the Park's transformation. Prove that the transformation is power invariant.	(16)	4	Analyzing	CO5
10.	Examine the influence of varying the rotor resistance on the torque-slip characteristics of a DFIG using its steady-state model equations. Relate your analysis to actual applications like wind turbines.	(16)	4	Analyzing	CO5
11.	Design a basic control loop for a DFIG system that maintains a constant stator voltage magnitude and frequency while allowing variable speed operation. Base your design on the $d-q$ modelling equations.	(16)	6	Creating	CO5
12.	Justify the necessity of position sensors in the control of certain motor drives (like SRM) and discuss how reference frame transformations in induction machine modeling obviate the need for complex mechanical sensors in some control schemes.	(16)	5	Evaluating	CO5
13.	Discuss the limitations of the simplified equivalent circuit model of an induction machine for dynamic analysis and explain how the machine variable form and arbitrary reference frame models overcome these limitations.	(16)	2	Understanding	CO5
14.	Develop the mathematical model for the mechanical system dynamics (torque, inertia, speed relationship) and integrate it with the electrical $d-q$ model of an induction machine to form a comprehensive dynamic model.	(16)	3	Applying	CO5
15.	Differentiate between the modeling of a standard squirrel-cage induction motor and a DFIG. Emphasize the unique aspects of the DFIG model due to the accessible rotor windings.	(16)	4	Analyzing	CO5
16.	Summarize the entire modeling process for induction machines, starting from physical principles to the final arbitrary reference frame equations. Create a flowchart or diagram to	(16)	6	Creating	CO5

	illustrate the steps clearly.				
17.	Analyze the impact of unbalances or harmonics on the performance of a DFIG, using the detailed machine variable model as a basis for understanding how these effects are represented mathematically.	(16)	4	Analyzing	CO5

Course Outcome:

CO1: Ability to review the perspectives of renewable energy systems

CO2: Ability to integrate photovoltaic systems with grid.

CO3: Ability to study inverter for PV systems.

CO4: Ability to elaborate the working of small wind power systems

CO5: Ability to study the features of induction machine and doubly fed induction machine