

SRM VALLIAMMAI ENGINEERING COLLEGE

(An autonomous Institution)

SRM Nagar, Kattankulathur – 603203

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING



QUESTION BANK

Academic Year 2025-2026 ODD

**PEE402 - DESIGN OF MOTOR AND POWER CONVERTERS
FOR ELECTRIC VEHICLES**

(Regulation 2023)

Prepared By

Mr. RAGUL KUMAR K./ Assistant Professor-(O.G)



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Department of Electrical and Electronics Engineering

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SUBJECT: PEE402 DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES

SEM / YEAR : III / V - Academic Year 2025–2026 ODD

UNIT I – ELECTRIC VEHICLE DYNAMICS

Standard drive cycles-Dynamics of Electric Vehicles-Tractive Force-Maximum speed, torque, power, energy requirements of EVs

PART-A

Q. No	Questions	BT Level	Competence	Course Outcome
1.	List the types of standard drive cycles used for EV testing.	BTL 1	Remembering	CO 1
2.	Name the main parameters considered in the design of drive cycles.	BTL 1	Remembering	CO 1
3.	Classify the drive cycles based on their usage conditions.	BTL 2	Understanding	CO 1
4.	Summarize the influence of drive cycles on energy estimation.	BTL 2	Understanding	CO 1
5.	Differentiate between FTP-75 and NEDC drive cycles.	BTL 2	Understanding	CO 1
6.	Summarize the impact of drive cycles on peak power requirement.	BTL 2	Understanding	CO 1
7.	Identify the components of total road load resistance.	BTL 1	Remembering	CO 1
8.	Name the resistive forces acting on a moving EV.	BTL 1	Remembering	CO 1
9.	Define aerodynamic drag.	BTL 1	Remembering	CO 1
10.	Recall the standard values for air density and drag coefficient.	BTL 1	Remembering	CO 1
11.	Discuss the relationship between tractive force and acceleration.	BTL 2	Understanding	CO 1
12.	Compare the effect of gradient on EV performance under two conditions.	BTL 2	Understanding	CO 1
13.	Define tractive force in electric vehicles.	BTL 1	Remembering	CO 1
14.	Recall the formula for calculating rolling resistance.	BTL 1	Remembering	CO 1
15.	State the effect of vehicle mass on tractive effort.	BTL 1	Remembering	CO 1
16.	Interpret the torque-speed characteristics of an EV during urban drive.	BTL 2	Understanding	CO 1
17.	Illustrate the influence of vehicle speed on tractive power requirement.	BTL 2	Understanding	CO 1
18.	Identify the units used for torque and power in EVs.	BTL 1	Remembering	CO 1
19.	State the equation to compute tractive power.	BTL 1	Remembering	CO 1

20.	Interpret the importance of maximum torque in motor selection.	BTL 2	Understanding	CO 1
21.	List the key variables affecting energy consumption in EVs.	BTL 1	Remembering	CO 1
22.	Classify the energy losses during EV operation.	BTL 2	Understanding	CO 1
23.	Predict the change in energy consumption for increased vehicle weight.	BTL 2	Understanding	CO 1
24.	Compare constant-speed and stop-go driving in terms of energy usage.	BTL 2	Understanding	CO 1
PART-B				
1.	Apply suitable drive cycles to analyze city and highway energy requirements of an EV.	BTL 3	Applying	CO 1
2.	Develop a simple MATLAB model to simulate the speed profile of an urban drive cycle.	BTL 3	Applying	CO 1
3.	Analyze the effect of drive cycle duration on battery discharge and motor efficiency.	BTL 4	Analyzing	CO 1
4.	Examine how different drive cycles affect the range estimation of an electric vehicle.	BTL 4	Analyzing	CO 1
5.	Calculate the total tractive force for an EV climbing a gradient with known parameters.	BTL 3	Applying	CO 1
6.	Apply Newton's laws to compute acceleration force under variable load conditions.	BTL 3	Applying	CO 1
7.	Analyze the effect of road load resistance on overall vehicle performance.	BTL 4	Analyzing	CO 1
8.	Compare vehicle dynamics on flat road and hilly terrain for same motor output.	BTL 4	Analyzing	CO 1
9.	Determine the required tractive effort for a vehicle cruising at constant speed on a slope.	BTL 3	Applying	CO 1
10.	Calculate the total energy required for a 50 km EV trip considering acceleration and braking.	BTL 3	Applying	CO 1
11.	Analyze the variation in power requirement with speed using appropriate equations.	BTL 4	Analyzing	CO 1
12.	Apply the torque-speed relationship to select an appropriate motor for urban driving.	BTL 3	Applying	CO 1
13.	Compare the torque-speed characteristics of induction and BLDC motors used in EVs.	BTL 4	Analyzing	CO 1
14.	Evaluate the effect of maximum torque on hill climbing capability of an EV.	BTL 4	Analyzing	CO 1
15.	Calculate energy consumption for different loads using simulated drive patterns.	BTL 3	Applying	CO 1
16.	Analyze how aerodynamic design changes impact energy efficiency of the EV.	BTL 4	Analyzing	CO 1

17.	Compare energy usage and motor temperature rise between two drive cycle profiles.	BTL 4	Analyzing	CO 1
UNIT - II MOTORS FOR ELECTRIC VEHICLES				
Introduction – Speed and Torque control of above and below rated speed-Speed control of EV in the constant power region of electric motors. DC Motors, Induction Motor, Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors, Switched Reluctance Motors (SRMs). Synchronous Reluctance Machines-Choice of electric machines for EVs.				
PART-A				
Q. No	Questions	BT Level	Competence	Course Outcome
1.	Define speed control in electric motors.	BTL 1	Remember	CO 2
2.	State the significance of torque control in electric vehicles.	BTL 1	Remember	CO 2
3.	Identify the region of operation above rated speed.	BTL 1	Remember	CO 2
4.	Name the control method used for below-rated speed operation.	BTL 1	Remember	CO 2
5.	Outline the characteristics of constant power region in EV motors.	BTL 2	Understand	CO 2
6.	Summarize the influence of voltage and current on torque in constant power region.	BTL 2	Understand	CO 2
7.	List any two types of DC motors used in EV propulsion.	BTL 1	Remember	CO 2
8.	Identify the torque-speed feature of a separately excited DC motor.	BTL 1	Remember	CO 2
9.	State the role of armature control in DC motor speed variation.	BTL 1	Remember	CO 2
10.	Outline the characteristics of an induction motor used in EVs.	BTL 2	Understand	CO 2
11.	Classify the types of induction motor control strategies.	BTL 2	Understand	CO 2
12.	Recall any two limitations of induction motors in variable-speed applications.	BTL 1	Remember	CO 2
13.	Define the working principle of a Permanent Magnet Synchronous Motor (PMSM).	BTL 1	Remember	CO 2
14.	List two performance advantages of PMSM in EV applications.	BTL 1	Remember	CO 2
15.	Summarize the torque generation in PMSM.	BTL 2	Understand	CO 2
16.	Recall the constructional features of Brushless DC motors.	BTL 1	Remember	CO 2
17.	Identify the commutation method in BLDC motors.	BTL 1	Remember	CO 2
18.	Outline the performance benefits of BLDC motors in light EVs.	BTL 2	Understand	CO 2
19.	State the principle of Switched Reluctance Motor (SRM).	BTL 1	Remember	CO 2
20.	List two control advantages of SRMs in traction.	BTL 1	Remember	CO 2
21.	Outline the speed-torque characteristics of SRMs.	BTL 2	Understand	CO 2
22.	Define synchronous reluctance machine used in EVs.	BTL 1	Remember	CO 2
23.	Compare torque density of synchronous reluctance motor with PMSM.	BTL 2	Understand	CO 2
24.	Summarize the factors for selecting an electric machine for EV application.	BTL 2	Understand	CO 2

PART-B				
1.	Apply the speed control method for operating a motor in the constant torque and constant power regions.	BTL 3	Apply	CO 2
2.	Analyze the transition between below-rated and above-rated speed operation for an EV motor drive.	BTL 4	Analyze	CO 2
3.	Apply suitable control strategy for torque regulation in an EV operating under variable load conditions.	BTL 3	Apply	CO 2
4.	Analyze the impact of flux weakening on the motor performance in the constant power region.	BTL 4	Analyze	CO 2
5.	Apply the armature voltage control method to achieve desired speed in a separately excited DC motor.	BTL 3	Apply	CO 2
6.	Analyze the suitability of DC series motor in hill-climbing performance of an electric vehicle.	BTL 4	Analyze	CO 2
7.	Apply the voltage/frequency (V/f) control method to estimate speed of an induction motor at partial load.	BTL 3	Apply	CO 2
8.	Analyze the losses and efficiency of an induction motor at rated load and speed.	BTL 4	Analyze	CO 2
9.	Apply vector control technique to determine the stator current components of an induction motor drive.	BTL 3	Apply	CO 2
10.	Analyze the electromagnetic torque expression of a PMSM and relate it to rotor position and current.	BTL 4	Analyze	CO 2
11.	Apply field-oriented control principles for PMSM to enhance speed control accuracy in EV application.	BTL 3	Apply	CO 2
12.	Analyze the torque ripple behavior of Brushless DC motors under different commutation strategies.	BTL 4	Analyze	CO 2
13.	Apply rotor position sensing method for effective control of Switched Reluctance Motor in low-speed EV operation.	BTL 3	Apply	CO 2
14.	Analyze the performance parameters of synchronous reluctance motor compared with PMSM and Induction Motor for medium-power EVs.	BTL 4	Analyze	CO 2
15.	Apply the speed control method for operating a motor in the constant torque and constant power regions.	BTL 3	Apply	CO 2
16.	Analyze the transition between below-rated and above-rated speed operation for an EV motor drive.	BTL 4	Analyze	CO 2
17.	Apply suitable control strategy for torque regulation in an EV operating under variable load conditions.	BTL 3	Apply	CO 2
UNIT - III BASICS OF SIMULATION IN CONTROL SYSTEMS				
Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model.				
PART-A				

Q.No	Questions	BT Level	Competence	Course Outcome
1.	Define transfer function of a linear time-invariant system.	BTL 1	Remember	CO 3
2.	List the assumptions used in deriving a transfer function.	BTL 1	Remember	CO 3
3.	Identify the input-output relationship for obtaining a transfer function.	BTL 1	Remember	CO 3
4.	Recall the standard form of a second-order transfer function.	BTL 1	Remember	CO 3
5.	Classify system behavior based on pole locations.	BTL 2	Understand	CO 3
6.	Identify poles and zeros from a given transfer function.	BTL 1	Remember	CO 3
7.	Locate the poles of a transfer function using factorization.	BTL 2	Understand	CO 3
8.	State the effect of pole locations on time-domain response.	BTL 1	Remember	CO 3
9.	Describe the shape of time response for an underdamped second-order system.	BTL 2	Understand	CO 3
10.	Sketch the time response plot of a first-order system.	BTL 2	Understand	CO 3
11.	Identify overshoot and settling time from a time response curve.	BTL 1	Remember	CO 3
12.	Recognize the components of a Bode plot.	BTL 1	Remember	CO 3
13.	Recall the magnitude and phase behavior of a constant function in Bode plot.	BTL 1	Remember	CO 3
14.	Interpret the slope change in Bode magnitude plot for a single pole function.	BTL 2	Understand	CO 3
15.	Identify the slope of a single zero function in a Bode magnitude plot.	BTL 1	Remember	CO 3
16.	Summarize the Bode magnitude plot for a system with a double integration term.	BTL 2	Understand	CO 3
17.	Classify the Bode plot features of a single differentiation function.	BTL 2	Understand	CO 3
18.	State the typical phase shift introduced by a single RHP pole.	BTL 1	Remember	CO 3
19.	Recognize the phase characteristics of a system with RHP zero.	BTL 1	Remember	CO 3
20.	Match Bode plot patterns to given system types (pole-zero combinations).	BTL 2	Understand	CO 3
21.	Recall the definition of state space model.	BTL 1	Remember	CO 3
22.	Identify state variables in a given physical system.	BTL 1	Remember	CO 3
23.	Relate the state-space matrices (A, B, C, D) to system dynamics.	BTL 2	Understand	CO 3
24.	Construct a transfer function from given state space representation.	BTL 2	Understand	CO 3
PART-B				
1.	Apply Laplace transform to obtain transfer function from a basic RLC circuit.	BTL 3	Apply	CO 3
2.	Construct a transfer function for a mechanical translational	BTL 3	Apply	

	system using standard system modeling rules.			CO 3
3.	Analyze the pole-zero locations for a given transfer function and relate them to system stability.	BTL 4	Analyze	CO 3
4.	Apply MATLAB simulation to generate time response of a second-order underdamped system.	BTL 3	Apply	CO 3
5.	Analyze the effect of moving a pole closer to the imaginary axis on time response performance.	BTL 4	Analyze	CO 3
6.	Apply knowledge of system functions to sketch time response curves for over-damped and under-damped systems.	BTL 3	Apply	CO 3
7.	Analyze the influence of system gain on peak overshoot and settling time using a unit step input.	BTL 4	Analyze	CO 3
8.	Apply standard rules to construct a Bode plot for a first-order low-pass transfer function.	BTL 3	Apply	CO 3
9.	Analyze the phase margin and gain margin using a given Bode plot.	BTL 4	Analyze	CO 3
10.	Apply the multiplication rule to derive the composite Bode magnitude plot for a cascade system.	BTL 3	Apply	CO 3
11.	Analyze the behavior of single and double integrator systems using slope changes in Bode plots.	BTL 4	Analyze	CO 3
12.	Construct the Bode plot for a system with a right-half-plane zero and comment on its stability implication.	BTL 3	Apply	CO 3
13.	Apply state variable formulation to represent a second-order system in state-space format.	BTL 3	Apply	CO 3
14.	Analyze the process of converting a state-space model into transfer function using matrix algebra.	BTL 4	Analyze	CO 3
15.	Apply Laplace transform to obtain transfer function from a basic RLC circuit.	BTL 3	Apply	CO 3
16.	Construct a transfer function for a mechanical translational system using standard system modeling rules.	BTL 3	Apply	CO 3
17.	Analyze the pole-zero locations for a given transfer function and relate them to system stability.	BTL 4	Analyze	CO 3

UNIT - IV MODELING OF DC-DC CONVERTERS

Overview of PWM Converter Modelling -Power Stage Modelling - PWM Block Modelling - Voltage Feedback Circuit and Small-Signal Model of PWM Converter - Averaging Power Stage Dynamics - Average Models for buck/boost Converter - Small-Signal Model of Converter Power Stage - Frequency Response of Converter-Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control.

PART-A

Q.No	Questions	BT Level	Competence	Course Outcome
1.	Define PWM converter.	BTL 1	Remember	CO 4
2.	List the basic components of a power stage in a DC-DC converter.	BTL 1	Remember	CO 4

3.	Identify the function of a PWM block in converter circuits.	BTL 1	Remember	CO 4
4.	Recall the role of duty cycle in PWM operation.	BTL 1	Remember	CO 4
5.	Classify PWM control techniques used in DC-DC converters.	BTL 2	Understand	CO 4
6.	Identify the voltage feedback components in a closed-loop converter.	BTL 1	Remember	CO 4
7.	Summarize the steps in obtaining a small-signal model of a PWM converter.	BTL 2	Understand	CO 4
8.	Define state-space averaging.	BTL 1	Remember	CO 4
9.	Recognize the significance of small-signal modeling.	BTL 1	Remember	CO 4
10.	Identify the control-to-output transfer function in converter models.	BTL 1	Remember	CO 4
11.	Recall the averaged model of a buck converter.	BTL 1	Remember	CO 4
12.	Compare the dynamic response of buck and boost converters.	BTL 2	Understand	CO 4
13.	Identify poles and zeros from a converter transfer function.	BTL 1	Remember	CO 4
14.	List the frequency response characteristics of a boost converter.	BTL 1	Remember	CO 4
15.	Define ZVC inverter.	BTL 1	Remember	CO 4
16.	Recall the principle of Zero Current Switching.	BTL 1	Remember	CO 4
17.	Compare ZVC and ZCS inverter topologies.	BTL 2	Understand	CO 4
18.	Identify the components in a single-phase ARS inverter topology.	BTL 1	Remember	CO 4
19.	Classify control strategies for induction motor drives.	BTL 2	Understand	CO 4
20.	Recall the basic idea of Field-Oriented Control (FOC).	BTL 1	Remember	CO 4
21.	Summarize the concept of adaptive control.	BTL 2	Understand	CO 4
22.	Identify the structure of Model Reference Adaptive Control (MRAC).	BTL 1	Remember	CO 4
23.	Recall the working principle of sliding mode control in power converters.	BTL 1	Remember	CO 4
24.	Compare conventional control and sliding mode control in converter dynamics.	BTL 2	Understand	CO 4
PART-B				
1.	Apply state-space averaging to obtain power stage model of a buck converter.	BTL 3	Apply	CO 4
2.	Analyze the dynamics of PWM power stage with and without averaging.	BTL 4	Analyze	CO 4
3.	Apply small-signal modeling technique to derive duty-to-output transfer function.	BTL 3	Apply	CO 4
4.	Analyze the role of voltage feedback loop in shaping frequency response.	BTL 4	Analyze	CO 4
5.	Apply averaging method to model a boost converter in continuous conduction mode.	BTL 3	Apply	CO 4

6.	Analyze the low-frequency and high-frequency behavior of a converter using Bode plots.	BTL 4	Analyze	CO 4
7.	Apply simulation to determine control-to-output gain of a PWM converter.	BTL 3	Apply	CO 4
8.	Analyze the pole-zero structure in the small-signal model of a boost converter.	BTL 4	Analyze	CO 4
9.	Apply switching function approach to model ZVS inverter.	BTL 3	Apply	CO 4
10.	Analyze switching losses in ZCS and ZVS converters.	BTL 4	Analyze	CO 4
11.	Apply knowledge of power electronics to model a single-phase ARS inverter.	BTL 3	Apply	CO 4
12.	Analyze the effect of inverter control on induction motor speed stability.	BTL 4	Analyze	CO 4
13.	Apply Field-Oriented Control to obtain torque-speed response.	BTL 3	Apply	CO 4
14.	Analyze the stability performance of MRAC and Sliding Mode Controllers for motor drive applications.	BTL 4	Analyze	CO 4
15.	Apply state-space averaging to obtain power stage model of a buck converter.	BTL 3	Apply	CO 4
16.	Analyze the dynamics of PWM power stage with and without averaging.	BTL 4	Analyze	CO 4
17.	Apply small-signal modeling technique to derive duty-to-output transfer function.	BTL 3	Apply	CO 4

UNIT - V POWER STAGE TRANSFER FUNCTIONS OF DC – DC CONVERTERS

Power Stage Transfer Functions of buck-boost Converter in CCM Operation, Input-to-Output Transfer Function, Duty Ratio-to-Output Transfer Function, Load Current-to-Output Transfer Function.

PART-A

Q. No	Questions	BT Level	Competence	Course Outcome
1.	Define Continuous Conduction Mode in buck-boost converter.	BTL 1	Remember	CO 5
2.	Identify the mode of operation for buck-boost converter in steady-state.	BTL 1	Remember	CO 5
3.	List the key assumptions in deriving buck-boost converter transfer functions.	BTL 1	Remember	CO 5
4.	Recall the general structure of power stage transfer functions.	BTL 1	Remember	CO 5
5.	State the mathematical form of duty ratio-to-output transfer function.	BTL 1	Remember	CO 5
6.	Identify the significance of small-signal transfer function in converter analysis.	BTL 1	Remember	CO 5
7.	Classify the types of transfer functions used in power stage modeling.	BTL 2	Understand	CO 5
8.	Match input and output variables used in each converter transfer function.	BTL 2	Understand	CO 5
9.	Recognize how input voltage affects output in buck-boost converter.	BTL 1	Remember	CO 5
10.	Recall the duty ratio range for proper operation of buck-boost converter.	BTL 1	Remember	CO 5

11.	Identify the control variable in duty-to-output transfer function.	BTL 1	Remember	CO 5
12.	Compare input-to-output and load-to-output transfer functions.	BTL 2	Understand	CO 5
13.	Define load current-to-output voltage transfer function.	BTL 1	Remember	CO 5
14.	Summarize the role of load resistance in dynamic response.	BTL 2	Understand	CO 5
15.	Identify poles and zeros in buck-boost converter transfer functions.	BTL 1	Remember	CO 5
16.	Recall the importance of ESR (Equivalent Series Resistance) in transfer function modeling.	BTL 1	Remember	CO 5
17.	State how output voltage changes with load current disturbances.	BTL 1	Remember	CO 5
18.	Identify effect of inductor value on system dynamics.	BTL 1	Remember	CO 5
19.	Summarize the small-signal response of buck-boost converter to input voltage variations.	BTL 2	Understand	CO 5
20.	Recognize how control-to-output transfer function is used in feedback loop design.	BTL 1	Remember	CO 5
21.	Recall the small-signal duty-to-output gain of buck-boost converter in CCM.	BTL 1	Remember	CO 5
22.	Compare large-signal and small-signal models of buck-boost converter.	BTL 2	Understand	CO 5
23.	Identify effect of duty ratio variation on converter output characteristics.	BTL 1	Remember	CO 5
24.	State the relationship between load current and output ripple.	BTL 1	Remember	CO 5
PART-B				
1.	Apply state-space averaging to derive duty ratio-to-output transfer function of a buck-boost converter.	BTL 3	Apply	CO 5
2.	Analyze the impact of ESR on transfer function characteristics in buck-boost topology.	BTL 4	Analyze	CO 5
3.	Apply small-signal modeling to derive input-to-output transfer function.	BTL 3	Apply	CO 5
4.	Analyze how control-to-output transfer function changes with duty ratio in CCM mode.	BTL 4	Analyze	CO 5
5.	Apply signal injection method to simulate load current-to-output gain.	BTL 3	Apply	CO 5
6.	Analyze the frequency response of buck-boost converter with variation in load resistance.	BTL 4	Analyze	CO 5
7.	Apply Laplace transforms to find system response for a step input in duty ratio.	BTL 3	Apply	CO 5
8.	Analyze the pole-zero structure of the duty-to-output transfer function.	BTL 4	Analyze	CO 5
9.	Apply MATLAB or simulation tools to visualize gain and phase margin for input-output transfer function.	BTL 3	Apply	CO 5
10.	Analyze the effect of parameter variations on small-signal model performance.	BTL 4	Analyze	CO 5
11.	Apply converter modeling techniques to validate power stage equations.	BTL 3	Apply	CO 5

12.	Analyze the stability limits using Bode plots of buck-boost converter.	BTL 4	Analyze	CO 5
13.	Apply root locus method to evaluate system sensitivity to duty cycle.	BTL 3	Apply	CO 5
14.	Analyze effect of switching frequency on converter bandwidth and ripple performance.	BTL 4	Analyze	CO 5
15.	Apply state-space averaging to derive duty ratio-to-output transfer function of a buck-boost converter.	BTL 3	Apply	CO 5
16.	Analyze the impact of ESR on transfer function characteristics in buck-boost topology.	BTL 4	Analyze	CO 5
17.	Apply small-signal modeling to derive input-to-output transfer function.	BTL 3	Apply	CO 5

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

- CO1. To use appropriate electric machine for electric vehicle application
- CO2. To compute transfer function with factors such as constant, integral, differential, first order factor and second order factor (both numerators & denominators)
- CO3. To compute transfer function from state models
- CO4. To design buck, boost and buck-boost converter.
- CO5. To compute a power stage transfer functions for DC-DC converters and to simulate DC-DC converters and to obtain gain margin and phase margin

1.