Techno India NJR Institute of Technology

Course File

Electric Drive (6EE4-05)

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(Professor)

Department of Electrical Engineering

Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

III Year - VI Semester: B.Tech. (Electrical Engineering)

6EE4-05: ELECTRICAL DRIVES

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	HOURS
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**DC motor characteristics** Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation	05
3	**Chopper fed DC drive** Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting..	05
4	**Multi-quadrant DC drive** Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking	06
5	**Closed-loop control of DC Drive** Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design	05
6	**Induction motor characteristics** Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation, vector control of IM, Direct torque control of IM.	06
7	**Scalar control or constant V/f control of induction motor** Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation	06
8	**Control of slip ring induction motor** Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery	06
	TOTAL	40

Course Overview:

- A field of Electrical Engineering that deals with the application of power semiconductor devices for the control and conversion of electric power.
- AC Drive: Electrical drives that use AC motors as the prime mover.
- DC Drive: Electrical drives that use DC motors as the prime mover.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Student will be able to classify Electrical Drives, And Justify Multi-Quadrant Operation Of Drives
2	Synthesis	Student will be able to design and develop concept along With Load Equalization
3	Design	Students will be able to analyse The Thermal Model And Determine The Motor Rating For Different
4	Design	Students will be able to describe duty Cycles Considering The Effect Of Load Inertia And Environmental
5	Design	Students will be able Identify Suitable Form Of Electrical Drives System In Industry

Prerequisites:

1. The prerequisites for this course are DC drives basics.
2. Students should be known to Chopper fed DC drives.
3. Students should be familiar with Induction Motor characteristics.
4. Scalr and V/F control of induction motor.

Course Outcome Mapping with Program Outcome:

Prerequisites:

5. The prerequisites for this course are DC drives basics.
6. Students should be known to Chopper fed DC drives.
7. Students should be familiar with Induction Motor characteristics.
8. Scalr and V/F control of induction motor.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	-	-	-	-	-	-	-
CO2	2	2	1	2	3	-	-	-	-	-	-	-
CO3	2	2	1	2	1	-	-	-	-	-	-	-
CO4	1	2	2	1	2	-	-	-	-	-	-	-
CO5	2	1	2	1	3	-	-	-	-	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**INTRODUCTION:** Objective, Scope and Outcome Of The Course.
2	**2**	**DC MOTOR:** Characteristics
3	2	Review of emf and torque equations of DC machine
4	2	review of torque- speed characteristics of separately excited dc motor
5	2	Change in torque- speed curve with armature voltage
6	2	Example load torque-speed characteristics
7	2	Operating point
8	2	armature voltage control for varying motor speed
9	2	Flux weakening for high speed operation
10	**3**	**CHOPPER FED DC DRIVE:** Dc Drive
11	3	Review of dc chopper and duty ratio control
12	3	Chopper fed dc motor for speed control
13	3	Steady state operation of a chopper fed drive
14	3	Armature current waveform and ripple
15	3	Calculation of losses in dc motor and chopper
16	3	Efficiency of dc drive
17	3	Smooth starting
18	**4**	**MULTI-QUADRANT DC DRIVE**: Review of motoring and generating modes
19	4	Review of motoring and generating modes operation of a separately excited dc machine

20	4	Four quadrant operation of dc machine
21	4	Single- quadrant
22	4	Two-quadrant and four-quadrant choppers
23	4	Steady-state operation of multi-quadrant chopper fed dc drive
24	4	Regenerative braking
25	**5**	**CLOSED-LOOP CONTROL OF DC DRIVE**
26	5	Control structure of DC drive
27	5	Inner current loop and outer speed loop
28	5	Dynamic model of dc motor
29	5	Dynamic equations and transfer functions
30	5	Modeling of chopper as gain with switching delay
31	5	Plant transfer function
32	5	For controller design
33	5	Current controller specification and design
34	5	Speed controller specification and design
35	**6**	**INDUCTION MOTOR CHARACTERISTICS**: Review of induction motor
36	6	Review of induction motor equivalent circuit and torque-speed characteristic
37	6	Variation of torque-speed curve
38	6	(i) Applied voltage, (ii) applied frequency and (iii) applied voltage and frequency
39	6	Typical torque-speed curves of fan and pump loads
40	6	Operating point, constant flux operation, flux weakening operation
41	6	Vector control of IM
42	6	Direct torque control of IM
43	**7**	**SCALAR CONTROL OR CONSTANT V/F CONTROL OF INDUCTION MOTOR**: Review of three-phase voltage source inverter
44	7	Review of three-phase voltage source inverter
45	7	Generation of three- phase PWM signals,
46	7	Sinusoidal modulation, space vector theory
47	7	Conventional space vector modulation
48	7	Constant V/f control of induction motor
49	7	Steady-state performance analysis based on equivalent circuit
50	7	Speed drop with loading, slip regulation
51	**8**	**CONTROL OF SLIP RING INDUCTION MOTOR:** Impact of rotor resistance
52	8	Impact of rotor resistance of the induction motor torque-speed curve

53	8	Operation of slip-ring induction motor with external rotor resistance
54	8	Starting torque, power electronic based rotor side control of slip ring motor
55	8	Slip power recovery

Text/Reference Books:

1 G. K. Dubey: Fundamentals of Electrical Drives, Narosa Publishing House, New Delhi.

2 B. K. Bose: Power Electronics and Motor Drives, Elsevier

3 V. Subrahmanyam: Electric Drives- Concepts and Applications, MGH

4 Theodore Wildi: Electrical Machines, Drives and Power Systems, Pearson

5 S. K. Pillai: A First Course on Electrical Drives, Wiley Eastern limited, India

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/104/108104140/
Quiz	https://www.sanfoundry.com/1000-electric-drives-questions-answers/
Notes	https://sites.google.com/site/eeenotes2u/courses/industrial-drives-and-applications

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous year paper

6E1575

Roll No. _____ [Total No. of Pages : 2]

6E1575

B.Tech. VI Sem. (Main/Back) Examination, June - 2022
Electrical Engg.
6EE4-05 Electric Drives

Time : 3 Hours **Maximum Marks : 120**
Min. Passing Marks : 42

Instructions to Candidates:

*Attempt **all ten** questions from **Part A**, **five** questions out of **Seven** from **Part B** and **Four** questions out of **Five** from **Part C**.*

Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No.205)

PART - A

(Answer should be given up to 25 words only)

All questions are **compulsory.** **(10×2=20)**

1. Draw the speed - torque characteristics of separately excited DC motor.
2. What do you understand with the term operating point?
3. What is electric drives and list the element of electric drives?
4. Draw the relation between speed - torque characteristics of induction motor and pump load.
5. What do you mean by smooth starting DC motor?
6. What are the different methods of speed control of slip ring IM?
7. What is field oriented control of induction motor?
8. List the factors affecting selection of electric drives.
9. State the selection of motor bases on load variation.
10. What are the advantages of Ward Leonard method?

PART - B

(Analytical/Problem solving questions)

Attempt any **five** questions. **(5×8=40)**

1. Draw and explain the block diagram of a closed loop control of DC drive.
2. Explain Ward Leonard method of speed controlling.

3. Explain four quadrant operation of chopper.
4. Explain direct torque control of induction motor and why it is needed?
5. Explain static Kramer drive for IM drives with necessary derivation and sketches.
6. Explain slip power recovery using phasor diagram.
7. The rotor of a 4 - pole, 50 - Hz, slip ring induction motor has a resistance of 0.25 Ω per phase and runs at 1440 rpm at full load. Calculate the external resistance per phase which must be added to lower the speed to 1200 rpm the torque being the same as before.

PART - C

(Descriptive/Analytical/Problem Solving/Design questions)

Attempt any **Four** questions. **(4×15=60)**

1. Explain PWM principle for speed control and slip energy recovery scheme of 3-ϕ induction motor drives. **(15)**
2. Explain vector control of speed control in 3-ϕ induction motor. Also write the limitation of vector control method. **(15)**
3. a. State and explain regenerative braking. **(6+9)**
   b. A 220 V, 200 A, 800 rpm DC separately excited motor has an armature resistance of 0.06 Ω. The motor armature is fed from a variable voltage source with an internal resistance of 0.04 Ω. Calculate internal voltage of the variable voltage when the motor is operating in regenerative braking at 80% of the rated motor torque and 600 rpm.
4. a. Comment with relevant justification that stator voltage control method is most suitable for fan and pump motor drives. **(7+8)**
   b. Draw and explain the speed torque characteristics of VVVF control of induction motor for various operating speed. Also discuss the speed limit to be achieved for obtaining constant motor torque using this method.
5. 3 - ϕ delta connected, 6 - pole, 50 Hz, 400 V, 925 rpm IM has following parameters: Rs = 0.2 Ω, R_r' = 0.3 Ω, X_s = 0.5 Ω, X_r' = 1 Ω motor is fed from VSI with V/f control. Determine :
   i. Speed for frequency of 40 Hz and full load.
   ii. Determine speed for 40 Hz and half load.
   iii. Determine frequency at 700 rpm and full load.
   iv. Determine frequency at 700 rpm and half load. **(3+4+4+4=15)**

Mid Term Papers

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY

B. TECH III – YEAR (VI SEM.)

Mid Term-1 Session 2022-23

Electrical Engineering

Electric Drives (6EE4-05)

Max Marks: 70

Time: 3 Hrs

Note:
1) The paper is divided into 2 parts: Part-A and, Part-B
2) Part-A contains 10 questions and carries 2 mark each.
3) Part-B contains 5 questions. Each question is having two options and carries 10 marks each.

PART – A

1.	Write the torque speed relation of DC motor.	[CO]
2.	What is back emf? Write the relation with terminal voltage.	[CO]
3.	Write the torque and armature current relation for different DC motors.	[CO]
4.	What is duty ratio in Chopper control?	[CO]
5.	Write the fundamental torque equation.	[CO]
6.	Write three differences between regenerative braking and dynamic braking.	[CO]
7.	Define term plugging.	[CO]
8.	What are different types of speed control of DC motor?	[CO]
9.	What is steady state characteristics of DC motor?	[CO]
10	Write advantages and disadvantages of electric drive.	[CO]

PART – B

1.	Explain the multi quadrant operation of electric motor driving a hoist.	[CO]
	OR	
1.	Explain steady state stability of electric drive with suitable diagram and assumptions.	[CO]

2.	Deduce the speed torque relation for separately excited and series DC motor.	[CO]
	OR	
2.	Draw and discuss the block diagram of an electrical drive.	[CO]

3.	Explain different types of converters used in electric drives.	[CO]
	OR	
3.	Explain Ward Leonard method in DC drive.	[CO]

4.	A 200 V, 875 rpm, 150 A separately excited DC motor has an armature resistance of 0.006 ohm. It is fed from a single phase fully controlled rectifier with an ac source voltage of 220V. assuming continuous conduction, calculate 1. firing angle for rated motor torque at 750 rpm 2. firing angle for rated motor torque and (-500) rpm 3. motor speed for $\alpha=160^0$	[CO]

	OR	
4.	A 200 V, 10.5 A, 2000 rpm shunt motor has the armature and field resistances of 0.5 and 400 ohm respectively. It drives a load whose torque is constant at rated motor torque. Calculate motor speed if the source voltage drops to 175V	[CO]

5.	A 220 V, 200 A, 800 rpm dc separately excited motor has an armature resistance of 0.06 ohm. The motor armature is fed from a variable voltage source with an internal resistance of 0.04 ohm. Calculate internal voltage of the variable voltage source when the motor is operating in regenerative braking at 80% of the rated motor torque and 600 rpm.	[CO]
	OR	
5.	Discuss with suitable diagram the operation of dual converter in dc drive.	[CO]

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (VI SEM.) – II MT

Electrical Drives (**6EE4-05**)

Time: 3 Hr **Max. Marks:** 70

Note:

1) The paper is divided into 2 parts: Part-A and, Part-B.
2) Part-A contains 10 questions and carries 2 mark each.
3) Part-B contains 5 questions. Each question is having two options and carries 10 marks each.

Part- A (20 Marks)

A.	Draw the speed-torque characteristics for DC motor.	CO1
B.	List the parts of Electric Drives.	CO1
C.	Draw the steady state point characteristics.	CO2
D.	List the factors affecting selection of electric drive.	CO2
E.	Write starting methods of DC motor.	CO3
F.	Draw speed torque characteristics of IM.	CO3
G.	What is the field-oriented control of Induction motor.	CO4
H.	Draw the inner loop control of IM.	CO4
I.	Define operating point of IM	CO5
J.	Draw V/f control of IM.	CO5

Part- B (50 Marks)

1. Draw and discuss the closed loop control of DC motor.	CO1
OR	
1. Explain the speed control of DC motor using chopper fed drive.	CO1
2. Explain Ward-Leonard method of speed control.	CO2
OR	
2. Explain the four-quadrant operation of chopper.	CO2
3. Explain in details the regenerative braking of DC motors.	CO3
OR	

3. Describe the closed loop control structure of DC drive in details.	CO3
4. Derive the dynamic equation and transfer function of DC motor.	CO4
OR	
4. Explain the three-phase voltage source inverter operation for IM.	CO4
5. What is constant v/f control of IM?	CO5
OR	
5. How the rotor resistance create impact on induction motor torque-speed curve? Explain in details.	CO5
