EET413	ELECTRIC DRIVES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To impart knowledge about the DC and AC motor drives and its applications

Prerequisite: EET306 Power Electronics, EET202 DC Machines and Transformers and EET307 Synchronous and Induction Machines.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Describe the transient and steady state aspects electric drives
CO 2	Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors
CO 3	Analyse the operation of chopper-fed DC motor drive in various quadrants
CO 4	Illustrate the various speed control techniques of induction motors
CO 5	Examine the vector control of induction motor drives
CO 6	Distinguish different speed control methods of synchronous motor drives

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	2		-	-	-	-	-	-	1
CO 3	3	2	-	2		-	-	-	-	-	-	1
CO 4	3	2	-	2		-	-	-	-	-	-	1
CO 5	3	1	-	2		-	-	-	-	-	-	1
CO 6	3	2	-	2		-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	20	20	40
Apply (K3)	20	20	40
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the condition for steady state stability (K3,K4, PO1, PO4).

2. Draw the speed torque characteristics of traction drive (K1, PO1).

3. Problems based on fundamental torque equations and equivalent values of drive parameters (K3, K4 , PO2, PO4).

Course Outcome 2 (CO2)

1. Numerical problems based on rectifier controlled separately excited dc motor. (K3, K4, PO2, PO4).

2. Describe the function of a three phase inverter driving a dc motor (K2, PO1).

3. Draw the circuit diagram of dual converter and explain the operation (K1, PO1).

Course Outcome 3(CO3):

1. Explain Motoring and braking operation of chopper controlled DC motor (K2,PO1).

2. Numerical problems based on chopper controlled separately excited dc motor. (K3, K4, PO2, PO4).

3. With the block diagram illustrate the closed loop control of SEDC motor (K2, PO4).

Course Outcome 4 (CO4):

1. List different speed control methods for three phase induction motors (K1, PO1)

2. Discuss sine triangle PWM control of three phase induction motor drive (K2, PO4).

3. Numerical problems based on speed control of induction motor drives (K3,K4, PO2, PO4).

Course Outcome 5 (CO5):

1. Draw the block diagram of direct vector control of induction motor drives (K2, PO1).

2. Figure out the differences of scalar and vector control methods of three phase induction motor (K3, PO1).

3. Draw the decoupled diagram and phasor diagram of three phase induction motor (K2, PO1) .

Course Outcome 6 (CO6):

1. Explain v/f control of three phase synchronous motor drive (K2, PO1).

2. Enumerate different speed control methods of synchronous motor drives (K1, PO1).

3. With the diagram of load commutated CSI synchronous motor drive discuss the operation (K2, PO1).

Model Question Paper

PAGES: 3

QPCODE:

Reg. No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B. TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code**: EET413**

Course Name: **ELECTRIC DRIVES**

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions.
Each question carries 3 Marks

1	Draw the block diagram of an electric drive.
2	List 3 classifications of load torque with one example for each.
3	For a single phase fully-controlled rectifier fed separately excited DC motor, the armature current is assumed to be continuous and ripple free ($i_a = I_a$). Draw the source current waveform for a firing angle of 45˚.

4 Can a half-controlled rectifier fed separately excited DC drive operated in quadrant IV? Justify your answer.

5 Draw the circuit diagram of a two-quadrant (class C) chopper showing the two quadrants of operation.

6 With the help of the torque – speed characteristics of a DC series motor, explain why it is used for high-starting torque applications?

7 Constant torque loads are not suitable for AC voltage controller fed induction motor drive. Why?

8 Why V/f ratio is kept constant upto base speed and V constant above base speed in variable frequency control of an induction motor?

9 Differentiate between true synchronous mode and self-control mode of operation of a synchronous motor.

10 List any two advantages of vector control of 3-phase induction motors.

PART B

Answer any one full question from each module.

Each question carries 14 Marks

Module 1

11	a)	What are the advantages of electric drives?	(7)
	b)	Explain the multi-quadrant operation of a motor driving a hoist load.	(7)
12	a)	Explain about steady state stability of equilibrium point in electric drive.	(7)
	b)	A drive has following parameters: - $J=10kg\text{-}m^2$, $T=100-0.1N$ and $T_l=0.05N$ where N is the speed in rpm. Initially the drive is operating in steady state. Now it is to be reversed. For this motor characteristics is changed to $T = -100-0.1N$. Calculate the time of reversal.	(7)

Module 2

13	a)	Explain the working of 3-phase fully-controlled separately excited DC drive with necessary waveforms.	(7)
	b)	A 220V, 1500rpm, 10A separately excited DC motor is fed from a single phase fully controlled rectifier with an ac source voltage of 230V, 50Hz. $R_a=2\Omega$. Conduction can be assumed to be continuous. Calculate the firing angles for rated motor torque and -1000rpm.	(7)
14	a)	Explain the discontinuous conduction mode of operation of a fully controlled rectifier fed separately excited DC motor with necessary waveforms.	(7)
	b)	Explain the working of a dual converter (circulating current type) fed separately excited DC motor.	(7)

Module 3

15	a)	Explain the operation of four quadrant chopper fed DC drives.	(7)
	b)	A chopper used to control the speed of a separately excited DC motor has supply voltage of 230V, T_{on} = 15ms, T_{off} = 5ms. Assuming continuous conduction of motor current, calculate the average load current when the motor speed is 3000rpm. Assume voltage constant K_v = 0.5V/rad/sec and R_a = 4Ω.	(7)

16	a)	Explain the chopper control of DC series motor.	(7)
	b)	Using a neat block diagram, explain the closed loop speed control for a separately excited DC motor.	(7)

Module 4

17	a)	Explain V/f control of 3-phase induction motor using necessary speed – torque characteristics.	(7)
	b)	A 440V, 3-phase, 50Hz, 6-pole, 945rpm, delta connected induction motor has following parameters referred to the stator: R_s = 2Ω, R_r' = 2Ω, X_s = 3Ω, X_r' = 4Ω. When driving a fan load at rated voltage it runs at rated speed. The motor speed is controlled by stator voltage control. Determine motor terminal voltage, current and torque at 800rpm.	(7)
18	a)	Explain the working of static rotor resistance control of 3-phase induction motor. Also derive the expression for the total rotor circuit resistance per phase.	(7)
	b)	Explain the static slip power recovery scheme using one uncontrolled bridge rectifier and one controlled bridge rectifier in the rotor circuit.	(7)

Module 5

19	a)	Describe the principle of operation of vector control.	(7)
	b)	Explain the variable frequency control of multiple synchronous motor.	(7)
20	a)	Explain Clerke and Park transformation with necessary equations.	(5)
	b)	Describe the working of a self-controlled synchronous motor drive employing load commutated thyristor inverter.	(9)

Syllabus (36 hours)

Module 1 (6 hours)

Introduction to electric drives – block diagram – advantages of electric drives – dynamics of motor load system, fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- effect of gearing - steady state stability.

Module 2 (7 hours)

Rectifier control of DC drives- separately excited DC motor drives using controlled rectifiers-single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode.

Module 3 (6 hours)

Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor.

Module 4 (10 hours)

Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - below and above base speed – Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below synchronous speed.

Module 5 (7 hours)

Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram [Ref.1].

Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated CSI fed synchronous motor.

Note: Simulation assignments can be given using modern simulation tools like MATLAB, PSIM, PSpice, LTspice etc. from all modules of 2, 3, 4 and 5.

Text Books

1.G. K. Dubey, "Fundamentals of Electric Drives", Narosa publishers, second edition, 2001

Reference Books.

1. Bimal K.Bose, "Power Electronics and and Motor Drives", Academic press, An Imprint of Elsevier, 2006.
2. Vedam Subrahmanyam, "Electric Drives Concepts and Applications", MC Graw Hill Education, second edition, 2011,New Delhi.
3. Dr. P. S. Bimbhra, "Power Electronics", Khanna publishers, fifth edition, 2012.
4. Ned Mohan, Tore M Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons Inc.,3rd edition
5. Muhammad H.Rashid, "Power Electronics, Devices, Circuits and Applications", Pearson, 3rd edition, 2014
6. R Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Prentice Hall, 2001.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Fundamentals of Electric drives (6 hours)**	
1.1	Introduction to electric drives- block diagram – advantages of electric drives	1
1.2	Dynamics of motor load system, fundamental torque equations,	1
1.3	four quadrant operation of drives	1
1.4	Types of load – classification of load torque	1
1.5	Equivalent values of drive parameters- effect of gearing -	1
1.6	Steady state stability	1
2	**Rectifier Control of DC drives (7 hours)**	
2.1	Rectifier controlled DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives discontinuous mode of operation,	2
2.2	continuous mode of operation - critical speed	1
2.3	single-phase semi converter fed drives (continuous mode of operation)	1
2.4	three-phase semi converter controlled converter fed drives (continuous mode of operation)	1
2.5	Three phase fully controlled converter fed drives (continuous mode of operation)	1
2.6	Dual converter control of DC motor - circulating current mode	1
3	**Chopper control of DC drives (6 hours)**	
3.1	Two quadrant chopper DC drives - motoring and regenerative braking	2
3.2	Four quadrant chopper DC drives	1
3.3	Chopper fed DC series motor drive	2
3.4	Closed loop speed control for separately excited dc motor.	1
4	**Three phase induction motor drives (10 hours)**	
4.1	Stator voltage control - Stator frequency control	1
4.2	v/f control - below and above base speed	2
4.3	Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM	2
4.4	Static rotor resistance speed control employing chopper	1
4.5	Static slip power recovery speed control scheme for speed control below synchronous speed.	1
4.6	Auto Sequential Commutated Current source Inverter (CSI) fed induction motor drives	1
4.7	Current regulated VSI using power semiconductor devices, operation and control scheme - comparison of CSI and VSI fed	2

	drives.	
5	**Concept of space vector , Synchronous motor drives (7 hours)**	
5.1	Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram.	4
5.2	Synchronous motor drives – v/f control – open loop control	1
5.3	Self-controlled mode – load commutated CSI fed synchronous motor.	2