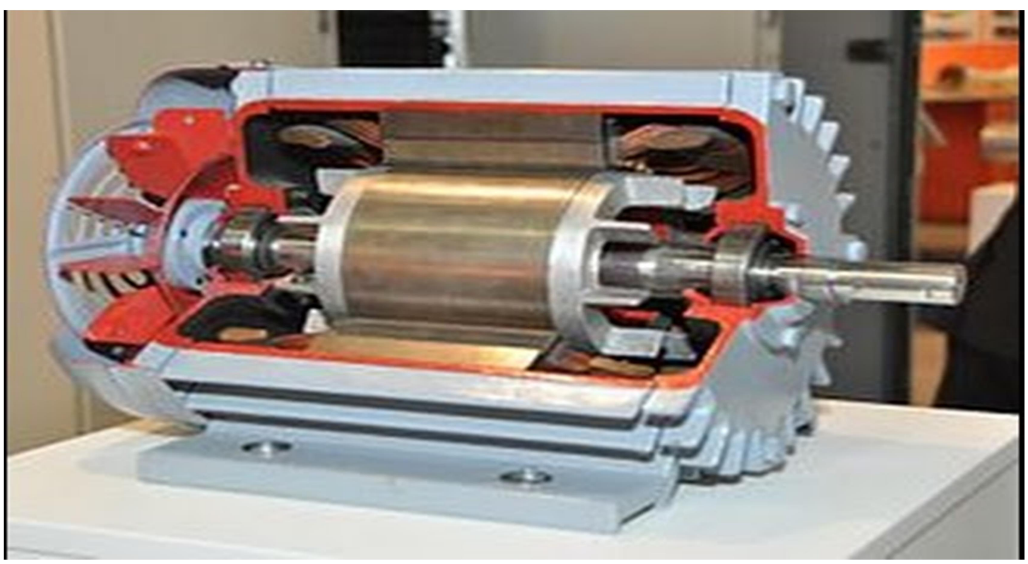
Darbhanga College of Engineering
Darbhanga

Course File
Of
Electrical Machine-I
(100307)



Course Co-ordinator
Prabhat Kumar
Asst. Prof.
EEE Dept., DCE Darbhanga

Content

Vision of Department

To bring forth engineers with an emphasis on higher studies and a fervour to serve national and multinational organizations and the society.

Mission of Department

M1: - To provide domain knowledge with advanced pedagogical tools and applications.
M2: - To acquaint graduates to the latest technology and research through collaboration with industry and research institutes.
M3: - To instil skills related to professional growth and development.
M4: - To inculcate ethical valued in graduates through various social-cultural activities.

PEO of Department

PEO 01 – The graduate will be able to apply the Electrical and Electrical Engineering concepts to excel in higher education and research and development.
PEO 02 – The graduate will be able to demonstrate the knowledge and skills to solve real life engineering problems and design electrical systems that are technically sound, economical and socially acceptable.
PEO 03 – The graduates will be able to showcase professional skills encapsulating team spirit, societal and ethical values.

PSO of Department

PSO 01 Students will be able to identify, formulate and solve problems using various software and other tools in the areas of Automation, Control Systems, Power Engineering and PCB designing.
PSO 02 Students will be able to provide sustainable solutions to growing energy demands.

Course Outcome

1. **Understand** the working principle, construction and operation of transformer and DC machines.
2. **Draw** various performance characteristics of DC motors
3. **Analyse** transformer using phasor diagram.
4. **Select** the speed control and starting method of dc machine.
5. **Acquire** knowledge about testing, performance parameter and application of transformer, dc machines.

Prerequisites

The fundamental knowledge of Engineering Physics and Mathematics.
The fundamental knowledge of Electromagnetic field theory,
Information about different insulation etc.

University Syllabus : Electrical Machines-I

Module 1: Magnetic fields and magnetic circuits (6 Hours)

Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: Electromagnetic force and torque (9 Hours)

B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: Transformers (12 Hours)

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

Module 4: DC machines (8 Hours)

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 5: DC machine - motoring and generation (7 Hours)

Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

Darbhanga College of Engineering

3rd Semester — w.e.f:

DAY	Dept.	09:00-11:00	11:00-01:00	01:00-02:00	02:00-5:00
MONDAY	EEE	EMFT	ECA		V. EM-I Lab
	CE	BIO	Humanity		V.Survey & Geomatics LAB
	CSE	V. AE Lab	DS		V. DS Lab
	ME	TD	BE		Virtual EM Lab - M1
TUESDAY	EEE	EM-I	DE		REMIDAL CLASSES
	CE	Survey & Geomatics	EM		V. BE LAB
	CSE	V. DS Lab	OOPS		REMIDAL CLASSES
	ME	EM	MATH-III		Virtual MD Lab
WEDNESDAY	EEE	EM	ECA		REMIDAL CLASSES
	CE	ICE	M-III		V. CACED LAB
	CSE	V. OOPS Lab	DS		Internship
	ME	BE(T1)	VREMIDAL LAB		MATH-III
THURSDAY	EEE	DE	EMFT		V. EM-I Lab
	CE	INTERNSHIP	EM		V. Survey & Geomatics LAB
	CSE	Tech. Writing	OOPS		V. OOPS Lab
	ME	BIO	MATH-III		Virtual EM Lab - M2
FRIDAY	EEE	HVPE	EM-I		Internship
	CE	Humanity	CACED		Project
	CSE	MIII	AE		V. AE Lab
	ME	TD	EM		Virtual MD Lab
SATURDAY	EEE	EM	HVPE		Project
	CE	BE	INTERNSHIP		REMIDAL CLASSES
	CSE	AE	MIII		REMIDAL CLASSES
	ME	BIO	BE		REMIDAL CLASSES

EEE (3rd Sem)

SN.	Subject	Faculty
1	ECA	Mr. Diwakar Verma
2	EM-I	Mr. Prabhat Kumar
3	DE	Ms. Sweta Kumari
4	EM	Mr. Vikash/Dr. Abhishek
5	EMFT	Dr. Ravi Ranjan/Mr. Ravi Kumar
6	HVPE	Dr. Ratnakshi Roy
7	CD Project	All faculty
8	Intership	All Faculty
9	MOOCS	All Faculty

CE (3rd Sem)

SN.	Subject	Faculty
1	BE	Mr. Deepak Kumar
2	BIO	Kumari Neeraj
3	CACED	Mr. Akash
4	EM	Mr. S. S. Chhoudhary
5	S & Geomatics	Mr. Akash
6	M-III	Dr. R. K. Jha
7	Humanities-I	Dr. Ratnakshi Roy
8	ICE	Mr. Ahsan Rabbani
9	Internship	All Faculty

ME (3rd Sem)

SN.	Subject	Faculty
1	MATH-III	GL-I (MATH)
2	EM	Mr. Vikash Kumar
3	TD	Mr. Navdeep Pandey
4	BE	Mr. Deepak Singh
5	MD	Dr. Md. Asjad Mokhtar
6	BIO	GL (BIO)

CSE (3rd Sem)

SN.	Subject	Faculty
1	DS	Mis. Poonam Prabha
2	OOPS	Mr. Dhirendr Kumar
3	MIII	Mr. Amrit Mahato
4	Tech. Writing	
5	CD Project	All faculty
6	Intership	Mr. Dhirendr Kumar
7	MOOCS	Mr. Anand Kamal

15/07/2020 for, HOD (EEE) — 15/07/2020 HOD (CE) — V. Singh 15/07/2020 HOD (ME) — 15/07/2020 HOD(CSE)

15/7/2020 Asst. Routine Incharge — 15/7/2020 Routine Incharge — 15/07/2020 Principal DCE Darbhanga

13. Lecture schedule with methodology being used/adopted

Unit	S.No.	Name of the Topic	No. of Period	Book Referred	Remarks
1	1	Review of magnetic circuit	1		
	2	Ampere's Law and Biot Savart Law	1		
	3	Visualization of Magnetic field	2		
	4	Influence of highly permeable material on magnetic field	1		
2	5	B-H Curve of Magnetic Materials	2	Electric Machines by DP Kothari & I J Nagrath	
	6	Energy stored in the magnetic circuit	2	”	
	7	Force and torque calculation	2	”	
3	8	Principle, construction and operation of single-phase transformers	2	”	
	9	Equivalent circuit and phasor diagram of transformer	2	”	
	10	voltage regulation, losses and efficiency	1	”	
	11	Testing - open circuit and short circuit tests, polarity test, back-to-back test	2	”	
	12	Three-phase transformer - construction, types of connection and their comparative features	1.5	Electric Machines by DP Kothari & I J Nagrath	
	13	Parallel operation of single-phase and three-phase transformers,	1	”	
	14	Autotransformers - construction, principle, applications and	2	”	

		comparison with two winding transformer,			
	15	Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current,	1	Electric Machines by DP Kothari & I J Nagrath	
	16	Phase conversion - Scott connection, three-phase to six-phase conversion,	1.5	Electric Machines by DP Kothari & I J Nagrath	
	17	Tap-changing transformers. Three-winding transformers.	1	”	
4	18	Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core	2	Electric Machines by DP Kothari & I J Nagrath	
	19	visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole	2	Electric Machines by DP Kothari & I J Nagrath	
	20	induced EMF in an armature coil. Armature winding and commutation -	1	”	
	21	Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation	1.5	Electric Machines by DP Kothari & I J Nagrath	
	22	Derivation of back EMF equation, armature MMF wave, derivation of torque equation	1	”	
	23	armature reaction, air gap flux density distribution with armature reaction.	1	Electric Machines by DP Kothari & I J Nagrath	
	24	Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series.	1	Electric Machines by DP Kothari & I J Nagrath	

5	25	voltage build-up in a shunt generator, critical field resistance and critical speed.	1	”	
		V- I characteristics and torque-speed characteristics of separately excited, shunt and series motors.	1	Electric Machines by DP Kothari & I J Nagrath	
		Speed control through armature voltage.	1.5	”	
		Losses, load testing and back-to-back testing of DC machines	1.5	”	

Question Bank of Transformer:

1 Explain construction features of transformer.

2 Explain working principle of transformer.

3 Explain the role of transformer in power system.

4 Explain current transformer and potential transformer.

5 Discuss the applications of instrument transformers in details.

6 Explain no load characteristics of 1-phase transformer..

7 Explain load characteristics of 1-phase transformer.

8 Explain regulation and its causes in transformer.

9 Explain various types of losses occur in transformer.

10 Explain the no load test in 1-phase transformer.

11 Explain the short circuit test in 1-phase transformer.

12 Explain the various connections for 3-phase transformer.

13 Compare 1-phase transformer with 3-phase transformer.

14 Explain the applications of transformer.

15 Define Transformer. How is the energy transferred from one circuit to another?

16 Give some transformer applications in electronic and control circuits.

17 Why iron is used for the construction of transformer core.

18 Why is the transformer core laminated?

19 Explain the principle of transformer action.

20 Derive an expression for e.m.f. induced in a transformer winding.

21 Draw and explain the no-load phasor diagram of a 1-phase transformer. Discuss how primary leakage flux accounted for in the phasor diagram?

22 Give the concept of single phase ideal transformer. Describe its performance with the help of emf equations, its phasor diagrams at no-load and under load.

23 A single phase transformer is design to operate at rated primary voltage 230 V and at rated frequency 50 Hz. If its primary voltage is increased by10 % on no-load, discuss what would happen to the transformer application?

24 Disuss the advantage of using CRGO laminations in transformer.

25 Explain why transformer rating is expressed in kVA or VA? Describe the significance of all the items mentioned on the name plate of a single phase transformer?

26 Draw the phasor diagram od a loaded single phase transformer and derive from this, the equivalent circuit of a transformer.

27 Develop the exact equivalent circuit of a single phase transformer. From this derive the approximate and simplified equivalent circuits of the transformer. Draw the phasor diagram of a single phase transformer supplying a lagging load, leading load and resistive load.

28 derive an expression for computing the per unit voltage regulation of a transformer both for lagging and leading power factor.

29 A 200-MVA, 15/200-kV single-phase power transformer has a per-unit resistance of 1.2 percent and a per-unit reactance of 5 percent (data taken from the transformer's nameplate). The magnetizing impedance is j80 per unit.

(a) Find the equivalent circuit referred to the low-voltage side of this transformer.

(b) Calculate the voltage regulation of this transformer for a full-load current at power factor of 0.8 lagging.

(c) Assume that the primary voltage of this transformer is a constant 15 kV, and plot

the secondary voltage as a function of load current for currents from no load to full load. Repeat this process for power factors of 0.8 lagging, 1.0, and 0.8 leading

30 A 5000-VA, 480/120-V conventional transformer is to be used to supply power from a

600-V source to a 120-V load. Consider the transformer to be ideal, and assume that all

insulation can handle 600 V.

(a) Sketch the transformer connection that will do the required job.

(b) Find the kilovolt ampere rating of the transformer in the configuration.

(c) Find the maximum primary and secondary currents under these conditions.

31

A 20-kVA, 20,000/480-V, 60-Hz distribution transformer is tested with the following
results:
Open-circuit test(measured from secondary side): VOC = 480 V, IOC = 1.60 A, POC = 305 W
Short-circuit test(measured from primary side): VSC = 1130 V, ISC = 1.00 A, PSC = 260 W
(a) Find the per-unit equivalent circuit for this transformer at 60 Hz.
(b) What would be the rating of this transformer be if it were operated on a 50-Hz
Power system?
(c) Sketch the per-unit equivalent circuit of this transformer referred to the primary
side if it is operating at 50 Hz.

32 The parameters of the equivalent circuit of a 150 kVA, 2400/240-V transformer are:

R_1=0.2 Ω R2=0.002 Ω
X1=0.45 Ω $X2=4.5\times10^{-3}$
Rc = 10k Ω Xm=1.6k Ω(as seen from 2400-V side)

Calculate:

(a) Open-circuit current, power and power factor when LV is excited at rated voltage.
(b) The voltage at which the HV should be excited to conduct a short-circuit test with full-load current flowing. What is the input and its power factor.
(c) Also calculate % voltage regulation and η at full-load and 0.8 pf lagging.

33 The following data were obtained on a 20kVA, 50Hz, 2000/200 V distribution transformer:

	Voltage(V)	Current(A)	Power(P)
Open Circuit Test	200	4	120
Short Circuit Test	60	10	300

With full-load on the LV side at rated voltage, calculate the excitation voltage on the HV side the load power factor is (i) 0.8 lagging (ii) 0.8 leading What is the voltage regulation of the transformer in each case

b)The transformer supplies full-load current at 0.8 lagging power factor with 2000V on the HV

side. Find the voltage at the load terminals and the operating efficiency

34 A sample of iron having a volume of 20 cm^3 is subjected to a magnetizing force varying sinusoidally at a frequency of 400 Hz. The area of the hysteresis loop is found to be 80 cm2 with the flux density plotted in Wb/m^2 and the magnetizing force in At/m. The scale factors used are 1 cm =0.03 T and 1 cm = 200 At/m. Find the hysteresis loss in watts

35 A 10-kVA, 4800V/240V, 50-Hz, single-phase transformer has an equivalent series impedance of 120 + j300 _ referred to the primary high voltage side. The exciting current of the transformer may be neglected.

(a) Find the equivalent series impedance referred to the secondary low-voltage side.

(b) Calculate the voltage at the primary high voltage terminals if the secondary supplies rated secondary current at 230 V and unity power factor.

36 A three-phase, 600-kVA, 2300:230-V,Y–Ytransformer bank has an iron loss of 4400Wand a full load copper loss of 7600 W. Find the efficiency of the transformer for 70% full load at 230 V and 0.85 power factor.

Calculate the voltage output by the secondary winding of a transformer if the primary voltage is 35 volts, the secondary winding has 4500 turns, and the primary winding has 355 turns.

DC Machines

Assignment No -1

1. Which type of DC generator is used in feeders also draw the magnetization characteristics of DC generator?
2. What is back E.M.F in DC motor . why does the sparking occurs at brushes?.
3. State the conditions to be satisfied for building up of voltage in DC Shunt Generator
4. What is armature reaction list various effects due to armature reaction in DC machine ?
5. What is compensating winding, write its function
6. a) Discuss in brief, Different methods of speed control also explain ward Leonard method, with example.

b) A 40 KW 400V 4pole generator has a two layer simplex winding in 30 slots with 12 conductors in each layer. If the brushes are given an actual lead of 10 degree calculate the following:

1) Demagnetizing AT/pole

2) Cross magnetizing At/pole

3) No. of turns per pole on compensating winding if pole arc to pole pitch is 0.8 and brushes are placed on geometric neutral plane ?

Assignment No -2

Q1 Describe the principle of operation of DC Motor and write its torque equation .

Q2 Describe interpole. Also write its effects on field winding of DC motor

Q 3 What is a starter why it is used in DC Motor? Draw the characteristics of DC motor? What is commutation in DC motor Discuss one method most commonly used.

Q4 A shunt generator delivers 195 A at terminal voltage of 200V .the armature resistance and shunt field resistance are 0.3 ohms , 40ohms respectively .yhe iron and friction losses are equal to 900w. Find

a) Generated EMF

b) Copper losses

c) Output of prime mover and

d) Commercial, Mechanical and Electrical efficiencies.

Q5 A 6pole Dc shunt generator has the following data:
field resistance = 120 ohms , armature resistance= 0.8 ohms , no. of conductors= 350 (wave connected). Flux /pole =0.02 Wb . Load resistance across the terminals = 12 ohms, armature rotates at 1000rpm. Calculate the power absorbed by load.

Assignment No -3

Q1 A 10 KW , 6pole DC generator develops an EMF of 200v at 1500rpm . The armature has a lap connected winding. The average flux density over a pole pitch is 0.9 T. the length and diameter of the armature are 0,25 m and 0.2m respectively. Calculate the (i) the flux/ pole
(ii) The total number of active conductors in the armature and (iii) the torque developed by the machine when the armature supplies a current of 50A.

Q2 What is the function of commutator ? give the commutation diagram

Q3 what are interpoles and how are they connected?

Q4 why are the brushes shifted from GNP in a DC generator ?

Q5 What is commutation plane ?

Assignment No -4

Q1 can a shunt generator build up voltage without residual magnetism?

Q2 What do you mean by NO load saturation characteristics?

Q3 what will be the effect on terminal volt when series field is short circuited at full load

Q4 what is parallel operation of DC generator?

Q5 what are the important characteristics of Dc Machines?

Q6 what is cause of mechanical losses in the armature?

Assignment No -5

1 What is the function of compensating windings?

2 Why the field winding having less no of turns in DC series motors?

3 Why are the brushes made of carbon in a DC machines ?

4 What is armature reaction? Write expression for Demagnetizing and cross magnetizing AT /pole

5 What are the conditions for building up voltage in self excited DC shunt generator?

6 What do you mean by NO load saturation characteristics?

7 What will be the effect on terminal volt when series field is open circuited at full load

8 What is OCC of DC generator?

9 What are the important characteristics of DC Machines?

10 what is cause of stray magnetic losses in the armature?

Assignment 6

1. Explain construction features of DC machine.
2. Explain working principle of DC motor.
3. Compare DC generator with DCmotor.
4. Explain types of DCmotors.
5. Discuss electromechanical conversion for electrical machines.
6. Explain the characteristics of DCgenerators.
7. Explain voltage built-up process in DCgenerator.
8. Derive E.M.F. equation of DC generator.
9. Discuss characteristics of DC shunt motor.
10. Discuss characteristics of DC series motor.
11. Explain the role of back emf in DC motor.
12. Explain three point starter used for DC shunt motor.
13. Explain four point starter used for DC shunt motor.
14. Explain methods of speed control for DC motors.
15. Explain characteristics of DC compound motors.
16. Explain ward leonard method for speed control of DC motor.
17. Explain the applications of DC generators.
18. Explain the armature reaction in DC machines.
19. Explain the condition for maximum efficiency in DC generator.
20. Explain the condition for maximum power in DC motor.

21 Explain necessity of starter in DC motor.

22 Derive of torque equation for DCmotor.

23 Explain the concept of static speed control concept of DCmotors.

24 Explain dummy coil importance in DC machines.

25 Compare lap winding with lap winding in DC machines.

26 Explain the process of commutation in DC genenerator