COURSE FILE

Course File contents

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20. Closure Report/Course Review (By the concerned Faculty)

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1. Academic Calendar declared by JNTU Kakinada (and our Institution)
2. First Mid Time Table declared by JNTU Kakinada (and our Institution)
3. First Mid Internal Marks of respective Subject, Mid Marks Analysis and Action Taken Report
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5. Second Mid Internal Marks of respective Subject, Mid Marks Analysis and Action Taken Report
6. End Examinations Time Table declared by JNTU Kakinada
7. Examinations Results declared by JNTU Kakinada
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9. Re Counting/Re Valuation Results declared by JNTU Kakinada

10. Examinations Results Analysis declared by our Institution after RC/RV Results
11. Backlog Classes/Remedial Classes information with necessary Proofs

DADI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by A.I.C.T.E., New Delhi & Permanently Affiliated to JNTUK, Kakinada)

NAAC Accredited Institute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified Institute

NH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DELIVERY PLAN

Subject: Basic Electrical Engineering **Class and Branch : I ECE**

Department: EEE **Academic Year:** 2020-2021

Prepared by Course Instructor
Name : P.Jagruthi
Designation : Assistant Professor
Signature :
Date :

Reviewed by Course Co-Ordinator
Name :
Designation :
Signature :
Date :

Reviewed by Program Co-Ordinator and HOD
Name :
Signature :
Date :

Approved by Academic Convenor
Name :
Signature :
Date :

1.Vision and Mission of the Institute and Department

Vision of the Institute:

To evolve into a premier value based technical institution ensuring academic excellence and promoting innovational research.

Mission of the Institute:

- To impart high quality technical and professional education to uplift the living standards of the youth by focusing on employability, higher education and research.
- To bridge the gap between industry and academia by introducing add on courses based on industrial and academic needs.
- To develop responsible citizens through disciplined career and acceptance of ethical values.
- To be a student centric institute imbibing experiential, innovative and lifelong learning skills addressing societal problems.

Vision of the Department:

To emerge as a hub of producing trained graduates in the field of Electrical and Electronics Engineering

Mission of the Department:

M1. To impart technical knowledge in an effective teaching and learning environment by providing good infrastructural facilities.

M2. To encourage industrial visits, internships, MoUs to promote passion for the industrial needs.

M3. To build a committed framework for promoting collaborative learning to succeed in career.

M4. To encourage co-curricular and extra-curricular activities with an emphasis on enhancing human values and spirited team work.

2. Syllabus of the Course

I Year B.Tech ECE - II Semester		L	T	P	C
		3	0	0	3
BASIC ELECTRICAL ENGINEERING					

Unit I

DC Machines

Principle of operation of DC generator – emf equation – types of DC machines – torque equation of DC motor – applications – three point starter - losses and efficiency - swinburne's test - speed control methods – OCC of DC generator- Brake test on DC Shunt motor-numerical problems

Unit II

Transformers

Principle of operation of single phase transformer constructional features – EMF equation – Losses and efficiency of transformer- regulation of transformer – OC & SC tests predetermination of efficiency and regulations – Sumpner's test-NumericalProblems.

Unit III

Synchronous Generators

Principle of operation and construction of alternators – types of alternators Regulation of alternator by synchronous impedance method-EMF equation of three phase alternator

Synchronous Motors

Construction of three phase synchronous motor - operating principle –equivalent circuit of synchronous motor.

Unit IV

Induction Machine: Principle of operation and construction of three-phase induction motors – slip ring and squirrel cage motors – slip-torque characteristics – efficiency calculation – starting methods-Brake test on 3-Phase Induction Motor.

Unit V

Special Machines: Principle of operation and construction - single phase induction motor - shaded pole motors – capacitor motors and AC servomotor.

TEXT BOOKS

T1. Principles of Electrical Machines by V.K. Mehta &Rohit Mehta,S.Chandpublications
T2. Theory & performance of Electrical Machines by J.B.Guptha, S.K.Kataria&Sons

REFERENCES

R1.Basic Electrical Engineering by M.S.Naidu and S.Kamakshiah,TMH Publications
R2.Fundamentals of Electrical Engineering by Rajendra Prasad, PHI Publications,2nd edition
R3. Basic Electrical Engineering by Nagsarkar,Sukhija, Oxford Publications,2ndedition

3.Additional Reference Books, Journals, websites and E-links

- Electrical machines by Bimbhra
- https://www.mdpi.com/journal/machines/special_issues
- https://www.elprocus.com/what-is-a-shaded-pole-motor-working-its-applications/

4. Gaps in the Syllabus to Meet Industry Requirements (if any)

- As per the industry levels the following are the known gaps of the **BEE** subject which is in the JNTU curriculum:

➢ Braking methods of AC and DC motors

5. Course Handout

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE HANDOUT

Part – A

(Course Description, Course Objectives, Course Outcomes, Course Articulation Matrix)

PROGRAM : I B.Tech., II-Sem., ECE, Section A&B
ACADEMIC YEAR : 2020-2021
COURSE NAME & CODE : Basic Electrical Engineering
L-T-P STRUCTURE : 3-0-0
COURSE CREDITS : 3
COURSE INSTRUCTOR : Ms P Jagruthi
COURSE COORDINATOR : Ms P Jagruthi
PRE-REQUISITE : Physics, Magnetism concepts

COURSE DESCRIPTION : This course covers various topics related to principle of operation and performance of various electrical machines.

COURSE OBJECTIVES

The student will be able

- To understand the principle of operation, constructional details and operational characteristics of DC generators.
- To understand the principle of operation, characteristics of DC motor. Methods of starting and speed control methods of DC motors.
- To learn the constructional details, principle of operation and performance of transformers.
- To study the principle of operation, construction and details of synchronous machines.
- To learn the principle of operation, constructional details, performance, torque – slip characteristics and starting methods of 3-phaseinduction motors.

COURSE OUTCOMES (COs)

After going through this course the student will be able

1. To explain the operation and analyze the characteristics of DC generator and DC motor. Acquire the skills to analyze the starting and speed control methods of DC motors.
2. To explain the operation and tests performed on single-phase transformers. Acquire the skills to analyze its regulation and efficiency
3. To explain the operation of Synchronous Machines

4. To analyze the performance and speed – torque characteristics of a 3-phase induction motor and understand starting methods of 3-phase induction motor.
5. To understand the operation of various special machines.

COURSE ARTICULATION MATRIX (Correlation between COs & POs, PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	3	2	-	-	-	-	-	-	2	3	-
CO2	3	3	-	3	3	-	-	-	-	-	-	2	3	-
CO3	3	3	-	3	3	-	-	-	-	-	-	2	3	-
CO4	3	3	-	3	3	-	-	-	-	-	-	2	3	-
CO5	1	1	-	1	2	-	-	-	-	-	-	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

Course Instructor **Course Coordinator** **Program Co-Ordinator & HOD**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DELIVERY PLAN

Subject : Basic Electrical Engineering **Class& Branch :** I B.Tech II Sem ECE A
Academic Year : 2020-2021 **Regulation** : R20
Faculty Name : P Jagruthi **Designation** : Assistant Professor

S.No	Topic	No. of periods required	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
	UNIT – 1 DC Machines					
1	Principle of operation of DC generator	2	TLM1	19-05-2021		
2	emf equation	1	TLM1	20-05-2021		
3	types of DC machines	2	TLM1	21-05-2021		
4	torque equation of DC motor	1	TLM1	26-05-2021		
5	applications	1	TLM6	26-05-2021		
6	three point starter	2	TLM1	27-05-2021		

7	losses and efficiency	1	TLM1	28-05-2021		
8	swinburne's test	1	TLM7	02-06-2021		
9	speed control methods	2	TLM5	03-06-2021		
10	OCC of DC generator	2	TLM1	04-06-2021		
11	Brake test on DC Shunt motor	2	TLM7	04-06-2021		
12	numerical problems	3	TLM3	09-06-2021		
	UNIT- 2 Transformers					
13	Principle of operation of single phase transformer constructional features	2	TLM1	10-06-2021		
14	EMF equation	1	TLM1	11-06-2021		
15	Losses and efficiency of transformer-	1	TLM4	16-06-2021		
16	regulation of transformer	2	TLM7	17-06-2021		
17	OC & SC tests predetermination of efficiency and regulations	3	TLM7	18-06-2021		
18	Sumpner's test	1	TLM7	23-06-2021		
19	Numerical Problems	3	TLM3	24-06-2021		
	UNIT – 3 Synchronous Generators					
20	Principle of operation and construction of alternators	2	TLM1&2	25-06-2021		
21	types of alternators	1	TLM2	30-06-2021		
22	Regulation of alternator by synchronous impedance method	2	TLM7	01-07-2021		
23	EMF equation of three phase alternator	1	TLM1	02-07-2021		
24	Construction of three phase synchronous motor	1	TLM1	07-07-2021		

25	operating principle	1	TLM2	08-07-2021		
26	equivalent circuit of synchronous motor.	1	TLM1	09-07-2021		

S.No	Topic	No. of periods require	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
	UNIT – 4 Induction Machine					
27	Principle of operation and construction of three-phase induction motors	2	TLM1&2	14-07-2021		
28	slip ring and squirrel cage motors	1	TLM1	15-07-2021		
29	slip-torque characteristics	1	TLM1	16-07-2021		
30	efficiency calculation	2	TLM3	21-07-2021		
31	starting methods	2	TLM2	22-07-2021		
32	Brake test on 3-Phase Induction Motor.	1	TLM7	23-07-2021		
	UNIT – 5 Special Machines					
33	Principle of operation and construction of single phase induction motor	2	TLM1	28-07-2021		
34	shaded pole motors	1	TLM1	29-07-2021		
35	capacitor motor	1	TLM1	06-08-2021		
36	AC servomotor	2	TLM1&8	13-08-2021		

Total No. of classes Required to complete the syllabus: **57**

Course Instructor **Course Coordinator** **Program Co-Ordinator &HOD**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DELIVERY PLAN

Subject : Basic Electrical Engineering **Class& Branch :** I B.Tech II Sem ECE B
Academic Year : 2020-2021 **Regulation** : R20
Faculty Name : P Jagruthi **Designation** : Assistant Professor

S.No	Topic	No. of periods required	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
	UNIT – 1 DC Machines					
1	Principle of operation of DC generator	2	TLM1	17-05-2021		
2	emf equation	1	TLM1	19-05-2021		
3	types of DC machines	2	TLM1	21-05-2021		
4	torque equation of DC motor	1	TLM1	24-05-2021		
5	applications	1	TLM6	26-05-2021		
6	three point starter	2	TLM1	28-05-2021		
7	losses and efficiency	1	TLM1	31-05-2021		
8	swinburne’s test	1	TLM7	02-06-2021		

9	speed control methods	2	TLM5	04-06-2021		
10	OCC of DC generator	2	TLM1	07-06-2021		
11	Brake test on DC Shunt motor	2	TLM7	09-06-2021		
12	numerical problems	3	TLM3	11-06-2021		
	UNIT- 2 Transformers					
13	Principle of operation of single phase transformer constructional features	2	TLM1	14-06-2021		
14	EMF equation	1	TLM1	16-06-2021		
15	Losses and efficiency of transformer-	1	TLM4	18-06-2021		
16	regulation of transformer	2	TLM7	21-06-2021		
17	OC & SC tests predetermination of efficiency and regulations	3	TLM7	23-06-2021		
18	Sumpner's test	1	TLM7	25-06-2021		
19	Numerical Problems	3	TLM3	28-06-2021		
	UNIT – 3 Synchronous Generators					
20	Principle of operation and construction of alternators	2	TLM1&2	30-06-2021		
21	types of alternators	1	TLM2	02-07-2021		
22	Regulation of alternator by synchronous impedance method	2	TLM7	02-07-2021		
23	EMF equation of three phase alternator	1	TLM1	05-07-2021		
24	Construction of three phase synchronous motor	1	TLM1	07-07-2021		
25	operating principle	1	TLM2	09-07-2021		
26	equivalent circuit of synchronous motor.	1	TLM1	12-07-2021		

S.No	Topic	No. of periods require	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
	UNIT – 4 Induction Machine					
27	Principle of operation and construction of three-phase induction motors	2	TLM1&2	14-07-2021		
28	slip ring and squirrel cage motors	1	TLM1	16-07-2021		
29	slip-torque characteristics	1	TLM1	19-07-2021		
30	efficiency calculation	2	TLM3	21-07-2021		
31	starting methods	2	TLM2	23-07-2021		
32	Brake test on 3-Phase Induction Motor.	1	TLM7	26-07-2021		
	UNIT – 5 Special Machines					
33	Principle of operation and construction of single phase induction motor	2	TLM1	28-07-2021		
34	shaded pole motors	1	TLM1	30-07-2021		
35	capacitor motor	1	TLM1	06-08-2021		
36	AC servomotor	2	TLM1&8	13-08-2021		

Total No. of classes Required to complete the syllabus: **57**

Course Instructor **Course Coordinator** **Program Co-Ordinator &HOD**

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Part – C

Name of the Course : BEE **Class& Branch :** I B.Tech II Sem ECE A&B

Academic Year : 2020-2021 **Regulation** : R20

ACADEMIC CALENDAR:

Description	From	To	Weeks
I Phase of Instructions-1	24.05.2021	10.07.2021	7W
I Mid Examinations	05.07.2021	10.07.2021	1W
II Phase of Instructions	12.07.2021	28.08.2021	7W
II Mid Examinations	23.08.2021	28.08.2021	1W
Preparation and Practicals	30.08.2021	04.09.2021	1W
Semester End Examinations	06.09.2021	18.09.2021	2W

EVALUATION PROCESS:

Evaluation Task	**COs**	**Marks**
First Mid Examination	1,2,3	M1=15
First Online Examination	1,2,3	OL1=10
First Assignment	1,2,3	A1=5
First Mid Marks Total (X1)=M1+OL1+A1	1,2,3	X1=30
Second Mid Examination	3,4,5	M2=15
Second Online Examination	3,4,5	OL2=10
Second Assignment	3,4,5	A2=5
Second Mid Marks Total (X2) =M2+OL2+A2	3,4,5	X2=30
Cumulative Internal Examination Marks (X): (80% of Highest + 80% of Lowest)	1,2,3,4,5	X=30
Semester End Examinations	1,2,3,4,5	Y=70
Total Marks: X+Y	1,2,3,4,5	100

Teaching Learning Methods			
TLM1	Chalk and Talk	**TLM5**	Activity based Learning
TLM2	LCD Projector	**TLM6**	Flipped//Blended Learning
TLM3	Tutorial (Problem Solving)	**TLM7**	Experiential Learning
TLM4	Participatory Learning	**TLM8**	Project Based Learning

Course Instructor **Course Coordinator** **Program Co-Ordinator &HOD**

6. PEOs and PO's

Program Educational Objectives

Program Educational Objectives of the UG in Electrical and Electronics Engineering are:

PEO 1. Students shall be engaged in ongoing learning and professional development through continuous education in electrical and electronics engineering and also in the fields related to electrical engineering.
PEO 2. Students shall be adapting updated knowledge exhibiting critical thinking skills and problem solving. skills in professional engineering practices to tackle the technical challenges for the benefit of the society
PEO 3. Students shall sustain in supportive and leading roles by improving good communication skills and by developing social ethical values.

Programme Outcomes

The Program Outcomes of UG in Electrical and Electronics Engineering are:

POs & PSO REFERENCE

Program Specific outcomes

PSO 1: Graduates are capable to demonstrate their logical and technical skills in analyzing various electrical systems

PSO 2: Graduates can transform and provide solution ethically and professionally for societal and environmental electrical engineering problems

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	
PO2	Problem Analysis	PO8	Ethics	PSO2	
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

PROGRAM OUTCOMES (POs):

PO 1:	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2:	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3:	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4:	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5:	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
PO 6:	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO 7:	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8:	**Ethic**s: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9:	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10:	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11:	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12:	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

7. List of the Students of the Class with Roll Numbers

I B.TECH II SEM STUDENTS LIST (A.Y 2020-21)

ECE-A (2020 Admitted Batch)

S.No.	HT.No	StudentName	Remarks
1	20U41A0401	ADARI YASHWANTHINI	
2	20U41A0402	BODDAPATI MEGHANA	
3	20U41A0403	MODE DEEPTHI	
4	20U41A0404	VASIREDDI SIVAJI	
5	20U41A0405	MATHALA VIJAYA	
6	20U41A0406	CHATTI DIVYA	
7	20U41A0407	ALLU ROOPA DEVI	
8	20U41A0408	KANDREGULA SANJANA	
9	20U41A0409	KARANAM AKHIL	
10	20U41A0410	VIYYAPU LOKESH	
11	20U41A0411	BANDARU AKHILA	
12	20U41A0412	VARRE ROHITH	
13	20U41A0413	YERUKULA SRIRAM SAI KUMAR	
14	20U41A0414	KASIREDDY SHYAM SAMPATH KUMAR	
15	20U41A0415	PADALA PREETHI	
16	20U41A0416	APPANA PREM VASANTH KUMAR	
17	20U41A0417	ALAJANGI BARGAVI	
18	20U41A0418	TAMARANA RAMA GANESH	
19	20U41A0419	KONATHALA DIVYASREE	
20	20U41A0420	KONCHADA REVANTH	

21	20U41A0421	ADARI KUSUMA	
22	20U41A0422	SARAGADAM PARNITHA	
23	20U41A0423	GANTA SUNIL KUMAR	
24	20U41A0424	DANNINA NAVYA	
25	20U41A0425	BOTTA BHANU LOKESH	
26	20U41A0426	MADETI NAVEENA	
27	20U41A0427	ADARI PRUDHVI	
28	20U41A0428	NEMALAPURI PRAVEENKUMAR	
29	20U41A0429	AMPOLU SAI TEJA	
30	20U41A0430	MAMIDI MOUNIKA	
31	20U41A0431	RANGU RAJASHEKAR	
32	20U41A0432	BALAJI VEYYIDHANAMULA	
33	20U41A0433	ATHOTA DINESH RAJ	
34	20U41A0434	KARANAM AJITH KUMAR	
35	20U41A0435	SATYALA SAI SRUJANA	
36	20U41A0436	PITHANI MURARI	
37	20U41A0437	VIYYAPU MOUNIKA SAI	
38	20U41A0438	PATNALA DEEPAK	
39	20U41A0439	TULAGAPU VINAY	
40	20U41A0440	PALLA ROHIT	
41	20U41A0441	BESETTI NANI AVINASH RATNA	
42	20U41A0442	GALLA VAHINI KRISHNA	
43	20U41A0443	MOYYA SAI MANI KANTA	
44	20U41A0444	SHANMUKHA NAIDU DATTI	

45	20U41A0445	BODDEDA KUSUMA	
46	20U41A0446	KARUKONDA SHIVA NAGA SAI ABHISHEK	
47	20U41A0447	KONATHALA MANOJ BABU	
48	20U41A0448	SIDDANATHI LEELADHAR	
49	20U41A0449	PYLA SIVA DURGA MANI TEJA	
50	20U41A0450	NANDANA SAI KUMAR GOUD	

I B.TECH II SEM STUDENTS LIST (A.Y 2020-21)
ECE-B (2020 Admitted Batch)

S.No.	HT.No	StudentName	Remar
1	20U41A0451	TENTU PRATYUSHA	
2	20U41A0452	LAKKOJU VEERENDRA SAI	
3	20U41A0453	TATTIKOTA RAMYA	
4	20U41A0454	TALARI SANDHYA SRI	
5	20U41A0455	PUCHAKAYALA VENKATA SATYANARAYANA REDDY	
6	20U41A0456	BONDA MOHAN KIRAN	
7	20U41A0457	MD HASSAIN AKRAM	
8	20U41A0458	PUTREVU JAI DEEP	
9	20U41A0459	BANDARU JYOTSNA	
10	20U41A0460	KANTREDDY LIKHITH	
11	20U41A0461	PATINA SHANKAR YASHWANTH	
12	20U41A0462	KOTYADA SAI ESWAR	
13	20U41A0463	MEDIBOYINA VAMSI	

14	20U41A0464	KOTAPADU SRINU	
15	20U41A0465	GANISETTI POORNA CHANDRA	
16	20U41A0466	VEGI MANI KISHOR	
17	20U41A0467	JANAPATI SESHA SAI MONIKA	
18	20U41A0468	KOIDALA NIKIL	
19	20U41A0469	RAVI JAYANTHI	
20	20U41A0470	BUDDHA JYOTSNA	
21	20U41A0471	CHANDAKA KIRAN KUMAR	
22	20U41A0472	MARADUPUDI PRANUSHA	
23	20U41A0473	PEMMADA SYAMA	
24	20U41A0474	BODDEDA SYAMJAY MADHAV	

8. Class Time Table and Individual Time Table

Brach: ECE --A Course/Year/sem:-B.Tech/I/II Academic Year -2020-21

W.e.f: 17/5/2021 LH:11 Class Teacher :Dr.K.MADHAVI Strength:50

Day/ Time	9-9.50 AM	9.50-10.40 AM		11-11.50AM	11:50-12:40PM		1.30- 2.20PM	2.20- 3.00PM
Monday	M-II		B R E A K	AP		L U N C H	NA	ES
Tuesday	NA			OOPS			AP	
Wednesday	AP			M-II			BEE	
Thursday	BEE			OOPS			NA	
Friday	OOPS			BEE	ES		M-II	

Brach: ECE-B Course/Year/sem:-B.Tech/I/II Academic Year -2020-21

W.e.f:: 17/5/2021 LH:12 Class Teacher :S.VANAJA Strength:24

Day/Time	9-9.50AM	9.50-10.40 AM		11-11.50AM	11:50-12:40PM		1.30-2.20PM	2.20-3.00PM
Monday	AP		B R E A K	OOPS		L U N C H	BEE	ES
Tuesday	OOPS			M-II			AP	
Wednesday	NA			BEE			M -II	
Thursday	M-II			NA	ES		OOPS	
Friday	NA			AP			BEE	ES

INDIVIDUAL:

	I	II		III	IV		V	VI
MON			**BREAK**	**PEPLC-B**		**LUNCH**	**BEE B**	
TUE	**PEPLC-A**	**PEPLC-A**					**PEPLC-B**	**PEPLC-B**
WED	**PEPLC-B**	**PEPLC-B**		**BEE B**	**BEE B**		**BEE A**	**BEE A**
THU	**BEE A**	**BEE A**		**PEPLC-A**	**PEPLC-A**			
FRI				**BEE A**	**PEPLC-A**		**BEE B**	

9. Tutorial Questions (Unit wise)

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NH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM **: I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR **:** 2020-2021

COURSE NAME & CODE **:** BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –1

Date:

1. Derive the torque equation of d.c. motor from the fundamentals

2. A long shunt compound d.c. generator delivers 25 kW to a load at 500V. The generator has shunt field, series field and armature resistance of 250 _, 0.03 _ and 0.05 _ respectively. Draw the schematic diagram of the generator. Calculate various branch currents and voltage generated in the armature winding. Assume 1V drop per brush.

Signature of Course Instructor

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –2

Date:

1. What are the losses that occur in a transformer and how can these losses be reduced?

2. Demonstrate Sumpner's test for testing two single phase transformers? Also explain why this test is beneficial.

Signature of Course Instructor

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –3

Date:

1. Explain the synchronous impedance method for determining regulation of alternator.

2. Describe the constructional details of salient pole alternator with neat sketches

Signature of Course Instructor

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –4

Date:

1. Explain the principle of operation of synchronous motor, describe its equivalent Circuit with neat sketch.

2. Explain the construction and working of synchronous motor

Signature of Course Instructor

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –5

Date:

1. The power supplied to a three-phase induction motor is 40 kW and the stator losses are 2 kW. If the slip is 4 per cent determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if frictional and wind age losses are 1.48 kW, and (iv) the efficiency of the motor, neglecting rotor iron loss.

2 . Sketch the torque speed characteristics of three phase induction motor and explain

Signature of Course Instructor

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

TUTORIAL –6

Date:

1. Describe the constructional details of shaded pole motor and explain its working

2. Draw the circuit diagram of a capacitor-start capacitor-run single phase induction motor and explain its working

Signature of Course Instructor

Course Instructor **Course Coordinator** **Program Co-Ordinator & HOD**

10. Assignment Questions (Unit wise)

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Phone: 08924-221111 / 221122/9963981111, www.diet.edu.in, E-mail: info@diet.edu.in
Department of EEE

Assignment 1

CLASS : **I** B.Tech., II-Sem., ECE., Section-A/Section B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Marks/Assignment : 1
Date of Assignment :

Note: Students have to submit the Assignment by

UNIT-1 : DC Machines

1. Derive the torque equation of d.c. motor from the fundamentals

2. A long shunt compound d.c. generator delivers 25 kW to a load at 500V. The generator has shunt field, series field and armature resistance of 250 _, 0.03 _ and 0.05 _ respectively. Draw the schematic diagram of the generator. Calculate various branch currents and voltage generated in the armature winding. Assume 1V drop per brush.

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Department of EEE

Assignment 2

CLASS : **I** B.Tech., II-Sem., ECE., Section-A/Section B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Marks/Assignment : 1

Date of Assignment :

Note: Students have to submit the Assignment by

UNIT-2 : Transformers

1. What are the losses that occur in a transformer and how can these losses be reduced?

2. Demonstrate Sumpner's test for testing two single phase transformers? Also explain why this test is beneficial.

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Department of EEE

Assignment 3

CLASS : **I** B.Tech., II-Sem., ECE., Section-A/Section B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Marks/Assignment : 1
Date of Assignment :

Note: Students have to submit the Assignment by

UNIT – 3 Synchronous Generators

1. Explain the synchronous impedance method for determining regulation of alternator.

2. Describe the constructional details of salient pole alternator with neat sketches

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Assignment 4

CLASS : **I** B.Tech., II-Sem., ECE., Section-A/Section B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Marks/Assignment : 1

Date of Assignment :

Note: Students have to submit the Assignment by

UNIT – 4 Induction Machine

1. The power supplied to a three-phase induction motor is 40 kW and the stator losses are 2 kW. If the slip is 4 per cent determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if frictional and wind age losses are 1.48 kW, and (iv) the efficiency of the motor, neglecting rotor iron loss.

2 . Sketch the torque speed characteristics of three phase induction motor and explain

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Department of EEE

Assignment 5

CLASS **: I** B.Tech., II-Sem., ECE., Section-A/Section B

ACADEMIC YEAR **:** 2020-2021

COURSE NAME & CODE **:** BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR **:** Ms. P.Jagruthi, Assistant Professor

Marks/Assignment : 1
Date of Assignment :

Note: Students have to submit the Assignment by

UNIT – 5 Special Machines

1. Describe the constructional details of shaded pole motor and explain its working

2. Draw the circuit diagram of a capacitor-start capacitor-run single phase induction motor and explain its working

Course Instructor **Course Coordinator** **Program Co-Ordinator &HOD**

11. Quiz Questions/Objective type Questions (Unit wise)

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Date:

Quiz Questions/Objective type Questions

UNIT-1

1. 1. What will happen if DC shunt motor is connected across AC supply?
   a) Will run at normal speed
   b) Will not run
   c) Will Run at lower speed
   d) Burn due to heat produced in the field winding
2. 4. Which part will surely tell that given motor is DC motor and not an AC type?
   a) Winding
   b) Shaft
   c) Commutator
   d) Stator
3. Direction of rotation of motor is determined by ____________
   a) Faraday's law
   b) Lenz's law
   c) Coulomb's law
   d) Fleming's left-hand rule
4. The current drawn by the armature of DC motor is directly proportional to ________________
   a) Torque
   b) Speed
   c) The voltage across the terminals
   d) Cannot be determined
5. Which power is mentioned on a name plate of a motor?
   a) Gross power
   b) Power drawn in kVA
   c) Power drawn in kW
   d) Output power available at the shaft

6. In DC machines the residual magnetism is present. The order of residual magnetism is ___________
   a) 2 to 3 per cent
   b) 10 to 15 per cent
   c) 20 to 25 per cent
   d) 50 to 75 per cent
7. Torque developed by a DC motor depends upon _____________
   a) magnetic field
   b) active length of the conductor
   c) current flow through the conductors
   d) Current, active length, no. of conductors, magnetic field all

8. Armature resistance control method is used for the speed _____________
a) Above rated speed
b) Below rated speed
c) Can be used anywhere
d) Can't tell

UNIT-2

1. Transformer core is generally made of ___________
a) Single block of core material
b) By stacking large number of sheets together
c) Can be made with any of the above method
d) Cannot be determined

2. Transformer core is constructed for ______________
a) Providing least effective magnetic linkage between two windings
b) Providing isolation between magnetic linkages of one coil from another
c) Providing most effective magnetic linkage between two windings
d) Cannot be determined

3. Which of the following statements is/are correct?
a) High frequency power supplies are light weight
b) Transformer size gets reduced at high frequency
c) Transformer size is more at higher frequency
d) High frequency power supplies are light weight and transformer size gets reduced at high frequency

4. In various radio devices and testing instruments we use ______________
a) Iron core transformer
b) Air core transformer
c) W/O core transformer
d) Any transformer can be used

5. Which type of flux does transformer action need?
a) Constant magnetic flux
b) Increasing magnetic flux
c) Alternating magnetic lux
d) Alternating electric flux

6. Different core construction is required for core type and shell type transformer.
a) True
b) False

7. There is only one magnetic flux path in the circuit. The transformer is definitely _________________
a) Core type
b) Shell type
c) Can be any of the above
d) Depends on other parameters

8. Which of the following is correct statement?
a) Core type transformer has more output than shell type
b) Core type transformer has higher efficiency compare to shell type
c) Core type transformer has lower efficiency than shell type

9. Sumpner's test is conducted on transformers to study effect of _____________
a) Temperature
b) Stray losses
c) All-day efficiency
d) Cannot be determined

10. Which of the following tests are enough to find all the parameters related to a transformer?
a) OC test
b) OC, SC test
c) OC, SC, Sumpner's test
d) Sumpner's test

UNIT-3

1. How many factors does the design of rotor of synchronous machines depend upon?
   a) 2
   b) 3
   c) 4
   d) 5
2. What is the formula for the flux in pole body?
   a) flux in pole body = leakage coefficient * useful flux per pole
   b) flux in pole body = leakage coefficient / useful flux per pole
   c) flux in pole body = leakage coefficient – useful flux per pole
   d) flux in pole body = leakage coefficient + useful flux per pole

3. How many types of losses are present in synchronous machines?
a) 7
b) 3
c) 4
d) 5

4. What is the classification of the iron loss due to the main field?
a) hysteresis loss
b) eddy current loss
c) hysteresis loss or eddy current loss
d) hysteresis loss and eddy current loss

5. What is the formula for the copper loss in the synchronous machine?
a) copper loss per phase = current per phase * dc resistance
b) copper loss per phase = current per phase2 * dc resistance^2
c) copper loss per phase = current per phase2 * dc resistance
d) copper loss per phase = current per phase * dc resistance^2

6. What is the cause of the stray load losses in the synchronous machine?
a) stray field
b) stray armature
c) stray field and stray armature
d) stray field or stray armature

7. What factors does the friction and windage loss depend upon?
a) construction of the machine
b) speed of the machine
c) rating of the machine
d) construction, speed, rating of the machine

8. What factor/s does the cooling coefficient depend upon?
a) speed of the cooling medium
b) configuration of the surface
c) speed of the machine and configuration of the surface
d) speed of the machine or configuration of the surface

9. What all factors does the heat to be dissipated by cooling surfaces depend upon?
a) hysteresis loss
b) eddy current loss
c) heating loss
d) hysteresis, eddy and heating losses

10. How is the voltage related with the air gap density?
a) air gap density is directly proportional to the voltage
b) air gap density is indirectly proportional to the voltage
c) air gap density is directly proportional to the square of the voltage
d) air gap density is indirectly proportional to the square of the voltage

Unit-4

1. The frame of an induction motor is made of _________
   a) Aluminum
   b) Silicon steel
   c) Cast iron
   d) Stainless steel

2. In an induction motor, no-load the slip is generally
1. Less than 1%
2. 5%
3. 2%
4. 4%

3. The shaft of an induction motor must be of
Solid
Hollow
Flexible
Any of the above
4. Slip ring of an induction motor is usually made up of
Aluminium
Copper
Phosphorus Bronze
Carbon

5. The starting torque of a squirrel-cage induction motor is
Full-load torque
Slightly more than full-load torque
Low
Negligible
6. A 50 Hz, 3-phase induction motor has a full load speed of 1440 r.p.m. The number of poles in the motor is
2 pole
4 pole
6 pole
8 pole
7. A three phase, 50 Hz induction motor has a full load speed of 1440 rpm. The full load slip will be
3%
5%
4%
2%

8 The good power factor of an induction motor can be achieved if the average flux density
in the air gap is
Infinity
Large
Absent
Small

9. The crawling in the induction motor is caused by
High Loads
Low Voltage supply
Harmonic developed in the motor
Improper design of machine

10. If any two phases for an induction motor are interchanged
The motor will run in the reverse direction
The motor will continue to run in the same direction
The motor will stop
The motor will Burn

Unit-5

1. What is the lamination used for the stator?
   a) cast iron
   b) die cast aluminium alloy frame
   c) cast iron or die cast aluminium alloy frame
   d) cast iron and die cast aluminium alloy frame

2. If the capacitor of a single-phase motor is short-circuited

   1. The motor will not start
   2. The motor will run in the same direction at a reduced speed
   3. The motor will run in the reverse direction
   4. None of the above

3. Which of the following motor will have a relatively higher power factor?

   1. Capacitor start motor
   2. Shaded pole motor
   3. Capacitor run motor
   4. Split phase motor

4. If a particular application needs high-speed and high starting torque, then which of the following motor will be preferred?

   1. Shaded pole motor
   2. Capacitor start motor
   3. Capacitor run motor
   4. Universal Motor

5. In a capacitor start single-phase motor when the capacitor is replaced by a resistance

   1. Motor will consume less power
   2. Motor will continue to run in the same direction
   3. Motor will stop
   4. None of the above

6. A capacitor start a single phase induction motor when the capacitor is replaced by an inductance

   1. Motor will not start
   2. Start and run

3. Small hp motor can start but large hp motor will not start
4. None of the above

7. In shaded pole motor, the direction of rotation of the motor is
    1. From shaded pole to the main pole
    2. From the main pole to the shaded pole
    3. Either 1 or 2
    4. None of the above

8. In a ceiling fan employing capacitor run motor
    1. Primary winding surrounds the secondary winding
    2. Secondary winding surrounds the primary winding
    3. Either 1 or 2
    4. None of the above

9. The rotor slots, in an induction motor, are usually not quite parallel to the shaft because

    1. Improve power factor
    2. Improve efficiency
    3. Reducing the tendency of the rotor teeth to remain under the stator teeth
    4. None of the above

10. If a single-phase induction motor runs slower than normal, the most likely defect is

    1. Short circuit winding
    2. Open circuit winding
    3. Worn bearing
    4. All of the above

12. Question Bank (Descriptive Questions with BLOOMS Taxonomy)

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAM : **I** B.Tech., II-Sem., ECE., Section-A&B

ACADEMIC YEAR : 2020-2021

COURSE NAME & CODE : BASIC ELECTRICAL ENGINEERING

COURSE INSTRUCTOR : Ms. P.Jagruthi, Assistant Professor

Question Number	**Question**	Blooms Taxonomy Level	Related Course Outcome CO	Marks
1	Derive the torque equation of d.c. motor from the fundamentals.	3	1	10
2	What are the losses that occur in a transformer and how can these losses be reduced?	1	2	10
3	Explain the synchronous impedance method for determining regulation of alternator.	3	3	10
4	A long shunt compound d.c. generator delivers 25 kW to a load at 500V. The generator has shunt field, series field and armature resistance of 250 _, 0.03 _ and 0.05 _ respectively. Draw the schematic diagram of the generator. Calculate various branch currents and voltage generated in the	3	1	10

	armature winding. Assume 1V drop per brush.			
5	Demonstrate Sumpner's test for testing two single phase transformers? Also explain why this test is beneficial.	3	2	10
6	Explain the synchronous impedance method for determining regulation of alternator.	3	3	10
7	Demonstrate Swinburne's test with the help of a neat diagram to find out the efficiency of a d.c. machine. What are the main advantages and disadvantages of this test?	3	1	10
8	A single-phase transformer has a voltage ratio of 6:1 and the h.v. winding is supplied at 540 V. The secondary winding provides a full load current of 30 A at a power factor of 0.8 lagging. Neglecting losses, Determine (i) the rating of the transformer, (ii) the power supplied to the load, (iii) the primary current	3	2	10
9	Describe the constructional details of salient pole alternator with neat sketches.	1	3	10
10	Explain the principle of operation of synchronous motor, describe its equivalent Circuit with neat sketch.	3	3	10
11	Describe with neat sketches the construction of a 3-phase wound induction motor.	1	4	10
12	Draw the circuit diagram of a capacitor-start capacitor-run single phase induction	3	5	10

	motor and explain its working.			
13	"Speed of the synchronous motor is constant." Defend the above statement. Describe how the torque is produced in this motor.	2	3	10
14	The power supplied to a three-phase induction motor is 40 kW and the stator losses are 2 kW. If the slip is 4 per cent determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if frictional and wind age losses are 1.48 kW, and (iv) the efficiency of the motor, neglecting rotor iron loss.	3	4	10
15	Describe the constructional details of shaded pole motor and explain its working.	1	5	10
16	Explain the construction and working of synchronous motor	1	3	10
17	Sketch the torque speed characteristics of three phase induction motor and explain.	3	4	10
18	Infer why the single phase induction motors do not have a starting torque.	2	5	10

CO : Course Outcomes Blooms Taxonomy Levels
L1: Remembering
L2 : Understanding
L3 : Applying
L4 : Analysing
L5 : Evaluating
L6 : Creating

13. Previous University Question papers (Minimum Five)

Code No: R19ES1211 **R19** SET - 1

I B. Tech II Semester Regular Examinations, December - 2020
BASIC ELECTRICAL ENGINEERING
(Com. to ECE, EIE)

Time: 3 hours Max. Marks: 75

Answer any five Questions one Question from Each Unit
All Questions Carry Equal Marks

~~~~~~

1. a) Derive the torque equation of d.c. motor from the fundamentals. (8M)

   b) A long shunt compound d.c. generator delivers 25 kW to a load at 500V. The generator has shunt field, series field and armature resistance of 250 Ω, 0.03 Ω and 0.05 Ω respectively. Draw the schematic diagram of the generator. Calculate various branch currents and voltage generated in the armature winding. Assume 1V drop per brush. (7M)

Or

2. a) Describe Swinburne's test with the help of a neat diagram to find out the efficiency of a d.c. machine. What are the main advantages and disadvantages of this test? (10M)

   b) The shaft torque required to drive a d.c. generator is 18.7 Nm when it is running at 1250 r.p.m. If its efficiency is 87% under these conditions and the armature current is 17.3 A, determine the voltage at the terminals of the generator. (5M)

3. a) What are the losses that occur in a transformer and how can these losses be reduced? (8M)

   b) The equivalent impedance referred to the primary of a 2300/230 V, 500-kVA, single-phase transformer is (7M)

$$Z = 0.2 + j0.6\ \Omega$$

   Calculate the percentage voltage regulation when the transformer delivers rated capacity at 0.8 power factor lagging at rated secondary voltage. Find the efficiency of the transformer at this condition given that core losses at rated voltage are 2 kW.

Or

4. a) Explain Sumpner's test for testing two single phase transformers? Also explain why this test is beneficial. (8M)

   b) A single-phase transformer has a voltage ratio of 6:1 and the h.v. winding is supplied at 540 V. The secondary winding provides a full load current of 30 A at a power factor of 0.8 lagging. Neglecting losses, find (i) the rating of the transformer, (ii) the power supplied to the load, (iii) the primary current (7M)

5. a) Describe the constructional details of salient pole alternator with neat sketches. (8M)

   b) Explain the principle of operation of synchronous motor, describe its equivalent circuit. (7M)

Or

6. a) Explain the synchronous impedance method for determining regulation of alternator. (8M)

   b) Why the speed of the synchronous motor is constant? Describe how the torque is produced in this motor. (7M)
~~~~~~

7. a) Describe with neat sketches the construction of a 3-phase wound induction motor. (8M)

   b) The power supplied to a three-phase induction motor is 40 kW and the stator losses are 2 kW. If the slip is 4 per cent determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if frictional and wind age losses are 1.48 kW, and (iv) the efficiency of the motor, neglecting rotor iron loss. (7M)

Or

8. a) A three-phase, 60-Hz induction motor runs at almost 1800 rpm at no load, and at 1710 rpm at full load. (8M)
   a) How many poles does the motor have?
   b) What is the per-unit slip at full load?
   c) What is the frequency of rotor voltages at full load?
   d) At full load, find the speed of (i) the rotor field with respect to the rotor, (ii) the rotor field with respect to the stator, and (iii) the rotor field with respect to the stator field

   b) Describe the torque speed characteristics of three phase induction motor with neat sketch. (7M)

9. a) Discuss why the single phase induction motors do not have a starting torque. (7M)

   b) Draw the circuit diagram of a capacitor-start capacitor-run single phase induction motor and explain its working. (8M)

Or

10. a) Describe the constructional details of shaded pole motor and explain its working. (10M)

    b) Explain the working principle of a.c. servo motors with neat sketches. (5M)

Code No: R19ES1211 **R19** SET - 2

I B. Tech II Semester Regular Examinations, December - 2020
BASIC ELECTRICAL ENGINEERING
(Com. to ECE, EIE)

Time: 3 hours Max. Marks: 75

Answer any five Questions one Question from Each Unit
All Questions Carry Equal Marks

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1. a) Explain the necessity of starter in a d.c. motor and describe three point starter with a neat sketch. (8M)

   b) A short shunt compound d.c. generator delivers 25 kW to a load at 250V. The generator has shunt field, series field and armature resistance of 130 Ω, 0.1 Ω and 0.1 Ω respectively. Draw the schematic diagram of the generator. Calculate various branch currents and voltage generated in the armature winding. Assume 1V drop per brush. (7M)

Or

2. a) Draw and explain power flow diagrams of a d.c. generator and a d.c. motor. (8M)

   b) A 220 V d.c. shunt motor has armature and field resistance as 0.8 Ω and 200 Ω. During Swinburne's test, current drawn from the supply is found to be 2.5 A. Estimate the efficiency of the machine,(i) When it is running as a motor drawing a line current of 40 A from the 220 V supply.(ii) When it is running as a generator delivering a load current of 40 A at 220 V. (7M)

3. a) Define voltage regulation of a transformer, derive the approximate equation of voltage regulation. (8M)

   b) The no-load input power to a 50 kVA, 2300/230 V, single-phase transformer is 200 VA at 0.15 power factor at rated voltage. The voltage drops due to resistance and leakage reactance are 0.012 and 0.018 times rated voltage when the transformer is operated at rated load. Calculate the input power and power factor when the load is 30 kW at 0.8 power factor lagging at rated voltage. (7M)

Or

4. a) Why the primary of the transformer draws current from the mains when the secondary is not carrying any load (open circuit)? (5M)

   b) Determine the efficiency of a 15 kVA transformer for the following conditions: (10M)
   (i) full-load, unity power factor
   (ii) 0.8 full-load, unity power factor
   (iii) half full-load, 0.8 power factor.
   Assume that iron losses are 200 W and the full-load copper loss is300 W

5. a) Derive the e.m.f. equation for an alternator, explain the meaning of (i) distribution factor (ii) coil span factor. (8M)

   b) A three-phase, six-pole, wye-connected synchronous generator is rated at 550 V and has a synchronous reactance X_s= 2 Ω. When the generator supplies 50 kVA at rated voltage and a power factor of 0.95 lagging, find the armature current I_a and the excitation voltage E_f. Sketch the phasor diagram of V_t, I_a, and E_f. Also, determine the regulation corresponding to the operating conditions (7M)

Or

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Code No: R19ES1211 **R19** SET - 2

6. a) What do you mean by synchronous reactance? Explain the term synchronous impedance of an alternator. (8M)

   b) Explain the principle of operation of synchronous motor. (7M)

7. a) Describe with neat sketches the construction of a 3-phase squirrel cage induction motor. (8M)

   b) A four-pole, three-phase induction motor is energized from a 60-Hz supply. It is running at a load condition for which the slip is 0.03. Determine: (i) The rotor speed in rpm. (ii) The rotor current frequency in Hz. (iii) The speed of the rotor rotating magnetic field with respect to the stator frame in rpm. (iv) The speed of the rotor rotating magnetic field with respect to the stator rotating magnetic field in rpm. (7M)

Or

8. a) What is meant by slip in induction motor? Why must slip be present for motor action? (8M)

   b) The power supplied to a three-phase induction motor is 32 kW and the stator losses are 1200 W. If the slip is 5 per cent, determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if friction and windage losses are 750 W, and (iv) the efficiency of the motor, neglecting rotor iron loss. (7M)

9. a) Explain the working of spilt-phase type single phase induction motor. (7M)

   b) Describe the working principle of two-phase a.c. servo motor and describe its characteristics. (8M)

Or

10. a) Describe the constructional details of shaded pole motor and explain its working. (10M)

    b) Enumerate applications of capacitor-start and capacitor-run single phase (5M)
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I B. Tech II Semester Regular Examinations, December - 2020
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(Com. to ECE, EIE)

Time: 3 hours Max. Marks: 75

Answer any five Questions one Question from Each Unit
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1. a) What are the different types of d.c. generators according to the ways in which fields are excited? Show the connection diagram of each type. (8M)

   b) A series motor having a series field resistance of 0.25 Ω and an armature resistance of 0.15 Ω, is connected to a 220V supply and at a particular load runs at 20 rev/s when drawing 20A from the supply. Calculate the e.m.f. generated at this load. Determine also the speed of the motor when the load is changed such that the current increases to 25A. Assume the flux increases by 25 per cent. (7M)

Or

2. a) What are the losses taking place in dc machine and how they vary with load current and derive the condition for maximum efficiency? (8M)

   b) A dc shunt machine has an armature winding resistance of 0.12 Ω and a shunt-field winding resistance of 50 Ω. The machine may be run on 250 V mains as either a generator or a motor. Find the ratio of the speed of the generator to the speed of the motor when the total line current is 80 A in both cases. (7M)

3. a) Explain the necessity for conducting OC and SC tests on a single phase transformer and how they are useful. (8M)

   b) A single phase transformer has 400 primary and 1000 secondary turns. The net cross-sectional area of the core is 60 cm^2. If the primary winding be connected to a 50 Hz supply at 500 V, Calculate (7M)
      (i) The peak value of the flux density in the core, and
      (ii) The voltage induced in the secondary winding.

Or

4. a) Describe the voltage regulation of a single phase transformer. Explain how it is determined. (8M)

   b) A 30KVA, 6000/230V, 50Hz single phase transformer has HV and LV winding resistances of 10.2Ω and 0.0016Ω respectively. The equivalent leakage reactance as referred to HV side is 34Ω. Find the voltage to be applied to the HV side in order to circulate the full load current with LV side short circuited. Also estimate the full load percentage regulation of the transformer at 0.8 lagging power factor. (7M)

5. a) Derive the expressions for (i) distribution factor (ii) coil span factor in an alternator. (8M)

   b) Explain the principle of operation of synchronous motor and describe characteristic features of this motor. (7M)

Or

6. a) Describe phasor diagrams of cylindrical rotor synchronous motor for different power factors. (8M)

   b) A 600 V, 60 kVA, single-phase alternator has an effective armature resistance of 0.3 Ω. An exciting current of 5 A produces an e.m.f. of 400 V on open circuit and an armature current of 200 A on short circuit. Calculate: (7M)
      (i) the synchronous impedance and synchronous reactance.
      (ii) the full load regulation with 0.8 p.f. lagging.

7. a) Why starters are necessary for starting induction motors? Name different starting methods for 3-pahse induction motor. (8M)

   b) A 4-pole, 3-phase induction motor operates from a supply whose frequency is 60 Hz. Calculate : (7M)
      (i) The speed at which the magnetic field of the stator is rotating
      (ii) The speed of the rotor when the slip is 0.04
      (iii) The frequency of the rotor current when slip is 0.03
      (iv) The frequency of the rotor current at standstill.

Or

8. a) Draw the torque-speed characteristics of 3-phase induction and explain how do you obtain this characteristics. (8M)

   b) A 400 V, three-phase, 50 Hz, 2-pole, star-connected induction motor runs at 48.5 rev/s on full load. The rotor resistance and reactance perphase are 0.4 Ω and 4.0 Ω respectively. Calculate at full load (i) the rotor current, (ii) the rotor copper loss, and (iii) the starting current. (7M)

9. a) Explain the working of capacitor-start type single phase induction motor. (8M)

   b) Describe the constructional details of shaded pole single phase induction motor. (7M)
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1. a) What is the principle of operation of d.c. generator and derive its e.m.f. equation? (8M)

   b) A six-pole lap-wound motor is connected to a 250V d.c. supply. The armature has 500 conductors and a resistance of 1 Ω. The flux per pole is 20 mWb. Calculate (i) the speed, (ii) torque developed when the armature current is 40A and what is speed at this load current? (7M)

Or

2. a) Discuss with suitable diagrams different types of dc generators and their field of applications. (8M)

   b) A 350 V shunt motor runs at its normal speed of 720 r.p.m when the armature current is 90 A. The resistance of the armature is 0.3 Ω. (i) Find the speed when the current is 45 A and a resistance of 0.4 Ω is connected in series with the armature, the shunt field remaining constant. (ii) Find the speed when the current is 45 A and the shunt field is reduced to 75% of its normal value by increasing resistance in the field circuit. (7M)

3. a) What are the losses that occur in a transformer and how can these losses be reduced? (8M)

   b) The secondary winding of a transformer has a terminal voltage of $v_s(t) = 282.8 \sin 377t$ V. The turns ratio of the transformer is 100:200 (k = 0.50). If the secondary current of the transformer is $i_s(t) = 7.07 \sin(377t - 36.87°)$ A, what is the primary current of this transformer? What are its voltage regulation and efficiency? The impedances of this transformer referred to the primary side are R_{eq}= 0.20 Ω, R_C= 300 Ω, X_{eq}= 0.75 Ω and X_M=80 Ω. (7M)

Or

4. a) Explain the working principle of transformer and derive its e.m.f. equation. (8M)

   b) A 3-kVA, 220:110-V, 60-Hz, single-phase transformer yields these test data: (7M)
   Open-circuit test: 200 V, 1.4 A, 50 W
   Short-circuit test: 4.5 V, 13.64 A, 30 W
   Determine the efficiency when the transformer delivers a load of 2 kVA at 0.85 power factor lagging.

5. a) Describe the working of synchronous motor and describe why this motor is not self-starting. (8M)

   b) The air gap flux of a 12 pole, 3 phase alternator is 0.058 wb per pole and is distributed sinusoidally over the pole. The stator has 2slots per pole per phase and 8 conductors per slot. The winding is a double layer winding with a coil span of 135^0 electrical apart. Find the voltage generated per phase at no-load when the machine runs at 500 r.p.m. (7M)

Or

6. a) Explain the concept of replacing the armature reaction in n alternator. (8M)

   b) What are the characteristic features of synchronous motor and describe its equivalent circuit. (7M)

7. a) Describe the working of (i) direct on-line starter (ii) auto-transformer starter. (8M)

   b) A three-phase, 50-Hz induction motor has a full load speed of 700 rpm and a no-load speed of740 rpm. (7M)
      a) How many poles does the machine have?
      b) Find the slip and the rotor frequency at full load.
      c) What is the speed of the rotor field at full load (i) with respect to the rotor? and (ii) with respect to the stator?

Or

8. a) Explain the working principle of three phase induction motor with neat sketches. (8M)

   b) The power supplied to a three-phase induction motor is 50 kW and the stator losses are 2 kW. If the slip is 4%, determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if friction and windage losses are 1 kW, and (iv) the efficiency of the motor, neglecting rotor iron losses. (7M)

9. a) Explain the construction and working principle of split-phase motor. (10M)

   b) Explain the working principle of a.c. servo motors with neat sketches. (5M)

Or
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14.GATE Questions (Unit wise)

This subject has no weightage in Gate examination

15.Campus Placement/Interview Questions (Unit wise)

UNIT-1

8. 1. What will happen if DC shunt motor is connected across AC supply?
   a) Will run at normal speed
   b) Will not run
   c) Will Run at lower speed
   d) Burn due to heat produced in the field winding
9. 4. Which part will surely tell that given motor is DC motor and not an AC type?
   a) Winding
   b) Shaft
   c) Commutator
   d) Stator
10. Direction of rotation of motor is determined by ____________
   a) Faraday's law
   b) Lenz's law
   c) Coulomb's law
   d) Fleming's left-hand rule
11. The current drawn by the armature of DC motor is directly proportional to ________________
   a) Torque
   b) Speed
   c) The voltage across the terminals
   d) Cannot be determined
12. Which power is mentioned on a name plate of a motor?
   a) Gross power
   b) Power drawn in kVA
   c) Power drawn in kW
   d) Output power available at the shaft
13. In DC machines the residual magnetism is present. The order of residual magnetism is ___________
   a) 2 to 3 per cent
   b) 10 to 15 per cent
   c) 20 to 25 per cent
   d) 50 to 75 per cent
14. Torque developed by a DC motor depends upon _____________
   a) magnetic field
   b) active length of the conductor
   c) current flow through the conductors
   d) Current, active length, no. of conductors, magnetic field all

8. Armature resistance control method is used for the speed _____________
a) Above rated speed
b) Below rated speed
c) Can be used anywhere
d) Can't tell

UNIT-2

1. Transformer core is generally made of ___________
a) Single block of core material
b) By stacking large number of sheets together
c) Can be made with any of the above method
d) Cannot be determined

2. Transformer core is constructed for ______________
a) Providing least effective magnetic linkage between two windings
b) Providing isolation between magnetic linkages of one coil from another
c) Providing most effective magnetic linkage between two windings
d) Cannot be determined

3. Which of the following statements is/are correct?
a) High frequency power supplies are light weight
b) Transformer size gets reduced at high frequency
c) Transformer size is more at higher frequency
d) High frequency power supplies are light weight and transformer size gets reduced at high frequency

4. In various radio devices and testing instruments we use ______________
a) Iron core transformer
b) Air core transformer
c) W/O core transformer
d) Any transformer can be used

5. Which type of flux does transformer action need?
a) Constant magnetic flux
b) Increasing magnetic flux
c) Alternating magnetic lux
d) Alternating electric flux

6. Different core construction is required for core type and shell type transformer.
a) True
b) False

7. There is only one magnetic flux path in the circuit. The transformer is definitely ________________
a) Core type

b) Shell type
c) Can be any of the above
d) Depends on other parameters

8. Which of the following is correct statement?
a) Core type transformer has more output than shell type
b) Core type transformer has higher efficiency compare to shell type
c) Core type transformer has lower efficiency than shell type

9. Sumpner's test is conducted on transformers to study effect of ____________
a) Temperature
b) Stray losses
c) All-day efficiency
d) Cannot be determined

10. Which of the following tests are enough to find all the parameters related to a transformer?
a) OC test
b) OC, SC test
c) OC, SC, Sumpner's test
d) Sumpner's test

UNIT-3

3. How many factors does the design of rotor of synchronous machines depend upon?
   a) 2
   b) 3
   c) 4
   d) 5
4. What is the formula for the flux in pole body?
   a) flux in pole body = leakage coefficient * useful flux per pole
   b) flux in pole body = leakage coefficient / useful flux per pole
   c) flux in pole body = leakage coefficient – useful flux per pole
   d) flux in pole body = leakage coefficient + useful flux per pole

3. How many types of losses are present in synchronous machines?
a) 7
b) 3
c) 4
d) 5

4. What is the classification of the iron loss due to the main field?
a) hysteresis loss
b) eddy current loss
c) hysteresis loss or eddy current loss
d) hysteresis loss and eddy current loss

5. What is the formula for the copper loss in the synchronous machine?
a) copper loss per phase = current per phase * dc resistance
b) copper loss per phase = current per phase2 * dc resistance^2
c) copper loss per phase = current per phase2 * dc resistance
d) copper loss per phase = current per phase * dc resistance^2

6. What is the cause of the stray load losses in the synchronous machine?
a) stray field
b) stray armature
c) stray field and stray armature
d) stray field or stray armature

7. What factors does the friction and windage loss depend upon?
a) construction of the machine
b) speed of the machine
c) rating of the machine
d) construction, speed, rating of the machine

8. What factor/s does the cooling coefficient depend upon?
a) speed of the cooling medium
b) configuration of the surface
c) speed of the machine and configuration of the surface
d) speed of the machine or configuration of the surface

9. What all factors does the heat to be dissipated by cooling surfaces depend upon?
a) hysteresis loss
b) eddy current loss
c) heating loss
d) hysteresis, eddy and heating losses

10. How is the voltage related with the air gap density?
a) air gap density is directly proportional to the voltage
b) air gap density is indirectly proportional to the voltage
c) air gap density is directly proportional to the square of the voltage
d) air gap density is indirectly proportional to the square of the voltage

Unit-4

1. The frame of an induction motor is made of _________
a) Aluminum
b) Silicon steel
c) Cast iron
d) Stainless steel

2. In an induction motor, no-load the slip is generally

5. Less than 1%
6. 5%
7. 2%
8. 4%

3. The shaft of an induction motor must be of
Solid
Hollow
Flexible
Any of the above
4. Slip ring of an induction motor is usually made up of
Aluminium
Copper
Phosphorus Bronze
Carbon

5. The starting torque of a squirrel-cage induction motor is
Full-load torque
Slightly more than full-load torque
Low
Negligible
6. A 50 Hz, 3-phase induction motor has a full load speed of 1440 r.p.m. The number of poles in the motor is
2 pole
4 pole
6 pole
8 pole
7. A three phase, 50 Hz induction motor has a full load speed of 1440 rpm. The full load slip will be
3%
5%
4%
2%

8 The good power factor of an induction motor can be achieved if the average flux density in the air gap is
Infinity
Large
Absent
Small

9. The crawling in the induction motor is caused by
High Loads
Low Voltage supply
Harmonic developed in the motor
Improper design of machine

10. If any two phases for an induction motor are interchanged
The motor will run in the reverse direction
The motor will continue to run in the same direction
The motor will stop
The motor will Burn

Unit-5

1. What is the lamination used for the stator?
    a) cast iron
    b) die cast aluminium alloy frame
    c) cast iron or die cast aluminium alloy frame
    d) cast iron and die cast aluminium alloy frame

2. If the capacitor of a single-phase motor is short-circuited

    5. The motor will not start
    6. The motor will run in the same direction at a reduced speed
    7. The motor will run in the reverse direction
    8. None of the above

3. Which of the following motor will have a relatively higher power factor?

    5. Capacitor start motor
    6. Shaded pole motor
    7. Capacitor run motor
    8. Split phase motor

4. If a particular application needs high-speed and high starting torque, then which of the following motor will be preferred?

    5. Shaded pole motor
    6. Capacitor start motor
    7. Capacitor run motor
    8. Universal Motor

5. In a capacitor start single-phase motor when the capacitor is replaced by a resistance

    5. Motor will consume less power
    6. Motor will continue to run in the same direction
    7. Motor will stop
    8. None of the above

6. A capacitor start a single phase induction motor when the capacitor is replaced by an inductance

    5. Motor will not start
    6. Start and run
    7. Small hp motor can start but large hp motor will not start
    8. None of the above

7. In shaded pole motor, the direction of rotation of the motor is
    5. From shaded pole to the main pole
    6. From the main pole to the shaded pole
    7. Either 1 or 2
    8. None of the above

8. In a ceiling fan employing capacitor run motor
    5. Primary winding surrounds the secondary winding
    6. Secondary winding surrounds the primary winding
    7. Either 1 or 2

8. None of the above

9. The rotor slots, in an induction motor, are usually not quite parallel to the shaft because

5. Improve power factor
6. Improve efficiency
7. Reducing the tendency of the rotor teeth to remain under the stator teeth
8. None of the above

10. If a single-phase induction motor runs slower than normal, the most likely defect is

5. Short circuit winding
6. Open circuit winding
7. Worn bearing
8. All of the above

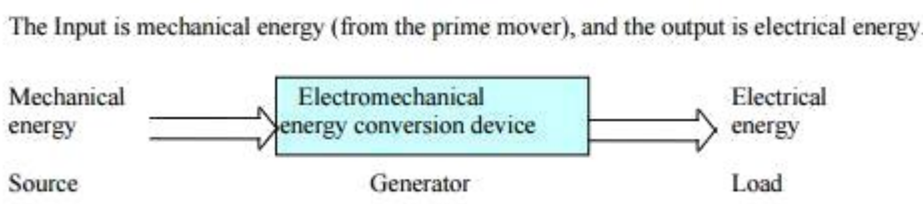
16. Detailed notes (Unit wise):

UNIT-I

Generators

There are two types of generators, one is ac generator and other is dc generator. Whatever may be the types of generators, it always converts mechanical power to electrical power. An ac generator produces alternating power. A DC generator produces direct power. Both of these generators produce electrical power, based on same fundamental principle of Faraday's law of electromagnetic induction. According to these law, when an conductor moves in a magnetic field it cuts magnetic lines force, due to which an emf is induced in the conductor. The magnitude of this induced emf depends upon the rate of change of flux (magnetic line force) linkage with the conductor. This emf will cause an current to flow if the conductor circuit is closed. Hence the most basic two essential parts of a generator are
1. a magnetic field

2. conductors which move inside that magnetic field.



Constructional Features

A DC generator has the following parts

1. Yoke
2. Pole of generator
3. Field winding
4. Armature of DC generator
5. Brushes of generator
6. Bearing

Yoke of DC Generator

Yoke of DC generator serves two purposes,

1. It holds the magnetic pole cores of the generator and acts as cover of the generator.
2. It carries the magnetic field flux.

In small generator, yoke are made of cast iron. Cast iron is cheaper in cost but heavier than steel. But for large **construction of DC generator**, where weight of the machine is concerned, lighter cast steel or rolled steel is preferable for constructing yoke of DC generator. Normally larger yokes are formed by rounding a rectangular steel slab and the edges are welded together at the bottom. Then feet, terminal box and hangers are welded to the outer periphery of the yoke frame.

Armature Core of DC Generator

The purpose of armature core is to hold the armature winding and provide low reluctance path for the flux through the armature from N pole to S pole. Although a DC generator provides directcurrent but induced current in the armature is alternating in nature. That is why, cylindrical or drum shaped armature core is build up of circular laminated sheet. In every circular lamination, slots are either die - cut or punched on the outer periphery and the key way is located on the inner periphery as shown. Air ducts are also punched of cut on each lamination for circulation of air through the core for providing better cooling.

Armature Winding of DC Generator

Armature winding are generally formed wound. These are first wound in the form of flatrectangular coils and are then pulled into their proper shape in a coil puller. Various conductorsof the coils are insulated from each other. The conductors are placed in the armature slots, which are lined with tough insulating material. This slot insulation is folded over above the armature conductors placed in it and secured in place by special hard wooden or fiber wedges.

Commutator of DC Generator

The commutator plays a vital role in dc generator. It collects current from armature and sends itto the load as direct current. It actually takes alternating current from armature and converts it to direct current and then send it to external load. It is cylindrical structured and is build up of wedge - shaped segments of high conductivity, hard drawn or drop forged copper. Each segment is insulated from the shaft by means of insulated commutator segment shown below. Each commutator segment is connected with corresponding armature conductor through segment riser or lug.

Brushes of DC Generator

The brushes are made of carbon. These are rectangular block shaped. The only function of these carbon brushes of DC generator is to collect current from commutator segments. The brushes are housed in the rectangular box shaped brush holder. As shown in figure, the brush face is placed on the commutator segment with attached to the brush holder.

Bearing of DC Generator

For small machine, ball bearing is used and for heavy duty dc generator, roller bearing is used. The bearing must always be lubricated properly for smooth operation and long life of generator.

Emf equation for dc generator

The derivation of **EMF equation for DC generator** has two parts:

1. Induced EMF of one conductor
2. Induced EMF of the generator

Derivation for Induced EMF of One Armature Conductor

For one revolution of the conductor,

Let,

Φ = Flux produced by each pole in weber (Wb) and P

= number of poles in the DC generator.

therefore,Total flux produced by all the poles = ø*p

And,

Time taken to complete one revolution = 60/N

Where,

N = speed of the armature conductor in rpm.

Now,according to Faraday‘s law of induction, the induced emf of the armature conductor isdenoted by –e‖ which is equal to rate of cutting the flux.

Therefore,

$$e = \frac{d\phi}{dt} \;\; and \; e = \frac{total \; flux}{time \; take}$$

Induced emf of one conductor is

$$e = \frac{\phi P}{\frac{60}{N}} = \phi P \frac{N}{60}$$

Derivation for Induced EMF for DC Generator

Let us suppose there are Z total numbers of conductor in a generator, and arranged in such amanner that all parallel paths are always in series. Here,

Z = total numbers of conductorA

= number of parallel paths Then,

Z/A = number of conductors connected in series

We know that induced emf in each path is same across theline

Therefore,

Induced emf of DC generator

E = emf of one conductor × number of conductor connected in series.

Induced emf of DC generator is

$$e = \phi P \frac{N}{60} X \frac{Z}{A} \; volts$$

Simple wave wound generator

Numbers of parallel paths are only 2 = A

Therefore,

Induced emf for wave type of winding generator is

$$\frac{\phi PN}{60} X \frac{Z}{2} = \frac{\phi ZPN}{120} \, volts$$

Simple lap-wound generator

Here, number of parallel paths is equal to number of conductors in one path i.e. P = A

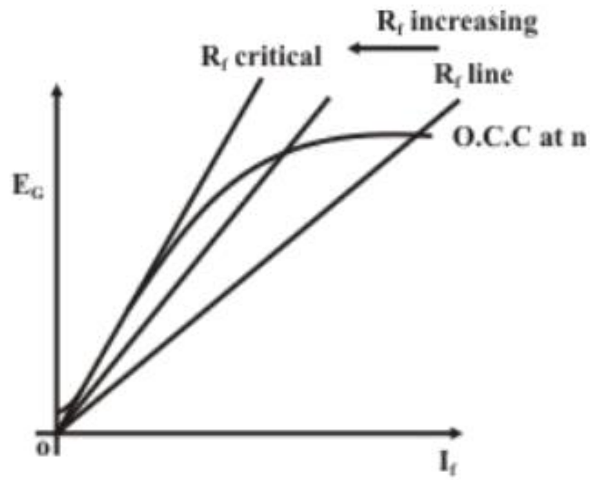
Therefore,

Induced emf for lap-wound generator is

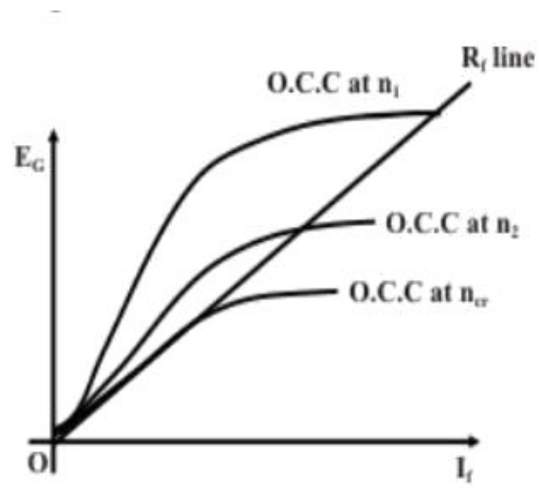
$$E_g = \frac{\phi ZN}{60} X \frac{P}{A} \, volt$$

CRITICAL FIELD RESISTANCE AND CRITICAL SPEED

The **critical field resistance** is the maximum field circuit resistance for a given speed with which the shunt generator would excite. The shunt generator will build up voltage only if field circuit resistance is less than critical field resistance. It is a tangent to the open circuit characteristics of the generator at a given speed.



Suppose a shunt generator has built up voltage at a certain speed. Now if the speed of the prime mover is reduced without changing Rf, the developed voltage will be less as because the O.C.C at lower speed will come down (refer to figure 38.8). If speed is further reduced to a certain critical speed (ncr), the present field resistance line will become tangential to the O.C.C at ncr. For any speed below ncr, no voltage built up is possible in a shunt generator.



Critical speed

METHODS OF EXCITATION

An electric generator or electric motor consists of a rotor spinning in a magnetic field. The magnetic field may be produced by permanent magnets or by field coils. In the case of a machine with field coils, a current must flow in the coils to generate the field, otherwise no power is transferred to or from the rotor. The process of generating a magnetic field by means of an electric current is called ***excitation***.

For a machine using field coils, which is most large generators, the field current must be supplied, otherwise the generator will be useless. Thus it is important to have a reliable supply. Although the output of a generator can be used once it starts up, it is also critical to be able to start the generators reliably. In any case, it is important to be able to control the field since this will maintain the system voltage.

Types of excitation (1)seperately
excited generator.

(2)self excited generator.

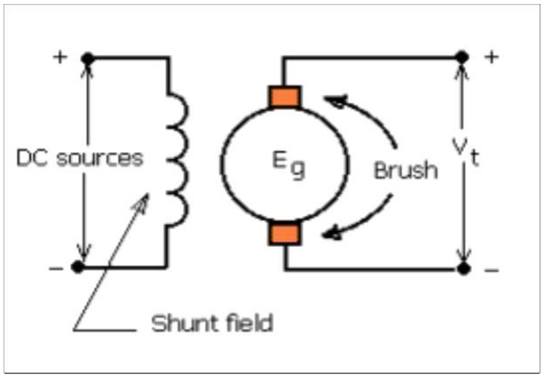
self generator is classified into 3 types.
1.shunt generator.
2.series generator.
3.compoundgenerator.

compoud generator is again classified into 2 types. 1.short shunt generator.

2.long shunt generator.

Separately excited generators.

These kind of generators has provided field exciter terminals which are external DC voltage source is supplies to produce separately magnetic field winding (shunt field) for magnetize of the generator as illustrated in figure as below.



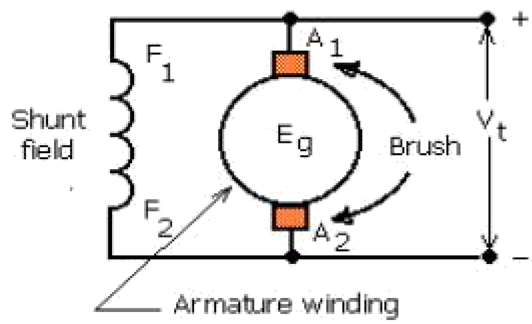
Separately excited generators.

Self excited field generators.

This type of generator has produced a magnetic field by itself without DC sources from an external. The electromotive force that produced by generator at armature winding is supply to a field winding (shunt field) instead of DC source from outside of the generator. Therefore, field winding is necessary connected to the armature winding. They may be further classified as

a) Shunt generator.

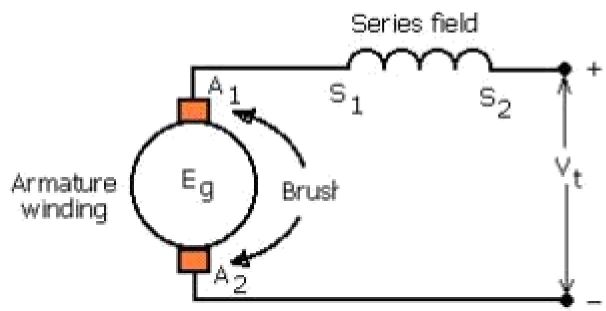
This generator, shunt field winding and armature winding are connected in parallel through commutator and carbon brush as illustrated in the figure below.



Shunt generator

b) Series generator

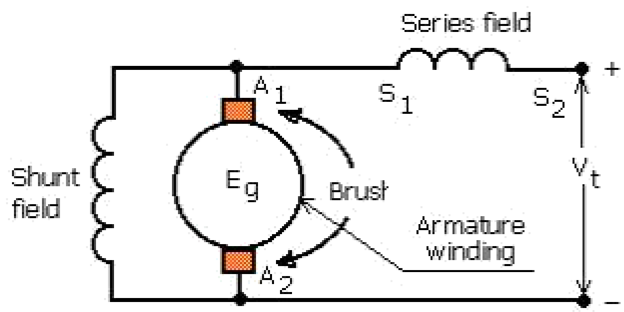
The field winding and armature winding is connected in series. There is different from shunt motor due to field winding is directly connected to the electric applications (load). Therefore, field winding conductor must be sized enough to carry the load current consumption and the basic circuit as illustrated below.



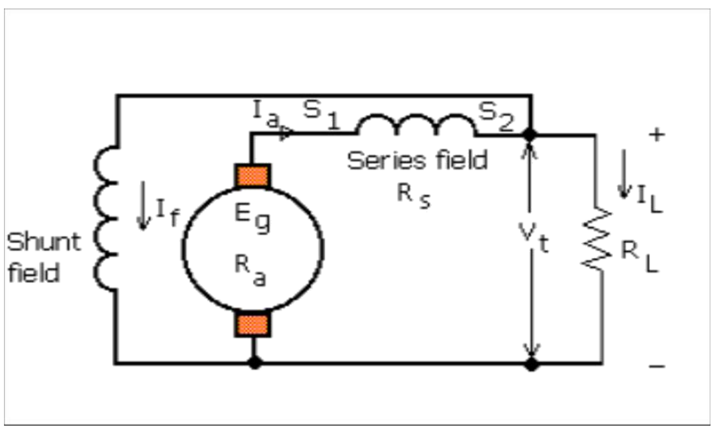
Series generator

c) Compound generator

The compound generator has provided with magnetic field in combine with excitation of shunt and series field winding, the shunt field has many turns of fine wire and caries of a small current, while the series field winding provided with a few turns of heavy wire since it is in series with an armature winding and caries the load current. There are two kinds of compound generator as illustrated in figure 5 and 6.



A short-shunt compound generator



A long-shunt compound generator

Characteristic of separately excited generator

The generated electromotive force (EMF) is proportional to both of a magnetic density of fluxper pole and the speed of the armature rotated as expression by the relation as following.

$$Eg = \kappa\ \varphi\ n$$

Where

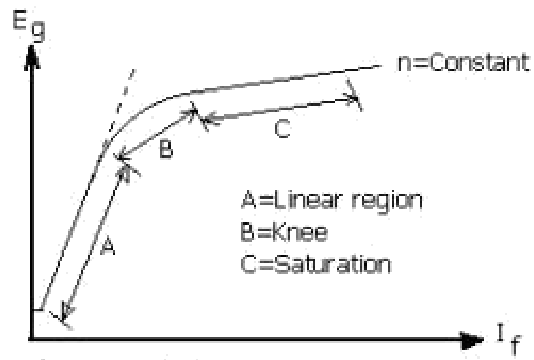
K = Constant for a specific machineφ =

The density of flux per pole

n = Speed of the armature rotationEg

= Generator voltage

By holding the armature speed (n) at a constant value it can show that generator voltage (Eg) is directly proportional to the magnetic flux density. Which, flux density is proportionately to the amount of field current (If). The relation of field current and generate voltage as impressed by figure .



The magnetization curve on open circuit of the separately excited dc machine.

From the figure when the field current (If) is become zero a small generate voltage is producedue to a residual magnetism.

As the field current increases cause to increase generated voltage linearly up to the knee of the magnetization curve. Beyond this point by increasing the field current still further causes saturation of the magnetic structure.

Generator voltage (Eg) is also directly to the armature speed. The formula and a magnetization curve can be both impressed about this relation.

$$E_g' = E_g \times \frac{n'}{n}$$

Where

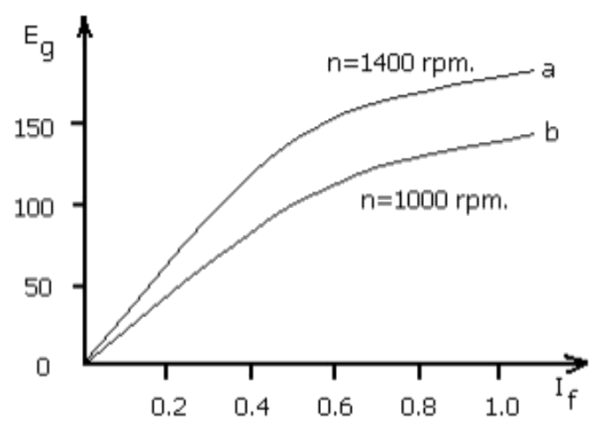
Eg = Generator voltage or the value of EMF at speed n Eg' = Generator voltage or the value of EMF at speed n‘n = Speed of the generator armature (n‘ ≠ n)

Example:

The open circuit terminal voltage versus the field current for a separately excited DC generator with provided the following test data at revolving speed 1400 rpm as show by the table1 below.

Voltage (V)	6	30	58	114	153	179
Ampere (A)	0	0.1	0.2	0.4	0.6	0.8

Table 1 No-load characteristic for 1400 rpm and 1000 rpm



Magnetic curve for example 3.1

Solution

Curve (a) in figure 8 shows the characteristic at revolving speed 1400 rpm obtained by the data as show in table 1. To obtain the characteristic at 1000 rpm, is made of the relation as Eg = Kφn

For instance, at a field current of 0.4 Amp the terminal voltage is 114 volts, when the speed is reached to 1400 rpm and kept its field current constant at this value, the open circuit voltage at

$$E_g = 114 \times \frac{1000}{1400} = 81.40 \text{ Volts}$$

1000 rpm becomes.

Voltage Regulation

When we add load on the generator, the terminal voltage will decrease due to

(a) The armature winding resistance is mainly of armature resistance. It is cause directlydecrease in terminal voltage as following relation.

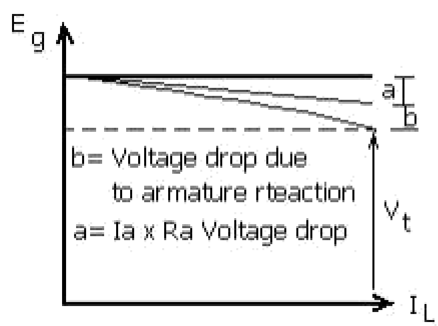
$$Vt = Eg - Ia\ Ra$$

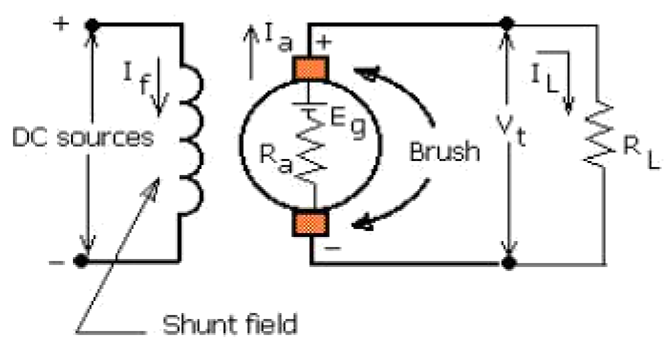
Where

Vt = Terminal or output voltage

Ia = Armature current or load currentRa

= Armature resistance





(a) Load characteristic of a separately excited DC generator

(b) Circuit diagram

The decrease in magnetic flux due to armature reaction. The armature current establishes a magneto motive force (MMF), which it distorts to main flux, and makes result in weakened flux. We can put inter-pole between main field poles to reduce the armature reaction.

To have some measure by how much the terminal voltage change from no-load condition and on load condition, which is called –voltage regulation‖.

$$\text{Voltage regulation} = \frac{V_{nl} - V_{fl}}{V_{fl}} \times 100 = \%$$

Where Vnl = No-load terminal voltage Vfl = Full-load terminal voltage

Remark:

A separately excited generator has disadvantage of requiring an external DC source. It is therefore used only where a wide range of terminal voltage required.

Example 2

The separately excited generator of example 1 is driven at revolving speed 1000 rpm and the field current is adjusted to 0.6 Amp. If the armature circuit resistance is 0.28 ohm, plot the output voltage as the load current is varied from 0 to 60 Amp. Neglect armature reaction effects. If the full-load current is 60 Amp, what is the voltage regulation?

Solution

From example 1, Eg = 153 volts when the field current is 0.6 Amp, which is the open circuit terminal voltage. When the generator is loaded, the terminal voltage is decreased by internal voltage drop,

namely.

$$V_t = E_g - I_a R_a$$

For a load current of, say 40 Amp.

$$V_t = 153 - (40 \times 0.28) = 141.80 \text{ Volts.}$$

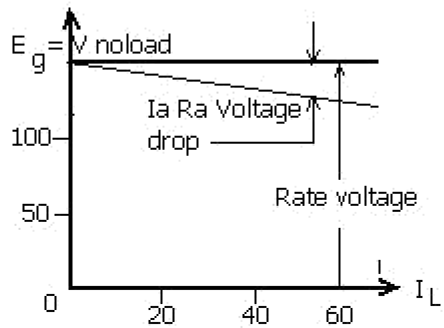
This calculation is for a number of load currents and the external characteristic canbe plotted as show in fig. 10 at full load the terminal voltage.

$$V_t = 153 - (60 \times 0.28) = 136.20 \text{ Volts.}$$

Therefore the voltage regulation is

$$\text{Voltage regulation} = \frac{V_{nl} - V_{fl}}{V_{fl}} \times 100 = \%$$

$$= \frac{153 - 136.2}{136.2} \times 100 = 12.3\,\%$$

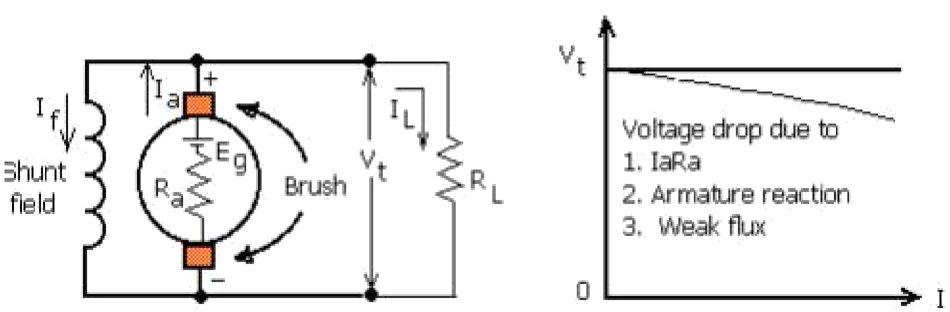


Calculated load characteristic of an example 3.2

Load characteristics

Self excited DC shunt generator

A shunt generator has its shunt field winding connected in parallel with the armature so that the machine provides it own excitation. For voltage to build up, there must be some residual magnetism in the field poles. There will be a small voltage (Er) generated.



(a) Shunt generator circuit (b) load characteristic of shunt generator

If the connection of the field and armature winding are such that the weak main pole flux aids to the residual flux, the induced voltage will become larger. Thus more voltage applied to the main field pole and cause to the terminal voltage increase rapidly to a large value.

When we add load on the generator, the terminal voltage will decrease due to.

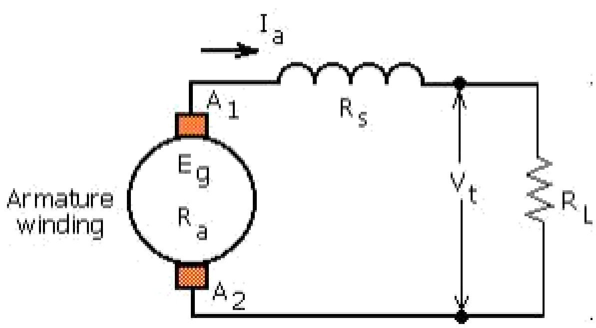
a) The armature winding resistance

b) The armature reaction

c) The weakened flux due to the connection of the generator to aids or oppose to the residual

Series Generator

The field winding of a series generator is connect in series with the armature winding. Since it carries the load current, the series field winding consists of only a few turns of thick wire. At no- load, the generator voltage is small due to residual field flux only. When a load is added, the flux increase, and so does the generated voltage.



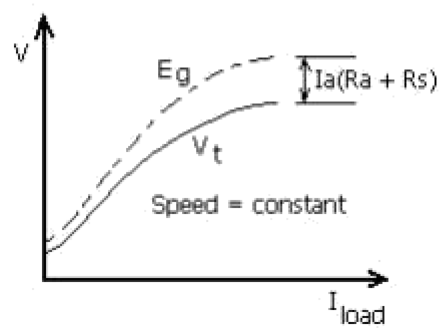


Figure shows the load characteristic of a series generator driven at a certain speed. The dash line indicated the generated EMF of the same machine with the armature opencircuited and the field separated excited. The different between the two curves is simply the voltage drop (IR) in the series field and armature winding.

$$V_t = Eg - Ia\ Ra + Rf$$

Where

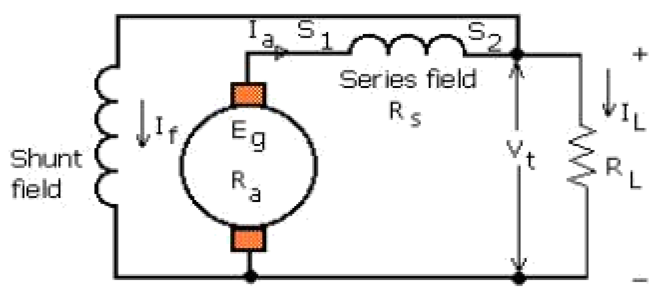
Rf = The series field winding resistanceRa

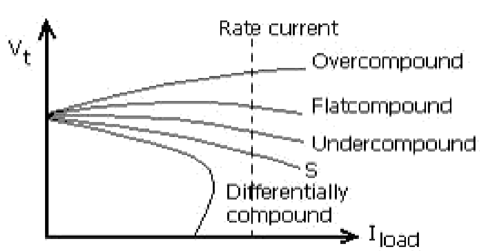
= The armature winding resistance

The series generators are obviously not suited for applications requiring good voltage regulation. Therefore, they have been used very little and only in special applications for example, as voltage booster. The generator is placed in series with a supply line. When the current consumption is increase, the generated voltage of the series machine goes up because themagnetic field current is increases.

Compound generator

compound generator has both a shunt and a series winding. The series field winding usually wound on the top of a shunt field. The two winding are usually connected such that their ampere-turns act in the same direction. As such the generator is said to be cumulatively compound





Terminal voltage characteristic of compound generator

(a) Curve s is represent the terminal voltage characteristic of shunt field winding alone. Under- compound, this condition the addition of series field winding too short it is cause the terminalvoltage no rise to certain value and reduce while increasing in load current.

(b) Flat compound by increasing the number of a series field turns. It is cause to rise up in terminal voltage and when no-load and full load condition a terminal voltage is made nearly same value or equal.

(c) Over-compound, if the number of series field turns is more than necessary to compensated ofthe reduce voltage. In this case while a full load condition a terminal voltage is higher than a no-load voltage. Therefore over-compound generator may use where load is at some distance from generator. Voltage drop in the line has compensated by used of an over-compound generator.

(d) If a reversing the polarity of the series field occur this cause to the relation between series field and shunt field, the field will oppose to each other more and more as the load current increase. Therefore terminal voltage will drop, such generator is said to be a differentially compound.

The compound generator are used more extensively than the other type of dc generator because its design to have a wide variety of terminal voltage characteristics.

MACHINE EFFICIENCY

The efficiency of any machine is the ratio of the ratio of the output power to the input power. The input power is provided by the prime mover to drive the generator. Because part of the energy delivered to the generator is converted into heat, it represents wasted energy. These losses are generally minimized in the design stage; however, some of these losses are unavoidable.

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input power}} \times 100\% \quad \text{or}$$

$$\text{Efficiency} = \frac{\text{Output power} \times 100\%}{\text{Input power} + \text{losses}}$$

Losses of generator

The losses of generators may be classified as

1) Copper losses

The copper losses are present because of the resistance of the windings. Currents flowing through these windings create ohmic losses. The windings that may be present in addition to the (I2 R) armature winding are the field windings, inter-pole and compensate windings.

2) Iron losses

As the armature rotates in the magnetic field, the iron parts of the armature as well as the conductors cut the magnetic flux. Since iron is a good conductor of electricity, the EMF s induced in the iron parts courses to flow through these parts. These are the eddy currents. Another loss occurring in the iron is due to the Hysteresis loss is present in the armature core.

3) Other rotational losses consist of 3.1 bearing friction loss

3.2 friction of the rushes riding on the commutator

3.3 windage losses

Windage losses are those associated with overcoming air friction in setting up circulation currents of air inside the machine for cooling purposes. These losses are usually very small.

APPLICATIONS OF DC GENERATORS

Applications of Separately Excited DC Generators

These types of DC generators are generally more expensive than self-excited DC generators because of their requirement of separate excitation source. Because of that their applications are restricted. They are generally used where the use of self-excited generators are unsatisfactory.

1. Because of their ability of giving wide range of voltage output, they are generally used fortesting purpose in the laboratories.
2. Separately excited generators operate in a stable condition with any variation in field excitation. Because of this property they are used as supply source of DC motors, whose speeds are to be controlled for various applications. Example- Ward Leonard Systems of speed control.

Applications of Shunt Wound DC Generators

The application of shunt generators are very much restricted for its dropping voltage characteristic. They are used to supply power to the apparatus situated very close to its position. These type of DC generators generally give constant terminal voltage for small distance operation with the help of field regulators from no load to full load.

1. They are used for general lighting.
2. They are used to charge battery because they can be made to give constant output voltage.
3. They are used for giving the excitation to the alternators.
4. They are also used for small power supply.

Applications of Series Wound DC Generators

These types of generators are restricted for the use of power supply because of their increasing terminal voltage characteristic with the increase in load current from no load to full load. We can clearly see this characteristic from the characteristic curve of series wound generator. They give constant current in the dropping portion of the characteristic curve. For this property they can be used as constant current source and employed for various applications.

1. They are used for supplying field excitation current in DC locomotives for regenerative breaking.

2. This types of generators are used as boosters to compensate the voltage drop in the feeder invarious types of distribution systems such as railway service.

3. In series arc lightening this type of generators are mainly used.

Applications of Compound Wound DC Generators

Among various types of DC generators, the compound wound DC generators are most widely used because of its compensating property. We can get desired terminal voltage by compensating the drop due to armature reaction and ohmic drop in the in the line. Such generators have various applications.

1. Cumulative compound wound generators are generally used lighting, power supply purpose and for heavy power services because of their constant voltage property. They are mainly made over compounded.
2. Cumulative compound wound generators are also used for driving a motor.
3. For small distance operation, such as power supply for hotels, offices, homes and lodges, theflat compounded generators are generally used.
4. The differential compound wound generators, because of their large demagnetization armature reaction, are used for arc welding where huge voltage drop and constant current is required.

At present time the **applications of DC generators** become very limited because of technical and economic reasons. Now a days the electric power is mainly generated in the form of alternating current with the help of various power electronics devices.

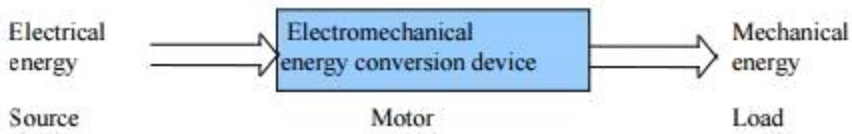
Direct Current Motor (DC motor)

DC motor is similar to dc generator; in fact the same machine can act as motor or generator. The only difference is that in a generator the EMF is greater than terminal voltage, whereas in motor the generated voltage EMF is less than terminal voltage. Thus the power flow is reversed, that is the motor converts electrical energy into mechanical energy. That is the reverse process of generator.

DC motors are highly versatile machines. For example, dc motors are better suited fore many processes that demand a high degree of flexibility in the control of speed and torque. The dc motor can provided high starting torque as well as high decelerating torque for application requiring quick stop or reversals.

DC motors are suited in speed control with over wide range is easily to achieve compare with others electromechanical.

The input is electrical energy (from the supply source), and the output is mechanical energy (to the load).



Construction

DC motors consist of one set of coils, called armature winding, inside another set of coils or a set of permanent magnets, called the stator. Applying a voltage to the coils produces a torque in the armature, resulting in motion.

Stator

The stator is the stationary outside part of a motor.

The stator of a permanent magnet dc motor is composed of two or more permanent magnetpole pieces.

The magnetic field can alternatively be created by an electromagnet. In this case, a DC coil(field winding) is wound around a magnetic material that forms part of the stator.

Rotor

The rotor is the inner part which rotates.

The rotor is composed of windings (called armature windings) which are connected to the external circuit through a mechanical commutator. Both stator and rotor are made of ferromagnetic materials. The two are separated by air-gap.

Winding

A winding is made up of series or parallel connection of coils.

Armature winding - The winding through which the voltage is applied or induced.Field winding - The winding through which a current is passed to produce flux (for the electromagnet)

Windings are usually made of copper.

DC Motor Basic Principles

(a) Energy Conversion

If electrical energy is supplied to a conductor lying perpendicular to a magnetic field, the interaction of current flowing in the conductor and the magnetic field will produce mechanical force (and therefore, mechanical energy).

(b) Value of Mechanical Force

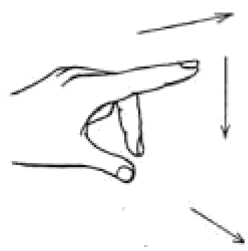
There are two conditions which are necessary to produce a force on the conductor. The conductor must be carrying current, and must be within a magnetic field. When these two conditions exist, a force will be applied to the conductor, which will attempt to move the conductor in a direction perpendicular to the magnetic field. This is the basic theory by whichall DC motors operate.

The force exerted upon the conductor can be expressed as follows.

$$F = B\ i\ l \text{ Newton} \qquad (1)$$

where B is the density of the magnetic field, l is the length of conductor, and i the value of current flowing in the conductor. The direction of motion can be found using Fleming's Left Hand Rule.

Fleming's Left Hand Rule



The first finger points in the direction of the magnetic field (first - field), which goes from the North pole to the South pole. The second finger points in the direction of the current in the wire (second - current). The thumb then points in the direction the wire is thrust or pushed while in the magnetic field (thumb - torque or thrust).

Principle of operation

Consider a coil in a magnetic field of flux density B (figure). When the two ends of thecoil are connected across a DC voltage source, current I flows through it. A force is exerted on the coil as a result of the interaction of magnetic field and electric current. The force on the two sides of the coil is such that the coil starts to move in the direction of force.

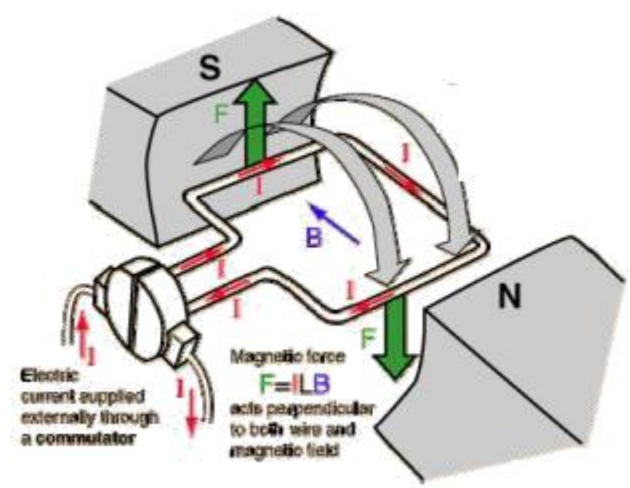


Fig.1. Torque production in a DC motor

In an actual DC motor, several such coils are wound on the rotor, all of which experience force, resulting in rotation. The greater the current in the wire, or the greater the magnetic field, the faster the wire moves because of the greater force created.

At the same time this torque is being produced, the conductors are moving in a magnetic field. At /dt) as shown in different positions, the flux linked with it changes, which causes an emfto be induced (e = d figure 5. This voltage is in opposition to the voltage that causes current flow through the conductor and is referred to as a counter-voltage or back emf.

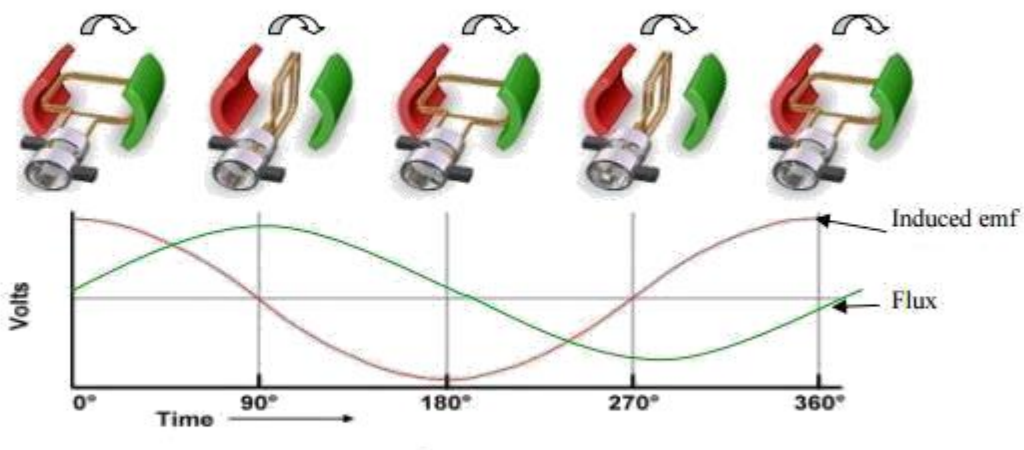


Fig.2. Induced voltage in the armature winding of DC motor

The value of current flowing through the armature is dependent upon the difference between the applied voltage and this counter-voltage. The current due to this counter-voltage tends to oppose the very cause for its production according to Lenz‘s law. It results in the rotor slowing down. Eventually, the rotor slows just enough so that the force created by the magnetic field (F = Bil) equals the load force applied on the shaft. Then the system moves at constant velocity.

Torque Developed

The equation for torque developed in a DC motor can be derived as follows.The force on one coil of wire F =i l x B Newton

Note that l and B are vector quantities Since B =ø/A where A is the area of the coil

Therefore the torque for a multi turn coil with an armature current of Ia:

$$T= K\o I_a \qquad (2)$$

where ø is the flux/pole in weber, K is a constant depending on coil geometry, and Ia is thecurrent flowing in Where the armature winding.

Note: Torque T is a function of force and the distance, equation (2) lumps all the constant parameters (eg. length, area and distance) in constant K.

The mechanical power generated is the product of the machine torque and the mechanical speedof rotation, m Or, Pm = m.T

$$= mKø I_a \qquad (3)$$

It is interesting to note that the same DC machine can be used either as a motor or as a generator,by reversing the terminal connections.

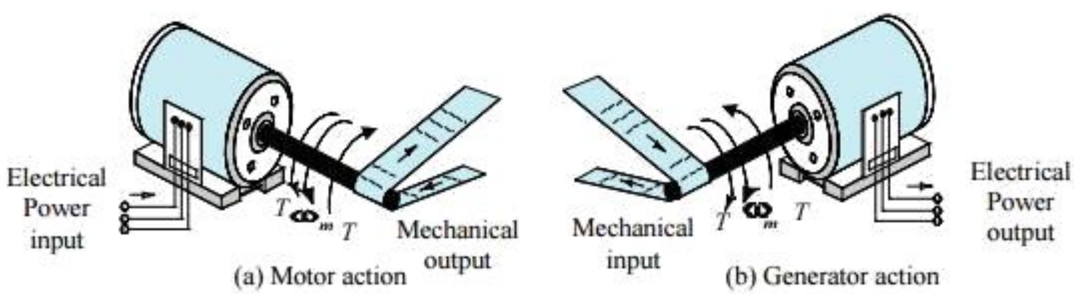


Fig.3. Reversability of a DC machine

Induced Counter-voltage (Back emf):

Due to the rotation of this coil in the magnetic field, the flux linked with it changes at different positions, which causes an emf to be induced (refer to figure 2).

The induced emf in a single coil, $e = dø_c/dt$

Since the flux linking the coil, c = Sin

Induced voltage , e =cos t (4)

Note that equation (4) gives the emf induced in one coil. As there are several coils wound all around the rotor, each with a different emf depending on the amount of flux change through it, the total emf can be obtained by summing up the individual emfs.

The total emf induced in the motor by several such coils wound on the rotor can be obtained by integrating equation (4), and expressed as:

$$Eb = K_m \qquad (5)$$

where K is an armature constant, and is related to the geometry and magnetic properties ofthe motor, and $_m$ is the speed of rotation.

The electrical power generated by the machine is given by:

$$Pdev = Eb\ Ia = K\ _m\ I_a \qquad (6)$$

DC Motor Equivalent circuit

The schematic diagram for a DC motor is shown below. A DC motor has two distinct circuits: Field circuit and armature circuit. The input is electrical power and the output ismechanical power. In this equivalent circuit, the field winding is supplied from a separate DC voltage source of voltage Vf. Rf and Lf represent the resistance and inductance of the field winding. The current If produced in the winding establishes the magnetic field necessary for motor operation. In the armature (rotor) circuit, VT is the voltage applied across the motor terminals, Ia is the current flowing in the armature circuit, Ra is the resistance of the armature winding, and Eb is the total voltage induced in the armature.

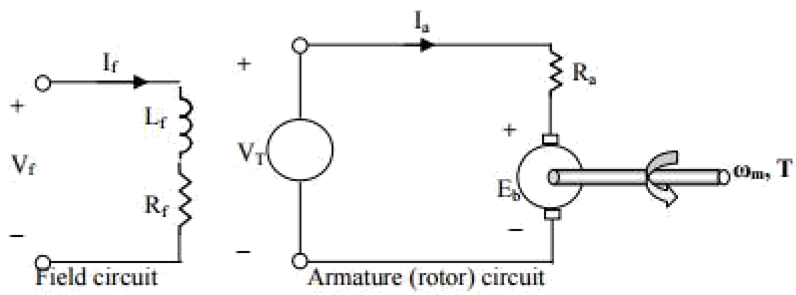


Fig.4. DC motor representation

Counter EMF in DC motor

When voltage is applied to dc motor, current will flow into the positive brush through the commutator into the armature winding. The motor armature winding is identical to the generator armature winding. Thus the conductors on the north field poles are carry current in one direction,while all conductors on the south field poles carry the current in opposite direction. When the armature carry current it will produce a magnetic field around the conductor of it own which interact with the main field. It is cause to the force developed on all conductors and tending to turn the armature.

The armature conductors continually cut through this resultant field. So that voltages are generated in the same conductors that experience force action. When operating the motor is simultaneously acting as generator. Naturally motor action is stronger than generator action.

Although the counter EMF is opposite with the supplied voltage, but it cannot exceed to applied voltage. The counter EMF is serves to limit the current in an armature winding. The armature current will be limited to the value just sufficient to take care of the developed power needed to drive the load.

In the case of no load is connected to the shaft. The counter EMF will almost equal to the appliedvoltage. The power develops by the armature in this case is just the power needed to overcome the rotational losses. It‘s mean that the armature current IA is controlled and limited by counter EMF therefore

$$Ia = \frac{VL - Ea}{Ra}$$

Where:

VL = Line voltage across the armature windingRa

= Resistance of the armature winding

Ea = Induced EMF or generated voltageIa =

Armature current

Since, EA is induced or generated voltage it is depend on the flux per pole and the speed of thearmature rotate (n) in rpm.

Therefore

$$E_a = K \varphi n$$

Where:

K = the constant value depending on armature winding and number of pole of machine.

φ = Rotation of the armature

And,

$$K = \frac{Z \times P}{a}$$

Where:

Z = Total number of conductor in the armature winding

a = Number of parallel circuit in the armature winding between positive and negative brushes. For wave wound armature –a‖ = 2

Lap wound armature –a‖ = P

Example

A dc motor operated at 1500 rpm when drawing 20 amps from 220 volts supply, if the armature resistance is 0.2 ohms. Calculate the no load speed assumed Ia = 0 amp (This amount to assuming the brushes and rotation loss are negligible)

Solution

When load condition Ia = 20 amps.

$$Ea = VL – Ia\ Ra = 220 – 20\ (0.2) = 216 \text{ Volts.}$$

And

$$Ea = k\ \phi\ n$$

$$216 = K\phi \times 1500$$

$$K\phi = 216/1500$$

$$= 0.144$$

At no load condition Ia = 0 Amp.

$$Ea = VL = 220 \text{ Volts.}$$

Hence

$$Ea = k\varphi n$$

$$n = 220/ k\varphi$$

$$= 220/ 0.144$$

$$= 1528 \text{ rpm.}$$

Mechanical power develop in dc motor (Pd)

Let,

Pd = Mechanical power develop

T = Torque exerted on the armature

$$Pd = \omega T$$

$$= \left(\frac{2\pi n}{60}\right) T$$

Where: $T = P_d / \omega$

$$= \frac{Ea \times Ia}{2\pi n / 60} \qquad = \frac{K\varphi n \times Ia}{(2\pi n)/60}$$

Therefore: $T = K\phi I_A$

Example: from the motor that mentions before, determine

Solution:

$$P_d = E_A I_A$$

$$= 216 \bullet 20$$

$$= 4320 \text{ watts.}$$

$$T = P_d / \omega$$

$$= 27.51 \ N_M$$

DC Machine Classification

DC Machines can be classified according to the electrical connections of the armature winding and the field windings. The different ways in which these windings are connected lead to machines operating with different characteristics. The field winding can be either self-excited or separately-excited, that is, the terminals of the winding can be connected across the input voltage terminals or fed from a separate voltage source (as in the previous section). Further, in self-excited motors, the field winding can be connected either in series or in parallel with the armature winding. These different types of connections give rise to very different types of machines, as we will study in this section.

(a) ***Separately excited machines***

The armature and field winding are electrically separate from eachother.

The field winding is excited by a separate DC source.

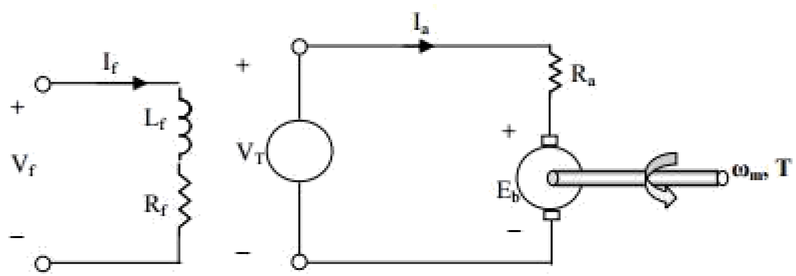


Fig.5. Separately excited dc motor

The voltage and power equations for this machine are same as those derived in the previoussection.
Note that the total input power = Vf If + VT Ia

(b) ***Self excited machines***

In these machines, instead of a separate voltage source, the field winding is connectedacross the main voltage terminals.

1. Shunt machine

The armature and field winding are connected in parallel.The

armature voltage and field voltage are the same.

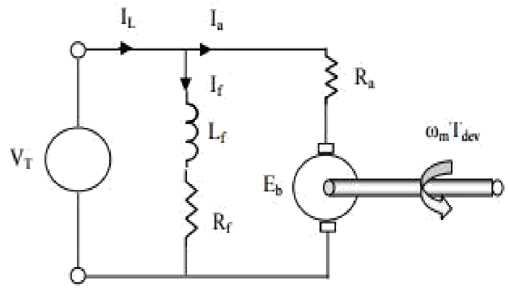


Fig.6. shunt motor

Total current drawn from the supply, IL = If + Ia

Total input power = VT IL

Voltage, current and power equations are given in equations (7), (8) and (9).

2. Series DC machine

The field winding and armature winding are connected in series. The

field winding carries the same current as the armature winding.

A series wound motor is also called a universal motor. It is universal in the sense that it will runequally well using either an ac or a dc voltage source.

Reversing the polarity of both the stator and the rotor cancel out. Thus the motor will alwaysrotate the same direction irregardless of the voltage polarity.

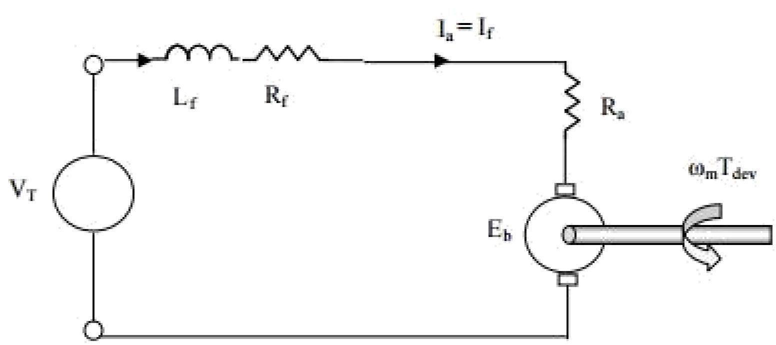


Fig.7.Series Motor

Compound DC machine

If both series and shunt field windings are used, the motor is said to be compounded. In a compound machine, the series field winding is connected in series with the armature, and the shunt field winding is connected in parallel. Two types of arrangements are possible in compound motors:

Cumulative compounding - If the magnetic fluxes produced by both series and shunt fieldwindings are in the same direction (i.e., additive), the machine is called cumulative compound.

Differential compounding - If the two fluxes are in opposition, the machine is differential compound.

In both these types, the connection can be either short shunt or long shunt.

Speed control of DC motor

Many applications require the speed of a motor to be varied over a wide range. One of the most attractive features of DC motors in comparison with AC motors is the ease with which their speed can be varied.

We know that the back emf for a separately excited DC motor:.

$$E_b = K\phi\omega_m = V_T - I_a R_a$$

Rearranging the terms,

$$\text{Speed } \omega_m = (V_T - I_a R_a)/K\phi \qquad (7)$$

From the above equation, it is evident that the speed can be varied by using any of the following methods:

Armature voltage control (By varying VT)

Field Control (By Varying)

Armature resistance control (By varying Ra)

Armature voltage control

This method is usually applicable to separately excited DC motors. In this method ofspeed control, Ra and are kept constant.

In normal operation, the drop across the armature resistance is small compared to Eb and therefore: Eb V_T

Since, Eb = Kø ω_m

Angular speed can be expressed as:

$$\omega_m = V_T / K\text{ø} \qquad (8)$$

From this equation, If flux is kept constant, the speed changes linearly with VT.As the

terminal voltage is increased, the speed increases and vice versa.

The relationship between speed and applied voltage is shown in figure 8. This method provides smooth variation of speed control.

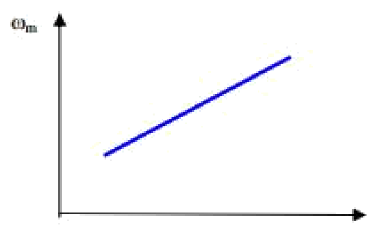


Fig.8.Variation of speed with applied voltage

Field Control , ( )

In this method of speed control, Ra and VT remain fixed.

Therefore, from equation (7):

m I/

Assuming magnetic linearity, If

(OR)mI/IF (9)

i.e., Speed can be controlled by varying field current If.

The field current can be changed by varying an adjustable rheostat in the field circuit (as shownin figure 9).

By increasing the value of total field resistance, field current can be reduced, and thereforespeed can be increased.

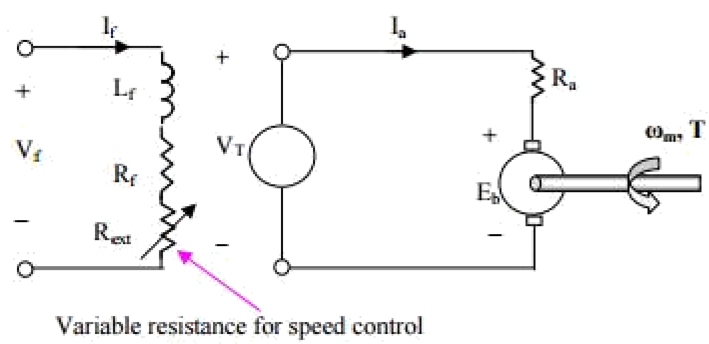


Fig.9.

The relationship between the field winding current and angular speed is shown in figure 10

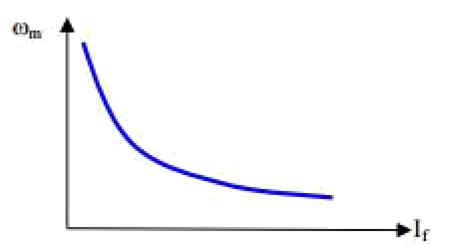


Fig.10: Variation of speed with field current

Armature Resistance Control

The voltage across the armature can be varied by inserting a variable resistance in series withthe armature circuit.

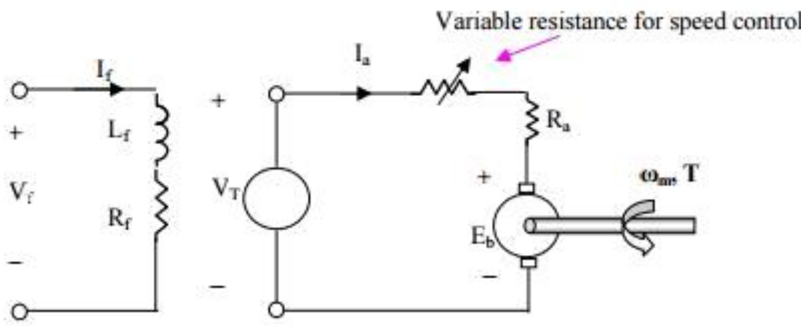


Fig.11. Armature resistance method for speed control

From speed-torque characteristics , we know that:

$$T_{dev} = \frac{K\phi}{R_a}(V_T - K\phi\omega_m)$$

For a load of constant torque VT and are kept constant, as the armature resistance Ra is increased, speed decreases. As the actual resistance of the armature winding is fixed for a given motor, the overall resistance in the armature circuit can be increased by inserting an additional variable resistance in series with the armature. The variation if speed with respect to change in this external resistance is shown in figure 12. This method provides smooth control of speed..

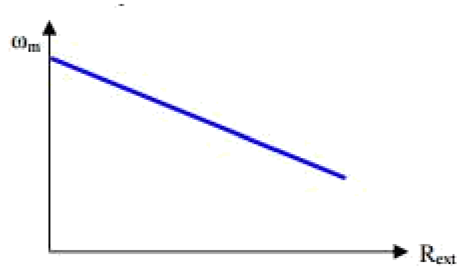


Fig. 12: Variation of speed with external armature resistance

DC Shunt Motor speed control

All three methods described above can be used for controlling the speed of DC Shunt Motors.

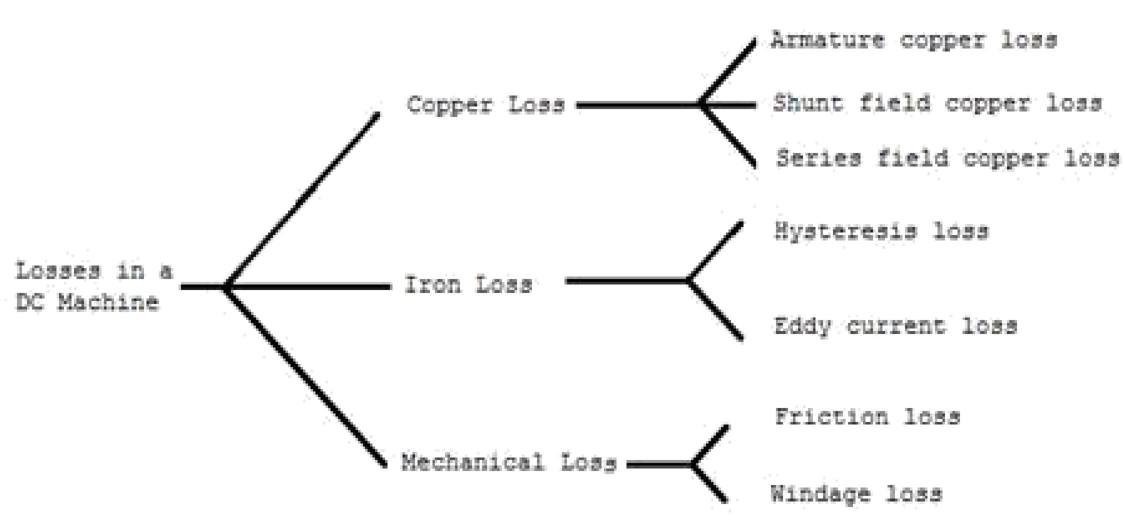
Series Motor speed control

The speed is usually controlled by changing an external resistance in series with the armature.The other two methods described above are not applicable to DC series motor speed control.

Applications of dc motors

d.c. shunt motor	lathes,fans,pumps disc and band saw drive requiring moderate torques.
d.c. series motor	Electric traction, high speed tools
d.c. compound motor	Rolling mills and other loads requiring large momentary toques.

Types of Losses in a DC Machines



The losses can be divided into three types in a dc machine (Generator or Motor). They are

1. Copper losses

2. Iron or core losses and

3. Mechanical losses.

All these losses seem as heat and therefore increase the temperature of the machine. Further the efficiency of the machine will reduce.

1. Copper Losses:

This loss generally occurs due to current in the various windings on of the machine. The different winding losses are;

Armature copper loss = $I^2 R_a$

Shunt field copper loss = $I^2_{sh} R_{sh}$

Series field copper loss = $I^2_{se} R_{se}$

Note: There's additionally brush contact loss attributable to brush contact resistance (i.e., resistance in the middle of the surface of brush and commutator). This loss is mostly enclosed in armature copper loss.

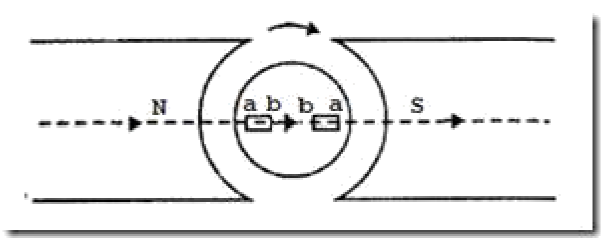
2. Iron Losses

This loss occurs within the armature of a d.c. machine and are attributable to the rotation of armature within the magnetic field of the poles. They're of 2 sorts viz.,

(i) Hysteresis loss

(ii) eddy current loss.

Hysteresis loss:



Hysteresis loss happens in the armature winding of the d.c. machine since any given part of the armature is exposed to magnetic field of reverses as it passes underneath sequence poles. The above fig shows the 2 pole DC machine of rotating armature. Consider a tiny low piece ab of the armature winding. Once the piece ab is underneath N-pole, the magnetic lines pass from a to b. Half a revolution well along, identical piece of iron is underneath S-pole and magnetic lines pass from b to a in order that magnetism within the iron is overturned. So as to reverse constantly the molecular magnets within the armature core, particular quantity of power must be spent that is named hysteresis loss. It‘s given by Steinmetz formula.

The steinmetz formula is

$$\textbf{Hysteresis loss } P_h = \eta B^{16}_{max} fV \textbf{ watts}$$

Where,

η = Steinmetz hysteresis co-efficient

B_{max} = Maximum flux Density in armature windingF =

Frequency of magnetic reversals

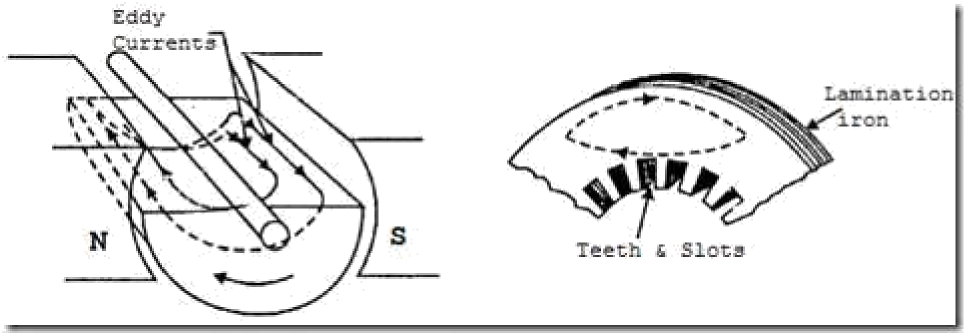
= NP/120 (N is in RPM)

V = Volume of armature in m^3

If you want to cut back this loss in a d.c. machine, armature core is created of such materials thathave an lesser value of Steinmetz hysteresis co-efficient e.g., silicon steel.

Eddy current loss:

In addition to the voltages evoked within the armature conductors, some of other voltages evoked within the armature core. These voltages turn out current currents within the coil core as shown in Fig. These are referred to as eddy currents and power loss attributable to their flow is named eddy current loss. This loss seems as heat that increases the temperature of the machine and efficiency will decrease.



If never-ending cast-iron core is employed, the resistance to eddy current path is tiny attributable to massive cross-sectional space of the core. Consequently, the magnitude of eddy current and therefore eddy current loss are massive. The magnitudes of eddy current are often decreased by creating core resistance as high as sensible. The core resistances are often greatly exaggerated by making the core of skinny, spherical iron sheets referred to as lamination's shown in the fig. The lamination's are insulated from one another with a layer of varnish. The insulating layer featuresa high resistance, thus only small amount of current flows from one lamination to the opposite. Also, as a result of every lamination is extremely skinny, the resistance to current passing over the breadth of a lamination is additionally quite massive. Therefore laminating a core will increase the core resistance that drops the eddy current and therefore the eddy current loss.

Eddy Current loss $P_e = K_e B^2_{max} f^2 t^2 V$ Watts

Where, k_e = constant

B_{max} = Maximum flux density in wb/m^2T

= Thickness of lamination in m

V = Volume of core in m^3

<u>Note:</u> Constant (**K_e**) depend upon the resistance of core and system of unit used.

It may well be noted that eddy current loss be subject to upon the sq. of lamination thickness. Forthis reason, lamination thickness ought to be unbroken as tiny as potential.

3. Mechanical Loss

These losses are attributable to friction and windage.

Friction loss occurs due to the friction in bearing, brushes etc.windage loss occurs due to the air friction of rotating coil.

These losses rely on the speed of the machine. Except for a given speed, they're much constant.

Constant and Variable Losses

The losses in a d.c. machine is also further classified into (i) constant losses (ii) variable losses.

Constant losses

Those losses in a d.c. generator that stay constant at all loads are referred to as constant losses.The constant losses in a very d.c. generator are:

(a)iron losses

(b)mechanical losses

(c)shunt field losses

Variable losses

Those losses in a d.c. generator that differ with load are referred to as variable losses. Thevariable losses in a very d.c. generator are:

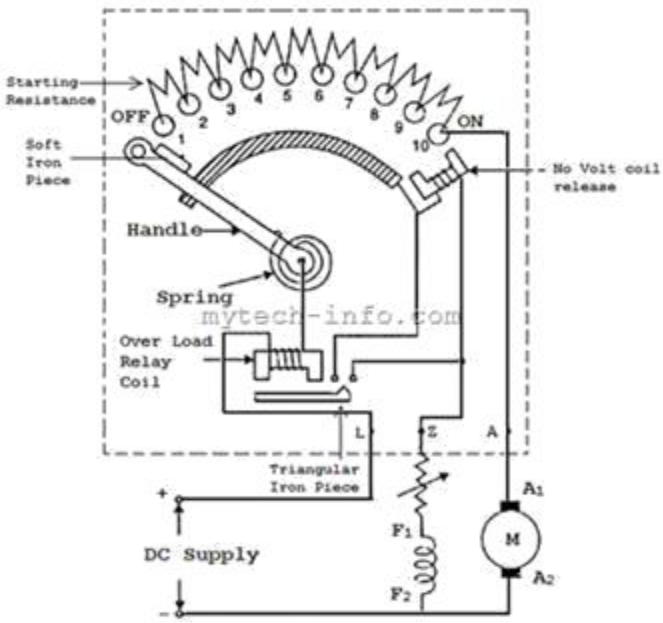
Copper loss in armature winding (I^2R_a)

Copper loss in series field winding ($I^2_{se}R_{se}$)

Total losses = Constant losses + Variable losses.

Generally this copper loss is constant for shunt and compound generators.

Three point starter



The figure above shows that typical representation diagram of a 3 point starter for DC shunt motors with its protective devices. It contains 3 terminals namely L, Z, & A; hence named 3 point starter. The starter is made up of of starting resistances divided into many section and which are connected in series within the armature. The each tapping point on the startingresistances is carried out to a no. of studs. The starter 3 terminals L,Z & A are connected to the positive terminal of line, shunt field and armature terminal of motor respectively. The remaining terminal of the shunt and armature are connected to the negative line terminal. The No volt coil release is connected in series with field winding. The handle one end is connected to the L terminal by means of over load release coil. Then another end of handle travels against the twisting spring & make touching base with every single stud in the course of starting operation, tripping out the starting resistance as it moves above every stud in clockwise.

Working:

Initially the DC supply is turned on with the handle is in OFF position.

Now the handle is moved towards clockwise direction to the 1st stud. Once it contacts with the1st stud, immediately the shunt field coil is connected to the supply, however the entire starting resistances is injected with armature circuit in series.

As the handle moved gradually towards the final stud, so that the starting resistance is cut outstep by step in armature circuit. And finally the handle is detained magnetically by the No volt coil release since it is energized by the filed winding.

In case if the shunt field winding excitation is cut out by accident or else the supply is interrupted then the no volt coil release gets demagnetized and handle returned back to theoriginal position under the influence of spring.

Note: If we were not used No volt coil release; then if the supply is cut off the handle wouldremain in the same position, causing an extreme current in armature.

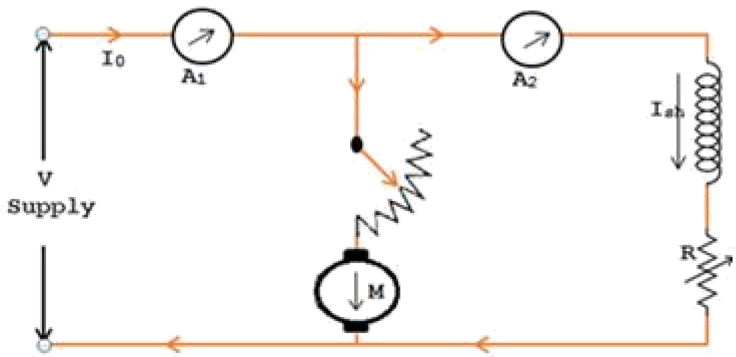
If any fault occurs on motor or overload, it will draw extreme current from the source. This current raise the ampere turns of OLR coil (over load relay) and pull the armature Coil, in consequence short circuiting the NVR coil (No volt relay coil). The NVR coil gets demagnetized and handle comes to the rest position under the influence of spring. Therefore the motor disconnected from the supply automatically.

Characteristic of DC Shunt Motor

Disadvantage:

In point starter, no volt relay coil is connected in series with field circuit; hence it carries shuntcurrent in the field. When the speed control of DC motor through field regulator, it may be weakened the shunt field current to such extent the no volt coil release might not in a position to hold the starter handle in ON position. This might the motor disconnected from the source when it is not anticipated. This can be overcome by using the point starter.

Swinburne's Test for DC Machines



In this technique, the DC Generator or DC Motor is run as a motor at no load; with that losses of the DC machines are determined. When the losses of DC machine well-known, then we can find the efficiency of a DC machine in advance at any desired load. In DC machines this test is applicable only throughout the flux is constant at all load (DC Shunt machine and DC Compound Machine). This test maintains of two steps;

Determination of Hot Resistance of Windings:

The resistance of armature windings and shunt field windings are measured with the help of a battery, ammeter and voltmeter. Since these armature and shunt filed resistances are measured while the DC machine is cold, it should be transformed to values equivalent to the temperature at which the DC machine would work at full load. These values are measured generally when the room temperature increases above 40^{o}C. Take on the hot resistance of armature winding and shunt field winding be R_a and R_{sh} correspondingly.

Condition for maximum Efficiency in DC Machine

Determination of Constant Losses:

On no load the DC machine run as a motor with the supply voltage is varied to the normal rated voltage. With the use of the field regulator R the motor speed is varied to run the rated speed which is shown in the figure.

Let

V = Supply Voltage

I_0 = No load current read by A_1

I_{sh} = Shunt Field current ready by A_2No

load armature current $I_{ao} = I_0 - I_{sh}$No

load Input power to motor = VI_0 No load

Input power to motor = VI_{a0}

$$= V (I_0 - I_{sh})$$

As the output power is nil, the no loads input power to the armature provides Iron loss, armature copper loss, friction loss and windage loss.

Constant loss W_c = Input power to Motor – Armature copper loss

$$W_c = VI_0 - (I_0 - I_{sh})^2 R_a$$

As the constant losses are identified, the efficiency of the DC machine at any loads can be determined. Suppose it is desired to determine the DC machine efficiency at no load current. Then, Armature current $I_a = I-I_{sh}$ (For Motoring)

$I_a = I+I_{sh}$ (For Generating)

To find the Efficiency when running as a motor:

Input power to motor = VI

Armature copper loss $=I_a^2 R_a = (I-I_{sh})^2 R_a$

Constant Loss = W_c

Total Loss = $(I-I_{sh})^2 R_a + W_c$

Motor Efficiency η = (Input power – Losses)/ Input

$\eta = \{VI - (I-I_{sh})^2 R_a\} / VI$

<u>Condition for maximum Efficiency in DC Machine</u>

To find the Efficiency when running as a Generator:

Output Power of Generator = VI Armature

copper loss $=I_a^2 R_a = (I+I_{sh})^2 R_a$ Constant Loss

= W_c

Total Loss = $(I+I_{sh})^2 R_a + W_c$

Motor Efficiency η= Output power/ (Output power + Losses)

$\eta = VI / \{VI + (I+I_{sh})^2 R_a + W_c\}$

UNIT-II

TRANSFORMERS

The transformer is a device that transfers electrical energy from one electrical circuit to another electrical circuit. The two circuits may be operating at different voltage levels but always work at the same frequency. Basically transformer is an electro-magnetic energy conversion device. It is commonly used in electrical power system and distribution systems.

SINGLE PHASE TRANSFORMERS

Introduction

In its simplest form a single-phase transformer consists of two windings, wound on an iron core one of the windings is connected to an ac source of supply f. The source supplies a current to this winding (called primary winding) which in turn produces a flux in the iron core. This flux is alternating in nature (Refer Figure 4.1). If the supplied voltage has a frequency f, the flux in the core also alternates at a frequency f. the alternating flux linking with the second winding, induces a voltage E2 in the second winding (called secondary winding). [Note that this alternating flux linking with primary winding will also induce a voltage in the primary winding, denoted as E1. Applied voltage V1 is very nearly equal to E1]. If the number of turns in the primary and secondary windings is N1 and N2 respectively, we shall see later in this unit that

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

The load is connected across the secondary winding, between the terminals a1, a2. Thus, the load can be supplied at a voltage higher or lower than the supply voltage, depending upon the ratio N1/N2

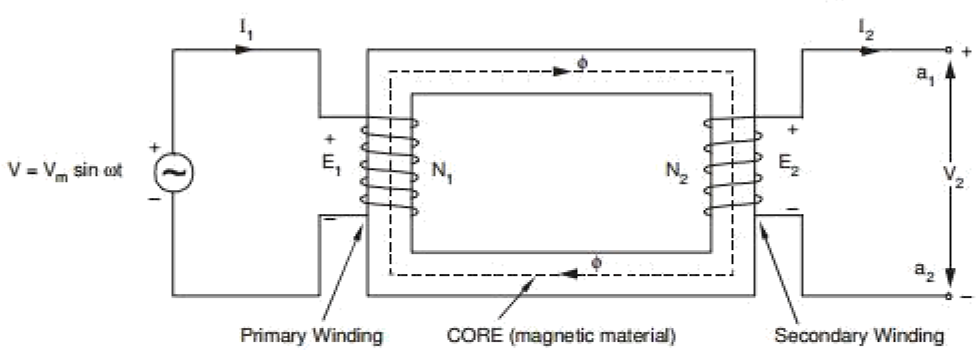


Figure 4.1 : Basic Arrangement of Transformer

When a load is connected across the secondary winding it carries a current I2, called load current. The primary current correspondingly increases to provide for the load current, in addition to the small no load current. The transfer of power from the primary side (or source) to the secondary side (or load) is through the mutual flux and core. There is no direct electrical connection between the primary and secondary sides.

In an actual transformer, when the iron core carries alternating flux, there is a power loss in the core called core loss, iron loss or no load loss. Further, the primary and secondary windings havea resistance, and the currents in primary and secondary windings give rise to I 2 R losses in transformer windings, also called copper losses. The losses lead to production of heat in the transformers, and a consequent temperature rise. Therefore, in transformer, cooling methods are adopted to ensure that the temperature remains within limit so that no damage is done towindings‘ insulation and material.

In the Figure 4.1 of a single-phase transformer, the primary winding has been shown connectedto a source of constant sinusoidal voltage of frequency f Hz and the secondary terminals are kept open. The primary winding of N1 turns draws a small amount of alternating current of instantaneous value i0, called the exciting current. This current establishes flux φ in the core (+ve direction marked on diagram). The strong coupling enables all of the flux φ to be confined to the core (i.e. there is no leakage of flux). Consequently, the flux linkage of primary winding is

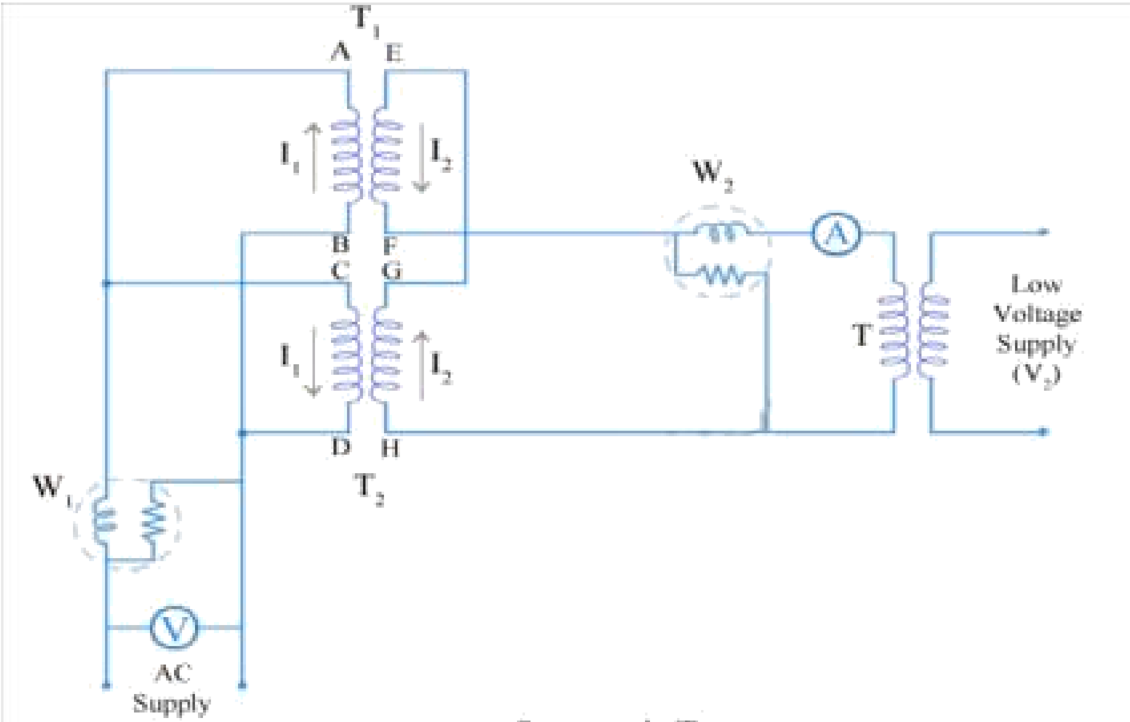
Sumpner's Test Or Back-To-Back Test On Transformer

Sumpner's test or back to back test on transformer is another method for determining transformer efficiency, voltage regulation and heating under loaded conditions. Short circuit and open circuit tests on transformer can give us parameters of equivalent circuit of transformer, but they can not help us in finding the heating information. Unlike O.C. and S.C. tests, actual loading is simulated in Sumpner's test. Thus the Sumpner's test give more accurate results of regulation and efficiency than O.C. and S.C. tests.

Sumpner's Test

Sumpner's test or back to back test can be employed only when two identical transformers are available. Both transformers are connected to supply such that one transformer is loaded on another. Primaries of the two identical transformers are connected in parallel across a supply.

Secondaries are connected in series such that emf's of them are opposite to each other. Another low voltage supply is connected in series with secondaries to get the readings, as shown in the circuit diagram shown below.



Sumpner's Test

In above diagram, T_1 and T_2 are identical transformers. Secondaries of them are connected in voltage opposition, i.e. E_{EF} and E_{GH}. Both the emf's cancel each other, as transformers are identical. In this case, as per superposition theorem, no current flows through secondary. And thus the no load test is simulated. The current drawn from V_1 is $2I_0$, where I_0 is equal to no loadcurrent of each transformer. Thus input power measured by wattmeter W_1 is equal to iron losses of both transformers.

i.e. iron loss per transformer $P_i = W_1/2$.

Now, a small voltage V_2 is injected into secondary with the help of a low voltage transformer. The voltage V_2 is adjusted so that, the rated current I_2 flows through the secondary. In this case, both primaries and secondaries carry rated current. Thus short circuit test is simulated andwattmeter W_2 shows total full load copper losses of both transformers.

i.e. copper loss per transformer $P_{Cu} = W_2/2$.

From above test results, the **full load efficiency of each transformer** can be given as -

$$\begin{matrix}\text{\% full load efficiency} \\ \text{of each transformer}\end{matrix} = \frac{\text{output}}{\text{output} + \frac{W_1}{2} + \frac{W_2}{2}} \times 100$$

O.C. and S.C. Tests on Single Phase Transformer

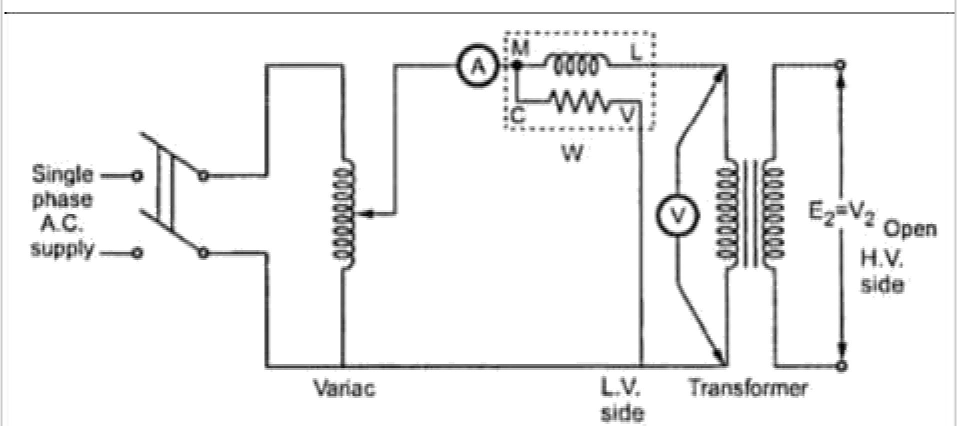
The efficiency and regulation of a transformer on any load condition and at any power factor condition can be predetermined by indirect loading method. In this method, the actual loadis not used on transformer. But the equivalent circuit parameters of a transformer are determined by conducting two tests on a transformer which are,

1. Open circuit test (O.C Test)
2. Short circuit test (S.C.Test)

The parameters calculated from these test results are effective in determining the regulation and efficiency of a transformer at any load and power factor condition, without actually loading the transformer. The advantage of this method is that without much power loss the tests can be performed and results can be obtained. Let us discuss in detail how to perform these tests and how to use the results to calculate equivalent circuit parameters.

Open Circuit Test (O.C. Test)

The experimental circuit to conduct O.C test is shown in the Fig. 1.



The transformer primary is connected to a.c. supply through ammeter, wattmeter and variac. The secondary of transformer is kept open. Usually low voltage side is used as primary and high voltage side as secondary to conduct O.C test.

The primary is excited by rated voltage, which is adjusted precisely with the help of a variac. The wattmeter measures input power. The ammeter measures input current. The voltemeter gives the value of rated primary voltage applied at rated frequency.

Sometimes a voltmeter may be connected across secondary to measure secondary voltage which is $V_2 = E_2$ when primary is supplied with rated voltage. As voltmeter resistance is very high, though voltmeter is connected, secondary is treated to be open circuit as voltmeter current is always negligibly small.

When the primary voltage is adjusted to its rated value with the help of variac, readings of ammeter and wattmeter are to be recorded.

Let,

V_o = Rated voltage

W_o = Input power

I_o = Input current = no load current

As transformer secondary is open, it is on no load. So current drawn by the primary is noload current I_o. The two components of this no load current are,

$$I_m = I_o \sin \Phi_o$$

$$I_c = I_o \cos \Phi_o$$

where $\cos \Phi_o$ = No load power factor And

hence power input can be written as,

$$W_o = V_o I_o \cos \Phi_o$$

The phasor diagram is shown in the Fig.

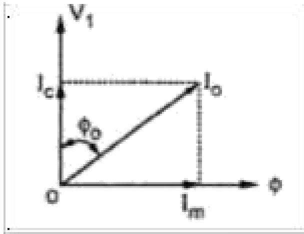


Fig.

As secondary is open, I_2 = 0. Thus its reflected current on primary is also zero. So we haveprimary current I_1 =I_o. The transformer no load current is always very small, hardly 2 to 4 % ofits full load value. As I_2 = 0, secondary copper losses are zero. And I_1 = I_o is very low hencecopper losses on primary are also very very low. Thus the total copper losses in O.C. test arenegligibly small. As against this the input voltage is rated at rated frequency hence flux densityin the core is at its maximum value. Hence iron losses are at rated voltage. As output power iszero and copper losses are very low, the total input power is used to supply iron losses. Thispower is measured by the wattmeter i.e. W_o. Hence the wattmeter in O.C. test gives iron losses which remain constant for all the loads.

$$\therefore \quad W_o = P_i = \text{Iron losses}$$

Calculations : We know that,

$$W_o = V_o\, I_o \cos \Phi$$

$$\cos \Phi_o = W_o /(V_o\, I_o) = \text{no load power factor}$$

Once cos Φ_o is known we can obtain,

$$I_c = I_o \cos \Phi_o$$

and $$I_m = I_o \sin \Phi_o$$

Once I_c and I_m are known we can determine exciting circuit parameters as,

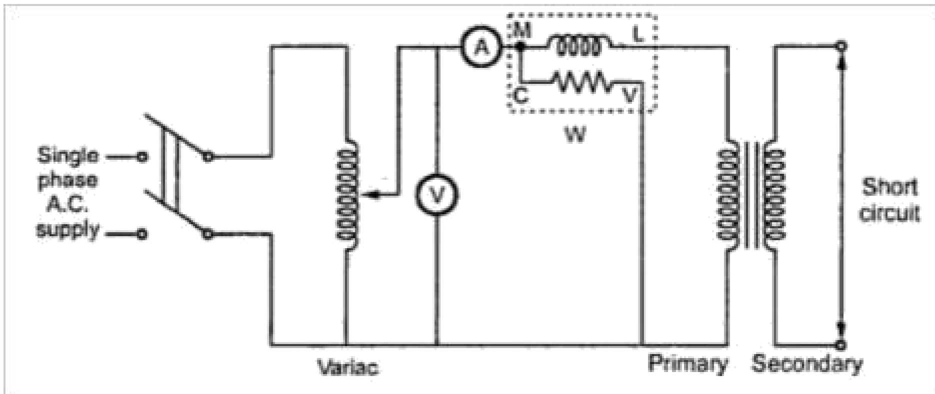
$$R_o = V_o / I_c \ \Omega$$

and $$X_o = V_o / I_m \ \Omega$$

Key Point : The no load power factor cos Φ_o is very low hence wattmeter used must be low power factor type otherwise there might be error in the results. If the meters are connected on secondary and primary is kept open then from O.C. test we get R_o'and X_o' with which we can obtain R_o and X_o knowing the transformation ratio K.

Short Circuit Test (S.C. Test)

In this test, primary is connected to a.c. supply through variac, ammeter and voltmeter as shown in the Fig. 3.



Experimental circuit for O.C. test

The secondary is short circuited with the help of thick copper wire or solid link. As high voltage side is always low current side, it is convenient to connect high voltage side to supply and shorting the low voltage side.

As secondary is shorted, its resistance is very very small and on rated voltage it may draw very large current. Such large current can cause overheating and burning of the transformer. To limit this short circuit current, primary is supplied with low voltage which is just enough to causerated current to flow through primary which can be observed on an ammeter. The low voltage can be adjusted with the help of variac. Hence this test is also called low voltage test or reduced voltage test. The wattmeter reading as well as voltmeter, ammeter readings are recorded.

Now the current flowing through the windings are rated current hence the total copper loss is full load copper loss. Now the voltage supplied is low which is a small fraction of the rated voltage. The iron losses are function of applied voltage. So the iron losses in reduced voltage test are verysmall. Hence the wattmeter reading is the power loss which is equal to full load copper losses as iron losses are very low.

∴ $W_{sc} = (P_{cu})$ F.L. = Full load copper loss

Calculations : From S.C. test readings we can write, W_{sc}

$= V_{sc} I_{sc} \cos \Phi_{sc}$

∴ $\cos \Phi sc = V_{sc} I_{sc} / W_{sc}$ = short circuit power factor

$W_{sc} = I_{sc}^2 R_{1e}$ = copper loss

$$\therefore \quad R_{1e} = W_{sc} / I_{sc}^2$$

while $\quad Z_{1e} = V_{sc} / I_{sc} = \sqrt{(R_{1e}^2 + X_{1e}^2)}$

$$\therefore \quad X_{1e} = \sqrt{(Z_{1e}^2 - R_{1e}^2)}$$

Thus we get the equivalent circuit parameters R_{1e}, X_{1e} and Z_{1e}. Knowing the transformationratio K, the equivalent circuit parameters referred to secondary also can be obtained.

Important Note : If the transformer is step up transformer, its primary is L.V. while secondaryis H.V. winding. In S.C. test, supply is given to H.V. winding and L.V is shorted. In such case we connect meters on H.V. side which is transformer secondary through for S.C. test purpose
H.V side acts as primary. In such case the parameters calculated from S.C. test readings are referred to secondary which are R_{2e}, Z_{2e} and X_{2e}. So before doing calculations it is necessary to find out where the readings are recorded on transformer primary or secondary and accordingly the parameters are to be determined. In step down transformer, primary is high voltage itself to which supply is given in S.C. test. So in such case test results give us parameters referred to primary i.e. R_{1e}, Z_{1e} and X_{1e}.

Key point : In short, if meters are connected to primary of transformer in S.C. test, calculations give us R_{1e} and Z_{1e} if meters are connected to secondary of transformer in S.C. test calculations give us R_{2e} and Z_{2e}.

Calculation of Efficiency from O.C. and S.C. Tests

We know that,

From O.C. test, $W_o = P_i$

From S.C. test, $W_{sc} = (P_{cu})$ F.L.

$$\therefore \quad \% \eta \text{ on full load} = \frac{V_2 (I_2) \text{F.L.} \cos \phi}{V_2 (I_2) \text{F.L.} \cos + W_o + W_{sc}} \times 100$$

Thus for any p.f. cos Φ_2 the efficiency can be predetermined. Similarly at any load which isfraction of full load then also efficiency can be predetermined as,

$$\% \eta \text{ at any load} = \frac{n \times (\text{VA rating}) \times \cos \phi}{n \times (\text{VA rating}) \times \cos \phi + W_o + n^2 W_{sc}} \times 100$$

where n = fraction of full load

$$\text{or} \qquad \% \eta = \frac{n V_2 I_2 \cos\phi}{n V_2 I_2 \cos\phi + W_o + n^2 W_{sc}} \times 100$$

where $I_2 = n (I_2)$ F.L.

<u>Calculation of Regulation</u>

From S.C. test we get the equivalent circuit parameters referred to primary or secondary.

The rated voltages V_1, V_2 and rated currents (I_1) F.L. and (I_2) F.L. are known for the given transformer. Hence the regulation can be determined as,

$$\% R = \frac{I_2 R_{2e} \cos\phi \pm I_2 X_{2e} \sin\phi}{V_2} \times 100$$

$$= \frac{I_1 R_{1e} \cos\phi \pm I_1 X_{1e} \sin\phi}{V_1} \times 100$$

where I_1, I_2 are rated currents for full load regulation.

For any other load the currents I_1, I_2 must be changed by fraction n.

∴ I_1, I_2 at any other load = $n (I_1)$ F.L., $n (I_2)$ F.L.

Key Point : Thus regulation at any load and any power factor can be predetermined, withoutactually loading the transformer.

Example 1 : A 5 KVA, 500/250 V, 50 Hz, single phase transformer gave the following readings,

O.C. Test : 500 V, 1 A, 50 W (L.V. side open)

S.C. Test : 25 V, 10 A, 60 W (L.V. side shorted) Determine : i)

The efficiency on full load, 0.8 lagging p.f.

ii) The voltage regulation on full load, 0.8 leading p.f.

iii) The efficiency on 60% of full load, 0.8 leading p.f.

iv) Draw the equivalent circuit referred to primary and insert all the values in it.

Solution : In both the tests, meters are on H.V. side which is primary of the transformer. Hencethe parameters obtained from test results will be referred to primary.

From O.C. test, $V_o = 500$ V, $I_o = 1$ A, $W_o = 50$ W

$\therefore$ $\cos \Phi_o = W_o/V_o I_o = 50/(500\times1) = 0.1$

$\therefore$ $I_c = I_o \cos = 1 \times 0.1 = 0.1$ A

and $I_m = I_o \sin \Phi_o = 1 \times 0.9949 = 0.9949$ A

$\therefore$ $R_o = V_o/I_c = 500/0.1 = 5000\ \Omega$

and $X_o = V_o/I_m = 500/0.9949 = 502.52\ \Omega$

and $W_o = P_i$ = iron losses = 50 W From

S.C. test, $V_{sc} = 25$ V, $I_{sc} = 10$ A, $W_{sc} = 60$ W

$\therefore$ $R_{1e} = W_{sc}/I_{sc}^2 = 60/(10)^2 = 0.6\ \Omega$

$Z_{1e} = V_{sc}/I_{sc} = 25/10 = 2.5\ \Omega$

$\therefore$ $X_{1e} = \sqrt{(2.5^2 - 0.6^2)} = 2.4269\ \Omega$

(I_1) F.L. = VA rating/V_1

$= (5 \times 10^3)/500 = 10$ A

and $I_{sc} = (I_1)$ F.L.

$\therefore$ $W_{sc} = (P_{cu})$ F.L. = 60 W

i) η on full load, cos = 0.8 lagging

$$\%\,\eta = \frac{(\text{VA rating})\cos\phi_2}{(\text{VA rating})\cos\phi_2 + P_i + (P_{cu})\text{ F. L.}} \times 100$$

$$= \frac{5\times10^3 \times 0.8}{5\times10^3 \times 0.8 + 50 + 60} \times 100 = \mathbf{97.32\ \%}$$

ii) Regulation on full load, $\cos \Phi_2 = 0.8$ leading

$$\%\,R = \frac{(I_1)\text{ F. L. } R_{1e}\cos\phi - (I_1)\text{ F. L. } X_{1e}\sin\phi}{V_1} \times 100$$

$$= \frac{10\times0.6\times0.8 - 10\times2.4269\times0.6}{500} \times 100$$

$= - 1.95\ \%$

iii) For 60% of full load, n = 0.6 and cos Φ_2 = 0.8 leading]

$\therefore$ P_{cu} = copper loss on new load = $n^2 \times (P_{cu})$ F.L.

$= (0.6)^2 \times 60 = 21.6$ W

= 97.103 %

iv) The equivalent circuit referred to primary is shown in the Fig. 4.

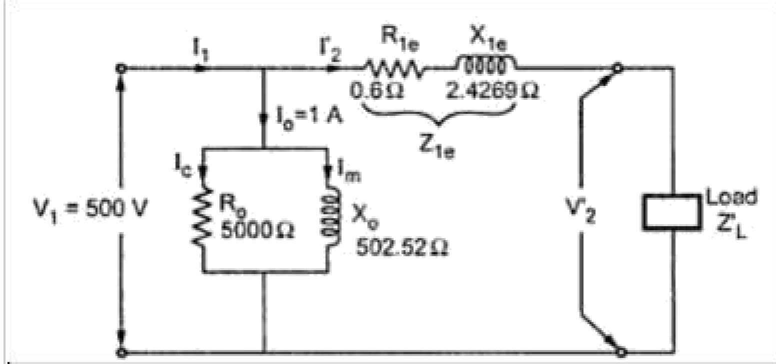


Fig. 4

Example 2 : The open circuit and short circuit tests on a 10 KVA, 125/250 V, 50 Hz, singlephase transformer gave the following results :

O.C. test : 125 V, 0.6 A, 50 W (on L.V. side)

S.C. test : 15 V, 30 A. 100 W (on H.V. side)

Calculate : i) copper loss on full load

ii) full load efficiency at 0.8 leading p.f.

iii) half load efficiency at 0.8 leading p.f.

iv) regulation at full load, 0.9 leading p.f.

Solution : From O.C. test we can weite,

$W_o = P_i$ = 50 W = Iron loss

From S.C. test we can find the parameters of equivalent circuit. Now S.C. test is conductedon H.V. side i.e. meters are on H.V. side which is transformer secondary. Hence parameters from S.C. test results will be referred to secondary.

V_{sc} = 15 V, I_{sc} = 30 A, W_{sc} = 100 W

∴ $R_{2e} = W_{sc}/(I_{sc})^2 = 10/(30)^2 = 0.111\Omega$

$Z_{1e} = V_{sc}/I_{sc} = 15/30 = 0.5\ \Omega$

∴ $X_{2e} = \sqrt{(Z_{2e}^2 - R_{2e}^2)} = 0.4875\ \Omega$

i) Copper loss on full load

(I_2) F.L. = VA rating/V_2 = $(10 \times 10^3)/250$ = 40 A

In short circuit test, I_{sc} = 30 A and not equal to full load value 40 A.

Hence W_{sc} does not give copper loss on full load

$\therefore$ $W_{sc} = P_{cu}$ at 30 A = 100 W

Now $P_{cu} \propto I^2$

$(P_{cu} \text{ at } 30\text{ A})/(P_{cu} \text{ at } 40\text{ A}) = (30/40)^2$

$100/(P_{cu} \text{ at } 40\text{ A}) = 900/1600$

P_{cu} at 40 A = 177.78 W

$\therefore$ (P_{cu}) F.L. = 177.78 W

i) Full load η , cos Φ_2 = 0.8

$$\% \eta \text{ on full load} = \frac{V_2(I_2)\text{ F. L. } \cos\phi_2}{V_2(I_2)\text{ F. L.} \cos\phi_2 + P_i + (P_{cu})\text{ F. L.}} \times 100$$

$$= \frac{250 \times 40 \times 0.8}{250 \times 40 \times 0.8 + 50 + 177.78} \times 100 = \mathbf{97.23\ \%}$$

ii) Half load η , cos Φ_2 = 0.8

n = 0.5 as half load, (I_2) H.L. = 0.5 x 40 = 20

$$\therefore \% \eta \text{ on half load} = \frac{V_2(I_2)\text{ H. L. } \cos\phi_2}{V_2(I_2)\text{ H. L.} \cos\phi_2 + P_i + n^2(P_{cu})\text{ F. L.}} \times 100$$

$$= \frac{n\,(\text{VA rating})\cos\phi_2}{n\,(\text{VA rating})\cos\phi_2 + P_i + n^2(P_{cu})\text{ F. L.}} \times 100$$

$$= \frac{0.5 \times 10 \times 10^3 \times 0.8}{0.5 \times 10 \times 10^3 \times 0.8 + 50 + (0.5)^2 \times 177.78} \times 100$$

= 97.69%

iii) Regulation at full load, cos Φ = 0.9 leading

$$\% R = \frac{(I_2)\text{ F.L.} R_{2e} \cos\phi - (I_2)\text{ F.L. } X_{2e} \sin\phi}{V_2} \times 100$$

$$= \frac{40 \times 0.111 \times 0.9 - 40 \times 0.4875 \times 0.4358}{250} \times 100$$

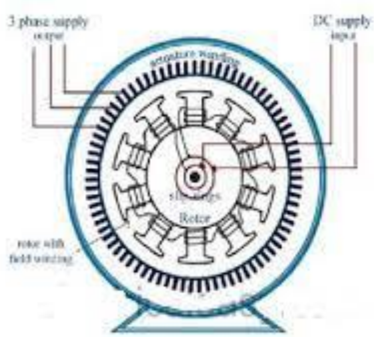
= -1.8015%

UNIT-III

Synchronous Generator:

Basically, an AC generator or alternator or synchronous generator is an electrical machine that converts mechanical energy into electrical energy in the form of Alternating Current (AC). Basic principle behind the working of an AC synchronous generator is also Faraday's law of electrical induction, somewhat similar to working of a DC generator.

Construction Of AC Synchronous Generator (Alternator)



The main parts of an alternator, obviously, consists of a stator and a rotor. But, unlike other machines, in most of the alternators, field exciters are rotating and the armature coil is stationary.

Stator: Unlike in a DC machine, the stator of an alternator is not meant to serve a path for magnetic flux. Instead, the stator is used for holding armature winding. The stator core is made up of lamination of steel alloys or magnetic iron, to minimize the eddy current losses

Why Armature Winding Is Stationary In An Alternator?

At high voltages, it is easier to insulate the stationary armature winding, which may be as high as 11 kV or even more in some cases.

The generated high voltage output can be directly taken out from the stationary armature. Whereas for a rotary armature, there will be large brush contact drop at higher voltages, also the sparking at the brush surface will be a problem to look after.

If the field exciter winding is placed in the rotor, low voltage DC can be transferred safely to the exciter winding via slip-rings.

The armature winding can be braced well, to prevent deformation caused by high centrifugal force if it was in the rotor.

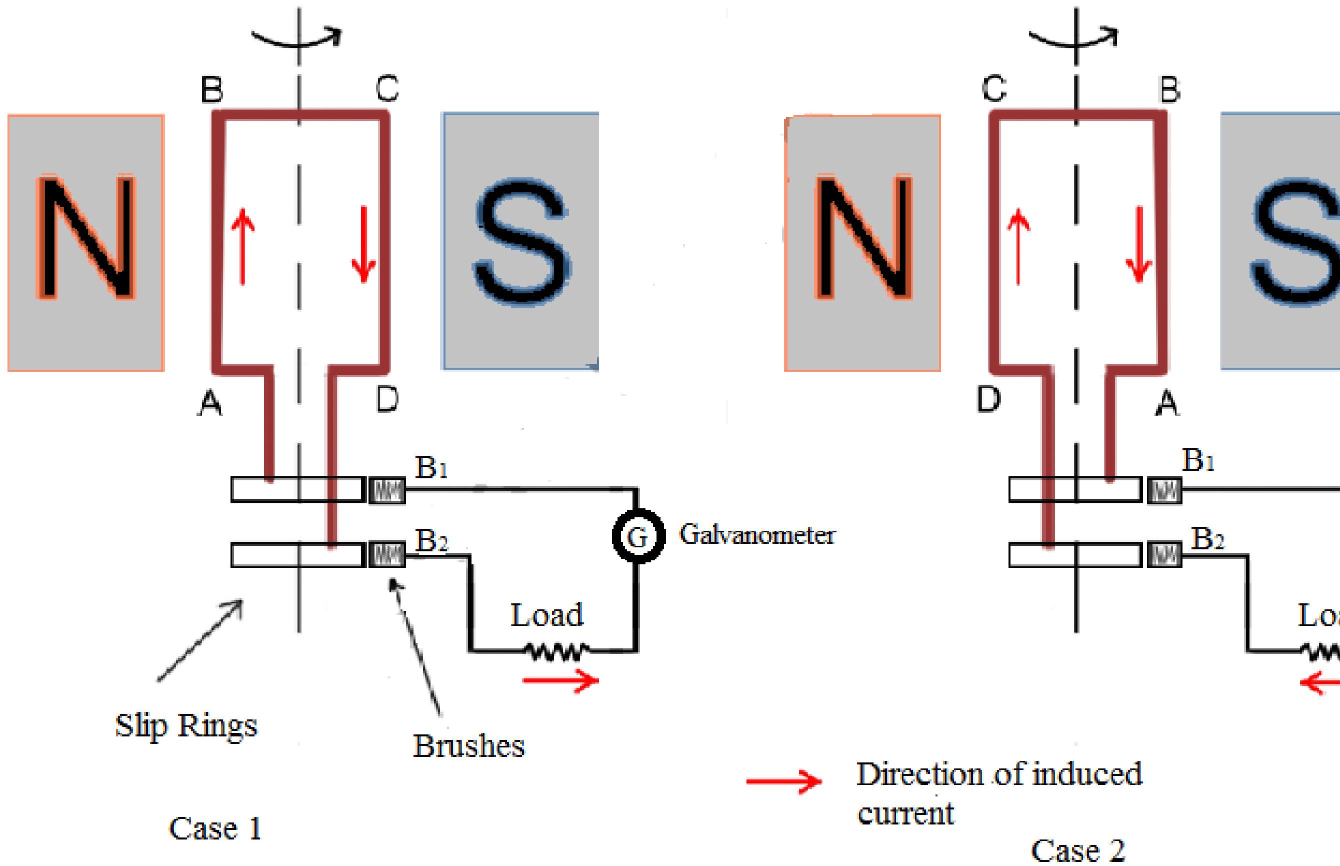
Rotor: There are two types of rotor used in an AC synchronous generator/alternator: (i) Salient and (ii) Cylindrical type

Salient pole type: Salient pole type rotor is used in low and medium speed alternators. The construction of an AC synchronous generator of a salient pole type rotor is shown in the figure above. This type of rotor consists of a large number of projected poles (called salient poles), bolted on a magnetic wheel. These poles are also laminated to minimize the eddy current losses. Alternators featuring this type of rotor are large in diameters and short in axial length.

Cylindrical type: Cylindrical type rotors are used in high-speed alternators, especially in turbo-alternators. This type of rotor consists of a smooth and solid steel cylinder having slots along its outer periphery. Field windings are placed in these slots.

A DC supply is given to the rotor winding through the 'slip-rings and brushes' arrangement.

Working :



The above figure illustrates how an alternator or AC synchronous generator work. According to Faraday's law of electromagnetic induction, whenever a conductor moves in a magnetic field, EMF gets induced across the conductor. If a closed path is provided to the conductor, induced emf causes current to flow in the circuit.

Now, in the above figure, let the conductor coil A-B-C-D is placed in a magnetic field. Direction of the magnetic flux will be from N pole to S pole. The coil is connected to slip rings, and the load is connected through brushes that are resting on the slip rings.

Now, consider the case 1 from the above figure. The coil is rotating clockwise, in this case, the direction of induced current can be given by Fleming's right-hand rule, and it will be along A-B-C-D.

As the coil is rotating clockwise, the position of the coil will be changed after half of the rotational period, as shown in the second case of the above figure. In this case, the direction of the induced current, according to Fleming's right-hand rule, will be along D-C-B-A. It shows that the direction of the current changes after every half of the rotational time period, that means we get an alternating current.

Types of Synchronous Generator:

Based upon the construction, there are mainly two types of rotors used in construction of alternator:

Salient pole type.

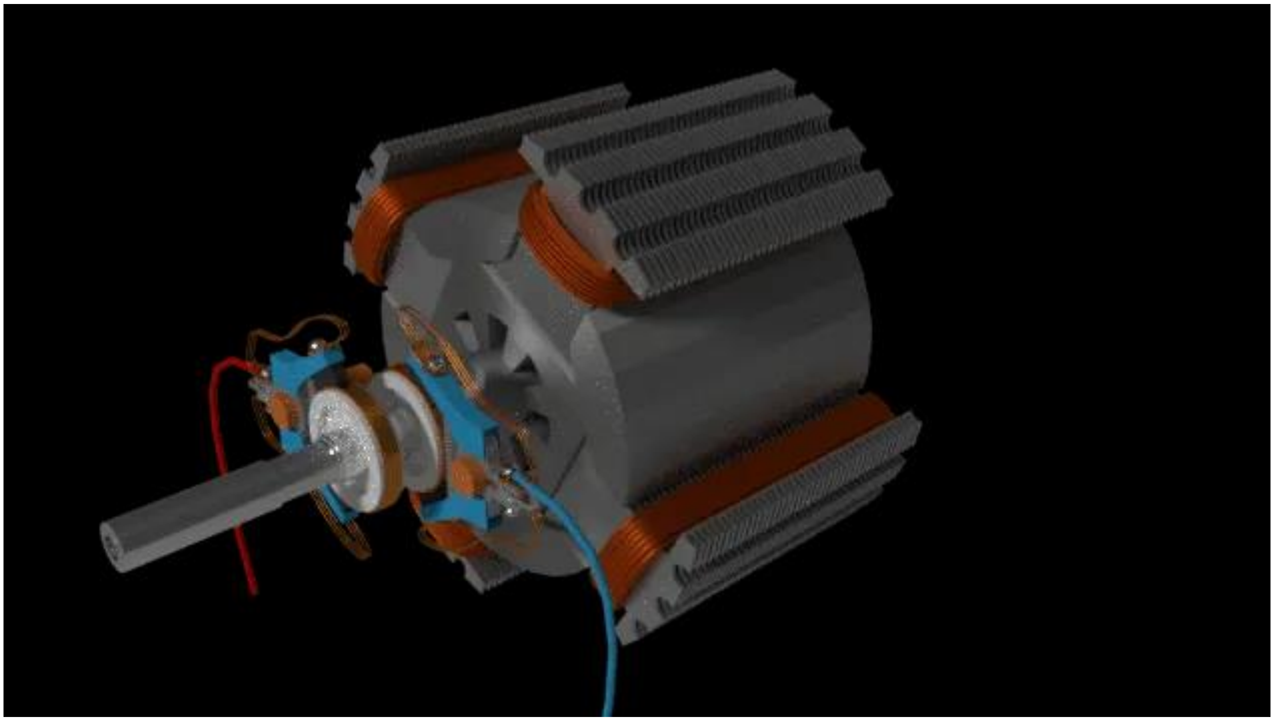
Cylindrical rotor type.

Salient Pole Type

The term salient means protruding or projecting. The salient pole type of rotor is generally used for slow speed machines having large diameters and relatively small axial lengths. The poles, in this case, are made of thick laminated steel sections riveted together and attached to a rotor with the help of joint.

An alternator as mentioned earlier is mostly responsible for generation of very high electrical power. To enable that, the mechanical input given to the machine in terms of rotating torque must also be very high. This high torque value results in oscillation or hunting effect of the alternator or synchronous generator. To prevent these oscillations from going beyond bounds the damper winding is provided in the pole faces as shown in the figure.

The damper windings are basically copper bars short-circuited at both ends are placed in the holes made in the pole axis. When the alternator is driven at a steady speed, the relative velocity of the damping winding with respect to the main field will be zero. But as soon as it departs from the synchronous speed there will be relative motion between the damper winding and the main field which is always rotating at synchronous speed. This relative difference will induce the current in them which will exert a torque on the field poles in such a way as to bring the alternator back to synchronous speed operation.



The salient feature of pole field structure has the following special feature-

They have a large horizontal diameter compared to a shorter axial length.

The pole shoes covers only about 2/3rd of pole pitch.

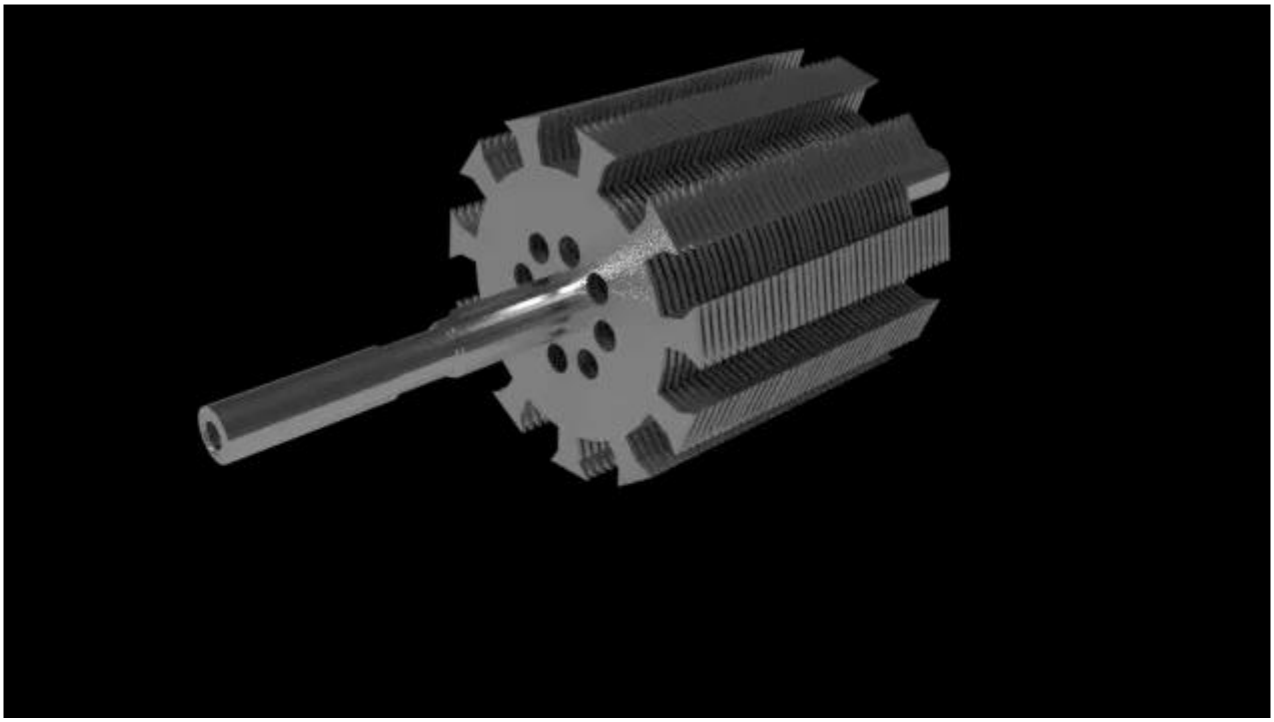
Poles are laminated to reduce eddy current loss.

The salient pole type motor is generally used for low-speed operations of around 100 to 400 rpm, and they are used in power stations with hydraulic turbines or diesel engines.

Salient pole alternators driven by water turbines are called hydro-alternators or hydro generators.

Cylindrical Rotor Type

The cylindrical rotor is generally used for very high speed operation and employed in steam turbine driven alternators like turbogenerators. The machines are built in a number of ratings from 10 MVA to over 1500 MVA. The cylindrical rotor type machine has a uniform length in all directions, giving a cylindrical shape to the rotor thus providing uniform flux cutting in all directions. The rotor, in this case, consists of a smooth solid steel cylinder, having a number of slots along its outer periphery for hosting the field coils.



The cylindrical rotor alternators are generally designed for 2-pole type giving very high speed of

$$N_s = \frac{(120 \times f)}{P} = \frac{(120 \times 50)}{2} = 3000\ rpm$$

Or 4-pole type running at a speed of

$$N_s = \frac{(120 \times f)}{P} = \frac{(120 \times 50)}{4} = 1500\ rpm$$

Where, f is the frequency of 50 Hz.

The cylindrical rotor synchronous generator does not have any projections coming out from the surface of the rotor. Rather, the central polar area is provided with slots for housing the field windings as we can see from the diagram above.

The field coils are so arranged around these poles that flux density is maximum on the polar central line and gradually falls away as we move out towards the periphery. The cylindrical rotor type machine gives better balance and quieter-operation along with lesser windage losses.

Regulation of alternator by synchronous impedance method:

Generally, we use this Synchronous Impedance Method for high-speed Alternators or synchronous generator. This method is also known as EMF method. Before calculating the voltage regulation we need to calculate the following data.

1.Armature Resistance per phase [Ra]

2.Open Circuit characteristics which is a graph between open circuit voltage [Vo.c.] and field current.

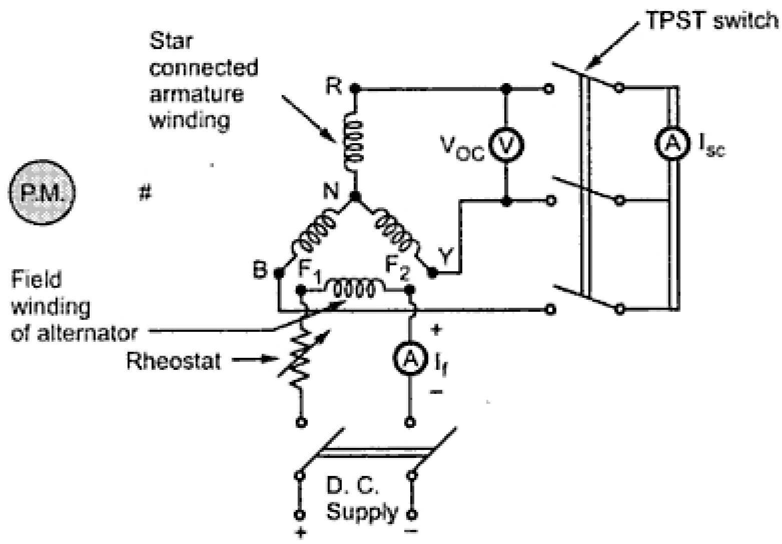
3.Short circuit characteristics which is a graph between short circuit current [Is.c.] and field current.

Voltage Regulation of a Synchronous Generator using direct loading test

The circuit diagram to perform this O.C test and S.C test is given below.

The alternator or synchronous generator is coupled with the prime mover to drive alternator at synchronous speed.The armature of the alternator or synchronous generator is connected to TPST switch.The three terminals of the switch are short circuited by an ammeter.

The voltmeter is connected between two line terminals to measure o.c voltage of the alternator.For the purpose of excitation, a DC supply is connected field winding.A rheostat is also connected in series with DC supply which is used to vary the field current i.e field excitation.



. O.C test

Procedure:

1) By using the prime mover start the alternator or synchronous generator and adjust its speed to the Synchronous speed.

2)Note that rheostat should be in maximum position and switch on the D.C supply.

3)The T.P.S.T. switch should be kept open in the armature circuit.

4)Field current is varied from its min. value to the rated value using the rheostat.So now flux increases, which leads to increase in the induced e.m.f. The voltmeter now the actual line value of open circuit voltage.For various values of field currents, voltmeter readings are noted in a table.

Now plot a graph between o.c phase voltage and field current.The graph obtained is called o.c.c .

2. S.C test

Procedure:

1)After the o.c test, the field rheostat should be kept at max. Position, reducing field current to min. value.

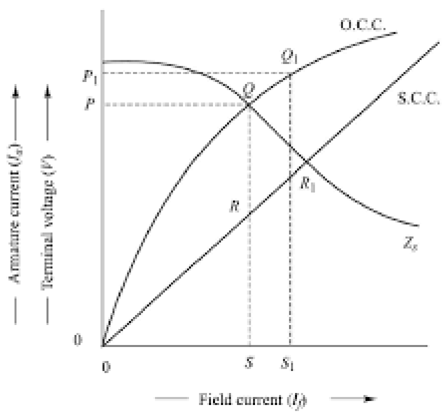
2)Now the T.P.S.T switch is closed.

3)The armature gets short circuited because ammeter has negligible resistance. Now increase the field excitation is increased gradually till full load current is obtained through armature windings.

This is observed on the ammeter connected in the armature circuit.Tabulate the values of field current and armature current values obtained.

4)Now plot a graph between s.c armature current and field current.The graph obtained is called S.C.C.

The S.C.C. is a straight line passing through origin but o.c.c resembles a B.H curve of a magnetic material.



Voltage Regulation of synchronous generator Calculations:

Zs can be determined from O.C.C and S.C.C for any load condition.The value of Ra should be known now.So it can be measured by applying d.c known voltage across the two terminals.

$$\text{Now} \qquad Z_s = \sqrt{(R_a)^2 + (X_s)^2}$$

$$\therefore \qquad \boxed{X_s = \sqrt{(Z_s)^2 - (R_a)^2} \ \Omega/\text{ph}}$$

So now induced e.m.f per phase is calculated as follows:

$$\boxed{E_{ph} = \sqrt{(V_{ph}\cos\phi + I_a R_a)^2 + (V_{ph}\sin\phi \pm I_a X_s)^2}}$$

Voltage regulation of alternator or synchronous generator is calculated by using the below formula

$$\%\ \text{Regulation} = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100$$

The above is the Voltage regulation of alternator or synchronous generator formula using Synchronous Impedance Method or EMF Method.

EMF EQUATION :

The emf induced by the alternator or synchronous generator is three-phase alternating in nature. Let us derive the mathematical equation of emf induced in the alternator.

Let,

Z = number of conductors in series per phase.

Z = 2T, where T is the number of coils or turns per phase. One turn has two coil sides or conductor as shown in the below diagram.

P = Number of poles.

f = frequency of induced emf in Hertz

Φ = flux per pole in webers.

Kp = pitch factor, Kd = distribution factor,

Kf = Form factor

N = Speed of the rotor in rpm(revolutions per minute)

N/60 = Speed of the rotor in revolutions per second.

Time taken by the rotor to complete one revolution,

dt = 1/(N/60)= 60/N second

In one revolution of the rotor, the total flux Φ cut the by each conductor in the stator poles, dΦ = ΦP weber

By faraday's law of electromagnetic induction, the emf induced is proportional to rate of change of flux.

$$Average\ \ emf\ \ induced\ \ per\ \ conductor = \frac{d\Phi}{dt} = \frac{\Phi P}{60/N} = \frac{\Phi NP}{60}$$

We know, the frequency of induced emf

$$f = \frac{PN}{120},\ N = \frac{120f}{P}$$

Submitting the value of N in the induced emf equation, We get

$$Average\ \ emf\ \ induced\ \ per\ \ conductor = \frac{\Phi P}{60} x \frac{120f}{P} = 2\Phi f\ \ volts$$

If there are Z conductors in series per phase,

$$Average\ \ emf\ \ induced\ \ per\ \ conductor = 2\Phi f Z = 4\Phi f T\ \ volts$$

RMS value of emf per phase = Form factor x Average value of induced emf = 1.11 x 4 Φ f T

RMS value of emf per phase = 4.44 Φ f T volts

The obtained above equation is the actual value of the induced emf for full pitched coil or concentrated coil. However, the voltage equation gets modified because of the winding factors.

Actual induced emf per phase = 4.44 Kp Kd Φ f T volts = 4 Kf Kp Kd Φ f T volts

SYNCHRONOUS MOTOR:

Construction:

Synchronous motors run at synchronous speed. The synchronous speed is given by

$$N_s = \frac{120f}{p}$$

Where, Ns = synchronous speed, f = supply frequency and p = number of poles. As we can see from the equation, the synchronous speed depends on the frequency of the supply and the number of poles.

The **construction of a synchronous motor** is very similar to the construction of an alternator. Both are synchronous machines where one we use as a motor and the other as a generator. Just like any other motor, the synchronous motor also has a stator and a rotor. We will look into the construction details of the various parts one by one in detail.

Stator of Synchronous Motor

The main stationary part of the machine is stator. The stator consists of the following parts.

Stator Frame

The stator frame is the outer part of the machine and is made up of cast iron. It protects the enter inner parts of the machine.

Stator Core

The stator core is made up of thin silicon laminations. It is insulated by a surface coating to minimize hysteresis and eddy current losses. Its main purpose is to provide a path of low reluctance for the magnetic lines of force and accommodate the stator windings.

Stator Winding

The stator core has cuts on the inner periphery to accommodate the stator windings. The stator windings could be either three-phase windings or single phase windings.

Enamelled copper is used as the winding material. In the case of 3 phase windings, the windings are distributed over several slots. This is done to produce a sinusoidal distribution of EMF

Rotor of Synchronous Motor

The rotor is the moving part of the machine. Rotors are available in two types:

- **Salient Pole Type**
- **Cylindrical Rotor Type**

The salient pole type rotor consists of poles projecting out from the rotor surface. It is made up of steel laminations to reduce eddy current losses.

- A salient pole machine has a non-uniform air gap. The gap is maximum between the poles and is minimum at the pole centres. They are generally used for medium and low-speed operations as they have a large number of poles. They contain damper windings which are used for starting the motor.

- A cylindrical rotor is made from solid forgings of high-grade nickel chrome molybdenum steel forgings of high-grade nickel chrome molybdenum steel. The poles are created by the current flowing through the windings. They are used for high-speed applications as they have less number of poles. They also produce less noise and windage losses as they have a uniform air gap. DC supply is given to the rotor windings via slip-rings. Once the rotor windings are excited, they act like poles.

Working:

Synchronous motors are a doubly excited machine, i.e., two electrical inputs are provided to it. Its stator winding which consists of a We provide three-phase supply to three-phase stator winding, and DC to the rotor winding.

The 3 phase stator winding carrying 3 phase currents produces 3 phase rotating magnetic flux. The rotor carrying DC supply also produces a constant flux. Considering the 50 Hz power frequency, from the above relation we can see that the 3 phase rotating flux rotates about 3000 revolutions in 1 min or 50 revolutions in 1 sec.

At a particular instant rotor and stator poles might be of the same polarity (N-N or S-S) causing a repulsive force on the rotor and the very next instant it will be N-S causing attractive force. But due to the inertia of the rotor, it is unable to rotate in any direction due to that attractive or repulsive forces, and the rotor remains in standstill condition. Hence a synchronous motor is not self-starting.

Here we use some mechanical means which initially rotates the rotor in the same direction as the magnetic field to speed very close to synchronous speed. On achieving synchronous speed, magnetic locking occurs, and the synchronous motor continues to rotate even after removal of external mechanical means.

Equivalent circuit of synchronous motor:

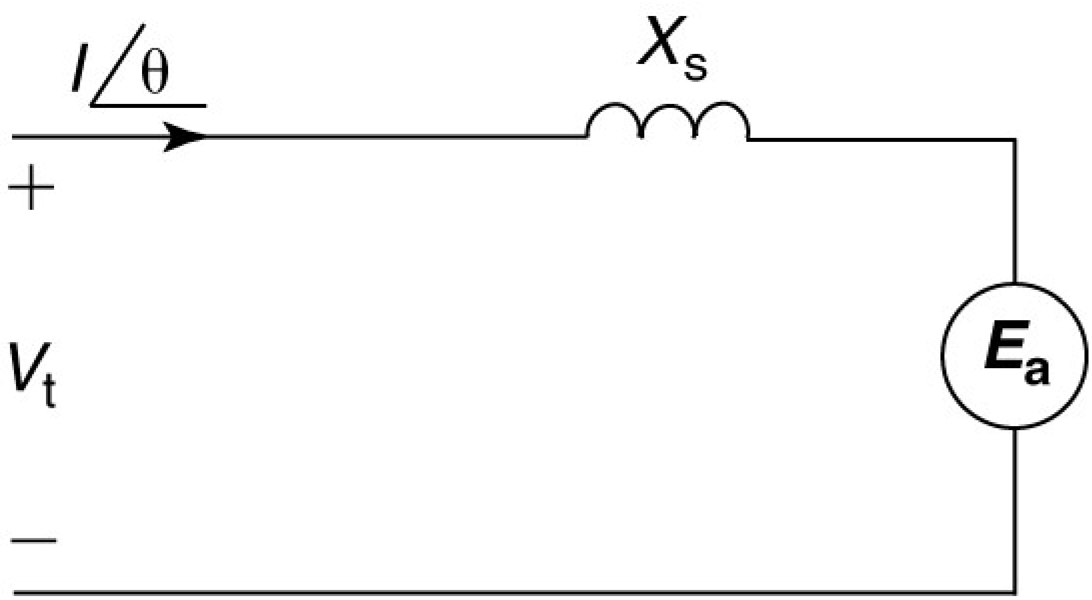
The equivalent circuit for one phase of a synchronous motor is shown in Figure 1. It is similar to the **synchronous generator** equivalent circuit, but with two differences.
First, it has been flipped to show the power system as the input to the motor, and, **second**, the current is referenced as positive into the motor.

The power system normally constitutes an infinite bus because the motor is much smaller than the rest of the power system. When the rotor field rotates at synchronous speed, a counter EMF (C-EMF), E_a, is induced into the armature windings. Writing a voltage loop equation yields

$V_t=E_a+jIX_s$ ....(1)

Which can be rearranged as

$E_a=V_t-jIX_s$...............(2)



UNIT-IV

4.1Three Phase Induction Motor

The most common type of AC motor being used throughout the work today is the "Induction Motor". Applications of three-phase induction motors of size varying from half akilowatt to thousands of kilowatts are numerous. They are found everywhere from a small workshop to a large manufacturing industry.

The advantages of three-phase AC induction motor are listed below:

- Simple design
- Rugged construction
- Reliable operation
- Low initial cost
- Easy operation and simple maintenance
- Simple control gear for starting and speed control
- High efficiency.

Induction motor is originated in the year 1891 with crude construction (The induction machine principle was invented by *NIKOLA TESLA* in 1888.). Then an improved construction with distributed stator windings and a cage rotor was built.

The slip ring rotor was developed after a decade or so. Since then a lot of improvement has takenplace on the design of these two types of induction motors. Lot of research work has beencarried out to improve its power factor and to achieve suitable methods of speed control.

4.2Types and Construction of Three Phase Induction Motor

Three phase induction motors are constructed into two major types:

1. Squirrel cage Induction Motors
2. Slip ring Induction Motors

4.2.1Squirrel cage Induction Motors

(a) Stator Construction

The induction motor stator resembles the stator of a revolving field, three phase alternator. The stator or the stationary part consists of three phase winding held in place in the slots of a laminated steel core which is enclosed and supported by a cast iron or a steel frame as shown in Fig: 4.1(a).

The phase windings are placed 120 electrical degrees apart and may be connected in either star or delta externally, for which six leads are brought out to a terminal box mounted on the frame ofthe motor.When the stator is energized from a three phase voltage it will produce a rotating magnetic field in the stator core.

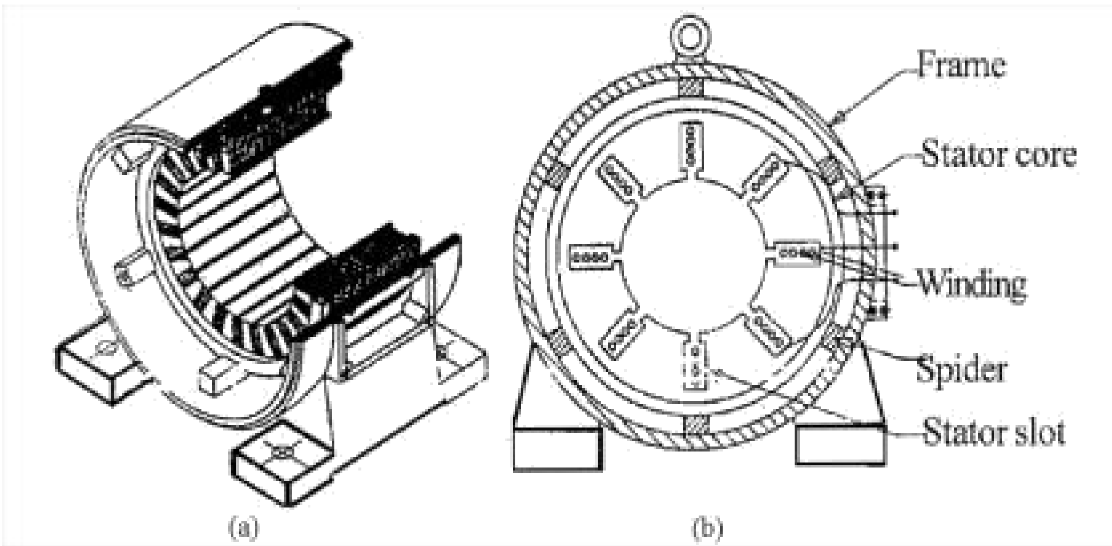


Fig.4.1.

(b) Rotor Construction

The rotor of the squirrel cage motor shown in Fig: 4.1(b) contains no windings. Instead it is a cylindrical core constructed of steel laminations with conductor bars mounted parallel to theshaft and embedded near the surface of the rotor core.

These conductor bars are short circuited by an end rings at both end of the rotor core. In large machines, these conductor bars and the end rings are made up of copper with the bars brazed or welded to the end rings shown in Fig: 4.1(b).In small machines the conductor bars and end rings are sometimes made of aluminium with the bars and rings cast in as part of the rotor core. Actually the entire construction (bars and end-rings) resembles a squirrel cage, from which the name is derived.

The rotor or rotating part is not connected electrically to the power supply but has voltage induced in it by transformer action from the stator. For this reason, the stator is sometimes called the primary and the rotor is referred to as the secondary of the motor since the motor operates on the principle of induction and as the construction of the rotor with the bars and end rings resembles a squirrel cage, the squirrel cage induction motor is used.

The rotor bars are not insulated from the rotor core because they are made of metals having less Resistance than the core. The induced current will flow mainly in them. Also the rotor bars are usually not quite parallel to the rotor shaft but are mounted in a slightly skewed position. This feature tends to produce a more uniform rotor field and torque. Also it helps to reduce some of the internal magnetic noise when the motor is running.

(c) End Shields

The function of the two end shields is to support the rotor shaft. They are fitted with bearings andAttached to the stator frame with the help of studs or bolts attention.

<u>**4.2.2** Slip ring Induction Motors</u>

(a) Stator Construction

The construction of the slip ring induction motor is exactly similar to the construction of squirrel cage induction motor. There is no difference between squirrel cage and slip ring motors.

(b) Rotor Construction

The rotor of the slip ring induction motor is also cylindrical or constructed of lamination.Squirrel cage motors have a rotor with short circuited bars whereas slip ring motors have wound rotors having "three windings" each connected in star.

The winding is made of copper wire. The terminals of the rotor windings of the slip ring motors are brought out through slip rings which are in contact with stationary brushes asshown in Fig.4.2.

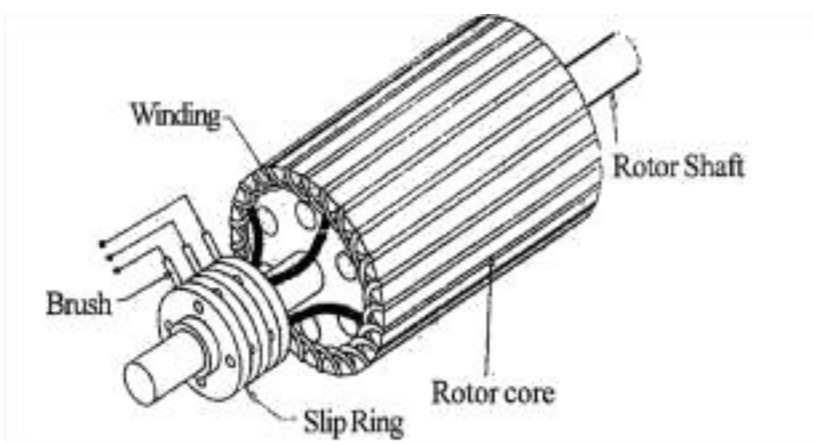


Fig.4.2

The Advantages Of The Slipring Motor

• It has susceptibility to speed control by regulating rotor resistance.

• High starting torque of 200 to 250% of full load value.

• Low starting current of the order of 250 to 350% of the full load current.

Hence slip ring motors are used where one or more of the above requirements are to be met.

4.2.3 Comparison of Squirrel Cage and Slip Ring Motor

Sl.No.	Property	*Squirrel cage motor*	*Slip ring motor*
1.	**Rotor Construction**	*Bars are used in rotor. Squirrel cage motor is very simple, rugged and long lasting. No slip rings and brushes*	*Winding wire is to be used.* *Wound rotor required attention.* *Slip ring and brushes are needed also need frequent maintenance.*
2.	**Starting**	*Can be started by D.O.L., star-delta, auto transformer starters*	*Rotor resistance starter is required.*
3.	**Starting torque**	*Low*	*Very high*
4.	**Starting Current**	*High*	*Low*
5.	**Speed variation**	*Not easy, but could be varied in large steps by pole changing or through smaller incremental steps through thyristors or by frequency variation.*	*Easy to vary speed.* *Speed change is possible by inserting rotor resistance using thyristors or by using frequency variation injecting emf in the rotor circuit cascading.*
6.	**Maintenance**	*Almost ZERO maintenance*	*Requires frequent maintenance*
7.	**Cost**	*Low*	*High*

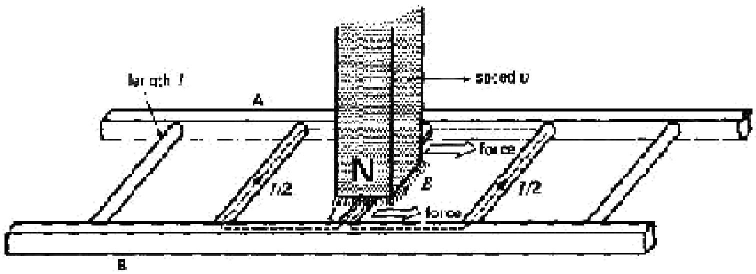
4.3 Principle of Operation

The operation of a 3-phase induction motor is based upon the application of Faraday Law and theLorentz force on a conductor. The behaviour can readily be understood by means of the following example.

Consider a series of conductors of length l, whose extremities are short-circuited by two bars A and B (Fig.3.3 a). A permanent magnet placed above this conducting ladder, moves rapidly tothe right at a speed v, so that its magnetic field B sweeps across the conductors. The following sequence of events then takes place.

1. A voltage E = Blv is induced in each conductor while it is being cut by the flux (Faraday law).
2. The induced voltage immediately produces a current I, which flows down the conductorunderneath the pole face, through the end-bars, and back through the other conductors.
3. Because the current carrying conductor lies in the magnetic field of the permanent magnet, itexperiences a mechanical force (Lorentz force).
4. The force always acts in a direction to drag the conductor along with the magnetic field. If the conducting ladder is free to move, it will accelerate toward the right. However, as it picks up speed, the conductors will be cut less rapidly by the moving magnet, with the result that the induced voltage E and the current I will diminish. Consequently, the force acting on the conductors wilt also decreases. If the ladder were to move at the same speed as the magnetic field, the induced voltage E, the current I, and the force dragging the ladder along would all become zero.

In an induction motor the ladder is closed upon itself to form a squirrel-cage (Fig.3.3b) and themoving magnet is replaced by a rotating field. The field is produced by the 3-phase currents that flow in the stator windings.



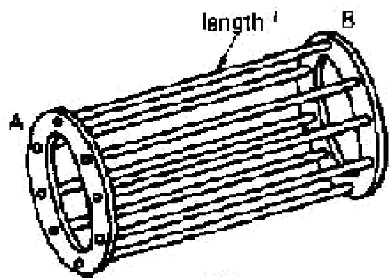


Fig.4.3

SLIP

The relationship between the supply frequency, *f*, the number of poles, *p*, and the synchronous speed (speed of rotating field), n_s is given by

$$n_s = \frac{120f}{p}$$

The stator magnetic field (rotating magnetic field) rotates at a speed, n_s, the synchronous speed. If, n= speed of the rotor, the slip, s for an induction motor is defined as

$$s = \frac{n_s - n}{n_s}$$

At stand still, rotor does not rotate , n = 0, so s = 1.

At synchronous speed, $n = n_S$, s = 0

The mechanical speed of the rotor, in terms of slip and synchronous speed is given by,

$$n=(1-s)\,n_s$$

Frequency of Rotor Current and Voltage

With the rotor at stand-still, the frequency of the induced voltages and currents is the same as that of the stator (supply) frequency, f_e.

If the rotor rotates at speed of n, then the relative speed is the slip speed:

$$n_{slip}=n_s-n$$

n_{slip} is responsible for induction.

Hence, the frequency of the induced voltages and currents in the rotor is, $f_r= sf_e$.

EXAMPLE

A three-phase, 20 hp, 208 V, 60 Hz, six pole, wye connected induction motor delivers 15 kW at a slip of 5%.

Calculate:

a) Synchronous speed
b) Rotor speed
c) Frequency of rotor current

SOLUTION:

Synchronous speed: $n_s = 120\ f / p = (120*60) / 6 = 1200$ rpm

Rotor speed: $n_r = (1\text{-}s)\ n_s = (1 - 0.05)\ (1200) = 1140$ rpm

Frequency of rotor current: $f_r = s\ f = (0.05)\ (60) = 3$ Hz

Example

A 3-phase, 460 V, 100 hp, 60 Hz, four-pole

induction machine delivers rated output power at a slip of 0.05.

Determine the:

(a) Synchronous speed and motor speed.

(b) Speed of the rotating air gap field.

(c) Frequency of the rotor circuit.

(d) Slip rpm.

(e) Speed of the rotor field relative to the (i) rotor structure. (ii)Stator structure. (iii) Stator rotating field.

(f) Rotor induced voltage at the operating speed, if thestator-to-rotor turns ratio is 1 : 0.5.

Solution

$$(a)\ n_s = \frac{120f}{p} = \frac{120*60}{4} = 1800\ rpm,$$

$$n = (1-s)n_s = (1-0.05)*1800 = 1710\ rpm$$

(b) *1800 rpm* (same as synchronous speed)

(c) $f_2 = sf_1 = 0.05 \times 60 = 3$ Hz.

(d) slip $rpm = s\ n_s = 0.05 * 1800 = 90\ rpm$

(e) (i) 90 rpm (ii) 1800 rpm (iii) 0 rpm

(f) Assume that the induced voltage in the stator winding is the same as the applied voltage. Now,

$$E_{2s} = sE_2 = s\frac{N_2}{N_1}E_1 = 0.05*0.5*\frac{460}{\sqrt{3}} = 6.64V / Phase$$

4.4 Rotating Magnetic Field and Induced Voltages

Consider a simple stator having 6 salient poles, each of which carries a coil having 5 turns (Fig.4.4). Coils that are diametrically opposite are connected in series by means of three jumpers that respectively connect terminals a-a, b-b, and c-c. This creates three identical sets of windings AN, BN, CN, which are mechanically spaced at 120 degrees to each other. The two coils in each winding produce magneto motive forces that act in the same direction.

The three sets of windings are connected in wye, thus forming a common neutral N. Owing to the perfectly symmetrical arrangement, the line to neutral impedances are identical. In other words, as regards terminals A, B, C, the windings constitute a balanced 3-phase system.

For a two-pole machine, rotating in the air gap, the magnetic field (i.e., flux density) being sinusoidally distributed with the peak along the centre of the magnetic poles. The result is illustrated in Fig.4.5. The rotating field will induce voltages in the phase coils aa', bb', and cc'. Expressions for the induced voltages can be obtained by using Faraday laws of induction.

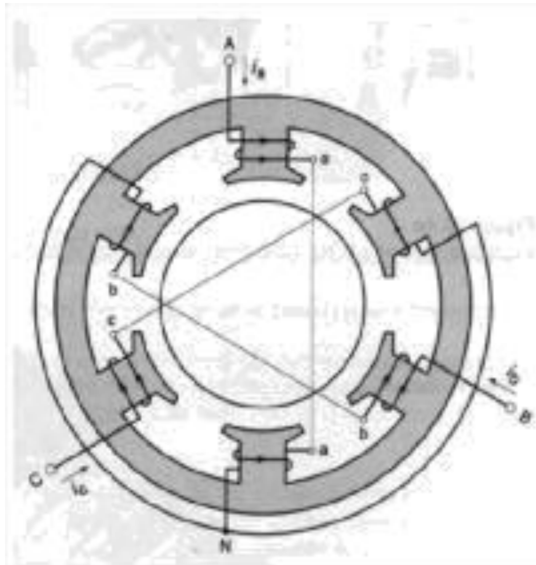


Fig: 4.4 Elementary stator having terminals A, B, C connected to a 3-phase source (not shown). Currents flowing from line to neutral are considered to be positive.

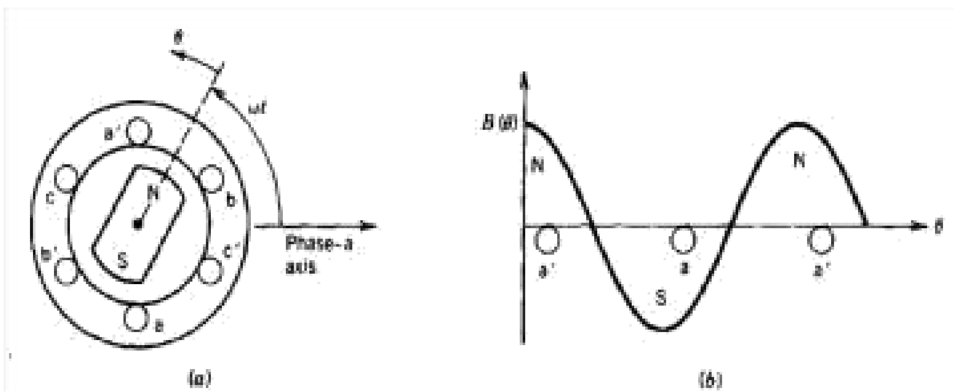


Fig: 4.5 Air gap flux density distribution.

The flux density distribution in the air gap can be expressed as:

$$B(\theta) = B_{\max} \cos \theta$$

The air gap flux per pole, ϕ_P, is:

$$\phi_p = \int_{-\pi/2}^{\pi/2} B(\theta) lr d\theta = 2B_{\max} lr$$

Where,

l is the axial length of the stator.

r is the radius of the stator at the air gap.

Let us consider that the phase coils are full-pitch coils of N turns (the coil sides of each phase are

180 electrical degrees apart as shown in Fig.4.5). It is obvious that as the rotating field moves (or the magnetic poles rotate) the flux linkage of a coil will vary. The flux linkage for coil aa' will be maximum.

($= N\phi_P \; at \; \omega t = 0^o$) (Fig. 45a) and zero at $\omega t = 90^o$. The flux linkage $\lambda_a(\omega t)$ will vary as the cosine of the angle ωt.

Hence,

$$\lambda_a(\omega t) = N\phi_p \cos \omega t$$

Therefore, the voltage induced in phase coil **aa'** is obtained from *Faraday law* as:

$$e_a = -\frac{d\lambda_a(\omega t)}{dt} = \omega N\phi_p \sin \omega t = E_{\max} \sin \omega t$$

The voltages induced in the other phase coils are also sinusoidal, but phase-shifted from each other by 120 electrical degrees. Thus,

$$e_b = E_{\max} \sin(\omega t - 120)$$

$$e_c = E_{\max} \sin(\omega t + 120).$$

the *rms* value of the induced voltage is:

$$E_{rms} = \frac{\omega N\phi_p}{\sqrt{2}} = \frac{2\pi f}{\sqrt{2}} N\phi_p = 4.44 fN\phi_p$$

Where f is the frequency in hertz. Above equation has the same form as that for the inducedvoltage in transformers. However, $Ø_P$ represents the flux per pole of the machine.

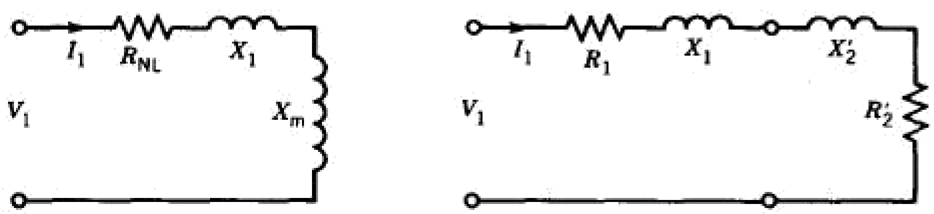
The above equation also shows the rms voltage per phase. The N is the total number of series turns per phase with the turns forming a concentrated full-pitch winding. In an actual AC machine each phase winding is distributed in a number of slots for better use of the iron and copper and to improve the waveform. For such a distributed winding, the EMF induced in various coils placed in different slots are not in time phase, and therefore the phasor sum of the EMF is less than their numerical sum when they are connected in series for the phase winding. A reduction factor Kw, called the winding factor, must therefore be applied. For most three-phasemachine windings Kw is about 0.85 to 0.95.

Therefore, for a distributed phase winding, the rms voltage per phase is

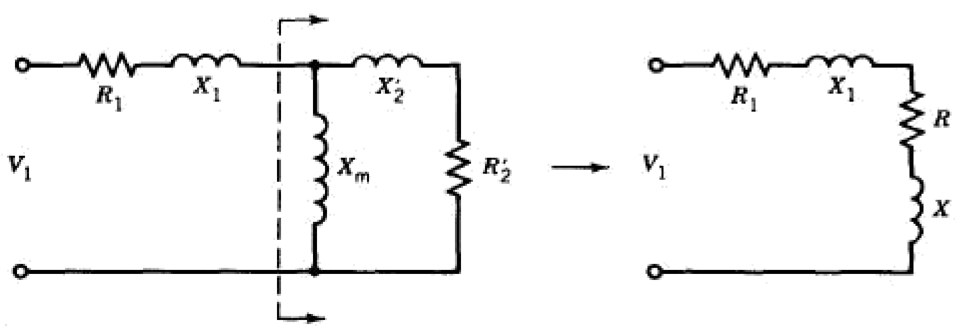
$$E_{rms} = 4.44 f N_{ph} \varphi_p K_w$$

Where N_{ph} is the number of turns in series per phase.

TORQUE EQUATION



(a) No-load equivalent circuit (b) Blocked-rotor equivalent circuit.



(c) Blocked-rotor equivalent circuit for improved value for R_2.

The equivalent circuits shown above is used to predict the performance characteristics of the induction machine. The important performance characteristics in the steady state are the efficiency, power factor, current, starting torque, maximum (or pull-out) torque, and so forth.

The mechanical torque developed *Tmech* per phase is given by

$$P_{mech} = T_{mech}\omega_{mech} = I_2^2 \frac{R_2}{s}(1-s) \qquad (1)$$

$$\text{Where } \omega_{mech} = \frac{2\pi n}{60} \tag{2}$$

The mechanical speed ω*mech* is related to the synchronous speed

$$\omega_{mech} = (1 - s)\omega_{syn} \tag{3}$$

$$\omega_{mech} = \frac{n_{syn}}{60} 2\pi (1 - s) \tag{4}$$

$$and\ \omega_{syn} = \frac{120 f}{60P} * 2\pi = \frac{4\pi\ f_1}{P} \tag{5}$$

From equations (1),(3), &(4)

$$T_{mech}\ \omega_{syn} = I_2^2 \frac{R_2}{s} = P_{ag} \tag{6}$$

$$\text{Then, } T_{mech} = \frac{1}{\omega_{syn}} P_{ag} \tag{7}$$

$$T_{mech} = \frac{1}{\omega_{syn}} I_2^2 \frac{R_2}{s} \tag{8}$$

$$T_{mech} = \frac{1}{\omega_{syn}} I_2'^2 \frac{R_2'}{s} \tag{9}$$

From the equivalent circuit of Fig. and Equation (9)

$$T_{mech} = \frac{1}{\omega_{syn}} * \frac{V_{th}^2}{\left(R_{th} + R_2'/s\right)^2 + \left(X_{th} + X_2'\right)^2} * \frac{R_2'}{s}$$

(10)

Note that if the approximate equivalent circuits (Fig.) are used to determine I_2 , in Equation (10), Vth , Rth , and Xth should be replaced by V1, R1, and X1 , respectively. The prediction ofperformance based on the approximate equivalent circuit (Fig.) may differ by 5 percent from those based on the equivalent circuit of Fig.

For a three-phase machine, Equation (10) should be multiplied by three to obtain the total torque developed by the machine. The torque-speed characteristic is shown in Fig. At low values of slip,

$$R_{th} + \frac{R_2'}{s} >> X_{th} + X_2' \ and \ \frac{R_2'}{s} >> R_{th}$$

(11)

$$\text{Thus } T_{mech} \cong \frac{1}{\omega_{syn}} * \frac{V_{th}^2}{R_2'} * s$$

(12)

The linear torque-speed relationship is evident in Fig. near the synchrouns speed. Note that if the approximate equivalent circuits (Fig.) are used, in Equation (12) *Vth* should be replaced by *V*1 . At larger values of slip,

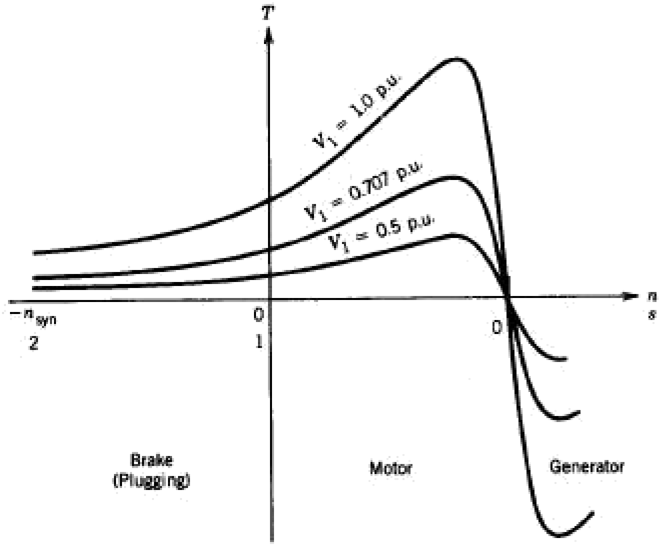
$$R_{th} + \frac{R_2'}{s} << X_{th} + X_2'$$

(13)

$$\text{And } T_{mech} = \frac{1}{\omega_{syn}} * \frac{V_{th}^2}{\left(X_{th} + X_2'\right)^2} * \frac{R_2'}{s}$$

(14)

The torque varies almost inversely with slip near $s = 1$, as seen from Fig. below.



Torque-speed profile at different voltages

Equation (5) also indicates that at a particular speed (i.e., a fixed value of *s*) the torque varies as the square of the supply voltage *Vth* (hence *V*1 Fig.above) shows the *T-n* profile at various supply voltages.

An expression for maximum torque can be obtained by setting *dT* / *ds* = 0. Differentiating Equation (10) with respect to slip *s* and equating the results to zero gives the following condition for maximum torque:

$$\frac{R_2'}{S_{T_{\max}}} = \sqrt{R_{th}^2 + \left(X_{th} + X_2'\right)^2} \tag{15}$$

This expression can also be derived from the fact that the condition for maximum torquecorresponds to the condition for maximum air gar power (Equation (7)). This occurs, by the familiar impedance-matching principle in circuit theory, when the impedance of *s R* / 2 ′ equalsin magnitude the impedance between it and the supply voltage *V*1 (Fig.) as shown in Equation (15).

The slip *ST*max at maximum torque *T*max is:

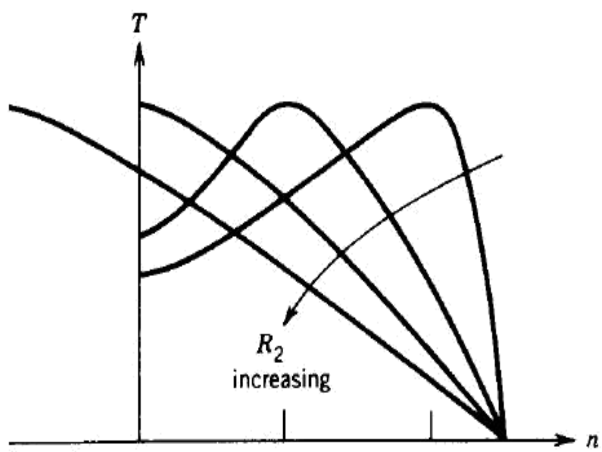
$$S_{T_{\max}} = \frac{R_2'}{\sqrt{R_{th}^2 + \left(X_{th} + X_2'\right)^2}} \tag{16}$$

The maximum torque per phase from Equations (5) and (16) is:

$$T_{\max} = \frac{1}{2\omega_{syn}} * \frac{V_{th}^2}{R_{th} + \sqrt{R_{th}^2 + \left(X_{th} + X_2'\right)^2}} \qquad (17)$$

Equation (17) shows that the maximum torque developed by the induction machine is independent of the rotor circuit resistance. However, from Equation (16) it is evident that the value of the rotor circuit resistance *R*2 determines the speed at which this maximum torque will occur. The torque speed characteristics for various values of *R*2 are shown in Fig.below. In a wound rotor induction motor, external resistance is added to them rotor circuit to make the maximum torque occur at standstill so that high starting torque can be obtained. As the motor speeds up, the external resistance is gradually decreased and finally taken out completely. Some induction motors are, in fact, designed so that maximum torque is available at start, that is, at zero speed.

Torque speed characteristics by varying R2



If the stator resistance *R*1 is small (hence *Rth* is negligibly small), from Equations (16) and (17),

$$s_{T_{\max}} \cong \frac{R_2'}{X_{th} + X_2'} \qquad (18)$$

$$T_{\max} = \frac{1}{2\omega_{syn}} * \frac{V_{th}^2}{X_{th} + X_2'} \qquad (19)$$

Equation (19) indicates that the maximum torque developed by an induction machine is inversely proportional to the sum of the leakage reactances.

From Equation (10), the ratio of the maximum developed torque to the torque developed atany speed is:

$$\frac{T_{\max}}{T} = \frac{(R_{th} + R_2'/s)^2 + (X_{th} + X_2')^2}{(R_{th} + R_2'/s_{T_{\max}})^2 + (X_{th} + X_2')^2} * \frac{s}{s_{T_{\max}}} \tag{20}$$

If $R1$ (hence Rth) is negligibly small,

$$\frac{T_{\max}}{T} = \frac{(R_2'/s)^2 + (X_{th} + X_2')^2}{(R_2'/s_{T_{\max}})^2 + (X_{th} + X_2')^2} * \frac{s}{s_{T_{\max}}} \tag{21}$$

From Equations (18) and (21)

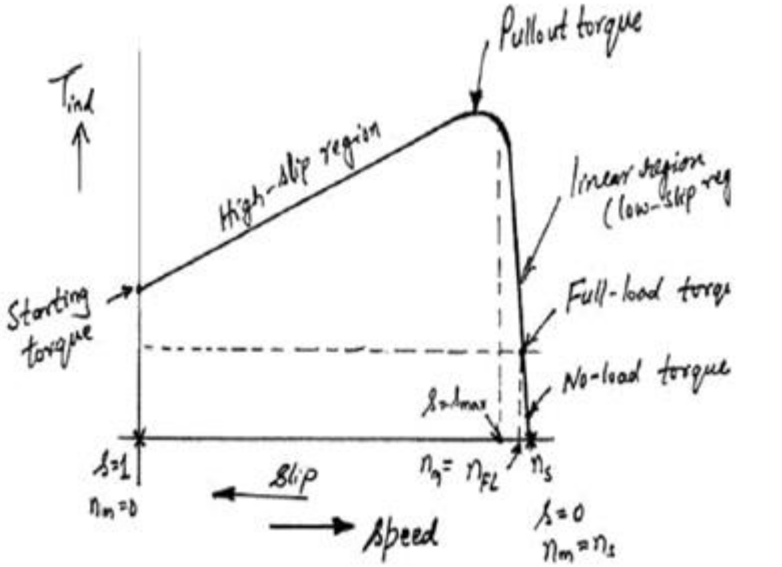
$$\frac{T_{\max}}{T} = \frac{(R_2'/s)^2 + (R_2'/s_{T_{\max}})^2}{2(R_2'/s_{T_{\max}})^2} * \frac{s}{s_{T_{\max}}} \tag{22}$$

$$\frac{T_{\max}}{T} = \frac{s_{T_{\max}}^2 + s^2}{2 * s_{T_{\max}} * s} \tag{23}$$

Equation (23) shows the relationship between torque at any speed and the maximum torque interms of their slip values.

TORQUE – SPEED CHARACTERISTICS

For small values of slip *s*, the torque is directly proportional to *s*. For large values of slip *s*, the torque is inversely proportional to *s*.



Pullout torque
T_{ind}
High-slip region
linear region
(low-slip reg
Starting torque
Full-load torq
No-load torque
$s = s_{max}$
$s=1$
$n_m = 0$
Slip
Speed
$n_m = n_{FL}$
n_s
$s=0$
$n_m = n_s$

UNIT-V

Single Phase Induction Motor

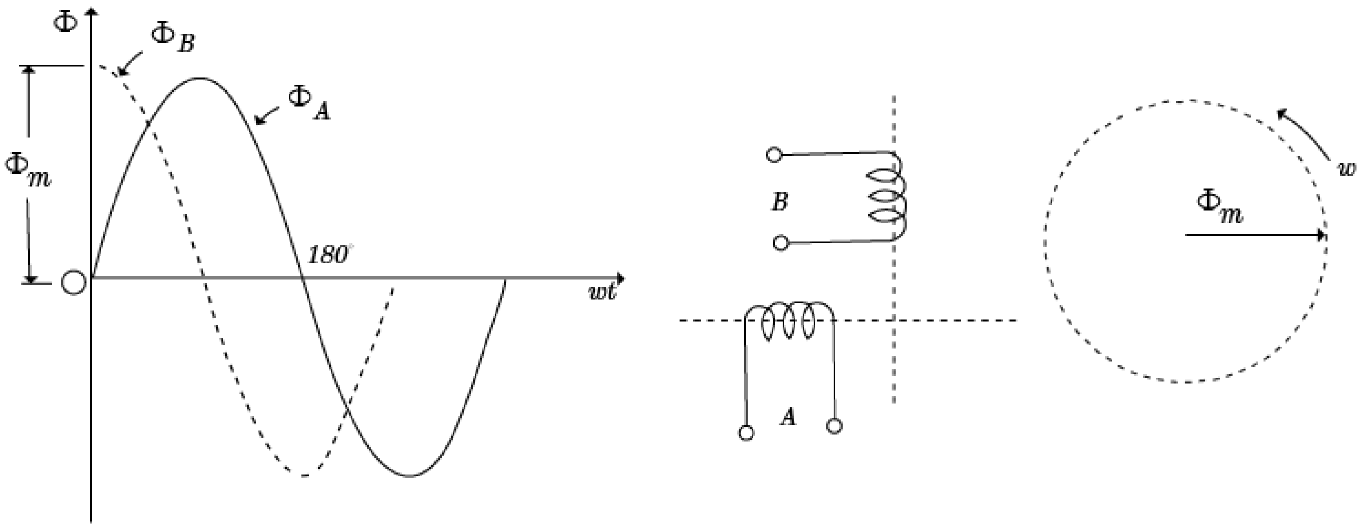
Working Principle of a Single Phase Induction Motor

Production of Rotating Field

Consider two winding 'A' and 'B' so displaced that they produce magnetic field 90° apart in space. The resultant of these two fields is a rotating magnetic field of constant magnitudeφ_m. Non-Uniform magnetic field produces a non-uniform torque which makes the operation of the motor noisy, affect starting torque.

$$\varphi_A = \varphi_m \sin \omega t$$

$$\varphi_B = \varphi_m \sin(\omega t + 90°)$$



A single phase induction motor consists of a single phase winding on the stator and a cage winding on the rotor. When a 1 phase supply is connected to the stator winding, a pulsating magnetic field is produced. In the pulsating field, the rotor does not rotate due to inertia. Therefore a single phase induction motor is not self-starting and requires some particular starting means. Two theories have been suggested to find the performance of a single phase induction motor.

1. Double revolving field theory.
2. Cross-field theory.

Shaded Pole Motors

The shaded pole induction motor is simply a self-starting single-phase induction motor whose one of the pole is shaded by the copper ring. The copper ring is also called the shaded ring. This copper ring act as a secondary winding for the motor. The shaded pole motor rotates only in one particular direction, and the reverse movement of the motor is not possible.

Construction of Shaded Pole Induction Motor

The shaded pole motor may have two or four poles. Here in this article, we use the two pole motor for the sake of simplicity. The speed of the motor is inversely proportional to the number of poles used in the motor.

Stator – The stator of the shaded pole motor has a salient pole. The salient pole means the poles of the magnet are projected towards the armature of the motor. Each pole of the motor is excited by its exciting coil. The copper rings shade the loops. The loops are known as the shading coil.

The poles of the motor are laminated. The lamination means multiple layers of material are used for making the poles. So, that the strength of the pole increases.

The slot is constructed at some distance apart from the edge of the poles. The short-circuited copper coil is placed in this slot. The part which is covered with the copper ring is called the shaded part and which are not covered by the rings are called unshaded part.

Rotor – The shaded pole motor uses the squirrel cage rotor. The bars of the rotor is skewed at an angle of 60º. The skew can be done for obtaining the better starting torque.

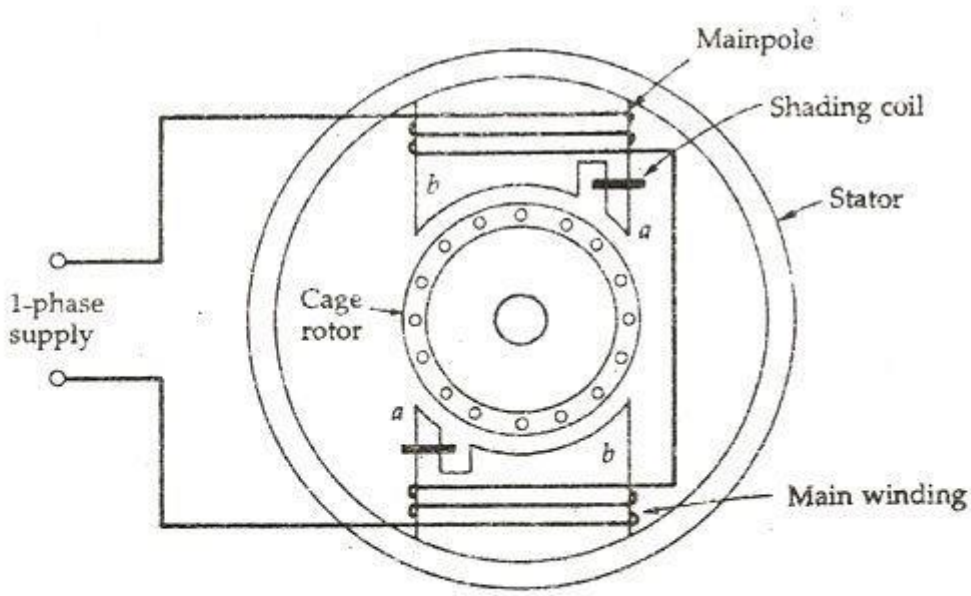
The construction of the motor is very simple because it does not contain any commutator, brushes, collector rings, etc. or any other part. The shaded pole induction motor does not have any centrifugal switch. Thus, the chances of failure of the motor are less.

Shaded Pole Induction Motor Working

When the supply is connected to the windings of the rotor, the alternating flux induces in the core of the rotor. The small portion of the flux link with the shaded coil of the motor as because it is short-circuited. The variation in the flux induces the voltage inside the ring because of which the circulating current induces in it.

The circulating current develops the flux in the ring which opposes the main flux of the motor. The flux induces in the shaded portion of the motor, i.e., a and the unshaded portion of the motor, i.e., b have a phase difference. The main motor flux and the shaded ring flux are also having a space displacement by an angle of 90°.

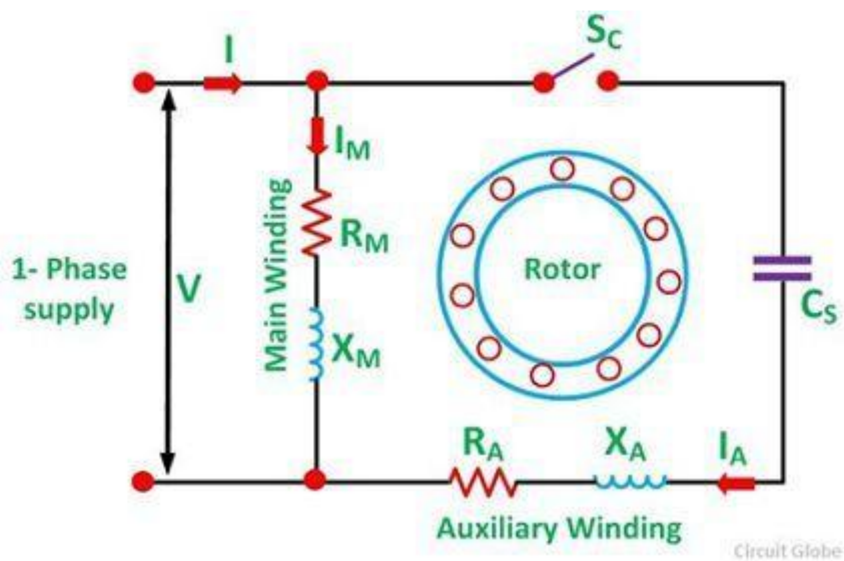
The connection diagram of the Shaded Pole Motor is shown below.



As there is time and space displacement between the two fluxes, the rotating magnetic field induces in the coil. The rotating magnetic field develops the starting torque in the motor. The field rotates from the unshaded portion to the shaded portion of the motor.

Capacitor Motors

A **Capacitor Start Motors** are a single phase Induction Motor that employs a capacitor in the auxiliary winding circuit to produce a greater phase difference between the current in the main and the auxiliary windings. The name capacitor starts itself shows that the motor uses a capacitor for the purpose of the starting. The figure below shows the connection diagram of a Capacitor Start Motor.



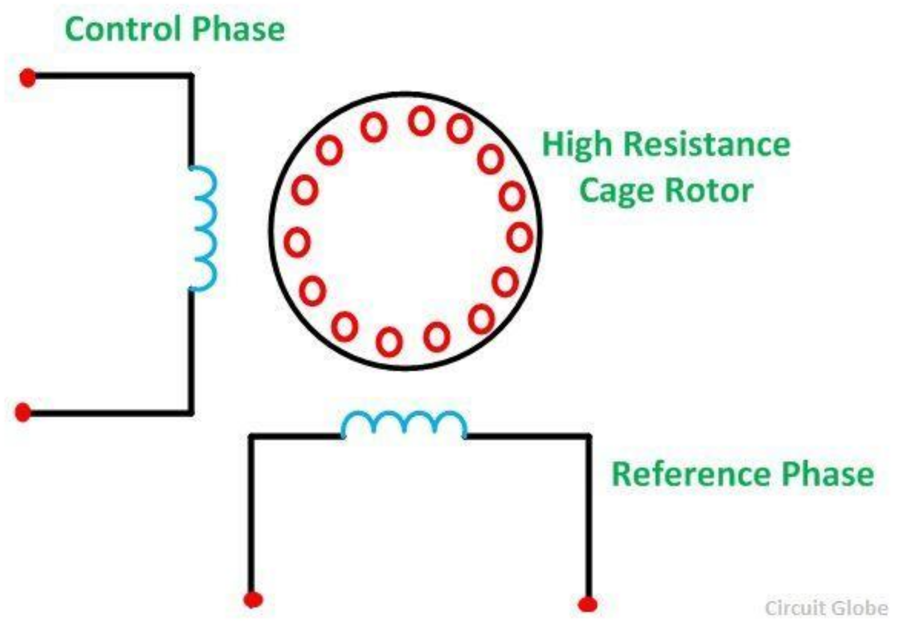
The capacitor start motor has a cage rotor and has two windings on the stator. They are known as the main winding and the auxiliary or the starting winding. The two windings are placed 90 degrees apart. A capacitor C_S is connected in series with the starting winding. A centrifugal switch S_C is also connected in the circuit.

AC servomotor

Servo Motor are also called Control motors. They are used in feedback control systems as output actuators and does not use for continuous energy conversion. The principle of the Servomotor is similar to that of the other electromagnetic motor, but the construction and the operation are different. Their power rating varies from a fraction of a watt to a few hundred watts.

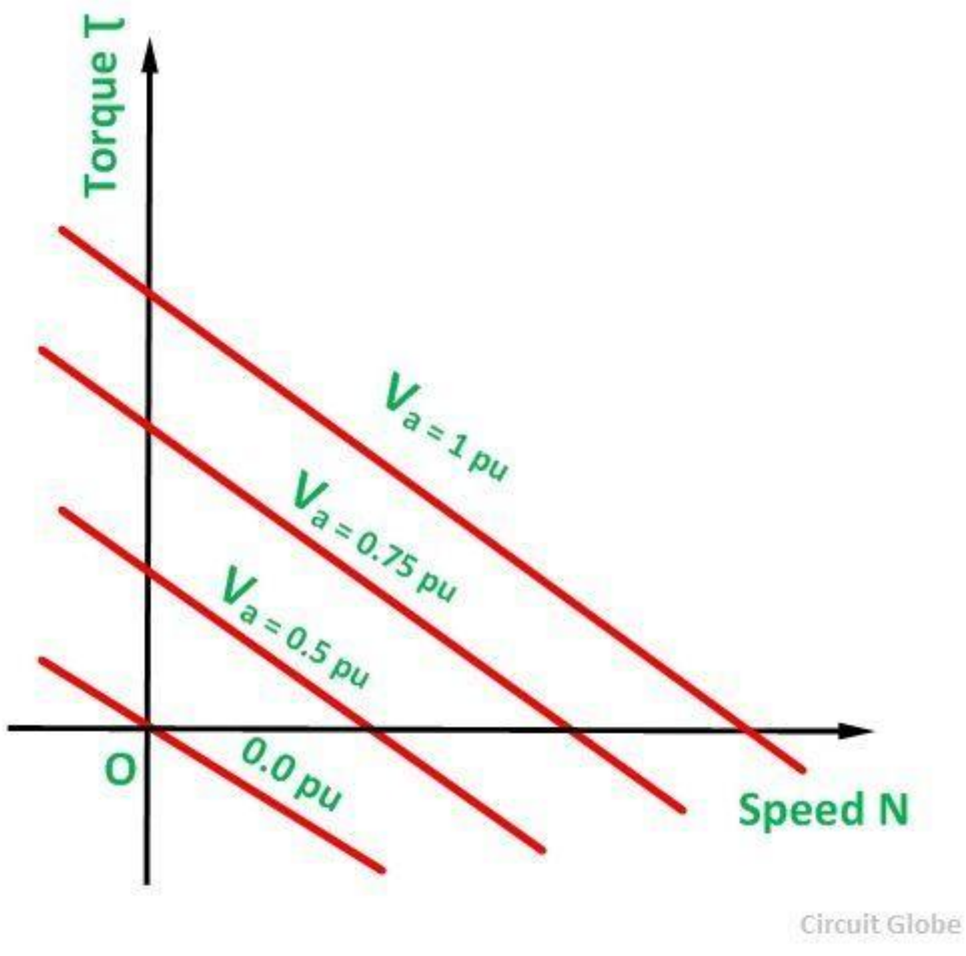
The AC Servo Motors are divided into two types 2 and 3 Phase AC servomotor. Most of the AC servomotor are of the two-phase squirrel cage induction motor type. They are used for low power applications. The three phase squirrel cage induction motor is now utilised for the applications where high power system is required.

The connection diagram of the two Phase AC Servo motor is shown below.



The control phase is usually supplied from a servo amplifier. The speed and torque of the rotor are controlled by the phase difference between the control voltage and the reference phase voltage. By reversing the phase difference from leading to lagging or vice versa, the direction of the rotation of the rotor can be reversed.

The torque speed characteristic of the two phase AC servomotor is shown in the figure below.



The negative slope represents a high rotor resistance and provides the motor with positive damping for better stability. The curve is linear for almost various control voltages.

17. Internal (Mid) Examinations Question Papers :

18. Quality measurement Sheets

- Course Survey
  (Students Internal Marks Performance and Action Taken Report)

- Teaching evaluation (Feedback received from IQAC)
- Academic Audit report received from IQAC

19. Attainment of Cos and Pos

(Detailed Procedure used to calculate the attainment of Cos and POs)

Note: Separate sheets must be attached

20. Closure Report/Course Review (By the concerned Faculty):

At the End of the course the report should be given by the concerned faculty

GUIDELINES:

Distribution of Periods:

- No. of classes required to cover JNTU Syllabus:
- No. of classes required to cover Additional Topics:
- No. of classes required to cover Assignment tests (for every 1 units 1 test) :
- No. of classes required to cover Tutorials:
- No. of classes required to cover Mid Tests:
- No of classes required to solve University Question papers:
- Total Periods:

- Total Number of classes planned -
- Total Number of classes actually taken -
- Total Number of students attended for the internal exam -
- Total Number of students attended for the external exam -
- Total number of students passed the exam -
- Pass percentage -