DIRECT CURRENT MACHINE

DYNAMO – is a rotating machine for converting mechanical energy into electrical energy.

Introduce voltage ; $E = (ZP\O_pN) / (60a) \times 10^{-8}$Volts

General Classification: [I].Motor [II].Generator

I – DC Motor – a continuous energy conversion devise used to convert electric energy to mechanical energy.

<u>General types of Self Excited Motors:</u>

1. Series wound D.C. Motor – a motor where is winding called series field winding is connected n series with the armature.

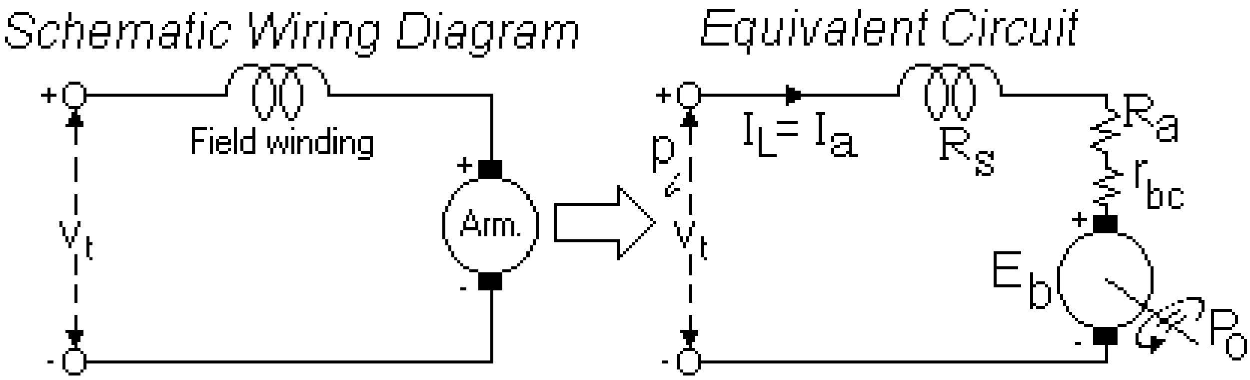
Speed Characteristics: Variable speed

Torque Characteristics: high starting torque

Uses: elevator, crane, conveyor, hoist gear drive.

*note: to reverse direction of rotation of this motor, interchange the brushes.

Caution: Never operate the motor if unloaded because t will “race” or “run away”



NOTATION:

V_T - terminal voltage

E_b - back emf or counter emf

V_{bc} - brush contract voltage drop

V_s -series field winding voltage drop

I_i -line current or input current

I_a -armature current

R_s -series field winding resistance

R_{bc} -brush contact resistance

R_a -armature resistance

R -equivalent resistance due to the power development in the armature

P_i -power input

P_s -power development in the armature

P_o -power input

-useful power

2. Shunt Wound D.C. Motor – a self-motor where its field winding called shunt field is connected across the armature.

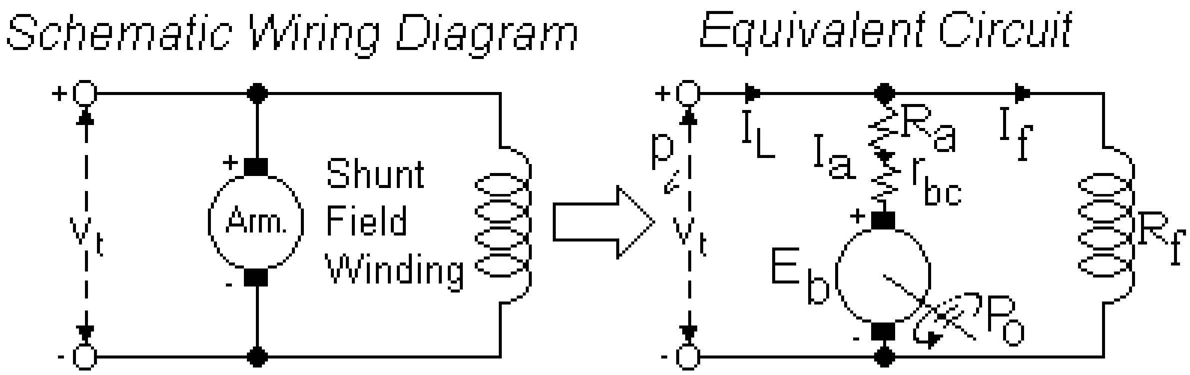
Speed Characteristics: nearly constant or adjustable speed.

Torque Characteristics: medium starting torque

Uses: fan, pump, grinder, blower, etc.

*note: to reverse the direction of rotation of the motor interchange the brushes or reverse the connection of the field windings but not both.

Caution: Never open the field winding while motors is running because it will “race” or run away”.



3. Compound Wound DC Motor – where its winding has series and shunt field windings, either connected long/ short shunt.

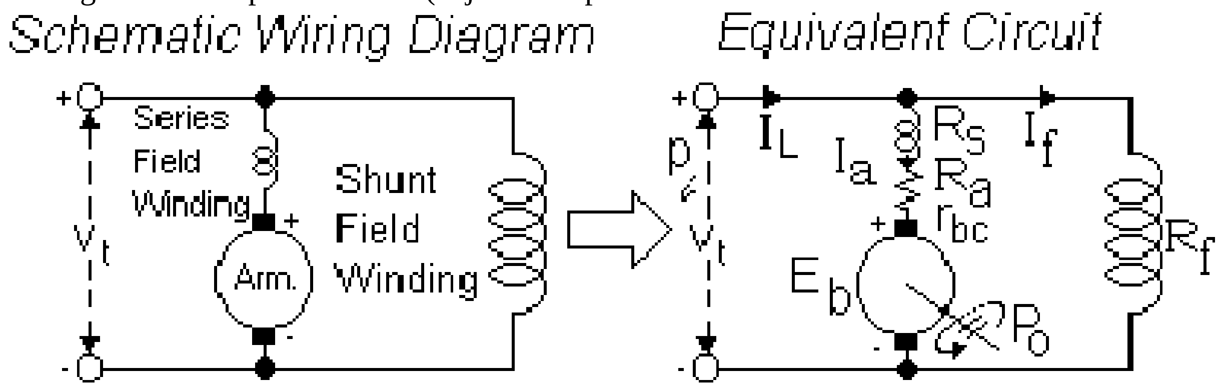
Speed Characteristics: variable or adjusted speeds

Torque Characteristics: high starting torque

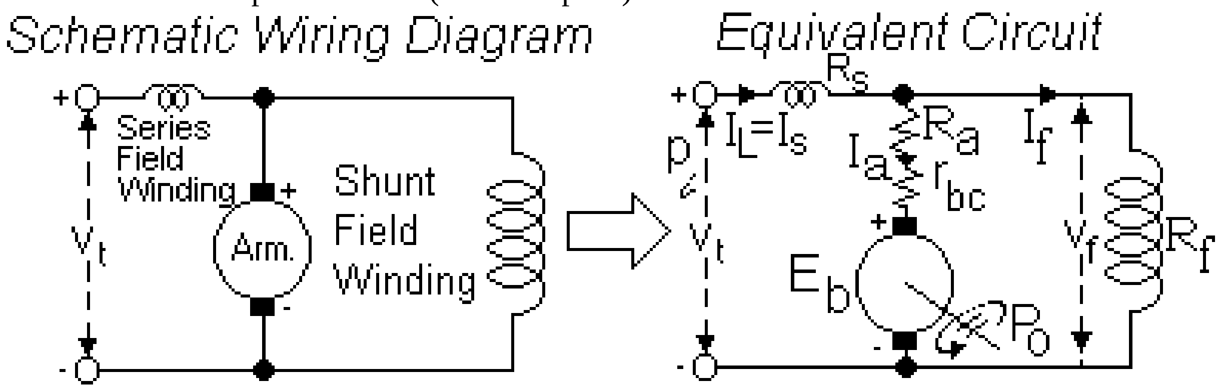
Uses: milling machine, punching machine, elevator, crane etc.

*note: To reverse the direction of rotation of the motor interchange the brushes.

a. Long Shunt Compound Motor (adjustable speed



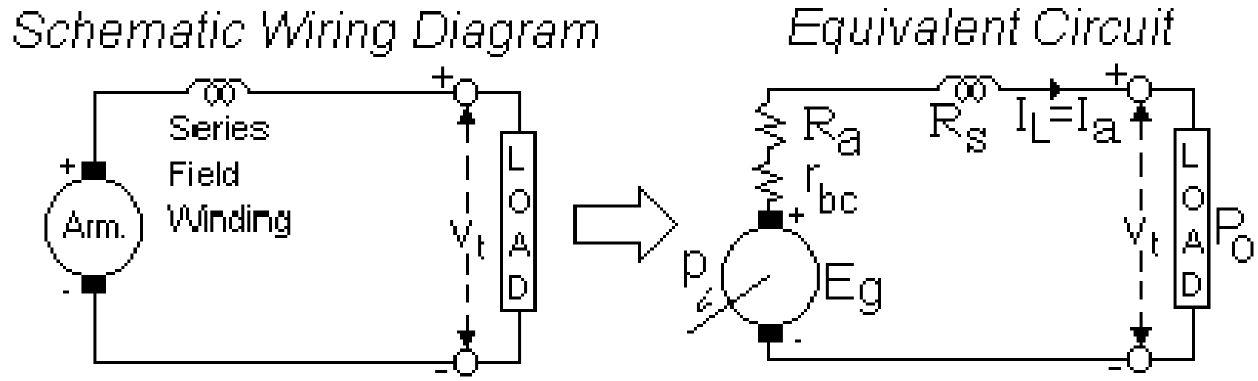
b. Short Shunt Compound Motor (variable speed)



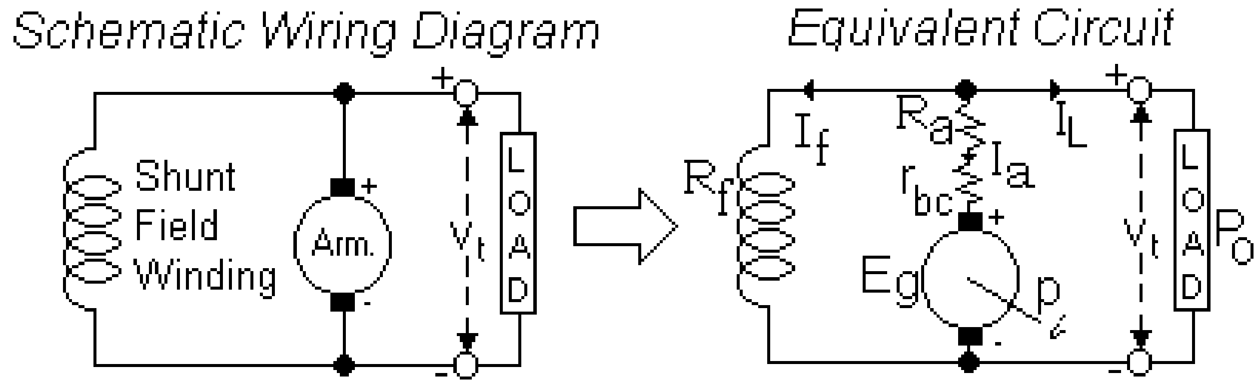
II - DC Generator - an energy conversion device used to convert mechanical energy to electrical energy.

General Types of Self Excited DC Generators

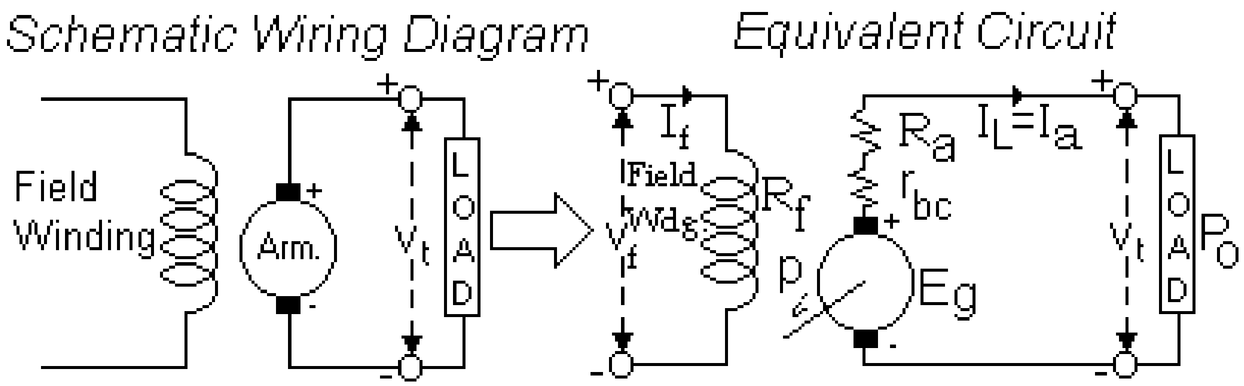
1. Series Wound DC Generators – like the series wound DC motor, its field winding is connected in series with the armature. It is used for constant current application like in series street lighting.



2. Shunt Wound D.C. Generator – like the shunt wound D.C. motor its field winding also called shunt field winding is connected across the armature. It is used for constant voltage application like in electric welding.

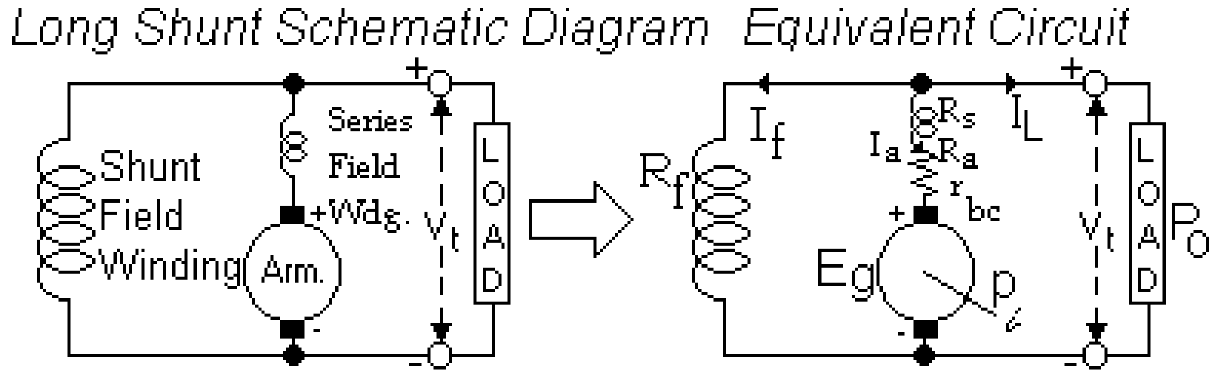


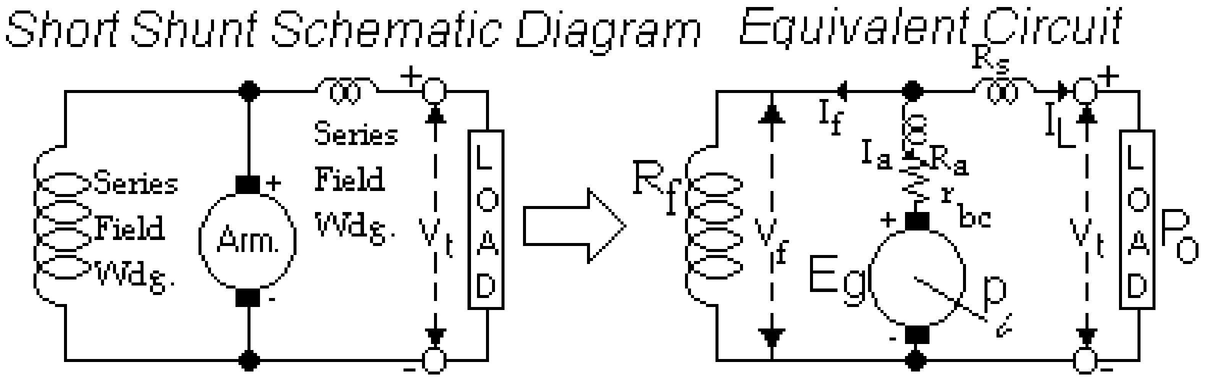
3.Seperately Excited Shunt Generator – its winding also called shunt field winding is connected to an outside source (a battery or another D.C generator). It is used for laboratory experiment purpose where voltages are likely to be varied.



4. Compound Wound D.C. Generator – like compound wound D.C. motor. It has series field windings and shunt field windings also either connected long shunt or short shunt.

Types of compound Gen. According to field windings connection;





Types of Compound Generator According to direction of flux:

a) Cumulative Compound Generator – the series field ending the shunt field for supplying power and lighting loads.

1 Under Compounded – the full load terminal voltage is less than the no load voltage. It is used when the load is near from the generator.

2 Flat Compound - the full load terminal voltage is the same as the no load voltage, it is used when the load is at medium distance from the generator.

3 Over Compounded – the full load terminal voltage is greater than the no load voltage, it is used when the load is far from the generator.

b) Differential Compound Generator – the direction of flux of the series field winding opposes the direction of flux of the shunt winding. It is used for electric welding.

Prime Movers

1. Hydraulic turbines
2. Steam Turbine
3. Internal Combustion Engine

*Note: Compensating Winding – Connected in series with the armature - Used to neutralize armature reaction.

Interpole Winding – In series with the armature - Used for spark less commutations.

Diverter resistance - parallel with the series field.

Parallel Operation of DC Generators:

Conditions to be met for ideal operation of DC generators in parallel are:

(1.) The no-load voltages of both generators should be adjusted to the same value (otherwise, current will circulate through the two machines that will cause additional losses).

(2.) The external characteristics curve of the two generators should be identical (otherwise, the generator will not share the load properly).

(3.) The polarity of the voltages of the two generators must be "opposing" in the series circuit of the two machines (otherwise, large current will circulate in the armature windings of the generators which will damage the windings).

(4.) For the case of compound generators in parallel there must be an "Equalizer" connection to make the operation stable (otherwise, there will be "motorization" i.e. one of the generator will acts as a motor).

DC MACHINE REVIEW PROBLEMS

1. The field poles are made of iron, either solid or laminations and support coils of wires called ____________

A. field windings B. interpoles C. the armature D. the commutator

2. What is the material commonly used for brushes on DC motors

A. carbon B. brass C. copper D. aluminum

3. Pigtails are used on carbon brushes to __________

A. compensate for wear C. supply the proper pressure
B. hold the brush in the holder D. make a good electrical connection

4. Commutators are generally found on _____________

A. Synchronous Motors B. DC Motor C. rectifier D. transformer

5. Dirt on the motor commutator may produce ___________

A. isolation B. excessive C. lower torque D. power loss

6. In a DC motor, which of the following does not cause sparking at the commutator

A. frozen armature C. use of graphite with good contact pressure
B. no load on the armature D. high brush contact resistance

7. In DC series motor, how is the field winding connected in the relation with the armature winding? BP Apr 04A. long shunt B. Parallel C. series D. parallel – series

8. In compound wound dc motor, what is the connection of the field winding in relation to the armature winding?A. shunt B. short C. Series D. parallel – series

9. Comparing the shunt field winding with the series field winding of a compound dc motor, it would be corrected to say that the shunt field winding has _____.

A. more turns but lower resistance C. more turn and a higher resistance
B. fewer turn but a higher resistance D. fewer turns and a lower resistance

10. It is a DC motor that tends to over – speed when the field opened while running.

A. shunt motor B. series motor C. split phase motor D. over – compounded motor

11. In dc series motor that has the line leads reversed, turns in the ____________ direction,

A. same B. opposite C. wrong D. reverse

12. With reference to the armature windings, lap windings are often called ____ winding.

A. ring B. series C. multiple or parallel D. cascade

13. The purpose of having a rheostat in the field circuit of a DC shunt motor is ________

A. reduce sparking the brushes C. control the speed of the motor
B. minimize the starting current D. limit the field current to a safe value

14. A motor whose speed increases as the load increases is a _________________

A. DC shunt B. DC Series C. Differential compound D. Cummulative compound

15. The armature of a motor has of 400 active conductors, the flux density in the field being 3,000 gauss. The axial length of the armature is 20.32 cm. The current is 30 amperes. Determine the total force exerted in the armature.A. 731.5 N B. 6458.9 N C. 0.07 N D. 439.2 N

16. A motor has a nameplate rating of 15 hp and 1160 rpm. Solve for the rated torque.

A. 56 lb-ft B. 68 lb-ft C. 122 lb-ft D. 93 lb-ft

17. What is the back emf of a 10 hp shunt motor operating at 110 volts terminals if 90 ampere flow though a 0.05-ohm armature resistance?

A. 107.5 V B. 106.5 V C. 105.5 V D. 108.5 V

18. A 120 Volt shunt motor has an armature resistance of 0.08 ohm and field resistance of 60 ohms. What is the power developed when it draws 67 amperes current.

A. 10 hp B. 7.8 hp C. 8.78 hp D. 5.5 hp

19. A certain shunt motor has an armature resistance of 0.07 ohm. It draws 50 amperes at a terminal voltage of 120 volts. Assume other miscellaneous losses of 2%. Determine the efficiency of the motor.

A. 97.1% B. 98% C. 95.1% D. 96.5%

20. In a break test of as shunt motor, ammeter and voltmeter measuring the input read 34 Amp and 220 – volts. The speed of the motor is found to be 910 rpm and the balance of a 2 – ft. brake arm reads 27.2 lb. The tare weight of the arm is found to be +32 lb. Determine the output of the motor.

A. 9.6 hp B. 8.8 hp C. 8.6 hp D. 6.5 hp

21. A dc shunt motor develops 15 hp at 120 volts. The armature resistance is 0.061 ohm. What is the current? . 95.81 Amperes B. 91.85 Amperes C. 96.15 Amperes D. 98.15 Amperes

22. A DC shunt motor draws as armature current of 98.16 A & a field current of 2A at 120V. the armature effective resistance is 0.06 Ω. What is overall efficient?

A. 95% B. 91% C. 94% D. 93%

23. A shunt generator when running light as a motor at 1000 rpm takes 12 Amp from 115-Volts mains. The field current is 7 Amp, and the armature resistance is 0.03 ohm. Determine stray – power loss of the machine at this particular value of flux and speed.

A. 574.25 W B. 576.25 W C. 575.25 W D. 577.25 W

24. Which statement about hysteresis loss in dc generator is FALSE?

A. it varies almost as square of the flux density
B. it doubles if armature rpm is doubled
C. it is independent of lamination
D. it can be minimized by laminating the armature

25. The eddy current loss in a motor is 600 watts when the total flux is 2,000,000 maxwells per pole and the speed is 800 rpm. Determine the loss when the flux is increased 2,500,000 maxwells and the speed is increased to 1,200 rpm.

A. 2,109 watts B. 4201 watts C. 1200 watts D. 1800 watts

26. The hysteresis and eddy current losses in a dc machines running at 100 rpm are 250 Watts and 100 Watts respectively. If the flux remains constant, what is the total iron loss 900 rpm?

A. 306 watts B. 3150 watts C. 444 watts D. 350 watts

27. To start a 7.5 hp, 220 volt, DC motor you should have ____________.

A. an across the line starter C. a "start-run switch" switch
B. suitable start box D. a compensator

28. DC motor starters are used for the following functions EXCEPT one. Which one is this?

A. Control the speed of the motor
B. Limit the starting current of the motor
C. Start large DC motor
D. Prevent large voltage drop during starting

29. The armature of a 230 volts shunt motor has a resistance of 0.82 ohm and takes 28.2 Ampere when operating at full load. Calculate the starting resistance required to limit the starting torque to 150% of the rated torque. (Assume a 3-volt brush drop)A. 7.33 Ohm B. 4.55 Ohm C. 7.23 Ohm D. 4.62 Ohm

30. A 230 Volts, 15 hp d.c. shunt motor has friction and iron loss of 200 W. the armature resistance is0.3 ohm and the shunt field resistance is 115 ohms. Calculate the output horsepower to achieve maximum efficiency.A. 15 B. 13.3 C. 12.7D. 17.5

31. A small d.c. series motors is plugged to an a.c. source. What will likely to happen?
A. Motor winding overheats fast C. Motor rotor rotates very slowly
B. Motor rotor is stacked D. Motor runs

32. Which of the following motor will over speed when it carries only a light load?
A. compound dc motor B. shunt dc motor C. series dc motor D. synchronous motor

33. A dc series motor develops 180 lbs.-ft of torque when the current is 30 Amp. The load increases so that the motor current rises to 50 Amp. The torque now is….
A. 500 lbs.-ft B. 300 lbs.-ft C. 64.8 lbs.-ft D. 108 lbs.-ft

34. If a self excited dc generator after being installed, fails to build up on its first trial run, the first thing to do is to..A. increase the field resistance C. reverse field connections
B. check armature insulation resistance D. increase of the speed of prime mover

35. If the armature of an 8 – pole machine were wound with a simplex wave winding, how many parallel paths would there be?A. 16 B. 8 C. 2 D. 4

36. In a 4 pole, 54 slot d.c. armature, calculate the coil pitch.A. 18 B. 9 C. 14 D. 13

37. Interpole winding in the motors are used primary __________
A. to compensate for field leakage C. as a means of varying the speed
B. to reduce the armature reaction D. to increase the efficiency

38. For both lap and wave windings, there are many commutator bars as the number of
A. poles B. slots C. armature conductors D. winding elements

39. The commutator pitch of the duplex lap - winding in a dc generator is…
A. 1 B. 3 C. 2 D. 4

40. A four pole dc generator with double layer lap winding 120 slots and 4 slots per pole.
A. 60 B. 120 C. 480 D. 240

41. The difference between the back pitch is 2. the front pitch is 21. If winding is lap retrogressive, what is the back pitch?
A. 21.5 B. 23 C. 21 D.19

42. A 2500-kw, 600-volt, 16-pole generator has a lap – wound armature with 2360 conductors. If the pole face 65% of the entire circumference, calculate the number of pole face conductor in each pole of a compensating winding.A. 5 B. 3 C. 4 D. 6

43. The pulley of the old Gen – set has a diameter of 20 inches. The belt exerts pull of 353 lbs. on the pulley. The Gen-set runs at 900 rpm. What is the approximate kw rating of the Gen-set.
A. 75 B. 250 C. 200 D.35

44. A 4 pole dc generator with duplex lap winding has 48 slots and 4 element per slot. The flux per pole is 2.5 x 10^6 maxwells and it runs at 1,500 rpm. What is the output voltage?
A. 60 V B. 360 V C. 225 V D. 120 V

45. A 2-pole dc generator with lap wound armature is turned at 1800 rpm. There are 100 conductors between the brushes. The average flux density in the air gap between pole faces and the armature is 1.2T. The pole have an area of 0.03 sq. m. what is the no load terminal voltage?
A. 216 V B. 99 V C. 432 V D. 108 V

46. The armature of shunt generator has 0.05-ohm effective resistance. Each brush has an effective resistance of 0.01 ohm. The terminal voltage is 100 volts while the current is 410 amperes. What is the efficiency?

A. 1670 watts B. 2000 watts C. 2180 watts D. 1518 watts

47. A DC generator has a no-load output voltage rating of 120-volt. Its armature circuit resistance is 0.95 and its field coils are separated energized. If a load of 2 kw at 115 volts is connected across the output, neglecting the effect of armature reaction and the line drops, what power will be absorbed by the loads?
A. 1670 watts B. 2000 watts C. 2180 watts D. 1518 watts
48. A 50-kw, 500-volt short shunt generator has an armature resistance, series field resistance and shunt field resistances are 0.05 ohm, 0.06 ohm and 253 ohms respectively. Stray power loss is 1000 watts and stray load loss is 1%. Calculate the horsepower requirement at this load.
A. 65 B. 75 C. 50 D. 72
49. A 250-kw, 230 – Volt short shunt generator is delivering 800 ampere at 230 volts. The shunt field current is 12 amp. The armature resistance is 0.007 ohm. The stray power at this load is 5,500 watts and stray load loss of 1%. The generator is connected long shunt. Determine the efficiency at this load.
A. 92% B. 95% C. 98% D. 93%
50. Two shunt generators A & B operates in parallel in their load characteristics may be taken as straight line. The voltage of generator A falls from 240 Volts at no-load to 220 Volts at 200 Amp while that B falls from 245 Volts to 330 Volts at 150 Amp. Determine the common terminal voltage when the load is 67 kW.A. 223 Volts B. 322 Volts C. 241 Volts D. 315 Volts

DC MACHINES SUPPLEMENTARY PROBLEMS

1. To reduce radio interference from household motor, the motor are sometimes provided with
a) condenser across the brushes c) resistance
b) complete enclosure of the motor d) grounded motor frame
2. An electric motor develops 20 HP at a speed of 600 rpm. What is the torque in N-m?
a) 240 b) 210 c) 290 d) 260
3. a 240 volt d.c. motor on the brake test took 52 Amp when running at 1500 rpm. The spring balance at the end of the 76 cm brake arm reads 93.5 N. what is the efficiency of the motor load?
a) 0.85 b) 0.90 c) 0.95 d) 0.86
4. A dc shunt motor develops 15 hp at 120 volts. The armature efficiency is 95%. What is the counter emf?a) 114 volts b) 118 volts c) 122 volts d) 117 volts
5. A dc shunt motor draws an armature current of 98.16 amperes at 120 volts. What is the hp output of the motor if the armature effective resistance is 0.06 ohm?a) 15.8 b) 7.5 c) 22 d) 15
6. Regarding eddy current loss in dc shunt generator which statement is FALSE?
a) it varies as square of the speed
b) it varies as square of the flux density
c) it varies as the square of lamination thickness
d) it is always constant
7. If a motor frame is found excessively hot, which of the following is the LEAST likely cause
a) very high ambient temperature c) inadequate internal ventilation
b) faulty starter d) excessive loading
8. A 440 Volt shunt motor has an armature resistance of 0.8 ohm and field resistance of 200 ohms. What is the armature power developed when giving an output of 7.46 kW at 85% efficiency.
a) 7.56 kW b) 7.46kW c) 8.46 kW d) 7.23 kW
9. A dc motor takes an armature current of 105 Amp at 480 volts when running at 720rpm. The resistance of the armature circuit is 0.2 Ohms and the field resistance is 96 Ohms. What is the torque developed in the armature? a) 668N-m b) 610N-m c) 752N-m d) 639 N-m.

10. A 200V shunt motor running at 720 rpm takes an armature current of 50A, Its effective resistance is 0.40 ohm. When a resistance of 1.6 ohm is placed in series with the armature, What is the new speed? Assume that load torque is constant. a) 720 rpm b) 600 rpm c) 750 rpm d) 680 rpm.
11. The simplest form of a motor controller is a) drum switch b) relay c) magnet switch d) toggle switch.
12. Rapid stopping of an electric motor by momentarily reversing its connections to the supply is a) jogging b) plugging c) inching d) sequence operation
13. In a 5HP, 230V, 1500 rpm shunt motor, the resistance of the armature including brushes is 0.175 ohm and that of the shunt field winding is 610 ohms. The stray power losses when the motor delivers rated load at rated voltage is 305W. The efficiency at rated load is nearest to
a) 98% b) 89% c) 90%d) 85%
14. A 20Hp, 110V DC shunt motor has an efficiency of 88% an exciting current of 4A and an armature resistance of 0.04 ohms. What starting resistance is required for full load torque.
a) 0.98 ohm b) 0.94 ohm c) 0.95 ohm d) 0.69 ohm
15. A 10Hp, 230V, 100 rpm series motor, having rated efficiency of 85.5%, armature resistance including brushes of 0.28 ohms and a field resistance of 0.15 ohms. What value of starting resistance so that the starting torque is equal to 150% of the rated load torque?
a) 4.95 ohms b) 4.52 ohms c) 5.94 ohms d) 4.67 ohms
16. A 60Hp, 230V shunt motor has a shunt field resistance of 38.3 ohms and an armature resistance of 0.04 ohms. If the resistance in the starter is 0.66 ohm and the brush drop is 3V. What is the input current to the motor at the instant it is started? a) 324A b) 328A c) 330A d) 344A
17. A series motor is never started without some mechanical load on it because it will… a) draw too much current b) produced vicious sparking of brushes c) develop excessive speed and damaged itself d) open fuse or trip off circuit breaker.
18. A 100V dc series motor run at 400 rpm when taking a current of 55Ampere. Armature resistance is 0.03 ohm, field resistance is 0.3 ohm. If the load torque remains the same, What is the input current when the field is shunted by a resistor of 0.02 ohm? a) 62A b) 87A c) 76A d) 82A
19. A dc generator may loose its residual magnetism because of … a) varying loads b) vibrations c) over-excitation d) heating of
20. In lap winding, front pitch is 17 and back pitch is 19. What is the average pitch?
a) 18 b) 18.5 c) 19 d) 17
21. A four pole dc generator with lap winding has 48 slots and 4 elements per slot. How many coils does it have? a) 48 b) 384 c) 192 d) 96
22. If the armature of an eight pole dc machine were wound with simplex wave winding, How many parallel path would there be? a) 16 path b) 2 path c) 8 path d) 4 path
23. One of those listed is not a type of dc generator winding.
a) drum b) gramme-ring c) progressive d)lap
24. In a 4pole, 35 slots dc armature, Calculate the coil span? a) 8 slots b) 7 slots c) 10 slots d) 9 slots
25. In a 10 pole, lap wound dc armature, the number of active armature conductor per pole is 50. The number of compensating conductor per pole required is a) 5 b) 500 c) 50 d) 10
26. A 4pole, 12 slot lap wound dc armature has two coil side per slot. Assuming single turn coil, Calculate the back pitch for progressive and retrogressive winding. a) 5 & 3 b) 3 & 5 c) 7&5 d) 6&4
27. A 4pole dc generator with simplex lap winding has 48 slots and four element per slot. The flux per pole is 2.5×10^6 maxwells and runs at 1500 rpm. What is the output voltage?
a) 60V b) 480V c) 225V d) 120V.
28. A 20Kw, 220V shunt generator has an armature resistance of 0.07 ohm and a shunt resistance of 200 ohms. Determine the power developed in the armature when it delivers its rated output? a) 27.9Kw b) 20.83Kw c) 19.2Kw d) 25.7Kw.

29. A 288V shunt generator has constant losses of 2880W. The armature circuit resistance is 0.20 ohm. If the generator is delivering a power at maximum efficiency, then its armature current is
a) 10A b) 120A c) 130A d) 64A
30. A 400Kw, 600V dc shunt generator has an armature resistance of 0.03 ohm. The field resistance is 48 ohms. The stray power loss for this machine at rated voltage and speed is 7200 Watts, What is the maximum efficiency? a) 93.4% b) 96.3% c) 95.3% d) 98.5%
31. A shunt generator delivers 195A of terminal voltage of 250V. The armature resistance and shunt field resistances are 0.02 ohms and 50 ohms respectively. The iron and friction losses equal to 950W. The over all efficiency is a) 94% b) 98% c) 95% d) 95%.
32. A 440V long shunt compound generator has a full load current of 200A. Its armature resistance, series field resistance and shunt field resistances are 0.02 ohm, 0.04 ohm and 100 ohm respectively. The stray load losses are 2000W. What is the full load efficiency of the generator?
a) 97% b) 95% c) 98% d) 93%
33. A 50Kw, 460V shunt generator has a voltage regulation of 8.7%, Calculate the load terminal voltage. a) 475 b) 500 c) 505 d) 490
34. The simplest way to shift load from a dc shunt generator running in parallel with another is to… a) adjust their field rheostat b) adjust speeds of their prime movers c) insert resistance in their armature circuit d) use equalizer connections
35. Two shunt generators A and B, with ratings of 250 and 400Kw respectively having equal no load voltage of 260V and full load voltage of 240V. Calculate the terminal voltage when the total output is 575Kw. a) 245.7V b) 238.4V c) 242.6V d) 234.6V.

POLYPHASE POWERLINE SYSTEM SERVICES

RME Review

#289 Carig Sur, Tuguegarao City

General Information Electrical Engineering

1. __Is an electric energy transfer measured in coulomb.
    a. electric charge b) capacitance c) Inductance d) force
2. The ratio of the amount of electricity transferred from one of its plate to the other, to the potential difference produced between the plates.
    a. electric charge b) capacitance c) Inductance d) force
3. Is a physical element which exhibit the property of capacitance.
    a. a) resistor b) inductor c) capacitor d) charge
4. __ is defined as work per unit positive charge moving between two points in the field.
    a. a) electric current b) electric potential c) electric charge d) electrons
5. __ is defined as work per unit time. a) energy b) power c) voltage d) current
6. __ is the ability of doing work or rate of doing work. a) energy b) power c) voltage d) current
7. The opposition to the flow of current to a circuit.
    a. a) resistance b) capacitance c) inductance d) electric charge
8. __ is the property of an electric circuit which causes the circuit to oppose any change of current in the circuit. a) resistance b) capacitance c) inductance d) electric charge
9. The unit of resistivity is a) ohm per meter b) ohm –meter c) mho-meter d) mho per meter.
10. The unit of conductivity is a) ohm per meter b) ohm –meter c) mho-meter d) mho per meter.
11. __ are materials with conductivities intermediate between those of conductors and insulators.
    a. a) semiconductors b) superconductors c) insulators d) inductors
12. __ are materials with low conductivity approximately 10^{-10} to 10^{-16} mho per meter.
    a. a) semiconductors b) superconductors c) insulators d) inductors
13. __ materials having resistivity approaches zero.
    a. a) semiconductors b) superconductors c) insulators d) inductors

14. __ materials with large values of conductivity approximately in the order of $10x10^6$ mho per meter. a) semiconductors b) superconductors c) insulators d) inductors
15. The conduction of electricity in the materials is by means of individual atomic scale species called a) electrical conduction b) charge carriers c) conductor d) insulator
16. A heater uses electric energy at the rate of 100W in 2hours when supplied by a constant voltage source of 120V, The energy consumed by the heater is
    a. a) 720KJ b) 0.200Kwh c) 0.240Kwh d) 1.240Kwh
17. A 12V battery is used to supply a 120W load in 10hours. How much electric charged stored in the battery. a) 360kCoulomb b) 12Coulomb c) 100Ah d) 30Coulomb.
18. Two points in an electric field have a potential difference of 5V. If an electric charge of 5Coulomb is moving from point to point, How much work is produced during transition.
    a. 1Joule b) 5Joule c) 25Joule d) 75Joule
19. A copper conductor 5m long having a cross-section of 2mm in diameter, has a potential difference of 12V across its terminal. The resistivity of copper at 20^0C is 1.72 x 10^{-8}ohm – meter. The resistance of the wire is a) 27.4 x 10^{-3}ohms b) 0.274ohms c) 2.74 x 10^{-3}ohms d) 274ohms
20. In item #19, the current flowing through the circuit is
    a. 219.2Amp b) 326.5Amp c) 358.7Amp d) nota
21. An electric heater, 220V takes 2Ampere of current. The energy consumed by the heater in 1hr is a) 4.4Kwh b) 44Kwh c) 0.44Kwh d) 8.8Kwh
22. The capacitors having a capacitance of 1Farad are connected in parallel. The equivalent capacitance is a) 1Farad b) 2Farad c) 3Farad d) 1/3Farad
23. If the capacitor in item #22 are connected in series, the equivalent capacitance is
    a. 1Farad b) 2Farad c) 3Farad d) 1/2Farad
24. A coil has an inductance of 5Henry. If the current changes from 10Ampere to 20Ampere in 1second, the average voltage is a) 50V b) 150V c) 100V d) 5V

25. A light bulb operates with a line voltage of 110V. The filament resistance is 200Ohms with 1mm diameter and 1m long. The conductivity of the material is a)29.5 x 10^6 mho per meter b) 35.3 x 10^6 mho per meter c) 10.3 x 10^6mho per meter d) nota

AC MACHINES (ALTERNATOR) REVIEW LECTURE

Alternators – An electrical converting mechanical energy to ac electrical energy.

General Types of Alternators

A) Synchronous generator – a generator synchronous because it is driven at constant speed (synchronous speed) and it is used in almost all type of applications.
B) Induction generator – it is an induction which run as a generator with a speed above synchronous speed. Ts p.f. is usually leading and connected in parallel with a synchronous generator in order to supply power for lighting loads.
C) Induction alternator – it generates voltage at higher frequency (500 Hz to 10,000Hz) it is used to supply power to induction furnace in order to supply power to induction furnace in order to heat and melt the metal.

Two types of alternator:

1. Revolving Armature Type
2. Revolving Field Type
    a. Stator – Stationary armature
    b. Rotor – Rotating field poles

Advantages of Stationary Armature

1. Output current is delivered to the load without passing it through brush contracts

2. Easier to insulate stationary armature winding for high ac voltage
3. Armature winding can be easily braced to prevent deformation which can be produce by mechanical stress.
4. Easily insulated slip rings which transfers low voltages, low power dc field circuit.

Two types of rotor used:

a. Salient pole construct – used for low speed alternator, large diameter than axial length, having more poles (from 6 to 40 poles)
b. Smooth cylindrical construction – used for high speed alternator, diameter is less than axial length, having less number of poles (2 or 4 pole)

Prime movers for Alternator

A) For large AC generator

1. Steam turbine
2. Gas turbine
3. Hydraulic turbine
4. Internal combustion engine

B) For Small generator

1. Use internal combustion engine

Frequency of General Emf

$f = (PN_s / 120)$ Hz ; Where: P = number of filed poles
N_s = synchronous speed, rpm

General Emf Equation (per phase)

$E\phi = 4.44\ \phi_p K_p K_d \times 10^{-8}$ volts (rms) (if ϕ_p is in lines or maxwells)
or $E\phi = 4.44\ \phi_p NfK_pK_d$ volts (rms) (if ϕ_p is in weber)
or $E\phi = 2.22\ \phi_p\ Zf NfK_pK_d$ volts (rms) (if ϕ_p is in weber)
or $E\phi = Z\ E_z\ K_pK_d$ volts (rms)

Notatons:

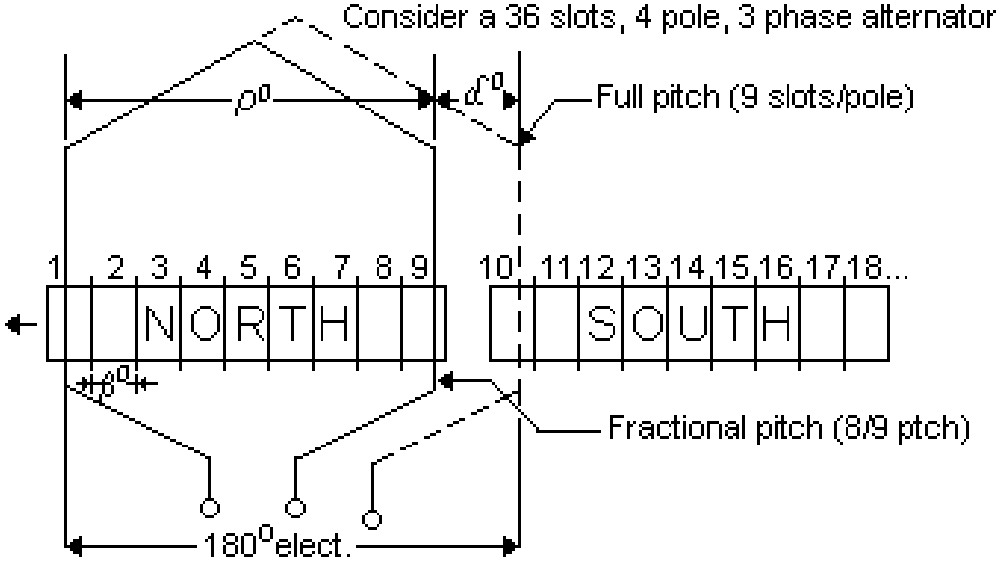
$E\phi$ = generated emf per phase; E_z = rms voltage per conductor
ϕ_p = flux per pole in weber or Maxwell
N = number of turns per phase
Z = number of conductors per phase.
f = frequency in Hz.
K_p = pitch factor or coil span factor
K_d = distribution or breadth factor

Pitch Factor or Coil Span Factor, K_p

K_p = (Vector sum of induced emf per coil) / (Arithmetic sum of induced emf per coil)
$K_p = \cos(\alpha^0/2) = \sin(\rho^0/2)$
$\alpha^0 = 180^0 - \rho^0$
where: ρ^O = (Coil pitch / Slot pitch) x 180^0 = (Fr.C.P. / Fu.C.P.) x 180^0

Distribution or Breadth Factor, K_d

K_d = (Vector sum of coil emf / Arithmetic sum of coil emf)
= (emf with distributed winding / emf with concentrated winding)
$K_d = \sin(n\beta^0/2) / n \sin(\beta^0/2)$; Where: $\beta^0 = 180^0$ / slots/pole
ρ^0 = distance in electrical degree between coil sides
α^0 = required distance n electrical degree to make it full pitch coil.
β^0 = distance in electrical degree between adjacent slots
n = number of slots per pole per phase
For instance:



Notations:

- R_c = effective armature (stator) resistance per phase
- X_s = synchronous reactance per phase = $X_{ar} + X_L$
- Z_s = synchronous impedance per phase
- X_L = leakage reactance per phase
- X_{ar} = reactance due to armature reaction
- $E\phi$ = generated or no-load voltage per phase
- E_L = generated no-load line-to-line voltage
- V_L = Line-to-line terminal voltage
- I_L = Line current
- $I_\phi = I_a$ = armature current or phase current
- V_f = exciter voltage
- R_f = field resistance
- I_f = field current

Alternator Voltage Regulation:

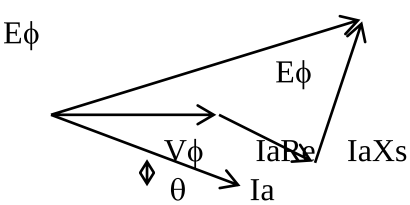
$$\% \, VR = [(V_{NL} – V_{FL}) / V_{FL}] \times 100\% = [(E_\phi - V_\phi) / V_\phi] \times 100\%$$

Alternator on load, the variation of terminal voltage is due to the following reasons:

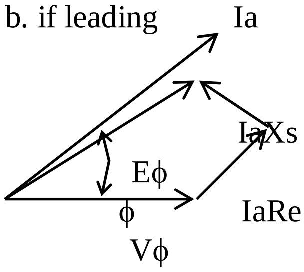
1. Voltage drop due to armature resistance
2. Voltage drop due to armature leakage reactance
3. Voltage drop due armature reaction (major reason)

Vector diagram:

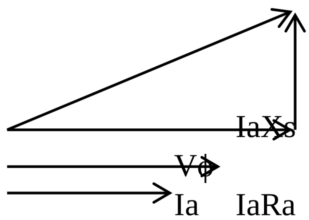
a. if lagging



b. if leading



c. if unity



in complex form

$$E\phi = V\phi + I_a (Z_s)$$

In magnitude

$$E_\phi = \sqrt{(V_\phi\cos\theta + I_aR_e)^2 + (V_\phi\sin\theta \pm I_aX_s)^2}$$

Where: + is lag'g. p.f. - for leading p.f. and $\theta = 0$ for infinity

Test for Alternators

a. DC Resistance Test – while Alternator is at rest, and dc field is open, measure the dc resistance between the terminals. The average of three sets of resistance is called R_f.
b. Open circuit Test or No load Test – the alternator is driven at synchronous speed, the field current (excitation) is adjusted from a low value up to that sufficient for voltage responsibility beyond the rated voltage.
c. Short Circuit Test – the alternator is driven at synchronous speed (rated frequency), the field current (excitation) is adjusted to give 150% to 200% of rated current to flow.

For wye-connected stator

$Z_s = (E_{oc} / I_{sc}) – [(V / \sqrt{3}) / I_{sc}];l$ $R_e = 1.5 R_{dc}$; $R_{dc} = ½ R_t$

For delta-connected Stator windings

$Z_s = (E_{oc}) / (I_{sc} / \sqrt{3}) = V / (I_{sc} / \sqrt{3})$; $R_e = 1.5 R_{dc}$; $R_{dc} = 3/2 R_t$

Where:

R_t = ohmic resistance between terminals (measured by ohmmeter)
R_{dc} = ohmic resistance per phase
R_e = effective resistance per phase
V = voltmeter reading or open circuit voltage between lines
E_{oc} = open circuit voltage per phase
I_{sc} = short circuit line current

Alternator Efficiency:

$\eta = (P_{out} / P_{in}) \times 100\% = [P_{out} / (P_{out} + P_{loss})] \times 100\% = [(P_{in} – P_{loss}) / P_{in}] \times 100\%$

Alternation Losses

1. Rotatoin losses
    a. Friction and windage loss
    b. Brush friction
    c. Ventilation loss
    d. Core loss
2. Electrical losses
    a. Field circuit copper loss
    b. Armature winding copper loss
    c. Brush contact loss
3. Stray load loss
4. Exciter loss

Parallel Operation of Alternators;

The requirement of connecting two alternators in parallel or connecting in alternator to the bus are:

1. The two effective values of voltage are equal at the terminals being connected.
2. The two frequency are same.
3. Two voltage are exactly opposite in phase (in the local circuit of the two machine).
4. The phase sequence of the voltages (for polyphase machine) are the same.
5. The two voltages have the same wave form.

The operation of properly connected synchronous generator n parallel with a system is called "synchronizing". If any of the above is requirements are not met, there will be cross-current between the alternator winding through the common bus-bars, with this cross current, the generator can not be synchronize.

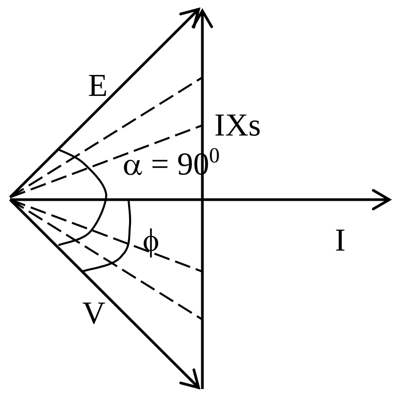
Maximum Power Output for Alternator:

P_{max} = EV watts / X_s ϕ If R_e is neglected

P_{max} = (V/ Z_s) (E – Vcos θ) if R_e is considered

$I_{max} = [\sqrt{(E^2+ V^2)}] / X_s$

P.f. = E / $[\sqrt{(E^2 + V^2)}]$



Where;

E = emf generated per phase

V = terminal voltage per phase

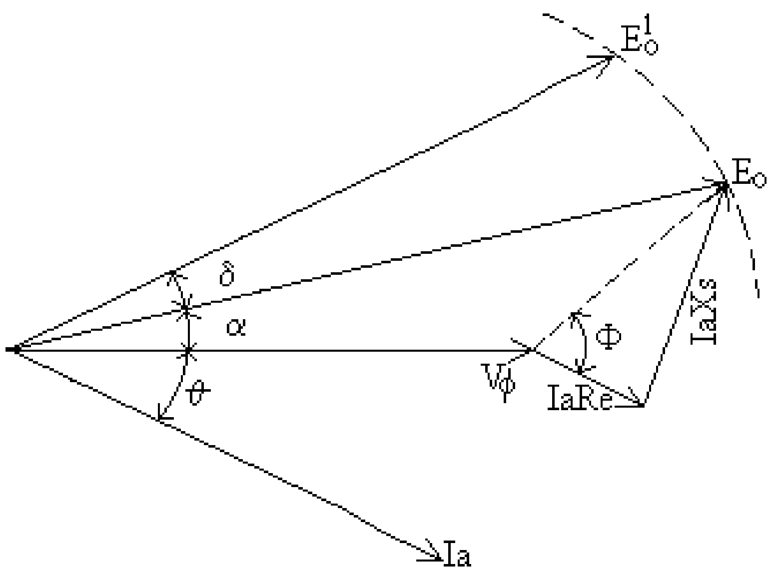
X_s = synchronous reactance per phase

Z_s = synchronous impedance per phase

Synchronizing Power (P_{SYN}) OF Alternator:

Because of some disturbance on the system, the power angle changes by ψ (as shown $V_o = V_o$), which cause the machine to develop the additional power, thereby keeping in synchronism. This additional power is known as the "synchronize power".

Consider the vector diagram with lagging p.f. load;



From the vector diagram

$I_a = (E_0 / \underline{a} - V_\phi / \underline{0^0}) / (Z_s / \underline{\phi}) = 1/Z_s [E_o \underline{/ \alpha - \phi} - V_\phi \underline{/ - \phi}]$

$I_a = 1/Z_s [E_o \cos(\alpha - \phi) - V_\phi \cos \phi] + j/Z_s [E_o \sin(\alpha - \phi) + V_\phi \sin \phi]$

Using

P_d = (Rectangular) of V_oI_a * after simplifying:

$P_d = V_\phi/Z_s [E_o \cos \phi - V_\phi \cos (\phi - \alpha)]$

When α becomes $\alpha + \delta$;

$P_d = E_o/Z_s [E_o \cos \phi - V_\phi \cos (\phi + \alpha + \delta)]$

And since $P_{syn} = P_d – P_d$

$P_{syn} = E_oV_\phi/Z_s [\sin \delta \sin (\phi + \alpha) + 2 \cos (\phi + \alpha) \sin^2 \delta/2]$ watts/ϕ

$P_{syn} = E_oV_\phi/Z_s [\cos \alpha \sin \delta]$ watts/ϕ

ALTERNATOR REVIEW PROBLEM

1. In large capacity generator, the moving part is
   a)brushes b)armature c)poles d)frame
2. Which of the following is NOT the integral part of synchronous generator system?
   a)excitation system b)distribution system c)protection system d)prime mover
3. An exciter of a generator is a
   a)shunt motor b)shunt generator c)series motor d)series generator
4. It plays an important role in over-speed protection of a generator
   a)governor b)Differential protection c)over current delay d)alarm
5. Salient pole type alternators are generally used on
   a) low voltage alternators
   b) high speed prime movers
   c) hydrogen cooled prime mover
   d) low/medium speed prime mover
6. The rotor preferred for alternators applied to hydraulic turbines are
a)salient pole type b)any of the above c)cylindrical rotor type d)solid rotor type
7. Three phase alternators are invariably star-connected because
   a) higher terminal voltage is obtain
   b) small conductors can be used
   c) less turn of wire is required
   d) magnetic losses are minimum
8. Increasing the speed of alternator, what will happen? a)decrease MW b)increase frequency c)increase MVAR d)decrease MVAR
9. Turbo alternators usually have a) 4 poles b) 2 poles c) 8 poles d) 12 poles
10. What is the frequency of the generated emf of a 10 pole alternator driven at 720 rpm?
    a) 50 hz b) 55 hz c) 60 hz d) 62.5 hz
11. In aircrafts, alternators have operating frequency of a)50Hz b)60Hz c)400Hz d)800Hz
12. The number of cycles generated in an 8-pole alternator in one revolution is…
    a) 4 b) 2 c) 6 d) 8
13. Determine the number of electrical degrees made per revolution for special-purpose 8 pole alternator. a) 28,800 b) 7,200 c) 14,400 d) 1,600
14. Due to which of the following reasons concentrated winding are not used in alternators
    a) increase the voltage harmonics
    b) increase copper iron ratio
    c) decrease the Induce emf/phase
    d) increase armature reactance
15. Harmonic component of generated emf will be more in

a)short pitch coil b)full pitch coil c)long pitch coil d)none of these

16. The winding of of a 3-phase, 6-pole, 60 cycle alternator has 8/9 pitch. what is the coil span?

a) 30^0 elect b) 120^0 elect c) 160^0 elect d) 20^0 elect

17. For a 3-phase winding with 5 slots per pole per phase and with coil span of 12 slot pitch, the value of pitch factor is a)0.851 b)0.98 c)0.951 d)1.05

18. If the alternator winding has a fractional pitch of 5/6, what is the pitch factor (K_p)?

a)0.966 b)0.957 c)0.951 d)0.972

19. Determine the breadth or belt factor for a 3-phase winding in which there are 5 slots per pole per phase. a)0.966 b)0.957 c)0.959 d)0.952

20. A 144-slots stator has a whole-coiled, 12 pole, 3-phase winding. What is the number of coils per phase? a) 48 b) 12 c) 24 d) 36

21. A part of an alternator winding consist five coils in series, each coil having an emf of 10 volts induce in it. The coils are placed in successive slots and between each slot and the next, there is an electrical displacement of 12°. Determine the emf of the five coils in series.

a) 48.64 Volts b) 50 Volts c) 48.3 Volts d) 47.83 Volts

22. Calculated generated emf per phase af a 10 pole, 3-phase, 60 Hz alternator with 5 slot per pole per phase and 4 conductors per slots in two layers. The winding is short by 3 slots & the flux per pole is 0.12 Weber. a) 2908Volts b) 1000Volts c) 720Volts d) 3200Volts

23. The harmonic which would be totally eliminated from the alternator emf using a fractional pitch of 6/7 is a)3rd b)5th c)7th d)9th

24. An alternator on open circuit generates 360 Volts at 60 Hz when the field current is 3.6 Amp. Neglecting saturation, determine the generated emf at a frequency of 30 Hz and a field current of 3.0 Amp. a) 240Volts b) 300Volts c) 160Volts d) 150Volts

25. A 30 MVA, 13.8 kVolt, 3ϕ, Y-connected alternator will have a per phase nominal impedance of… a) 7.5 ohms b) 2.9 ohms c) 6.4 ohms d) 15 ohms

26. To get the armature resistance of a 100 MW, 13.8 kv and 90% power factor generator, two terminals are connected to dc source. The measured current and voltage are 87.6 amperes and 6 volts respectively. What is the dc resistance per phase?

27. A generator is rated 100 MW, 13.8 kV and 90% factor. The effective resistance to ohmic resistance is 1.5. The ohmic resistance is obtained by two terminals to a 6 volts d.c. source. If the current 43.8 Amperes, what is the percent resistance per phase?

a) 1.5% b) 6% c) 4.5% d) 6.9%

28. To get the armature resistance of a delta connected 500 kw, 230-v, 85% power factor generator, two terminals are connected to a 6-Volt DC. The measured current is 90A. What is the armature resistance? a) 0.67 b) 0.1 c) 0.06 d) 0.09

29. Synchronous impedance test is taken on a 3-phase generator. Under short circuit condition, the currents in the three lines are 26.2A, 23.7A, and 27.4A. What current should be used for the test? a) 26.3A b) 25.7A c) 24.6A d) 25.4A

30. A generator rated 100MW, 13.8 kVolt and 90% power factor has an effective ac resistance of 0.436 ohm between terminals. The field current of 103 Amp produces an open circuit emf of 13,800 volt between terminals. The same field current required to produce rated full-loaded current at short-circuit. What is the synchronous reactance per phase?

a) 1.72 ohms b) 2.97 ohms c) 1.7 ohms d) 2.96 ohms

31. If the excitation of 10 A in a single phase alternator gives a current of 150 A on short circuit and terminal voltage of 900V on open circuit, what the internal drop with a load current of 60A?

a) 360V b) 180V c) 240V d) 60V

32. If the load on an isolated alternator increased without increasing the power input to the prime mover. The alternator a)will shot down b)voltage increases c)speed up d)field current will increase

33. A 100 MW, 13,800 volts 90% power factor synchronous generator has an ohmic resistance of 0.1 ohm and synchronous reactance of 0.42 ohm is operating at rated condition. Find the angle between the voltages. a) 9.55 deg. b) 7.45 deg. c) 6.72 deg. d) 3.25 deg.

34. A 3-phase 100MW, 22 kV, wye connected alternator supplies full load 85% power factor lagging. Its resistance is 0.1 ohm and synchronous reactance is 0.7 ohm per phase. what is the voltage regulation? a) 24.54% b) 11.8% c) 22.3% d) 12.59%

35. A 1500 kVA, 2,300 Volt, 3-phase, 8-pole, 60 Hz alternator has an ohmic resistance between terminals of 0.08 ohm. The ratio of effective to ohmic resistance is 1.5. The field takes 70 Amp at 120 Volts from exciter equipment. The friction and the windage loss is 15 kW, iron losses are 35 kW and stray load loss is 1.5kW. What s the efficiency at rated load and 80% p.f. lagging?

a) 93.4% b) 89.7% c) 92.3% d) 95.3%

36. What is the solution to reduce rotor friction to a large generator?

a) use SF6 gas in the rotor chamber
b) use lubricant oil n the rotor chamber
c) use hydrogen gas in the rotor chamber
d) apply an vacuum in the rotor chamber

37. The dark and bright lamp method is use for

a) transfer of load b)synchronizing c)balancing of load d)phase sequence

38. Out of the following conditions, the one which does not have to be met by alternators working in parallel is

a) the machine must have equal rating
b) terminal voltage of each machine must be the same
c) the machines must have the same phase rotation
d) the machine must operate at the same frequency

39. A generator is being synchronized to a large system. The actual system voltage and frequency are 13.7 kV and 60 Hz respectively. The generator voltage and frequency are 13.6 and 60 Hz respectively. When the generator is switch to the system. Choose which one happens.

a) Generator delivers MVAR b) Generator takes in MVAR
c) Generator delivers MW d) Generator take in MW

40. A generator is being synchronized to a large system. The actual system voltage and frequency are 13.8 kV and 60 Hz respectively. The generator voltage and frequency are 13.8 kV and 60.1 Hz respectively when the generator is switched to the system. Choose which one happens. a) Generator delivers both MW and MVAR b) Generator takes in MVAR c) Generator delivers MW d) Generator takes MW

41. The distribution of load between two alternator operating in parallel can be change by changing… a)phase sequence b)field excitation of alternator c)driving torque of prime mover d) all of these

42. When two alternators are operated in parallel and the field current of one of the generator is increased, it will a) take a large share of the load b) speed up c) causes a flow of reactive VAR between two machines d) take a smaller share of the load

43. The driving power from the prime mover driving an alternator is lost but the alternator remain connected to the supply (i.e. its power circuit breaker failed to trip) and its excitation is on. The alternator will… a) behaves as an induction motor b) stop & get burnt

c) behaves as synchronous motor but will rotate n reverse or opposite direction.
d) behaves as synchronous motor and rotate at the same direction

44. Damper or "Amortisseur" winding are used in alternation to…
a)achieve synchronism b) prevent hunting c) reduce windage losses d)start up

45. Which of the following relay come into operation in the event of failure of prime-mover connected to the generator? a) Buchholz relay b) Reverse power relay c) Differential relay d) Distance relay

46. The power factor of an alternator is 75%. The operator is ordered to increase the power factor to 80%. What shall he do? a) increase the voltage b) increase the excitation c) operate the governor d) decrease the excitation

47. Two 1500 kVA AC generators running in parallel supplies the total load of 2,250 kW at 0.90 p.f. lagging. One machine is loaded to 1000 kW at 0.85 p.f lagging. What is the kW & p.f. of the other machine? a) 1750 & 0.8 lagging b) 470 & 0.96 leading c) 1335 & 0.94 lagging d) 1250 & 0.78 leading

48. Two alternators are driven by shunt motors. The shunt motors have speed load-drop characteristic of 3% and 4% respectively. The alternators are in parallel and each carrying 50 kW. there is no automatic speed-load control. An additional 50 kW is switch on. What are the resulting loads of the alternators assuming that the speed-load control of each is not adjusted? a) 78.57kW & 71.43kW b) 82.51kW & 67.49kW c) 78kW & 75kW d) 80.31kw & 69.69kW

49. A 3ϕ, Y-connected, 1000kVA, 6.6kVolt turbo-alternator has a synchronous reactance of 8.7 ohms per phase but negligible resistance. when it is supplying full load at 80% power factor lagging to a large power system, the emf is 4311 volts per phase. if the excitation s reduce by 5%. What is the new value of armature current? a)87.5Amp b)27.5Amp c)77.2Amp d)75.5Amp

50. A 3ϕ, Y-connected, 1000kVA, 6.6kV alternator has a reactance of 8.7 ohms per phase but negligible resistance. When it is supplying power to a large power system, the emf s 4311 volt per phase. If steam supply is gradually increase without changing the excitation. What is the maximum load current and maximum power that the generator can supply before gong out of synchronism? a) 87.5A & 6,600 kW b) 661A & 5,600 kW c) 87.5 A & 1000 kW d) 661 A & 800 kW

AC Machines Supplementary Problems

1. In case of turbo alternators the rotor is usually made of a) cast iron b) laminated stainless steel c) forged steel d) manganese steel

2. What kind of rotor s most suitable for turbo-alternators which are designed to run at high speed a) salient pole b) non-salient pole type c) either A or B d) none of these

3. In an alternator one of the advantages of distributing the winding is to a)improve the voltage waveform b)none of the above c) reduce nose d) save on copper

4. A 6 pole, three phase AC generator has 72 slots, the coil span is 12. what is the pitch factor?
a) 1.00 b) 0.939 c) 0.985 d) 0.966

5. The winding of a 3-phase, 6-pole, 60 cycle alternator has five-sixths pitch. What is the chording angle? a) 30^0 b) 180^0 c) 150^0 d) 0^0

6. Determine the belt factor for a 3-phase winding in which there are 18 slots per pole.
a) 0.966 b) 0.967 c) 0.958 d) 0.956

7. A 3-ϕ, 60 hz, 10-pole alternator has 120 slots and 4 turns in every coil. The coil pitch is short by 2 slots. The winding distribution factor of the alternation is…
a) 0.925 b) 0.967 c) 0.987 d) 0.957

8. A 4 pole, 1500 rpm alternator will generate emf at a) 20 Hz b) 60 Hz c) 50 Hz d) 40 Hz

9. Calculate the voltage generated between lines of a wye-connected 60 Hz, alternator with the following data: slots = 144, poles = 8, turns per coil = 6, flux per pole = 1.8 x 10^6 lines, coil span = slots 1 – 16 and winding being whole coiled. a) 1276Volts b) 635Volts c) 2,200Volts d)1,100Volts
10. A 100 MVA, 13.8 kVolt, 3ϕ, Y-connected alternator will have a per phase nominal impedance of… a) 7.5 ohms b) 2.9 ohms c) 1.9 ohms d) 3.5 ohms
11. A generator is rated 100MW, 13.8kV and 90% power factor. The effective resistance is 1.5. The ohmic resistance is obtain by connecting two terminals two a d.c. source. The current & voltage are 87.6 Amperes and 6 volts respectively. What is the percent resistance?
a) 3 b) 2 c) 4.2 d) 1
12. A wye-connected alternator was tested for its effective resistance. The ratio of the effective resistance to ohmic resistance was previously determined to be 1.35. A 12-v battery was connected across two terminals and the ammeter read 120 amperes. What is the per phase effective resistance of the alternator? a)0.135 ohm b)0.117 ohm c)0.0685 ohm d)0.0617 ohm
13. A generator s rated 100 MW at 22 kV, and 90% power factor. The effective ac resistance to ohmic resistance is 1.5. The ohmic resistance is obtained by connecting two terminals to a dc source. The current & voltage are 87.6 Amperes and 6 Volts respectively. What is the resistance per phase? a)0.0513 ohm b)0.342 ohm c)0.0685 ohm d)0.0617 ohm
14. A generator is rated 100 MW at 22 kV, and 90% power factor. The effective ac resistance to ohmic resistance is 1.35. The ohmic resistance is obtain be connecting two terminals to a 12 volts dc source. If the current is 120 Amperes, what is the percent effective resistance per phase?
a) 1.5% b) 6% c) 4.5% d) 6.9%
15. A generator is rated 100 MW, 13.8 kV, and 90% power factor. The effective resistance to ohmic resistance ratio is 1.5. The ohmic resistance is obtain by connecting two terminals of the wye connected windings to a D.C. source of 6 volts. The current drawn is 87.6 amperes. What is the percent effective resistance. a) 3% b) 4.2% c) 1% d) 2%
16. A dc resistance test is conducted on 3-phase, 200kVA, 240 volts, delta connected generator. When the two terminals are connected from 6 volts dc source, the ammeter inserted in the line reads 150 Amperes. The effective resistance to ohmic resistance is 1.25. What is the percent resistance per phase? a) 7.5% b) 8.7% c) 26% d) 4.6%
17. If, in a 3-phase alternator, field current of 50 A, produces a full load current of 200 A on short circuit and 1730 V on open circuit, then its synchronous impedance is…
a) 8.66 b) 5 c) 4 d) 34.6
18. The power factor of an alternator s determined by its
a) load b)speed c)excitation d)voltage rating
19. A 3-phase, 1000 kVA, 2,300 Volts alternator is short circuited and open circuited and is operates at rated current. With the short circuit removed and the same excitation, the voltage between stator terminals is 860 volts. The effective ac resistance between stator terminals is 1.2 ohms. Determine the percent voltage regulation at 0.9 power factor loagging.
a) 29 b) 15 c) 32 d) 26.7
20. A 25 kVA, 220 Volt 3-phase alternator delivers rated kVA at 0.84 power factor. The effective ac resistance between the armature winding terminals is 0.18. The field takes 9.3 Amperes at 155 Volts. If the friction and windage loss is 460 watts and the core loss is 610 watts. What is the hp delivered by the prime mover? a) 32.6 b) 31.54 c) 28.15 d) 33.23
21. In a large alternator dampers a) reduce frequency fluctuation b) reduce voltage fluctuation c) increase stability d) none of the above

22. A generator is being synchronized to a large system. The actual system voltage and frequency are 13.7 kV and 60 Hz respectively. The generator voltage and frequency are 13.9 and 60 Hz respectively when the generator is switch to the system. Choose which one happens.

a) Generator delivers both MW and MVAR
b) Generator delivers MW
c) Generator delvers MVAR
d) Generator takes n MW

23. It is never advisable to connect a stationary alternator to live bus-bars because it…

a) is likely to run as synchronous motor
b) will get short circuited
c) will decrease bus-bar voltage though momentarily
d) will disturb generated emf of the other alternator connected in parallel

24. An alternator is operating with 100 Amp field current. If the field current is increased to 125 Amp with the same electrical load on the machines, it will ___________.

a) be less likely to go out of synchronism
b) be more likely to go out of synchronism
c) operates at new power factor angle
d) overheat

25. Dirt accumulation in generator can use all of the following except

a) low power factor b) flashover c) poor voltage regulator d)overheating

26. Two-3ϕ alternators operating in parallel delivers power at a line potential of 2200 Volts to an inductive load of 150 kW at 80% p.f. If the armature currents of the two alternators be equal one be operating at unity p.f. How much power does each alternator supply to the load?

a) 117.2 kW for unity p.f. & 32.8 kW
b) 112.7 kW for unity p.f. & 38.2 kW
c) both 75 kW one at unity p.f.
d) 100 kW for unity & 50 kW

27. Two-3ϕ synchronous generators connected in parallel are driven by waterwheel whose speed-load characteristics are as follows: The speed of the first falls uniformly from 624 rpm at no-load to 600 rpm at full-load at 1000 kW. The speed of the second waterwheel falls uniformly from 630 rpm to no-load to 600 at 1000 kV loading. The output of each generators when the load is 1250 kVA, 0.80 p.f. are nearest to a) 500 kW each b) 667 kW and 333 kW c) 445 kW and 555 kW d) 700 kW and 300 kW

28. Hydrogen is used in large alternators mainly to a)reduce distortion of wave form b)strengthen the magnetic field c)cool the machine d)reduce the eddy current losses

29. Two identical 2000 kW alternator operates in parallel. The governor of the first machine is such is that the frequency is drops uniformly from 50 Hz at no-load to 48 Hz at full-load. The corresponding uniform speed drop of the second machine is 50 Hz to 47.5 Hz. What is the maximum load that can be delivered without overloading either machine?

a) 3600 kW b) 4000 kW c) 6300 kW d) 1723 kW

30. A wye-connected turbo alternator having synchronous reactance of 0.5 and negligible resistance is connected to a large power system having a bus bar voltage of 13.8 kV supplying a load of 15000 kVA at 0.8 lagging power factor. If the steam supply is cut-off, what current will the machine carry assuming negligible losses? a)256.55 A b)384.26 A c) 525.62 A d)627.55 A

AC MOTOR REVIEW LECTURE

I. Induction Motors

An induction motor is one in which the magnetic filed in the rotor is induce by current flowing in the stator windings. The rotor has no connection whatsoever to the line. It differs from the synchronous motor, the rotor of the induction motor does not rotate as fast as the rotating field in the armature. The armature difference in speed is called the slip. The slip is usually expressed as a percentage of synchronous speed.

% Slip = $(N_S – N_R)/N_S$ x 100% ; $N_R = N_S (1\text{-}s)$

Slip is also the measure of the rotor winding losses, i.e.

Slip motor = Rotor Copper Loss/Rotor Power Input (RCL/RPI)

Slip is also connected with rotor efficiency, the higher the slip, the lower the efficiency, i.e.

$\eta = N_R/N_S$ x 100%

TYPES OF 3-PHASE INDUCTION MOTORS:

1. Squirrel-cage type – the rotor winding is practically self-contained and its not connected either mechanically or electrically with the outside power supply or control circuit. it consist of number of straight bar uniformly distributed around the periphery of the rotor and skewed and short circuited at the both ends by end ring to which they are integrally joined.

   Speed characteristics: nearly constant speed

   Torque characteristics: starting torque depends on the resistance of the rotor winding

   Applications: constant speed service as fans, blowers, compressors, pumps, ect.

2. Wound-rotor type – this is a 3-phase motor that has another 3-phase winding instead of a squirrel-cage rotor, the terminals of which are connected to 3 slip-rings. Brushes rides this slip rings and deliver the current to an external 3-phase rheostat or variable resistor to vary the characteristic of the motor. At start, all the resistance are in the circuit; as a the motor picks-up speed, the resistance are gradually decrease until the finally the slip rings are short circuited.

   Speed characteristics: variable speed

   Torque characteristics: by inserting various value of resistance in the rotor circuit, a variety of torque values (high or low) are obtainable.

   Applications: Where high starting with low starting current or where limited speed control is required, as in fans, centrifugal and plunger pumps, compressors, conveyors, hoist and cranes, etc.

INDUCTION MOTOR FUNDAMENTAL FORMULAS:

1. Synchronous speed $N_S = 120\phi / P$
2. Slip speed = $N_S - N_R$
3. Slip, $S = (N_S – N_R) / N_S = 100\%$
4. Rotor frequency, $f_R = S (f)$
5. Rotor reactance, $X_R = S (X_2)$
6. Rotor standstill induce voltage, $E_2 = aV\phi$; if a is less than 1.0

   $E_2 = V\phi/ a$ if a is more than 1.0
7. Rotor induce voltage per phase $E_R = S (E_2)$
8. Equivalent load resistance peer phase $R_{load} = R_2 [(1\text{-}S)/S]$

POWER FORMULARS

1. Rotor Power Input, RPI = I_2^2 R_2/S watts per phase
2. Rotor Copper Loss, RCL = I_2^2 R_2/S watts per phase
3. Rotor Power Input, RPD = I_2^2 R_{load} = = $I_2^2R_2[(1-S)/S]$ watts per phase

ADVANTAGES OF SYNCHRONOUS MOTOR OVER INDUCTION MOTOR:

1. They can be operated at leading power factor and they improve the power factor of an industrial plant from the one that is normally lagging to that is close unity.
2. They less costly in certain horsepower and speed range.
3. They can be constructed with wider air-gap induction motor, which makes them beter mechanically.
4. They usually operate at higher efficiency, especially at low speed unity power factor range.

ADVANTAGES OF INDUCTION MOTOR OVER SYNCHRONOUS MOTOR:

1. They are and rugged hence easier to maintain and operate
2. Their speed can be easily adjusted or varied over a wide range
3. They are cheaper to first cost

METHODS EMPLOYED TO START 3-PHASE MOTORS:

1. Across the line starting – this customarily used when the motor must operate at a high starting torque. it is to be used in connection with a time delay over-current relay which will became operative before the winding can be damage by the surge current.
2. Reduce voltage starting – this is used I order to reduced the staring in rush current which may have detrimental effects on the line voltage and may disturb other apparatus.
   A. Line resistance starting – it uses suitable high current, low ohmic – value resistance is removed in steps or all at once.
   B. Line reactance starting – it use suitable iron –core reactance in replace of the resistance in (a) to accomplish the result
   C. Auto-transformer starting – is uses tapped auto – transformers in open –delta connection to reduce the motor voltage.
   D. Wye-delta starting – it used when the motor is designed for delta operation at its rated voltage. The motor phase winding are connected by contractor for a wye circuit starting. As a result, each phase will take the normal line current divided by 3.
3. Part winding method – This method is particularly adopted to Dual-voltage motors (those designed to operate at two voltages). The motor winding is divided into two identical wye-connected sections. One of which is used when is used when the motor is started and after its accelerates to about rated speed, the two section are joined in parallel for normal operation.

Test for Induction Motor:

A. No –load Test:

When supplied with rated voltage and frequency, voltage, current, and power input are measured. The no-load power input represent core loss, friction & windage, small stator copper loss and rotor copper loss (which is almost negligible).

$P_{in} = P_{NL}$ = core loss = friction & windage + small curloss

TWO BASIC PARTS OF SYNCHRONOUS MOTOR:

A. Field (rotor) structure – carrying de-excited winding.
B. Armature (stator) structure – often has 3-phase winding which is connected to an AC source

TORQUE ASSOCIATED WITH SYCHRONOUS MOTOR:

1. Starting Torque – Torque developed when voltage is applied in stator.
2. Pull – in torque – amount of torque or load at which the motor will pull into step, when it is started as an induction motor (2 to 5%) below synchronous speed until it is synchronous to the system.
3. Running Torque – torque developed by the motor while running
4. Pull-out Torque – maximum torque at which the motor will develop pulling out-of-step or out of synchronism, with an increase in torque produces backward shift "α", too much shift of torque angle of the rotor (at about ½ distance between adjacent pole) will cause motor stop.

APPLICATION OF SYNCHRONOUS MOTORS:

A) Power factor Correction:

When synchronous motors are employed as a p.f. correction device, it is called "synchronous condenser", this can be done by running the synchronous motor without mechanical load with field over-excited.

B) Constant speed load drives:

When constant speed is required such as drives for centrifugal pump, dc generator, belt driven reciprocating compressor, fans, blowers etc.

C) Voltage Regulators:

At the end of a transmission line, the voltage is controlled.

METHODS/PROCEDURES FOR STARTING SYNCHRONOUS MOTOR:

1. First, main field winding is short-circuited.
2. Reduce voltages, with the help of auto-transformers, were applied across stator terminals, the motor starts up.
3. When it reaches a steady (as judged by its sound), a weak excitation is applied by removing the short-circuit on the main field winding. If excitation is sufficient, then the machine will be pulled into synchronism.
4. Full supply voltage is applied across the armature (stator) terminals by cutting out the auto-transformers.
5. The motor may be operated at any desired power factor by changing the dc excitation.

III – SINGLE-PHASE AC MOTOR:

(A) single-phase Induction Motor – it is similar to 3ϕ IM, but it is NOT self-starting.

(1) Split-phase motor – it has stator windings, which is the main and the auxiliary windings.

a. Standard split-phase motor – in series with a the auxiliary winding is a centrifugal switch that will disconnect this winding from the source once the motor has reached 75% to 80% of its synchronous speed.

Uses: grinder, blower, etc.

B. Block – Rotor Test:

When reduced voltage is applied, hold the rotor firmly so that cannot rotate, voltage current and input power are measured, Ammeter reading represents the black rotor input current (short circuit current). The power input represent “stator and rotor copper and small core loss” (almost negligible).

$P_{in} = P_{BR}$ = stator Cu loss + rotor Cu loss + small core loss

= total copper losses + small core loss (almost negligible)

for 3ϕ, Y – connected stator induction motor:

$Re = P_{BR}/3I^2BR$; $Z_e = (V_{BR}\sqrt{3}) / I_{BR}$ then $X_e = \sqrt{(Z_e^2 - R_e^2)}$ → equivalent resistance & reactance

Double Squirrel Cage Induction Motor:

The main disadvantages of squirrel-cage IM is its poor because of low rotor resistance. The starting torque could be increased by having cage of high resistance, but the motor will have poor efficiency under running conditions (because there will be more copper losses). This can be accomplished by introducing two rotor cages. The outer cage has a high-resistance bar low inductance and being close to the rotor, while surface, while the inner-cage is low-resistance bars and has high inductance and being nearly surrounded by ion.

CASCADE/CONCATENATED OR TANDEM OPERATION:

In this method, two induction motors are used and are ordinary mounted on the same haft so that both run the same speed (or else they may be geared together). The stator winding of motor A (a wound rotor IM) is connected to the main source, and its rotor winding is the joined to the stator winding of motor B (a squirrel IM or wound rotor IM).

II – Synchronous Motors

An AC motor that can run only at definite constant speed called “synchronous speed” regardless of the load applied to it.

Some Characteristics Features of Synchronous Motor are:

1. It runs either at synchronous speed or not all, i,e, while running it maintains a constant speed. The only way to change is speed is to vary the supply frequency.
2. It is inherently self-starting. It has to be run to synchronous (or near synchronous) speed by some means before it can synchronized to the supply, so in practice they are built with “damper or amortisseur winding” this damper bars on the rotor come into play during transient or starting. It also prevent hunting swinging of the rotor with varying loads.
3. It is also capable of being operated over a wide range of factor correction purposes , in addition to supply torque to drive mechanical loads.

b. Capacitor – similar to the standard split phase motor, only it has a capacitor connected in series with the auxiliary winding to make the starting torque higher.

Uses: refrigerator, air conditioning unit, pump, etc.

c. Capacitor start and run motor – it has two capacitors, one for starting another for running.

Uses: same as capacitor start motor

3. Shaded pole motor – it uses shading coils instead of auxiliary winding.

Uses: small fans

b. Cummutator Motor – it rotor is the dc armature

1. Universal Motor – it is small series wound motor which can be operated using ac or dc source at approximately same output power. Uses: sewing machine, portable tools, ect.
2. Repulsion – its brushes are short circuited making the armature as a large magnet. Uses: vacuum cleaner, floor polisher, etc.
3. Repulsion Start-induction rug motor – similar to the repulsion motor, only the cummutator is automatically short circuited once the motor has reached 80% of its synchronous speed.
4. Repulsion induction motor – similar to repulsion motor only it has squirrel cage winding placed on the rotor. This motor start as induction motor and repulsion motor at the same time. Uses: refrigerator, compressor, gasoline pump, etc.

b) Unexcited 1φ synchronous Motor – it runs at a constant speed and it is self-starting.

These are two types:

1. Reluctance Motor – it has a squirrel-cage rotor of unsymmetrical magnetic construction which is achieved by removing some teeth of the symmetrical motor punching. Uses: timers, recording instrument, photographs, etc.
2. Hysteresis motor – it operates on the presence of a continuously- revolving magnetic flux, usually shaded-pole principle is employed, the only difference it has smooth chrome-steel cylindrical rotor having high retentivity so that hysteresis loss is high. Uses: driving-tape deck, turn-tables, clock, etc.

Methods Employed to Start Single Phase Motors:

1. Split-phase method (capacitor start is the most popular)
2. Shaded-pole method
3. Repulsion method
4. Repulsion-induction method

Methods of Reversing the Direction of Rotation:

Standard Split Phase Motor } You reverse the connection of the
Capacitor Start Motor } main or the auxiliary winding but
Capacitor Run Motor } not both
Capacitor Start Run Motor }

Repulsion Induction Motor – you move the brushes in the rotation of the original rotation, until the direction of rotation is reversed.

Universal Motor – you interchange the brushes.

AC MOTOR REVIEW PROBLEMS

1. The frame of the induction motor is usually made of a)silicon steel b)bronze c)cast iron d)aluminum
2. The shaft of induction motor is made of a)high speed steel b)cast iron c)stainless steel d)carbon steel
3. In squirrel cage induction motors, the rotors slots are usually given slight skew in order to a)reduce windage loss b)reduce accumulation of dirt and dust c)reduce eddy current loss d)reduce magnetic hum
4. Slip rings are made of a) copper b) carbon c) phosphor bronze d) aluminum

5. The crawling in an induction motor is caused by a) high loads b) harmonics developed in the motor c) improper design of machine d) low voltage supply

6. A 3-phase induction motor delta connected is carrying full load and one of its fuse blows-out, then the motor will

a) will continue running burning its one phase
b) will stop and carry heavy current causing permanent damage to its winding
c) will continue running burning its two phase
d) will continue running without any harm to winding

7. Out of the following methods of starting a 3-phase induction motor, which one requires six stator terminals? a)direct-on-line b)auto-transformer c)rotor rheostat d)star-delta

8. Two of the power supply terminals to a 3-phase induction motor got interchanged during reconnection after maintenance. When put back into service, the motor will

a) rotae in the directional as it was
b) rotate in opposite direction as it was
c) fail to rotate
d) burn out

9. A 3-phase; 4 pole, 60 Hz induction motor has full load speed of 1746 rpm. What is the slip speed of the motor? a) 56 rpm b) 46 rpm c) 54 rpm d) 60 rpm

10. The rotor efficiency of a 60 Hz, 4-pole induction motor is 95%. What is the spped of the motor? a) 1760 rpm b) 1750 rpm c) 1788 rpm d) 1710 rpm

11. A 3-phase 440 volts, 50 Hz induction motor has 4% slip. The frequency of the rotor emf wll be a) 200 Hz b) 2 Hz c) 50 Hz d) 0.2 Hz

12. What is the speed of an induction motor of 6 poles if the percent slip is 2.5%?
a) 1462 rpm b) 877 rpm c) 1170 rpm d) 1755 rpm

13. An induction motor runs at 1164 rpm. What is the slip?
a.) 3% b.) 4% c.) 2% d.) 5%

14. An induction motor runs at 1150 rpm. What is the frequency of the rotor?
a.) 1Hz b.) 19 Hz c.) 57.9 Hz d.) 2.5 Hz

15. The nameplate speed of a 60 Hz induction motor is 1164 rpm. If the speed at no load is 1188 rpm, what is the percent speed regulation?
a.) 2.06 b.) 2.77 c.) 2.86 d.) 4.24

16. A 4 pole, 60 Hz, 3-phase induction motor has a full load speed of 1750 rpm. What is the speed at half load in rpm?
a.) 1770 b.) 1775 c.) 3500 d.) 875

17. An AC squirrel cage induction motor has a speed rating of 1750 rpm. If the leads were such that they could be reconnected for consequent winding, what would be the resulting speed?
a.) 3500 rpm b.) 875 rpm c.)1780 rpm d.) 3450 rpm

18. An induction motor has rotor resistance and standstill reactance of 0.1 ohm and 3.5 ohm per phase respectively. The rotor emf at standstill is 60 volts per phase, for a slip of 5%, what is the power developed? a.) 1.7 hp b.) 75 hp c.) 10 hp d.) 15 hp

19. A 20 HP, 3 phase 400 Volt, 60 Hz, 4 pole induction motor delivers full-load at 5% slip. The mechanical rotational losses are 400 Watts. Calculate the electromagnetic torque.
a.) 58.5 N-m b.) 85.5 N-m c.) 53.3 N-m d.) 95.5 N-m

20. A 3 phase150 hp, 60 Hz, 460 Volts, 6 pole induction motor has a full load torque of 679 lb-ft. What is the full load slip? a.) 1.5% b.) 2.8 % c.) 3% d.) 4%

21. A 4-pole, 60 Hz, 30-phase induction motor has a blocked rotor reactance of 0.4 ohm per phase and the rotor resistance is 0.1 ohm per phase. At what speed will the motor develop maximum torque? a) 1200 rpm b) 1500 rpm c) 1350 rpm d) 1620 rpm

22. If the maximum torque of an induction motor is 200 kg-m at slip of 12% and the torque at 6% slip would be ______kg-m a) 100 b) 160 c) 50 d) 40
23. If a motor has a slip of 2% at rated voltage, determine the approximate value of the slip when developing the same torque at 10% above the rated voltage. a)1.8% b)1.75% c)1.55% d)1.65%
24. A 440V 3-phase, 50 hp, 1750 rpm squirrel cage induction motor is connected to 440 V bus through a feeder which the voltage drop of 10% of bus voltage when the motor is drawing rated current. The maximum continuous power the motor can safety deliver to its load is nearly equal to a) 40 hp b) 45 hp c) 42 hp d) 48 hp
25. A squirrel cage motor is started at 50% its rated voltage. What is the starting torque relative to its rated voltage starting torque. a) 50% b) 100% c) 25% d) 75%
26. A three phase 230 volts, 77% power factor, 75 hp induction motor draws a starting current 5 times of full load current. What is the starting current? a)1125 amperes b)360 amperes c) 250 amperes d) 912 amperes
27. A 10 hp, 550 Volts, 60 Hz, 87% efficiency and 75% power factor 3-phase induction motor has starting current of 5 times the full load current. If the motor is used in a 440 V at 60 Hz system. What is the starting current? a) 60 Amp. b) 41.5Amp. c) 48 Amp. d) 52.4 Amp
28. Magnetic contractor required for wye-delta starting motors a) 2 b) 1 c) 3 d) 4
29. For wound rotor motor, where is the reduced voltage starting device applied a) rotor b) Panel board c) Stator d) field
30. In a magnetic contractor, NO and NC auxiliary contracts are used for
a) electrical interlocking b) mechanical interlocking c) over voltage protection d) over current protection
31. A 25 hp, 230 Volts, 3-phase motor with 85% power factor has a starting current of 5.5 times rated current. To reduce the starting current, a wye-delta starter is stalled. What is the new starting current? a) 195 Amp b) 302 Amp c) 135 Amp d) 155 Amp
32. A 7.5 Hp, 440 Volt, 3-phase, 10 Amp, 1730 rpm induction has starting current of 6 times the full-load current when started at full voltage. The motor is equipped with an auto-transformer or starting compensator. If the auto-transformer is set 65% tap, the starting line current is nearest to a) 25.4 Amp b) 60 Amp c) 21.6 Amp d) 36 Amp
33. Find the percentage tap in an auto-transformer starter to start a squirrel cage motor against ½ of full load torque. The short circuit current on normal voltage is 6 times the full load and the full load slipis 3%. a) 72% b) 81.53% c) 85.13% d)65%
34.A 6 pole, 60 Hz, 3-phase induction motor operates with slip 2% to requires 11 Amp and 3500 Watts when driving its rated load. At no-load this requires 4.3 Amp and 290 Watts, when the rotor is block 440 Watts and 52 Volts are required to calculate a current of 14 Amp. Calculate the efficiency of this motor at rated load. a)83.15% b)81.53% c)85.13% d)88.53%
35. A 3-phase motor, 10 hp, 240 volt, 0.85 power factor has a load of 6 hp. One winding is suddenly cut, a) the motor will run but reduce speed b) the motor will stop c) the motor will run d) the motor will run but overheat
36. A 4-pole induction motor and 6 pole induction motor are connected in cumulative cascade. The frequency in the circuit of the 6-pole is observed to be 1.0 Hz. Determine the actual speed of the concatenated set, when the supply frequency is taken at 60 Hz. a) 600 rpm b) 718 rpm c) 588 rpm d) 708 rpm
37. Which of the following motor has no inherent starting torque?
a) split phase motor b) synchronous motor c) dc series motor d) induction motor

38. Which of the following method is used to start a synchronous motor
a) resistance starter in the armature circuit
b) damper winding
c) damper winding in conjuction will star-delta starter
d) star-delta starter

39. At what speed will a synchronous motor operate, if it has 10 poles and is connected to 60 Hz source a) 720 rpm b) 120 rpm c) 1800 rpm d) 600 rpm

40. A 4 pole synchronous motor has a speed of 1645 rpm at certain instant, what is gthe frequency? a) 58.2 Hz b) 59.5 Hz c) 55 Hz d) 54.8 Hz

41. A 10 Hp, 250 V, 3-phase star connected synchronous motor has an effective armature resistance of 0.25 ohm and synchronous impedance of 4 ohms per phase. To what voltage must motor be excited to give full load output at unity power factor? Assume armature efficiency of 88%. a) 292 V b) 277 V c) 253 V d) 250 V

42. A 416 Volts, 3-phase star-connected synchronous motor has negligible resistance and synchronous reactance of 10 ohms. Assuming rotational loss of 500 watts. What is the maximum horsepower that the motor can deliver if the excitation is held constant at 460 Volts?a) 17 b) 29.3 c) 19 d) 25

43. A single phase 10 Hp, 220-v motor rated 75%pf, 97.56% efficient has a load of 8 hp at 210V. Find the line current? a) 36.67 A b) 35 A c) 46.3 A d) 38.84 A

44. Which is statement about split phase motor is FALSE?
a) it has two windings called main and starting winding
b) the two stator windings are connected in series across the supply
c) the main winding has low resistance but high reactance
d) the starting winding has a high resistance but low reactance

45. If starting winding of a single phase induction motor is left in the circuit, it will
a) run faster b) draw excessive current & overheat c) run slower d) spark at light load

46. If a single phase motor runs hot the probable cause cannot be a) blown fuses b) low voltage c) high voltage d) shorted stator coils

47. If a single phase induction motor runs slower than normal, the most likely defect is a) worn bearing b) short circuit in the winding c) open-circuit in the winding d) none of the above

48. Select the motor that will give relatively high starting torque… a) shaded pole motor b) short c) capacitor run motor d) capacitor start motor

49. A split phase induction motor is defective, but if the motor is energized and the rotor is rotated by the hand, the motor runs. What is wrong with the motor? a) one winding is open b) loose connection c) capacitor is defective d) winding is burn out.

50. What is the part of a synchronous motor that allows it to develop starting torque?
a) Cranking system b) pulley c) Ammortisseur winding d) Pilot starter

AC MACHNES (TRANSFORMER) REVIEW LECTURRE

Transformers

Is an electrical machine that transfers electrical energy from one circuit to another without changing the frequency, it works on the principle of electromagnetic induction, also its windings are linked by a common magnetic circuit.

Classification of transformers

1. According to the core construction:
   a. Core type – L-core ; High Voltage, high power
   b. Shell type – E-type
   c. Berry type – Circular type
2. According to the purpose for which used:
   a. Transmission transformer
   b. Distribution transformer
   c. Generator transformer
   d. Testing transformer
   e. Instrument transformer
      1. current (CT)
      2. potential (PT)
3. According to the method of cooling:
   a. Self-cooled (AA)
   b. Forced air cooled (FA)
   c. Oil-self-cooled (OA)
   d. Forced-oil cooled with air or water (OA/FA)

Ideal Transformer

A transformer is considered ideal if there is no voltage drop across its windings, if resistance and leakage flux are neglected, in which losses are neglected, power input is the same as power output.

Transformer Generated Voltage Equation

$E_P = 4.44\ f\ \varphi_m\ N_P$ in rms Volts

$E_S = 4.44\ f\ \varphi_m\ N_P$ in rms Volts

Where:

f = frequency in Hz

φ_m = mutual flux in Wb

N = number turn for every windings

= a constant equal to 4(1.11) where 1.11 is the form factor of sinusoidal wave

Note: K_f = RMS value / AVE value = $(1 / \sqrt{2})$ max. value / $(2 / \pi)$ max. value = 1.11

Transformer Losses and Efficiency

η = (Output / Input) x 100% = [Output / (Output+ Losses)] x 100% = [(Input – Losses) / Input] x 100%

Transformer Losses

1. Core Losses-are fixed losses result of hysteresis and eddy current losses in the magnetic circuit (core) of the transformer

Hysteresis Loss, $P_h = K_h\ f\ \beta m^{1.6} = K_h\ V^{1.6} / f^{0.6}$ $\beta m = K\ (^E/_f)$

$P_h \propto f$; $P_h = K_h\ f$ $\Rightarrow$ if φ_m & β_m is constant

Eddy Current Loss, $P_e = K_e f^2 \beta_m^2 = K_e V^2$;

$P_e \propto f^2$; $P_e = K_e\ f^2$ $\Rightarrow$ if φ_m & β_m is constant

Note: P_h & P_e can be determine by open circuit test.

2. Copper losses – vary with the load and result of heating of transformer windings.

$P_{cu} = I_P^2 r_P + I_S^2 r_S$ $\Rightarrow$ based from extract equivalent circuit

$P_{cu} = I_p^2 R_{ep} = I_s^2 R_{es}$ $\Rightarrow$ based from approximate equivalent circuit

Note : P_{cu} can be determined by short circuit test.

Test on Transformers:

a. Open circuit test
b. Short circuit test

Conditions of Maximum Efficiency:

$\eta = [P_{OUT} / (P_{OUT} + P_{LOSSES})] \times 100\% = [(VI\cos\theta) / (VI\cos\theta + i^2R_e + P_K)] \times 100\%$

to have max efficiency: take $d\eta/dI = [(VI\cos\theta + I^2R_e + P_K)(V\cos\theta) - VI\cos\theta(V\cos\theta + 2IRe)] / (VI\cos\theta + I^2R_e + P_K)^2$

dividing by $V\cos\theta$ & simplify;

$$I^2R_e = P_K$$

Variable loss = Constant loss

All-Day Efficiency:

It is the ratio of the energy delivered with in 24 hr period to the energy input in the same period of time. For distribution transformers whose primary energized for 24 hr a day, thus the core loss of this transformer must be designed to be low as possible. It is always less than the commercial efficiency.

$\eta_{all\text{-}day} = [(ENERGY_{OUTPUT}/day) / (ENERGY_{OUTPUT}/day + ENERGY_{LOSS}/DAY) \times 100\%$

at max all day efficiency:

Energy Copper Loss = Energy Core Loss

Transformer Polarity

Conditions: 1. When the voltmeter reading is greater than the input test voltage the polarity is Additive, $V = V_P^1 + (V_P^1/a)$

2. When the voltmeter reading is less than input test voltage the polarity is Subtractive, $V = V_P^1 + (V_P^1/a)$

Note: By the standards all 1φ, 200 kVA, 8660 Volts or less are ADDITIVE.

Auto Transformer;

The auto transformer is one having a single continuous winding, part of which is common to both primary and secondary circuits. It can be used for either step-up or step-down application with a relatively small change in voltage between the input and output voltages, and should not used when there is a large change in voltage because the circuits are connected electrically.

Parallel Operation of Transformers:

Important conditions that must be fulfillment if two or more transformers are to be operated successfully in parallel to deliver a common load

1. Voltage ratings of both primaries and secondaries must be identical, or the transformation are the same. (otherwise, current will circulate through the transformer windings which will contribute to the losses of the transformer).
2. The transformer must be properly connected with regards to polarity. (otherwise, a large current will circulate through the transformer winding which could damage the windings).
    a. The equivalent impedances should be inversely proportional to the respective kVA ratings. (otherwise, the transformer will not share the load in proportional to their ratings).
    Z_e a $1/S$; $Z_{e1} / Z_{e2} = S_2 / S_1$

b. The ratio of the equivalent resistance to the equivalent reactance of the all transformer should be the same. (otherwise, each transformer will not takes its correct fraction of the load)

$$Re_1/Xe_1 = Re_2/Xe_2$$

Also the condition for the two transformers connected in parallel to operate at the same p.f.

$$Is_1 = [(a_2 – a_1)Vs_1 + a_2Zes_2I_{Load}] / (a_1Zes_1 + a_2Zes_2)$$

$$Is_2 = [(a_1Zes_1I_{Load} – (a_2 – a_1) / (a_1Zes_1 + a_2Zes_2)$$

For the circulating current (set $I_{Load} = 0$)

$Ic_1 = (a_2 – a_1)Vs_1 / (a_1Zes_1 + a_2Zes_2)$ or $Ic_2 = -(a_2 – a_1)Vs_1 / a_1Zes_1 + a_2Zes_2$

Most Common 3φ Transformer Connections:

1. Y – Y with connected neutrals

has the advantage the windings are subjected to the line voltage divide by √3. this connection without neutrals are rarely used since high unequal voltage may result from an unbalance load.

2. Δ - Δ connection

suitable for moderate voltage, large current operation.

3. Δ - Y connection

Primarily used to step-up the voltage. it is also used in step – down applications where a conventional distribution voltage is reduced to supply two voltages for lighting and power loads.

4. Y - Δ connection

use for stepping down voltages

5. T (scott) connection

used to convert 3φ to 2φ or vice – versa.

6. V – V (open delta) connection

a) used when the load is still small so that to use of Δ - Δ bank is unwarranted.
b) Used if one transformer of the Δ - Δ bank fails.

7. Autotransformer – also called as a “compensator” used for reduced voltage starting, also used for stepping down or up the voltages.

Instrument Transformers:

Instrument transformers are of two kinds:

1. Current transformer (CT)
2. Potential transformer (PT)

These are used to supply power to ammeters, voltmeters, wattmeters, relays and so on, which is called the “Burden of Instrument Transformer”.

AC MACHINES (TRANSFORMER) REVIEW PROBLEMS

1. Material used for construction of transformer core is usually a) wood b) copper c) aluminum d) silicon steel