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Tutorial 1: Circuit Parameters and Ohms law

1. A copper wire of diameter 1 cm had a resistance of 0.15 Ω. It was drawn under pressure so that its diameter was reduced to 50%. What is the new resistance of the wire ? [Ans: 2.4 Ohms]
2. A lead wire and an iron wire are connected in parallel. Their respective specific resistances are in the ratio 49 : 24. The former carries 80% more current than the latter and the latter 47% longer than the former. Determine the ratio of their cross-sectional areas. [Ans: $a_2/a_1=0.4$]
3. An aluminium wire 7.5 m long is connected in parallel with a copper wire 6 m long. When a current of 5 A is passed through the combination, it is found that the current in the aluminium wire is 3 A. The diameter of the aluminium wire is 1 mm. Determine the diameter of the copper wire. Resistivity of copper is 0.017 μΩm ; that of the aluminium is 0.028 μΩ m. [Ans:d_c = 0.569 mm]
4. Three resistors are connected in series across a 12 V battery. The first resistance has a value of 1 Ω, second has a voltage drop of 4 V and third has a power dissipation of 12 W. Calculate the value of the circuit current. [Ans: 6A]
5. Find equivalent resistance R_{12} in figure 1.1. [Ans: 11.2 Ohms]

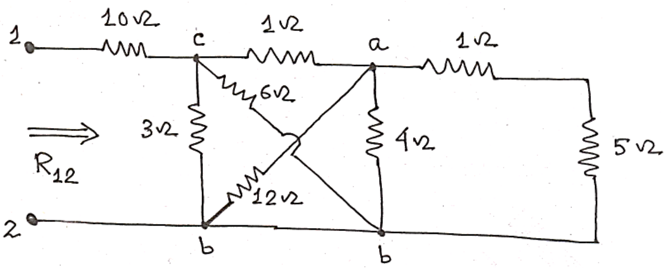

Fig. 1.1

6. A resistance of 10 ohms is connected in series with a combination of two resistances arranged in parallel each of value 20 ohms. Determine the resistance R3 which should be shunted across the parallel combination so that current drawn by the circuit is 1.5 A with applied voltage of 20 V. [Ans: 5 Ohms]
7. A battery of unknown e.m.f. is connected across resistances as shown in Fig. 1.3. The voltage drop across the 8 Ω resistor is 20 V. What will be the current reading in the ammeter? What is the e.m.f. of the battery? [Ans: 0.7 A, 67.3 V]
8. Find the voltage VAB in the circuit shown in Fig. 1.3 [Ans: 0.953 V]

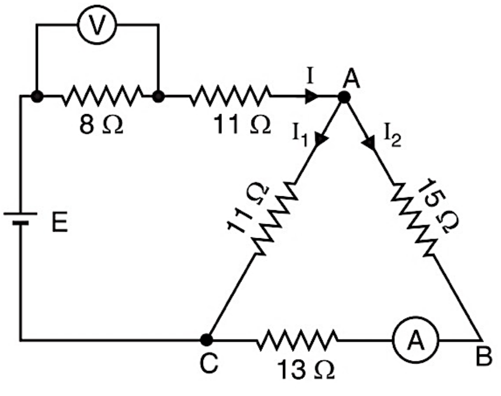

Fig. 1.2

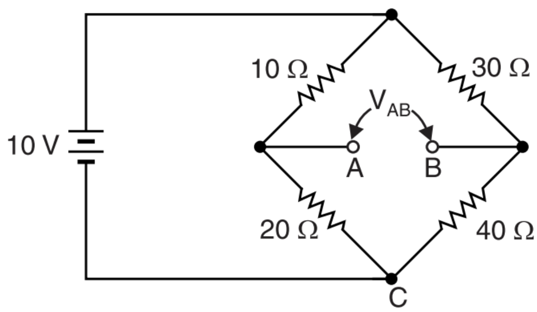

Fig. 1.3

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Tutorial 2: Mesh Analysis

1. By using mesh analysis, calculate the current in each mesh of the circuit shown in Fig. 2.1.
[Ans: 1.65 A, 2.12 A, 1.5 A]
2. Determine the current supplied by each battery in the circuit shown in Fig. 2.2.
[Ans: 2.56 A, 0.74 A, 4.97 A, 1.82 A, 3.15 A]

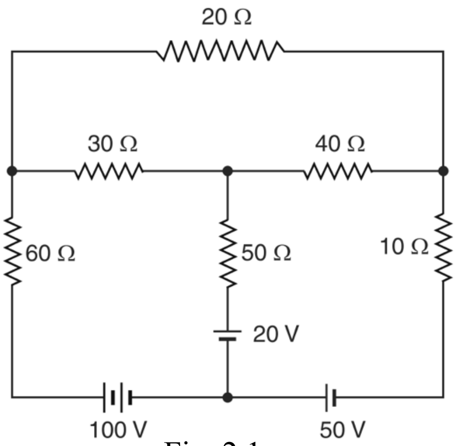

Fig. 2.1

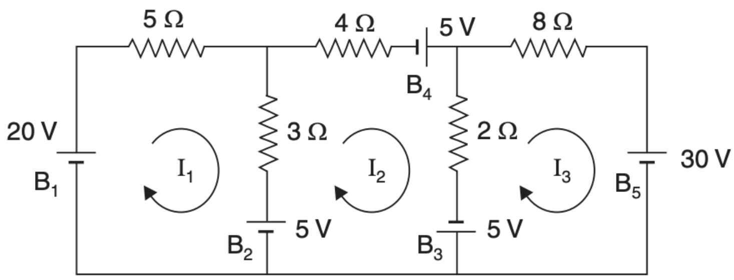

Fig. 2.2

3. Determine the mesh currents of the bridge circuit shown in Fig. 2.3.
[Ans: $I_1 = 6.10$ A, $I_2 = 2.56$ A, $I_3 = 2.72$ A]
4. Using mesh current method, find the currents in resistances R3, R4 and R5 in Fig. 2.4.
[Ans: 0.75 A (A to B); 0A ; 0.375A (D to B)]

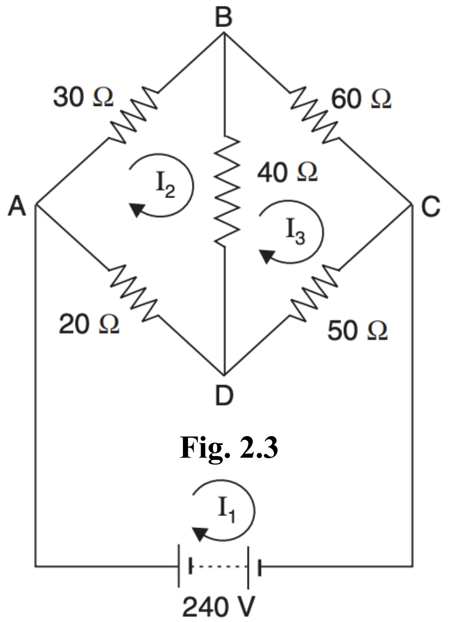

Fig. 2.3

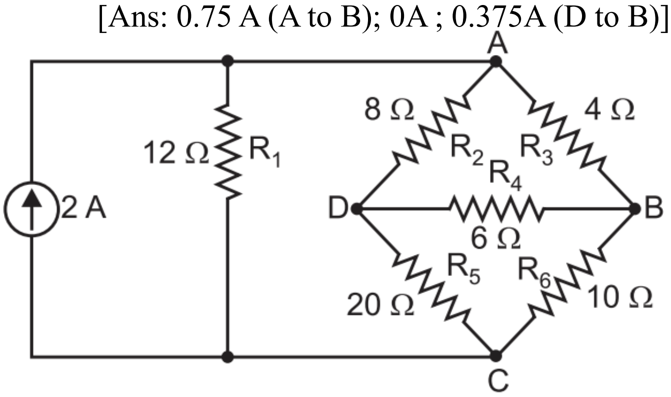

Fig. 2.4

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5. Find Mesh Currents of the circuit shown in Fig. 2.5. [Ans: -0.95A, -8.09A, 1.9 A]
6. Determine the current through each resistor using Mesh Analysis for the network shown in figure 2.6. [Ans: 1.73A, 1.68 A, 0.05A, 2.95A]

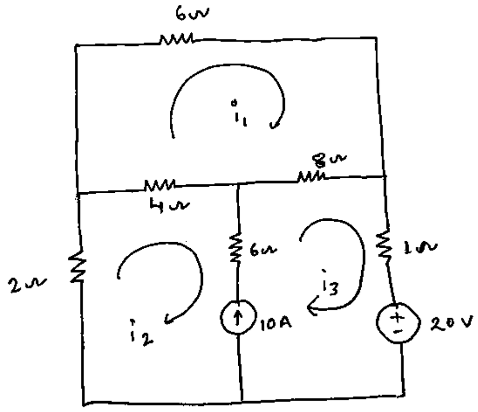

Fig. 2.5

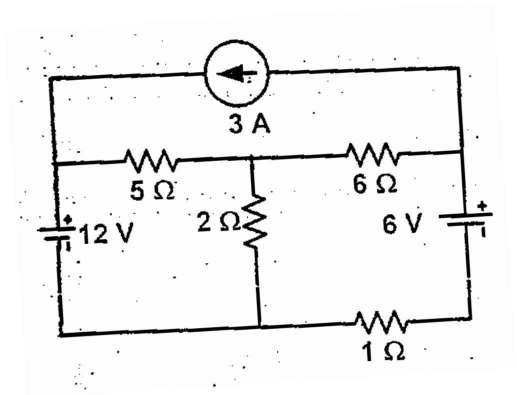

Fig. 2.6

7. Determine the mesh current of the circuit shown in Fig. 2.7 using Mesh Analysis. [Ans: 3.574A, 0.473A, 1.1052A]
8. For the circuit shown in Fig. 2.8, find V_{CE} and V_{AG} [Ans: -5V, 30V]

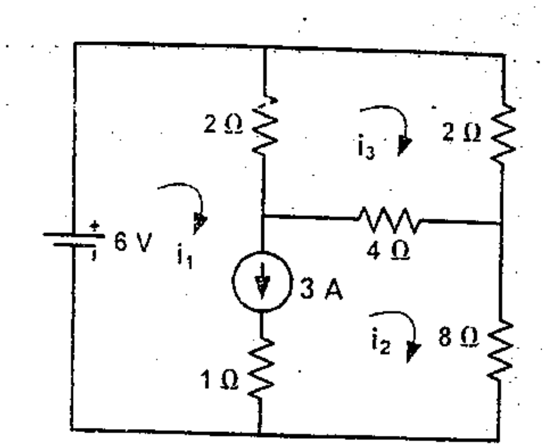

Fig. 2.7

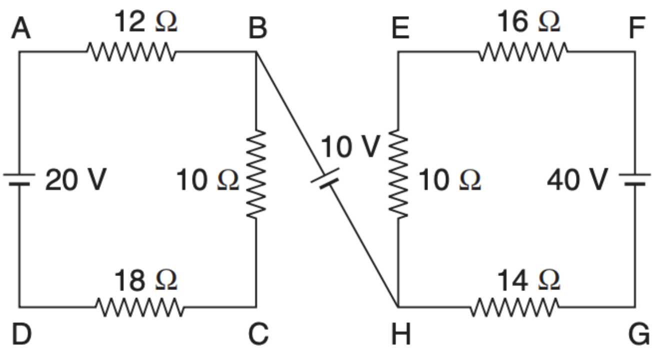

Fig. 2.8

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Tutorial 3: Nodal Analysis

1. Use nodal analysis to find the nodal voltage and currents in 1 Ohm and 2 Ohm resistors of the circuit shown in Fig. 3.1
   Ans: [$V_1 = \frac{6572}{545}V$; $V_2 = \frac{556}{109}V$; $V_3 = \frac{2072}{545}V$ and $I_{1\Omega} = 1.3A$, $I_{2\Omega} = 6.03\ A$]

2. Use nodal analysis to find the current and voltage drop through 5 Ohm Resistor of the circuit shown in Fig. 3.2. [Ans: 1A, 5V]

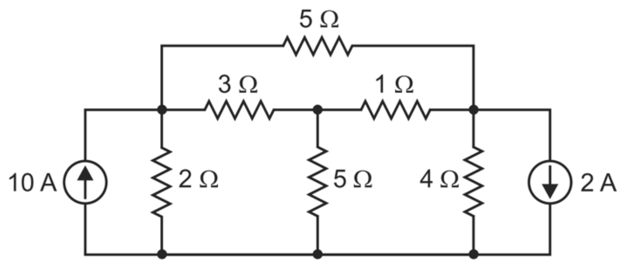


Fig. 3.1

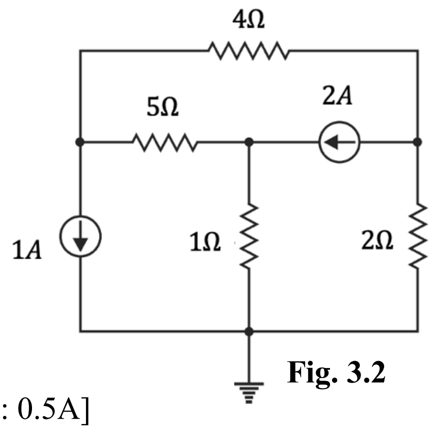
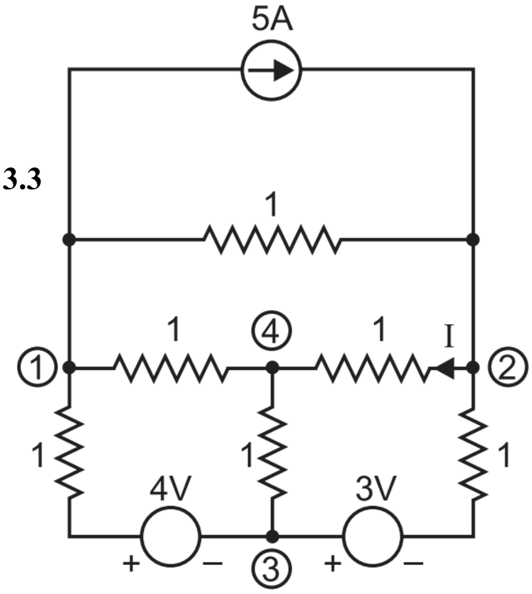


Fig. 3.2

3. Find the current I in Fig. 3.3 using nodal method. [Ans: 0.5A]
4. Using Nodal Method, find the current through each resistor of the network of Fig. 3.4.
   [Ans: 3.6A, 0.375A, 2.76 A, 3.63A]

Fig. 3.3



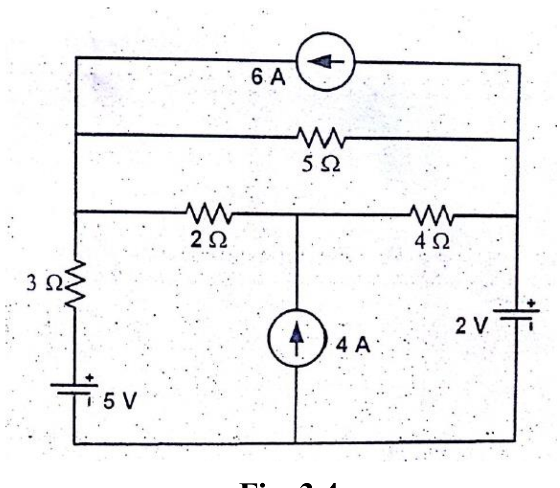


Fig. 3.4

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5. Find Nodal Voltage using Nodal Analysis of circuit shown if figure 3.5. [Ans: $V_1 = -7.33\ and\ V_2 = -5.33$]

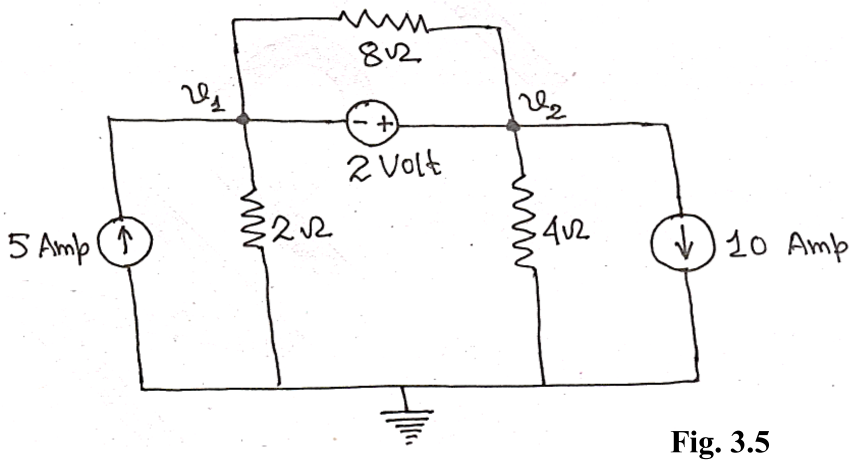

Fig. 3.5

6. Using Nodal Analysis method, find v_1,v_2,v_3 and i of the circuit shown in figure 3.6.
[Ans: -27.27V, -72.73V, -45.45V and 0.909 A]

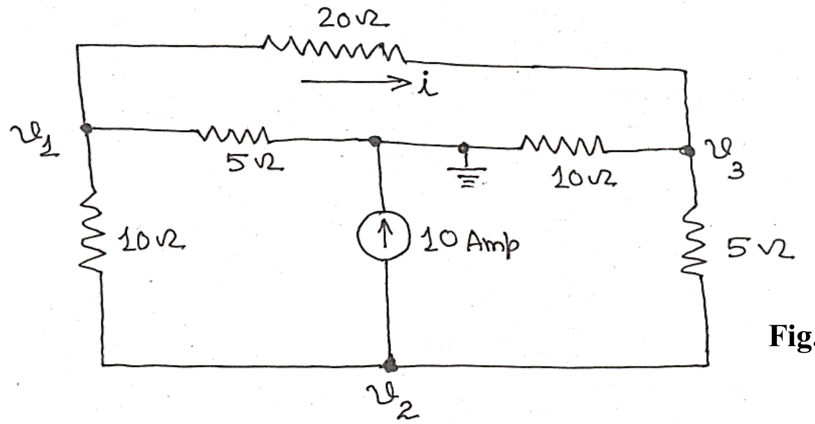

Fig. 3.6

7. Find nodal voltage of the circuit shown in figure 3.7. [Ans: 3.75V and -2.625V]

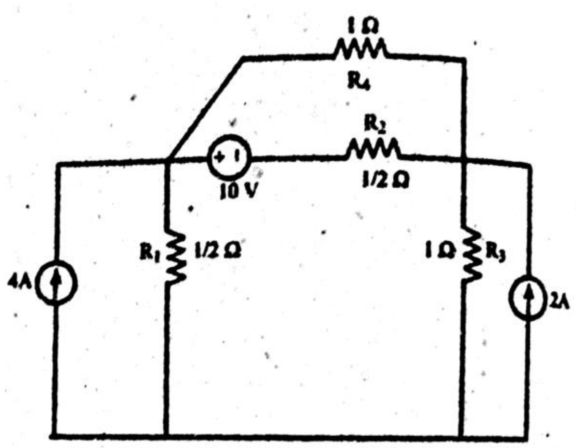

Fig. 3.7

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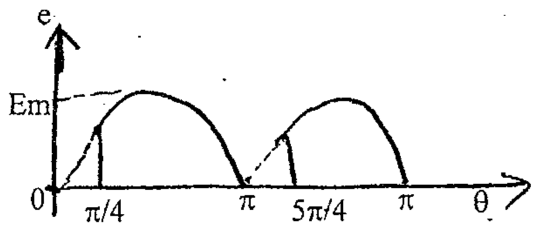
Tutorial 4: Fundamental of AC Quantity

1. An alternating current varying sinusoidally with a frequency of 50 Hz has an r.m.s. value of 40 A. Find : (i) The instantaneous value 0.0025 seconds after passing through maximum positive value, and (ii) The time measured from a maximum value when the instantaneous current is 14.14 A. [Ans: 40A, 0.00419 s]
2. Find Form Factor and Peak Factor of waveform shown in figure below.



3. A half wave single anode rectifier has a voltage given by 100 sin ωt applied to it. Estimate the average value on the d.c. side. [Ans: 22.9 V]

4. Prove that if a D.C. current of I Amps. is superposed in a conductor by an A.C. current of max. value I Amps, the r.m.s. value of the resultant is $\sqrt{\frac{3}{2}}\, I$
5. Find the effective value of a resultant current in a wire which carries simultaneously a direct current of 10 A and alternating current given by, $= 12\sin wt + 6\sin\left(3wt - \frac{\pi}{6}\right) + 4\sin\left(5wt + \frac{\pi}{3}\right)$. [Ans: 14.0712 A]

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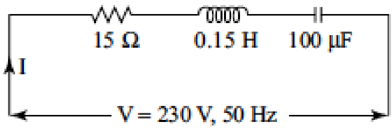
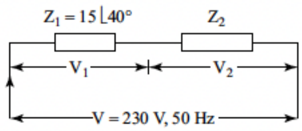
Tutorial 5: AC Circuit Analysis

1. A 230 V, 50 Hz sinusoidal supply is connected across a i) resistance of 25 Ω; (ii) inductance of 0.5 H; (iii) capacitance of 100 μF. Write the expressions for instantaneous current in each case.
2. An alternating voltage of RMS value 100 V, 50 Hz is applied separately across a resistance of 10 Ω, an inductor of 100 mH, and a capacitor of 100 μF. Calculate the current flow in each case. Also draw and explain the phasor diagrams. [Ans: 10A, 3.18A, 3.1A]
3. A coil having a resistance of 5 Ω and inductance of 30 mH in series are connected across a 230 V, 50 Hz supply. Calculate current, power factor, and power consumed. [Ans: 21.57A, 0.47(lag), 2331.7W]
4. For the R–L–C series circuit shown in Fig., calculate current, power factor, and power consumed.

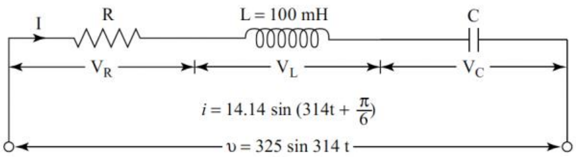


[Ans: $10.75\angle -45.3°$A, 0.703 lagging and 1738.16 W]

5. Two coils having impedance Z1 and Z2 are connected in series across a 230 V, 50 Hz power supply as shown in Fig. The voltage drop across Z1 is equal to $120\angle 30^0$ V. Calculate the value of Z2 and C_2. [Ans: *16.82 − j4.6 and 687.8μF]*



6. A voltage v = 100 sin 314t – 50 cos 314t, is applied to a circuit having R = 20 Ωin series with C = 100 μF. Obtain expression for instantaneous current, r.m.s. value of current and the power in the circuit. [Ans: 2.1 A, 88.32 W]
7. A two-element series circuit is connected across an A.C. source $e = 200\sqrt{2}\sin(\omega t + 20°)$ V. The current in the circuit then is found to be $i = 10\sqrt{2}\cos(314\,t - 25°)$ A. Determine parameters of the circuit. [Ans: 14.14 Ω, 225.1 μF]
8. An alternating voltage, V = (160 + j170)V is connected across an L–R series circuit. A current of I = (12 – j5) A flows through the circuit. Calculate impedance, power factor, and power consumed. Draw the phasor diagram. [Ans: 4.24 + j 11.28, 0.35 (lag), 1565.76 W, 35mH]
9. The expression of applied voltage and current flowing through an ac series L–R circuit are: v= 200 sin (314 t +60) and i = 20 sin (314 t +30). Calculate for the circuit (i) power factor; (ii) average power; (iii) impedance; (iv) R and L [Ans: 0.866(lag), 1732 W, $10\angle 30°$, 8.66 W, 15.92 mH]
10. In the circuit shown in Fig. below, calculate the value of R and C. [Ans: 19.9 Ω, 72.23 μF]



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Tutorial 6: Three Phase Analysis

1. Three inductive coils each having resistance of 16 ohm and reactance of 12 ohm are connected in star across a 400 V, three-phase 50 Hz supply. Calculate: i) Line voltage, ii) Phase voltage, iii) Line current, iv) Phase current, v) Power factor, vi) Power absorbed. Draw phasor diagram
2. Three identical coils, each having resistance of 10 Ω and inductance of 0.03 H are connected in delta across a three-phase, 400 V, 50 Hz supply. Calculate: 1) The phase current, ii) The line current, iii) The total power consumed, iv) p.f. and pf. angle. Draw a neat phasor diagram.
3. Three equal impedances each of $10\angle 60°$ ohms are connected in star across 3-phase, 400 volts 50 Hz supply. Calculate
   i. Line voltage and phase voltage
   ii. Line current and phase current
   iii. Power factor and active power consumed
   iv. If the same three impedances are connected in delta to the same source of supply what is the active power consumed?
4. The three-phase balanced load has Zy=(8+j6) ohm. If the load is connected to 208-volt lines, predict the readings of W_1 and W_2. Also find P_T and Q_T
5. The three-phase balanced load has Z_Δ =(30-j40) ohm. If the load is connected to V_L=440 volt, Determine W_1, W_2, P_T and Q_T
6. The two-wattmeter method produces wattmeter readings W_1 = 1560 W and W_2 = 2100 W when connected to a delta-connected load. If the line voltage is 220 V, calculate: (a) the per-phase average power, (b) the per phase reactive power, (c) the power factor, and (d) the phase impedance.

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Tutorial 7: Transformer

1. A sinusoidal flux 0.02 Wb links with 55 turns of a transformer secondary coil. Calculate the r.m.s. value of the induced emf in the secondary. The supply frequency is 50 Hz.
2. For a single phase 50Hz transformer having primary ,and secondary turn of 80 and 400 respectively, determine the emf induced in the secondary windings and maximum value of flux density if cross sectional area is 200 cm^2 and primary winding is connected to 240V.
   [Ans: 1200 and 0.6756]
3. For a single phase transformer having primary ,and secondary turn of 440 and 880 respectively, determine the transformer kVA rating if half load secondary is 7.5 A and maximum value of core flux is 2.25 mWb.
4. The emf per turn of a single-phase, 6.6 kV, 440 V, 50 Hz transformer is approximately 12 V. Calculate number of turns is the HV and LV windings and the net cross-sectional area of the core for a maximum flux density of 1.5 T.
5. The no load current of a transformer 10A at power factor of 0.25 lagging, when connected to 400 V, 50 Hz supply. Calculate,
   a. Magnetizing component of no load current
   b. Iron loss and
   c. Maximum Value of flux in the core. Assume primary winding turns as 500.
6. A single phase transformer takes 10A on no-load at 0.2 p.f. lagging. The turn ratio is 4:1(step down). If the load on the secondary is 200A at a pf of 0.85 lagging, find the primary current and power factor. Neglect the voltage drop in the winding. Also draw the phasor diagram.
7. A 400/200V transformer takes 1A at a power factor of 0.4 on no-load. If the load current of 50A at 0.8 lagging power factor, calculate the primary current.
   (Ans: I_1=25.874A and pf_1=0.788(lag))
8. The primary and secondary windings of a 500kVA transformer have a resistance of 0.4 Ohm and 0.001 ohm respectively. The primary and secondary voltages are 6600V and 400V respectively. The iron loss is 3kW. Calculate the efficiency of the transformer on full load, the load power factor being 0.8 lagging.
9. In a 25kVA, 2000/200V, single phase transformer, the iron loss and copper losses are 350 and 400W respectively. Calculate the efficiency at unity power factor on a) Full load and b) Half Load
10. A 250 kVA single phase transformer has iron losses of 1.8kW. The full load copper losses is 2000 watts. Calculate,
    i. Efficiency at full load, 0.8 lagging pf
    ii. kVA supplied at maximum Efficiency
    iii. Maximum Efficiency at 0.8 lagging p.f.
11. A 200 kVA single-phase transformer is in circuit throughout 24 hours. For 8 hours in a day, the load is 150 kW at 0.8 power factor lagging and for 7 hours, the load is 90 kW at 0.9 power factor. Remaining time or the rest period, it is at no-load condition. Full-load Cu loss is 4 kW and the iron loss is 1.8 kW. Calculate the all-day efficiency of the transformer.

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Tutorial 8: Three Phase Induction Motor

1. A 4-pole, 3-phase induction motor operates from a supply whose frequency is 50 Hz. Calculate: (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 currents when the slip is 0.03. (iv) the frequency of the rotor currents at standstill.
[Ans: 1500 rpm, 1440 rpm, 90 rpm, 50Hz]
2. A 3-6 induction motor having a star-connected rotor has an induced e.m.f. of 80 volts between slip-rings at standstill on open-circuit. The rotor has a resistance and reactance per phase of 1 Ω and 4 Ω respectively. Calculate current/phase and power factor when (a) slip-rings are short-circuited (b) slip-rings are connected to a star-connected rheostat of 3 Ω per phase. [Ans: 11.2A, 0.243, 8.16A, 0.707]
3. A 1100-V, 50-Hz delta-connected induction motor has a star-connected slip-ring rotor with a phase transformation ratio of 1/3.8. The rotor resistance and standstill leakage reactance are 0.012 ohm and 0.25 ohm per phase respectively. Neglecting stator impedance and magnetising current determine. (i) the rotor current at start with slip-rings shorted (ii) the rotor power factor at start with slip-rings shorted (iii) the rotor current at 4% slip with slip-rings shorted (iv) the rotor power factor at 4% slip with slip-rings shorted (v) the external rotor resistance per phase required to obtain a starting current of 100 A in the stator supply lines. [Ans: 1157A, 0.048(lag), 742.3A, 0.77, 0.707 Ohms]
4. A 3-phase, slip-ring, induction motor with star-connected rotor has an induced e.m.f. of 120 volts between slip-rings at standstill with normal voltage applied to the stator. The rotor winding has a resistance per phase of 0.3 ohm and standstill leakage reactance per phase of 1.5 ohm. Calculate (i) rotor current/phase when running short-circuited with 4 percent slip and (ii) the slip and rotor current per phase when the rotor is developing maximum torque.
[Ans: 9A, 33A]
5. A 3-phase, 460 V, 100 hp, 60 Hz, 4-pole induction machine delivers rated output power at a slip of 0.05. Determine the:
   i. Synchronous speed and motor speed,
   ii. Speed of the rotating air gap field,
   iii. Frequency of the rotor current,
   iv. Rotor induced voltage at the operating speed, if the stator-to-rotor turns ratio is 2 and
   v. Rated torque

   [Ans: 1800 rpm, 1710 rpm, 1800 rpm, 3Hz, 6.64V/phase, 416.6Nm]
6. A 50 Hz, 8 pole induction motor has full load slip of 4%. The resistance/phase is 0.01 Ohms and standstill reactance per phase is 0.1 ohm. Find the ratio of maximum to full load torque and the speed at which maximum torque occurs. [Ans: 2.48/1.45, 675 rpm]
7. A four pole, 30 HP three phase, 400V, 50 Hz induction motor operates at an efficiency of 0.8 with a pf of 0.75 lagging. Calculate the current drawn by the motor from mains.

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Tutorial 9: DC Motor and Synchronous Generator

1. A four-pole dc machine having wave-wound armature winding has 51 slots, each slot containing 20 conductors. Calculate the back emf generated in the armature when driven at 1500 rpm. Assume flux per pole to be 0.5 mWb. [Ans: 25.5V]
2. A six-pole, lap-connected dc machine has a total of 650 conductors. The flux per pole is 0·05 Wb. Calculate the speed at which the armature is to be driven to generate a Back EMF of 220 V. [Ans: 406 rpm]
3. Calculate the input power of a 12-pole separately excited having 1200 lap-connected conductors each carrying a current if 15 A. The armature is being driven at 300 rpm. The flux per pole is 60 mWb. Resistance if armature circuit is 0.1 Ω. [Ans: 68.04 kW]
4. The back emf of a shunt motor is 230V, the field resistance is 160 Ohms and the field current is 1.5A. If the line current is 37A, find the armature resistance. Also, find the armature current when the motor is stationary. [Ans: 0.2817A, 851.97A]

5. A four-pole, 500 V, wave-wound dc shunt motor has 900 conductors on its armature. Calculate the speed of the motor if its armature current is 80 A, the flux per pole is 21 mWb and armature resistance is 0.1 Ω and field resistance is 500 Ω and find field current. [Ans: 780 rpm, 1A]
6. Same as 5 but with total brush voltage drop of 2V.

7. A four-pole 220 V dc series motor has 240 slots in the armature and each slot has six conductors. The armature winding is wave connected. The flux per pole is 1.75×10^{-2} Wb when the motor takes 80 A. The field resistance is 0.05 Ω and the armature resistance is 0.1 Ω. The iron and friction losses 440 W. Calculate the speed of the motor. Also calculate the output power. [Ans: 248 rpm, 16.2kW]
8. A dc machine induces an EMF of 240 V at 1500 rpm. Find the developed torque for an armature current of 25 A. [Ans: 38.2 N-m]
9. A 4 pole 220V dc shunt motor, lap wound has 960 conductors. The flux per pole is 20mWb. Determine the torque developed by the armature in Nm when the current drawn by the motor is 28A. The armature resistance is 0.1 Ohms and the field resistance is 125 Ohm. [Ans: 679.3 rpm, 80.183 Nm]

10. The induced EMF in a synchronous machine is 11,000 V with a distributed fractional pitch winding. If a concentrated full-pitch winding were made, what would have been the induced EMFs. Assume the distribution factor and the pitch factor as 0.96 and 0.98, respectively. [Ans: 11962V]