UNIT 2

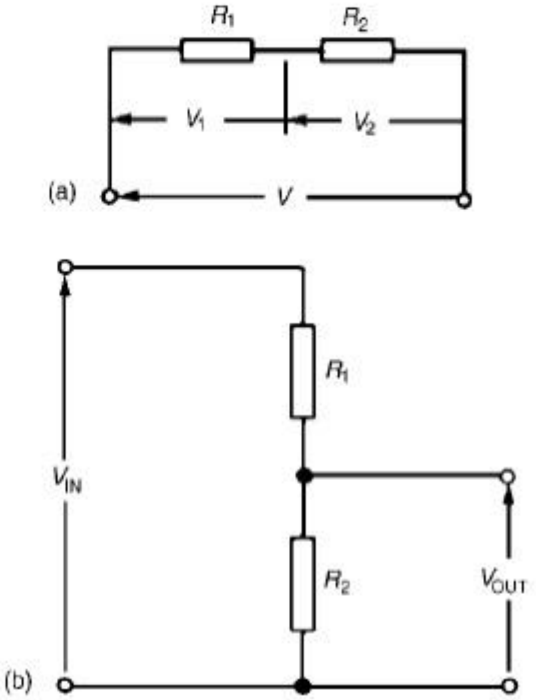
NETWORK REDUCTION AND NETWORK THEOREMS FOR DC ANDAC CIRCUITS

POTENTIAL DIVIDER:

The voltage distribution for the circuit shown in Figure

$$V_1 = \left(\frac{R_1}{R_1 + R_2}\right) \mathrm{V}$$

$$V_2 = \left(\frac{R_2}{R_1 + R_1}\right) \mathrm{V}$$

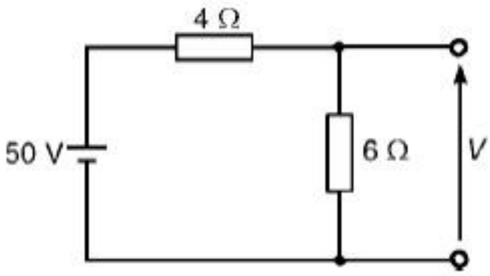


The circuit shown in Figure (b) is often referred to as a potential divider circuit. Such a circuit can consist of a number of similar elements in series connected across a voltage source, voltages being taken from connections between the elements. Frequently the divider consists of two resistors as shown in Figure (b), where

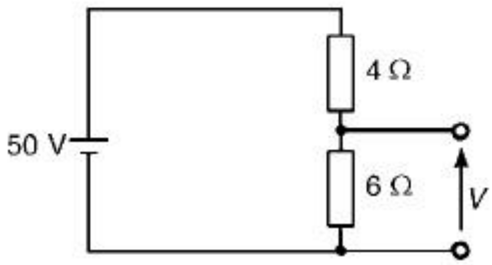
$$V_{OUT} = \left(\frac{R_2}{R_1 + R_2}\right) V_{IN}$$

A potential divider is the simplest way of producing a source of lower e.m.f. from a source of higher e.m.f., and is the basic operating mechanism of the potentiometer, a measuring device for accurately measuring potential differences

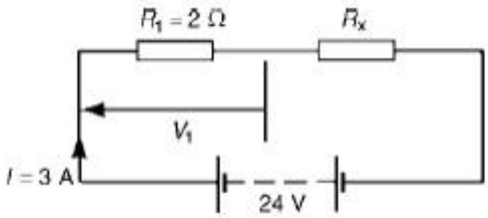
Problem 1: Determine the value of voltage V shown in Figure



$$V = \left(\frac{6}{6+4}\right)(50) = \mathbf{30\ V}$$



Problem 2: Two resistors are connected in series across a 24V supply and a current of 3A flows in the circuit. If one of the resistors has resis and (b) the p.d. across the 2 Ωresistor. If the circuit is connected for 50 hours, how much energy is used?



(a) Total circuit resistance R= V/ I

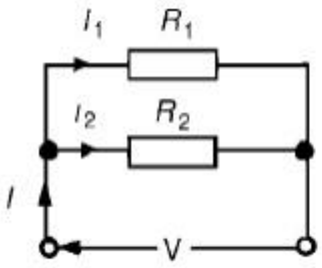
= 24/3=8 Ω Value of unknown resistance, Rx =8 −2=6 Ω

(b) P.d. across 2 Ωresistor, $V_1 = IR_1 = 3 \times 2 = 6V$ Alternatively, from above,

$V_1 = (R_1/R_1 + Rx))\ V = (2/2 + 6)\ (24) = 6V$ Energy used = power × time

= V × I × t
= (24 × 3W) (50 h)
= 3600Wh = 3.6kWh

Current division:
For the circuit shown in Figure, the total circuit resistance, RT is given by:
$R_T = R_1R_2/R_1 + R_2$



and $V = IR_T = I\left(\frac{R_1R_2}{R_1+R_2}\right)$

Current $I_1 = \frac{V}{R_1} = \frac{I}{R_1}\left(\frac{R_1R_2}{R_1+R_2}\right) = \left(\frac{R_2}{R_1+R_2}\right)(I)$

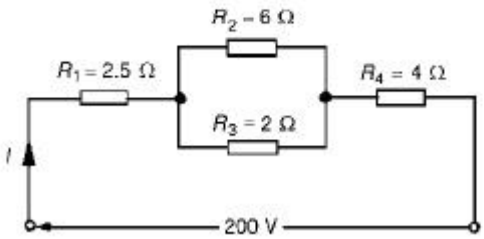
Similarly,

current $I_2 = \frac{V}{R_2} = \frac{I}{R_2}\left(\frac{R_1R_2}{R_1+R_2}\right) = \left(\frac{R_1}{R_1+R_2}\right)(I)$

Summarizing, with reference to Figure 5.20

$$\boxed{I_1 = \left(\frac{R_2}{R_1+R_2}\right)(I)} \text{ and } \boxed{I_2 = \left(\frac{R_1}{R_1+R_2}\right)(I)}$$

Problem 1: For the series-parallel arrangement shown in Figure, find (a) the supply current, (b) the current flowing through each resistor and (c) the p.d. across each resistor.



(a) The equivalent resistance Rx of R2 and R3 in parallel is: Rx = 6 × 2/6 + 2

= 12/8
= 1.5 Ω

The equivalent resistance R_T of R_1, Rx and R_4 in series is:

$R_T = 2.5 + 1.5 + 4 = 8\ \Omega$ Supply current $I = V/R_T$
= 200/8
= 25A

The current flowing through R_1 and R_4 is 25A The current flowing through R_2

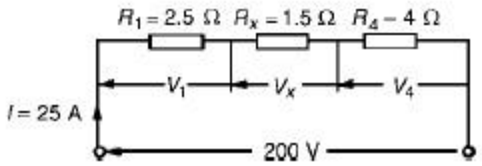
$$= \left(\frac{R_3}{R_2 + R_3}\right) I = \left(\frac{2}{6+2}\right) 25$$

= **6.25A**
The current flowing through R3

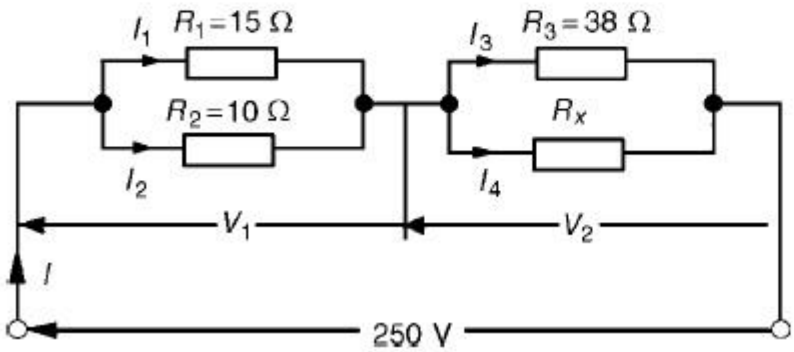
$$= \left(\frac{R_2}{R_2 + R_3}\right) I = \left(\frac{6}{6+2}\right) 25$$

= **18.75A**
(c) The equivalent circuit of Figure is

p.d. across R1, i.e. V1 =IR1 =(25)(2.5)=**62.5V** p.d. across Rx, i.e. Vx =IRx =(25)(1.5)=**37.5V** p.d. across R4, i.e. V4 =IR4 =(25)(4)=**100V**
Hence the p.d. across R2 =p.d. across R3 =**37.5V**



Problem 2: For the circuit shown in Figure 5.23 calculate (a) the value of resistor Rx such that the total power dissipated in the circuit is 2.5kW, and (b) the current flowing in each of the four resistors.



(a) Power dissipated P=VI watts, hence 2500=(250)(I) i.e. I = 2500/250

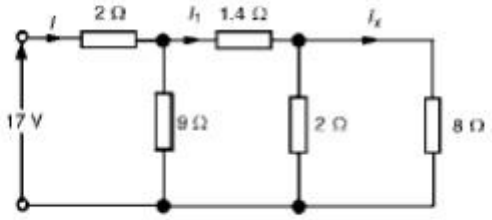
= 10A
From Ohm'sR_T=V/I=law,250/10

=25 Ω, where RT is the equivalent circuit resistance. The equivalent resistance of R_1 and R_2 in parallel is =15 × 10/15 + 10

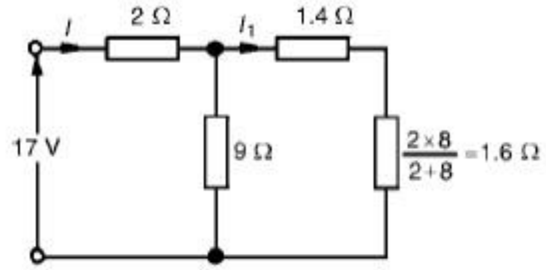
= 150/25
= 6 Ω

The equivalent resistance of resistors R3 and Rx in parallel is equal to 25 Ω−6 Ω, i.e. 19 Ω. There are three methods whereby Rx can be determined.

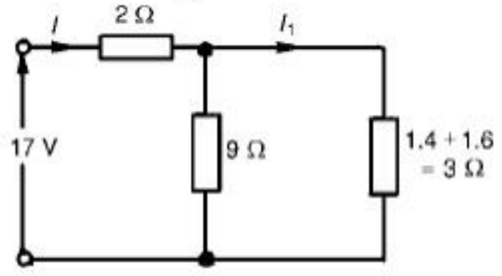
Problem 3: For the arrangement shown in Figure find the current Ix.



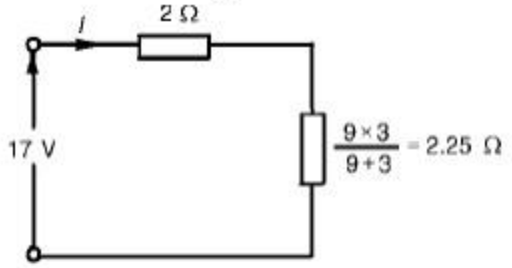
Commencing at the right-hand side of the arrangement shown in Figure, the circuit is gradually reduced in stages as shown in Figure



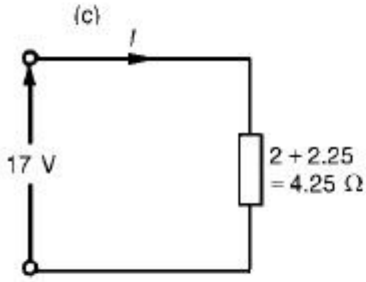
(a)



(b)



(c)



(d)

From Figure (d), I = 17/4.25 =4A

From Figure (b), I_1 =9/9 + 3(I) = 12/ (4) =3A From Figure, Ix =2/2 + 8(I1) = 2/10(3) =0.6A

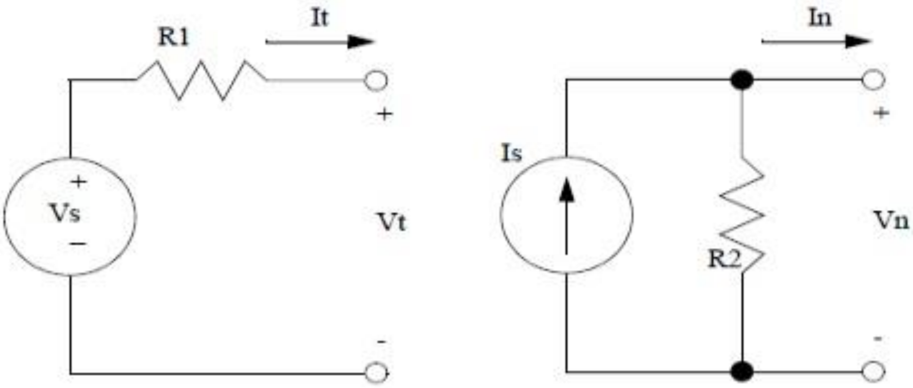
Source transformation:

Source transformation is defined as to concert the sources for easy analysis of circuit. In mesh analysis. it is easier if the circuit has voltage sources.

In nodal analysis. it is easier if the circuit has current sources.

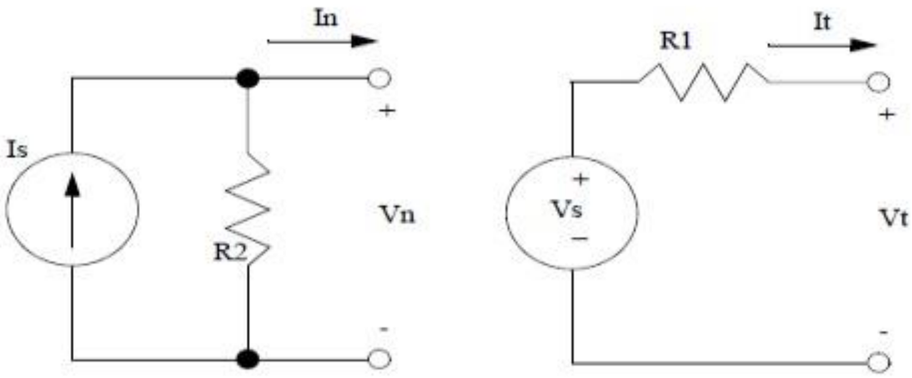
4. VOLTAGE SOURCE TO CURRENT SOURCE TRANSFORMATION:

If voltage source is converted to current source, then the current source **I = V/Rse** with parallel resistance equal to Rse.



5. CURRENT SOURCE TO VOLTAGE SOURCE TRANSFORMATION:

If current source is converted to voltage source, then the voltage source I = V/ R sh with series resistance equal to Rsh.

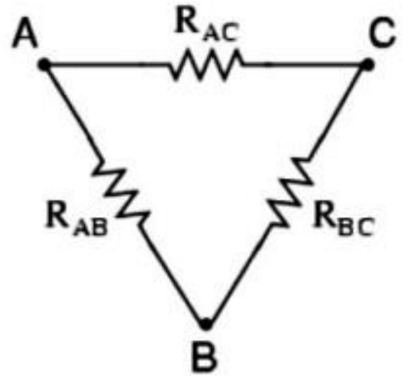


6. STAR DELTA CONVERSION:

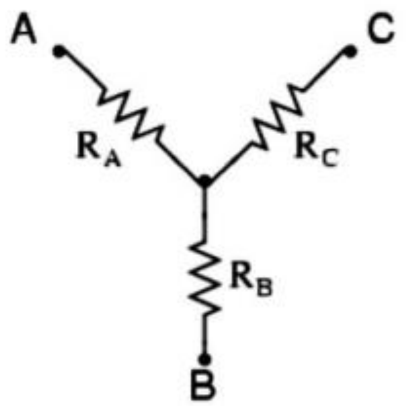
In many circuit applications, we encounter components connected together in one of two ways to

form a three-terminal network: the ―Delta or (also the ―Star (also known as the ―Y) configuration

Delta (Δ) network



Wye (Y) network



To convert a Delta (Δ) to a Wye (Y)

$$R_A = \frac{R_{AB}\,R_{AC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_B = \frac{R_{AB}\,R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_C = \frac{R_{AC}\,R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

To convert a Wye (Y) to a Delta (Δ)

$$R_{AB} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_A}$$

$$R_{AC} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_B}$$

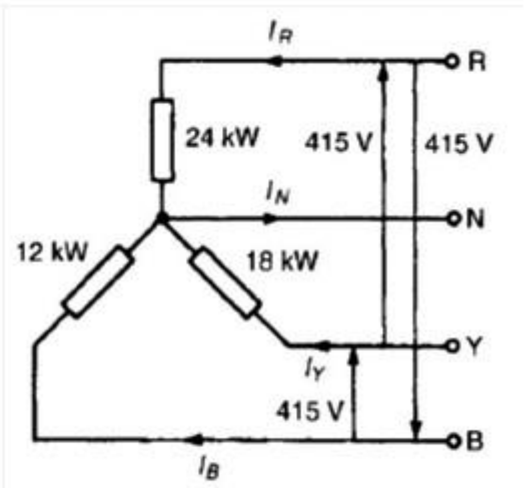
Problem 1: A star-connected load consists of three identical coils each of resistance 30 Ω and inductance 127.3 mH. If the line current is 5.08 A, calculate the line voltage if the supply frequency is 50 Hz.
Inductive reactance XL =2πfL

$$=2\pi(50)\,(127.3\times10^{-3}) = 40\ \Omega$$

Impedance of each phase Zp =√(R2 + X2L) =√(302 +402) =50 Ω For a star connection IL =Ip =VpZp

Hence phase voltage Vp =IpZp = (5.08)(50)=254V Line voltage **VL** =√3Vp =√3(254) =440V

Problem 2: A 415V, 3-phase, 4 wire, star-connected system supplies three resistive loads as shown in Figure Determine (a) the current in each line and (b) the current in the neutral conductor.



(a) For a star-connected system VL =√3Vp

Hence $V_p = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 240\,\text{V}$

Since current I = Power P/Voltage V for a resistive load then IR = PR/VR= 24 000/240=100A

IY = PY/VY= 18 000/240=75A and IB = PB/VB= 12 000/240=50A

(b) The three line currents are shown in the phasor diagram of Figure Since each load is resistive the currents are in phase with the phase voltages and are hence mutually displaced by 120°.The current in the neutral conductor is given by:
IN = IR + IY + IB phasorially.

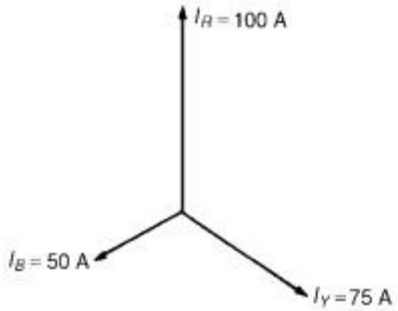


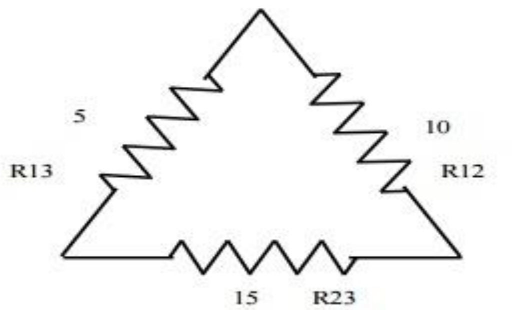
Figure shows the three line currents added phasorially.Oa represents IR in magnitude and direction. From the nose of Oa, ab is drawn representing IY in magnitude and direction. From the nose of ab, bc is drawn representing IB in magnitude and direction. Oc represents the resultant, IN.
By measurement, **IN** =43A

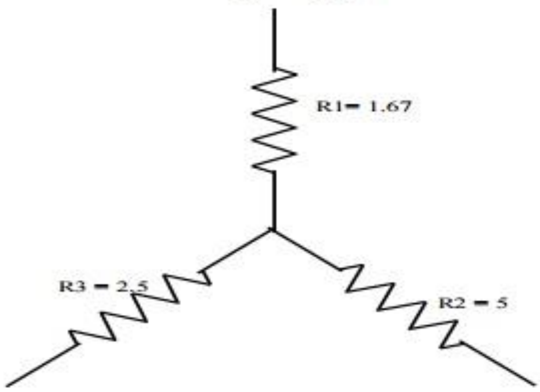
Alternatively, by calculation, considering IR at 90°, IB at 210° and IY at 330°:

Total horizontal component = 100 cos 90° + 75 cos 330° +50 cos 210° = 21.65

Total vertical component = 100 sin 90° + 75 sin 330° +50 sin 210° = 37.50
Hence magnitude of IN $=\sqrt{(21.65^2 + 37.50^2)}$
= 43.3A

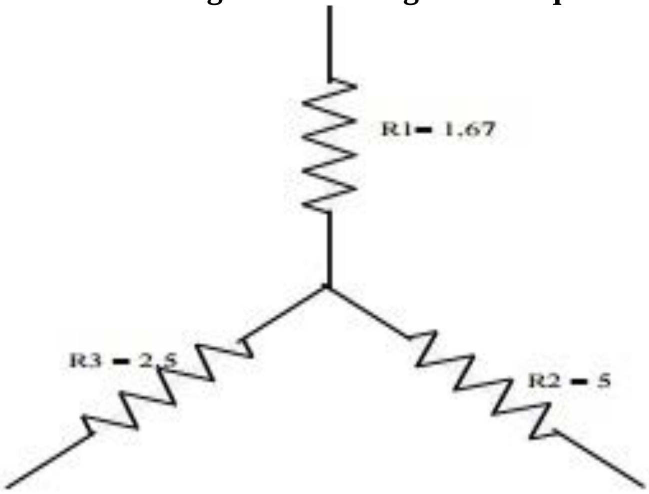
Problem 3: Convert the given delta fig into equivalent star.

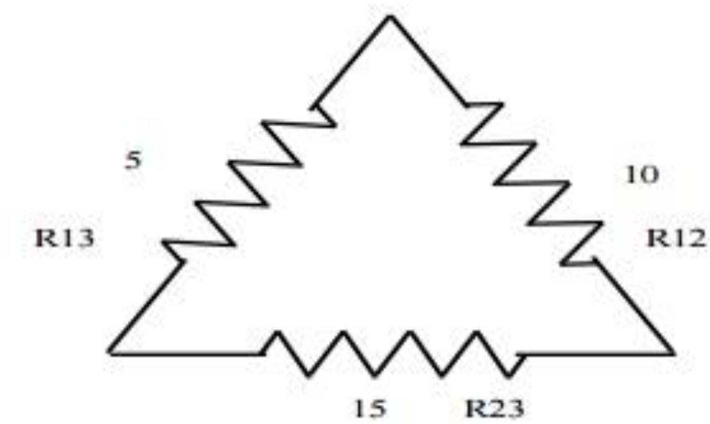




R_1 = $R_{12}xR_{13}/R_{12}+R_{13}+R_{23}$
R_1 = 10x5/30 = 1.67Ω
R_2 = 10 x 15/30 = 5Ω
R_3 = 5 x 15/30 = 2.5Ω

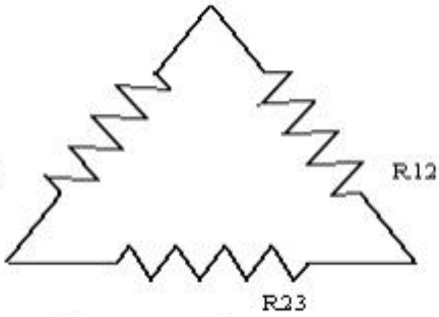
Problem 4: Convert the given star in fig into an equivalent delta.

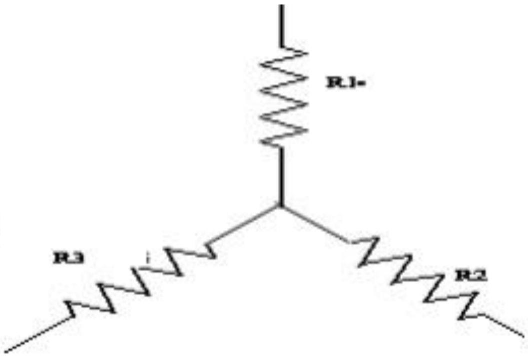




R_{12} = R1+R2 + R1R2/R3 = 1.67 x 5/2.5 + 1.67+5 = 10Ω
R_{23} = 2.5+5 2.5x5/1.67 = 15Ω
R_{31} = 2.5+1.67+ 2.5 x 1.67/5 = 5Ω

Problem 5: Obtain the delta connected equivalent for the star connected circuit.





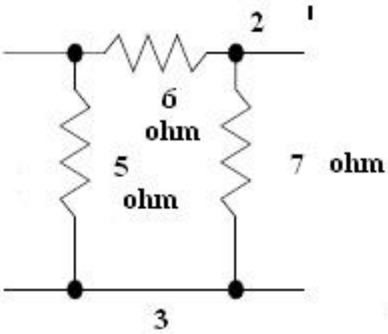
$$R_1 = 10\Omega, R_2 = 20\Omega, R_3 = 30\Omega$$

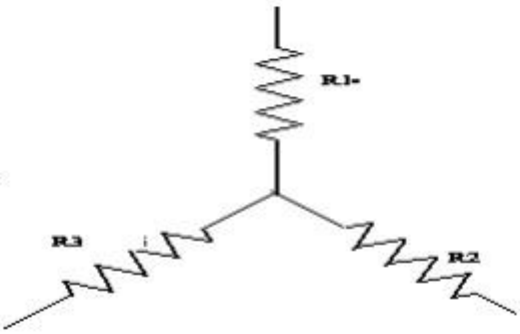
$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{10\times 20 + 20\times 30 + 30\times 10}{30} = 36.67\Omega$$

$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = \frac{10\times 20 + 20\times 30 + 30\times 10}{10} = 110\Omega$$

$$R_{31} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = \frac{10\times 20 + 20\times 30 + 30\times 10}{20} = 55\Omega$$

Problem 6: Obtain the star connected equivalent for the delta connected circuit.





$$R_1 = \frac{R_{12}R_{31}}{R_{12} + R_{23} + R_{31}} = \frac{6\times 5}{5+6+7} = 1.67\Omega$$

$$R_2 = \frac{R_{23}R_{12}}{R_{12} + R_{23} + R_{31}} = \frac{6\times 7}{5+6+7} = 2.33\Omega$$

$$R_3 = \frac{R_{31}R_{23}}{R_{12} + R_{23} + R_{31}} = \frac{5\times 7}{5+6+7} = 1.94\Omega$$