DELTA–STAR CONVERSION

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6 - 1 INTRODUCTION

Star connections is generally used in long distance transmission lines as insulation requirement is less in star connection. Delta connections are generally used in distribution networks for short distances. Alternators and generators are usually star connected. Transformer windings are connected in Star/Delta Connections. Generating transformer near to power plant generator are connected in star connection to provide grounding protection.

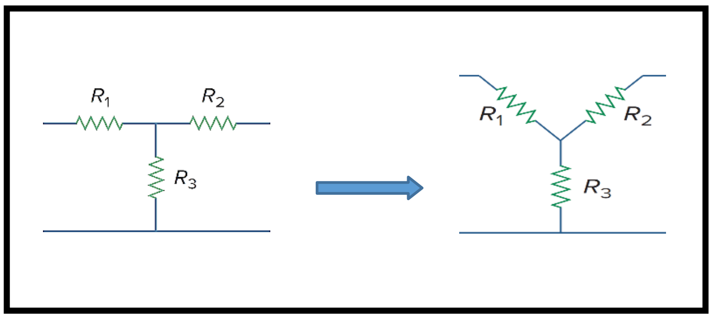
AC motors winding are connected in star/delta connection depending on requirement and application. Star and Delta connections are used in starting of three phase induction motors using STAR-DELTA Starter.

Delta-Star Starters are installed in cement industries for high inertial load applications. Star/Delta connection is an arrangement of passive elements R, L and Csuch that the formed shape resembles a star or a delta symbol.

- These connection are neither series and nor parallel.
- Such connections are simplified using star-to-delta or delta-to-starconversion.
- Such connections are found in complex DC circuits, full bridgerectifiers.
- Such connections has larger application in three phase AC system.

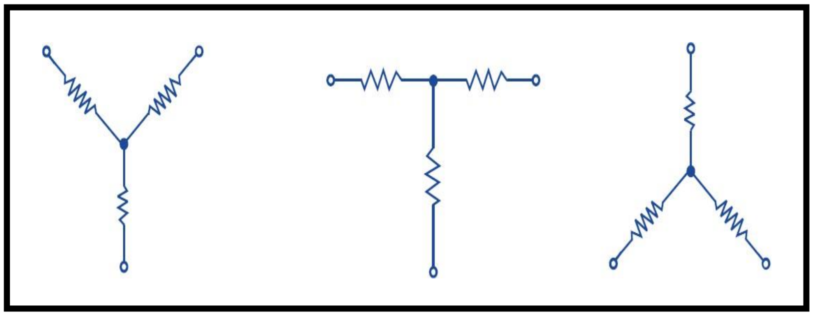
6-2 STAR CONNECTIONA

star network is rearranged form of Tee (T) network.



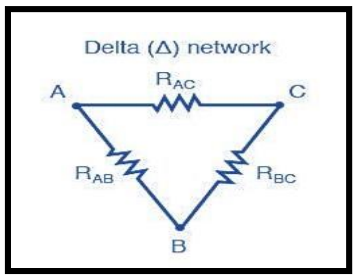
Three ends of resistors are connected in wye (Y) or star fashion. A common node point of star connection is known as neutral.

Three ways in which star connection may appear in a circuit.

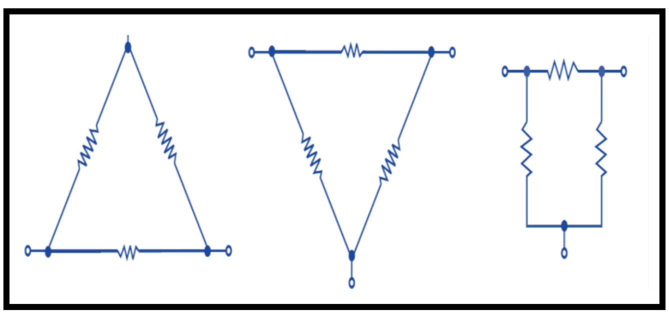


6 - 3 DELTA CONNECTION

When three resistors are connected in a fashion to form a closed mesh Δ, connection formed is known as Delta Connection.



Three ways in which delta connection may appear in a circuit.



6 - 4 DELTA TO STAR TRANSFORMATION

Situations often arise in circuit analysis when the resistors are neither in parallel nor in series. For example, consider the bridge circuit in **Fig. 6.1**. How do we combine resistors **R1** through **R6** when the resistors are neither in series nor in parallel? Many circuits of the type shown in **Fig. 6.1** can be simplified by using three-terminal equivalent networks. These are the wye (**Y**) or tee (**T**) network shown in **Fig. 6. 2** and the delta (**Δ**) or pi (**π**) network shown in **Fig. 6. 3**.

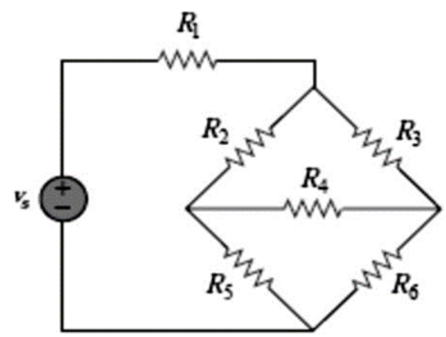


Figure 6.1The bridge network.

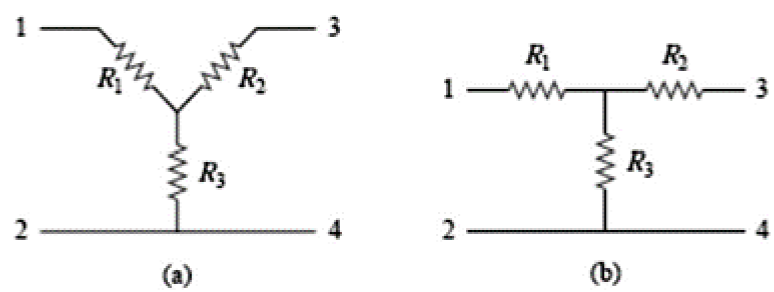


Figure 6. 2 Two forms of the same network: (a) Y, (b) T.

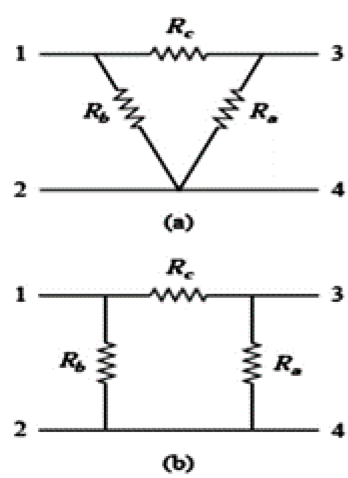


Figure 6. 3 Two forms of thesame network: (a) Δ, (b) π.

➢Delta to Wye Conversion

Suppose it is more convenient to work with a **wye** network in a place where the circuit contains a delta configuration. We superimpose a **wye** network on the existing **delta** network and find the equivalent resistances in the **wye** network. For terminals 1 and 2 in **Figs. 6. 2** and **6.3**, for example,

$$R12(Y) = R1 + R3, \quad R12(\Delta) = Rb \parallel (Ra + Rc) \tag{6.1}$$

Setting **R12(Y) = R12 (Δ)** gives

$$R_{12} = R_1 + R_3 = \frac{R_b(R_a + R_c)}{R_a + R_b + R_c}$$

$$R_{13} = R_1 + R_2 = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c} \qquad R_{34} = R_2 + R_3 = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c} \tag{6.2}$$

By solving previous equations, we get

$$R_1 = \frac{R_b\,R_c}{R_a + R_b + R_c} \tag{6.3}$$

$$R_2 = \frac{R_c\,R_a}{R_a + R_b + R_c} \tag{6.4}$$

$$R_3 = \frac{R_a\,R_b}{R_a + R_b + R_c} \tag{6.5}$$

➢ Wye to Delta Conversion

Reversing the **Δ-to-Y** transformation also is possible. That is, we can start with the **Y** structure and replace it with an equivalent **Δ** structure. The expressions for the three **Δ**-connected resistors as functions of the three **Y**-connected resistors are

$$Ra = \frac{R1R2 + R2R3 + R3R1}{R1} \tag{6.6}$$

$$Rb = \frac{R1R2 + R2R3 + R3R1}{R2} \tag{6.7}$$

$$Rc = \frac{R1R2 + R2R3 + R3R1}{R3} \tag{6.8}$$

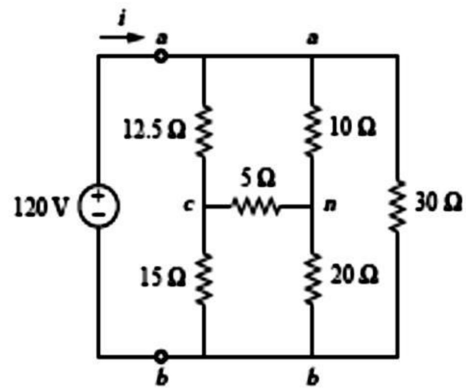
The Y and Δ networks are said to be balanced when

$$R_1 = R_2 = R_3 = R_Y, \quad R_a = R_b = R_c = R_\Delta \tag{6.9}$$

Under these conditions, conversion formulas become

$$R_Y = R_\Delta / 3 \text{ or } R_\Delta = 3R_Y \quad (6.10)$$

Example 6.1: Obtain the equivalent resistance $\mathbf{R_{ab}}$ for the circuit in Figure below and use it to find current **i**.



Solution: In this circuit, there are two **Y**-networks and one **Δ**-network. Transforming just one of these will simplify the circuit. If we convert the **Y**-network comprising the 5-Ω, 10- Ω, and 20-Ω resistors, we may select

$\mathbf{R_1 = 10\ \Omega}$, $\mathbf{R_2 = 20\ \Omega}$, $\mathbf{R_3 = 5\ \Omega}$

Thus, from Eqs. (6.6) to (6.8) we have

$$Ra = \frac{R1R2 + R2R3 + R3R1}{R1} = \frac{10\times20+20\times5+5\times10}{10} = \frac{350}{10} = 35\ \Omega$$

$$Rb = \frac{R1R2 + R2R3 + R3R1}{R2} = \frac{350}{20} = 17.5\Omega$$

$$Rc = \frac{R1R2 + R2R3 + R3R1}{R3} = \frac{350}{5} = 70\Omega$$

With the **Y** converted to **Δ**, the equivalent circuit (with the voltage source removed fornow) is shown in **Fig. 2 (a)**. Combining the three pairs of resistors in parallel, we obtain

$\mathbf{70 \parallel 30 = 70 \times 30/ (70 + 30) = 21\ \Omega}$

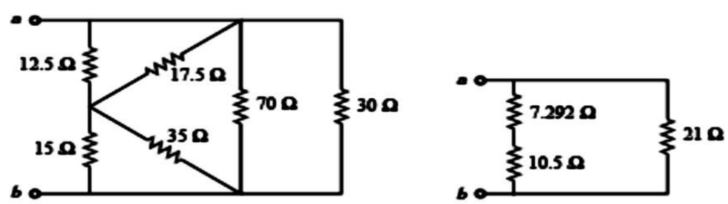
$\mathbf{12.5 \parallel 17.5 = 12.5 \times 17.5/ (12.5 + 17.5) = 7.2917\ \Omega}$

$\mathbf{15 \parallel 35 = 15 \times 35/ (15 + 35) = 10.5\ \Omega}$

so that the equivalent circuit is shown in Figure below Hence, we find

$\mathbf{R_{ab} = (7.292 + 10.5) \parallel 21 = 17.792 \times 21/ (17.792 + 21) = 9.632\ \Omega}$

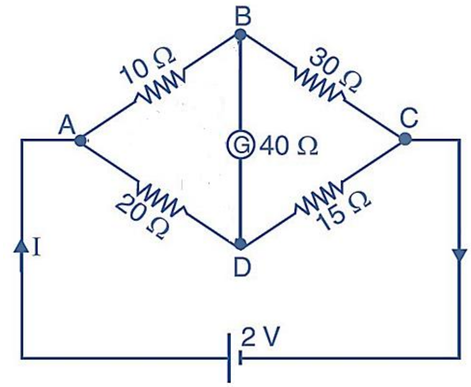
Then $\mathbf{i = vs/ Rab = 120/ 9.632 = 12.458\ A}$



(a) (b)

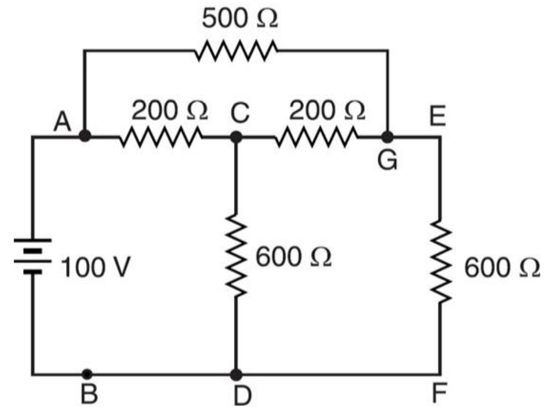
Practice problem 1.

Using delta/star transformation, find equivalent resistance across AC.



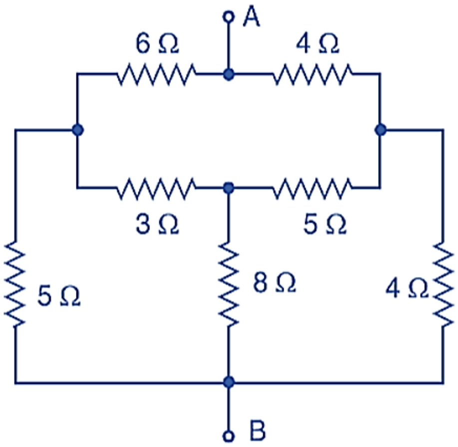
Practice problem 2.

Using delta/star transformation, find equivalent resistance.



Practice problem 3.

Calculate equivalent resistance across terminals A and B.



Thank You