Chapter 2 — Wye-Delta Transformations

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Overview

1. Introduction
2. Delta to Wye Conversion
3. Wye to Delta Conversion
4. Examples
5. Conclusions

Reference:
Problem Statement

- Situations often arise in circuit analysis when the resistors are neither in parallel nor in series.
- For example, consider the bridge circuit shown.
- How do we combine resistors $R_1 - R_6$ when the resistors are neither in series nor in parallel?
- Many circuits of the type shown can be simplified by using three-terminal networks.
- These are the wye ($Y$) or tee ($T$) network, and the delta ($\Delta$) or pi ($\Pi$) network as will be shown next.
- These networks occur by themselves or as part of a larger network.
Y, T, Δ, and Π Resistors Connections

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

Two forms of the same network: (a) Δ, (b) Π.
Delta to Wye Conversion

\[ R_1 = \frac{R_b R_c}{R_a + R_b + R_c} \]  

\[ R_2 = \frac{R_c R_a}{R_a + R_b + R_c} \]  

\[ R_3 = \frac{R_a R_b}{R_a + R_b + R_c} \]  

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### Wye to Delta Conversion

\[
R_a = R_2 + R_3 + \frac{R_2 R_3}{R_1} \quad (4)
\]

\[
R_b = R_1 + R_3 + \frac{R_1 R_3}{R_2} \quad (5)
\]

\[
R_c = R_1 + R_2 + \frac{R_1 R_2}{R_3} \quad (6)
\]
Special Cases: Balanced Y and Δ

If in a Y resistors connection

\[ R_1 = R_2 = R_3 = R_Y \]  \hspace{1cm} (7)

and in a Δ resistors connection

\[ R_a = R_b = R_c = R_\Delta, \]  \hspace{1cm} (8)

both Y and Δ networks are said to be balanced and in these cases:

\[ R_Y = \frac{R_\Delta}{3} \quad \text{or} \quad R_\Delta = 3R_Y \]  \hspace{1cm} (9)
Examples 1

1) Transform the wye network shown to a delta network.

Answer: $R_a = 140 \, \Omega$, $R_b = 70 \, \Omega$, $R_c = 35 \, \Omega$. 

![Diagram of a wye network with resistors $R_1$, $R_2$, and $R_3$.]
Examples 2

2) For the bridge network shown, find $R_{ab}$ and $i$.
Answer: $40\Omega$, 2.5 A.
3) Obtain the equivalent resistance at the terminals a-b of the circuit shown.
Answer: 36.25Ω.
Concluding remarks

- In circuit analysis there are situations often arise when the resistors are neither in parallel nor in series.
- In these situations, it is very helpful to use three-terminal equivalent circuit transformations.
- These are known as Wye-Delta or Delta-Wye Transformations.
- Both cases are studied and discussed.
- Some illustrative examples are given.