THEVENIN'S THEOREM

As originally stated in terms of DC resistive circuits only, Thévenin's theorem holds that:

- Any linear electrical network containing only voltage sources, current sources and resistances can be replaced at terminals A-B by an equivalent combination of a voltage source V_{th} in a series connection with a resistance R_{th}.

- The equivalent voltage V_{th} is the voltage obtained at terminals A-B of the network with terminals A-B open circuited.
- The equivalent resistance R_{th} is the resistance that the circuit between terminals A and B would have if all ideal voltage sources in the circuit were replaced by a short circuit and all ideal current sources were replaced by an open circuit.
- If terminals A and B are connected to one another, the current flowing from A to B will be V_{th}/R_{th}. This means that R_{th} could alternatively be calculated as V_{th} divided by the short-circuit current between A and B when they are connected together.

In circuit theory terms, the theorem allows any one-port network to be reduced to a single voltage source and a single impedance.

The theorem also applies to frequency domain AC circuits consisting of reactive and resistive impedances. It means the theorem applies for AC in an exactly same way to DC except that resistances are generalized to impedances.

The theorem was independently derived in 1853 by the German scientist Hermann von Helmholtz and in 1883 by Léon Charles Thévenin (1857–1926), an electrical engineer with France's national Postes et Télégraphes telecommunications organization.

Thévenin's theorem and its dual, Norton's theorem, are widely used to make circuit analysis simpler and to study a circuit's initial-condition and steady-state response. Thévenin's theorem can be used to convert any circuit's sources and impedances to a Thévenin equivalent; use of the theorem may in some cases be more convenient than use of Kirchhoff's circuit laws.

In the previous three tutorials we have looked at solving complex electrical circuits using Kirchhoff's Circuit Laws, Mesh Analysis and finally Nodal Analysis. But there are many more "Circuit Analysis Theorems" available to choose from which can calculate the currents and voltages at any point in a circuit. In this tutorial we will look at one of the more common circuit analysis theorems (next to Kirchhoff´s) that has been developed, Thevenin's Theorem.

Thevenin's Theorem states that "*Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load*". In other words, it is possible to simplify any electrical circuit, no matter how complex, to an equivalent two-terminal circuit with just a single constant voltage source in series with a resistance (or impedance) connected to a load as shown below.

Thevenin's Theorem is especially useful in the circuit analysis of power or battery systems and other interconnected resistive circuits where it will have an effect on the adjoining part of the circuit.

Calculating the Thévenin equivalent

The equivalent circuit is a voltage source with voltage V_{Th} in series with a resistance R_{Th}.

The Thévenin-equivalent voltage V_{Th} is the open-circuit voltage at the output terminals of the original circuit. When calculating a Thévenin-equivalent voltage, the voltage divider principle is often useful, by declaring one terminal to be V_{out} and the other terminal to be at the ground point.

The Thévenin-equivalent resistance R_{Th} is the resistance measured across points A and B "looking back" into the circuit. The resistance is measured after replacing all voltage- and current-sources with their internal resistances. That means an ideal voltage source The is replaced with a short circuit, and an ideal current source is replaced with an open circuit. Resistance can then be calculated across the terminals using the formulae for series and parallel circuits. This method is valid only for circuits with independent sources. If there are dependent sources in the circuit, another method must be used such as connecting a test source across A and B and calculating the voltage across or current through the test source.

The replacements of voltage and current sources do what the sources would do if their values were set to zero. A zero valued voltage source would create a potential difference of zero volts between its terminals, regardless of the current that passes through it; its replacement, a short circuit, does the same thing. A zero valued current source passes zero current, regardless of the voltage across it; its replacement, an open circuit, does the same thing.

Example .

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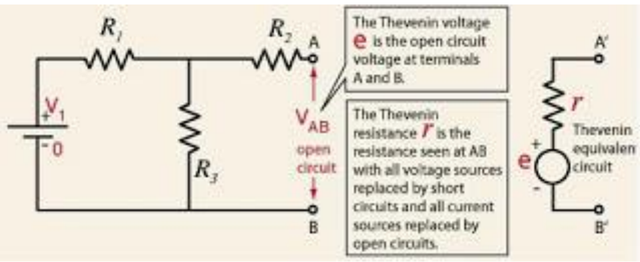
Applications of Thevenin's Theorem:

- Thevenin's Theorem is especially useful in analyzing power systems and other circuits where one particular resistor in the circuit (called the “load” resistor) is subject to change, and recalculation of the circuit is necessary with each trial value of load resistance, to determine voltage across it and current through it.

- Source modeling and resistance measurement using the Wheatstone bridge provide applications for Thevenin's theorem.

Advantages of Thevenin's Theorem

- It reduces a complex circuit to a simple circuit viz a single source of e.m.f. Eth in series with a single resistance RTh.
- It greatly simplifies the portion of the circuit of the lesser importance and enables us to view the action of the output part directly.
- The theorem is particularly useful to find current in a particular branch of a network as the resistance of that branch is varied while all other resistances and e.m.f source remain constant.



Thevenin's Theorem Summary

We have seen here that Thevenin's theorem is another type of circuit analysis tool that can be used to reduce any complicated electrical network into a simple circuit consisting of a single voltage source, Vs in series with a single resistor, Rs.

When looking back from terminals A and B, this single circuit behaves in exactly the same way electrically as the complex circuit it replaces. That is the i-v relationships at terminals A-B are identical.