ELECTRICAL NETWORK

An electrical network is an interconnection of electrical elements such as resistors, inductors, capacitors, and switches. It can also refer to large electricity distribution or transmission network.

Explained

An electrical circuit is a network that has a closed loop, giving a return path for the current.

A network is a connection of two or more simple circuit elements, and may not necessarily be a circuit.

Design aims

In the case of power distribution networks, engineers design the circuit to transport the energy as efficiently as possible, while at the same time taking into account economic factors, network safety and redundancy. These networks use components such as power lines, cables, circuit breakers, switches andtransformers.

Design methods

To design any electrical circuits, electrical engineers need to be able to predict the voltages and currents in the circuit. Linear circuits can be analysed to a certain extent by hand because complex number theory gives engineers the ability to treat all linear elements using a single mathematical representation.

Many engineers utilize special software to design and simulate circuits before building them. This method increases both time and cost efficiency since it does not require the engineer to build every circuit prototype in order to test it. The development of technologies such as VHDL have also eased the burden from engineers by simulating and automatically generating circuit designs.

Electrical laws

A number of electrical laws apply to all electrical networks. These include

Kirchhoff's current lawlaw[[1]]: the sum of all currents entering a node is equal to the sum of all currents leaving the node.

Kirchhoff's voltage law[[2]]: the directed sum of the electrical potential differences around a circuit must be zero.

Ohm's law: the voltage across a resistor is the product of its resistance and the current flowing through it.

the Y-delta transform

Norton's theorem[[3]]: any two-terminal collection of voltage sources and resistors is electrically equivalent to an ideal current source in parallel with a single resistor.

Thevenin's theorem[[4]]: any two-terminal combination of voltage sources and resistors is electrically equivalent to a single voltage source in series with a single resistor.

Millman's Theorem[[5]]: the voltage on the ends of branches in parallel is equal to the sum of the currents flowing in every branch divided by the total equivalent conductance.

See also Analysis of resistive circuits.

Other more complex laws may be needed if the network contains nonlinear or reactive components. Non-linear self-regenerative heterodyning systems can be approximated. Applying these laws results in a set ofsimultaneous equations that can be solved either by hand or by a computer.

Network simulation software

In more complex circuits, engineers need to turn to circuit simulation software. SPICE[[6]] and EMTP are the most famous of these.

Linearization around operating point

When faced with a new circuit, the software first tries to find a steady state solution. This is a solution where all nodes conform to Kirchhoff's Current Law and the voltages across and through each element of the circuit conform to the voltage/current equations governing that element.

Once the steady state solution is found, the operating points of each element in the circuit are known. For a small signal analysis, every non-linear element can be linearized around its operation point to obtain the small-signal estimate of the voltages and currents. This is an application of Ohm's Law. The resulting linear circuit matrix can be solved with Gauss-Jordan elimination[[7]].

Piece-wise linear approximation

This type of simulator uses piece-wise linear approximations of the equations governing the elements of a circuit. This approximation comes down to splitting the circuit into two parts: a completely linear network with a number of terminals that connect to ideal diodes. Every time a diode switches from on to off or vice versa, the linear network is configured differently. Increasing the accuracy of the simulation can be achieved by adding more detail to the approximation of equations, this will increase the running time of the simulation. This flexibility allows an engineer to make a trade-off between simulation time and the precision of the results, something that is not easily done with the previous simulation technique.

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