1.2 Network theorems:

Concept of superposition theorem

The concept of superposition theorem is foundational in the analysis of linear electrical circuits. This theorem is used to calculate the total response in a circuit containing multiple independent sources by considering the effect of each source separately. In this process, all other sources are replaced with their internal impedances. For instance, voltage sources are replaced with short circuits, while current sources are replaced with open circuits. After determining the contributions of each source individually, the total response is obtained by summing these contributions algebraically. Superposition is particularly beneficial in simplifying the analysis of circuits with multiple power sources, making it easier to determine voltage, current, or power at any point in the circuit. This theorem is limited to linear systems where the principle of superposition applies.

Thevenin`s theorem

Thevenin's theorem is another powerful tool used in circuit analysis, particularly for simplifying complex networks. According to this theorem, any linear electrical network with voltage sources and resistances can be represented as an equivalent circuit with a single voltage source in series with a resistance. To apply Thevenin's theorem, the portion of the circuit of interest is first isolated by removing the load resistance. The open-circuit voltage, also known as the Thevenin voltage, is then determined across the terminals where the load was connected. The equivalent resistance is found by deactivating all independent sources and calculating the resistance seen from the terminals. This equivalent circuit simplifies the analysis, especially when studying the effect of different load resistances on the circuit.

Norton`s theorem

Norton’s theorem offers an alternative way to simplify electrical networks. It states that a linear electrical network can be reduced to an equivalent circuit consisting of a single current source in parallel with a resistance. To derive the Norton equivalent, the short-circuit current is calculated across the terminals of interest, while the equivalent resistance is found in the same manner as in Thevenin's theorem. Norton’s equivalent circuit is particularly useful in systems where parallel configurations dominate, as it simplifies the study of how current divides among parallel branches.

Maximum power transfer theorem

The maximum power transfer theorem focuses on the conditions under which a load receives maximum power from a network. According to this theorem, maximum power is delivered to the load when the load resistance equals the internal resistance of the source or the Thevenin equivalent resistance. This principle is widely applied in electrical and electronic engineering, particularly in designing systems like audio amplifiers and communication circuits. The trade-off between efficiency and maximum power is an important consideration, as achieving maximum power does not necessarily imply maximum efficiency.

R-L, R-C, R-L-C circuits

Circuits containing combinations of resistors, inductors, and capacitors, such as R-L, R-C, and R-L-C circuits, exhibit unique characteristics depending on their configurations and the type of current applied. R-L circuits consist of a resistor and inductor in series or parallel. The current in these circuits lags the voltage due to the inductive reactance, which increases with frequency. In R-C circuits, comprising resistors and capacitors, the current leads the voltage due to capacitive reactance, which decreases with frequency. R-L-C circuits combine resistors, inductors, and capacitors, and their behavior is determined by the resonance condition. These circuits are fundamental in the design of filters, oscillators, and tuning circuits in communication systems.

resonance in AC series and parallel circuit

Resonance in AC circuits occurs when the inductive reactance and capacitive reactance become equal, resulting in a purely resistive impedance at a specific frequency known as the resonant frequency. In series resonance, the total impedance of the circuit is minimized, and the current is maximized, making it useful in applications such as tuning radio frequencies. In contrast, parallel resonance occurs when the circuit impedance is maximized, and the current is minimized, which is often used in power systems to limit unwanted currents. Resonance phenomena are critical in the design and analysis of AC circuits for achieving desired frequency responses.

active and reactive power

In AC circuits, the concept of power is divided into active and reactive power. Active power, measured in watts, represents the real power consumed by resistive elements to perform useful work. Reactive power, measured in volt-amperes reactive (VAR), represents the power that oscillates between the source and reactive components, such as inductors and capacitors, without being dissipated. The combination of these powers forms the apparent power, which is represented as a vector sum in the power triangle. Understanding the interplay between active and reactive power is crucial in power system design and operation, as it affects the efficiency and stability of electrical systems.