EEE 2023 (previous question’s short overview) from Sadman boss and Sharafat noob.

**Definition type:**

**For DC:**

**1.** Ohm’s law (with explanation): Ohm's law states that the current flowing through a conductor is directly proportional to the voltage across the conductor, provided the physical conditions of the conductor do not change.

Mathematically, Ohm's law can be expressed as V = IR, where:

V is the voltage across the conductor (in volts)

I is the current flowing through the conductor (in amps)

R is the resistance of the conductor (in ohms)

Here is an explanation of Ohm's law:

The voltage across a conductor is the difference in electrical potential between two points in the conductor.

The current flowing through a conductor is the amount of electrical charge that flows through the conductor per unit time.

The resistance of a conductor is a measure of how difficult it is for current to flow through the conductor**.**

**2. superposition theorem:** The superposition theorem is a theorem in circuit analysis that states that the response (voltage or current) in any branch of a linear circuit having more than one independent source equals the algebraic sum of the responses caused by each independent source acting alone, where all the other independent sources are replaced by their internal impedances.

**3.** **circuit**: A circuit is a complete path that electricity flows through. A simple circuit consists of a current source, conductors, and a load.

**4. short circuit:** A short circuit is an electrical circuit that allows a current to travel along an unintended path with no or very low electrical impedance. This results in an excessive current flowing through the circuit.

**5. open circuit:** An open circuit is an electrical circuit in which there is a break in the conducting path. This means that no current can flow through the circuit.

**6. resistance:** Resistance is a measure of the opposition to current flow in an electrical circuit. It is measured in ohms, symbolized by the Greek letter omega (Ω). The higher the resistance, the lower the current flow. The lower the resistance, the higher the current flow

**7. dependent source**: A dependent source is a current or voltage source whose value depends on some other circuit current or voltage. Dependent sources are useful in modeling the behavior of amplifiers.

**AC:**

1. **instantaneous power:** Instantaneous power is the power measured at a given instant in time. It is the product of instantaneous voltage and instantaneous current.
2. **RMS value:** The RMS value, or root mean square value, is a measure of the average power of a periodic signal. It is calculated by squaring the instantaneous values of the signal, averaging them, and then taking the square root of the average.
3. **form factor:** In electrical engineering, the form factor of an alternating current (AC) waveform is the ratio of the RMS (root mean square) value to the average value of the waveform. It is a measure of the "peakiness" of the waveform.
4. **power factor:** Power factor is a measure of how efficiently electrical energy is used in an AC circuit. It is the ratio of the real power (watts) to the apparent power (volt-amperes).
5. **phasor diagram**: A phasor diagram is a graphical representation of a sinusoidal waveform. It is a vector that rotates counterclockwise at a constant angular velocity. The length of the phasor represents the amplitude of the waveform, and the angle of the phasor represents the phase of the waveform.
6. **active network:** An active network is a network that contains one or more sources of electromotive force (EMF).
7. **Mesh**:A mesh connection is a type of electrical circuit in which each component is connected to two or more other components. This creates a network of interconnected components, which allows current to flow through the circuit in multiple paths.

**Short discussion type:**

**DC:**

**Maximum power theorem:** The maximum power theorem (MPT) is a theorem in circuit analysis that states that the maximum amount of power is transferred from a source to a load when the load resistance is equal to the source resistance.

Here are some of the applications of the maximum power theorem:

Designing power amplifiers: Power amplifiers are used to amplify the power of an electronic signal. The MPT can be used to design power amplifiers that maximize power transfer.

Designing antenna systems: Antenna systems are used to transmit and receive radio waves. The MPT can be used to design antenna systems that maximize power transfer.

Designing electronic circuits: The MPT can be used to design a wide variety of electronic circuits, including amplifiers, filters, and oscillators.

The maximum power theorem is a powerful tool that can be used to improve the performance of a wide variety of circuits.

2**. Thevenin’s theorem:** Thevenin's theorem is a circuit analysis theorem that states that any linear circuit can be replaced with an equivalent circuit consisting of a single voltage source and a single resistor connected in series.

Here are some of the applications of Thevenin's theorem:

Simplifying circuit analysis: Thevenin's theorem can be used to simplify the analysis of complex circuits. This can be helpful for troubleshooting problems with circuits and for designing new circuits.

Calculating current and voltage: Thevenin's theorem can be used to calculate the current and voltage at any point in a circuit. This can be helpful for understanding the behavior of circuits and for designing circuits that meet specific requirements.

Impedance matching: Thevenin's theorem can be used to impedance match circuits. Impedance matching is the process of ensuring that the impedance of a load is matched to the impedance of a source. This can be helpful for maximizing power transfer and for minimizing signal distortion.

Thevenin's theorem is a powerful tool that can be used to simplify the analysis of complex circuits and to calculate the current and voltage at any point in a circuit. It is a versatile theorem that can be applied to a wide variety of circuits.

**3. Norton’s theorem:** Norton's theorem is a circuit analysis theorem that states that any linear circuit can be replaced with an equivalent circuit consisting of a single current source and a single resistor connected in parallel.

Here are some of the applications of Norton's theorem:

Simplifying circuit analysis: Norton's theorem can be used to simplify the analysis of complex circuits. This can be helpful for troubleshooting problems with circuits and for designing new circuits.

Calculating current and voltage: Norton's theorem can be used to calculate the current and voltage at any point in a circuit. This can be helpful for understanding the behavior of circuits and for designing circuits that meet specific requirements.

Impedance matching: Norton's theorem can be used to impedance match circuits. Impedance matching is the process of ensuring that the impedance of a load is matched to the impedance of a source. This can be helpful for maximizing power transfer and for minimizing signal distortion.

4. **loop:** A loop in an electrical circuit is a closed path that current can flow through. Loops are important in circuit analysis because they allow us to apply Kirchhoff's loop rule, which states that the sum of the voltage drops around any closed loop in a circuit is equal to zero.

There are two types of loops in electrical circuits:

**Meshes**: Meshes are loops that do not share any nodes.

**Branches**: Branches are loops that share at least one node.

Meshes are easier to analyze than branches, because the current in a mesh can only flow in one direction. Branches, on the other hand, can have current flowing in both directions.

To analyze a loop in an electrical circuit, we can use the following steps:

Identify the loops in the circuit.

Assign a direction to the current in each loop.

Apply Kirchhoff's loop rule to each loop.

Solve the equations for the currents in the loops.

Once we have solved for the currents in the loops, we can use them to calculate the voltages across the components in the circuit.

Here are some of the applications of loops in electrical circuits:

Circuit analysis: Loops are used in circuit analysis to apply Kirchhoff's loop rule and to calculate the currents in the loops.

Troubleshooting: Loops can be used to troubleshoot problems in circuits by identifying the loops that are not working properly.

Design: Loops can be used in circuit design to ensure that the current flows in the desired direction.

Loops are an important concept in electrical circuit analysis and design. They can be used to simplify the analysis of complex circuits and to troubleshoot problems in circuits.

5. **basic laws of electrical engineering:** There are many basic laws of electrical engineering, but some of the most important include:

**Ohm's law**: This law states that the current flowing through a conductor is directly proportional to the voltage across the conductor and inversely proportional to the resistance of the conductor.

**Kirchhoff's voltage law (KVL):** This law states that the sum of the voltages around any closed loop in a circuit is equal to zero.

**Kirchhoff's current law (KCL):** This law states that the sum of the currents entering and leaving any node in a circuit is equal to zero.

**Thevenin's theorem:** This theorem states that any linear circuit can be replaced with an equivalent circuit consisting of a single voltage source and a single resistor connected in series.

**Norton's theorem:** This theorem states that any linear circuit can be replaced with an equivalent circuit consisting of a single current source and a single resistor connected in parallel.

6. **properties of series and parallel current:**

Series and parallel circuits are two basic topologies used to connect electrical components in a circuit. The properties of series and parallel circuits are different, and they affect the way that current flows through the circuit.

In a series circuit, the components are connected end-to-end, so that the current has only one path to flow through. This means that the current is the same through all of the components in the circuit. The voltage across each component is different, and it is equal to the product of the current and the resistance of the component.

In a parallel circuit, the components are connected across each other, so that the current has multiple paths to flow through. This means that the current is divided among the components in the circuit. The voltage across each component is the same, and it is equal to the voltage of the source.

A screenshot of a computer

Description automatically generated

7. **KVL and KCL:** Kirchhoff's voltage law (KVL) states that the sum of the voltages around any closed loop in a circuit is equal to zero. This means that the voltage drops across the components in a circuit must add up to zero.

Kirchhoff's current law (KCL) states that the sum of the currents entering and leaving any node in a circuit is equal to zero. This means that the current flowing into a node must equal the current flowing out of the node.

Here are some of the applications of KVL and KCL:

Circuit analysis: KVL and KCL are used in circuit analysis to calculate the currents, voltages, and power in circuits.

Troubleshooting: KVL and KCL can be used to troubleshoot problems in circuits by identifying the components that are not working properly.

Design: KVL and KCL can be used in circuit design to ensure that the circuits meet specific requirements.

1. **laws of resistance:**

There are two laws of resistance:

**Ohm's law**: states that the current flowing through a conductor is directly proportional to the voltage across the conductor and inversely proportional to the resistance of the conductor.

**Joule's law:** states that the heat generated in a resistor is proportional to the square of the current flowing through the resistor and the resistance of the resistor.

Ohm's law (V = IR) states that the voltage (V) across a resistor is directly proportional to the current (I) flowing through the resistor and inversely proportional to the resistance (R) of the resistor. This means that if the current through a resistor increases, the voltage across the resistor will also increase. Similarly, if the resistance of a resistor increases, the voltage across the resistor will also increase.

Joule's law (H = I^2Rt) states that the heat (H) generated in a resistor is proportional to the square of the current (I) flowing through the resistor, the resistance (R) of the resistor, and the time (t) for which the current flows through the resistor. This means that if the current through a resistor increases, the amount of heat generated will increase. Similarly, if the resistance of a resistor increases, the amount of heat generated will also increase.

Here are some of the applications of the laws of resistance:

**Circuit analysis**: The laws of resistance are used in circuit analysis to calculate the current, voltage, and power in circuits.

**Troubleshooting**: The laws of resistance can be used to troubleshoot problems in circuits by identifying the components that are not working properly.

**Design:** The laws of resistance can be used in circuit design to ensure that the circuits meet specific requirements.

**Short discussion type  
AC**

**Effects of temperature on resistance**

1. When a material is heated, its resistance increases.

2. As the temperature of a conductor rises, its conductivity drops.

3. Materials with a positive temperature coefficient of resistance (PTCR) increase in resistance as temperature increases, while materials with a negative temperature coefficient of resistance (NTCR) decrease in resistance as temperature increases.

4. A Wheatstone bridge can be used to measure the temperature dependence of resistance.

5. Materials with lower melting points are more affected by temperature changes.

6. The changing resistance with temperature can be used in circuits to maintain a stable output in electronic devices.

**Bilateral Circuit**

A bilateral circuit is one that exhibits the same electrical behavior regardless of the direction of current flow. In other words, the circuit components and their characteristics remain the same regardless of whether the current flows from left to right or right to left. In bilateral circuits, the voltage-current relationship is symmetric, and the circuit's behavior is reciprocal.

For example, a resistor is a bilateral circuit element. The resistance offered by a resistor remains the same whether the current flows through it from one terminal to the other or in the opposite direction. The V-I relationship for a resistor is linear and follows Ohm's law (V = IR) irrespective of the current direction.

**Unilateral Circuit**

In contrast, a unilateral circuit is one that exhibits different electrical behavior depending on the direction of current flow. The circuit's components or characteristics are asymmetrical, meaning that they respond differently to current flowing in different directions.

An example of a unilateral circuit element is a diode. A diode allows current to flow easily in one direction (forward bias) while offering a high resistance to current flow in the opposite direction (reverse bias). The V-I relationship of a diode is nonlinear, with exponential growth in current in the forward bias direction and minimal or negligible current flow in the reverse bias direction.

**A linear circuit**

It is an electrical circuit in which the relationship between voltage and current follows linear principles. In a linear circuit, the current through a circuit element is directly proportional to the voltage across it, obeying Ohm's law (V = IR) where R is the resistance.

Key characteristics of linear circuits include:

1. Proportionality: The voltage-current relationship is linear, meaning that doubling the voltage results in a doubling of the current.
2. Superposition: The principle of superposition holds, which means that the response of the circuit to multiple input signals can be determined by analyzing the individual responses to each input signal separately and then summing them.
3. Linearity of components: Linear circuit elements, such as resistors, capacitors, and inductors, have constant parameters that do not change with voltage or current.

**a non-linear circuit**

It is an electrical circuit where the voltage-current relationship does not follow linear principles. The current-voltage relationship in a non-linear circuit is not directly proportional and may exhibit complex or nonlinear behavior.

Key characteristics of non-linear circuits include:

1. Non-proportionality: The voltage-current relationship is not linear, meaning that doubling the voltage may not result in a doubling of the current.
2. Non-superposition: The principle of superposition does not hold in non-linear circuits, and the response to multiple input signals cannot be determined by analyzing the individual responses separately and then summing them.
3. Nonlinear components: Nonlinear circuit elements, such as diodes, transistors, and certain types of capacitors or inductors, exhibit voltage-dependent or current-dependent behavior that can significantly impact the overall circuit response.

**Alternating current (AC)**

It is an electrical current that periodically changes direction, alternating between positive and negative cycles. In an AC system, the flow of electric charge periodically reverses its direction, typically at a frequency of 50 or 60 cycles per second, depending on the region.

The key characteristics of alternating current include:

1. Direction: AC periodically changes direction, flowing in one direction for a certain period of time and then reversing its direction. This reversal happens in a cyclical manner.
2. Voltage Variation: The voltage of an AC waveform also alternates, regularly changing between positive and negative values. The voltage rises to a maximum positive value, returns to zero, then reaches a maximum negative value, and returns to zero again. This cycle repeats continuously.
3. Frequency: The frequency of an AC system represents the number of cycles or complete reversals that occur per second and is measured in Hertz (Hz). In many regions, the standard frequency for AC power systems is 50 Hz or 60 Hz.

**Voltage in pure capacitor (AC) circuit**

check sheet \*

**Faraday's Laws of Electromagnetic Induction**

1. **Faraday's First Law**: When a magnetic field is changed, an electromotive force (EMF) is induced in a conductor. The magnitude of the induced EMF is directly proportional to the rate of change of magnetic flux through the conductor. Mathematically, it can be expressed as:

EMF = -dΦ/dt,

where EMF is the induced electromotive force, Φ is the magnetic flux, and dt/dt represents the rate of change of magnetic flux.

2. **Faraday's Second Law**: The magnitude of the induced EMF in a closed loop is equal to the rate of change of magnetic flux through the loop. This law is commonly expressed by Faraday's Law of Electromagnetic Induction:

ε = -dΦ/dt,

where ε represents the induced EMF in the loop, Φ is the magnetic flux, and dt/dt represents the rate of change of magnetic flux.

*Striked parts are out of syllabus though*

**~~Bandwidth of a Series Resonance Circuit~~**

~~The bandwidth of a series resonance circuit is the range of frequencies over which the circuit can resonate effectively. It is determined by the quality factor (Q-factor) of the circuit. The bandwidth is generally defined as the difference between the upper and lower cutoff frequencies. In a series resonance circuit, the bandwidth can be calculated using the formula:~~

~~Bandwidth = f₂ - f₁,~~

~~where f₂ is the upper cutoff frequency and f₁ is the lower cutoff frequency.~~

**True and Reactive Power by Power Triangle**

In an alternating current (AC) circuit, the power triangle is a graphical representation that relates the true power (P), reactive power (Q), and apparent power (S). The power triangle helps understand the relationship between these power components.

1. **True Power (P)**: True power represents the power that is actively converted into useful work or dissipated as heat in an AC circuit. It is measured in watts (W) and is the component of power that performs actual work.

2. **Reactive Power (Q)**: Reactive power is the power component in an AC circuit that oscillates between the source and the reactive elements (such as capacitors and inductors). It represents the energy stored and released by reactive components in the circuit. Reactive power is measured in volt-amperes reactive (VAR) or kilovolt-amperes reactive (kVAR).

3. **Apparent Power (S)**: Apparent power is the vector sum of true power and reactive power. It represents the total power flow in an AC circuit and is measured in volt-amperes (VA) or kilovolt-amperes (kVA).

**Effective Value (RMS) in AC**

In AC circuits, the effective value, also known as the root mean square (RMS) value, is used to quantify the magnitude of the AC voltage or current. The effective value represents the equivalent steady DC value that would produce the same average power in a resistive load.

Using the effective value is important because AC voltages and currents vary sinusoidally with time, and their peak or amplitude values alone do not give an accurate representation of the power or heating effect in a circuit. By using the effective value, calculations involving AC circuits can be simplified, and power calculations can be based on the equivalent DC values.

*Equations are available on the sheet \**

**~~Right-Hand Rule for the Conductor~~**

~~The right-hand rule is a mnemonic or guideline used to determine the direction of a magnetic field, current, or force in a conductor. Specifically, the right-hand rule for a conductor relates to the direction of the magnetic field around a current-carrying conductor.~~

~~The right-hand rule states that if you point your right thumb in the direction of the current flow (conventional current flow), with the fingers curled around the conductor, the direction in which your fingers naturally curl represents the direction of the magnetic field lines around the conductor.~~

**The phenomena of force production between two parallel conductors** depend on the direction of the current flowing through them. Let's explore the effects for the cases of same and opposite current directions:

1. Same Current Direction:

When the currents in two parallel conductors flow in the same direction, they create magnetic fields around each conductor. According to Ampère's Law, these magnetic fields interact with each other, resulting in an attractive force between the conductors. The force acts in the direction that tends to bring the conductors closer together.

~~This phenomenon is utilized in various applications, such as in electromagnets, transformers, and electric motors, where the force between parallel conductors is used to generate mechanical motion or to transfer energy between circuits.~~

2. Opposite Current Direction:

When the currents in two parallel conductors flow in opposite directions, their magnetic fields also interact. In this case, the magnetic fields repel each other, creating a repulsive force between the conductors. The force acts in the direction that tends to push the conductors apart.

~~The repulsive force between parallel conductors with opposite current directions can be observed in situations where current-carrying conductors are positioned close to each other and are trying to move away from each other due to the repulsion.~~

~~It's worth noting that the magnitude of the force between the conductors depends on various factors, including the distance between the conductors, the magnitude of the currents, and the permeability of the medium in which the conductors are located.~~

~~The phenomena of force production between parallel conductors with same and opposite current directions are significant in electrical engineering and have practical applications in the design and operation of various electrical devices and systems.~~