



1 To study the magnetic field produced by a solenoid and verify the relationship between current and magnetic field strength.

To study the magnetic field produced by a solenoid and verify the relationship between current and magnetic field strength, you will need to plan your experiment carefully with attention to both equipment requirements and safety measures.

Items Required:

- Power supply: To control the current through the solenoid.
- Solenoid: The device that generates the magnetic field when an electric current passes through it.
- Ammeter: To measure the current flowing through the solenoid.
- Voltmeter: To measure the voltage across the solenoid terminals.
- Gauss meter or Hall effect sensor: For measuring the strength of the magnetic field generated inside the solenoid.
- Wires and connectors: For assembling the circuit.

Experiment Steps:

1. **Circuit Assembly:** Assemble your circuit with the solenoid connected to the power supply, ensuring that an ammeter is in series for current measurement and a voltmeter across the solenoid terminals for voltage measurement. Secure all connections properly using insulated wires where necessary to prevent electrical shocks.
2. **Sensor Setup:** Position the Gauss meter or Hall effect sensor at the center of the solenoid to measure the magnetic field strength without making direct contact with the energized coil. Ensure that there is no interference from external magnetic

fields and that the setup is stable.

3. **Data Collection:** Gradually increase the current through the solenoid using the power supply, starting from a low value. At each step, record both the ammeter readings (current) and the Gauss meter or Hall effect sensor readings (magnetic field strength).
4. **Safety Measures:** Throughout the experiment, wear appropriate safety gear including insulated gloves and goggles to protect against electrical hazards and potential injuries from sudden movements of the solenoid if it becomes energized.

By following these steps and using the items listed above, you can safely conduct your experiment on measuring the magnetic field produced by a solenoid as current changes. This approach not only helps in verifying the theoretical relationship between current and magnetic field strength but also ensures that all safety protocols are adhered to during the experimental process.

2 To generate and analyze Lissajous figures using an oscilloscope by applying two sinusoidal signals with different frequencies.

To conduct an experiment aimed at generating and analyzing Lissajous figures using an oscilloscope by applying two sinusoidal signals with different frequencies, you will need specific equipment and should follow certain steps to ensure safety and success.

Required Items:

1. **An Oscilloscope** capable of displaying XY mode.
2. **Function Generators or Signal Sources** to produce the sinusoidal signals.
3. **Connecting Cables** to interface between the function generators and oscilloscope.
4. A **Stable Power Supply** for powering all devices.

Steps to Follow:

1. **Grounding:** Ensure that all equipment is properly grounded to avoid electrical hazards.
2. **Setting Up Function Generators:**
 - Configure two separate function generators or signal sources to produce sinusoidal signals with different frequencies, ensuring they are within their specified voltage limits for safety and proper display on the oscilloscope.
 - For optimal analysis, choose frequencies that have a simple ratio (e.g., 1:2, 2:3) to create clearer Lissajous figures.
3. **Connecting Signals to Oscilloscope:**
 - Connect one function generator output to the X input of the oscilloscope.
 - Connect the other function generator output to the Y input of the oscilloscope using suitable connecting cables.
4. **Oscilloscope Settings:**
 - Set your oscilloscope in XY mode, which allows for the display of Lissajous figures rather than time-based waveforms.
 - Adjust the X and Y gain settings on the oscilloscope until a clear Lissajous figure is visible on the screen.
5. **Analyzing Results:**
 - Observe and analyze the shape of the generated Lissajous figure to determine the frequency ratio between the two input signals. The specific shape can provide insights into the relationship between the frequencies and phases of the sinusoidal waves.

By following these steps, you will be able to safely generate and study Lissajous figures using an oscilloscope, which can further your understanding of wave interactions and frequency ratios in a practical setting.

3 To measure the input and output impedances of an operational amplifier (Op-Amp) in a given configuration.

Experiment: Measuring Input and Output Impedances of an Operational Amplifier

Objective:

To measure the input and output impedances of an operational amplifier (Op-Amp) in a given configuration while ensuring safety.

Items Required:

- Op-Amp (configured as needed for testing)
- High-impedance voltmeter or oscilloscope
- Resistors (of known values, typically high resistance)
- Signal generator
- Multimeter capable of measuring both current and voltage

Experiment Steps:

1. Set Up the Circuit:

- Configure the Op-Amp according to your specific needs for testing (e.g., inverting or non-inverting amplifier configuration).
- Ensure that all components are correctly connected and there is no

short circuit.

2. Measuring Input Impedance:

- Connect a known resistor (preferably high value) in series with one of the Op-Amp's inputs (non-inverting or inverting input).
- Use an oscilloscope or a high-impedance voltmeter to measure the voltage drop across this resistor.
- Calculate the input impedance using Ohm's Law, where $Z_{in} = \frac{V}{I}$ and $I \approx \frac{V_{measured}}{R}$.

3. Measuring Output Impedance:

- Apply a small-signal test source from your signal generator to the output of the Op-Amp.
- Measure both the voltage drop across this load (using the multimeter in voltage mode) and the current through it (using the multimeter in current mode).
- Calculate the output impedance as $Z_{out} = \frac{\Delta V}{\Delta I}$, where ΔV is the change in measured output voltage due to the test source, and ΔI is the resulting change in output current.

4. Safety Precautions:

- Ensure all connections are secure before applying power.
- Use insulated tools to avoid electrical shocks.
- Work in a safe environment; follow standard electrical safety guidelines such as handling components with care, ensuring no exposure to high voltages without proper protection, and using grounding equipment where necessary.

By following these steps and taking the mentioned precautions, you can accurately measure both the input and output impedances of an operational amplifier while maintaining safety throughout the experiment.

4 To study the frequency response of a low-pass filter and determine its cutoff frequency.

To study the frequency response of a low-pass filter and determine its cutoff frequency while ensuring all safety parameters are met, follow these guidelines:

Items Required:

- Oscilloscope
- Function generator
- Resistors and capacitors (to build the low-pass filter)
- Breadboard or circuit board for assembly
- Connecting wires

Safety Measures:

- Ensure that all equipment is properly grounded.
- Use protective eyewear to safeguard your eyes from any potential hazards.
- Avoid direct contact with live circuits.
- Work on non-conductive surfaces to prevent electrical accidents.

Experiment Steps:

1. **Circuit Assembly:** Assemble the low-pass filter using resistors and capacitors on a breadboard or circuit board according to your design specifications.
2. **Setup Function Generator:** Connect the function generator to the input of the

filter. Set it initially to produce sine waves at a low frequency (e.g., 1 Hz). This will serve as your baseline measurement point.

3. **Connect Oscilloscope:** Connect the output side of the filter to the oscilloscope to monitor and record voltage levels across different frequencies.
4. **Frequency Sweep:** Gradually increase the frequency of the sine wave from the function generator while continuously observing the amplitude (voltage) of the output signal on the oscilloscope. Make sure to maintain a steady increase in frequency to obtain clear data points for analysis.
5. **Data Recording:** Document both the frequencies and corresponding voltage levels observed at each step throughout the range, extending well beyond what you anticipate as the cutoff frequency based on your resistor-capacitor values (R and C).
6. **Determine Cutoff Frequency:** Identify the specific point where the output voltage drops to approximately 70.7% of its peak value or -3 dB relative to the input signal. This marks the cutoff frequency of your low-pass filter.

By following these steps and adhering to safety measures, you can effectively study the frequency response characteristics of a low-pass filter and accurately determine its cutoff frequency.

5 To construct and analyze a bridge rectifier circuit and compare its performance with a half-wave rectifier.

Experiment Plan: Bridge Rectifier vs. Half-Wave Rectifier

Objective:

To construct, analyze, and compare the performance of a bridge rectifier circuit with that of a half-wave rectifier circuit.

Items Required:

- **Bridge Rectifier Components:** Four 1N4007 diodes
- **Half-Wave Rectifier Component:** One 1N4007 diode
- Load resistors
- AC voltage source
- Connecting wires
- Multimeter
- Breadboard or circuit board for assembling the circuits

Safety Guidelines:

1. Use insulated tools and ensure your workspace is properly grounded.
2. Verify voltage levels before connecting any power sources using a multimeter.
3. Always disconnect the power supply before making changes to the circuit setup.

Experiment Steps:

Step 1: Setup Preparation

- Ensure all components are available on a flat, non-conductive surface.
- Organize tools and materials needed for safe electrical work.

Step 2: Constructing the Bridge Rectifier Circuit

1. Arrange four diodes (1N4007) in a diamond shape, with AC input connected to two opposite corners of this arrangement.
2. Connect the remaining two corners as DC output points.
3. Attach load resistors at these points for measuring rectified output voltage.

Step 3: Measuring Bridge Rectifier Output

- Using a multimeter, measure and record both the input (AC) and output (DC) voltages of the bridge rectifier under various conditions if necessary.

Step 4: Transition to Half-Wave Rectifier Setup

1. Safely disconnect power sources from the existing setup.
2. Rearrange components to form a half-wave rectifier circuit by connecting one diode in series with a load resistor to an AC source.

Step 5: Measuring Half-Wave Rectifier Output

- Again, use the multimeter to measure and record both input (AC) and output (DC) voltages of this new configuration.

Step 6: Comparative Analysis

1. Compare the performance of both circuits based on recorded data.
2. Note any differences or observations made during testing regarding rectification efficiency, output voltage stability, etc.

Conclusion:

This experiment allows for a direct comparison between bridge and half-wave rectifiers in terms of their ability to convert AC to DC. It ensures that all steps are conducted within safe parameters, providing insights into the practical applications and limitations of each type of rectifier circuit configuration.

6 To determine the turns ratio of a transformer and verify the relationship between the primary and secondary voltages.

To determine the turns ratio of a transformer and verify the relationship between the primary and secondary voltages while ensuring safety parameters are met, follow these guidelines:

Items Required:

- **Transformer** (step-down or step-up)
- **AC voltage source** (such as a function generator)
- **Voltmeter**
- **Connecting wires**
- **Insulated gloves**

Experimental Steps:

1. **Safety Precautions:** Ensure the area is dry and free from water to avoid any electrical hazards. Use insulated tools and wear protective gear like insulated gloves.
2. **Setup Circuit:** Connect the transformer to the AC voltage source with all power off initially for safety. Securely connect the primary winding of the transformer to the AC voltage source using connecting wires.
3. **Measure Primary Voltage:** Turn on the AC voltage source (function generator) and measure the voltage across the primary side using a voltmeter. Record this value as V_1 .
4. **Measure Secondary Voltage:** Without altering the input voltage, now measure the voltage across the secondary winding of the transformer using the same voltmeter technique. Record this value as V_2 .
5. **Calculate Turns Ratio:** The turns ratio (N_1/N_2) can be calculated using the relationship between primary and secondary voltages:

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

6. **Verification:** Compare your measured values with expected theoretical ones if available to verify the relationship.

Safety Measures:

- Ensure all connections are made with the power off.
- Use insulated tools and wear protective gear like insulated gloves.
- Keep the area dry and free from any water or conductive materials that could cause short circuits.

By following these steps and safety measures, you can safely determine the turns ratio of a transformer and verify the relationship between primary and secondary voltages.

7 To calibrate an oscilloscope for accurate measurements of voltage and time.

To effectively calibrate an oscilloscope for accurate measurements of voltage and time, while ensuring that all steps are within safety parameters, follow this detailed plan:

Items Required:

- Oscilloscope (with user manual)
- Calibrated signal generator
- Appropriate cables/adapters

Calibration Procedure with Safety Considerations:

1. **Grounding:** Ensure that both the oscilloscope and any additional equipment like the calibrated signal generator are grounded before beginning the process.
2. **Power Off Connections:** Turn off power to both the oscilloscope and the signal generator before making any connections to avoid electrical shocks or damage to equipment.
3. **Connecting Equipment:** Use appropriate cables/adapters to connect the calibrated signal generator to the oscilloscope. Make sure that all connections are secure and well-insulated to prevent accidental shorts.
4. **Consult User Manual:** Refer to the oscilloscope's user manual for specific calibration procedures unique to your model. This ensures you follow the correct steps provided by the manufacturer.
5. **Vertical Scale Calibration:**

- Input known voltage signals from the calibrated signal generator into the oscilloscope.
 - Adjust the vertical scale settings on the oscilloscope until the displayed voltages match those of the input signal as closely as possible.
6. **Time Base Calibration:**
- Use a known frequency signal from the calibrated signal generator to adjust the time base accuracy of your oscilloscope.
 - Verify that the waveform period matches the expected value based on the input frequency.
7. **Double-Check Connections:** Before powering on, ensure all connections are secure and there is no exposed circuitry accessible which could lead to electrical hazards.
8. **Power Up and Test:**
- Power up both devices.
 - Verify that the measurements remain consistent across multiple tests to confirm accurate calibration.

Safety Considerations:

- **Environment:** Work in a dry environment to prevent electrical shorts and ensure there is no moisture present.
- **Tools:** Use insulated tools when making connections or adjustments to reduce the risk of electric shocks.
- **Emergency Preparedness:** Keep a fire extinguisher nearby that is suitable for dealing with electrical fires, should the need arise.
- **Power Management:** Always turn off power sources before adjusting settings or changing connections to prevent unexpected electrical discharges.

By following these steps and taking into account the outlined safety measures, you can ensure that your oscilloscope calibration process is both accurate and safe.

8 To investigate the resonance behavior of an LC circuit and measure the resonant frequency.

To investigate the resonance behavior of an LC circuit and measure its resonant frequency while ensuring all procedures comply with safety guidelines, follow this plan:

Items Required:

1. Inductor (L)
2. Capacitor (C)
3. Function generator
4. Oscilloscope
5. Resistors and wires for connections

Experiment Steps:

1. **Assemble the LC Circuit:** Connect the inductor L and capacitor C either in parallel or series to form the LC circuit.
2. **Set Up Measurement Equipment:**
 - Connect one end of the LC circuit to the output of a function generator, which will provide a variable frequency input.
 - Use an oscilloscope to measure the voltage across the LC circuit. The oscilloscope should be set up to display the voltage as it varies with changes in frequency.
3. **Measure Resonant Frequency:**
 - Adjust the frequency generated by the function generator and observe

the output on the oscilloscope.

- Identify the resonant frequency, which corresponds to a peak or maximum amplitude displayed on the oscilloscope.

Safety Parameters:

- **Insulated Tools:** Use insulated tools when setting up and adjusting the circuit to avoid short circuits or electrical shocks.
- **Avoid Touching Exposed Components:** Do not touch any exposed components during operation to prevent electric shock.
- **Safe Voltage Levels:** Ensure that the voltage settings on the function generator do not exceed safe limits, typically low-voltage DC and AC sources are used for this type of experiment.
- **Power Handling:** Before making any adjustments or changes to the circuit setup, disconnect the power supply.

By following these steps and maintaining adherence to safety guidelines, you can successfully investigate the resonance behavior of an LC circuit and measure its resonant frequency.

9 To investigate the charging and discharging behavior of a capacitor in an RC circuit and understand the time constant.

To investigate the charging and discharging behavior of a capacitor in an RC circuit and understand the time constant, you will need specific materials and should follow detailed steps to ensure both educational insight and safety during the experiment.

Items Required:

- Resistors (various values depending on your desired time constants)
- Capacitors (suitable for demonstration purposes, various capacitance values)
- Low-voltage DC power supply
- Oscilloscope or multimeter for measurement
- Connecting wires
- Breadboard (optional for easier setup)
- Alligator clips
- Insulated gloves
- Safety goggles

Experiment Steps:

1. Safety Preparation:

- Ensure you are wearing insulated gloves and safety goggles to protect against electrical hazards.
- Make sure the work area is well-ventilated.

2. Circuit Setup:

- Arrange your components on a breadboard or directly wire them according to the RC circuit diagram (resistor in series with capacitor, powered by DC supply).
- Secure all connections using alligator clips and ensure there are no loose wires that could cause shorts.

3. Initial Measurement:

- Connect an oscilloscope or multimeter across the capacitor to measure voltage during charging.
- Power on the circuit at a low voltage setting to start with a safe level of current.

4. Charging Phase:

- Begin the experiment by closing the switch in your circuit and observe how the voltage across the capacitor increases over time until it reaches its maximum value, indicating that the capacitor is fully charged.
- Record data points at regular intervals using the oscilloscope or multimeter to plot a charging curve.

5. **Discharging Phase:**

- Once the capacitor is fully charged, open the switch and measure how the voltage decreases over time as the capacitor discharges through the resistor.
- Again, record data points regularly to plot the discharge curve.

6. **Analysis of Results:**

- Use the recorded data from both charging and discharging phases to calculate the time constant (τ) of your RC circuit using the formula $\tau = R \times C$, where R is resistance and C is capacitance.
- Compare calculated values with observed behavior to validate theoretical understanding.

Safety Guidelines:

- Always ensure that hands are dry before handling electrical components.
- Double-check all connections for secure fastening and insulation.
- Operate the experiment in a well-ventilated area.
- Start with low voltages, increasing only if necessary after ensuring safety measures are in place.

This plan provides a structured approach to understanding RC circuits while prioritizing safety at every step.

10 To verify the operation of basic logic gates: AND, OR, NOT, NAND, NOR, XOR, and XNOR

To verify the operation of basic logic gates (AND, OR, NOT, NAND, NOR, XOR, and XNOR) within safety parameters, follow these guidelines:

Items Required:

- Breadboard
- Logic probes
- LEDs (light-emitting diodes)
- Resistors (to protect LEDs from excessive current)
- Power supply (preferably 5V DC for low voltage safety)
- Logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR) - these can be obtained in IC packages like the 7400 series or CD4000 series

Experiment Steps:

1. Set Up Breadboard:

- Place a power supply to provide necessary voltage.
- Connect one terminal of your power supply to the positive rail and the other to the ground rail on the breadboard.

2. Logic Gate Testing Setup:

- For each gate, connect its inputs (A and B for two-input gates) using jumper wires from different positions on the breadboard where you can easily switch input states.
- Connect an LED with a series resistor to the output of each gate to visually observe the output state.

3. Testing Each Gate:

- Use logic probes or manually toggle inputs by connecting them directly to power (for high state) or ground (for low state).
- Record the output for every possible combination of inputs according to each gate's truth table.
 - AND Gate: Output is high only if both A and B are high.
 - OR Gate: Output is high if at least one input (A or B) is high.
 - NOT Gate: Output is the inverse of the single input.
 - NAND Gate: Output is low only if both A and B are high; otherwise, it's high.
 - NOR Gate: Output is high only if both A and B are low; otherwise, it's low.
 - XOR Gate: Output is high if one but not both inputs (A or

B) are high.

- XNOR Gate: Output is high if both inputs match (both high or both low).

4. **Observation and Verification:**

- Compare the observed output states with each gate's expected truth table to verify their operation.

Safety Precautions:

- Use a low voltage power supply (like 5V DC) to reduce risk.
- Ensure proper grounding of all components to prevent electrical shocks.
- Avoid touching exposed terminals, especially when they are connected to power sources.
- Wear protective eyewear to guard against potential debris or if working with hot soldering irons.
- Always disconnect the power source before making any changes to the circuit setup.

By following these steps and adhering to safety measures, you can effectively verify the operation of each basic logic gate within safe parameters.

11 To implement and analyze operational amplifier (Op-Amp) circuits: inverting, non-inverting, summing, and differentiator configurations.

To conduct experiments on operational amplifier (Op-Amp) circuits including inverting, non-inverting, summing, and differentiator configurations, you will need the following components:

- Operational Amplifier ICs (like LM741)
- Resistors
- Capacitors
- DC Power Supply
- Breadboard or PCB for circuit assembly
- Multimeter to measure voltages and currents
- Oscilloscope (optional but useful for observing waveforms)

Below are detailed steps for each Op-Amp configuration, including safety guidelines:

Inverting Op-Amp Circuit:

1. **Connect the non-inverting input terminal of the Op-Amp to ground.**
2. **Apply the input voltage to the inverting input through a resistor (R_1).**
3. **Place another resistor (R_f) between the inverting input and the output terminal of the Op-Amp, forming a feedback loop.**
4. **Use the multimeter or oscilloscope to measure the output.**

Non-Inverting Op-Amp Circuit:

1. **Apply the input voltage directly to the non-inverting terminal.**
2. **Connect one end of resistor R_1 between inverting and non-inverting inputs.**
3. **Place another resistor (R_f) between output and inverting input, creating the feedback loop.**
4. **Measure the output using a multimeter or oscilloscope.**

Summing Op-Amp Circuit:

1. **Connect each input through individual resistors (R_1 , R_2) directly into the inverting terminal.**
2. **Place a feedback resistor between output and inverting input.**
3. **Use the multimeter or oscilloscope to measure the combined output voltage.**

Differentiating Op-Amp Circuit:

1. **Connect a capacitor between the inverting terminal of the Op-Amp and its input source.**

2. **Place resistor R_f from output to inverting terminal for feedback.**
3. **Use the multimeter or oscilloscope to measure the derivative signal at the output.**

Safety Guidelines:

- Always use the correct polarity when connecting DC power supplies.
- Avoid overloading resistors by exceeding their wattage ratings.
- Keep hands dry and remove all jewelry before handling circuits.
- Ensure capacitors are discharged safely after removing from power supply.

By following these steps and adhering to safety guidelines, you can effectively implement and analyze various operational amplifier circuits while ensuring the experiments remain within safe parameters.

12 To design a common emitter amplifier and analyze its frequency response.

To design and analyze a common emitter amplifier, including its frequency response while ensuring safety parameters are met, follow this detailed plan:

Items Required:

1. **BC547 Transistor** - A commonly used NPN transistor suitable for amplifying signals.
2. **Resistors** (various values based on your design calculations) - Used to set the biasing and gain of the amplifier.
3. **Capacitors** (values based on design requirements) - For coupling capacitors that

allow AC signals while blocking DC components, and bypass capacitors for stabilizing voltage levels.

4. **Power Supply Unit** capable of providing required voltages safely - A stable power supply is essential to ensure safe operation without exceeding component ratings.
5. **Breadboard or PCB** - To assemble the circuit either temporarily (breadboard) or permanently (PCB).
6. **Oscilloscope** - For observing and measuring output signals, ensuring accuracy in your measurements.
7. **Function Generator** - To provide a range of input frequencies for testing the frequency response.

Experimental Steps:

1. **Design the Circuit:** Using appropriate resistor and capacitor values based on design calculations to achieve a desired gain and stability. The choice of components significantly impacts the performance of the amplifier.
2. **Assemble Components Safely:** Connect all components on either a breadboard or PCB ensuring correct polarity, especially for diodes and transistors (BC547). Verify that each component is rated appropriately to avoid damage from exceeding voltage or current limits.
3. **Apply Power and Monitor Signals:**
 - Turn on the power supply unit and use an oscilloscope to monitor output signals.
 - Use a function generator to vary input frequency while observing how the amplifier's gain changes with different frequencies.
4. **Analyze Data:** Record measurements of gain across various frequencies to understand the bandwidth (frequency response) of your common emitter amplifier.
5. **Ensure Safety:**
 - Properly ground all equipment before starting and during experimentation.
 - Always double-check connections for correct polarity, especially when dealing with power sources.

By following these steps carefully, you can design a functional common emitter amplifier circuit while ensuring safety through proper grounding and component rating checks throughout the experiment.

13 To analyze the input and output characteristics of Bipolar Junction Transistors (BJTs) and Field-Effect Transistors (FETs).

To analyze the input and output characteristics of Bipolar Junction Transistors (BJTs) and Field-Effect Transistors (FETs), you should follow these steps while ensuring safety and adhering to best practices in electrical engineering labs.

Items Required:

1. **DC Power Supply:** To supply necessary voltages.
2. **Multimeter/Oscilloscope:** For measuring voltages, currents, and plotting characteristics curves.
3. **Function Generator (optional):** Useful for AC experiments but not essential for DC characterization.
4. **Resistors:** For current limiting and to create biasing conditions.
5. **Ammeters/Voltmeters:** To measure specific current or voltage levels accurately.
6. **Breadboard/Protoboard:** To set up circuits easily without soldering.
7. **Connecting Wires:** To interconnect components in the circuit.
8. **Insulated Gloves and Safety Goggles:** For protection against electrical hazards.

Experiment Steps:

1. **Circuit Setup:**

- Set up a common-emitter configuration for BJT and a common-source configuration for FET on your breadboard or protoboard. Ensure that all connections are secure to avoid loose wires.

2. BJT Characterization:

- For input characteristics, vary the base-emitter voltage V_{BE} while keeping the collector-emitter voltage V_{CE} constant (usually at around 5-10V), and record the corresponding changes in base current I_B . Plot I_B vs. V_{BE} .
- For output characteristics, fix a small base current I_B and vary the collector-emitter voltage V_{CE} while recording changes in collector current I_C . Plot I_C vs. V_{CE} .

3. FET Characterization:

- For input characteristics, vary the gate-source voltage V_{GS} at different levels of drain-source voltage V_{DS} , and record the corresponding changes in drain current I_D . Plot I_D vs. V_{GS} .
- For output characteristics, fix a specific value for V_{GS} and vary V_{DS} , recording changes in I_D . Plot I_D vs. V_{DS} .

4. Safety Measures:

- Ensure all equipment is properly grounded to avoid electrical shock.
- Avoid creating short circuits that could damage the components or cause injury.
- Use insulated gloves and safety goggles when handling potentially hazardous voltages or materials.
- Keep a fire extinguisher accessible in case of an emergency.

By following these steps and maintaining safety protocols, you can effectively analyze both the input and output characteristics of BJTs and FETs.

14 To analyze and implement wave-shaping circuits using diodes for clipping and clamping applications.

To analyze and implement wave-shaping circuits using diodes for clipping and clamping applications, follow these detailed instructions that adhere to safety parameters:

Items Required:

- **Signal Diode:** 1N4148 (or equivalent)
- **Resistors:** For clipping circuit; values depend on the application
- **Capacitors:** For clamping circuit; values depend on the application
- **AC Source:** To generate input waveform
- **Voltmeter or Oscilloscope:** To measure and observe voltage changes across different points in the circuits

Safety Checks:

1. **Use Insulated Tools:** Ensure that all tools used are insulated to avoid accidental short-circuits.
2. **Wear Protective Eyewear:** Protect eyes from potential splashes or sparks during experimentation.
3. **Proper Grounding of Power Supplies:** Make sure power supplies are properly grounded before connecting any components.

Experiment Steps:

Clipping Circuit:

1. Connect one end of the AC source to one end of a resistor.
2. Connect the other end of the resistor to the anode (positive terminal) of the diode for a positive clipper, or the cathode (negative terminal) for a negative clipper.
3. Ground the cathode (if using a positive clipper) or the anode (for a negative clipper).
4. Use a voltmeter or oscilloscope to measure and observe voltage changes across different points in the circuit.

Clamping Circuit:

1. Connect one end of the AC source to one end of a capacitor.
2. Connect the other end of the capacitor through a diode (oriented according to the type of clamping: positive clamping requires forward biasing, negative clamping reverse biasing).
3. Ground the side opposite to where the AC source is connected.
4. Measure the midpoint between the resistor and capacitor for voltage shifts using a voltmeter or oscilloscope.

By following these steps while adhering to safety guidelines, you can successfully analyze and implement wave-shaping circuits using diodes for both clipping and clamping applications.

15 To construct and analyze the performance of half-wave and full-wave rectifiers, both with and without filters.

To construct and analyze the performance of half-wave and full-wave rectifiers both with and without filters, you'll need the following items:

- Diodes (rectifying elements)
- Resistors (load resistors)
- Capacitors (for filtering if applicable)
- Transformer (to step down voltage for safety and practicality)
- AC power supply
- Multimeter (for measurements)

Safety Measures:

1. Use a transformer with an output voltage appropriate for your experiment to avoid working with dangerous levels of AC voltage.
2. Always use insulated tools when handling circuits that could carry current.
3. Ensure capacitors are discharged after the circuit is powered down to prevent electrical shock.

Experiment Steps:

Half-Wave Rectifier:

1. Without Filter:

- Connect one end of the primary winding of the transformer to your AC power supply, and connect the other end to ground.
- Across the secondary winding, connect a diode with its anode connected to the positive terminal of a DC load (resistor) and cathode to the negative side of the load.

2. With Filter:

- Follow steps 1 and 2 for connecting the transformer and diode to the load resistor as described above.
- Add a capacitor in parallel with the load resistor to smooth out the output voltage.

Full-Wave Rectifier:

1. Without Filter (using center-tapped transformer):

- Connect one end of the primary winding of the transformer to your AC power supply, and connect the other end to ground.
- Use a center-tapped transformer for secondary connections; the center tap is connected to the anode side of two diodes while the cathodes are directed towards both ends of a load resistor.

2. With Filter (using center-tapped transformer):

- Follow steps 1 and 2 as described above.
- Add a capacitor across the load resistor for smoothing the output voltage.

3. Without Filter (bridge configuration):

- Connect one end of the primary winding to your AC power supply, and connect the other end to ground.
- Use four diodes in a bridge configuration where two pairs are connected back-to-back such that they conduct on alternate half-cycles of the input signal.

4. With Filter (bridge configuration):

- Follow steps 1 and 2 as described above for the bridge setup.

- Add a capacitor across the load resistor to filter out ripples in the output voltage.

Analyzing Performance:

- Use a multimeter to measure the DC output voltages of each rectifier circuit both with and without filters.
- Observe how filtering affects the ripple factor (the ratio of AC component to DC component) for both types of rectifiers.
- Document your observations on waveforms using an oscilloscope if available, noting differences in ripple voltage levels.

Ensure you follow all safety guidelines throughout the experiment to protect yourself and ensure accurate results.

16 To analyze voltage regulation using a Zener diode.

Experiment: Analyze Voltage Regulation Using a Zener Diode

Objective:

To analyze how a Zener diode regulates voltage by maintaining a constant output voltage across a load resistor.

Safety Precautions:

- Ensure that all connections are made securely to prevent accidental short circuits or loose wires, which could cause equipment damage or electrical shock.
- Use an appropriate current-limiting resistor to avoid excessive current flow through the Zener diode and potentially damaging it.

- Always disconnect the power supply when making circuit adjustments.

Items Required:

1. **Zener Diode:** Choose one with a desired voltage regulation level.
2. **Resistors:**
 - One for limiting the current flowing into the Zener diode (based on maximum expected input voltage and the Zener's rated current).
 - One load resistor to serve as the output point where regulated voltage is measured.
3. **Variable DC Power Supply:** To supply adjustable voltage levels.
4. **Voltmeter or Multimeter:** For measuring voltages.

Experiment Steps:

1. **Select Components:**
 - Choose a Zener diode with the desired regulation level (e.g., 5V, 9V).
 - Select resistors suitable for your circuit: one for current limiting and one as a load resistor.
2. **Setup the Circuit:**
 - Connect the anode of the Zener diode to the positive terminal of the variable DC power supply through the current-limiting resistor.
 - Connect the cathode of the Zener diode directly to one end of the load resistor.
 - The other end of the load resistor should connect back to the negative terminal of the power supply, completing the circuit.
3. **Measure Voltage:**
 - Use a voltmeter or multimeter and set it up across the load resistor (between its two ends) to measure the regulated output voltage.
4. **Apply Power and Observe:**
 - Turn on the variable DC power supply.
 - Gradually adjust the input voltage while observing the output voltage measured across the load resistor.
 - Note how the Zener diode maintains a constant regulated output even as the input voltage changes, provided that it remains above the Zener breakdown voltage.

5. **Ensure Safety:**

- Secure all connections to prevent loose wires or short circuits.
- After completing the measurements and observations, turn off the power supply and carefully disconnect and disassemble your circuit.

Conclusion:

This experiment demonstrates the role of a Zener diode in voltage regulation within a basic electronic setup. By following these steps with safety measures in mind, you can effectively analyze how the Zener diode maintains a constant output voltage across various input voltages.

17 To study the forward and reverse bias characteristics of a PN junction diode.

To study the forward and reverse bias characteristics of a PN junction diode, you will need the following items:

- A DC power supply
- Diodes (PN junction)
- Ammeter or multimeter for measuring current
- Voltmeter or multimeter for measuring voltage
- Connecting wires
- Breadboard or circuit board

Follow these steps to conduct your experiment safely and effectively:

1. **Setup:** Arrange your breadboard or circuit board.
2. **Forward Bias Connection:** Connect the diode to the power supply through an

ammeter (to measure current) and voltmeter (to measure voltage). Ensure that you respect polarity conventions; connect the positive terminal of the power source to the p-side of the diode for forward bias.

3. **Voltage Ramp-Up in Forward Bias:** Start with a low voltage from the power supply, then slowly increase it step by step while recording both the voltage across and the current through the diode.
4. **Reverse Bias Connection:** Reverse the connections for reverse bias testing, ensuring that you connect the positive terminal of the power source to the n-side of the diode.
5. **Voltage Ramp-Up in Reverse Bias:** Again start at a low voltage and gradually increase it while recording both the voltage across and current through the diode.
6. **Data Recording and Analysis:** Carefully record your data for each step. Plot a graph of voltage versus current to observe and analyze the characteristics of the PN junction diode under both forward and reverse bias conditions.
7. **Safety Precautions:** Ensure not to exceed the maximum ratings of the diode to avoid damage or safety hazards.

By following these steps, you can study how a PN junction diode behaves under forward and reverse biases while maintaining safe experimental practices.

18 To study the behavior of resistors in series and parallel configurations, including the equivalent resistance calculation.

To study the behavior of resistors in both series and parallel configurations, including calculating equivalent resistance, you can follow these steps while ensuring adherence to safety parameters:

Items Required:

- **Resistors** (with known resistances)
- **Power Supply**
- **Connecting Wires**
- **Ammeter**
- **Voltmeter**
- **Ohmmeter** (optional for checking individual resistor values)

Experiment Steps with Safety Considerations:

Series Configuration Experiment:

1. **Setup:** Ensure that all connections are secure and prevent any short circuits.
 - Connect the power supply to one end of the first resistor.
 - Continue connecting subsequent resistors in series using wires, ensuring no direct connection between the positive and negative terminals of the power supply.
2. **Measure Current:**
 - Attach an ammeter in series within the circuit to measure the current flowing through it.
3. **Voltage Measurement:**
 - Use a voltmeter to measure the voltage drop across each resistor.
4. **Calculate Equivalent Resistance:**
 - Add up the individual resistances of all resistors connected in series to find the equivalent resistance ($R_{eq} = R_1 + R_2 + \dots + R_n$).
5. **Safety Precautions:** Ensure that the power supply is low-voltage and that the resistors can handle the current without overheating.

Parallel Configuration Experiment:

1. **Setup:**
 - Connect all one side of the resistors to a single point, then connect their other sides together and link this to another point.
 - Make sure no short circuits occur during connection setup.
2. **Measure Current:**
 - Use an ammeter to measure the total current supplied by the power

source.

3. **Voltage Measurement:**

- Measure the voltage drop across each resistor using a voltmeter.

4. **Calculate Equivalent Resistance:**

- Calculate the equivalent resistance (R_{eq}) for resistors in parallel by summing up the reciprocals of individual resistances and taking the reciprocal of this sum ($1/R_{eq} = 1/R_1 + 1/R_2 + \dots + 1/R_n$).

5. **Safety Precautions:** Verify that connections are secure, avoid short circuits, and ensure the power supply voltage is appropriate for your setup to prevent overheating.

By following these steps and considering safety measures such as using a low-voltage power supply and ensuring resistors can handle the current, you will be able to safely study and understand the behavior of resistors in both series and parallel configurations.

19 To apply Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) to analyze and validate simple electrical circuits.

Experiment Plan: Application of Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL)

Objective:

To apply Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) to analyze and validate simple electrical circuits while ensuring all procedures are within safety parameters.

Materials Required:

- Resistors (various values)
- Battery or power supply
- Voltmeter
- Ammeter
- Wires with appropriate insulation

Safety Parameters:

1. Use insulated tools and wear protective gear such as safety glasses.
2. Ensure voltages do not exceed the ratings of components used, like resistors.
3. Secure all connections to avoid unintended disconnections.

Experiment Steps:

For Kirchhoff's Voltage Law (KVL):

1. Circuit Setup:

- Connect a battery or power supply with two resistors in series using insulated wires.

2. Measurements and Analysis:

- Measure the voltage across each resistor using a voltmeter.
- Record these values.
- Sum up all measured voltages around the loop, including the supply voltage (taking into account direction).
- Validate KVL by confirming that the sum of the voltages around any closed loop equals zero.

For Kirchhoff's Current Law (KCL):

1. Circuit Setup:

- Connect a battery or power supply to form a parallel circuit with resistors.

2. Measurements and Analysis:

- Identify nodes where currents can split or combine.
- Measure the current entering each node using an ammeter.
- Record these values.

- Sum up all currents entering and leaving each node.
- Validate KCL by confirming that the sum of currents entering a node equals the sum of currents leaving it.

Conclusion:

By following this experimental setup, you can effectively apply both Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL). The steps are designed to ensure safety while providing clear evidence supporting these fundamental principles in circuit analysis.

20 To verify the relationship between voltage (V), current (I), and resistance (R) in an electrical circuit, as expressed by Ohm's Law: $V=IR$ $V = IR$ $V=IR$

To conduct an experiment to verify Ohm's Law ($V = IR$), where V is voltage, I is current, and R is resistance, follow these steps while ensuring safety guidelines are adhered to:

Items Required:

- A variable power supply (to vary the voltage)
- An ammeter (to measure current through the circuit)
- A voltmeter (to measure voltage across the resistor)
- Resistors of known values
- Connecting wires
- Breadboard or a circuit board for setting up the experiment

Safety Parameters:

1. Use low voltages to prevent damage to components and injury.
2. Avoid touching any parts of the circuit while it is powered.
3. Ensure all connections are secure to prevent short circuits.

Experiment Steps:

1. **Set Up Circuit:** Construct a simple electrical circuit using a variable power supply, resistor, connecting wires on a breadboard or circuit board.
2. **Ammeter in Series:** Connect an ammeter in series with the resistor to measure the current flowing through it accurately.
3. **Voltmeter Across Resistor:** Attach a voltmeter across the resistor to measure the voltage drop directly over the resistor.
4. **Adjust Voltage Safely:** Using the variable power supply, adjust the output voltage at several different levels (within safe limits) and record the corresponding current readings for each voltage setting. Ensure you remain within the safety parameters by using low voltages to prevent any hazards.
5. **Data Collection & Calculation:** With the recorded data of V and I , calculate the resistance ($R = \frac{V}{I}$) at various voltage levels.
6. **Verification:** Compare the calculated resistances with the known value of the resistor used in your setup to verify if Ohm's Law holds true for each measurement. This comparison will allow you to validate whether $V = IR$ is accurately represented by your experimental data.

By following these detailed steps and adhering to safety measures, you can successfully conduct an experiment to verify Ohm's Law while ensuring the safety of all participants involved.