DIVERGING (REFLECTOR)

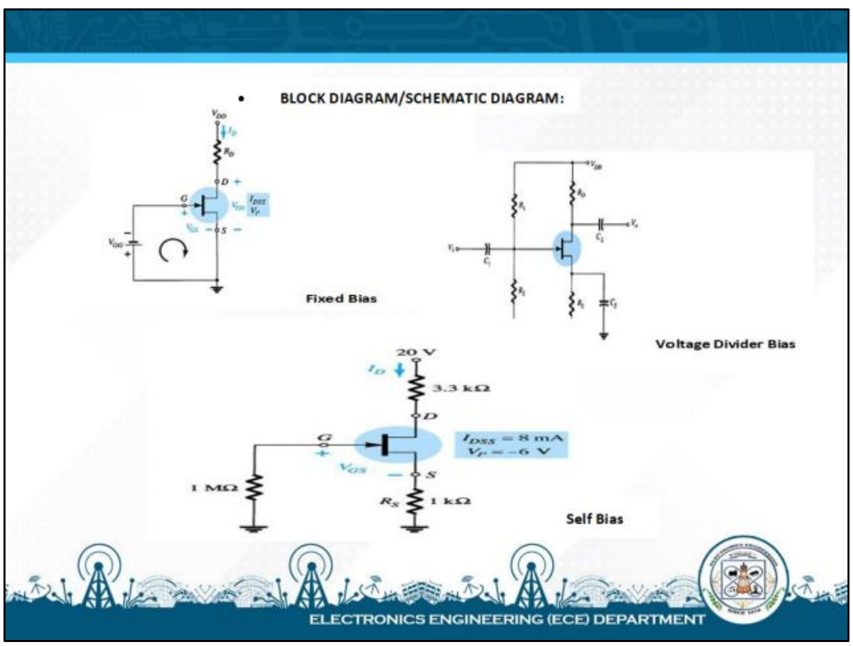
EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

BEGINNER

I. **Main Objective**: To observe and reflect on the process of building FET bias circuits and understand how voltage and current readings relate to circuit behavior.

II. **Procedure:**

1. Enter the virtual laboratory. Start by watching a short in-VR presentation.
2. Use what you learned from the presentation to decide on values for the resistors and capacitors in your circuit. You may apply basic design formulas, but you're free to make reasonable choices based on your understanding.
3. Assemble the FET bias circuit shown below within the VR environment. Use the same structure but apply the component values you selected.
4. Insert virtual measuring tools such as voltmeters and ammeters to monitor voltages and currents at key points in the circuit especially at the gate, drain, and source.
5. Record your measurements on a worksheet outside the VR environment for analysis.
6. Compare your recorded results with the expected values based on your chosen components. Use the formulas discussed in the presentation to help with your calculations. Note any differences and reflect on possible reasons why.
7. Create a simple block diagram to represent how your measurement setup looked inside the VR lab. Include where the meters were placed and what values you measured. This helps visualize how your version of the circuit was tested.



EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

1. OBJECTIVES	
A. Content Standards	• Learners demonstrate understanding of the basic operation of a FET bias circuit by assembling a given circuit correctly in a VR laboratory. • Learners apply safe handling practices of virtual instruments (breadboard, voltmeter, ammeter) for basic measurement tasks.
B. Performance Standards	• Learners accurately follow a guided procedure to assemble a simple FET bias circuit in VR. • Learners take basic voltage and current readings at specified points with minimal error. • Learners record and compute basic voltage and current values using straightforward formulas.
C. Learning Competencies/Objectives	• Assemble the given FET bias circuit in VR following basic guided instructions. • Perform simple voltage and current measurements using VR instruments. • Record measurements in a basic table and apply simple formulas to compute voltage and current values. • Create a basic block diagram showing instrument connections.
2. CONTENT	Experiment 5: Field Effect Transistor Biasing
3. LEARNING RESOURCES	
A. References	• ECEN 30034 Experiments Material Module 9 • ECEN 30034 Instructional Material • Electronics Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky 10 ed.
4. PROCEDURES	
A. Pre-Activity Preparation	**NAVIGATION OF VIRTUAL LABORATORY** • Students enter the VR laboratory environment and are given 5 minutes to practice basic navigation • Teachers will facilitate the activity by giving instructions, answering questions, and ensuring students are familiar with the VR setup while they explore. **LEARNING STYLE IDENTIFICATION** • Students are given 5 minutes to complete a quick Learning Style Questionnaire to determine if they are Pragmatist, Theorist, Reflector, or Activist.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

	KNOWLEDGE LEVEL ASSESSMENT • Students are given 10 minutes to take a pre-test assessing their understanding of FET bias circuits. This will classify them into Beginner, Intermediate, or Advanced levels. **ASSIGNMENT OF TRACKS** • Based on learning style and knowledge level results, students are assigned the appropriate version of the VR presentation and activity procedure.
B. Discussion of Concepts	**INTRODUCTION** A pleasant morning everyone! I'm excited to see you here in our virtual classroom today! Welcome to the Electrosphere! Today, we will explore how to assemble and measure a basic FET bias circuit. We'll work step-by-step, applying only what's practical and needed to complete the task. Don't worry about complex theories right now. We'll focus on doing the circuit using tools properly, reading voltages, and understanding how a circuit works through real actions. Are you ready to get started? Let's jump into our virtual world and bring these circuits to life! **PART 1: WHY FET BIAS CIRCUIT?** Before jumping into building, let's take a moment to observe and reflect on why setting up a proper FET bias circuit matters. In many electronic devices like amplifiers and radios, the Field-Effect Transistor (FET) must operate within a specific region. This depends heavily on biasing—the way we apply voltages and currents to the transistor. Without correct biasing, the FET may not turn on properly, may distort signals, or may even fail to work entirely. As you watch the VR presentation, focus on these visual elements: • A simple FET circuit diagram and how the components connect.

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The positions of resistors and capacitors in the bias network.
Where and how the power supply (VDD) is applied to the circuit.

Take time to pause and reflect on each stage shown in the VR demo. Consider:

Why are the resistors placed in those positions?
What role do the capacitors play?
What would happen if the VDD was too high or too low?

Your goal today is to build this circuit virtually, observe how it behaves, and compare your measured values with what you expect. Through this, you’ll deepen your understanding of how a FET bias circuit supports proper transistor operation.

Let your observations guide your design choices.

PART 2: WHAT IS VDD AND WHY DOES IT MATTER?

Before selecting a value for VDD, take a step back and reflect on its role in the circuit.

VDD is the main supply voltage connected to the drain of the FET. It’s what powers the circuit. The value you choose directly affects how the FET behaves—too low, and it may not turn on; too high, and it could overheat or distort the signal.

As you explore the VR simulation, observe how different VDD values influence circuit behavior.

Think about:

How does the output signal change as VDD increases?
What signs show that the FET is entering distortion or cutoff?

Visual cues in the VR presentation:

Watch how the waveform responds when VDD is too low or too high.

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- Observe the temperature or voltage stress indicators on the FET.
- Reflect on how component choices adapt to each VDD level.

Common VDD ranges and where they are used:

- 5V–9V: Used in low-power applications (e.g., sensors, portable devices).
- 12V–15V: Common for analog circuits in labs or classrooms.
- 18V–24V: Seen in RF or power applications (requires cooling and protection).

As a reflector learner, take a moment after the demo to compare these use cases and consider:

What application are you aiming for?
Which VDD range best fits your design?
What could go wrong if the wrong value is used?

Use this insight to guide your design decisions in the next steps of the activity.

PART 3: COMPONENTS' PREVIEW

Before diving into the activity, pause and explore each component you'll be working with. Understanding their role and how they connect can help avoid confusion later on.

Components to Observe in the VR Lab:

- Resistors – You'll use pre-selected values. Take note of their position and what they limit (e.g., current at gate or drain).
- Capacitors – Used for filtering or coupling. Watch how they influence stability.
- Breadboard – Visualize the layout. Trace where each wire goes. Mistakes in placement often lead to errors.
- Multimeter – Used to measure voltage and current. Explore where to place the probes in different test points.

PART 4: OBSERVING FET BIASING METHODS

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

Before you try building anything, take a moment to explore and reflect on the different ways to bias a FET. Each method has its own behavior and purpose. In the VR lab, you can visually examine how the circuit layout and component positions change depending on the biasing type.

Explore These Common Biasing Techniques:

1. Fixed Bias
   - Simple and fast.
   - Gate is connected directly to the supply through one resistor.
2. Self-Bias
   - Uses a resistor at the source (RS) to create feedback.
3. Voltage Divider Bias
   - Uses two resistors to form a voltage divider that sets the gate voltage.
4. Feedback Bias
   - A resistor connects the output back to the gate.
   - Often used with enhancement-mode MOSFETs.

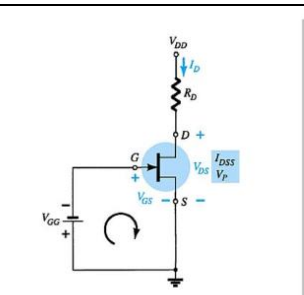
PART 5: REFLECTING ON BASIC FORMULAS

Instead of jumping straight into solving, take a step back and **observe how each formula connects to real parts of the circuit**. Watch the VR demo to see these formulas in action. Notice where values are measured and how they're applied.

Key Formulas Presented:

- *Ohm's Law: V = IR (to find correct resistor values for gate, drain, and source)*
- *Fixed-Bias Calculations*

$$V_{DS} = V_{DD} - I_D R_D$$
$$V_S = 0V$$
$$V_C = V_{DS}$$
$$V = V_{GS}$$
$$V_{GS} = -V_{GG}$$



- *Self-Bias Calculations*

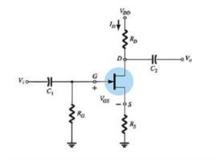
EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

For the indicated loop, $V_{GS} = -I_D R_S$

To solve this equation:

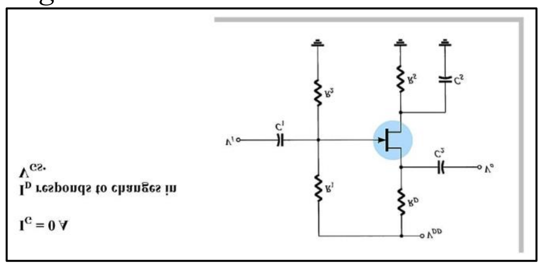
- **Select an $I_D < I_{DSS}$ and use the component value of R_S to calculate V_{GS}**
- **Plot the point identified by I_D and V_{GS}. Draw a line from the origin of the axis to this point.**
- **Plot the transfer curve using I_{DSS} and V_P ($V_P = V_{GSoff}$ in specification sheets) and a few points such as $I_D = I_{DSS} / 4$ and $I_D = I_{DSS} / 2$ etc.**

The Q-point is located where the first line intersects the transfer curve. Use the value of I_D at the Q-point (I_{DQ}) to solve for the other voltages:



$$V_{DS} = V_{DD} - I_D(R_S + R_D)$$
$$V_S = I_D R_S$$
$$V_D = V_{DS} + V_S = V_{DD} - V_{RD}$$

- *Voltage-Divider Bias Calculations*



V_G is equal to the voltage across divider resistor R_2:

$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$$

Using Kirchhoff's Law:

$$V_{GS} = V_G - I_D R_S$$

The Q point is established by plotting a line that intersects the transfer curve.

Voltage-Divider Q-point

Step 1

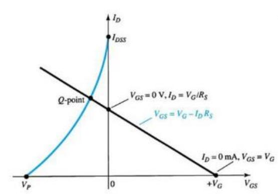
Plot the line by plotting two points:
- $V_{GS} = V_G$, $I_D = 0$ A
- $V_{GS} = 0$ V, $I_D = V_G / R_S$

Step 2

Plot the transfer curve by plotting I_{DSS}, V_P and the calculated values of I_D

Step 3

The Q-point is located where the line intersects the transfer curve



Using the value of I_D at the Q-point, solve for the other variables in the voltage-divider bias circuit:

$$V_{DS} = V_{DD} - I_D(R_D + R_S)$$
$$V_D = V_{DD} - I_D R_D$$
$$V_S = I_D R_S$$
$$I_{R1} = I_{R2} = \frac{V_{DD}}{R_1 + R_2}$$

- *Reminder that capacitors help smooth out voltages*

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

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PART 6: BASIC SETUP

Before starting your own setup, **observe the complete demonstration in VR**. A voice-guided teacher will walk you through each step—watch closely how each component is placed and connected.

What the student will See in the VR Demo:

- *Dragging and placing the FET onto the breadboard*
- *Inserting the resistors and capacitors into correct positions*
- *Attaching the power supply (VDD) correctly*
- *Proper placement of multimeter probes for accurate readings*

Student's task:

- Focus on understanding why each part goes where it does.
- Observe how the setup looks when it's done correctly.

PART 7: MEASURE AND REFLECT

Now that your circuit is set up, take a moment to observe how it looks and feels before measuring. Make sure your connections resemble the VR demonstration.
What You'll Measure Using the Multimeter:

- VGS — Voltage from Gate to Source
- VDS — Voltage from Drain to Source
- ID — Current flowing through the Drain

PART 8: CONCLUSION

You now have everything you need to start building your first FET bias circuit. Today, you learned the essentials: what a bias circuit does, how VDD powers the circuit, how to use simple formulas and how to choose the right resistors and capacitors. Now, it's your turn to make your FET bias circuit!

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C. Presentation of the Experiment and Establishing a Purpose

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EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

Materials: VR headset and controller, worksheet

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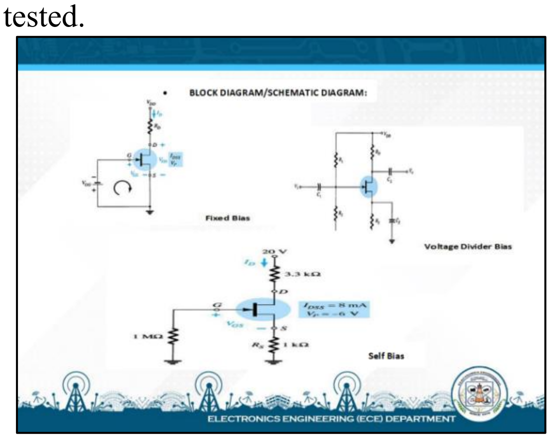
EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

Main Objective: To observe and reflect on the process of building FET bias circuits and understand how voltage and current readings relate to circuit behavior.

Procedure:

1. Enter the virtual laboratory. Start by watching a short in-VR presentation.
2. Use what you learned from the presentation to decide on values for the resistors and capacitors in your circuit. You may apply basic design formulas, but you're free to make reasonable choices based on your understanding.
3. Assemble the FET bias circuit shown below within the VR environment. Use the same structure but apply the component values you selected.
4. Insert virtual measuring tools such as voltmeters and ammeters to monitor voltages and currents at key points in the circuit especially at the gate, drain, and source.
5. Record your measurements on a worksheet outside the VR environment for analysis.
6. Compare your recorded results with the expected values based on your chosen components. Use the formulas discussed in the presentation to help with your calculations. Note any differences and reflect on possible reasons why.
7. Create a simple block diagram to represent how your measurement setup looked inside the VR lab. Include where the meters were placed and what values you measured. This helps visualize how your version of the circuit was tested.



EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

D. Post-Assessment (Knowledge Check)	Students are given 10 minutes to take a post-test inside VR to measure knowledge improvement by comparing pre-test and post-test results.
E. Experiment Conclusion	The teacher summarizes key learnings, discusses results, and addresses common challenges observed during the VR activities.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

INTERMEDIATE

I. **Main Objective:** To observe and reflect on the process of building FET bias circuits and understand how voltage and current readings relate to circuit behavior through practical simulation and thoughtful experimentation.

II. **Procedure:**

1. Enter the virtual laboratory and begin watching the briefly revisits FET biasing principles.
2. Based on your understanding, decide on suitable resistor and capacitor values using basic design equations. Consider how different values might shift the circuit's behavior.
3. Examine the reference circuit diagram displayed in the VR space. Use this as your layout guide. You will use your own component values based on your calculations.
4. Assemble the circuit in the VR environment.
5. Attach virtual voltmeters and ammeters at essential points (gate, drain, source) to monitor circuit behavior. Consider placing tools strategically to observe how voltage divides and current flows.
6. Run the simulation and take note of voltage and current values across different nodes. Record your observations manually in a worksheet outside the VR simulation.
7. Compare your measured values with those expected from your calculations. Use the equations discussed in the presentation to check for accuracy. Reflect on any discrepancies and explain them based on your understanding of circuit behavior.
8. Create a clear block diagram showing your measurement setup inside the VR lab. Indicate where the meters were placed and the values observed to help illustrate how your test was conducted.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

1. OBJECTIVES	
A. Content Standards	• Learners demonstrate understanding of FET bias circuit behavior through independent assembly and theoretical validation using measurement results. • Learners apply analytical thinking to recognize and explain minor discrepancies between theoretical and practical measurements.
B. Performance Standards	• Learners independently assemble the given FET bias circuit in VR, selecting appropriate resistor and capacitor values based on calculations. • Learners perform accurate multi-point measurements and organize data for analysis. • Learners compare theoretical and measured results and explain possible causes of deviations.
C. Learning Competencies/Objectives	• Assemble the given FET bias circuit in VR independently with minimal guidance. • Select suitable resistor and capacitor values based on theoretical calculations. • Accurately measure voltages and currents across multiple circuit points. • Organize data systematically, compare theoretical and measured values, and reflect on minor discrepancies. • Create a functional block diagram of the actual VR measurement setup.
2. CONTENT	Experiment 5: Field Effect Transistor Biasing
3. LEARNING RESOURCES	
A. References	• ECEN 30034 Experiments Material Module 9 • ECEN 30034 Instructional Material • Electronics Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky 10 ed.
4. PROCEDURES	
A. Pre-Activity Preparation	**NAVIGATION OF VIRTUAL LABORATORY** • Students enter the VR laboratory environment and are given 5 minutes to practice basic navigation • Teachers will facilitate the activity by giving instructions, answering questions, and ensuring students are familiar with the VR setup while they explore. **LEARNING STYLE IDENTIFICATION**

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

	• Students are given 5 minutes to complete a quick Learning Style Questionnaire to determine if they are Pragmatist, Theorist, Reflector, or Activist. **KNOWLEDGE LEVEL ASSESSMENT** • Students are given 10 minutes to take a pre-test assessing their understanding of FET bias circuits. This will classify them into Beginner, Intermediate, or Advanced levels. **ASSIGNMENT OF TRACKS** • Based on learning style and knowledge level results, students are assigned the appropriate version of the VR presentation and activity procedure.
B. Discussion of Concepts	**INTRODUCTION** Good day. Welcome to the Electrosphere! Today, we're diving deeper into the practical side of FET biasing, not just wiring up components but understanding why we choose certain values and how each part affects the transistor's operation. In this session, we'll revisit and apply key concepts like typical VDD, resistor, and capacitor values, biasing methods, and formulas. This goes beyond basic connection because we'll talk about setting the correct operating point, avoiding distortion, and ensuring your FET performs reliably. Let's start! **PART 1 – REVISITING FET BIASING METHODS** Before you build circuits, take time to observe how each FET biasing method behaves. Instead of memorizing right away, your goal is to notice patterns and think about why each setup works the way it does. You already understand how a transistor functions. Now focus on contrasting these biasing methods and identifying their strengths and limitations in real-world use: **1.** Fixed Bias • The gate connects to VDD through a resistor.

	• Simple and quick—but very sensitive to temperature changes. • Reflect on when simplicity is useful, like in test benches or quick switching circuits. **2.** Self-Bias • Source resistor (RS) creates feedback by lifting source voltage. • Adds more stability and responds better to changes. • Notice how VGS adjusts as RS values change. *Ask: what does this mean for amplifier consistency?* **3.** Voltage Divider Bias • Uses two resistors to form a stable voltage at the gate. • Most reliable for keeping FET at the correct Q-point. • As you explore in VR, visualize the circuit as a Thevenin equivalent. • Compare this with Self-Bias—when might one be better than the other? **4.** Feedback Bias • Connects a resistor from drain to gate. • Offers dynamic adjustment as drain current changes. During the VR walkthrough, take time to observe how changing VDD levels (usually between 9V and 15V) affects the overall circuit behavior. Instead of jumping to conclusions, reflect on how each voltage level shifts the operating point of the FET. Similarly, look closely at how RC time constants—set by the values of resistors and capacitors—influence how quickly the signal responds and how stable the bias point remains. You'll revisit these settings to match the specific biasing method and better understand how small variations affect the circuit's performance.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

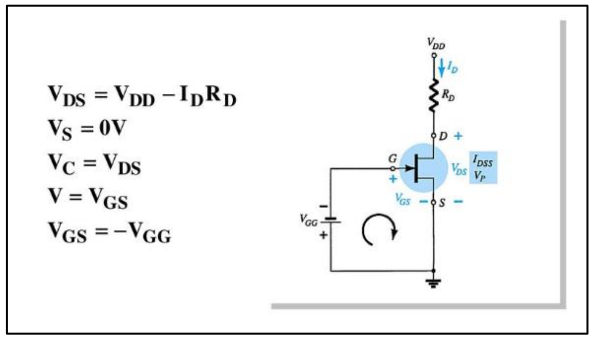
	Your goal isn't just to build—it's to recognize how each method shapes performance and when each is appropriate based on circuit demands.

PART 2. REVIEW OF BASIC FORMULAS

We'll use only simple formulas today to help pick resistor values.

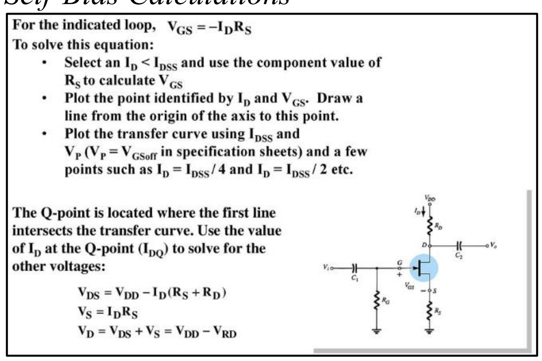
Key Formulas Presented:

- *Ohm's Law: V = IR (to find correct resistor values for gate, drain, and source)*
- *Fixed-Bias Calculations*



$$V_{DS} = V_{DD} - I_D R_D$$
$$V_S = 0V$$
$$V_C = V_{DS}$$
$$V = V_{GS}$$
$$V_{GS} = -V_{GG}$$

- *Self-Bias Calculations*



For the indicated loop, $V_{GS} = -I_D R_S$

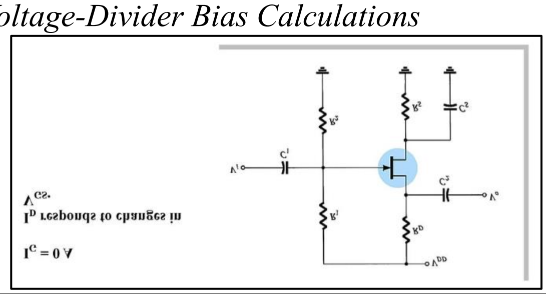
To solve this equation:

- Select an $I_D < I_{DSS}$ and use the component value of R_S to calculate V_{GS}
- Plot the point identified by I_D and V_{GS}. Draw a line from the origin of the axis to this point.
- Plot the transfer curve using I_{DSS} and V_P ($V_P = V_{GSoff}$ in specification sheets) and a few points such as $I_D = I_{DSS} / 4$ and $I_D = I_{DSS} / 2$ etc.

The Q-point is located where the first line intersects the transfer curve. Use the value of I_D at the Q-point (I_{DQ}) to solve for the other voltages:

$$V_{DS} = V_{DD} - I_D(R_S + R_D)$$
$$V_S = I_D R_S$$
$$V_D = V_{DS} + V_S = V_{DD} - V_{RD}$$

- *Voltage-Divider Bias Calculations*



EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

V_G is equal to the voltage across divider resistor R_2:

$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$$

Using Kirchhoff's Law:

$$V_{GS} = V_G - I_D R_S$$

The Q point is established by plotting a line that intersects the transfer curve.

Voltage-Divider Q-point

Step 1

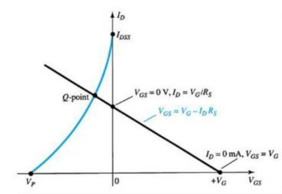
Plot the line by plotting two points:
- $V_{GS} = V_G$, $I_D = 0$ A
- $V_{GS} = 0$ V, $I_D = V_G / R_S$

Step 2

Plot the transfer curve by plotting I_{DSS}, V_P and the calculated values of I_D

Step 3

The Q-point is located where the line intersects the transfer curve



Using the value of I_D at the Q-point, solve for the other variables in the voltage-divider bias circuit:

$$V_{DS} = V_{DD} - I_D(R_D + R_S)$$
$$V_D = V_{DD} - I_D R_D$$
$$V_S = I_D R_S$$
$$I_{R1} = I_{R2} = \frac{V_{DD}}{R_1 + R_2}$$

- *Reminder that capacitors help smooth out voltages*

PART 3: CONCLUSION

Great job following through the discussion! You've now reviewed the key principles behind FET biasing, including how to set VDD correctly, and how resistor-capacitor combinations shape the transistor's performance.

It's now your turn to put these concepts into action. Begin your virtual lab activity by assembling the bias circuit, measuring VGS, VDS, and ID, and analyzing whether your design aligns with expected values.

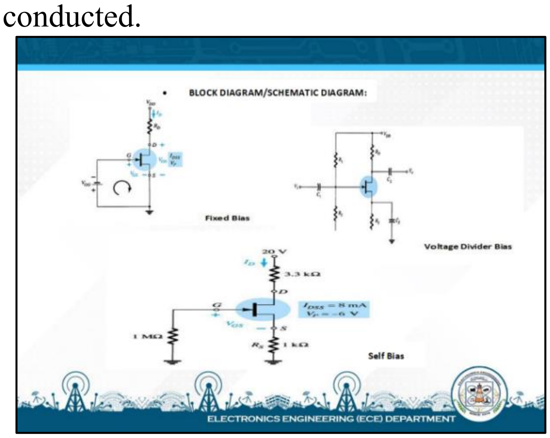
C. Presentation of the Experiment and Establishing a Purpose	**EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING** **Materials:** VR headset and controller, worksheet **Main Objective:** To observe and reflect on the process of building FET bias circuits and understand how

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

voltage and current readings relate to circuit behavior through practical simulation and thoughtful experimentation.

Procedure:

1. Enter the virtual laboratory and begin watching the briefly revisits FET biasing principles.
2. Based on your understanding, decide on suitable resistor and capacitor values using basic design equations. Consider how different values might shift the circuit's behavior.
3. Examine the reference circuit diagram displayed in the VR space. Use this as your layout guide. You will use your own component values based on your calculations.
4. Assemble the circuit in the VR environment.
5. Attach virtual voltmeters and ammeters at essential points (gate, drain, source) to monitor circuit behavior. Consider placing tools strategically to observe how voltage divides and current flows.
6. Run the simulation and take note of voltage and current values across different nodes. Record your observations manually in a worksheet outside the VR simulation.
7. Compare your measured values with those expected from your calculations. Use the equations discussed in the presentation to check for accuracy. Reflect on any discrepancies and explain them based on your understanding of circuit behavior.
8. Create a clear block diagram showing your measurement setup inside the VR lab. Indicate where the meters were placed and the values observed to help illustrate how your test was conducted.



EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

D. Post-Assessment (Knowledge Check)	Students are given 10 minutes to take a post-test inside VR to measure knowledge improvement by comparing pre-test and post-test results.
E. Experiment Conclusion	The teacher summarizes key learnings, discusses results, and addresses common challenges observed during the VR activities.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

DIFFICULT

I. **Main Objective**: To design, simulate, and analyze a FET bias circuit within a virtual environment, applying advanced understanding of electronic principles to reflect on real-world circuit performance and optimization.

II. **Procedure:**

1. Enter the virtual lab and begin with the in-VR presentation.
2. Based on your understanding, decide on suitable resistor and capacitor values using basic design equations. Consider how different values might shift the circuit's behavior.
3. Examine the reference circuit diagram displayed in the VR space. Use this as your layout guide. You will use your own component values based on your calculations.
4. Design and assemble your own version of the FET bias circuit within the VR lab.
5. Attach virtual voltmeters and ammeters at essential points (gate, drain, source) to monitor circuit behavior. Consider placing tools strategically to observe how voltage divides and current flows.
6. Simulate and observe results. Take multiple measurements under different simulated conditions (e.g., changing load, temperature, or input signal).
7. Take note of voltage and current values across different nodes. Record your observations manually in a worksheet outside the VR simulation.
8. Compare your measured values with those expected from your calculations. Use the equations discussed in the presentation to check for accuracy. Reflect on any discrepancies and explain them based on your understanding of circuit behavior.
9. Create a clear block diagram showing your measurement setup inside the VR lab. Indicate where the meters were placed and the values observed to help illustrate how your test was conducted.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

I. OBJECTIVES	
A. Content Standards	• Learners demonstrate advanced understanding of FET bias circuit performance, identifying causes of real-world measurement deviations and proposing optimizations. • Learners apply troubleshooting strategies and critical analysis to enhance circuit reliability and performance.
B. Performance Standards	• Learners optimize resistor and capacitor values based on theoretical understanding and practical VR results. • Learners troubleshoot and refine the assembled FET bias circuit to achieve closer alignment between measured and expected values. • Learners develop a detailed block diagram showing refined signal and measurement flows based on their analysis.
C. Learning Competencies/Objectives	• Independently select optimized resistor and capacitor values for improved FET bias performance. • Assemble, measure, and troubleshoot the given FET bias circuit in VR with minimal supervision. • Analyze significant deviations between expected and measured results, diagnose causes, and propose refined solutions. • Develop a detailed block diagram illustrating instrument signal flow and finalized circuit setup.
II. CONTENT	Experiment 5: Field Effect Transistor Biasing
III. LEARNING RESOURCES	
B. References	• ECEN 30034 Experiments Material Module 9 • ECEN 30034 Instructional Material • Electronics Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky 10 ed.
IV. PROCEDURES	
F. Pre-Activity Preparation	**NAVIGATION OF VIRTUAL LABORATORY** • Students enter the VR laboratory environment and are given 5 minutes to practice basic navigation • Teachers will facilitate the activity by giving instructions, answering questions, and ensuring students are familiar with the VR setup while they explore. **LEARNING STYLE IDENTIFICATION**

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

<table>
<tr><td></td><td>
V. Students are given 5 minutes to complete a quick Learning Style Questionnaire to determine if they are Pragmatist, Theorist, Reflector, or Activist.

KNOWLEDGE LEVEL ASSESSMENT
VI. Students are given 10 minutes to take a pre-test assessing their understanding of FET bias circuits. This will classify them into Beginner, Intermediate, or Advanced levels.

ASSIGNMENT OF TRACKS
VII. Based on learning style and knowledge level results, students are assigned the appropriate version of the VR presentation and activity procedure.
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<tr><td>G. Discussion of Concepts</td><td>
INTRODUCTION

A pleasant morning everyone! It’s great to welcome you here to the Electrosphere!
Today, we’re leveling up! This session is crafted for those who already have a strong grasp of basic biasing.

We’ll focus not just on building circuits, but on optimizing bias circuits for the best performance. You’ll learn practical strategies to fine-tune circuit behavior, balancing parameters like gain, linearity, power efficiency, and stability.

Ready to elevate your circuit design skills? Let’s dive into advanced biasing optimization in our virtual world!

PART 1: WHY OPTIMIZE BIAS CIRCUITS?

Have you ever assembled a transistor amplifier that “works” but performs poorly? Take a moment to reflect on circuits you've seen that seemed functional but produced distorted signals or overheated under prolonged use. Why do these issues occur even if the basic biasing is applied?
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EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

Let’s explore some of the common problems caused by poor bias optimization:

- Non-linearity – Think about what happens to a guitar amplifier that adds unwanted distortion. What causes the signal to lose its shape?
- Thermal runaway – Have you encountered a component that gets unexpectedly hot over time? What might be happening at the current level?
- Reduced gain or incorrect operating region – Consider an amplifier that sounds too quiet or behaves inconsistently. Is it operating where it should be?
- Poor noise performance – In sensitive circuits, like radio receivers or sensors, how does improper biasing make noise more noticeable?

Now reflect on what optimization aims to achieve:

- A stable Q-point that prevents erratic performance. Why is stability important in long-running systems?
- Maximum symmetrical swing that avoids clipping—how does signal headroom affect audio or sensor output?
- Minimal distortion—why is signal purity critical in communication systems?
- Controlled power dissipation—what risks arise when thermal management is overlooked?

From the VR presentation, you were shown scenarios illustrating:

- The importance of setting the Q-point in the middle of the load line—did you notice how off-center biasing clipped part of the signal?
- How parameters like β (BJT) or Vth (FET) shift with temperature—what did you observe when temperature increased?

- How load variations, temperature drift, and manufacturing tolerances impact real-world circuits—how do these factors change your design or troubleshooting approach?

PART 2: STRATEGIES FOR BIAS OPTIMIZATION

Have you ever wondered why two seemingly identical amplifiers behave so differently under heat or signal stress? During the VR session, you were shown several real-world scenarios where small changes in biasing made big differences in circuit performance. Let’s reflect on the key techniques used and why they matter.

1. Emitter/Source Degeneration
Think back to circuits you've tested with and without emitter (or source) resistors. Did you notice how adding a resistor improved linearity and reduced drift? That resistor introduces negative feedback—how did it change your signal stability?

2. Fine-Tuning Base/Gate Voltage
In practice, setting the perfect Vb or Vg isn't always straightforward. Have you experimented with a trimmer potentiometer in a voltage divider? How did it feel to "dial in" the Q-point manually?

3. Temperature Compensation
Imagine your circuit running in a hot environment—what could go wrong? In the demo, you saw how diodes or thermistors can help maintain stable biasing.

4. Load Line Shifting
We often assume ideal components—but real resistors and transistors vary. When you recalculate the load line based on actual measurements, how did your Q-point shift?

5. Bypass Capacitor Optimization
Recall the effects of bypass capacitors across emitter/source resistors. How did they restore AC gain while maintaining DC bias stability?

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

Each of these strategies invites experimentation, observation, and adaptation. The more circuits you build and tweak, the more patterns you'll see. Biasing isn’t just a calculation—it’s a craft shaped by real-world insight.

PART 3: WHAT TO MEASURE AND FINE-TUNE

After applying various optimization techniques, it's important to step back and reflect: How well did the circuit actually perform? You might recall from the VR simulation that even small changes can lead to noticeable effects. Let’s revisit the critical measurements and what they reveal.

VCE / VDS – Centering the Q-point

- Think back to when your transistor amplifier didn't deliver clean output. Was the Q-point off-center? Measuring the collector-to-emitter or drain-to-source voltage helps you visualize where your device operates on the load line.

IC / ID – Bias Current Stability

- Current drift over time or with heat is a common issue. Monitoring IC or ID helps you understand how stable your biasing really is.

Gain (Av) – Meeting Design Expectations

- You designed for a certain gain—but did you reach it? Measuring Av validates whether your capacitor choices, resistor values, and transistor parameters worked as intended.

Distortion – Observing Output Symmetry

- Symmetrical waveforms suggest clean amplification. Any clipping or uneven curves indicate biasing or load issues.

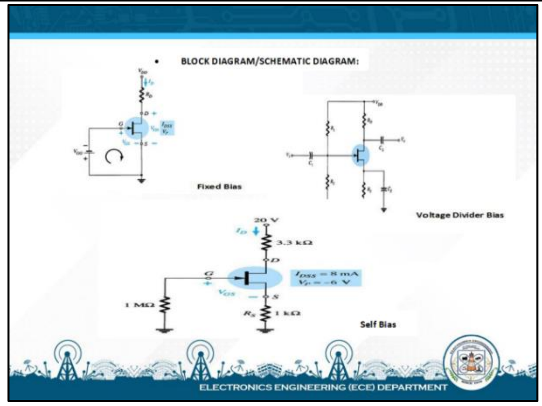
Power Dissipation – Staying Within Safe Limits

- Finally, consider device longevity. Measuring power across components reminds you that optimization isn't just about performance—it’s also about safety.

Even small ±10% variations in resistors or VDD can test a circuit’s stability. Reflecting on how your design

	handled these changes is a critical learning moment. Good designs adapt—great designs anticipate. **PART 4: CONCLUSION** Today, you explored how bias circuit optimization is not just about making circuits “work,” but making them perform reliably and efficiently. You learned practical fine-tuning strategies. Now, it’s your turn! Do the experiment and apply these techniques. Let’s start!
H. Presentation of the Experiment and Establishing a Purpose	**EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING** **Materials:** VR headset and controller, worksheet **Main Objective:** To practice basic FET bias circuit building and measurement skills by assembling a simple circuit, taking voltage and current readings, and applying simple formulas to check circuit behavior. **Procedures:** **1.** Enter the virtual lab and watch the presentation to learn the basic concepts of FET bias circuits, suggested VDD values, and how to choose resistor and capacitor values. **2.** Based on the presentation, manually select appropriate resistor and capacitor values for your circuit during the simulation. **3.** Assemble the FET bias circuit below in the VR environment using the virtual breadboard, FET, resistors, and capacitors provided. **4.** Use the virtual voltmeter and ammeter to measure the voltage and current at the input and output terminals of the circuit. **5.** Record your measurements manually in a worksheet outside the VR environment. **6.** Calculate basic voltage and current values manually using the formulas explained during the VR presentation and put in the worksheet. **7.** Create a basic block diagram that shows how the voltmeter and ammeter were connected to the circuit during your simulation.

EXPERIMENT 5: FIELD EFFECT TRANSISTOR BIASING

	
I. Post-Assessment (Knowledge Check)	Students are given 10 minutes to take a post-test inside VR to measure knowledge improvement by comparing pre-test and post-test results.
J. Experiment Conclusion	The teacher summarizes key learnings, discusses results, and addresses common challenges observed during the VR activities.