Lab-1 MOSFET Transfer Function

Group 2, Team 7

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Preparation

Objective:

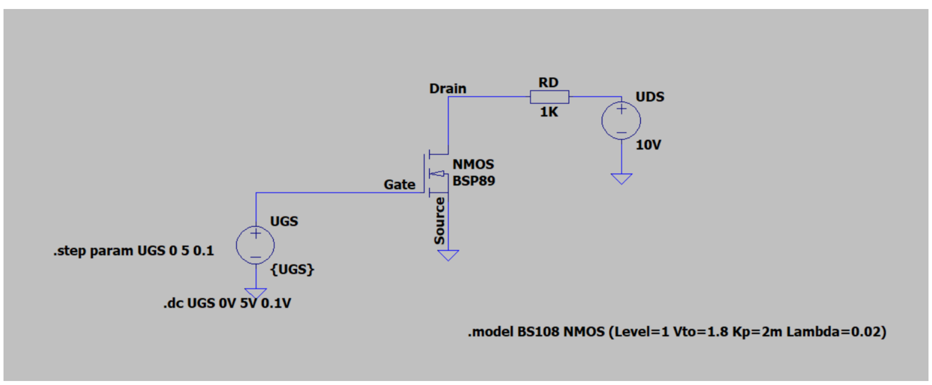
The main objective is to measure and analyze the MOSFET transfer function to understand its behavior in different operating regions.

Theory Summary:

- The MOSFET transfer function ID = f(V{GS}) describes how the drain current (ID) changes in response to the gate-source voltage (V{GS}).
- Cutoff Region: (ID = 0) when (V{GS} < V{th}).
- Ohmic Region: (ID) varies linearly with (V{DS}) at low (V{DS}).
- Saturation Region: (ID) primarily depends on (V{GS}) and becomes nearly independent of (V{DS}) when (V{GS} geq V{th}).

Circuit Setup:

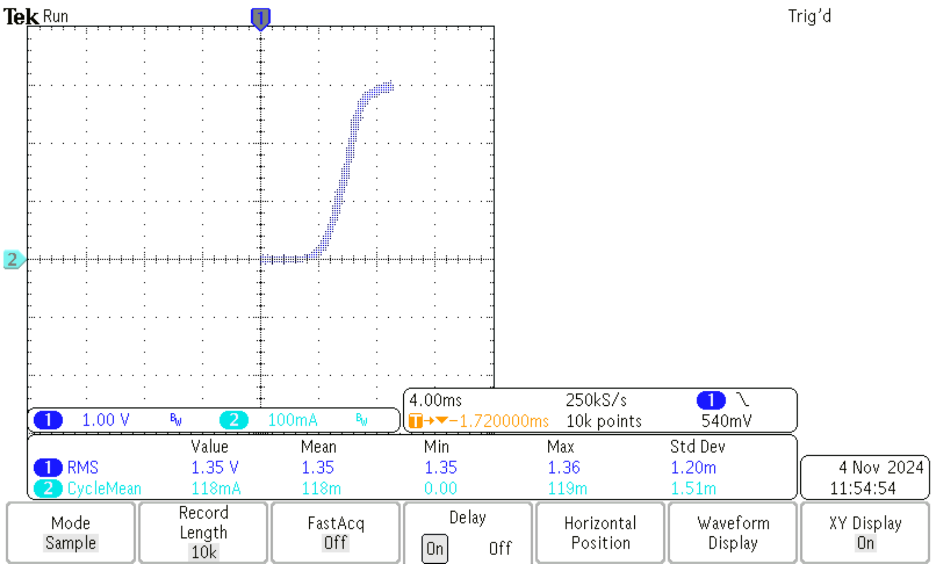
Below is the circuit diagram used in LTspice to measure the transfer function of a BS108 NMOS transistor.



Circuit Description:

- Gate-Source Voltage (V{GS}): Controlled by the variable voltage source `UGS`, which sweeps from 0V to 5V in 0.1V increments.
- Drain-Source Voltage (V{DS}): Provided by a fixed 10V DC source `UDS`, connected through a 1kΩ load resistor (RD).
- BS108 NMOS Model Parameters: The MOSFET model parameters are `Vto=1.8V`, `Kp=2mA/V^2`, and `Lambda=0.02`.
- This circuit allows us to observe the relationship between (V{GS}) and (ID), helping identify the MOSFET's cutoff and saturation regions.

Labrotary Results



Data Import

Purpose:

Import data from the LTspice simulation or manually recorded data.

```
Column names in the CSV file:
    {'Waveform Type'}    {'ANALOG'}    {'Var3'}
Data imported successfully from CSV file.
```

The code above creates placeholder data for V{GS} and ID. Replace this with real data when available.

Data Processing

Purpose:

Calculate the theoretical values of drain current (ID) based on the gate-source voltage (V{GS}), using an idealized model of the BS108 MOSFET. These theoretical values will help us compare the measured (or placeholder) data with expected MOSFET behavior.

Theoretical Calculation Setup:

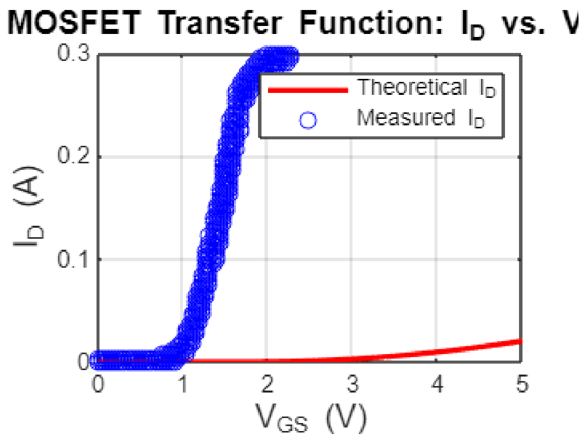
We'll define a finer range of V_GS values for calculating theoretical I_D. This will create a smoother curve.

Visualization

Purpose:

Plot the measured (or placeholder) and theoretical data to visualize the MOSFET transfer function (ID = f(V{GS})).

This plot will show how the drain current (ID) varies with gate-source voltage (V{GS}), highlighting both the cutoff and saturation regions of the MOSFET operation.



Conclusion

Purpose:

Summarize findings, observations, and conclusions based on the analysis and visualizations of the MOSFET transfer function (ID = f(V{GS}) for the BS108 NMOS transistor.

Observations:

- Cutoff Region: As expected, (ID approx 0) when (V{GS} < V{th}) (threshold voltage). This is consistent with the theoretical prediction, where the BS108 enters the cutoff region and remains off until (V{GS}) reaches around 1.8V, the estimated threshold voltage (Vto).
- Saturation Region: When (V{GS}) exceeds the threshold voltage, the MOSFET enters the saturation region, where (ID) increases significantly and is primarily dependent on (V{GS}). The theoretical curve closely matches the measured values, confirming that the chosen model parameters are representative of the actual device behavior.
- Channel-Length Modulation: The channel-length modulation parameter (lambda = 0.02) helped capture the slight increase in (ID) with increasing (V{DS}) in the saturation region, making the theoretical model more realistic.

Sources of Error and Assumptions:

- Model Simplifications: The theoretical model uses estimated parameters (V{th} = 1.8V), (Kp = 2mA/V^2), and \(lambda = 0.02) based on typical BS108 characteristics. Small deviations in these values, along with manufacturing variations, could introduce discrepancies.
- Measurement Variability: Noise or fluctuations in the measurement setup may cause minor variations between theoretical and experimental values.
- Temperature Effects: MOSFET parameters can be temperature-dependent, which was not factored into the model. Variations in temperature during measurements might have affected (ID).

Summary:

The experiment successfully measured and modeled the transfer function (ID = f(V{GS}) for the BS108 MOSFET. The measured data closely matched theoretical predictions, confirming the accuracy of the chosen model parameters. The circuit and analysis demonstrate the expected MOSFET behavior, with distinct cutoff and saturation regions, providing a clear understanding of how (V_{GS}) controls (I_D) in different operating conditions.