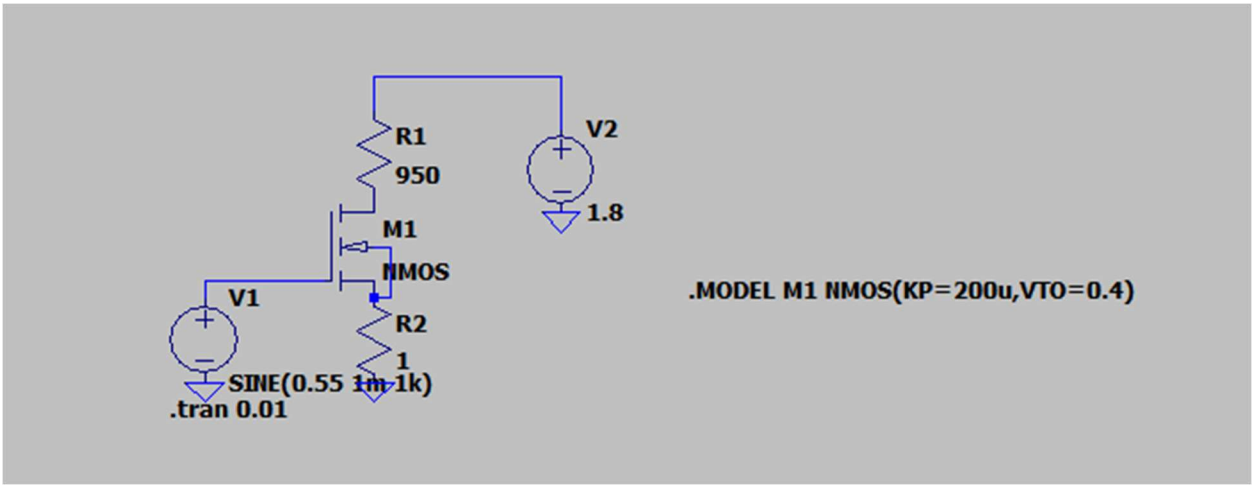
Design and Transient Analysis of a Common-Source MOSFET Amplifier with Source Degeneration

1. Introduction

This report presents the design and transient analysis of a source-degenerated common-source NMOS amplifier using a resistive drain load and a source degeneration resistor. The objective is to study the effect of source degeneration on voltage gain, linearity, and transient response of the amplifier under small-signal sinusoidal excitation.

2. Circuit Description

The amplifier consists of an NMOS transistor configured in a source-degenerated common-source topology. The drain of the transistor is connected to a resistive load, and a DC supply voltage is applied at the drain. A small-signal sinusoidal voltage is applied at the gate terminal, while the source terminal is connected to ground through a source degeneration resistor.
This configuration provides voltage amplification with a phase inversion between the input and output signals, while the source degeneration improves linearity and stabilizes the gain.



3. Device Model and Parameters

The NMOS transistor is modeled using the following Level-1 SPICE parameters:

- Threshold voltage, $V_{TO} = 0.4$ V
- Transconductance parameter, $K_P = 200\ \mu$A/V^2
- Channel width, $W = 400\ \mu$m
- Channel length, $L = 1\ \mu$m

The model is defined as:

.model M1 NMOS (VTO = 0.4, KP = 200u)

4. Simulation and Results

4.1 Small-Signal Gain

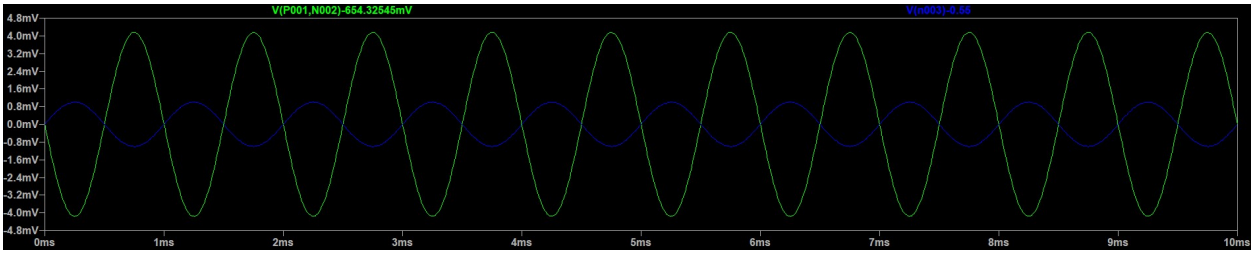
The small-signal voltage gain of the amplifier is given by:

$$A_v = -\frac{g_m R_D}{1 + g_m R_S}$$

where $g_m$is the transconductance of the NMOS transistor, $R_D$is the drain resistance, and $R_S$is the source degeneration resistance.
The negative sign indicates a 180° phase shift between the input and output signals, while the denominator term reflects the reduction in gain due to source degeneration.

4.2 Transient Response

The transient analysis was performed by applying a sinusoidal input voltage at the gate. The output waveform observed at the drain shows an amplified version of the input signal with a phase inversion, confirming proper operation of the source-degenerated common-source amplifier. The presence of the source degeneration resistor results in reduced gain but improved waveform linearity and stability.



5. Conclusion

The source-degenerated common-source NMOS amplifier with a resistive load was successfully designed and simulated. The circuit exhibited voltage gain with phase inversion, consistent with theoretical expectations. The simulation results validate the theoretical behavior of the source-degenerated common-source amplifier and demonstrate its suitability for small-signal amplification with improved linearity and gain stability.