University of Washington

BEE331 Lab 4

2301991
Jason Truong

2130474
Henry Haight

supervised by
Prof. Joseph Decuir

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NMOS Amplifier Circuit
Design Objective

In this lab, we introduce ourselves to the MOSFET Amplifier. We characterise and build an audio-amplifier's small-signal single-stage circuit.

Circuit Design Outline

With a sinusoidal voltage source V_{AC} - @ $V_p = 50mV$ and a frequency of $10kHz$ in series with a capacitor $C_{C1} = 0.1\mu F$. In parallel - a series DC voltage source V_{DD} connected to a resistor $R_{G_1} = 38.2k$, another resistor $R_{G_2} = 95.3k$, and Gate to an NMOSFET $NMOS_G$.
From the NMOSFET,

- Source

  Parallel, a capacitor $C_s = 10\mu F$ and resistor $R_S = 200\Omega$.

- Drain

  In parallel - a resistor $R_D = 500\Omega$, to a series Capacitor C_{C2} and Resistor R_L.

Descriptions of Measurements & Calculations

Analysis

- **1.2.3 Calculate the Voltage gain of the amplifier circuit of Figure 6 using the following two equations:**

  $\frac{v_o}{v_{sig}=g_m R_d}$

  $g_m = k_n V_{ov} = \frac{2I_D}{V_{ov}}$

- **2.3 How does the calculated voltage gain (using $\frac{v_o}{v_{sig}} = g_m R_D$) compare with the measured voltage gain? Explain the potential sources of error. You can reference your explanation to the more previse expression for the voltage gain.**

  How does the calculate Voltage Gain compare?

  See addendum for calculations

  Sources of Error

  Imperfect Components

  Imprecise Calculations (approximates)

  Metrics of R_D leading to a lowered measured gain.

  Measurements error overall.

- **2.4 Give a brief summary of how your audio amplifier worked and what gain in decibels ($|A_v|_{dB} = 20log(\frac{v_o}{v_{sig}})$ you achieved at 10 kHz)**

  [See addendum for calculations]

  The audio amplifier's output is dependent on the ratio of $\frac{v_o}{v_{sig}}$.

- **2.5 How would you increase the gain by an additional 10 dB? How does the gain behave as a function of frequency?**

  [See addendum for calculations]

  Understand voltage gain in dB $20log \approx 3.16$

  $A_v^n ew = 3.16 * A_v^{original}$

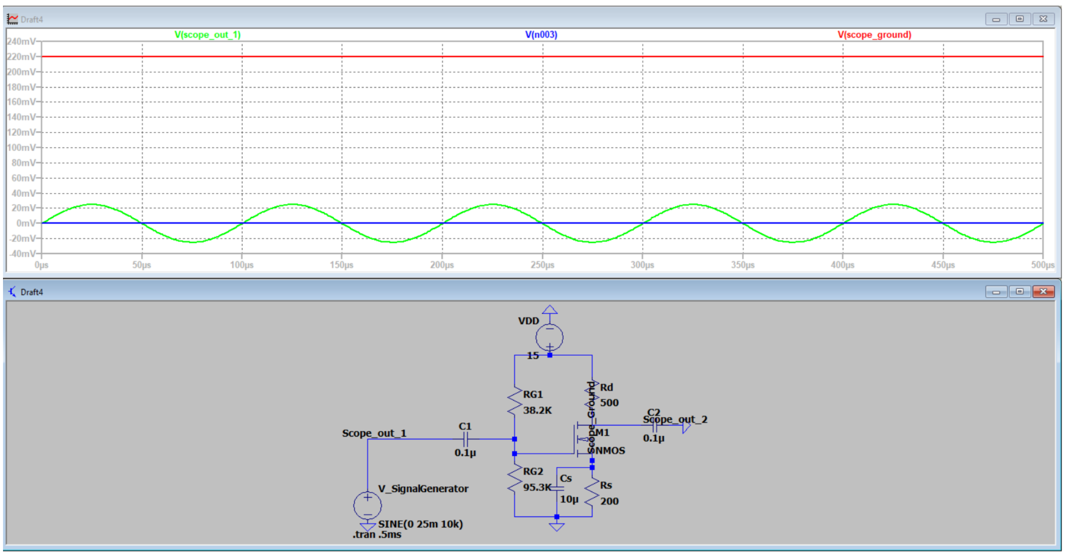
  Increasing the value of the Midband $g_m R_D$

  Decreasing the High-Frequency Roll-Off in the MOSFET

  Gain behaves as a function of frequency in relation to $v_{sig} = V_p cos(2\pi f + \phi)$.

Figure 1: MOSFET Amplifier

(a) NMOS Amplifier



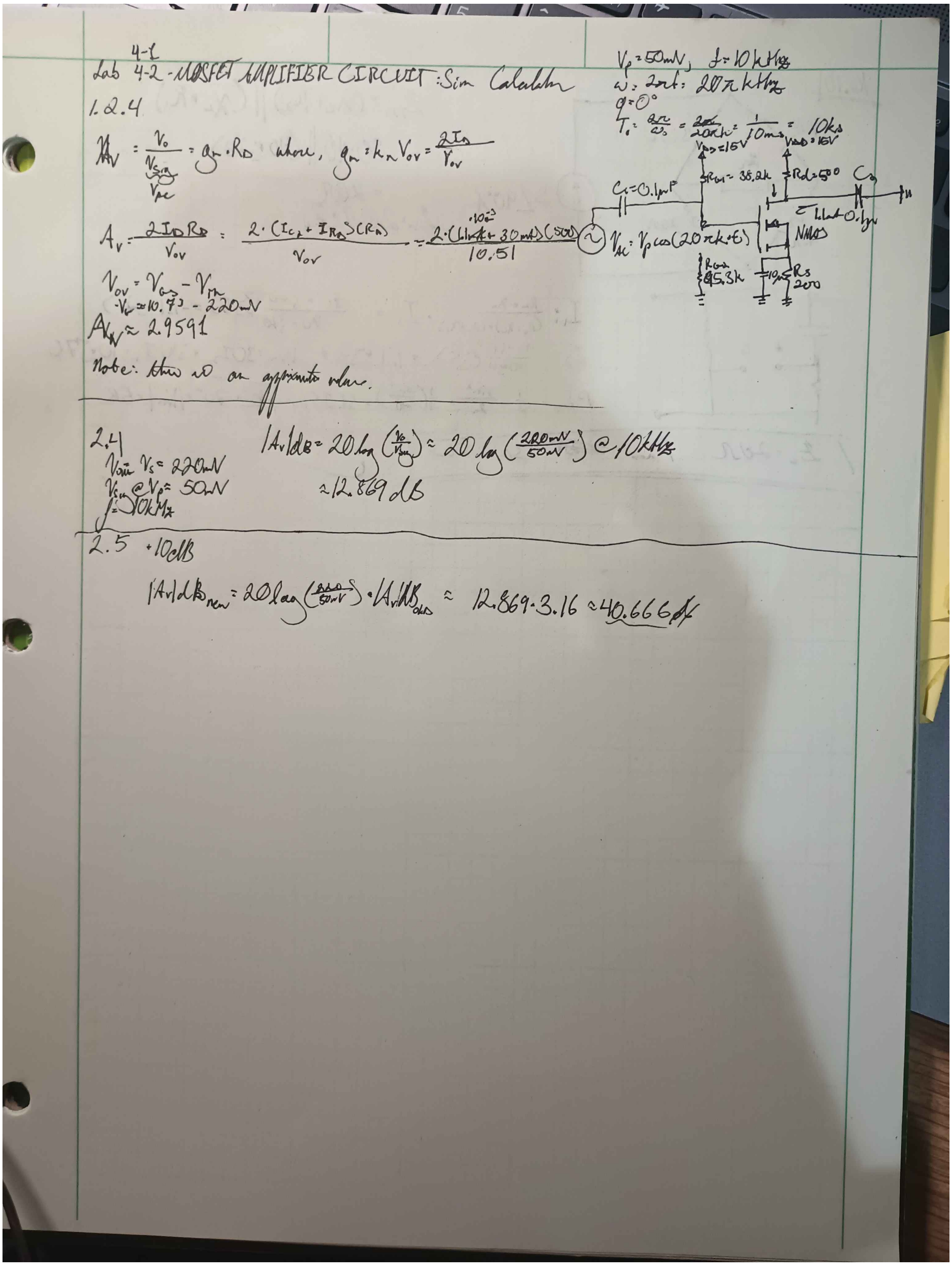
Summary & Conclusions

Revealed in Figure RD-Circuit 1A & 1B, the generated oscilloscope readings of the two periodic function match the characteristics of the transfer function found in 1b (RD Circuit). So the measurements do infact closely align.

Addendum Pages

Figure 2: Jason Truong Addendum

(a) Lab 4 Calculations



4-1

Lab 4-2 - MOSFET AMPLIFIER CIRCUIT : Sim Calculation

1.2.4

$A_V = \frac{V_o}{V_{sig}} = g_m \cdot R_D$ where, $g_m = k_n V_{ov} = \frac{2I_D}{V_{ov}}$

$A_V = \frac{2 I_D R_D}{V_{ov}} = \frac{2 \cdot (I_{C_2} + I_{R_D})(R_D)}{V_{ov}} \approx \frac{2 \cdot (1.1mA + 30mA)(500)}{10.51}$

$V_{ov} = V_{GS} - V_{tn}$

$V_{tn} \approx 10.73 - 220mV$

$A_V \approx 2.9591$

Note: this is an approximate value.

2.4

V_{out} $V_s = 220mV$

V_{sig} @ $V_p = 50mV$

$f = 10kHz$

$|A_v|_{dB} = 20 \log\left(\frac{V_o}{V_{sig}}\right) \approx 20 \log\left(\frac{220mV}{50mV}\right)$ @ 10kHz

$\approx 12.869 \, dB$

2.5 +10dB

$|A_v|dB_{new} = 20 \log\left(\frac{880}{50mV}\right) \cdot |A_v|dB_{old} \approx 12.869 \cdot 3.16 \approx 40.666 \, dB$

Bibliography

Cited:

- Lab 1 Manual
- Sedra, Adel, and Kenneth Smith. Microelectronic Circuits. S.L., Oxford Univ Press Us, 2019.
- “How Do You Calculate, a Silicon Junction Diode with N = 1 Has v = 0.7 v al I = 1 MA. What Is the Voltage Drop at

I=0.1 MA and I=10 MA.?" Quora, 2024, appliedmathematics.quora.com/How-to-calculate-A-silicon-junction-diode-with-n-1-has-v-0-7-V-al-I-1-mA-What-is-the-voltage-drop-at-I-0-1-mA-an?top_ans=223007030. Accessed 15 July 2024.

(a) Good work.