Lab 11: MOSFET Amplifier Configurations

ECEN 325 - 511

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Date Performed: November 30, 2021

Due Date: December 7, 2021

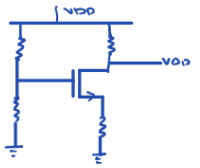
Purpose

_____The objective of this lab was to be able to analyze MOS amplifier configurations. Different factors for common-source and common-drain topologies are learned.

Calculations

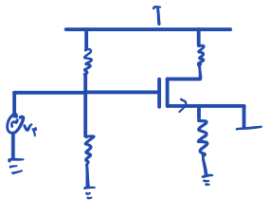
1)

DC & AC Analysis



$V_G = \frac{V_{DD} \times R_{G2}}{R_{G1} + R_{G2}}$

$R_G = (R_{G1} \| R_{G2})$



$R_i \geq 10k\Omega$

$R_i = (R_{G1} \| R_{G2}) = R_G$

$\frac{R_{G1} \cdot R_{G2}}{R_{G1} + R_{G2}} \geq 10k\Omega$

So assume $R_i = 30k\Omega \geq 10k\Omega$

$R_{G1} = 40k\Omega$ & $R_{G2} = 120k\Omega$ so $R_i = 30k\Omega$

$V_G = \frac{V_{DD} \times R_{G2}}{R_{G1} + R_{G2}} = \frac{5 \times 120k}{(40+120)k} = 5.75V$

$-V_G + V_{GS} + V_{RS} = 0$

$V_{GS} = V_G - V_{RS}$

$= 3.75 - 1$ $\quad V_{GS} = 2.75$

$V_t = 1V$

$g_m = k \frac{W}{L}$

$k_n = \frac{1}{2} k W/L = 1mA/V^2$

$I_{DS} = k_n (V_{GS} - V_t)^2 \Rightarrow I_{DS} = 3.0625mA$

$V_{RS} = 1V$ $\quad R_D = 0.32k\Omega$

$A_V = 25$

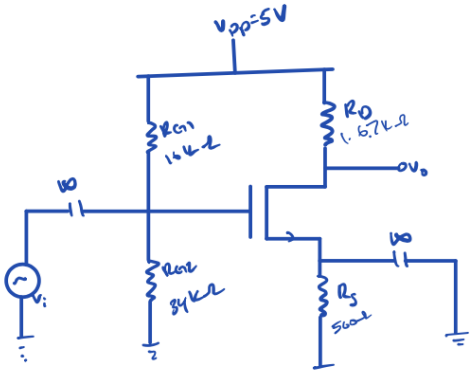
$g_m = 2k_n (V_{GS} - V_t) = 2 \times 1 (2.75 - 1)$

$= 3.5$

$gain = |3.5 \times 10^{-3} \times R_D| = 25$

$R_D = 1.67k\Omega$

Whole circuit :



0 to peak $\rightarrow V_o \geq 1V$

$|gain| V_i \geq 1V$

$25 \cdot 1 \geq 1V$

$V_i \geq 1/25 \Rightarrow V_i \geq 0.04V$

$V_i \geq 40mV$

2)

$R_i = R_{G1} \parallel R_{G2}$

$= 40k \parallel 120k = \frac{40k \times 120k}{40 + 120} = 30k\Omega$

to gate : $1/g_m$

$R_{out} = R_3 \parallel 1/g_m = 320 \parallel 1/g_m$

from 2N7000G datasheet

$g_m = 100 \times 10^{-6} A/V$

$A_V = \frac{g_m R_s}{1 + g_m R_s}$

$= R_s \Big/ \frac{1}{g_m} + R_3$

$R_{out} = 320 \parallel 1/100 \times 10^{-6} = \frac{0.32k \times 10k}{0.32k + 10k} = 310.07\Omega$

$A_V = \frac{8 \cdot 520}{10k + 320} = 0.031$

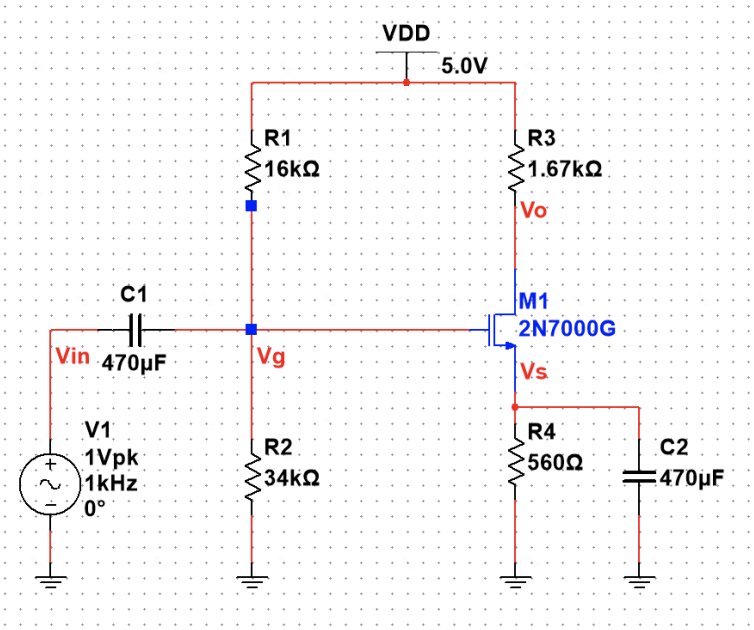
$R_i = 30k\Omega$

$R_o = 310.07\Omega$

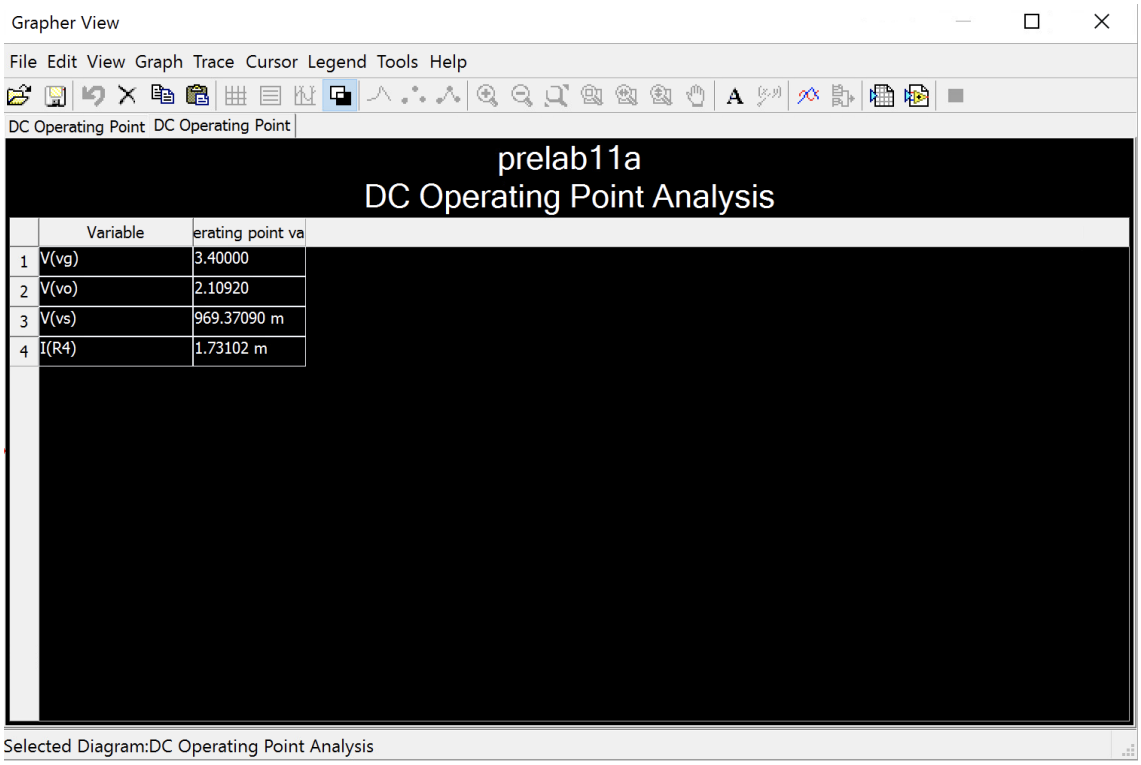
$A_V = 0.031$

Simulations (on Multisim)

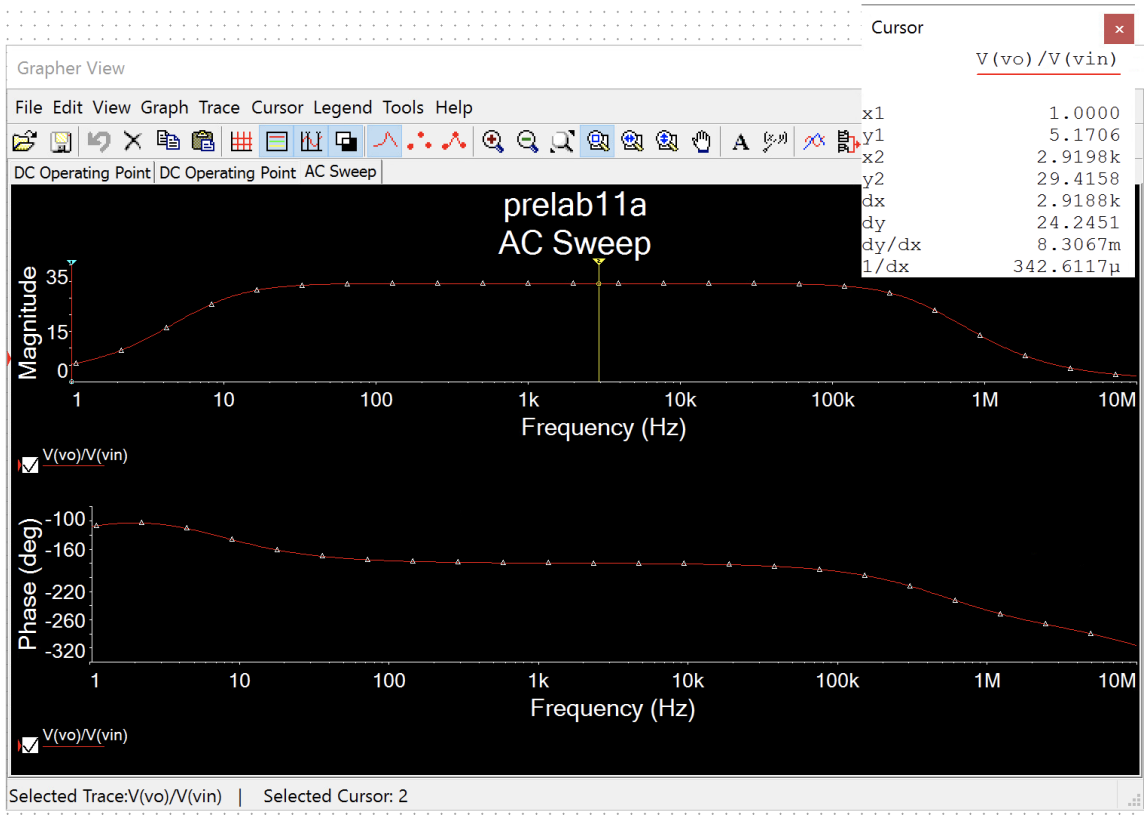
3a Schematic



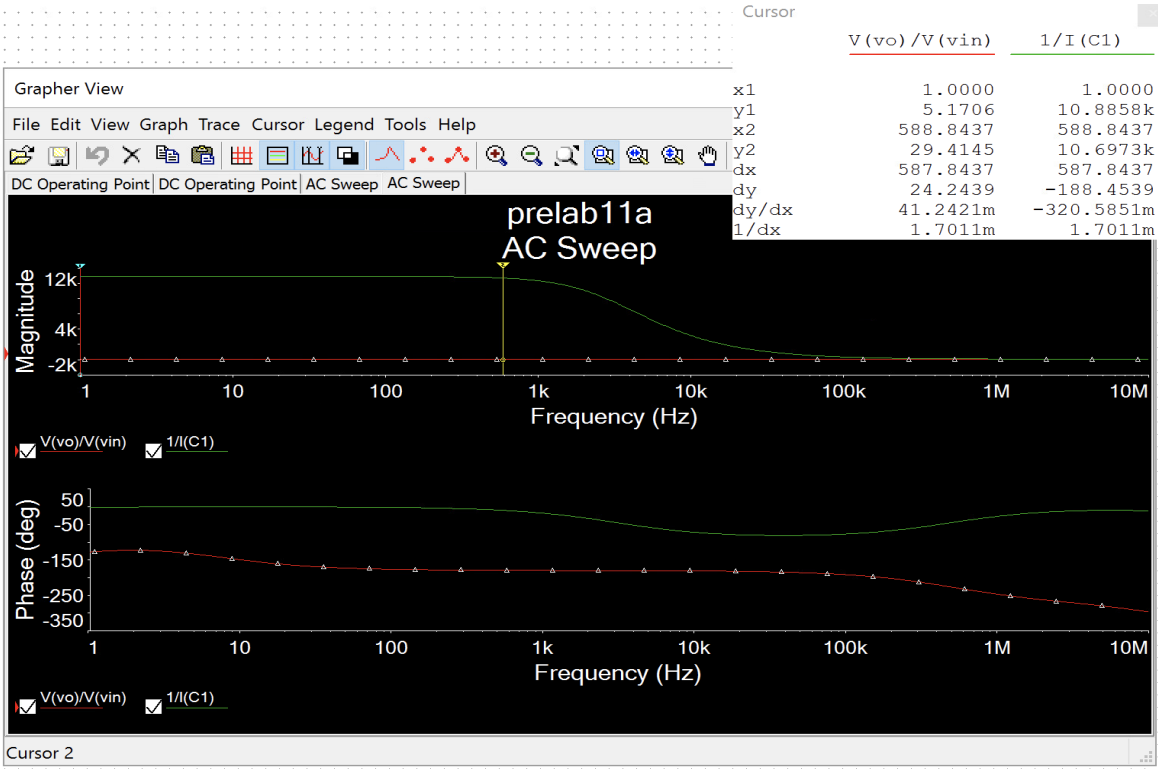
3a DC Operating point



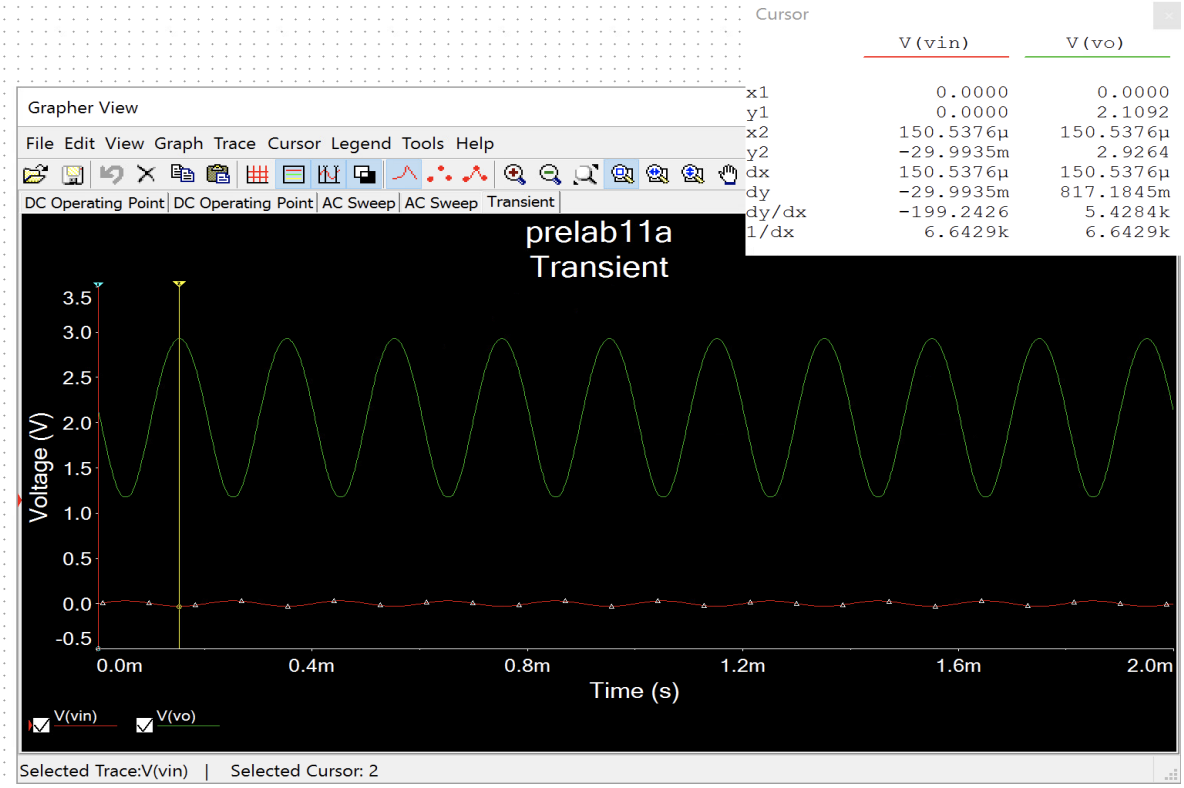
3a AC simulation A_V



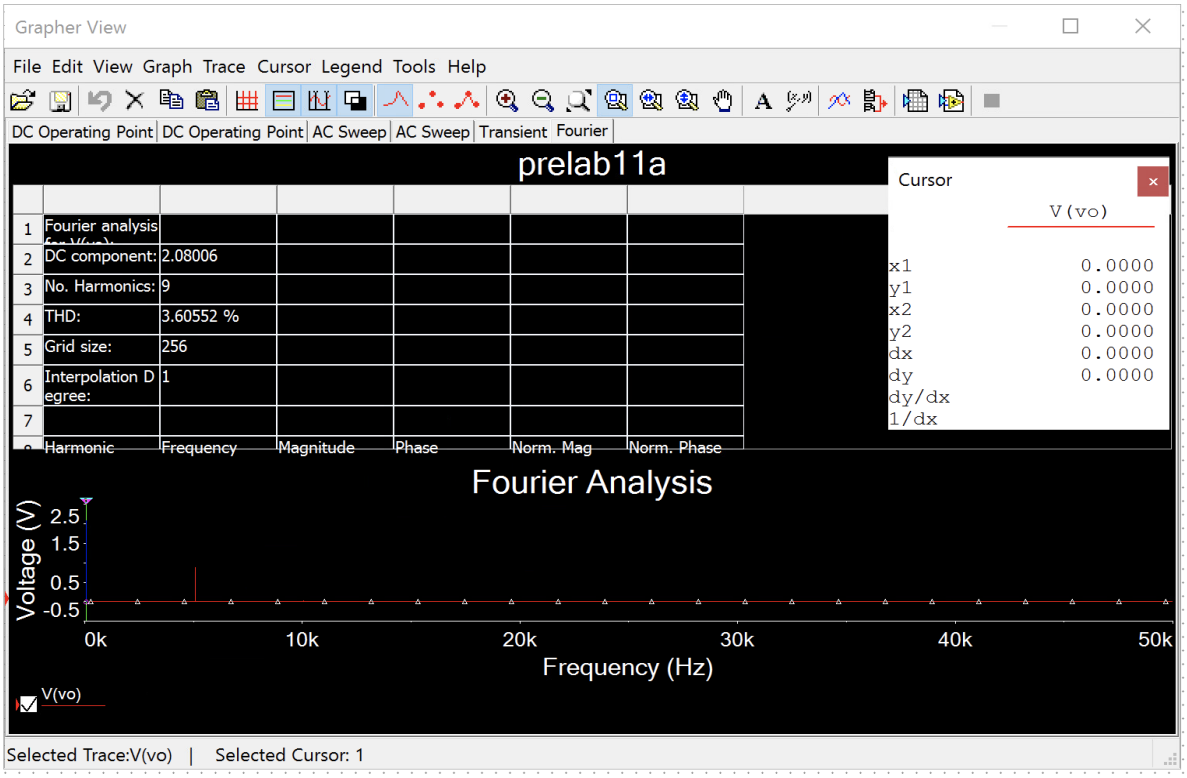
3a AC simulation R_i



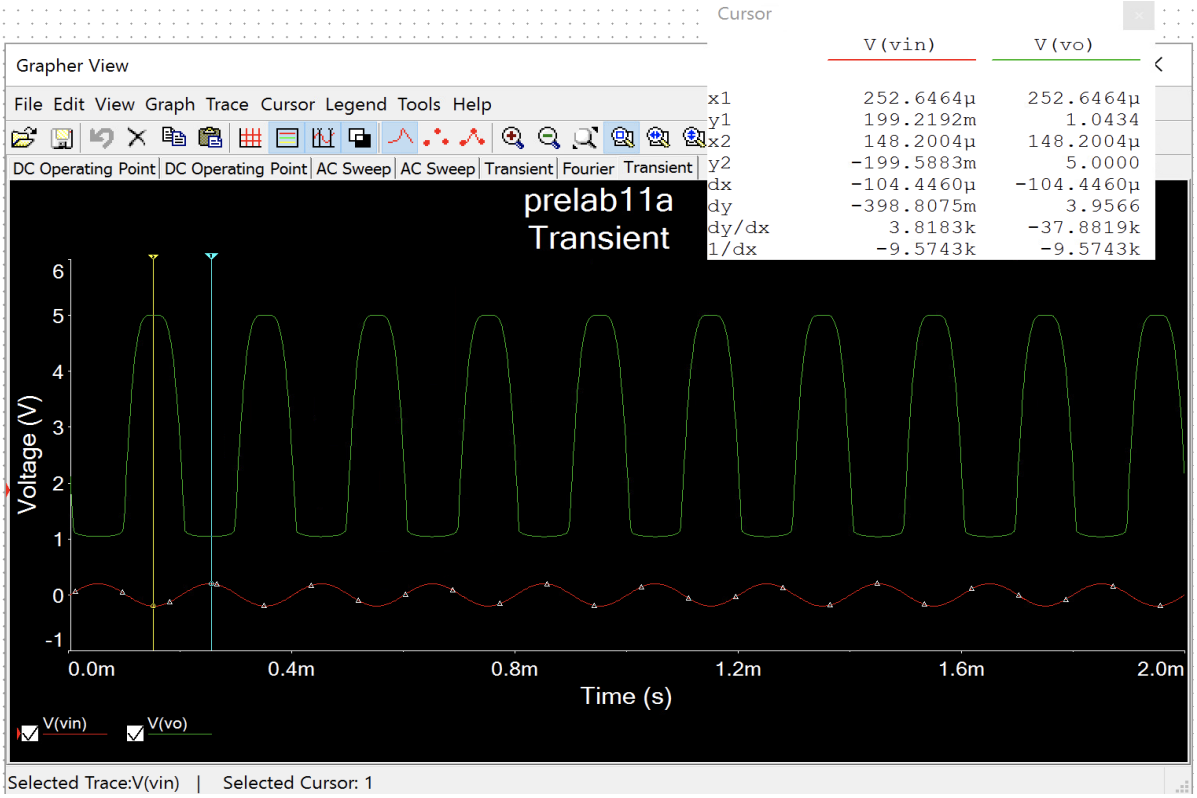
3a Transient



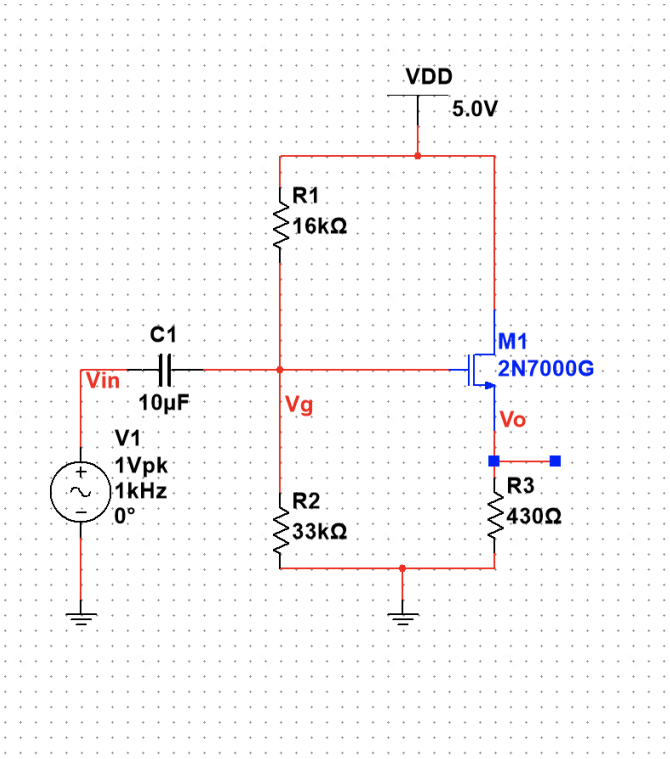
3a THD



3a Clipping



5a Schematic



5a DC Operating point

Grapher View

File Edit View Graph Trace Cursor Legend Tools Help

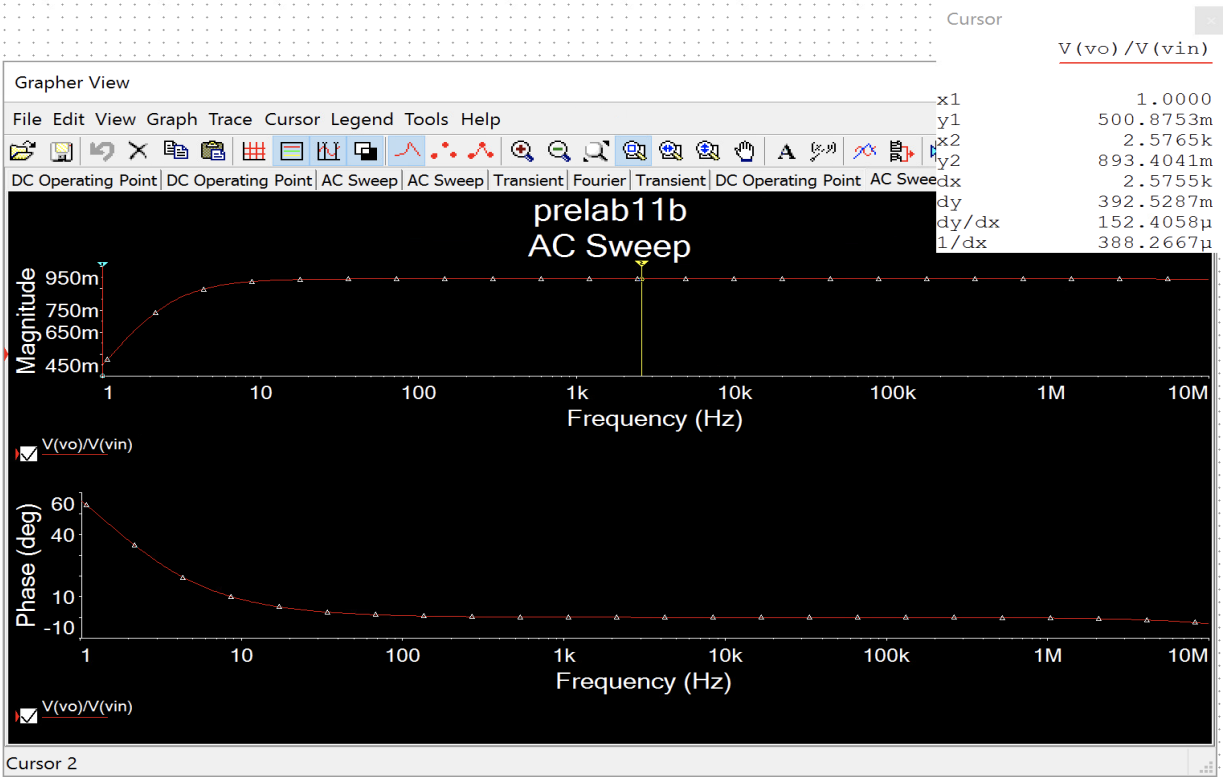
DC Operating Point | DC Operating Point | AC Sweep | AC Sweep | Transient | Fourier | Transient | DC Operating Point

prelab11b
DC Operating Point Analysis

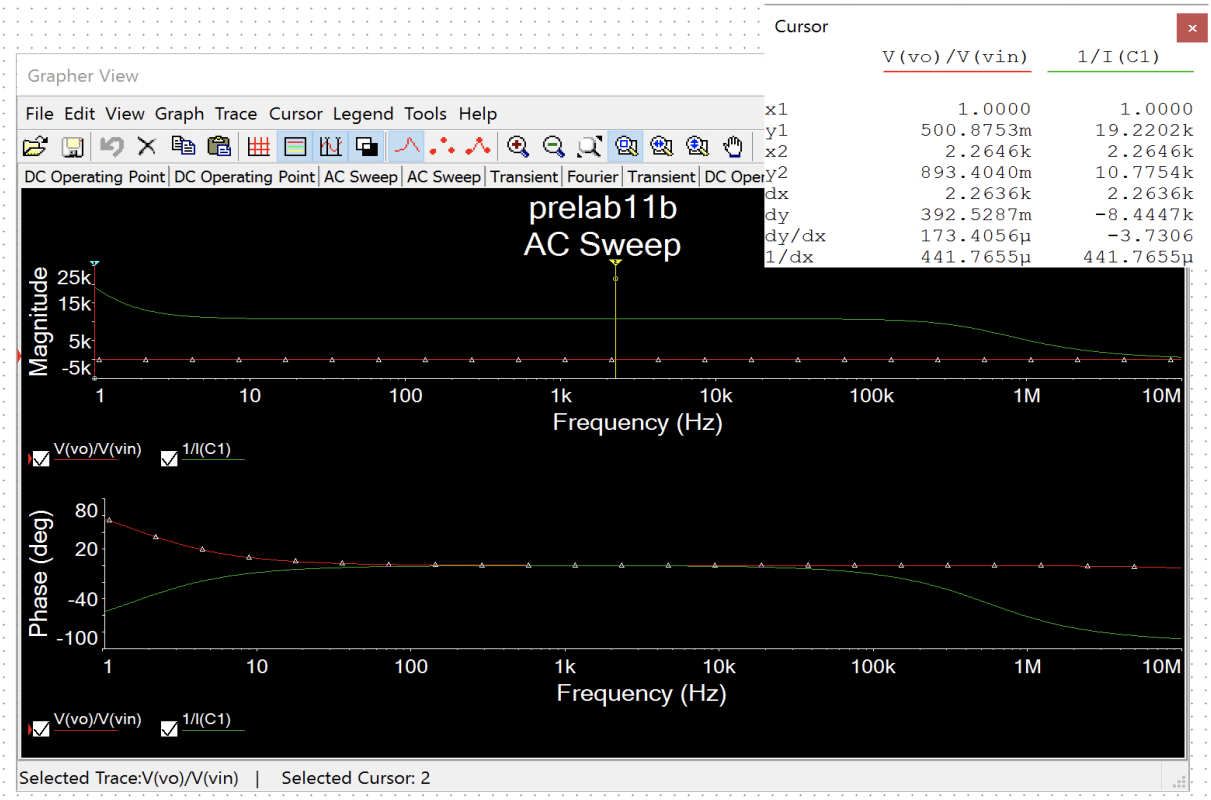
	Variable	erating point va
1	V(vg)	3.36735
2	V(vo)	915.29072 m
3	I(R1)	102.04082 u

Selected Diagram:DC Operating Point Analysis

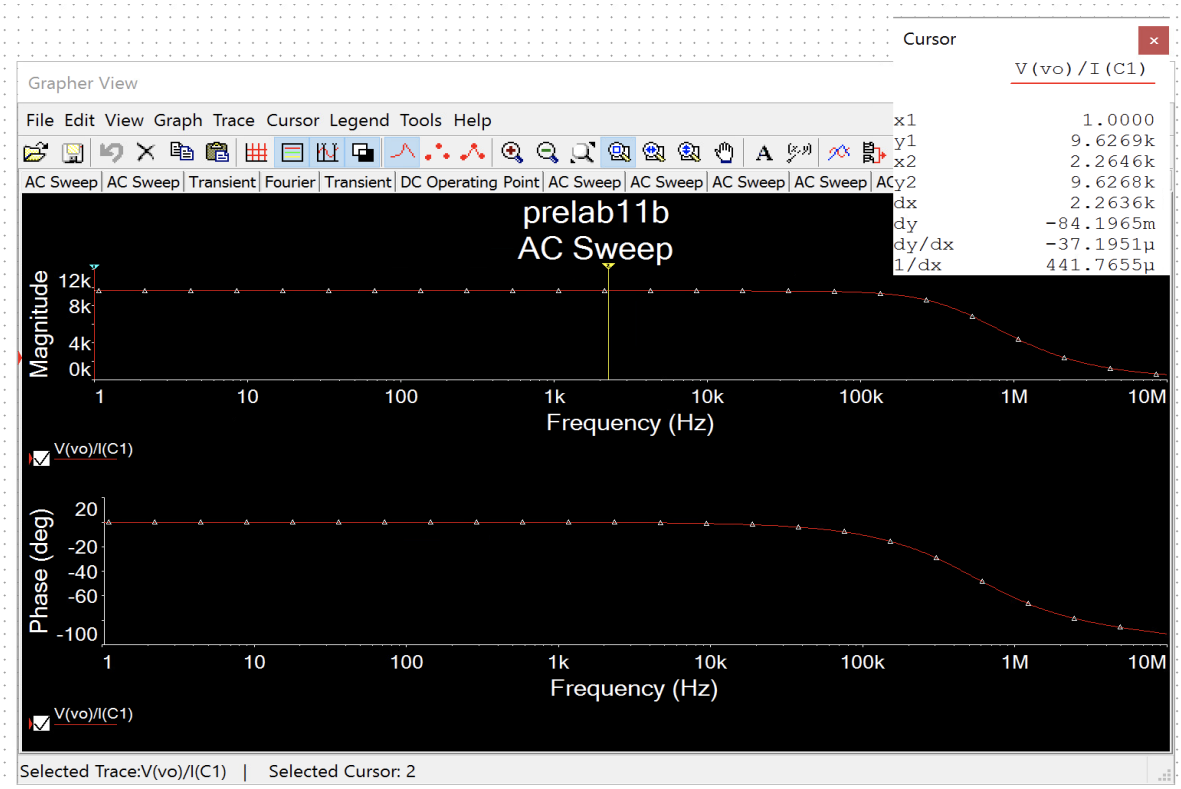
5a AC simulation A_V



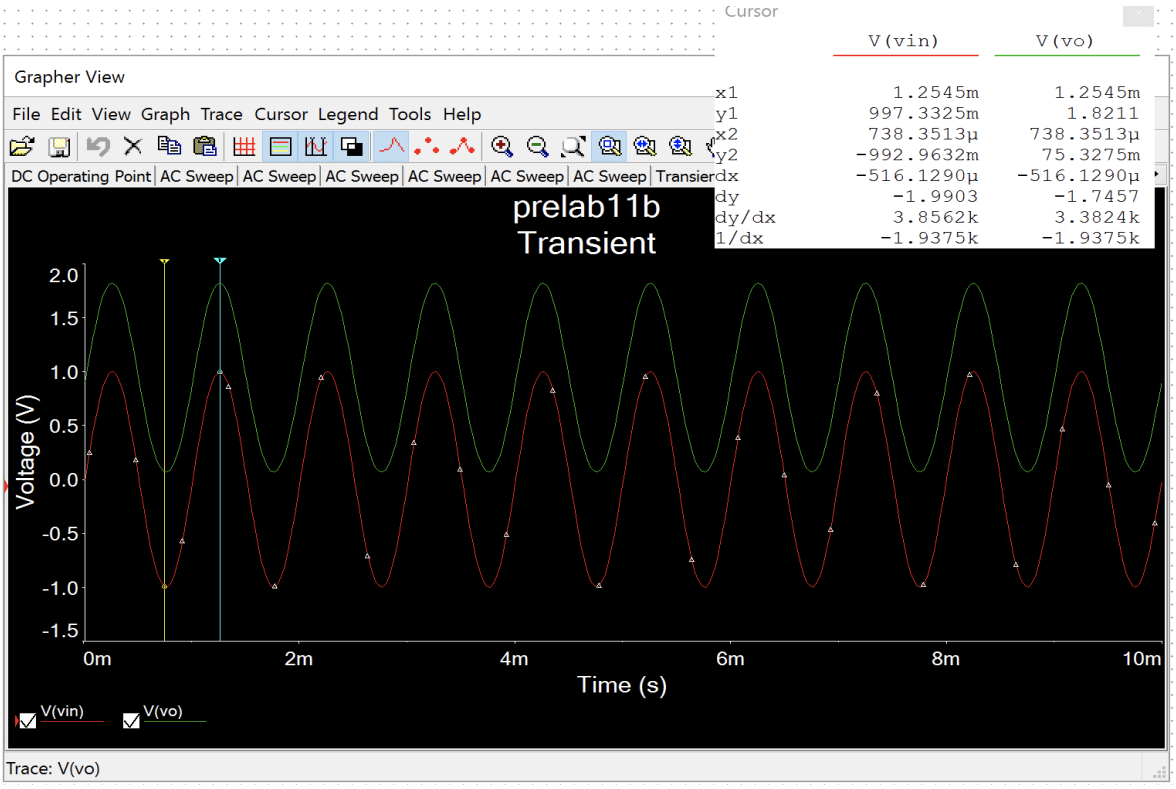
5a AC simulation R_i



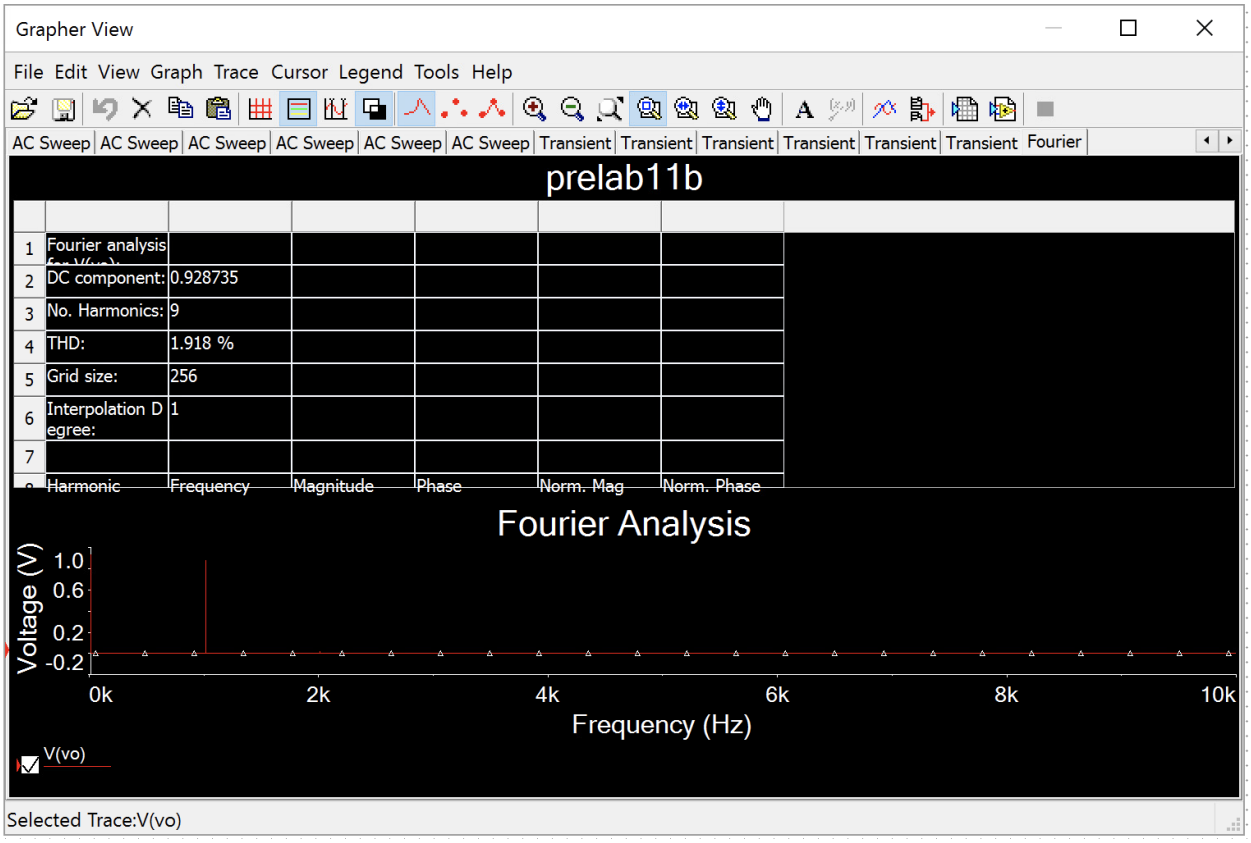
5a AC simulation R_o



5a Transient



5a THD

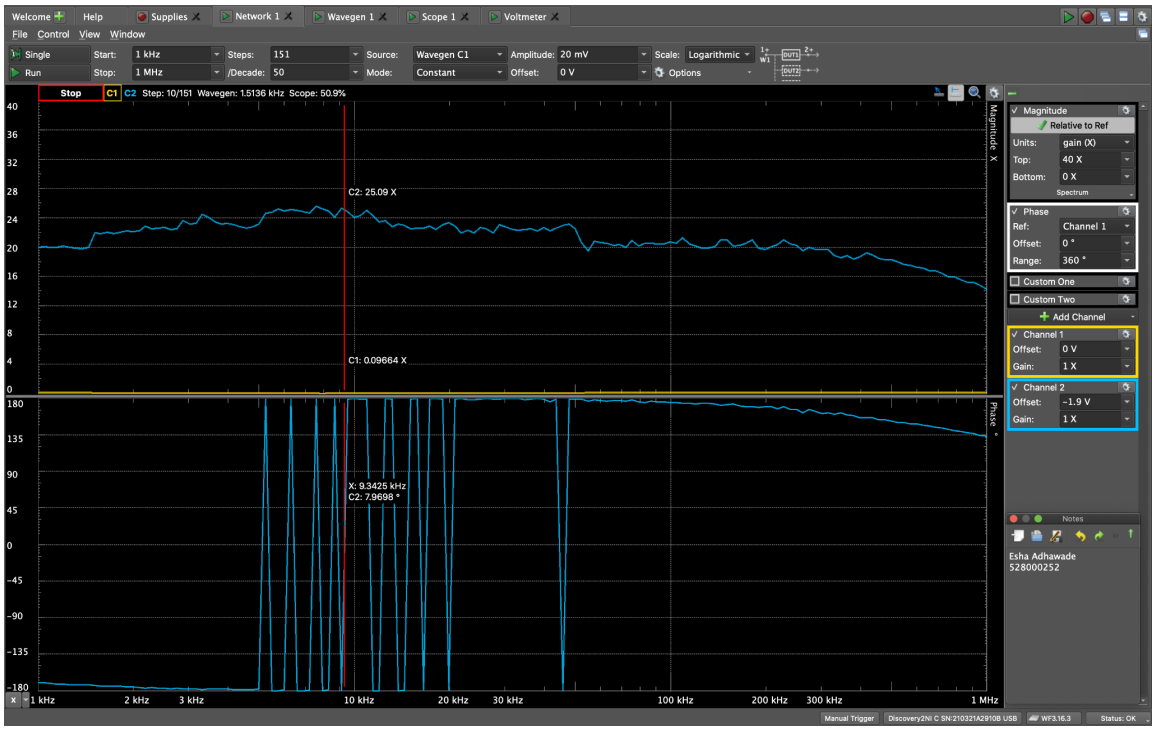

Grapher View
File Edit View Graph Trace Cursor Legend Tools Help
AC Sweep AC Sweep AC Sweep AC Sweep AC Sweep AC Sweep Transient Transient Transient Transient Transient Transient Fourier
prelab11b
1 Fourier analysis
2 DC component: 0.928735
3 No. Harmonics: 9
4 THD: 1.918 %
5 Grid size: 256
6 Interpolation Degree: 1
7
Harmonic Frequency Magnitude Phase Norm. Mag Norm. Phase
Fourier Analysis
Voltage (V)
1.0
0.6
0.2
-0.2
0k
2k
4k
6k
8k
10k
Frequency (Hz)
V(vo)
Selected Trace:V(vo)

Measurements

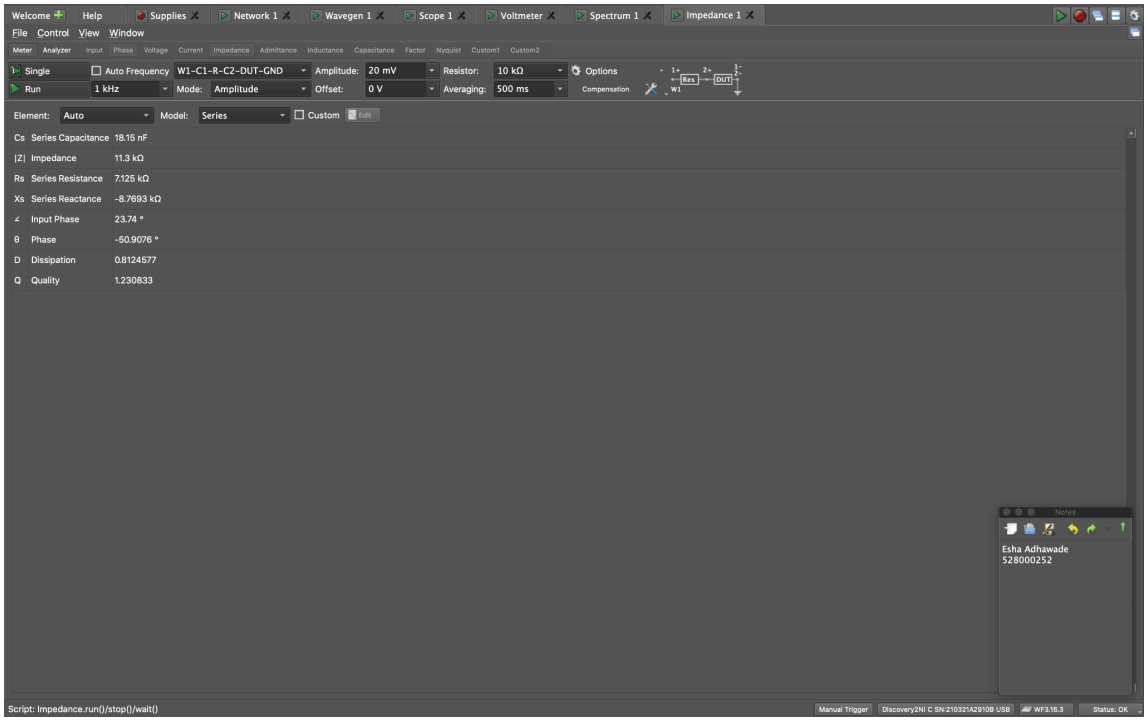
3a DC Values

In the Data Tables Section

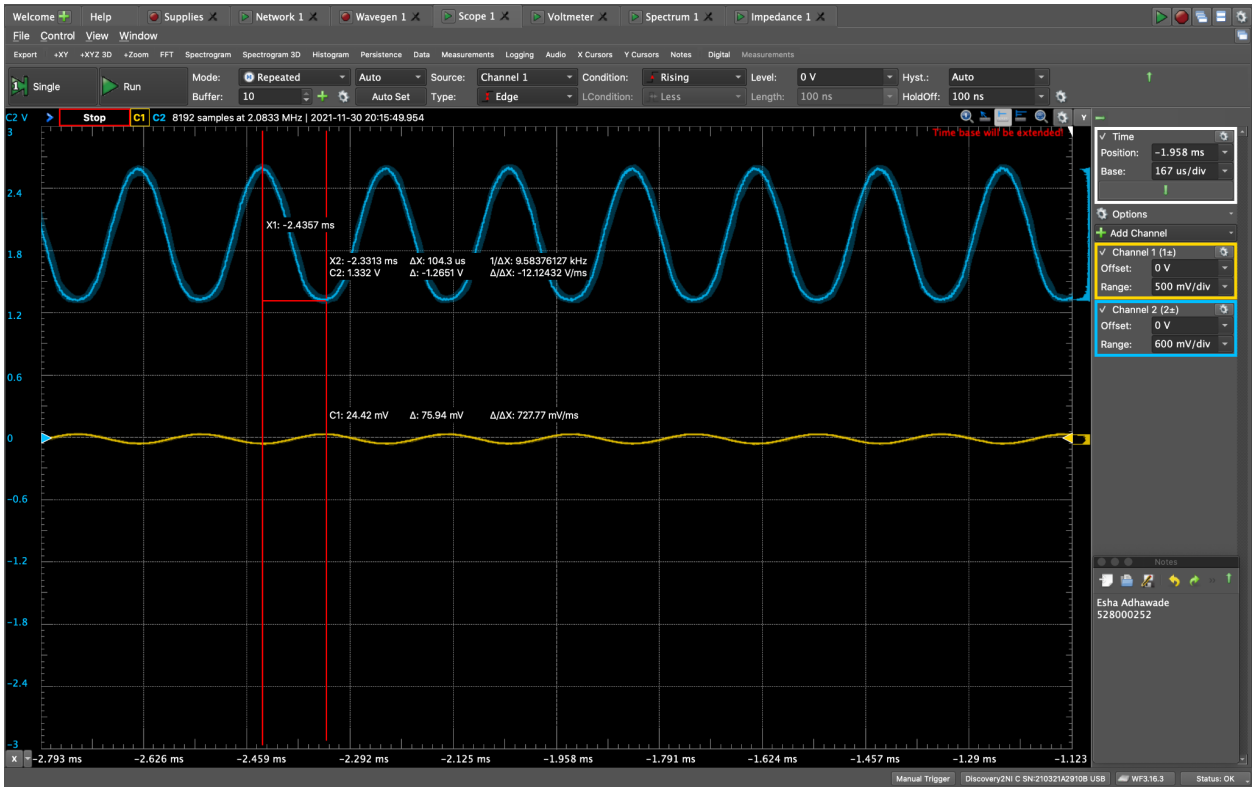
3a AC simulation A_V



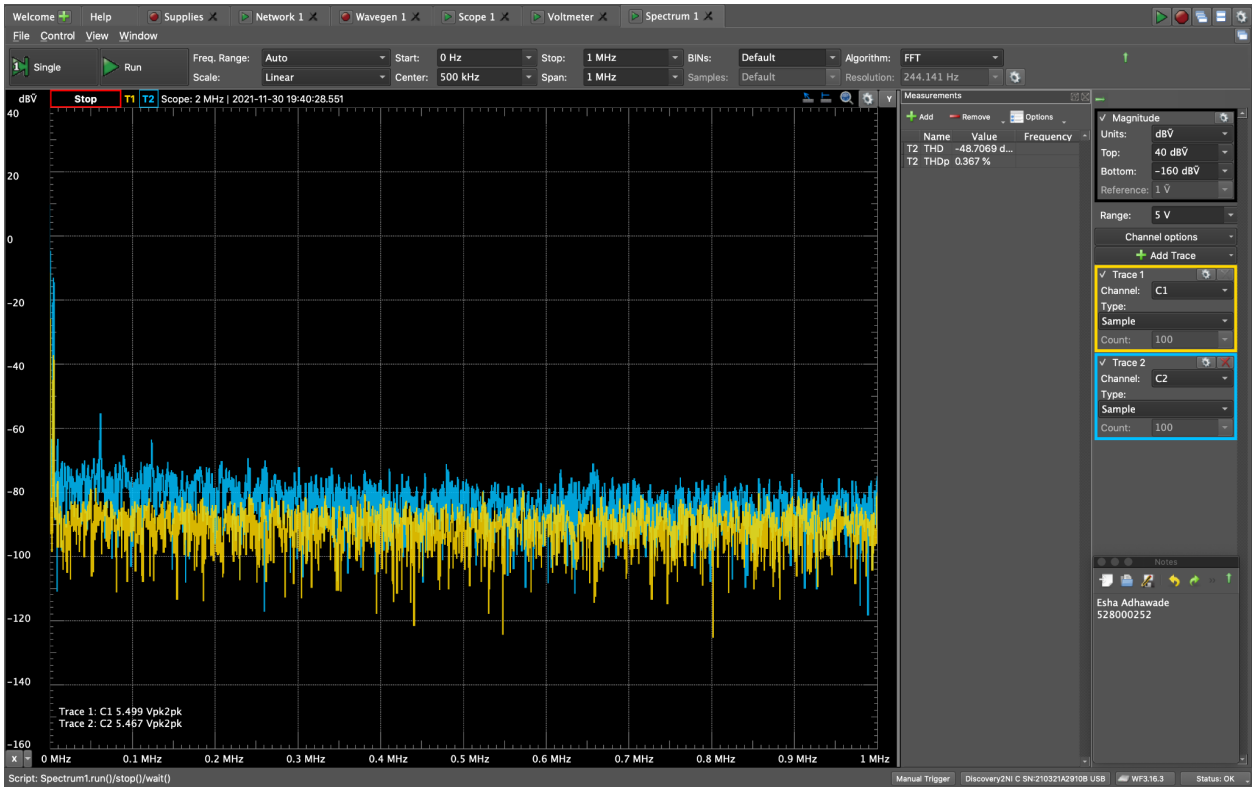
3a AC simulation R_i



3a Transient



3a THD

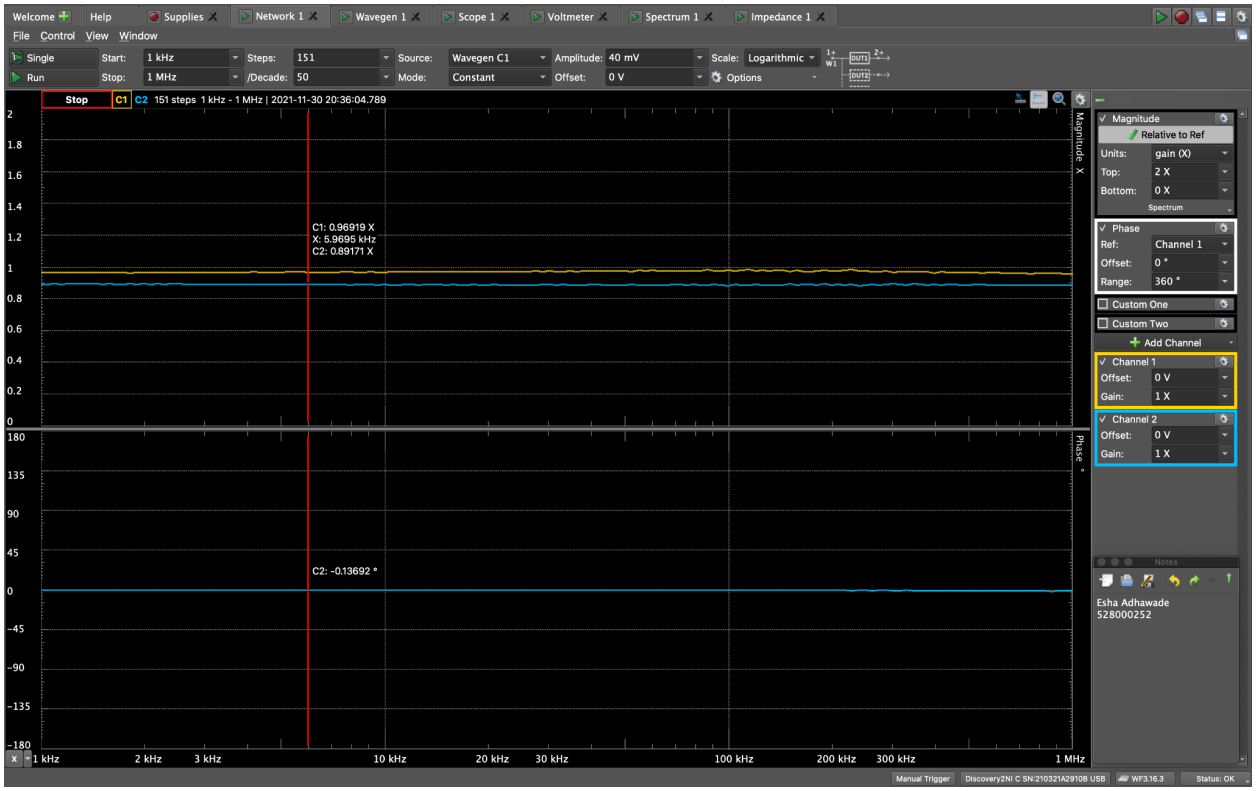


3a Clipping Point: 55 mV

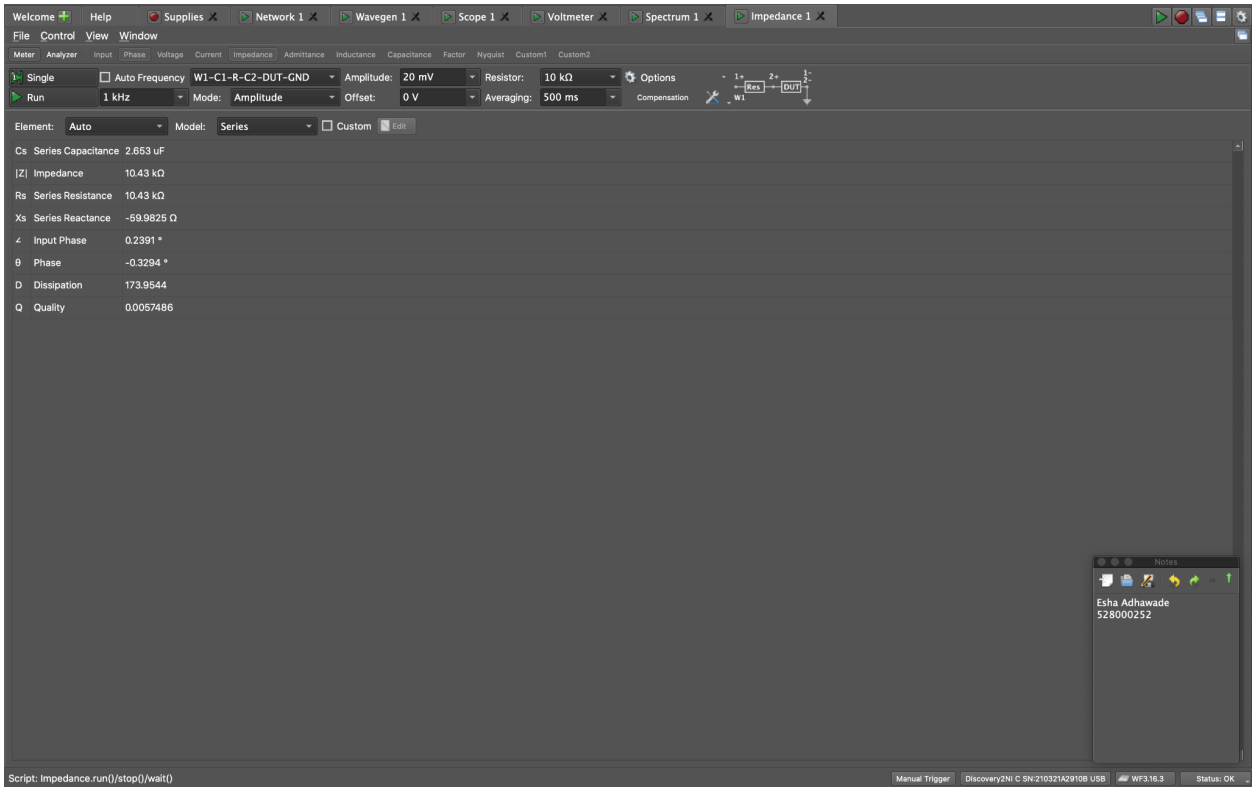
5a DC Values

In the Data Tables Section

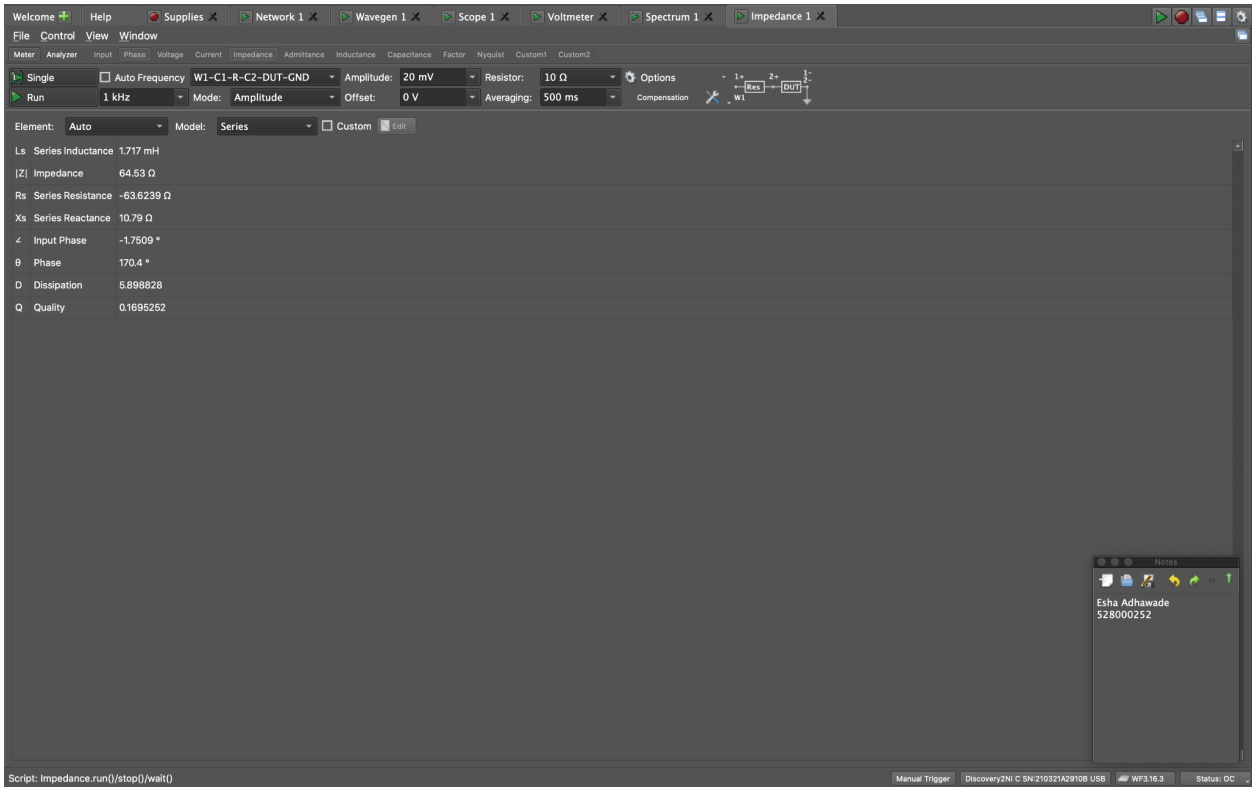
5a AC simulation A_V



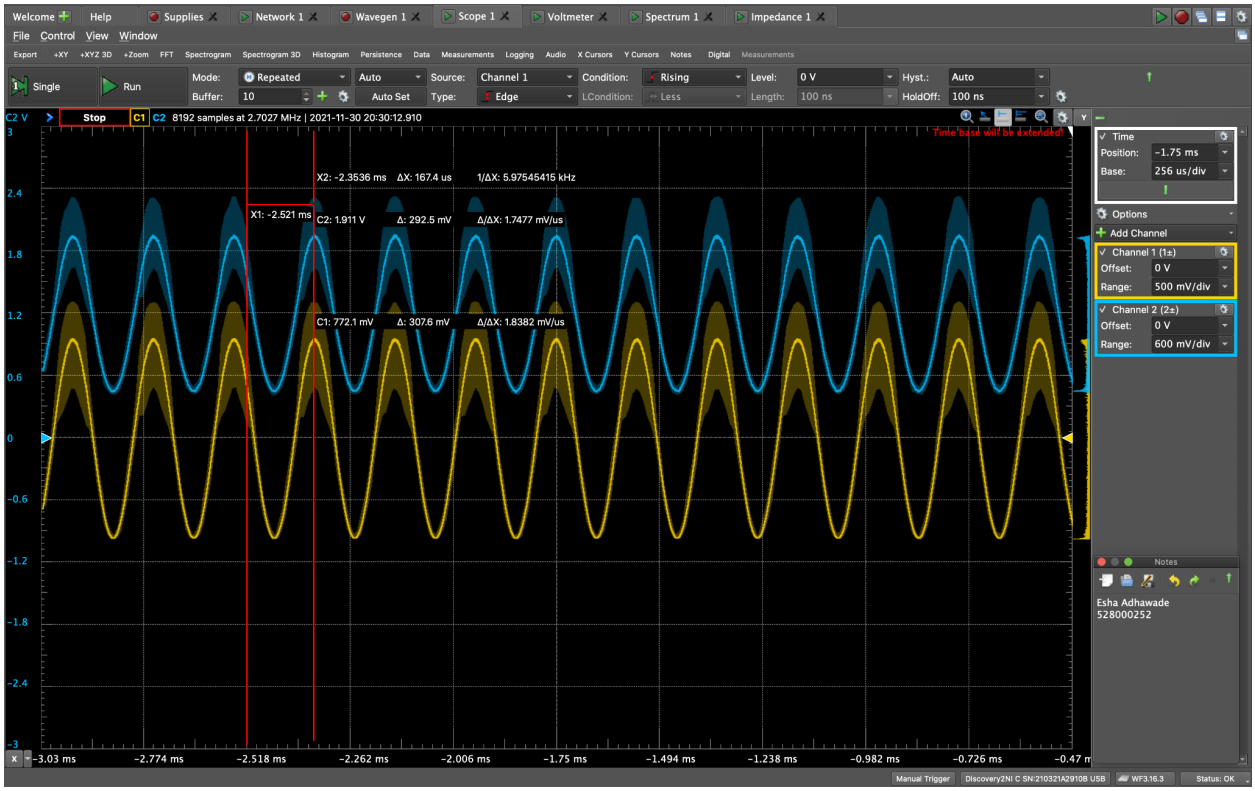
5a AC simulation R_i



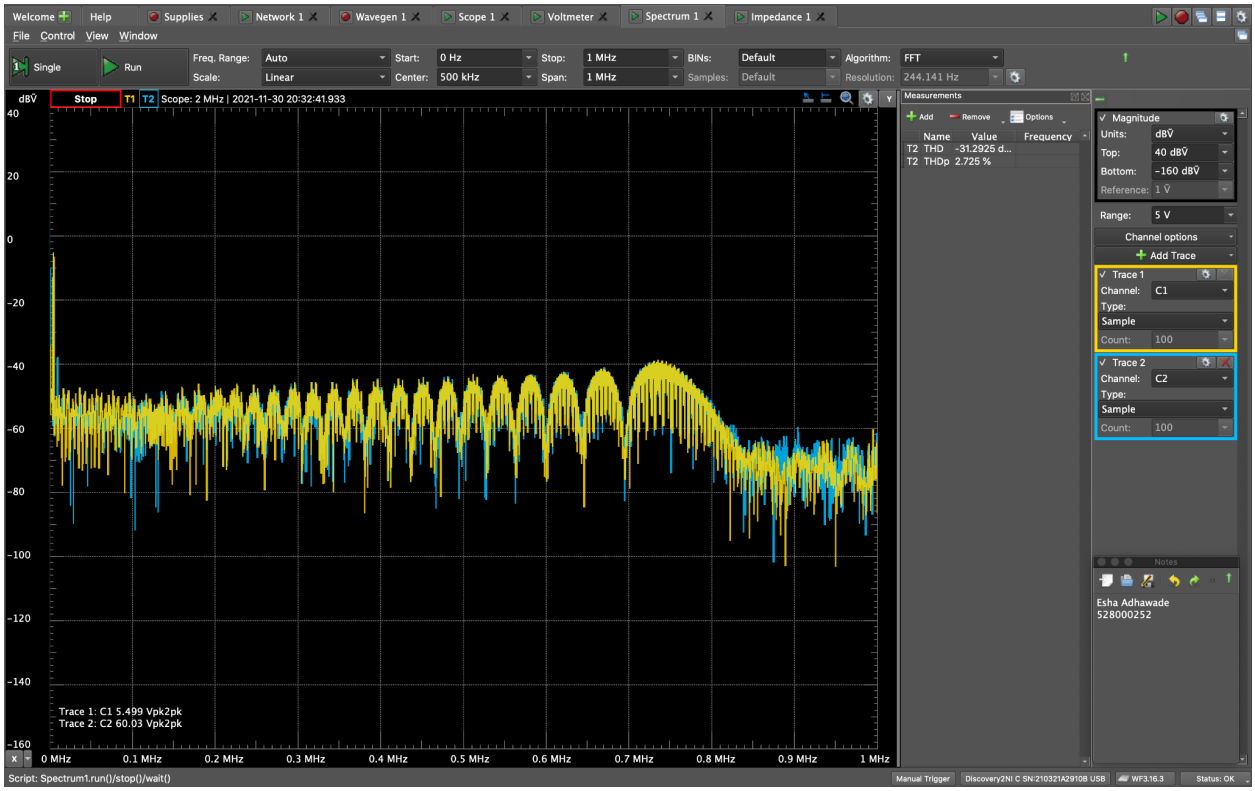
5a AC simulation R_o



5a Transient



5a THD



Data Tables

Figure 3

DC Values

	Simulations	**Measurements**
$\mathbf{V_{RG2}}$	3.4000 V	3.325 V
$\mathbf{V_{RS}}$	969.37090 mV	1.0014 V
$\mathbf{V_{RD}}$	1.934 V	2.076 V
$\mathbf{V_{o,\,dc}}$	2.10920 V	2.0961 V
$\mathbf{I_C}$	1.73102 mA	1.92013 mA

Other

	Calculations	**Simulations**	**Measurements**
$\mathbf{A_V}$	25	29.415	25.09
$\mathbf{R_i}$	10k	10.6973k	11.3k
THD	-	3.60552%	0.367%

Figure 5

DC Values

	Simulations	**Measurements**
$\mathbf{V_{RG2}}$	3.36735	3.5667 V
$\mathbf{V_{RS}}$	952.278 mV	1.0012 V
$\mathbf{I_C}$	102.04082 μA	1.0812 mA

Other

	Calculations	**Simulations**	**Measurements**
$\mathbf{A_V}$	0.031	0.89340	0.89171
$\mathbf{R_i}$	10k	10.7754k	10.43k
$\mathbf{R_o}$	310.07	84.234	64.53
THD	-	1.918%	2.725%

Discussion

For lab 11, students learned to analyze MOS amplifier configurations. Most of the values between the simulations and measurements were pretty consistent for the circuits. If there were any minor differences, that's probably because of component differences, old breadboards, or loose wires. In this lab, I used slightly different resistor values in my measurements in comparison to simulations.