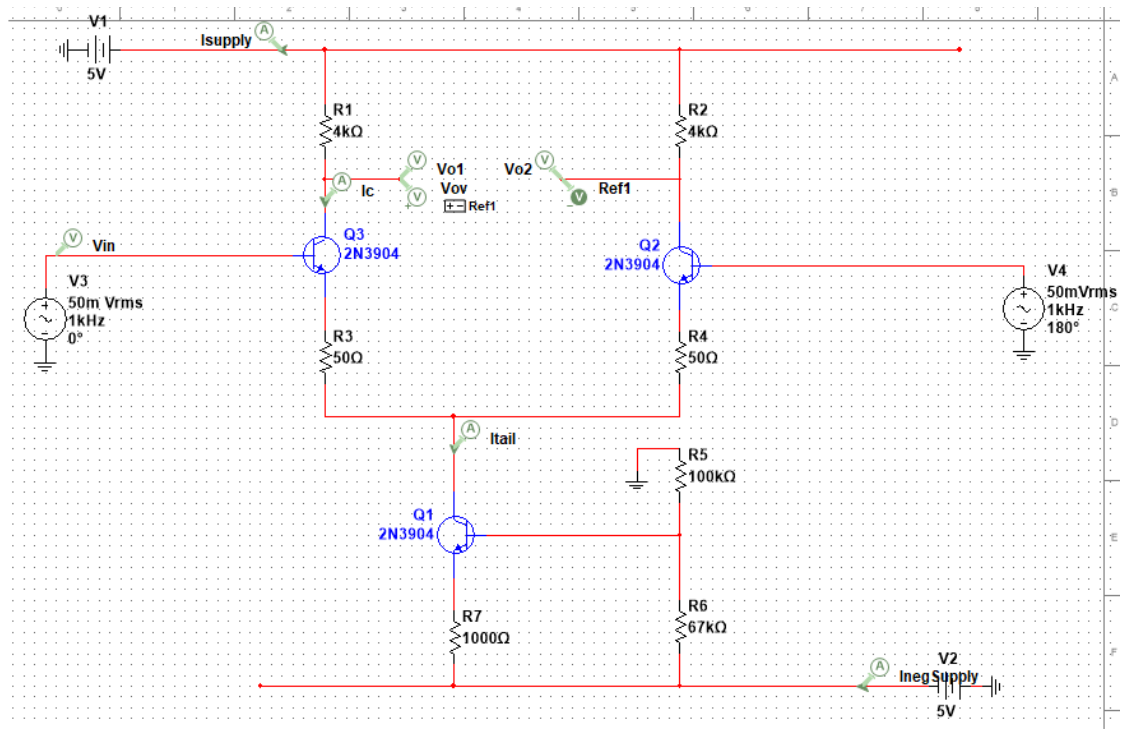Matthew Loden

ECEN 326-503

Lab 4: Design of a BJT Differential Amplifier
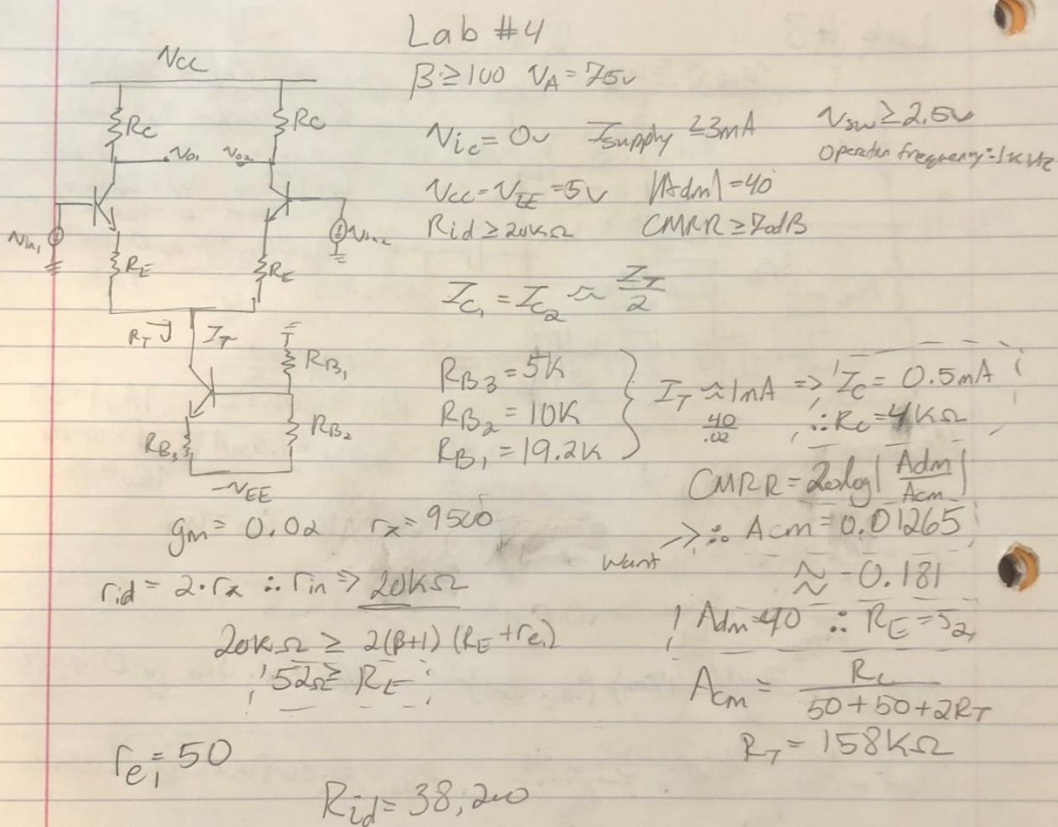
Procedure:

In this lab we designed a BJT differential amplifier with emitter resistors and a current source at the bottom.
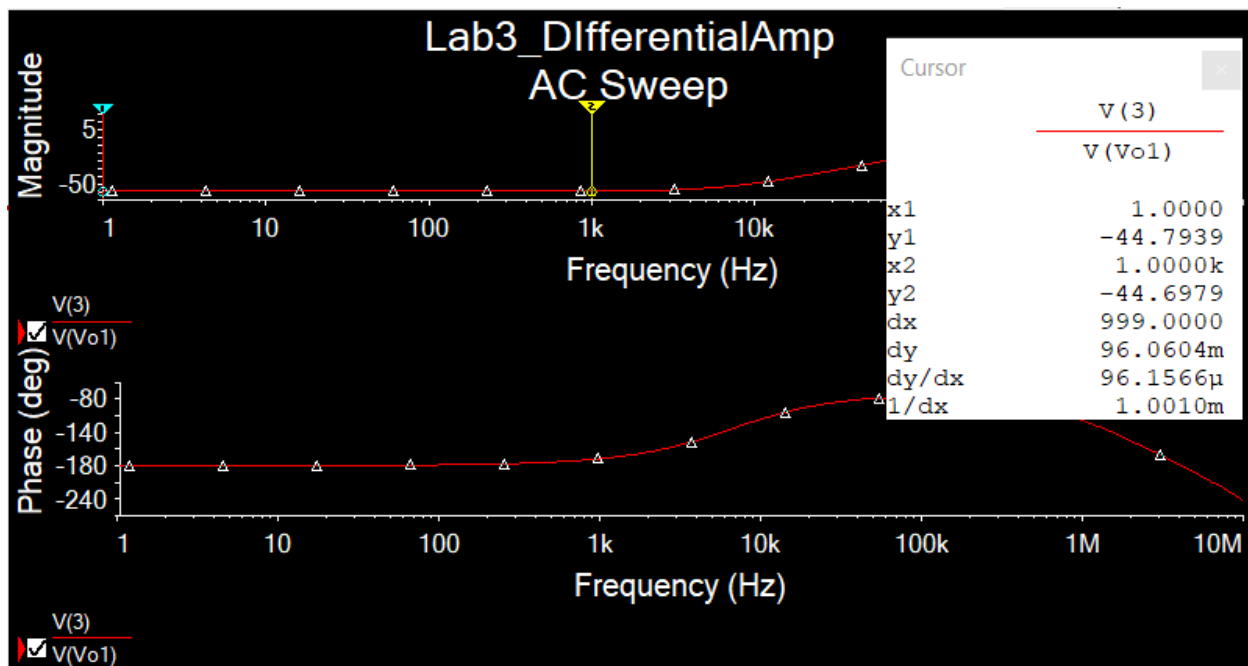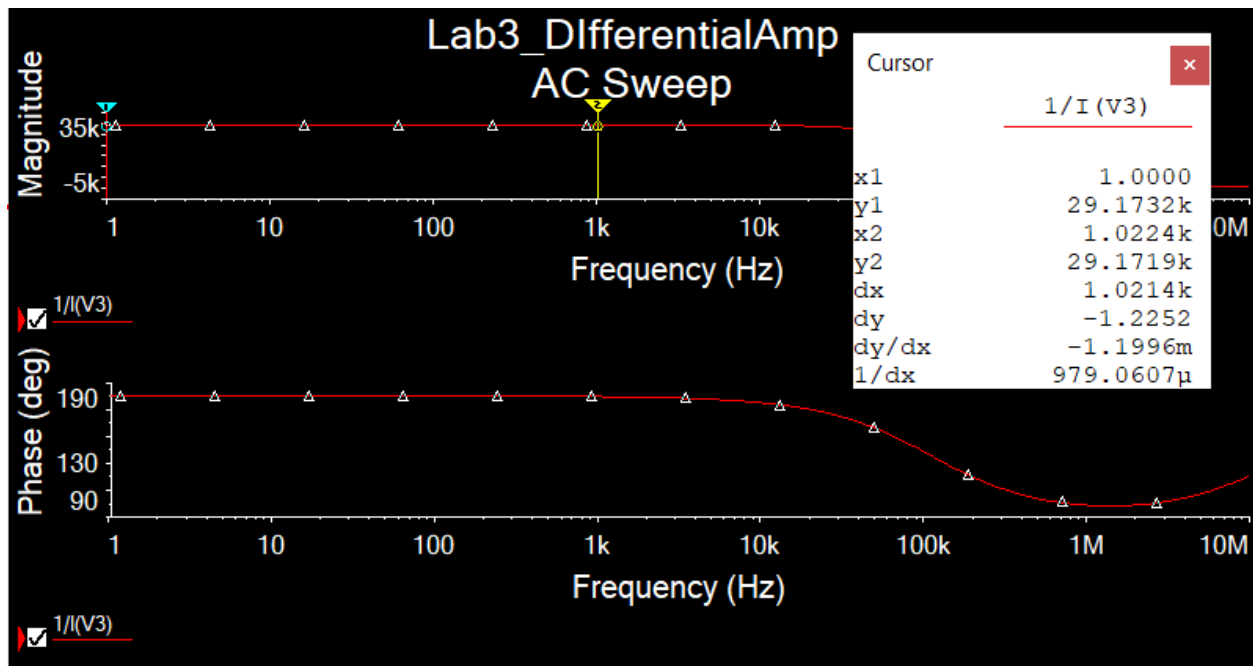
Design:

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Calculations:

Lab #4

$\beta \geq 100$ $V_A = 75v$

$N_{ic} = 0v$ $I_{supply} \approx 3mA$ $V_{sw} \geq 2.5v$
Operating frequency $\approx 1kHz$

$V_{cc} = V_{EE} = 5v$ $|Adm| = 40$

$R_{id} \geq 20k\Omega$ $CMRR \geq 7dB$

$$I_{C_1} = I_{C_2} \approx \frac{I_T}{2}$$

$R_{B3} = 5k$
$R_{B2} = 10k$ $\}$ $I_T \approx 1mA \Rightarrow I_C = 0.5mA$
$R_{B1} = 19.2k$ $\frac{40}{.02}$ $\therefore R_C = 4k\Omega$

$g_m = 0.02$ $r_x = 95\Omega$

$CMRR = 2\log\left|\frac{Adm}{Acm}\right|$

$r_{id} = 2 \cdot r_x \therefore r_{in} \Rightarrow \underline{20k\Omega}$ Want $\Rightarrow \therefore Acm = 0.01265$

$20k\Omega \geq 2(\beta+1)(R_E + r_{e_1})$ ≈ -0.181

$\underline{152\Omega \geq R_E}$ $|Adm 40 \therefore R_E = 5\Omega$

$r_{e_1} = 50$ $Acm = \frac{R_C}{50 + 50 + 2R_T}$

$R_{id} = 38,200$ $R_T = 158k\Omega$

Simulations:

DcOp:

	Variable	Operating point value
1	I(Q3:C)	I(Ic)	511.75850 u
2	-I(V2:2)	I(InegSupply)	-1.06461 m
3	I(V1:1)	I(Isupply)	-1.02352 m
4	I(Q1:C)	I(Itail)	1.03166 m
5	V(10)	V(Vin)	0.00000e+00
6	V(3)	V(Vo1)	2.95297
7	V(9)	V(Vo2)	2.95297
8	V(3) - V(9)	V(Vov)	-7.10543e-15

Differential Gain:

Rid:

Lab3_DIfferentialAmp
AC Sweep

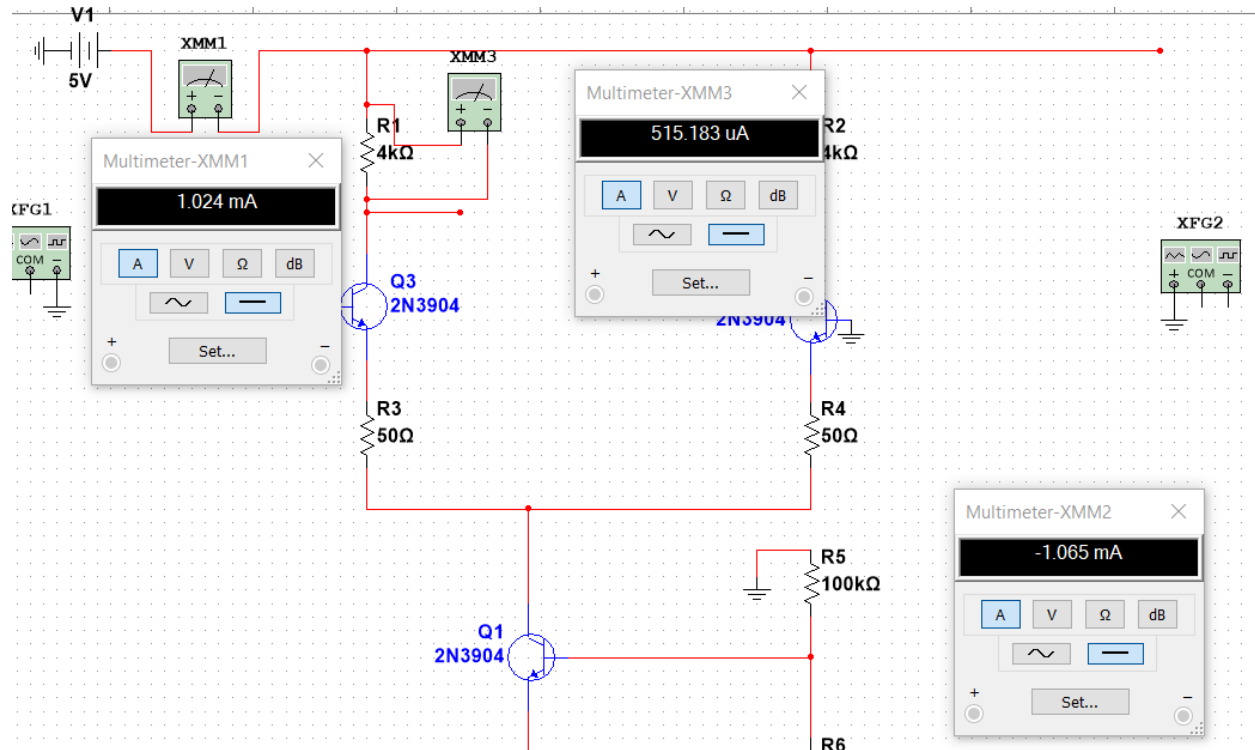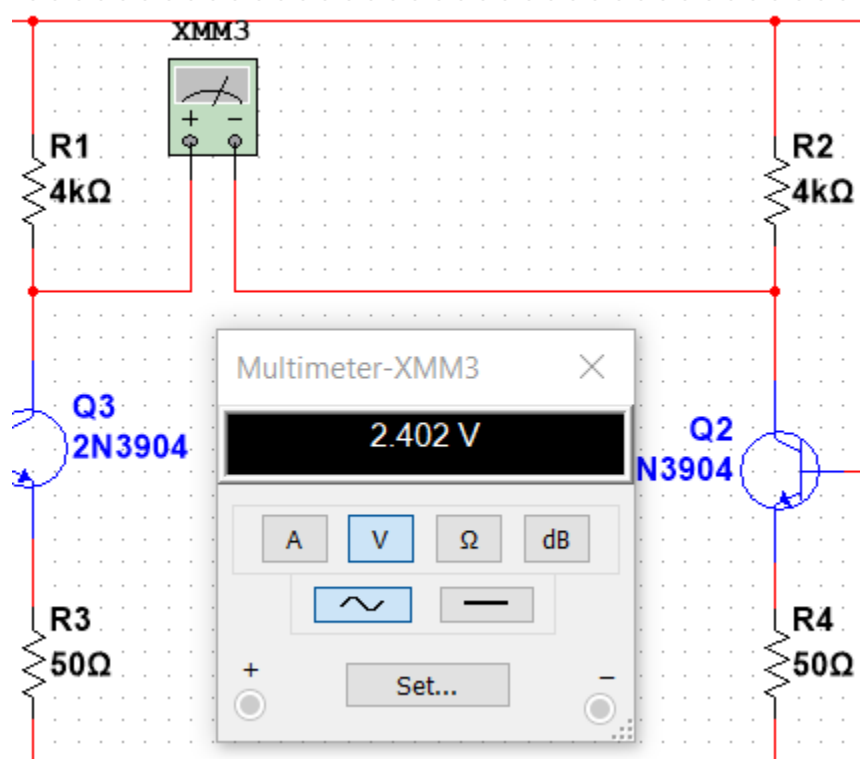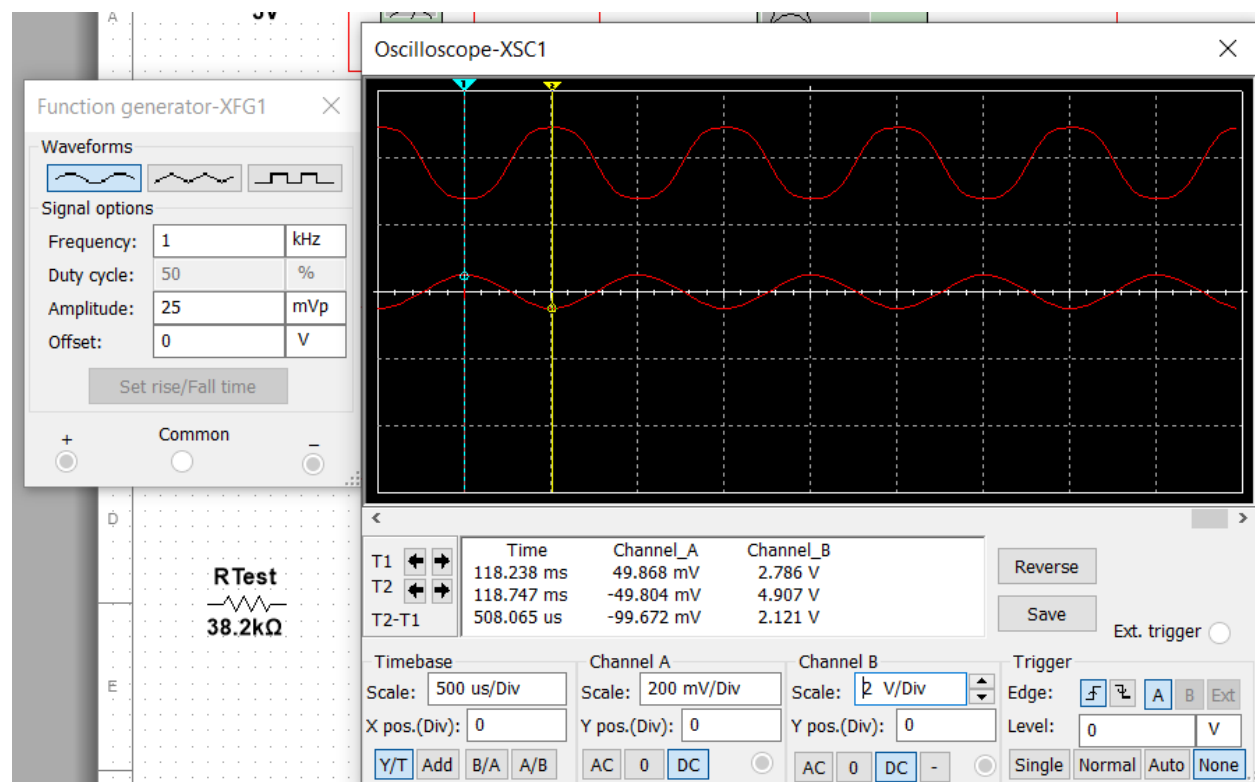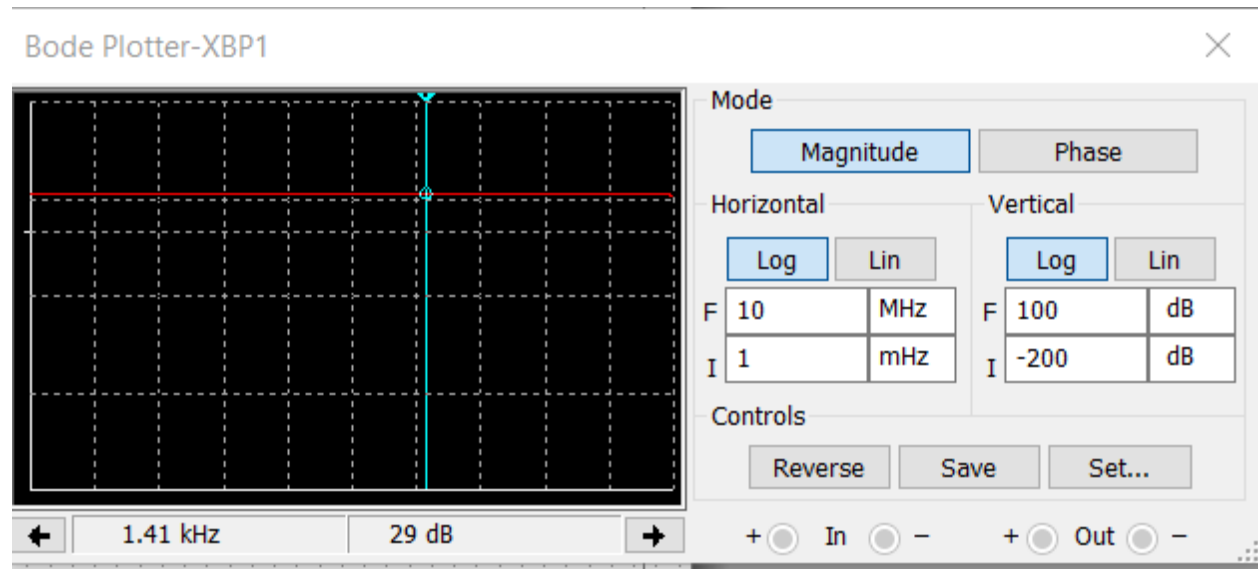| Cursor	1/I(V3)
x1	1.0000
y1	29.1732k
x2	1.0224k
y2	29.1719k
dx	1.0214k
dy	-1.2252
dy/dx	-1.1996m
1/dx	979.0607µ

Measurements:

DcOp:

Vov:

Unclipped Swing

Adm:

Rid ratio @ Rtest = 38.2k:

Rid = 3k * 2 = 6k

THD @ 1%:

Waveforms

Signal options

Frequency:	1	kHz
Duty cycle:	50	%
Amplitude:	9	mVp
Offset:	0	V

Waveforms

Signal options

Frequency:	1	kHz
Duty cycle:	50	%
Amplitude:	9	mVp
Offset:	0	V

tortion analyzer-XDA1
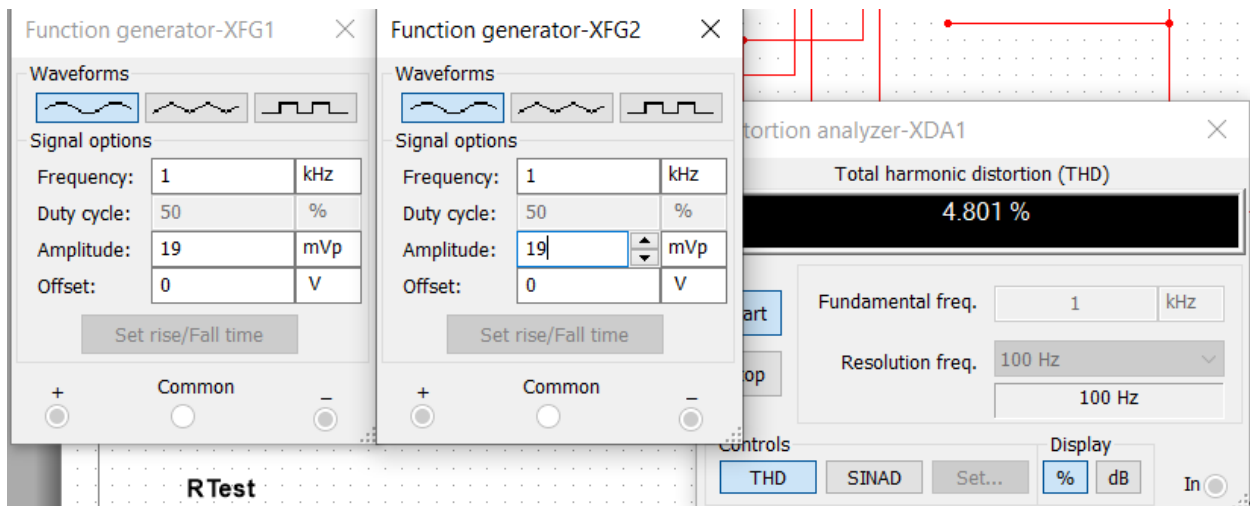
Total harmonic distortion (THD)

1.039 %

Fundamental freq.	1	kHz
Resolution freq.	100 Hz	
	100 Hz	

Controls: THD SINAD Set...
Display: % dB In

THD @5%:

Function generator-XFG1

Waveforms

Signal options

Frequency:	1	kHz
Duty cycle:	50	%
Amplitude:	19	mVp
Offset:	0	V

Function generator-XFG2

Waveforms

Signal options

Frequency:	1	kHz
Duty cycle:	50	%
Amplitude:	19	mVp
Offset:	0	V

tortion analyzer-XDA1

Total harmonic distortion (THD)

4.801 %

Fundamental freq.	1	kHz
Resolution freq.	100 Hz	
	100 Hz	

Controls: THD SINAD Set...
Display: % dB In

Common Mode Gain:

Results:

	Calculated	Simulated	Measured
Itail	1mA	1.03mA	2*Ic = 1.03mA
Ic	500uA	511uA	515uA
Isupply	1mA	1.03mA	1.024mA
Vov	0v	0v	2.4v
Adm	40dB	44.69dB	29dB
Acm	0.01265	-	-
Rid	38.2kΩ	29.17kΩ	6kΩ
Unclipped Swing	2.5v	2.03v	2.12v

A big difference in my data comes from the differences between my measured data and my simulated/calculated data. My simulations line up very similarly to what I've calculated however when I switch my instruments over to the measurements the numbers start to go a little crazy. For starters, the voltage difference from the output 2 – output 1 is zero when the circuit is in differential mode however when measured it outputs around 2.4 volts for some reason. I'm not sure if this has something to do with how the simulation deals with grounded sources or if there was something that was miscalculated. Another smaller difference comes from the gain, where the simulated is above the calculated value and the measured is noticeably below. There is about a ten dB drop from the simulated differential gain to the measured gain which is significant however I'm not sure what has caused this. I again think this might have something to do with the way the simulation deals with ACsweep vs the bode plotter. The input resistance is my largest difference with aa reasonable calculation value, a higher than minimum simulated value and an incredibly low measured value. The measured value is so low that it isn't even meeting the minimum requirement for this amplifier. Finally, my common mode gain was something that I could not figure out how to calculate for this lab. I tried running the simulation with the two inputs voltages connected and producing the same signal however I only could measure large values with that. I know that this value must be very small so that the CMRR can be large, and I know that the value should be very small when the circuit is mirrored correctly so I think my value should be right however I don't know how to measure it.