Lossy integrator

1) $V_{in} = V_{in}\left(\frac{R_2}{R_1+R_2}\right)$ $\quad R_{TH} = \frac{R_1R_2}{R_1+R_2}$

$V_o(t) = V_{TH}\, e^{-t/RC} = V_{in}\left(\frac{R_2}{R_1+R_2}\right) e^{-t/\frac{R_1R_2C}{R_1+R_2}}$

$$V_o(t) = V_{in}\left(\frac{R_2}{R_1+R_2}\right) e^{\frac{-t(R_1+R_2)}{R_1R_2C}}$$

2) $\frac{V_o}{V_i} = \frac{-R_2/R_1}{1+sR_2C}$ $\quad s=0$ $\quad \frac{V_o}{V_i} = -R_2/R_1 = \frac{-R_2}{R_1} = -22$

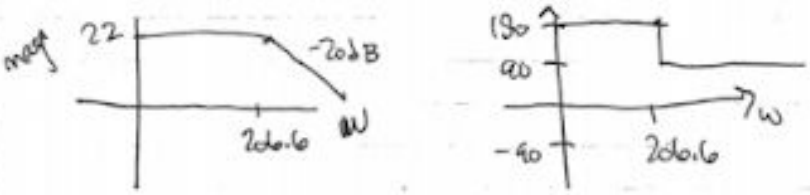
$\frac{R_1+R_2}{R_1R_2C} = \frac{23k}{(22k)(220n)} \rightarrow 4.75206\text{kHz}$

$R_1 = 1\text{k}\Omega$

$R_2 = 22\text{k}\Omega$

$C = 220\text{ nF}$

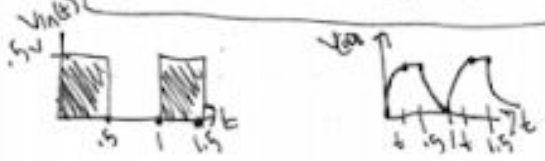
3) $22\left(\frac{1}{s+\frac{1}{.00434}}\right) = 22\left(\frac{1}{s+206.6}\right)$



4) $-22\left(\frac{1}{1+\frac{w}{206.6}}\right)$ $\quad V_o(t) = -22 \cdot .5 \times \left(\frac{1}{\sqrt{1+\frac{w^2}{206.6^2}}}\right) \sin\left(2\pi 1000t - \tan^{-1}\left(\frac{1000}{206.6}\right)\right)$

$V_o(t) = .3605 \sin(2\pi 1000t - 89.16°)$

5)



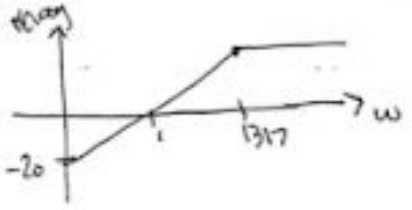
Pseudo Differentiator

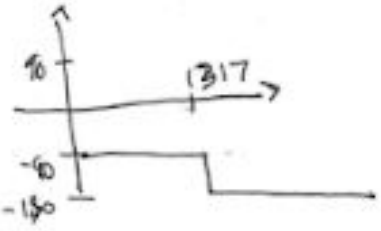
$V_{TH} = V_i(t)\left(\frac{R_2}{R_1+R_2}\right)$ $\quad \tau = (R_1+R_2)C$

$V_o(t) = V_{TH}\, e^{-t/\tau} = V_i(t)\left(\frac{R_2}{R_1+R_2}\right) e^{-t/(R_1+R_2)C}$

$\frac{V_o}{V_i} = \frac{-R_2}{R_1} = -22$ $\quad R_1 = 1k\Omega \quad R_2 = 22k\Omega \quad C = 33nF$

$22\,\frac{s}{s+1/RC}$ $\quad 1317.5\,Hz$

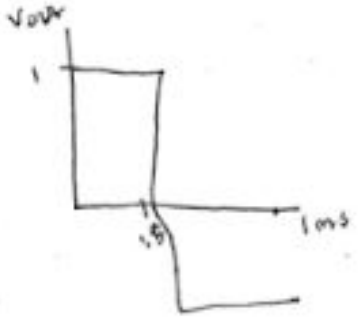




$V_i(t) = 0.1\sin(2\pi 1000t)$

$\frac{V_o}{V_i} = -22(1)\sqrt{\frac{2000\pi}{\sqrt{1+\left(\frac{2000\pi}{1317.5}\right)^2}}}\sin\left(2000\pi + 90 - \tan^{-1}\left(\frac{1}{1317}\right)\right)$

$= .09\sin(2\pi 1000 + 11.84^{\circ})$



Finite GBW Limitations

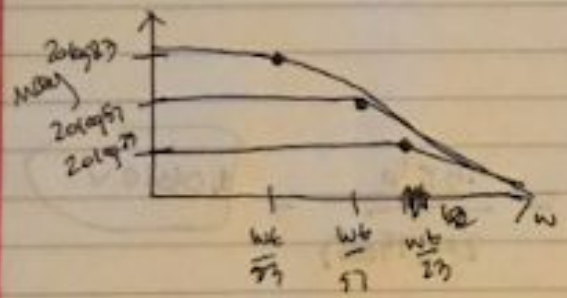
$R_1 = 1k\Omega$ $\quad 23 = 1 + \frac{R_2}{R_1}$ $\quad R_2 = 22k\Omega$

gain $= 1 + \frac{R_2}{R_1}$ $\quad 57 = 1 + \frac{R_2}{R_1}$ $\quad R_2 = 56k\Omega$

$82 = 1 + \frac{R_2}{R_1}$ $\quad R_2 = 82k\Omega$

$$\frac{V_O}{V_I} = G\left(\frac{1}{1 + \frac{s}{\omega_0}}\right) = \frac{G}{1 + s/\omega_{GB}}$$

$$\frac{23}{1 + \frac{s/\omega_{GB}}{23}} = \frac{23}{1 + \frac{23s}{\omega_{GB}}} = \frac{23\omega_t}{\omega_t + 23s} = \frac{23\omega_t}{s + \frac{\omega_t}{23}}$$



$$\frac{57\omega_t}{s + \frac{\omega_t}{57}}$$

$$\frac{82\omega_t}{s + \frac{\omega_t}{82}}$$

Slew Rate Limitations

$\frac{V_o}{V_i} = 1$

$.5\ V/\mu s = .5E6\ V/s$

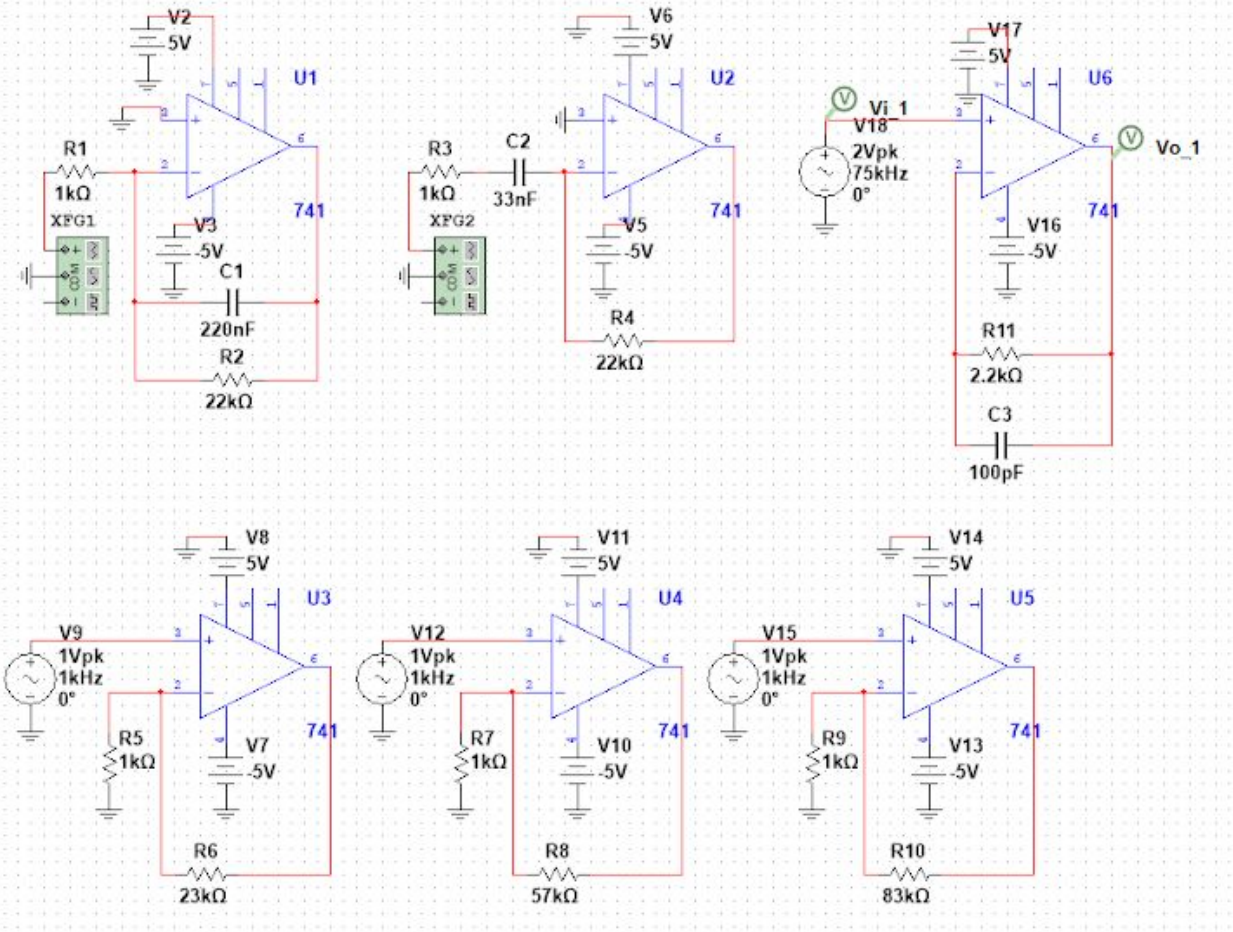
$V_{out_{max}} = \sqrt{V_o^2 + V_i^2} = \sqrt{2}\ V$

$f_{max} = \frac{S_{Rate}}{2\pi V_{omax}} = \frac{.5E6}{2\pi\sqrt{2}} = 56269.76\ Hz$

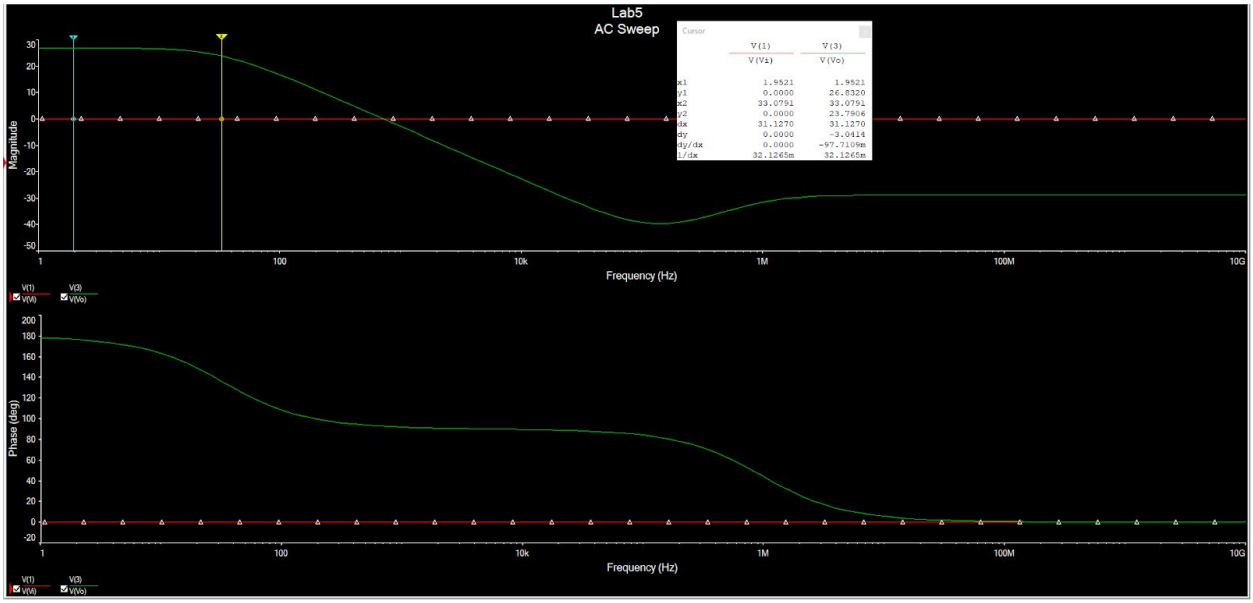
$f_{max} = 75000\ Hz$

$V_{omax} = \frac{S_{Rate}}{2\pi f_{max}} = \frac{.5E6}{2\pi(75000)} = 1.0610\ V$

Simulations

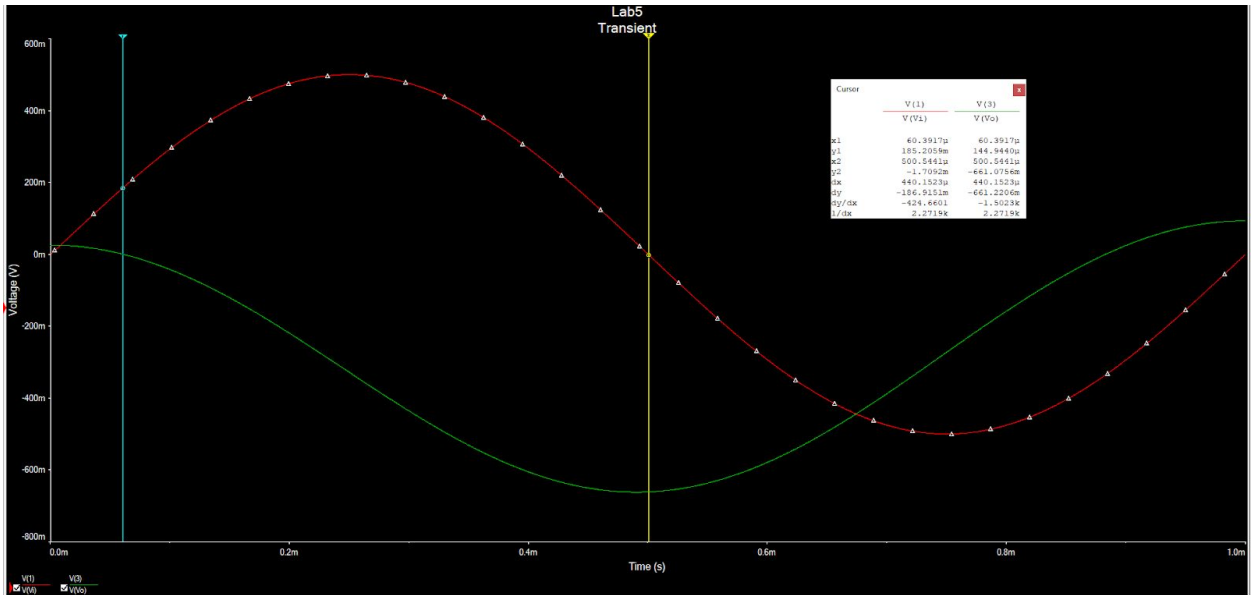


Lossy Integrator Bode Simulation



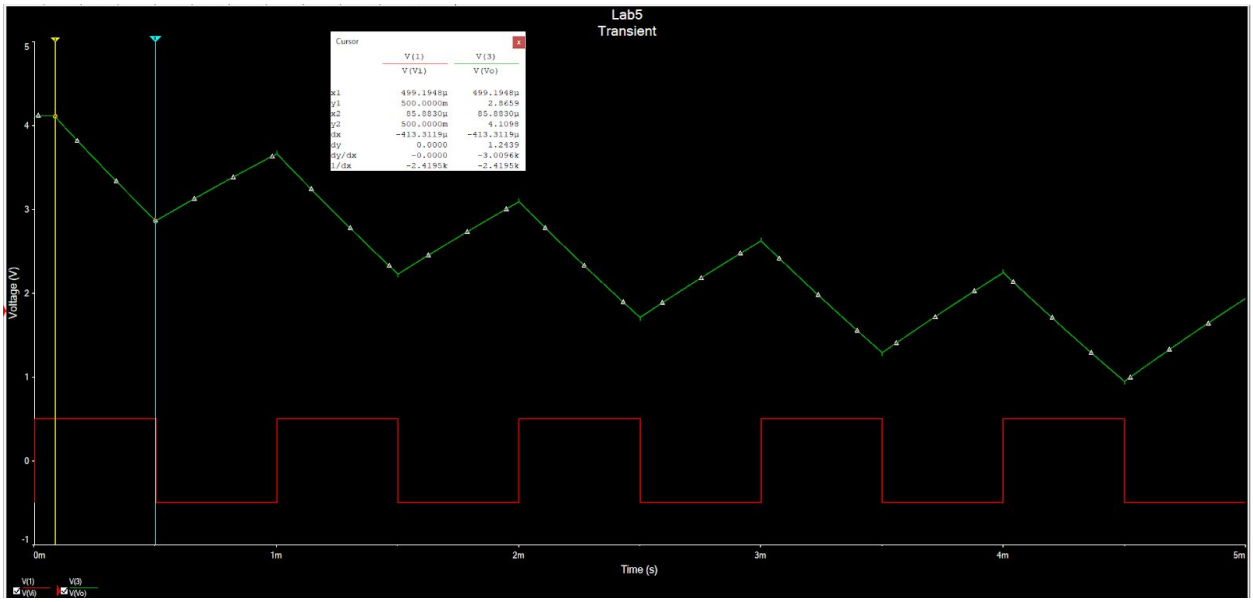
Low frequency gain = 26.8320 dB
3 dB frequency = 33.0791 Hz
1 kHz magnitude = 26.8320 dB
1 kHz phase = 178.25 °

Lossy Integrator Time-Domain Simulation



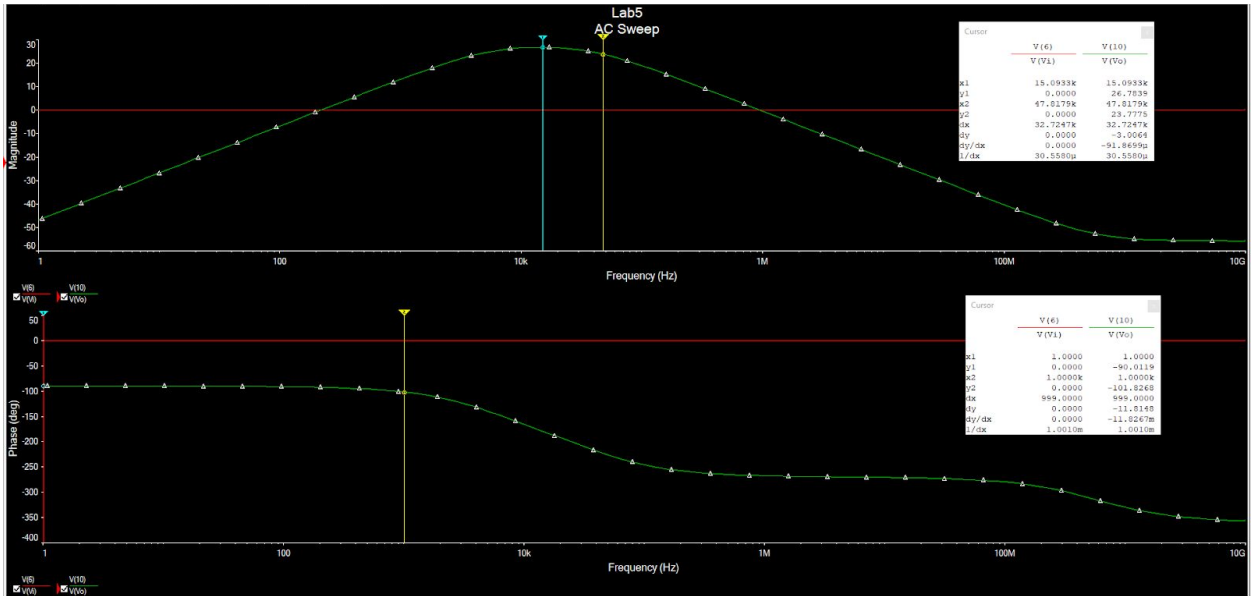
Vi Amplitude = 25.5433 mV
Vo Amplitude = 499.99 mV
Phase Difference = 158.063 °

Lossy Integrator Time-Domain Simulation (Square Wave)



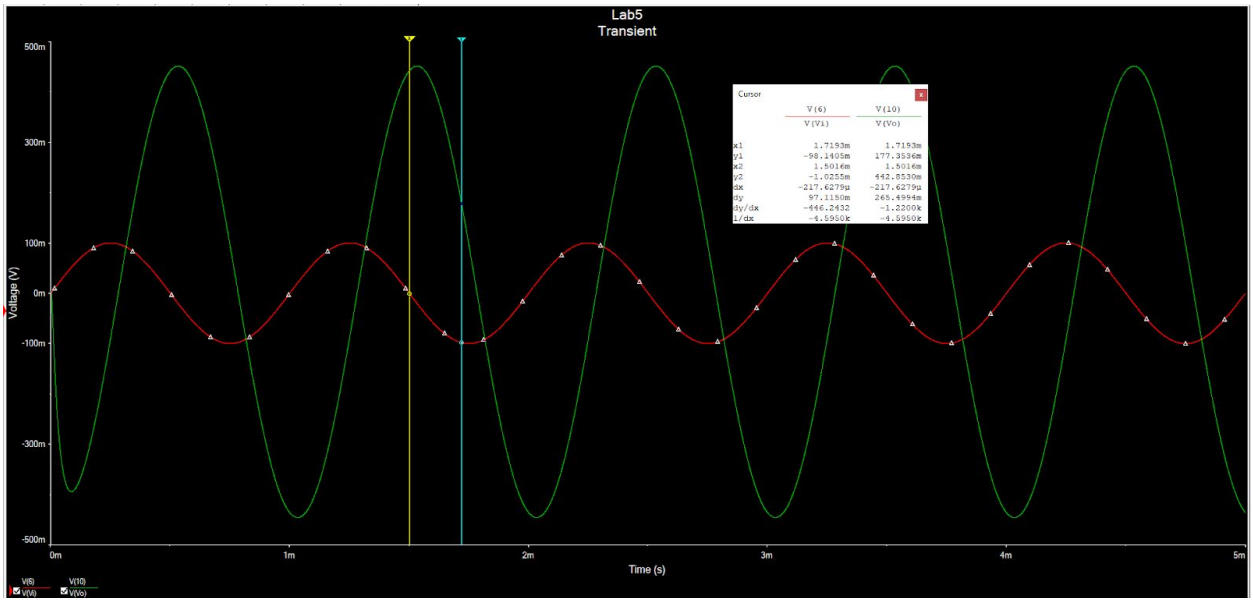
Vp2p = 1.2439 V

Pseudo Differential Bode Simulation



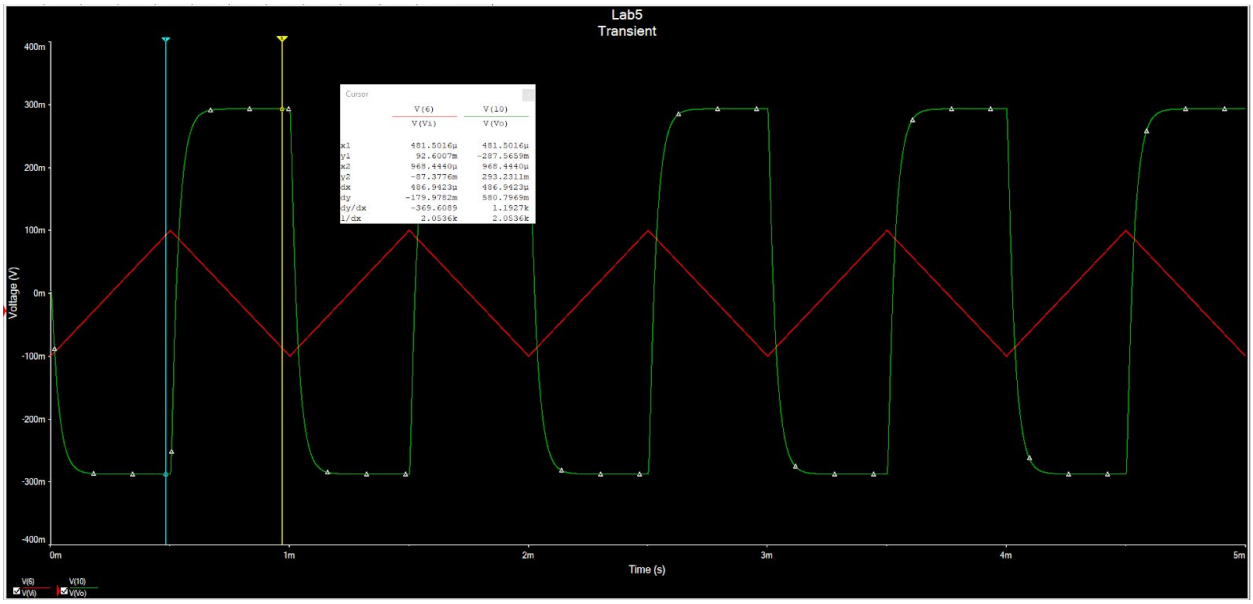
Low frequency gain = -63.0482 dB
3 dB frequency low = 4368 Hz
3 dB frequency high = 47817 Hz
1 kHz magnitude = 13.2338 dB
1 khz phase = -101.8268 °

Pseudo Differential Time-Domain Simulation



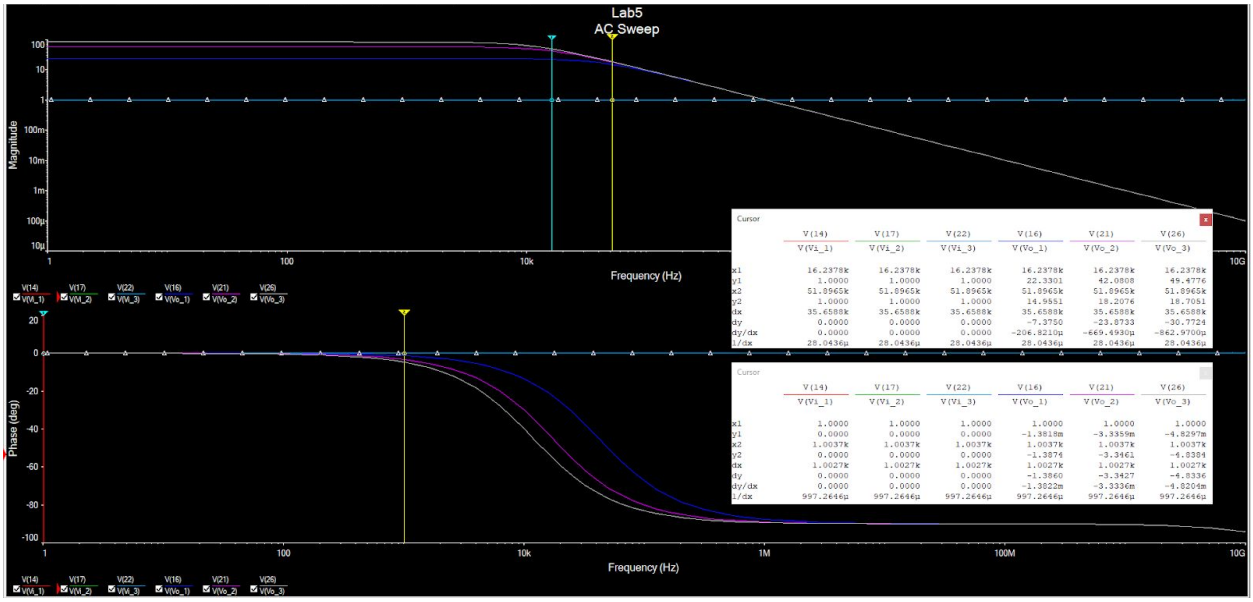
Vi Amplitude = 99.967 mV
Vo Amplitude = 451.4386 mV
Phase Difference = -79.308 °

Pseudo Differential Time-Domain Simulation (Triangular Wave)



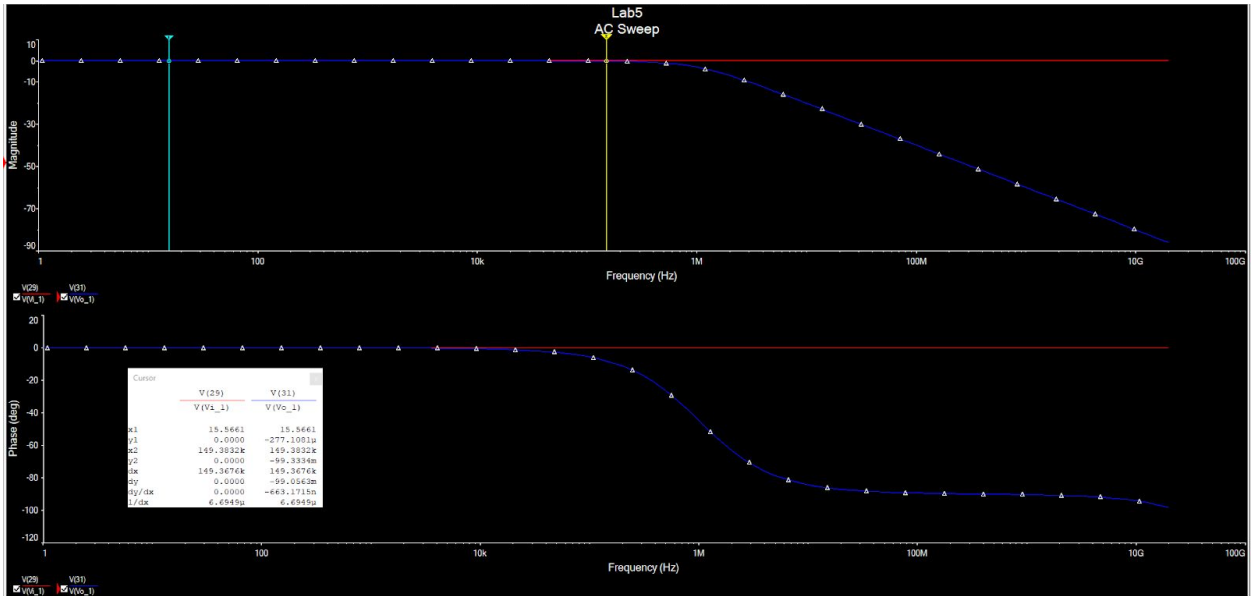
Vp2p = 580.7969 mV

Finite GBW Limitations Bode Simulation



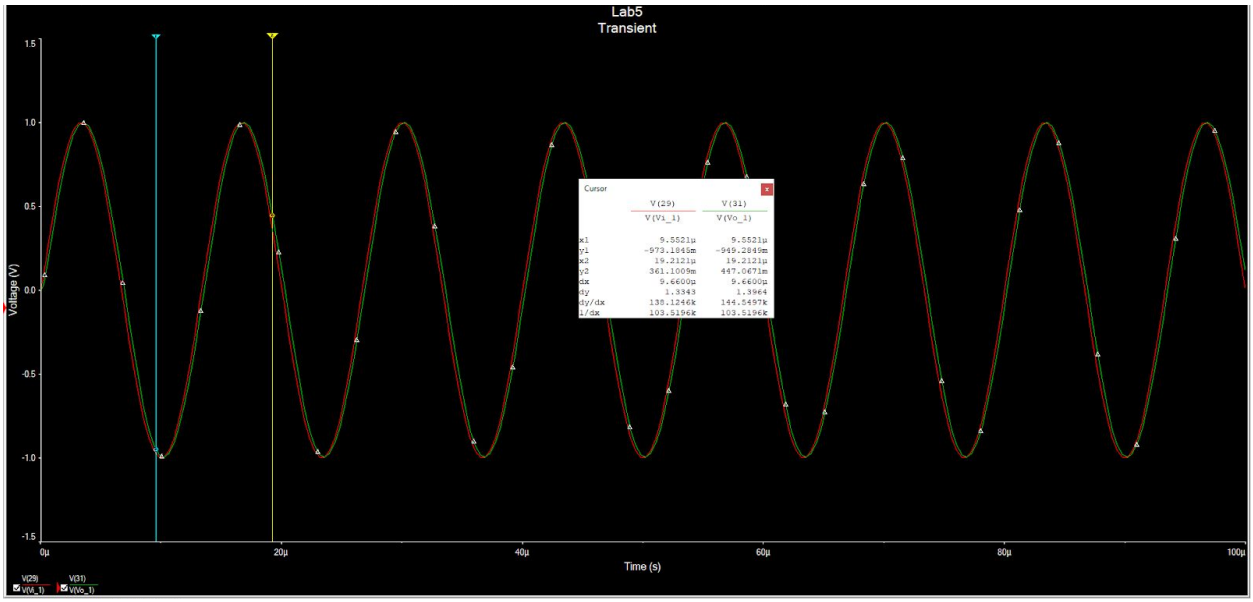
Low Frequency Gain @ 23 = 27.6029 dB
Low Frequency Gain @ 57 = 35.2658 dB
Low Frequency Gain @ 83 = 38.4817 dB
3 dB Frequency @ 23 = 41.325 kHz
3 dB Frequency @ 57 = 17.2917 kHz
3 dB Frequency @ 83 = 12.052 kHz

Slew Rate Limitations Bode Simulation

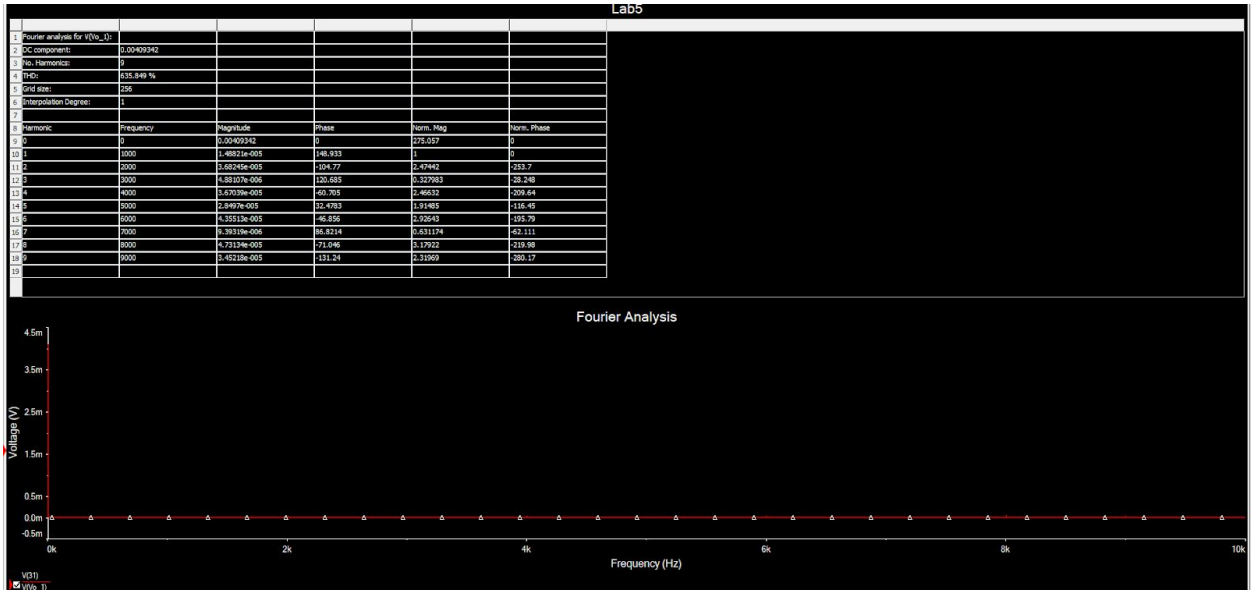


Low Frequency Gain = -277.1081 μdB
3 dB Frequency = 994.8678 kHz
75 kHz Magnitude = -25.9007 mdB
150 kHz Magnitude = -99.3334 mdB

Slew Rate Limitations Time-Domain Simulation (75 kHz 1V)

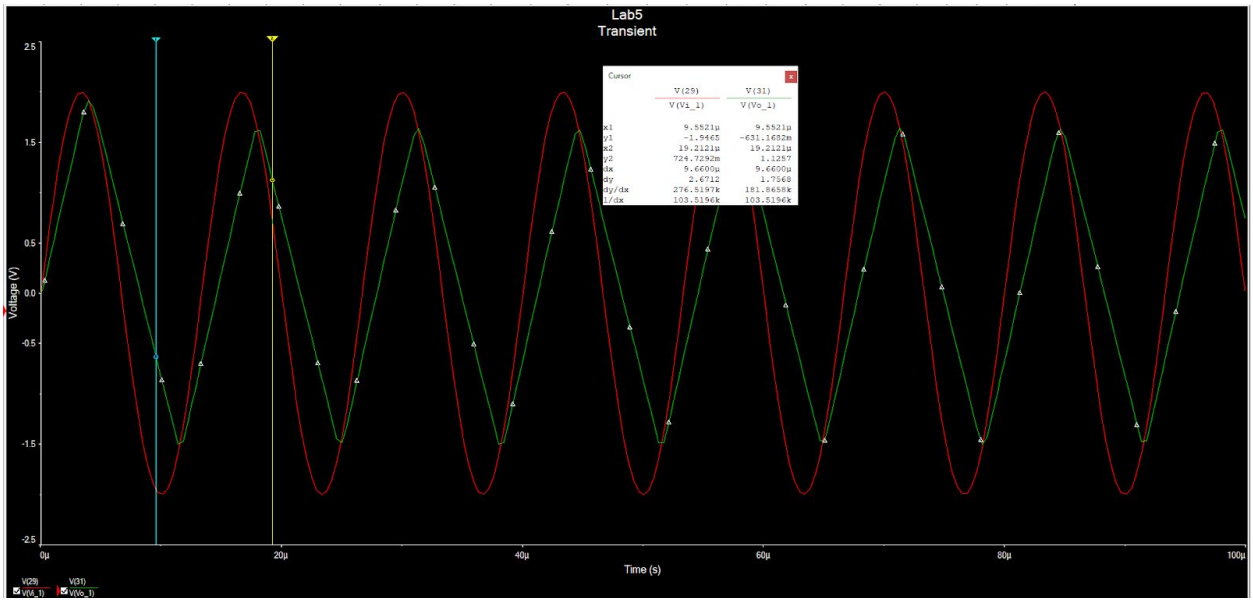


Slew Rate Limitations Fourier Simulation (75 kHz 1V)

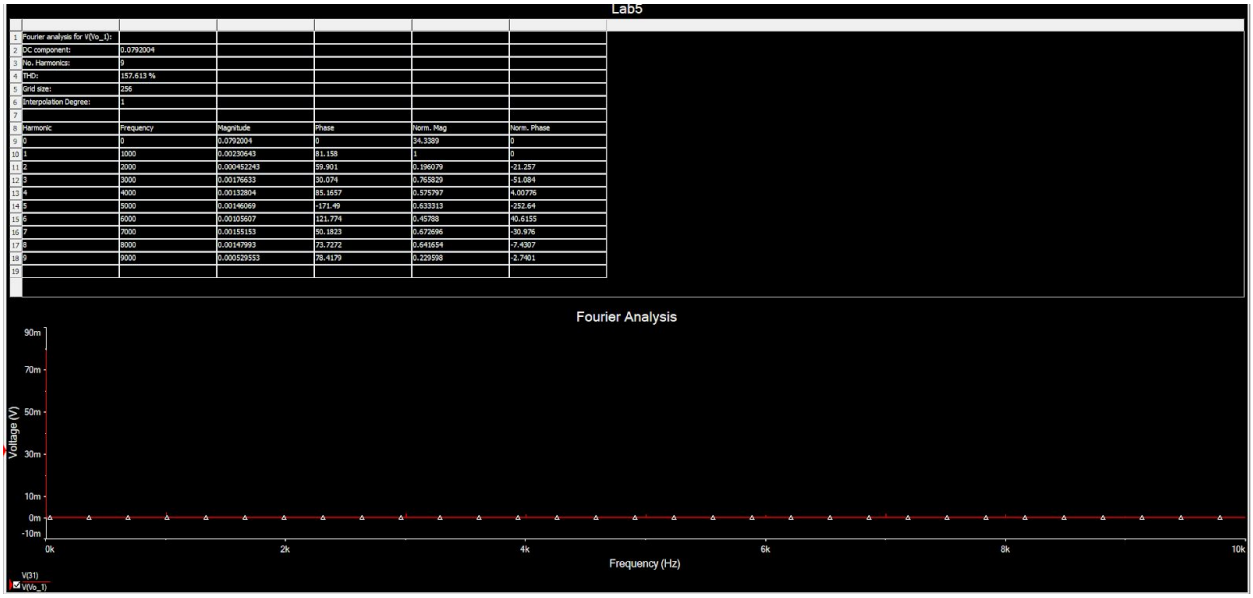


THD = 635.849 %

Slew Rate Limitations Time-Domain Simulation (75 kHz 2V)



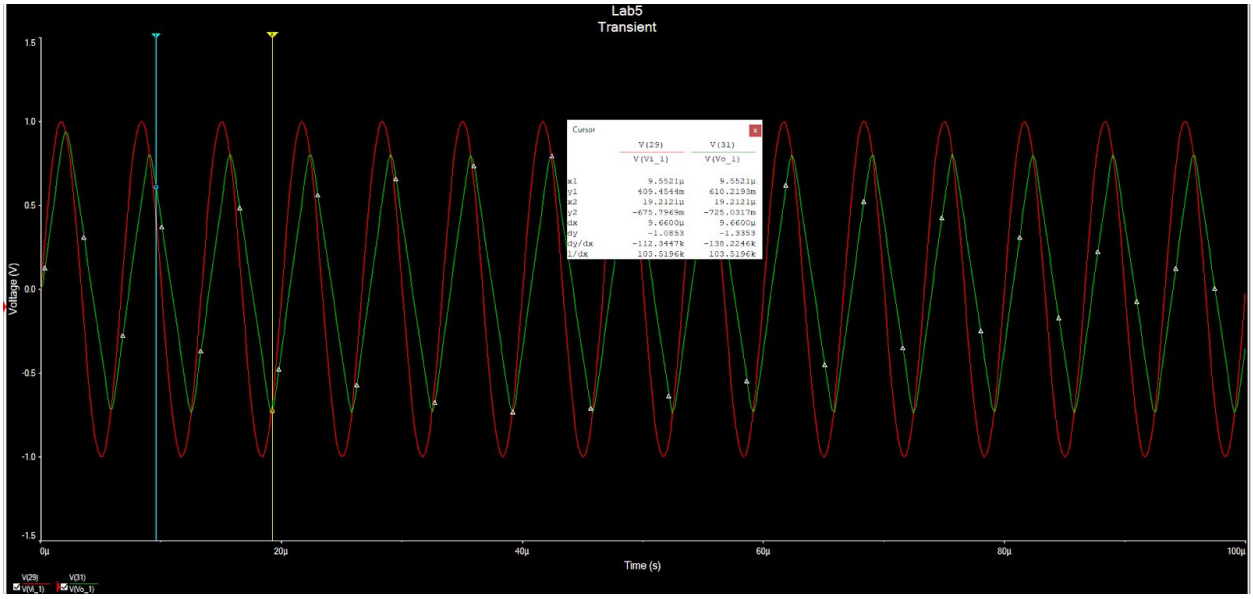
Slew Rate Limitations Fourier Simulation (75 kHz 2V)



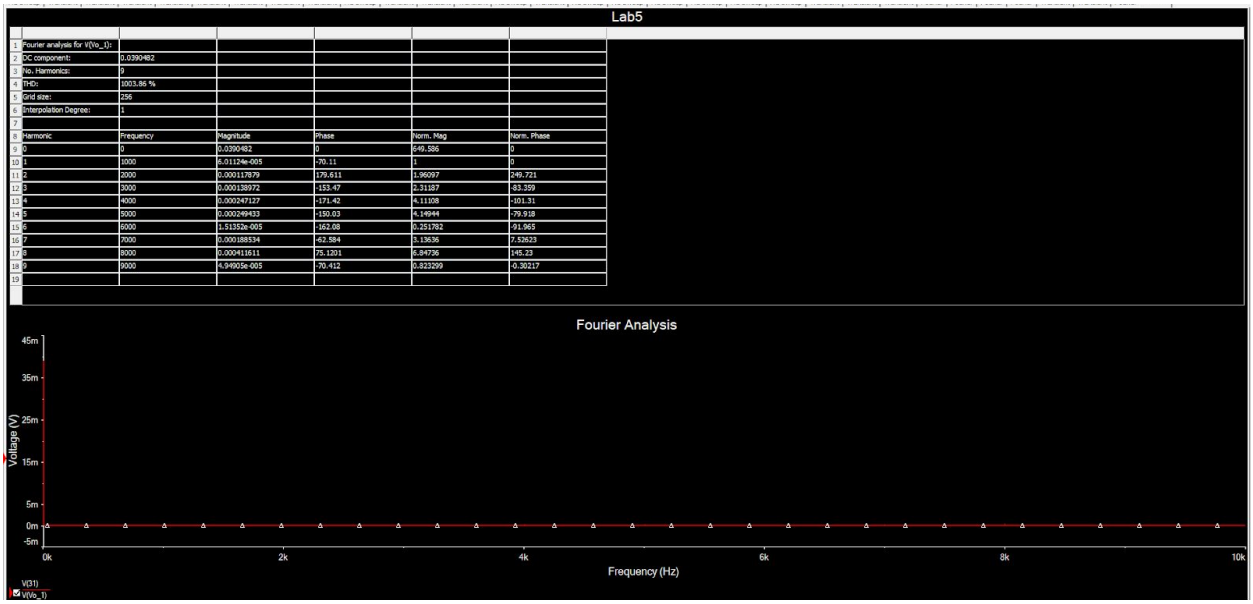
Fourier analysis for V(Vo_1):					
DC component:	0.0792004				
No. Harmonics:	9				
THD:	157.613 %				
Grid size:	256				
Interpolation Degree:	1				
Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
0	0	0.0792004	0	34.3389	0
1	1000	0.00230643	81.158	1	0
2	2000	0.000452243	59.901	0.196079	-21.257
3	3000	0.00176633	30.074	0.765829	-51.084
4	4000	0.00132804	85.1657	0.575797	4.00776
5	5000	0.00146069	-171.49	0.633313	-252.64
6	6000	0.00105607	121.774	0.45788	40.6155
7	7000	0.00155153	50.1823	0.672696	-30.976
8	8000	0.00147993	73.7272	0.641654	-7.4307
9	9000	0.000529533	78.4179	0.229598	-2.7401

THD = 157.613 %

Slew Rate Limitations Time-Domain Simulation (150 kHz 1V)



Slew Rate Limitations Fourier Simulation (150 kHz 1V)



THD = 1003.86 %