Prelab 6 OpAmp

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Prelab 6 Op Amps

1. $V_o = \frac{R_f}{R_i}(V_2 - V_1)$ $\quad R_{f_1} = R_{f_2} = R_f, \quad R_{i_1} = R_{i_2} = R_i$

$V_1 = 0.05\sin(2\pi \cdot 1e^3 \cdot t + 180) = 0.05e^{j\pi}$ $\qquad (V_2 - V_1) = 0.05 + 0j - (-0.05 + 0j)$

$V_2 = 0.05\sin(2\pi \cdot 1e^3 \cdot t) = 0.05e^{j}$ $\qquad = 0.1e^{j}$

$\cancel{10(0.1e^{j}) = \frac{10k}{R_i}(0.1e^{j}) = e^{j}}$ $\qquad 500mV = \frac{10k}{R_i}\,(0.1)\;\cancel{50mV}$ (amplitude)

$R_i = 2k$ $\qquad \frac{10k}{2k} = 5 \cdot 0.1 = 500mV$

2. $V_o = -j\omega C R_f V_{in} = -j\omega(1nF)(10k\Omega)(2V_{pp})$

$\frac{V_o}{V_{in}} = -j\omega(10)$

$\omega = 500 \Rightarrow \text{Gain} = -5{,}000$

$\omega = 1k \Rightarrow \text{Gain} = -10{,}000$

$\omega = 5k \Rightarrow \text{Gain} = -50{,}000$

$\omega = 10k \Rightarrow \text{Gain} = -100{,}000$

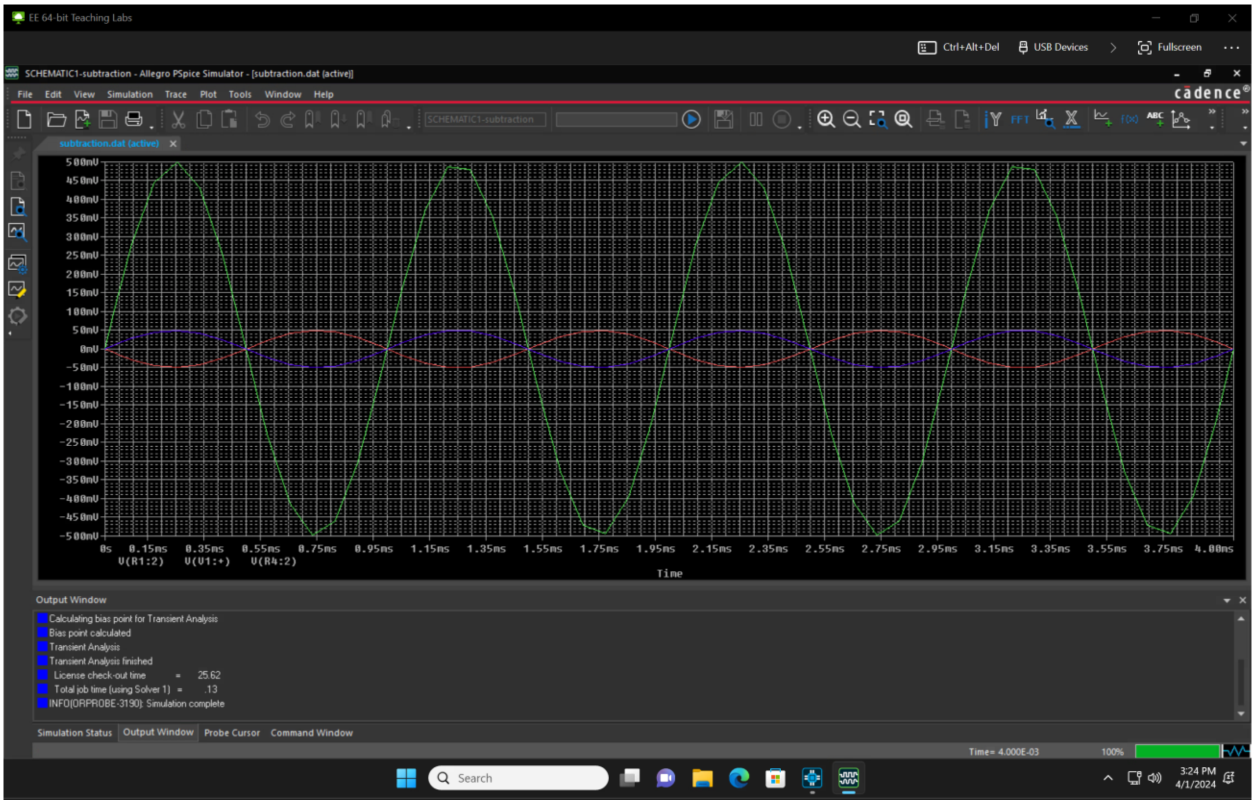
3. $V_o = -\frac{1}{j\omega C R_i} \cdot V_{in}$ $\qquad$ as $\omega \uparrow$, gain $\downarrow$

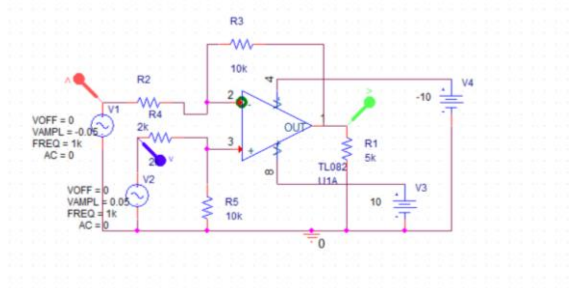
as $\omega \downarrow$, gain $\uparrow$

4. $1.7 = \frac{10k}{10k + R_2}(10) \Rightarrow 0.17(10k + R_2) = 10k \Rightarrow R_2 = 48.8k$

5. $1000 = \frac{1}{2\pi(22nF)R} \Rightarrow R = \frac{1}{2\pi(22nF)(1k)} = 7.234k = R = R_3 = R_4$

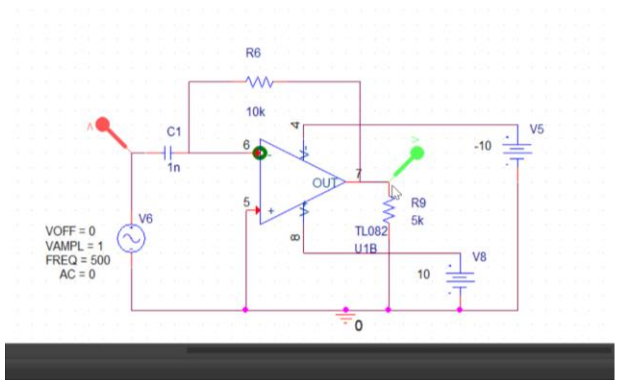
1. Differencing output . Blue and red are the 180 degree out of phase inputs. The green is the output, with the specified gain of 10. Below the output is an image of the schematic implemented.

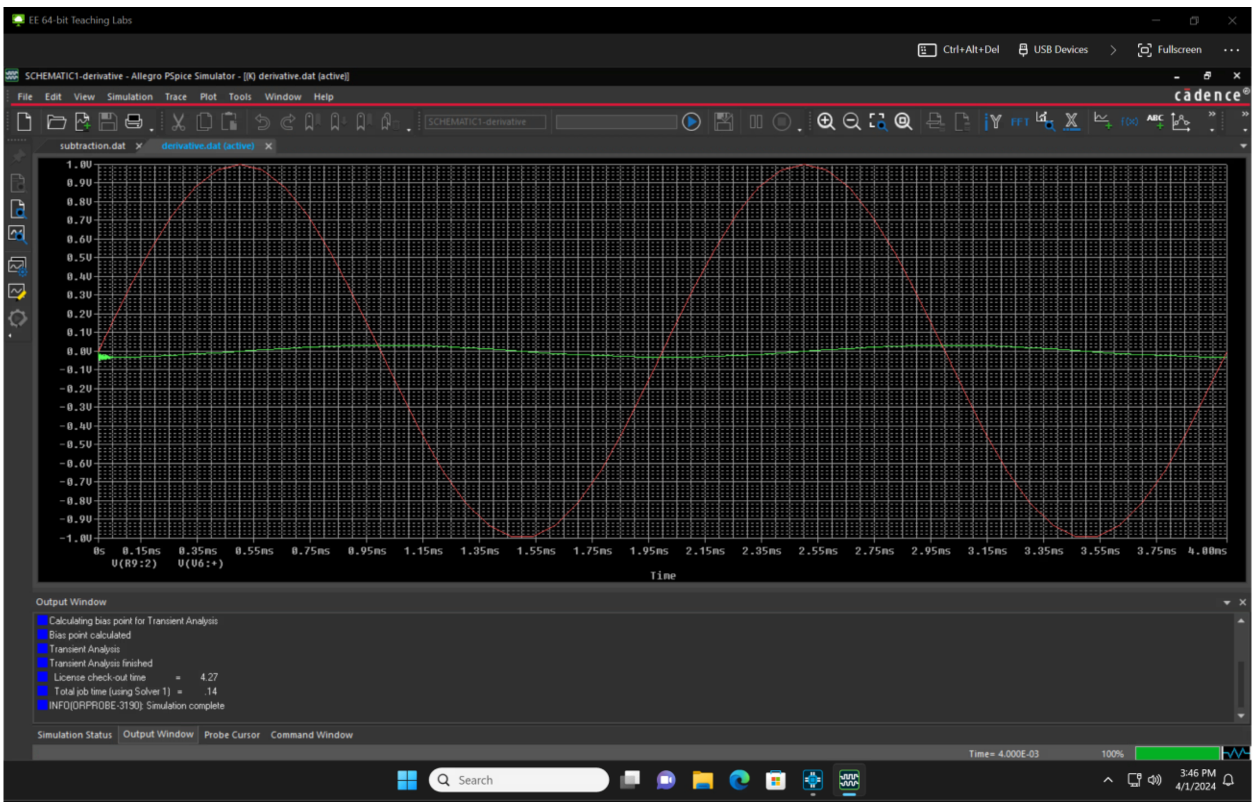




2. Derivative

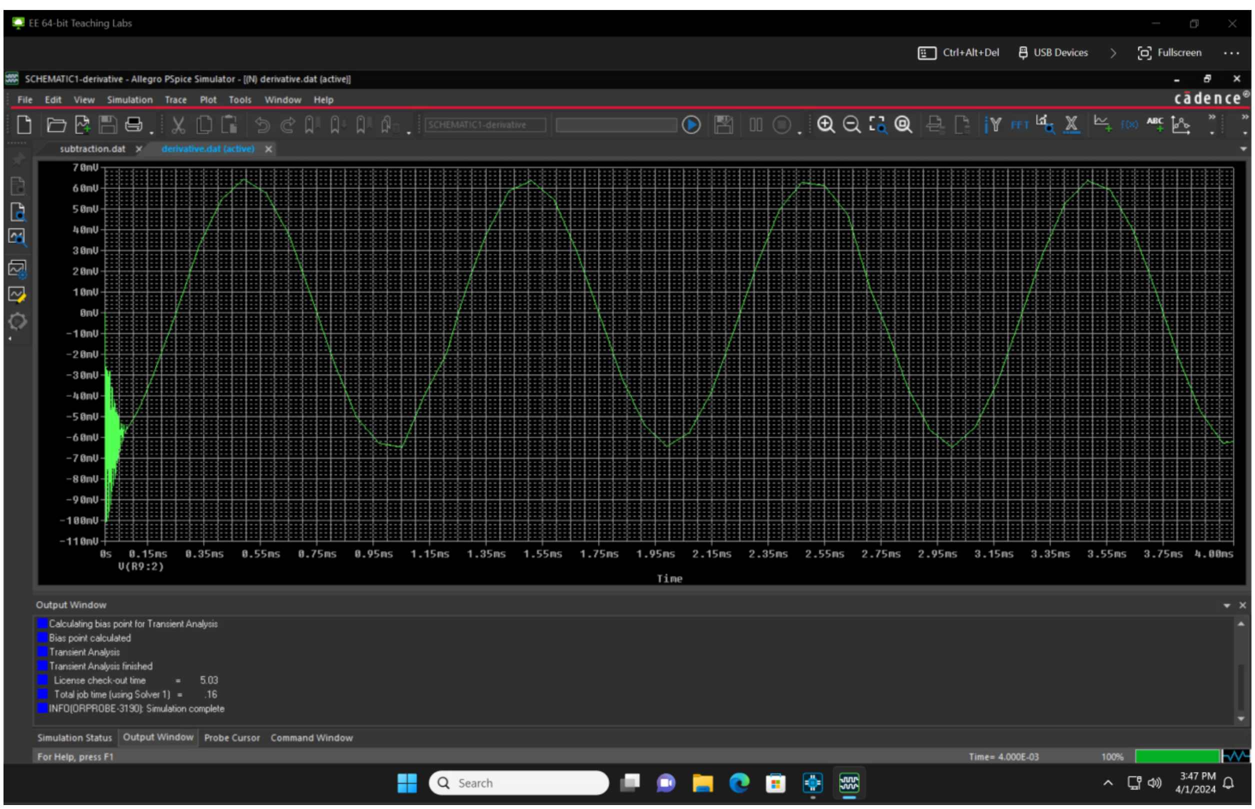
The differentiating amplifier was implemented with the schematic below. Answers to questions are below all differentiating output pictures.



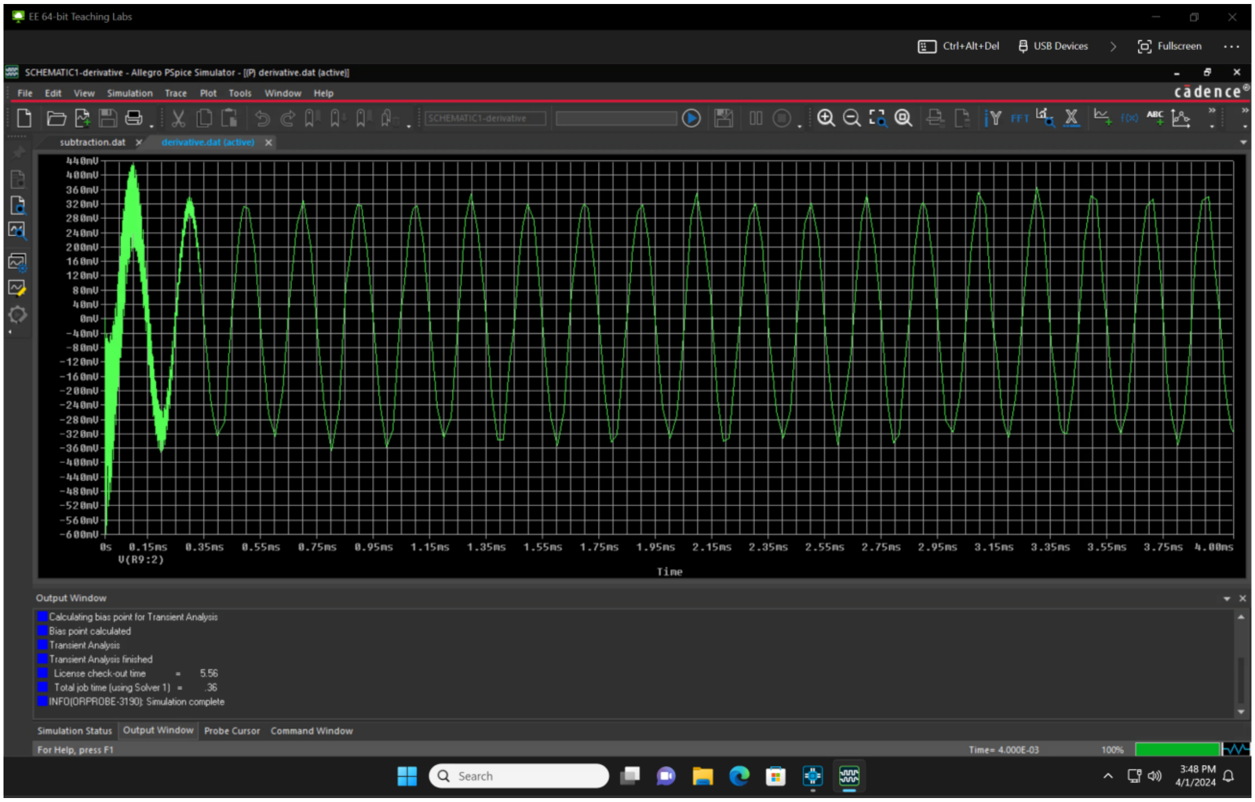


500Hz ^ Input (Red) and output (green)

500Hz ^ with just the output in green



1kHz ^ output voltage



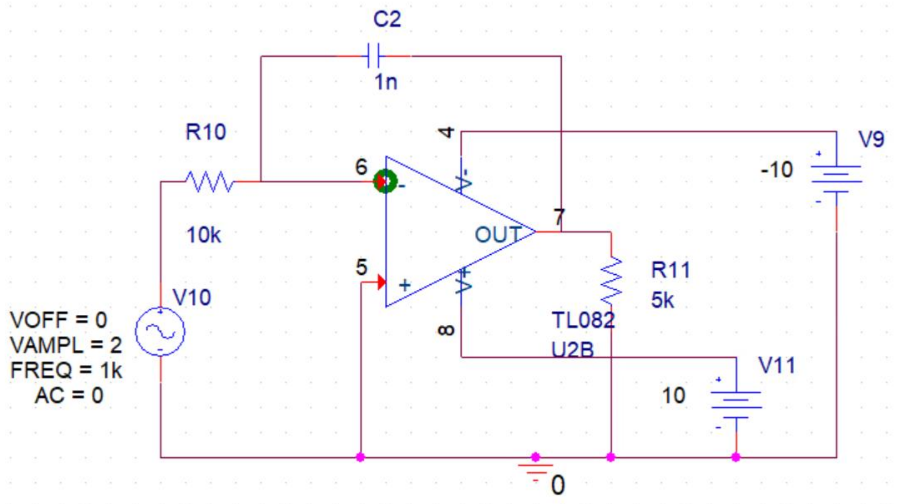
5kHz^output

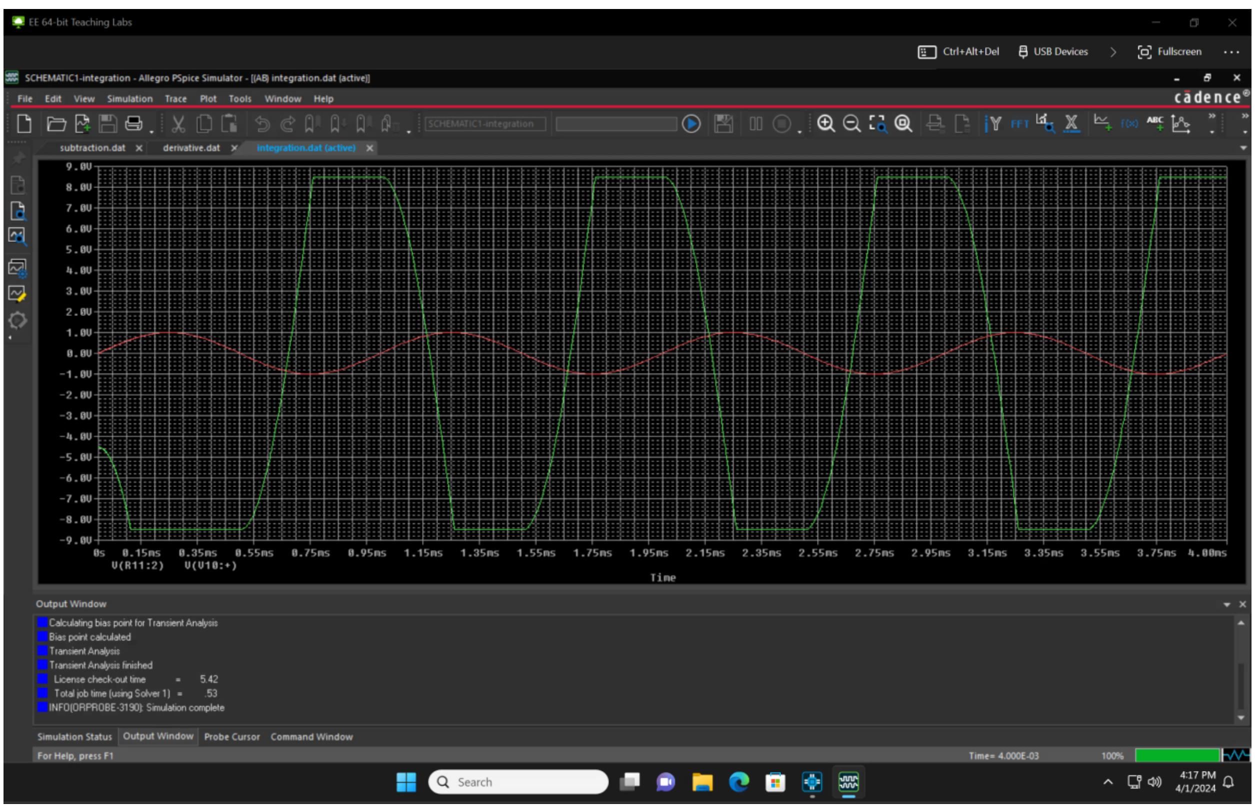
10k^ with output (green) and input (red)

For the deriving amplifier, gain seems to increase as frequency increases. This is consistent with the equation written in the handwritten work at the top of the prelab. Output voltage is proportional to frequency. This is why the gain changes with changing frequencies. The circuit does indeed behave as a differentiator, which is something that can be observed by comparing the input and output graphs. The output is lagging the input by a 90 degree phase shift. This is characteristic of a phasor differentiation, where the original function is multiplied by -jw. This is equivalent to a 90 degree counter clowckwise rotation in the complex plane, which corresponds to a lagging output.

3. Integrator

The integrating amplifier was implemented with the schematic below. Answers to questions are below all integrating output pictures.





1kHz ^


EE 64-bit Teaching Labs
SCHEMATIC1-integration - Allegro PSpice Simulator - [(AA) integration.dat (active)]
subtraction.dat
derivative.dat
integration.dat (active)
V(R11:2)
V(V10:+)
Time
Output Window
Calculating bias point for Transient Analysis
Bias point calculated
Transient Analysis
Transient Analysis finished
License check-out time = 4.78
Total job time (using Solver 1) = .52
INFO(ORPROBE-3190): Simulation complete

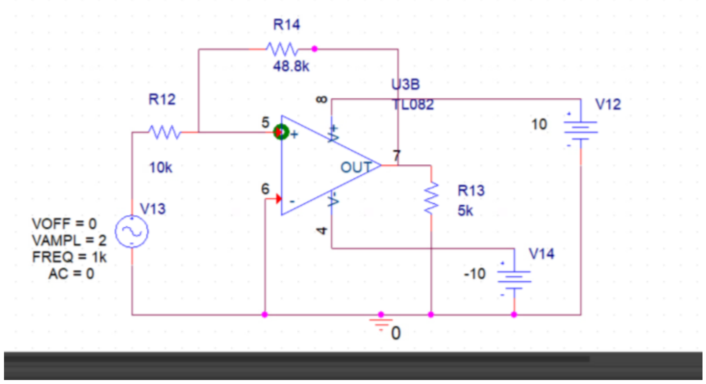
5kHz ^

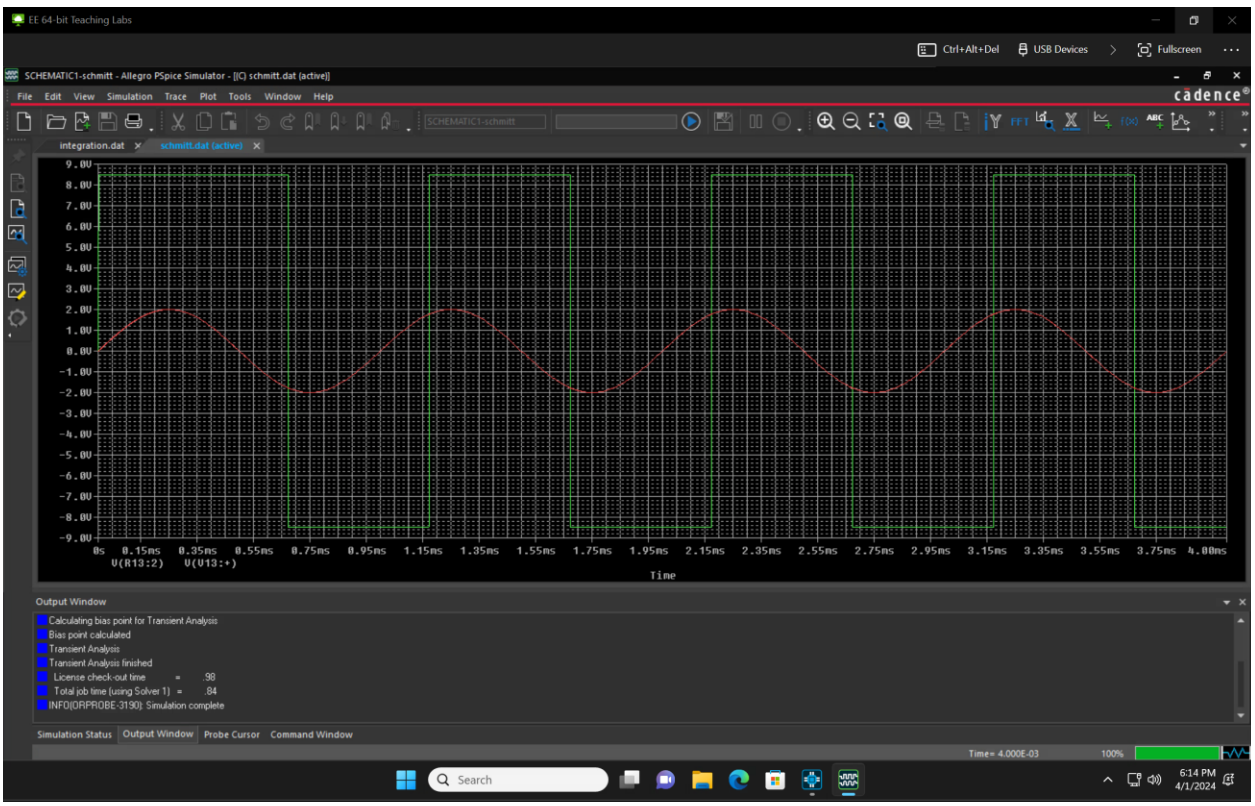
10kHz ^

The unusual gain for the 1kHz case is due to clipping of the opamp's output. Because it is only supplied with +- 10V rails, it cannot output gain greater than this range, hence why the gain output of the 1kHz input is clipped. Because gain is inversely proportional to frequency, the output observed has a greater gain as the input frequency was decreasing. This relationship is observed in the gain equation Vout = -1/(jwCR)*Vin. The circuit does behave as an integrator, because as explained for the differentiator above, integration causes a 90 degree phase shift in the opposite direction. This causes the output to lead the input by 90 degree, which can be observed in the above images. Multiplying a phasor by -1/jw is the same as a +90 degree phase shift, or a leading phase with respect to the input.

4. Schmitt

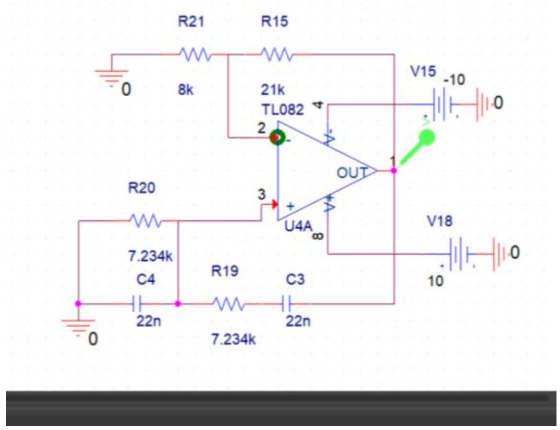
Schematic used to implement the Schmitt trigger. Below that is the output of the simulation. As can be seen, the swing is from +-8.5 Volts, and the trigger voltage is around +- 1.7 V, as specified. The work for calculating R2 is at the top of this report, handwritten.

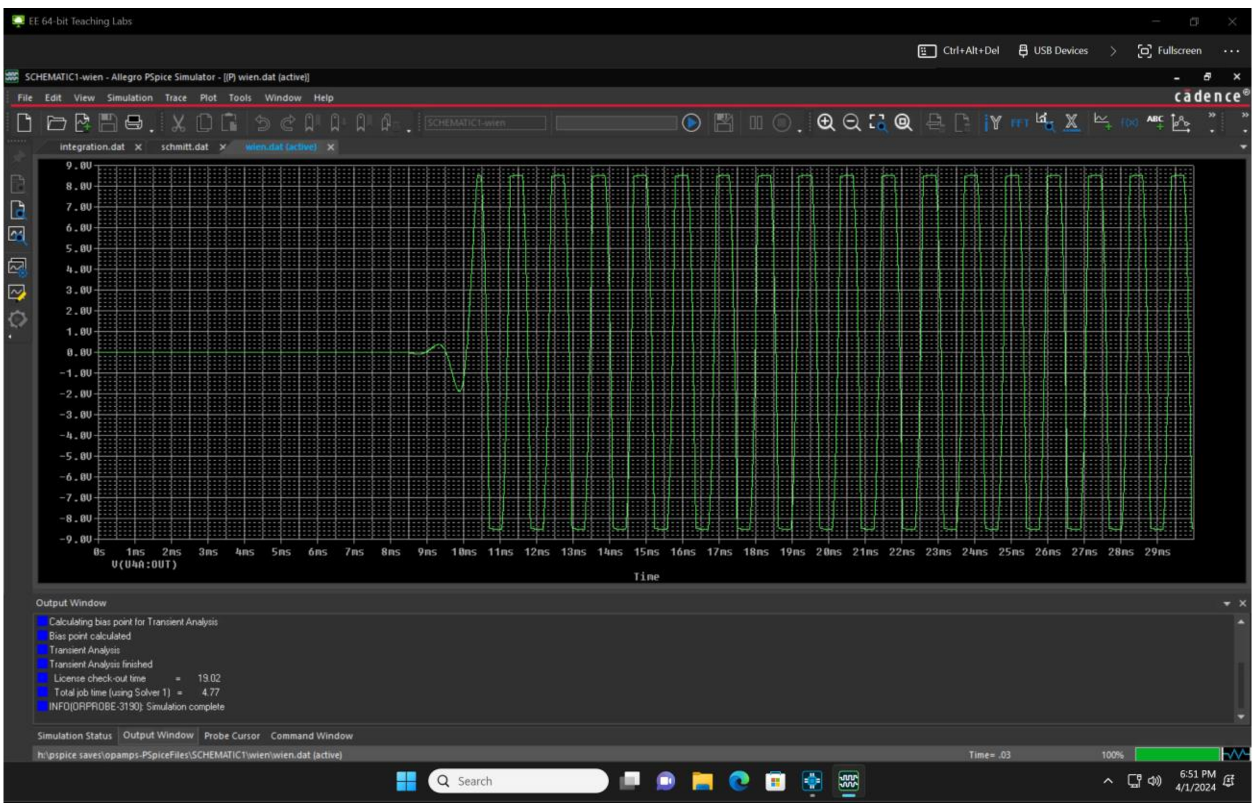




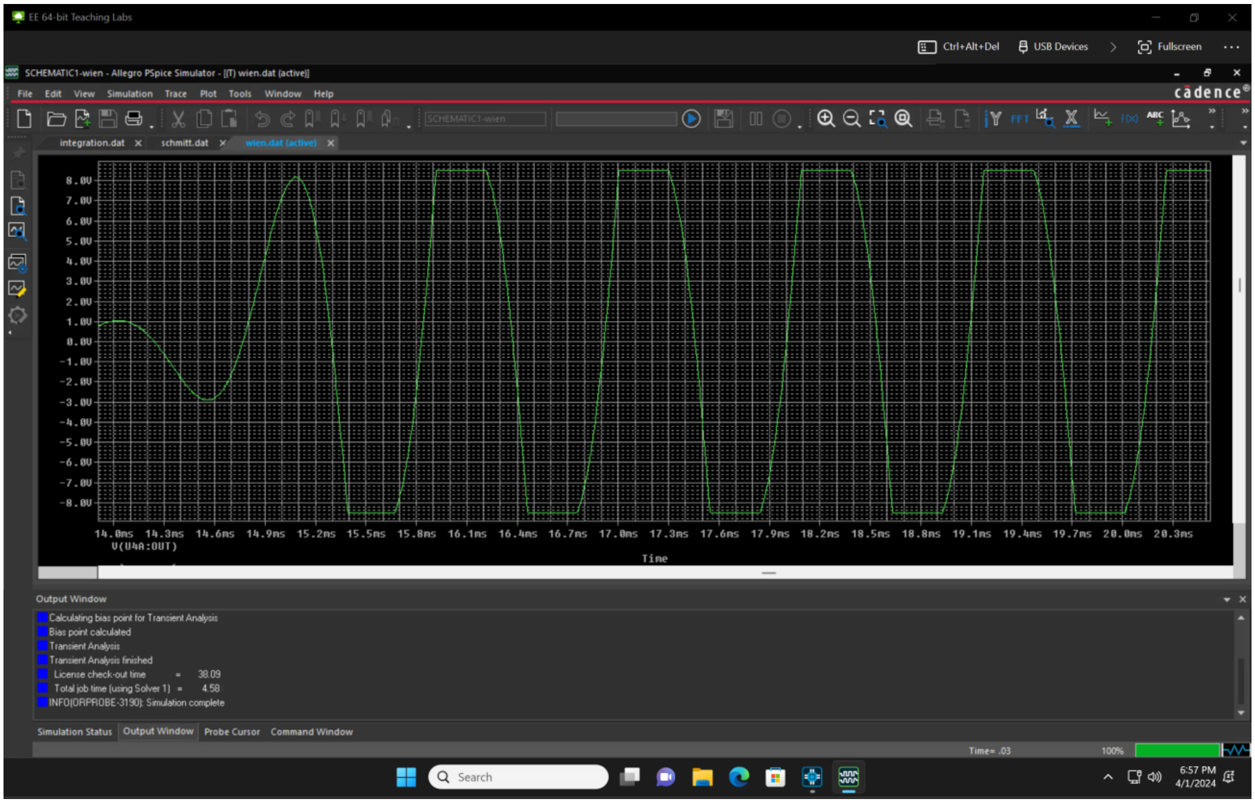
5. Wien

Wien bridge oscillator implemented using below schematic





Normal output of simulation ^. Stabilization is after 10ms



Zoomed in simulation output. The frequency as calculated from the midpoints of two waves is (17.0ms – 15.9ms) inverted, which is 1/1.1ms = 910kHz, which is very close to the theoretical 1MHz calculation