PHY405 Lab 8

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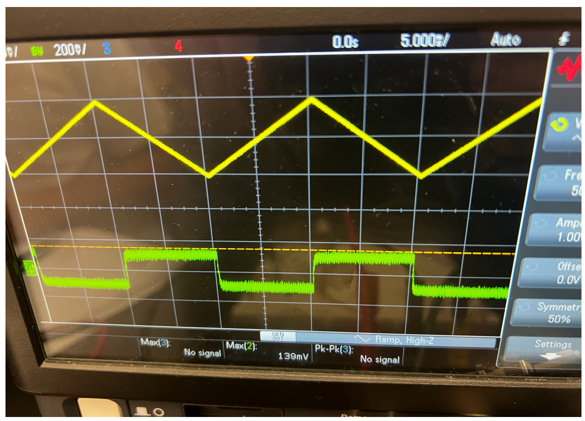
Collaborators for all questions: none. Partner (for Lab 1-8): Jacob Villasana.

R-1 / R-2

[R1] Since the circuit is a differentiator, if we input a 50Hz, 1Vpp ramp wave, we should expect a square wave an an output of the same frequency with lower amplitude proportional to RC (~ 0.001 V).



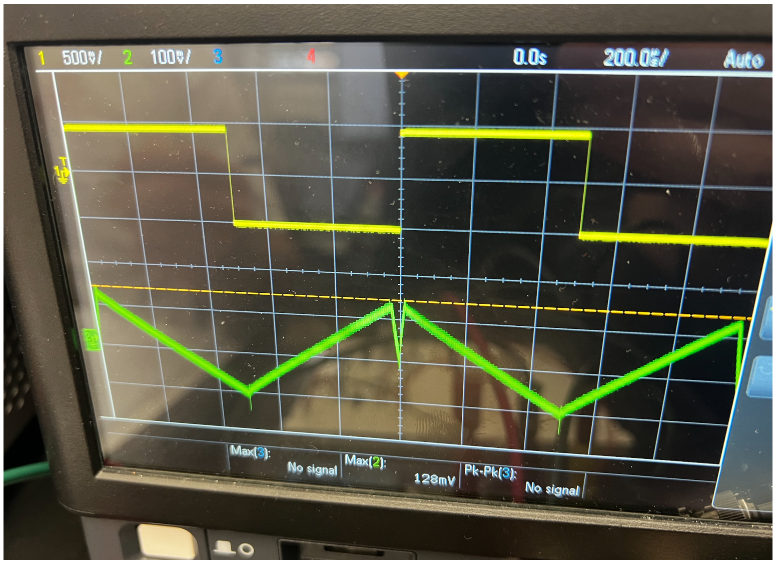
[Figure 1]: scope image capture of the differentiator circuit with a 50Hz, 1Vpp input ramp wave. The differentiated wave is shown in green (square wave).

[R2] When we place a 100nF capacitor in parallel with the resistor, we notice that the derivative (output) from the differentiator is smoothed out slightly, with an increased attack and decay rate with respect to voltage changes.

[Figure 2]: scope image captures when a 100nF capacitor is placed in parallel to the resistor. As frequency of the wavegen is increased, the smoothing of the attack/decay of the output is increased, which suggests that the capacitor reduces the rate of change of voltage slightly.

R-3

For an integrator circuit, if we were to input a 1kHz, 1Vpp square wave, one would also expect a ramp wave with the same frequency but with amplitude proportional to $-\frac{1}{RC}$ (~ 1000 V).

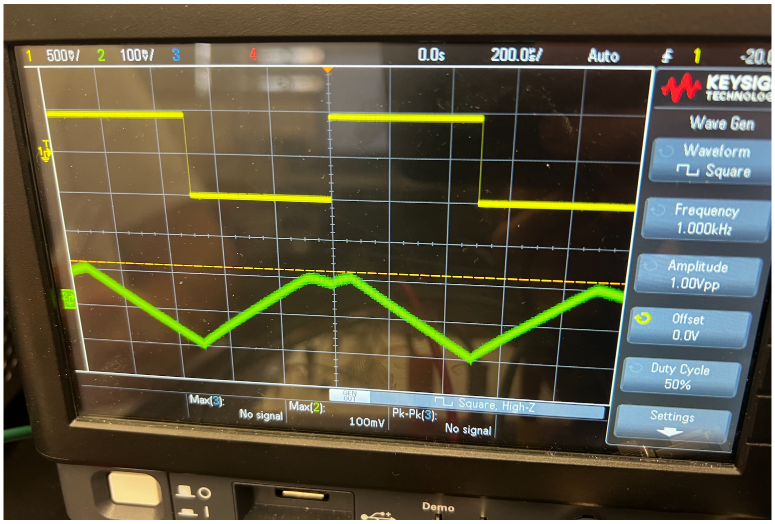


[Figure 3]: scope screen capture of the integrator circuit input (yellow) and output (green). Distortions of the output are produced by clipping.

One unexpected observation in the output is the clipping of the waves at the peaks and troughs. The op-amp was powered with 15V DC, yet according to the voltage relations, this should have no effect on the output amplitude. This was investigated and fixed in R-4, but for now, shifting the wavegen offset to a value less than around -3 mV caused the distortions to disappear.

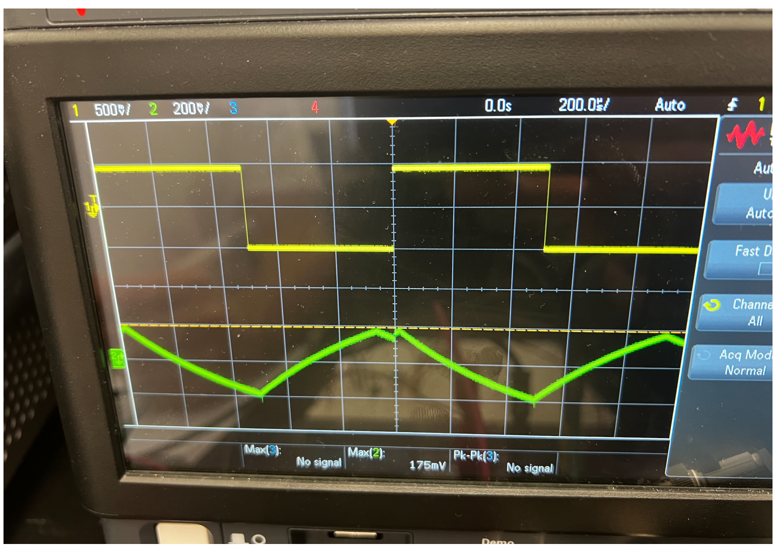
R-4

To block AC / DC, we had used a 1k resistor and 1μF capacitor, respectively, adding only one component at a time. First, when blocking DC offset to the input or output of the op-amp (using a capacitor to ground), we noticed the same result, that the perturbatioons in clipping were reduced but not vanishing.



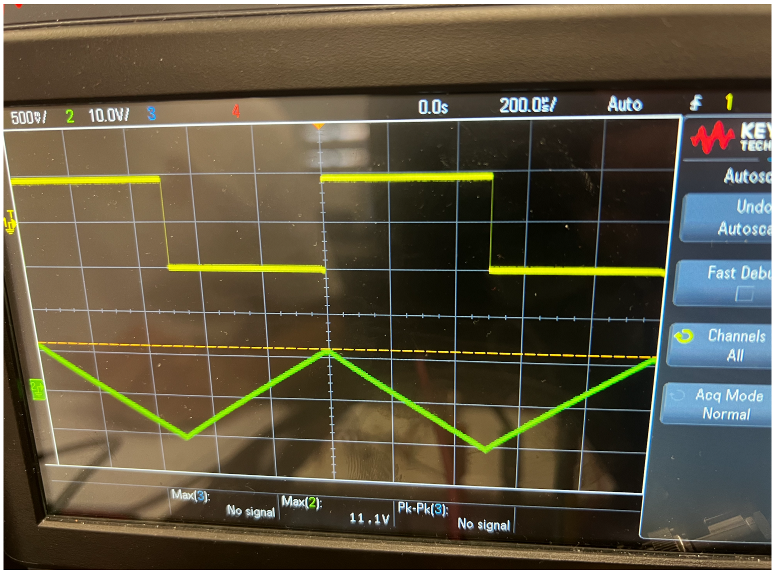
[Figure 4]: scope screen capture of the integrator circuit when DC offset at the input and output of the wave was blocked (both yielded the same result).

When adding DC feedback to the AC feedback (resistor looping back to AC feedback), while also blocking DC at the output (capacitor to ground at out) we had noticed a similar effect.



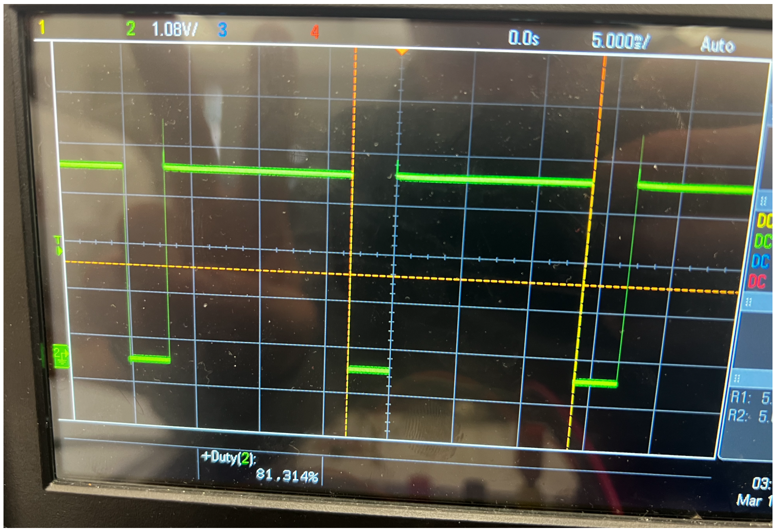
[Figure 5]: scope screen capture of the integrator circuit when DC feedback was added to the AC feedback op-amp loop. The same result was also produced when grounding the DC offset to ground at the output of the circuit.

Lastly, we tried some combinations. When we had tried shorting DC at the circuit output while adding DC feedback, and this yielded the same previous result. When we had tried shorting DC at the output using a different capacitor (10nF), this had seemed to provide a more continuous output:



[Figure 6]: scope screen capture of the integrator circuit when DC output was shorted at the output, but this time using a 10nF capacitor instead of 1μF.

R-5

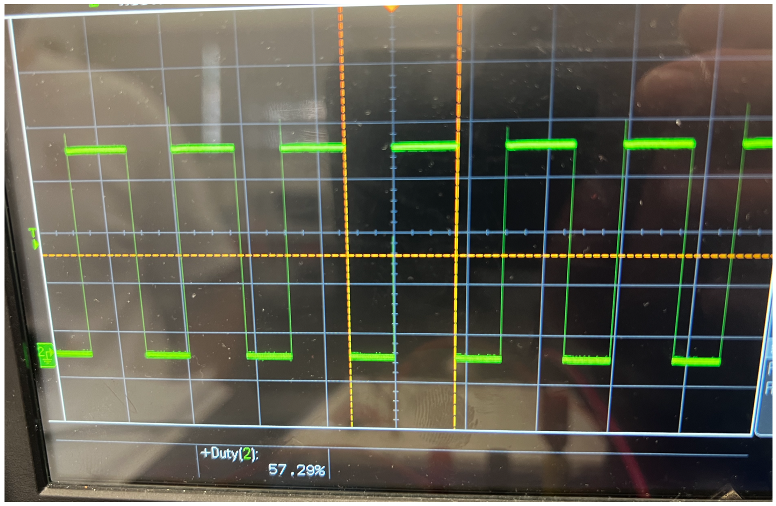


[Figure 7]: LM555 output within the astable timer circuit using 100k, 300k resistors and a 47nF capacitor. The resulting frequency was approximately 59Hz (expected 59Hz) with an 81% *duty cycle (expected* 81.7%*)*

R-6

The frequency of the astable circuit LM555 timer is given by $f = \dfrac{1.44}{C(R_A + 2R_B)}$ while the square wave duty cycle, as a percentage, is given by $\dfrac{R_A + R_B}{R_A + 2R_B}$. This implies that the capacitor should only change the frequency and not the duty cycle. The image in R5 was produced using $R_A = 330\text{k}\Omega$,

$R_B = 100\text{k}\Omega$ and $C = 47\text{nF}$, which yields the correct 81% duty cycle and 59Hz frequency (as expected). Also trying an $R_B = 1\text{M}\Omega$ resistor with a $1\mu\text{F}$ capacitor instead of the 47nF, we found the scope to measure $f = 1.396\text{Hz}$ (expected 1.5Hz) with a 56% duty cycle.



[Figure 8]: LM555 output within the astable timer circuit using 1M, 300k resistors and a 1μF capacitor. The resulting frequency was approximately 1.4Hz (expected 1.5Hz) with a 56% duty cycle (expected 57%).

R-7 / R-8

At first, we had thought we had replaced R_B with the trim pot because R_B has a greater influence on the frequency when it is changed. We, however, changed R_A instead. To adjust for this, since we didn't want to re-wire our whole circuit, was we switched R_B out with a smaller resistor. Thus, we went with $R_A = 100\text{k}$ (pot) and $R_B = 300\text{k}\Omega$ (we assumed just swapping the resistors would be ok), but we found the buzz coming from the piezo to be too small. We 'guessed' R_B and accidentally placed a 470Ω resistor in place of the 100k, and this seemed to buzz great including the pitch adjustment. See video (yes, this was accidental, but it worked for some reason).