Physics 117 Lab 6:OP-Amp applications

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UCLA Winter 2019

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1. Current to Voltage Converter (8-6)

1.1. Part A

The first objective of this lab was to use the op-amp to amplify the voltage given off a photo-transistor, specifically a IF-D92. The circuit diagram for the amplification is given in figure 1. To amplify the voltage we simply fed the photo transistor voltage on the collector of 15V, the base is collected light and the emitter gives out the voltage that is then amplified by in our case a $10M\Omega$ resistor rather than the 20 $M\Omega$ mentioned. The only thing we are asked to do in part b of the lab segment is measure the photo current, which is the current out of the emitter which can be given by equation 1. For us with plenty of light we got a value of 1.38 μAmp. We can see the output in figure 2.

$$I_E = \frac{V_{out}}{R} \qquad [1]$$

The next part of the lab had use the photo transistor and induce it with the oscilloscope itself, this can be achieved with the use of 2 banana cables with grabbers at the end, where we simply connect them to each other and then connect 1 pair of grabbers to the output voltage and ground of the circuit, which we then connect to the photo-transistor which now is mobile and allows capture of the oscilloscope screen, we show the output in figure 3. We are also asked to show the circuit does not work when we remove the feedback resistor in figure 4.

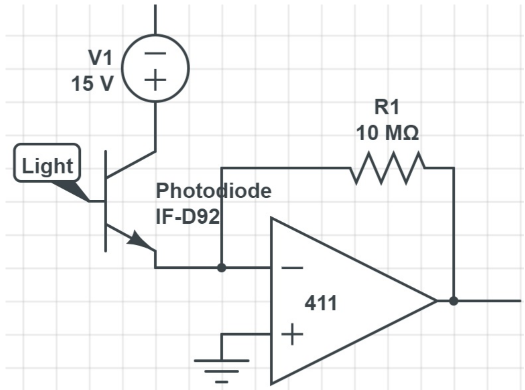

Figure 1: This simple schematic represents the Photo transistor circuit

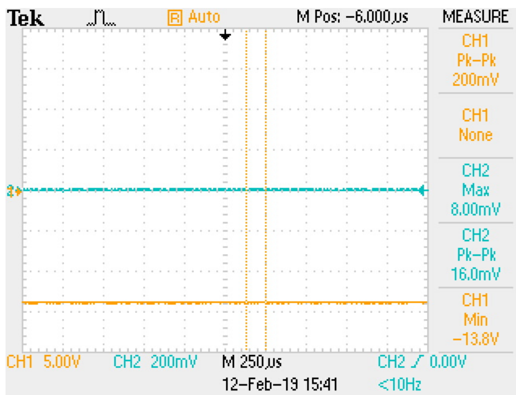

Figure 2: This simple line is the output for the Photo-transistor Op-Amp circuit

2. Push Pull Buffer (8-8)

2.1. Part B

The next part of the lab had us build a Push-pull Buffer circuit which can be seen in figure 5. We are asked to drive it with a small frequency wave, which we expect to see a crossover distortion. you can see the output in figure 6.

The next part of the experiment had us run a speaker on a breadboard speaker, which we first had to determine had a good safe amplitude, which we confirm to be 1.4 Volts using equation 2, with 15 Volts and 8 ohm resistance. We then reconnect the feedback resistor and see the crossover distortion is gone which can be seen in figure 7. We are asked what the signal should look like it is stunted a little bit. We are then asked to listen to the waveform,

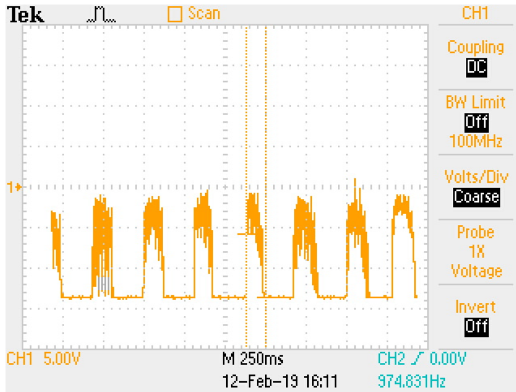

Figure 3: This output is what we were able to draw with the photo-diode from the oscilloscope itself

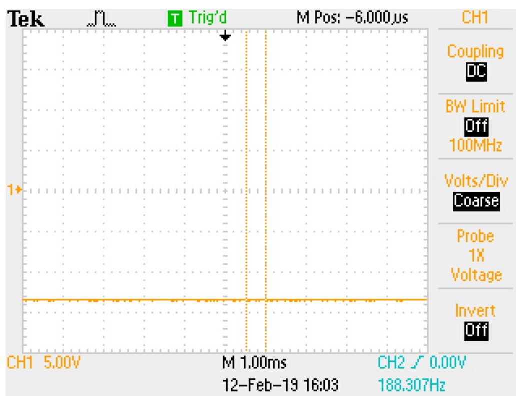

Figure 4: This output is when the feedback resistor is removed basically no voltage

and asked if it was smoother which it was, and then asked why the crossover distortion sounds buzzy, which is the crossover distortion itself causes a odd 0 gap that distorts the sound, basically rolling over it. Lastly we are asked what happens when we increase the frequency, which is that the wave forms become bad and this occurs around 1kHz and it is best around 100Hz.

$$P = \frac{V^2}{R} \qquad [2]$$

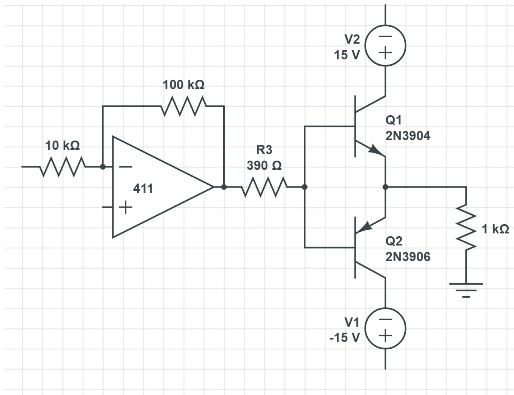

Figure 5: This Shows the circuit diagram for the Push Pull Buffer circuit

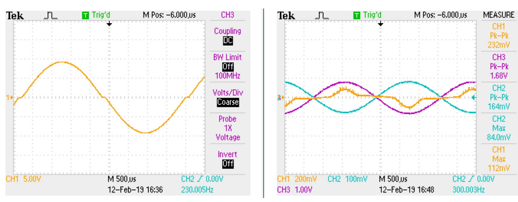

Figure 6: This Shows the Output for the Push Pull circuit at varying amplitudes

3. Op-amp Limitations (9-1)

3.1. Part C

The next stage of the lab had us create a basic circuit for the op-amp to test the effects of the slew rate, by comparing a 411 and 741 op-amp. The circuit can be seen in figure 8. The first stage of this experiment had us drive a square wave around 1kHz, and then collect the respective slew rates. Using equation 3 we are able to calculate the slew rates which we receive a value of 11.8 Volts/μs for the 411, and .62 Volts/μs.

$$SlewRate = \frac{V}{\mu s} \qquad [3]$$

$$SlewRate = 2\pi f V \qquad [4]$$

The next part of the experiment had us instead run a sine wave and measure the frequency where they begin to decay, which is around 2.3 MHz for the 411 and 53 kHz for the 741, this corresponds to a Slew rate of 14.4

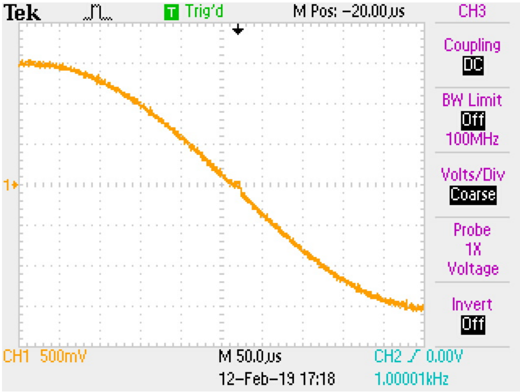

Figure 7: This Shows the Output for the Push Pull circuit when feedback resistor gets rid of crossover distortion

for the 411 and .33 for the 741, we computed this using equation 4. We are asked if if this is the Slew rate we measured, it is not but it is close. We are lastly asked to compare the Slew rates we measured to the reported value of .5 Volts/μs for the 741 and 15 Volts/μs for the 411, which for us we are very close to but not exactly at, those values which can be attributed to the age of the op-amps we are using or just internal problems of the circuit. I put the output for the decaying sine wave frequency in figure 21.

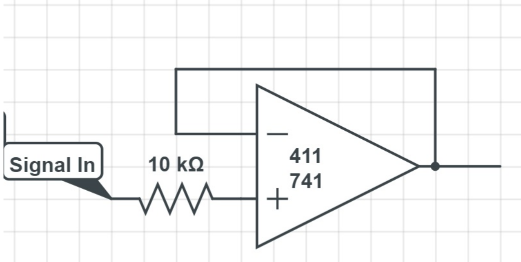

Figure 8: This figure shows the circuit diagram for the Op-amp when testing slew rate

4. Integrator (9-2)

4.1. Part D

The next section had us create an integrating circuit seen in figure 9. What we had to do was drive it with a 1KHz square wave,you can see it in figure 10, We are asked to predict the resultant triangle wave amplitude which we expect from a 500Hz square which we expect a triangle wave that is half the amplitude of the square, what we get is one that is 1/4 the value. We show the output in figure 11.

We are now asked What the function of the 10 $M\Omega$ resistor is, the op-amp intergrator circuit needs a resistor to catch the DC stray from the input, as well as prevents railing to the -10V rail in this circuit. We then are asked to remove it and then play with the DC offset which can be seen in figure 12.

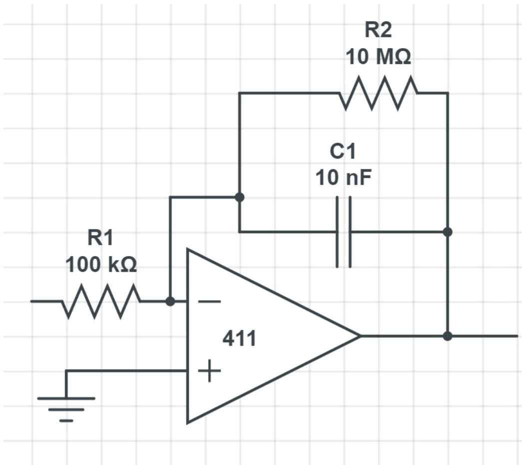

Figure 9: This figure shows the circuit diagram for the Op-amp when Intergrating

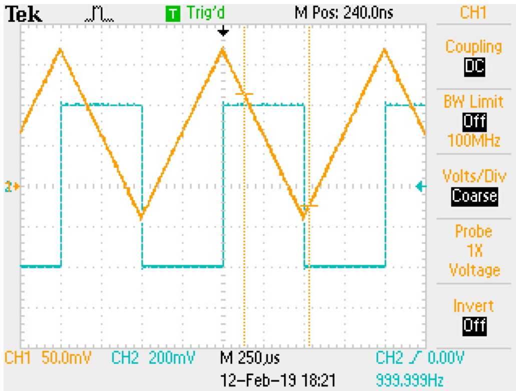

Figure 10: This is the output from 1kHZ square wave in intergrator

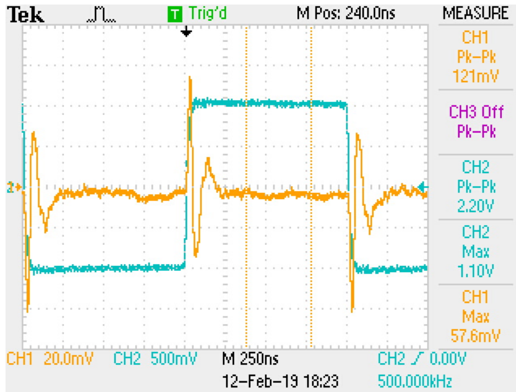

Figure 11: This figure shows the output for the 500Hz square wave input

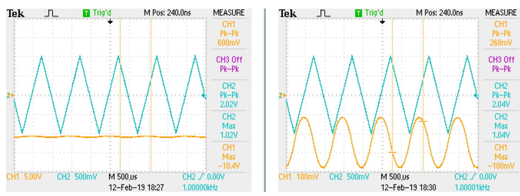

Figure 12: This shows the circuit without 10 MOhm resistor and when we play with the offset

5. Differentiator (9-3)

5.1. Part E

The next part of the lab had us create a differentiator which can be seen in figure 13. We drive it with a 1kHZ triangle wave which can be seen in figure 14, along with a cosine wave that is more or less comprised of many waves from a series of diodes.

6. AC Amplifier: microphone amplifier (9-4)

6.1. Part F

In this section we build the single supply op amp, The op-amp we use is the Lf411, and we use a 15 Volt power supply, We run the negative rail to ground. the circuit diagram can be seen in figure 15. The objective of the experiment had us amplify the output of a microphone. The FET's varying output current is able to become a voltage due to the 2.2k pull up resistor. The main purpose of this experiment was to see a output of something we

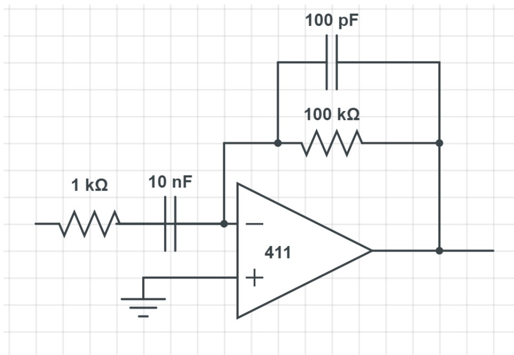

Figure 13: This is the circuit diagram for the differentiatior circuit

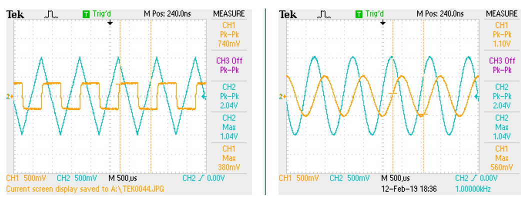

Figure 14: This shows waveform driven by the 1kHz triangle wave and sine wave

spoke into the microphone, it does not matter what we spoke but rather the output wave form which can be seen in figure 16.

7. Diode Feedback

7.1. Part G

The next section had us build an inverting amplifier but replacing the feedback resistor, where we replace the feedback resistor with a diode. The circuit diagram can be seen in figure 17. We are then asked to drive the input with a saw tooth wave, setting the function generator for only positive outputs, the function we witness it and invert it which we show in figure 18. We are asked to explain the output with op-amp rules and it basically is a logarithmic amplification of the input, this is due to the diode having a logarithmic resistance. We are lastly asked why the signals must be positive. The reason why we needed to make our signals positive is that we are using a diode and the diode with its properties only allows the transfer of positive voltages.

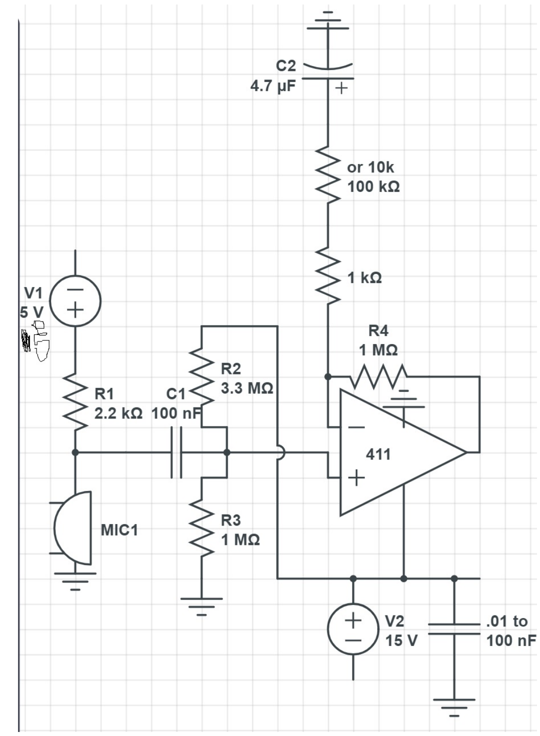

Figure 15: This shows the circuit diagram AC amplifier.

8. Wien Bridge

8.1. Part H

The last circuit we built was a Wien Bridge, which can be seen in figure 18. We use a 12V, 60mA lamp and a 100Ω resistor rather than the exact thesis circuit.We are first asked to show the output which can be seen in figure 19 We are now asked what happens when we remove the small amounts of negative feedback and the result it jumps back and forth between the rails. When we replace the lamp with an equivalent resistor it does not work anymore, and causes it to have a odd square like output seen in figure 20. The key property of the lamp is that it has a changing resistance rather than being static so it handles the impedance of the system differently, making the system oscillate.

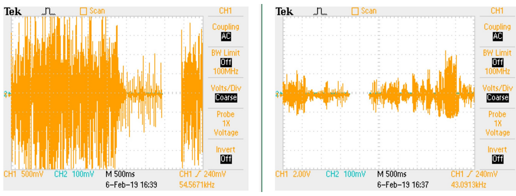

Figure 16: This shows the Output AC amplifier, which was a voice waveform for various noises.

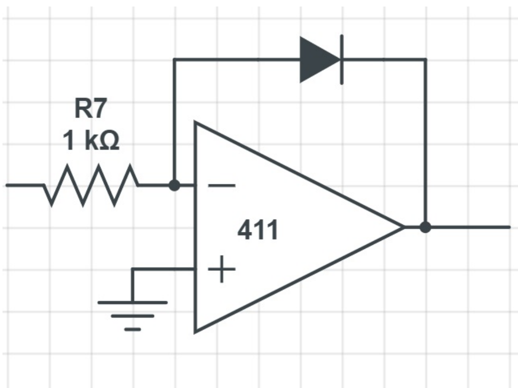

Figure 17: This is the circuit for Inverting Amplifier with diode.

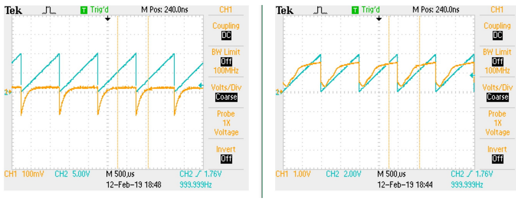

Figure 18: This is the Output for Inverting Amplifier with diode, inverted and not.

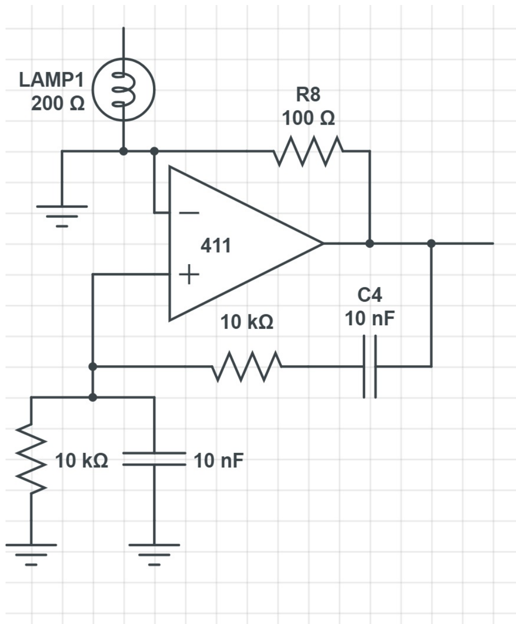

Figure 19: Wien Bridge Circuit Diagram.

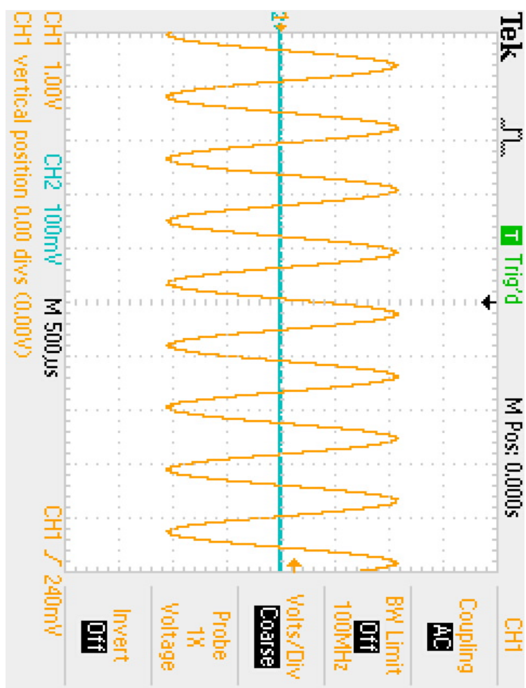

Figure 20: Wien Bridge Output.

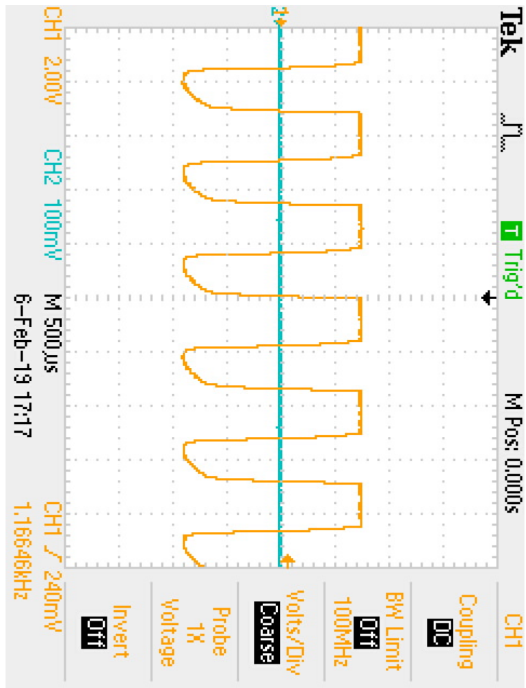

Figure 21: Wien Bridge Output broken.

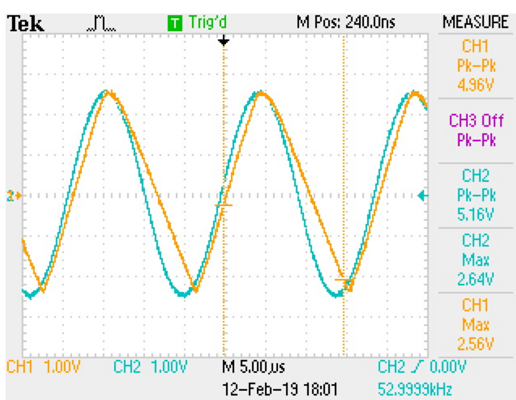

Figure 22: Slew rate frequency of the 741 .