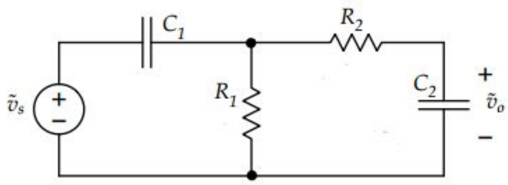
Names: Brenda Lopez, Luke Milius
Lab Section: D
TA: Shravan Kumar

Final Design Project

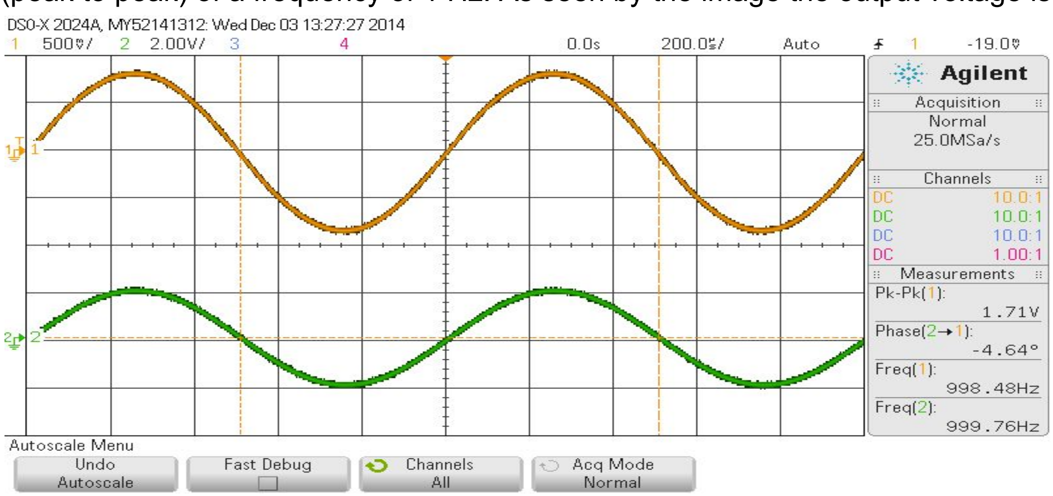
Intro

The purpose of this lab is to design a simple signaling device that lights a red LED when one button is pushed and a green LED when another button is pushed. For this lab we decided the red LED would be lighted when the transmitter produced a frequency of approximately 10 kHz. Also, we decided the green LED would be lighted when the transmitter produced a frequency of approximately 1 kHz. We built both the transmitter and receiver circuits. We decided to build each component and test them individually before connecting them all together as either transmitter or receiver circuits. Each part is how we began and ended our lab design process.

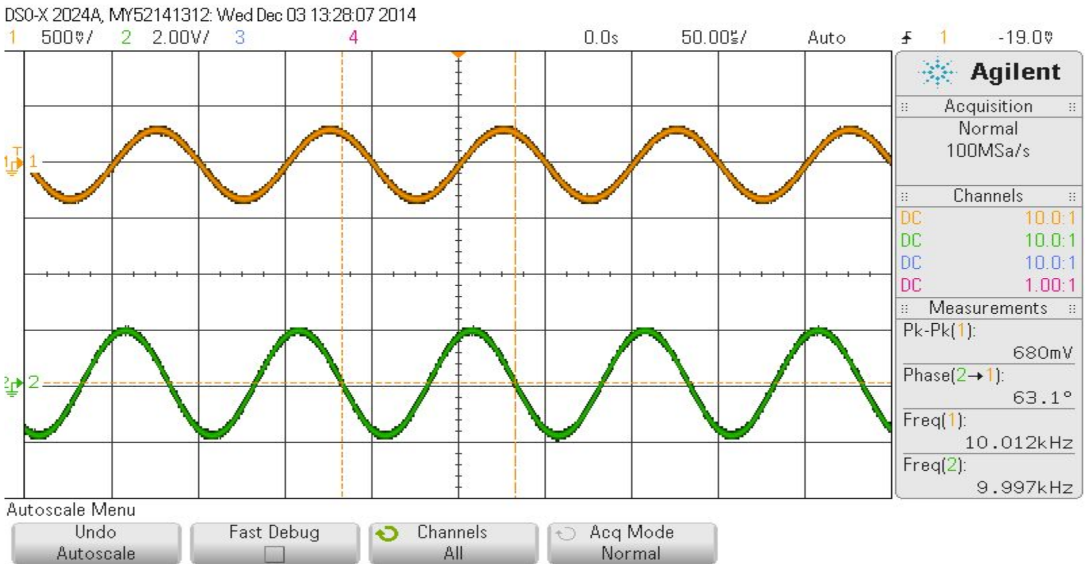
Part A: Building two band pass filters



The circuit shown above is how we built both band pass filters. However the values of the resistors and capacitors were not the same. All the calculations may be found in Appendix A. Once we built the circuit we first tested the band pass filter design for a frequency of 1 kHz. We used the function generator as our voltage source and used the oscilloscope to measure the output versus the input. We used channel 1 to measure the output and used channel 2 to measure the input. The image shown below is when we applied a sinusoidal wave with 2 Vpp (peak to peak) of a frequency of 1 Hz. As seen by the image the output voltage is 1.71 Vpp.

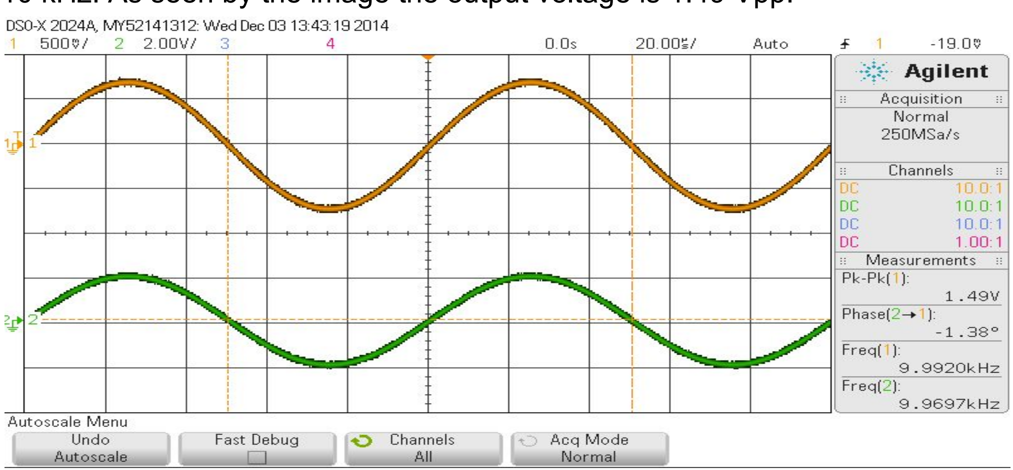


Next we applied a sinusoidal wave with 2 Vpp (peak to peak) of a frequency of 10 kHz. As seen by the image the output voltage is 680 mV. The oscilloscope image is shown below:

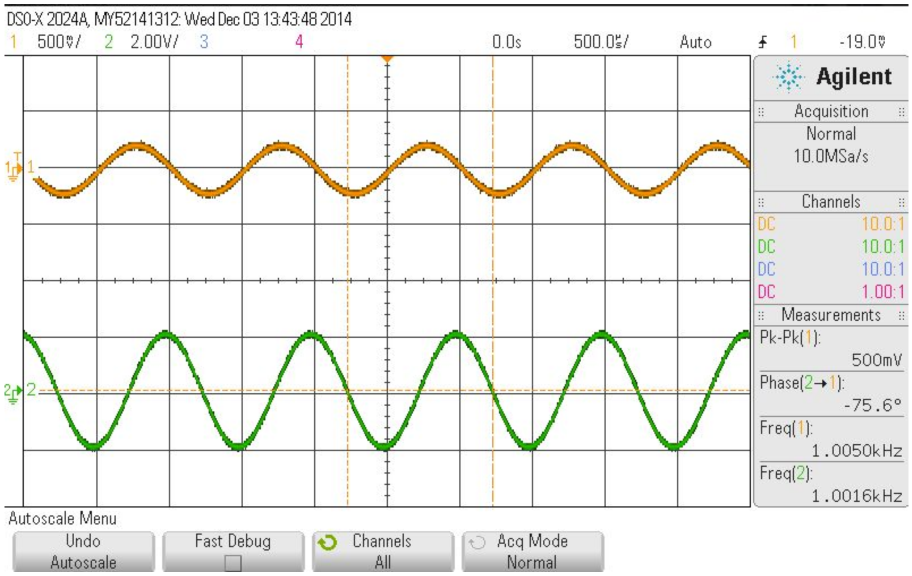


Since the output voltage is very small at 10 kHz, and the output voltage is larger than the latter, the band pass filter for the 1 kHz is working as we predicted it to be.

Next we tested the bandpass filter for a frequency of 10 kHz. The circuit is the same as the image shown above, but with different resistor and capacitor values. We used the function generator as the source voltage, and used the oscilloscope to measure output versus input. We used channel 1 to measure the output and used channel 2 to measure the input. The image shown below is when we applied a sinusoidal wave with 2 Vpp (peak to peak) of a frequency of 10 kHz. As seen by the image the output voltage is 1.49 Vpp.



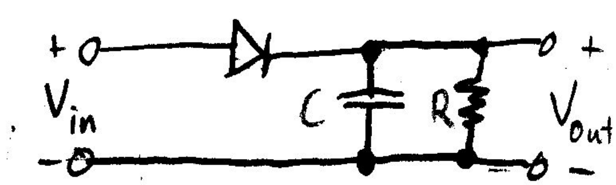
Next we applied a sinusoidal wave with 2 Vpp (peak to peak) of a frequency of 1 kHz. As seen by the image the output voltage is 500 mV. The oscilloscope image is shown below:



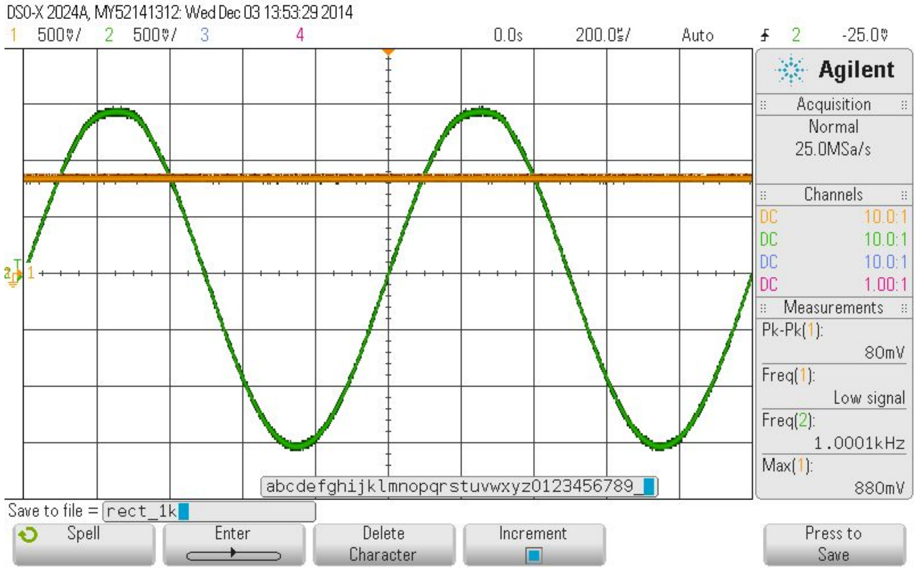
Since the output voltage is very small at 1 kHz, and the output voltage is larger than the latter, the band pass filter for a frequency of 10 kHz is working as we predicted it to be.

Part B: Building two rectifier circuits

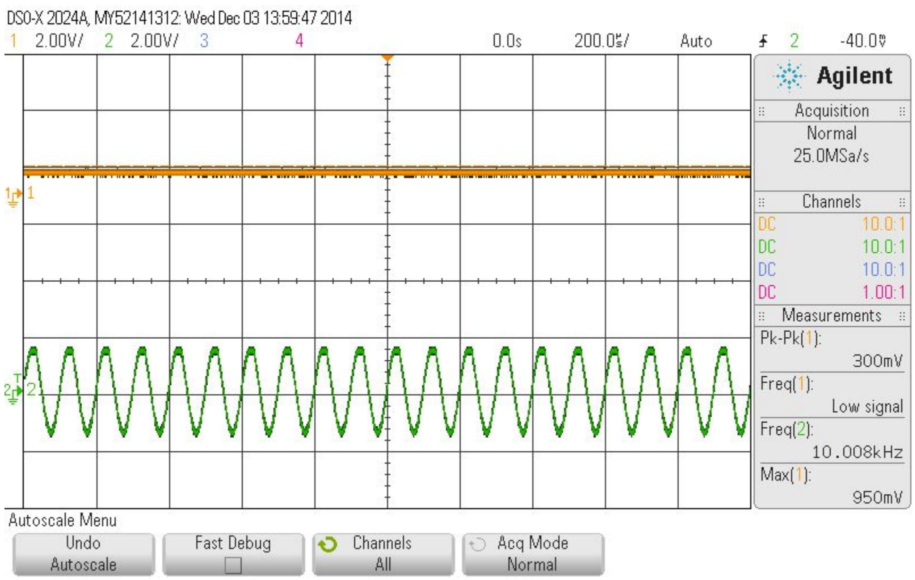
For the two rectifier circuits, we built them both the same because it does not depend on the frequency at all. We designed just a simple half-wave rectifier with a large capacitor (100 μF) in parallel with the resistor on the output. By adding the capacitor in parallel, it allows us to get a smaller ripple voltage across the resistor in order to get a constant enough signal to trigger a comparator circuit above a set voltage level. Shown below is our circuit diagram for both of our rectifier circuits:



As indicated above, the capacitance value was 100 μF while the resistor value was 10 $k\Omega$. Using these values, we calculated that the ripple voltage for the 1 kHz signal should be about 80 mV on the output while the 10 kHz signal should be around 200 mV on the output. In both of the images below, the orange wave is the output, while the green is the input signal we were feeding into the rectifiers from the function generator. The oscilloscope output is shown below for the 1 kHz signal, where we measured a ripple voltage of 80 mV:



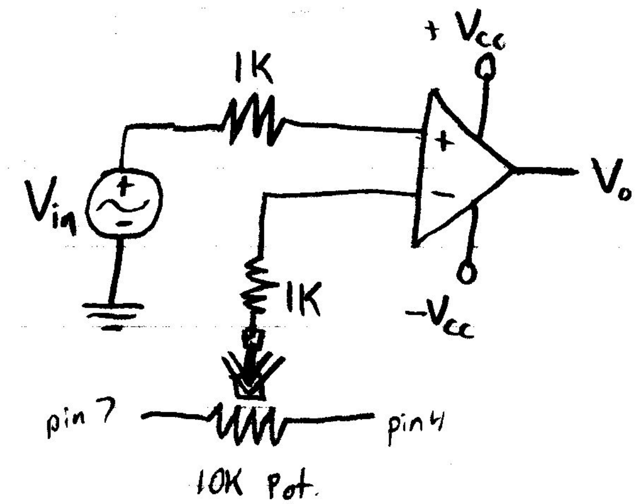
The oscilloscope output for the 10 kHz signal is shown below, where we measured about 300 mV for our actual ripple voltage:



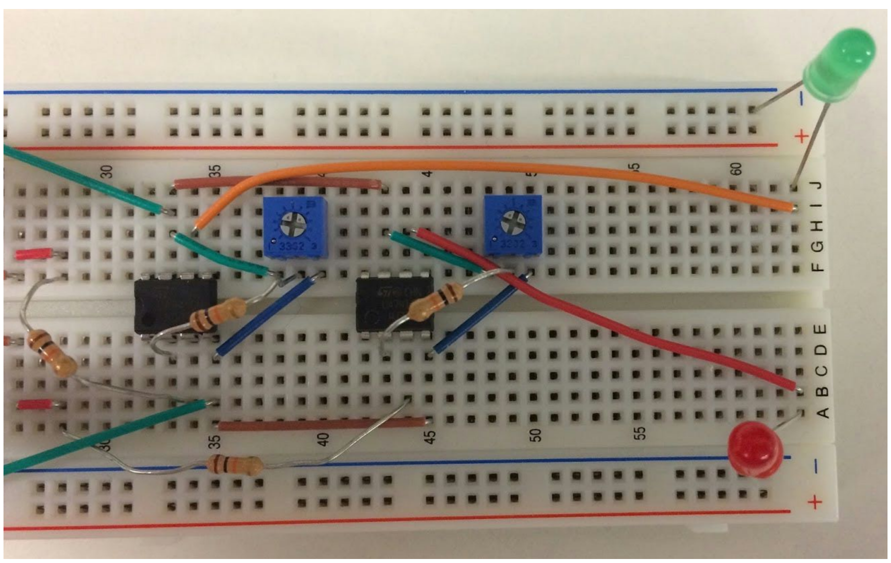
All calculations found in Appendix B.

Part C: Building the comparator circuit

For the comparator circuits, we also built two circuits the same, one for the 1 kHz signal, and one for the 10 kHz signal. The circuit diagram is shown below:

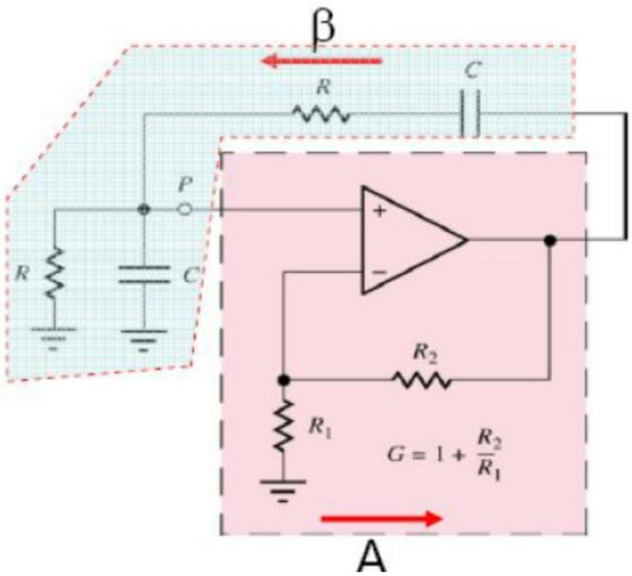


Where the resistors are both 1 $k\Omega$ each, and a 10 $k\Omega$ potentiometer to be able to tune the comparator to get exactly the trigger voltage that we need based on the output from the rectifiers. The two side inputs are connected to the same voltage source as the +Vcc and -Vcc that are connected to the op-amp (pin 7 goes to +Vcc while pin 4 goes to -Vcc). The Vin in this diagram is connected to the output of the rectifier while the Vo is connected to the positive lead of the LED. The negative lead of the LED is then connected to the ground to complete the circuit and allow the LED to turn on when it is given enough voltage. Shown below are the circuits that we built for both the 1 kHz and the 10 kHz comparator circuits. The op-amp, two resistors and potentiometer on the left is the 1 kHz hooked up to the green LED while the circuit on the right is the 10 kHz comparator that is hooked up to the red LED.

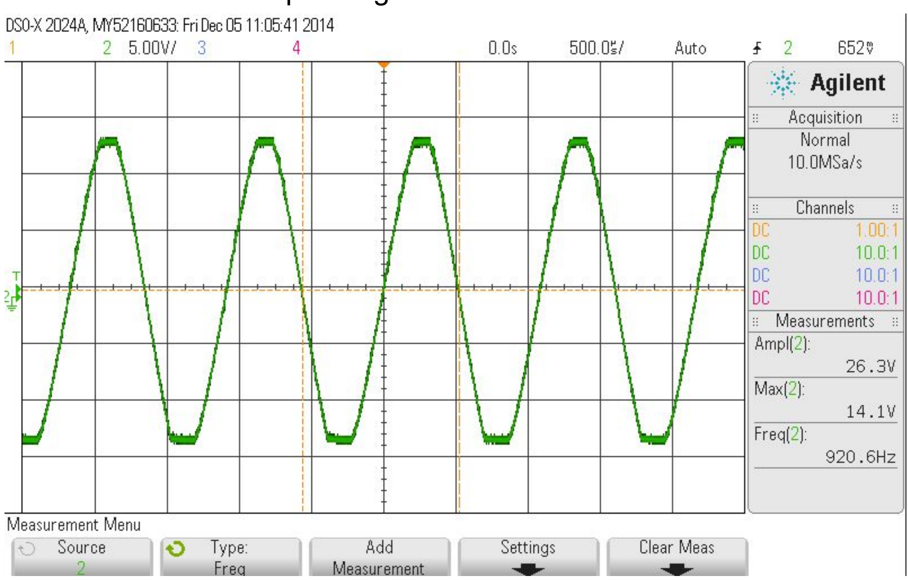


Both op-amps took in a bias +Vcc and -Vcc of +/- 15 V respectively. They compared the input given over the inverting and noninverting input to determine when the voltage level has a difference of 1.5V, then it will send an output voltage to the LED. These circuits are just the simple configurable comparators that we used in Lab 9.
All calculations found in Appendix C.

Part D: Building two oscillator circuits

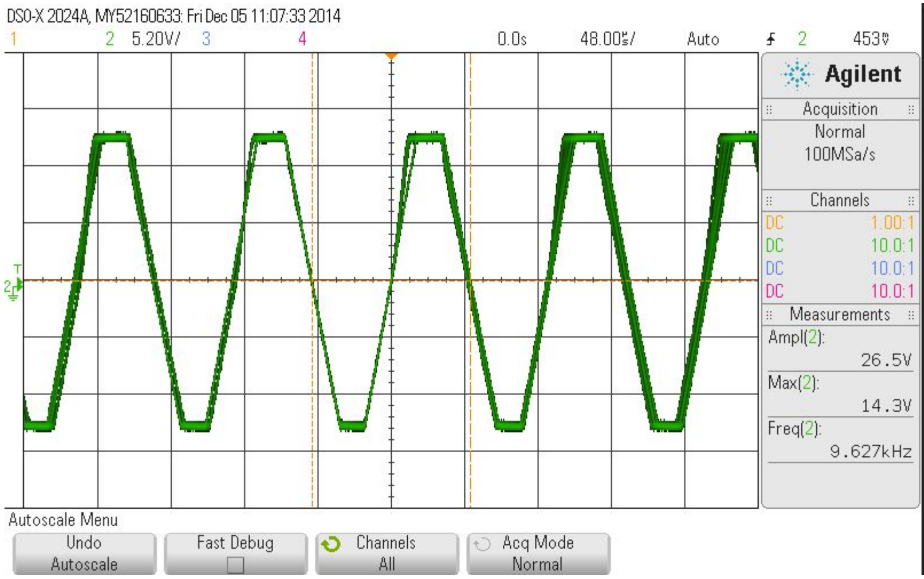


We decided to build a Wien-Bridge oscillator circuit, one for a frequency of 1 kHz and the other for 10 kHz. The circuit diagram shown above is how it was built, but the resistor and capacitor values changed in accordance to what frequency we wanted to output. All calculations may be found in Appendix D. First we built both Wien-Bridge oscillator circuits and then tested each circuit independently. The bias voltage for each op-amp was ±15 V, and we used the triple output DC supply as our only voltage source to the circuit which was to the ±VCC of the op-amp. We used the oscilloscope to test the oscillator circuit that would produce a frequency of 1 kHz. The oscilloscope image is shown below:



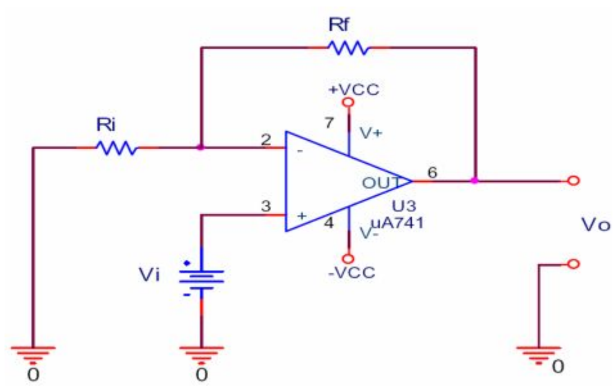
As seen by the image above, our oscillator produces 920.6 Hz, with a voltage of 26.3 Vpp (peak to peak).

Next we test the oscillator circuit that is supposed to produce a frequency of 10 kHz. We used the oscilloscope, and the image is shown below:



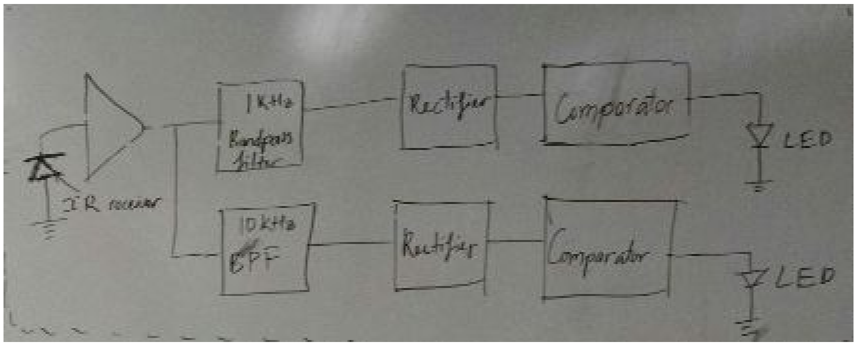
As shown by the image above, our oscillator produces a frequency of 9.627 kHz and a voltage of 26.5 Vpp (peak to peak). Since both oscillator circuits are producing the frequencies we desire to output, we are safe to assume they would work when we put every component together.

Part E: Building non-inverting amplifiers

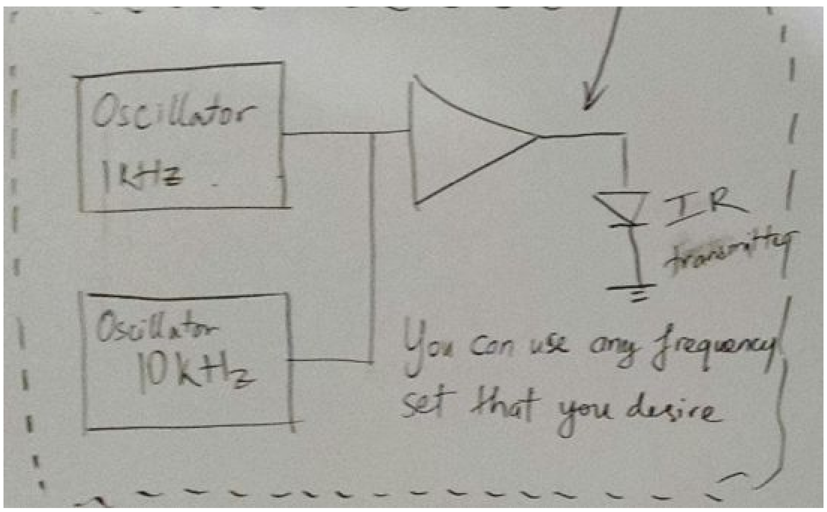


We decided to build two non-inverting amplifiers. One amplifier will amplify the transmitter, and the other the receiver. Both of the non-inverting amplifiers had a gain of 11 V/V. All the calculations may be found in Appendix E.

Part F: Putting it all together



First we assembled the receiver circuit. The receiver circuit consists of the IR sensor, with one amplifier, then it was both connected to the bandpass filters, the rectifier circuits, the comparator circuits, and finally to the green and red LED's. The image is shown above. Next we assembled the transmitter circuit shown below:



Since we tested each component before assembling together, we were confident our transmitter and receiver circuits will work. We first transmitted a frequency of 1 kHz and our green LED light turned on, but also our red LED light. We adjusted the potentiometer in our comparator circuit, to turn off the red LED light. Next, we transmitted a frequency of 10 kHz and the green LED light turned off, but our red LED light stayed off. Again we adjusted the potentiometer in our comparator circuit, and the red LED light turned on. We went back to transmitting a frequency of 1 kHz and the red LED light still stayed on. We realized the green LED light worked as we intended but the red LED light did not. We measured the voltage across the IR transmitter when we were transmitting 1 kHz and 10 kHz, and it was the approximately the same value of 26.7 Vpp (peak to peak). However, the 10 kHz transmitter would only provide a very small to none voltage across the IR receiver. We tried to attenuate the voltage across the IR transmitter, but that did not work. To attenuate the voltage across the IR transmitter, we used a non-inverting op-amp circuit, and next we tried a voltage divider. Also, we tried different resistor and capacitor values for our oscillator circuit. Finally, we decided to not use the oscillator circuit that produced the 10 kHz frequency and demonstrate our oscillator circuit that produce 1 kHz worked. Next we used the function generator, to help distinguish between 1 kHz and 10 kHz, and our circuit worked. When the function generator was 1 kHz our green LED light turned on and the red LED light remained off. When the function generator was 10 kHz our red LED light turned on and the green LED light turned off.

Conclusion

In conclusion, we designed a circuit that will wirelessly transmit different frequencies to light up a particular LED on the receiver end of the circuit. We designed two oscillators that produced a 1 kHz signal and a 10 kHz signal. These two can be switched between the two by flipping a switch designating which signal gets connected to the IR transmitter. On the receiving end, we have an IR receiver that receives the signal from the transmitter with the desired frequency. Then the circuit splits in two where the signal goes through a band-pass filter on each side that only one passes through with the given frequency. That passed signal then gets passed to a half-wave rectifier to output close to a DC signal with a low ripple voltage. That new signal is then passed into the comparator circuit to be compared and if it exceeds a particular voltage level, then it outputs a voltage high enough to turn on the respective LED. After building each module of the circuit, we tested each part individually and know that they all work just fine. When testing out the complete circuit, we found out that the 1 kHz signal works great, but the 10 kHz signal did not. The voltage level was not high enough coming from the IR transmitter which we believe was not getting enough current to output a high enough amplitude on the signal. By replacing the IR receiver with the function generator, the circuit functioned as expected.