Project: **Active crossover network**

Lab work done by _____Tejas Agarwal_____

and _____Sean Gordon_____

Lab work date: 4-24-2019

Report submission date: 4-24-2019

Lab Section: E

Graded by _____

Score _____

Introduction -
This design project centered around the creation of a circuit that takes an input of any type and sorts it into different frequencies, split at 300 and 5000 Hz. This will be created using various filters in parallel for the desired outputs.

Design Requirements -
This circuit requires the input signal to be split into three different frequency groups:

- 0 Hz - 300 Hz:
- 300 Hz - 5000 Hz:
- 5000 Hz - ∞Hz:

The entire circuit must have an input resistance of greater than 10,000 Ω.
The lower frequency comes with the added requirement of variable gain so that $1 \leq G \geq 5$.

Components -
This circuit will be made using three different filters: One low-pass, one band-pass, and one high-pass.

Low-Pass (0 Hz - 300 Hz):

- R1 = 7957.75 Ω = 6800+1000+150+10
- C1 = .1μf
- R2 = 7957.75 Ω = 6800+1000+150+10
- C2 = .1μf

Band-Pass (300 Hz - 5000 Hz):

- R1 = 318.3 Ω = 220+100
- C1 = .1μf
- R2 = 5302.2 Ω = 3300+1000+1000
- C2 = .1μf

High-Pass (5000 Hz - ∞Hz):

- R1 = 265.26 Ω = 220+47
- C1 = .1μf
- R2 = 2652.6 Ω = 2200+330+100+22
- C2 = .01μf

To satisfy the requirement of input resistance being at least 10,000 Ω, we will put a 10,000 Ω resistor followed by a unity gain amplifier directly after V_i leading into the circuit.

To satisfy the requirement of variable low-pass gain, R_A in the low pass filter will be substituted with a 10,000 Ω potentiometer, while R_B = 2500 Ω = 150 + (4700 | 4700).

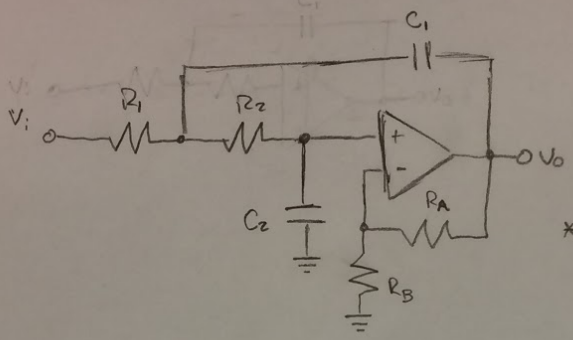
The op-amps in the circuit will be the LMC660, with ±8 V power supplies.

OLD Notes and Written Diagram -

For this design project, we need:

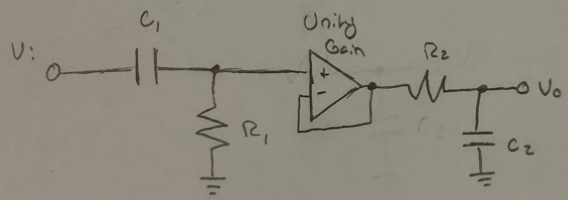
- 1 2nd-order low-pass (active)
- 1 2nd-order band-pass
- 1 2nd-order high-pass

Low pass:

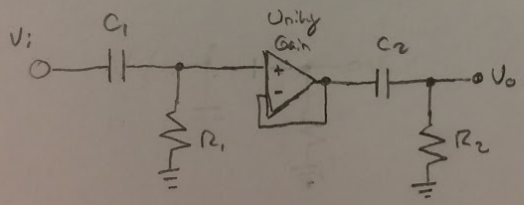


*In this filter, gain will be controlled by a potentiometer, in the range of $1 \leq G \leq 5$

Band Pass:

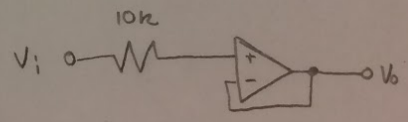


High Pass:



Input:

To satisfy the requirement that input resistance > 10,000 Ω



Calculations

Low Pass:

$$F_{center} = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = 200\,Hz \qquad \omega = 2\pi f$$

$$R_1R_2C_1C_2 = \frac{1}{16\pi^2 \times 10^4}$$

If we choose $C_1 = C_2 = 0.1\,\mu F$

$$R_1 = R_2 = 7957.75\,\Omega$$

$6800 + 1000 + 150 + 10$

Band - Pass: $F_{center} = \sqrt{F_L \cdot F_H} = \sqrt{300 \cdot 5000} = 1224.7\,Hz \qquad \omega = 2\pi F$

Low Pass - $C_2 = \frac{1}{2\pi \cdot F_L \cdot R_2} = \frac{1}{2\pi(300)R_2}$ If we choose $C_2 = .1\,\mu F$ $R_2 = 5305.2\,\Omega$

$3300 + 1000 + 1000$

High Pass - $C_1 = \frac{1}{2\pi F_H \cdot R_1} = \frac{1}{2\pi(5000)R_1}$ If we choose $C_1 = .1\,\mu F$ $R_1 = 318.3\,\Omega$

$220 + 100$

High Pass; In order to reduce loading effect, we will scale $R_2 = 10\,R_1$ & $C_2 = \frac{C_1}{10}$

$$\frac{1}{2\pi \cdot 6{,}000} = \sqrt{R_1C_1R_2C_2} = \sqrt{10R_1^2 \cdot C_1^2/10} = \sqrt{R_1^2 \cdot C_1^2}$$

$$7.036 \cdot 10^{-10} = R_1^2 \cdot C_1^2$$

If we pick $C_1 = .1\,\mu F$, $R_1 = 265.26\,\Omega$

$220 + 47$

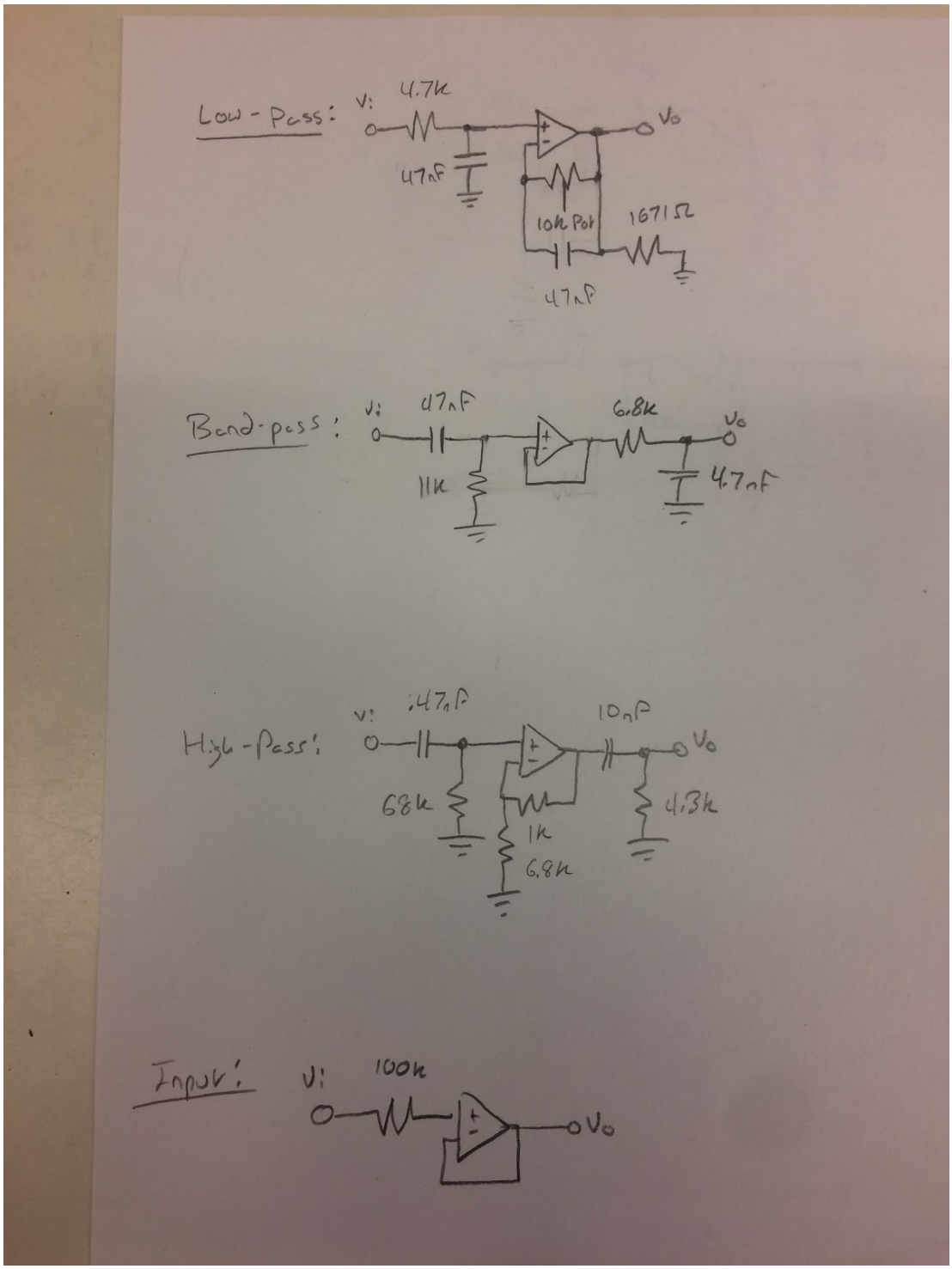
$\therefore$

$C_2 = .01\,\mu F$, $R_2 = 2{,}652.6\,\Omega$

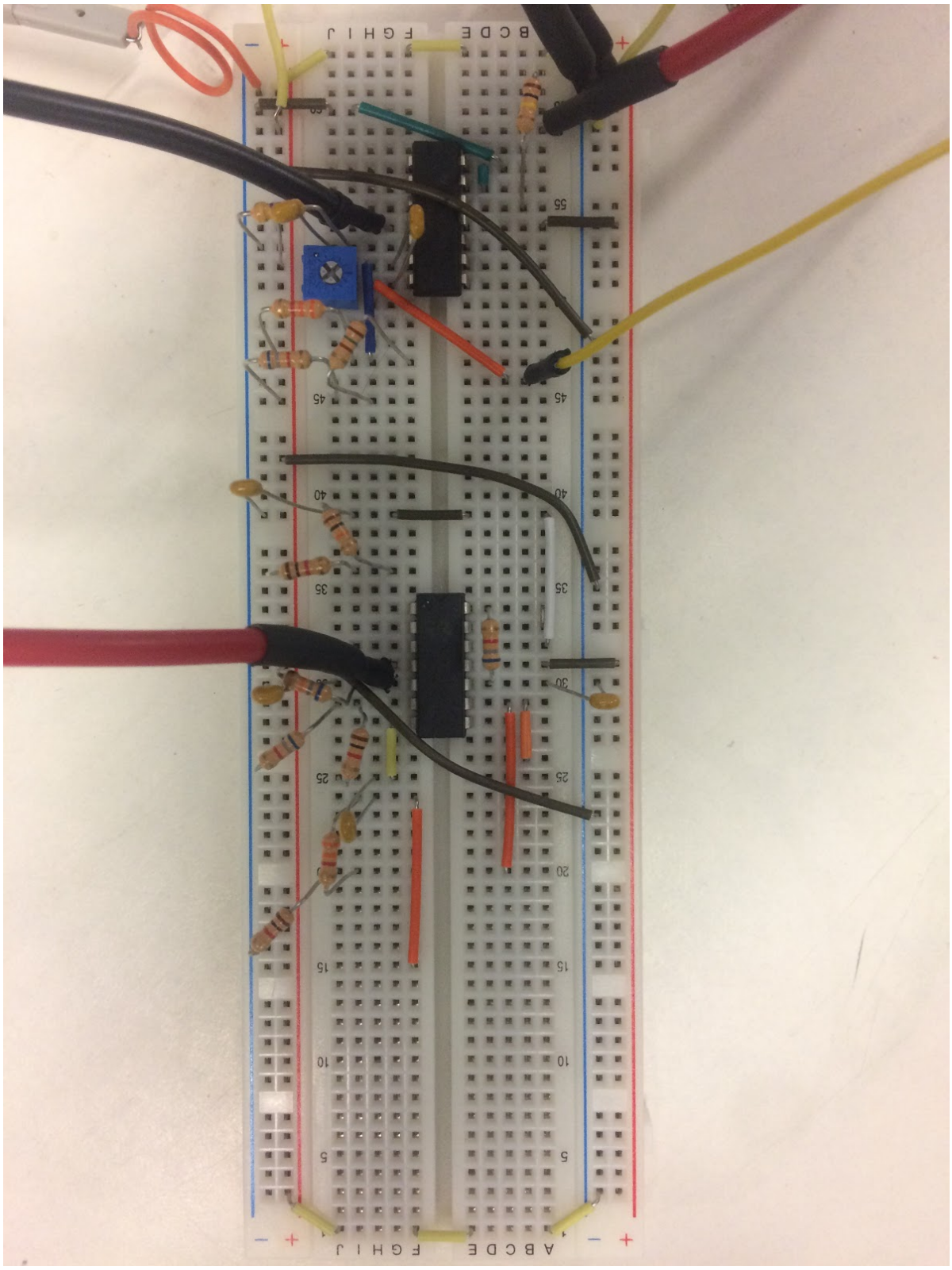
$2200 + 330 + 100 + 22$

NEW Circuit Diagram -

After a fair amount of fiddling and a complete rebuild of the low-pass filter, the final circuit diagram appears as so:



Circuit Implementation -



Testing -
To test the circuit we attached a sinusoidal input of arbitrary frequency and used a DSOX2024A Oscilloscope with probes hooked up to the input and the three outputs separately. At a specific frequency, we checked to make sure the specific output was active.

Conclusion -
This lab was focused on the creation and combination of each type of filter in order to split an input into three frequency groups, ensuring the use of at least one active filter by requiring variable gain on the low-pass filter. The first design didn't work, and building the second set of filters using calculations didn't work either, so each filter was created using a combination of calculations and guess and check..