ECE 321 - Final - Name _____

Spring 2020. Due Wednesday, May 13th at midnight

alculators, internet, Matlab, circuit lab, tarot cards permitted. Just not someone else.

Please sign pledge if able (i.e. you did not work with anyone else)

No aid given, received, or observer: _____

Background: With a microprocessor, it is fairly easy to generate a square wave. Using an H-bridge, you can then drive a speaker (ECE 320 problem). This results in a harsh sounding electronic piano due to the harmonics of a square wave.

One way to produce a cleaner sounding electronic piano is to

- Amplify the resulting sine wave to -10V to +10V,
- Filter the square wave to remove the harmonics (leaving a clean sine wave), and then
- Drive a speaker using a power amplifier (push-pull amplifier).

This final exam goes through each part of this design.
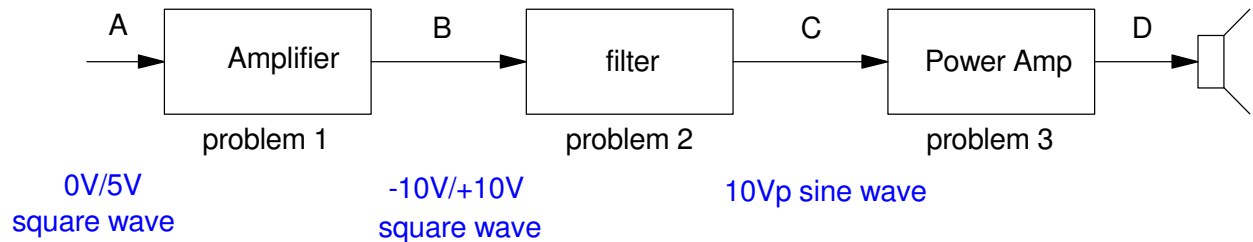
Problem 1) Amplifier: Design a circuit to convert a 0V / 5V square wave into a -10V / +10V square wave

Input (X): 220Hz to 440Hz square wave

- 0V / 5V
- Capable of driving 10mA

Output (Y): 220Hz to 440 Hz square wave

- -10V to +10V
- Capable of driving 10mA

Relationship:

- Y = 4X - 10

Problem 2) Filter. A square wave has odd harmonics. A sine wave has no harmonics. One way to turn a square wave into a sine wave is to filter out the harmonics.

Design a filter to meet the following requirements

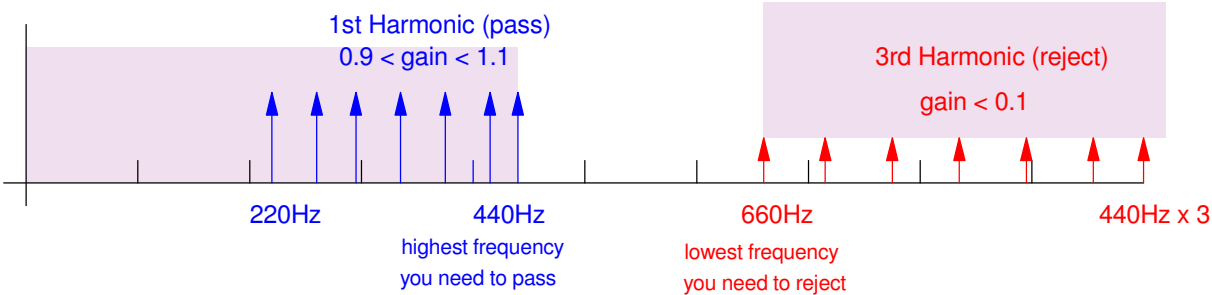Input (X): 220Hz to 440Hz square wave (i.e. problem #1)
- -10V to +10V
- Capable of driving up to 10mA

Output (Y): 220Hz to 440Hz sine wave
- Capable of driving up to 10mA

Relationship:
- $0.9 <$ gain < 1.1 $0 <$ frequency < 440Hz
- $0.1 <$ gain   frequency > 660Hz

1st Harmonic (pass)
$0.9 <$ gain < 1.1

3rd Harmonic (reject)
gain < 0.1

220Hz

440Hz
highest frequency
you need to pass

660Hz
lowest frequency
you need to reject

440Hz x 3

Problem 3) Power Amplifier. Design a circuit to take the output of the filter and drive an 8-Ohm speaker

Input (X) (problem #2)

- -10V to +10V sine wave
- 220Hz to 440Hz
- Capable of driving 10mA

Output (Y): 8-Ohm speaker

Relationship:

- Y = X
- +/- 100mV

Problem 4) CircuitLab Simulation.

Verify your design using CircuitLab.

- Adjust the gain of the amplifier (problem #1) so that the output is a +10V to -10V sine wave
- Verify the output of the resulting amplifier (problem 1) at 220Hz and 440Hz
- Verify the output of the filter (problem 2) at 220Hz and 440Hz
- Verify the output of push-pull amplifier (problem #3) at 220Hz and 440Hz

Bonus!

(If you would like to remain anonymous, please send your response to Anne Campbell and then just note this on your final exam)

Having the unique experience of taking ECE 320/321 both in-person and on-line in the same semester, I'm interested in your opinions.

i) It's very possible that many ECE classes will be available for on-line instruction next fall. If on-line classes were offered (meaning you don't need to even be in Fargo), what is the chance you would take the on-line version?

$$0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10$$
Not a chance   highly likely

ii) Please give an example of something done well with the on-line instruction for ECE 320/321

iii) Please give an example of something that needs improving with this class

Have a nice summer!