ECE 2100

Lab. VI – AC Signals, Linear Circuits, and Second-Order Filters

Pre-Lab

Important notes: To answer the questions, you need to go to the full Lab-VI description web page

1. Besides lab instruments, AC voltage or current are found exclusively in 60-Hz AC power system. True or False.
2. To generate an AC voltage or current, besides the wall plug power system, one must use scientific/ engineering lab equipment. True of False.
3. Can you generate AC signals with just yourself (your body) without anything, any instrument? Yes or No (*hint: this and this – you can say that AC signals are in your heart and mind – you certainly don't want either one in the DC state or "flat-lined"*).
4. All AC circuit must contain at least one capacitor. True or False.
5. The purpose of a linear circuit is to add two signals together, multiply a signal with a constant, or both. True or False.
6. Circle all **that are false**: A linear circuit:
   a. can take a sinusoidal input of frequency f and give a sinusoidal output of the same frequency, f
   b. if given a sinusoidal input of frequency f, always output a sinusoidal with equal or lower amplitude compared to the input.
   c. with a 1-V pp input at 1 kHz, gives 0.7-V pp at 1 kHz. Hence, when given an input of 2-V pp at 2 kHz, it will give 1.4-V pp at 2 kHz.
   d. can take two sinusoidal inputs of frequency f1 and f2, respectively, and yield a sinusoidal output of frequency f1+f2
   e. will always give a square wave output if given a square wave input
7. A purpose of Lab VI is to see how the amplitude and phase of a sinusoidal input changes as a function of frequency. True or False.
8. The change of amplitude and phase of a sinusoidal signal can cause distortion, hence the goal of any circuit is to minimize this undesirable effect. True or False.
9. This is only a test to see if you can do computation, if you can, do it for credit, if not, skip this question and it won't affect your pre-Lab score. The signal below is input into a linear circuit:

$$\text{Sin}[2\,\pi\,f\,t] + \text{Sin}[4\,\pi\,f\,t] + 0.4\,\text{Sin}[6\,\pi\,f\,t]$$

Where f= 1 kHz. The circuit response function (in frequency f, not angular frequency ω) is:

H[1 kHz]= $e^{i\,\pi}$; H[2 kHz]= $0.5\,e^{i\,0.5\,\pi}$; H[3 kHz]=0.125 ;

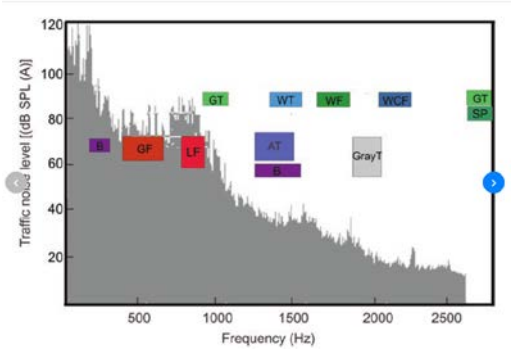
Plot the output.

10. Based on the signal distortion observed in Q. 8 above, would you say the circuit is good or bad? (you can answer this question without answering Q. 8 – feel free to write your opinion in the space provide).

11. If we listen to sound or music and the treble (high frequency part) is too loud and undesirable, can one use a circuit to attenuate the high-frequency portion and leave the low-frequency portion almost the same? Yes or No.

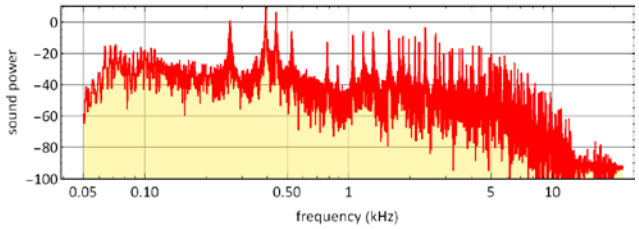
12. In Lab VI, what is the name you would call the circuit in Q. 11 above?

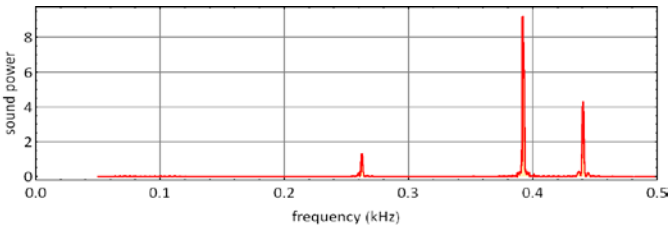
13. You are building a robot that is supposed to respond to commands from a special whistle. The frequency of your whistle is 1.5 kHz and above. The robot is deployed in noisy urban environment as shown in the sound spectrum on the side. Sound spectrum is a measure of the sound level for each frequency over a certain frequency range. As shown on the side, it is a plot of sound level as a function of frequency. What signal processing do you think a good idea for your robot sound receiver? (few words)



Effects of Anthropogenic Noise on Amphibians and Reptiles - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/Spectrum-of-highway-traffic-noise-in-relation-to-the-spectral-composition-of_fig1_327132779

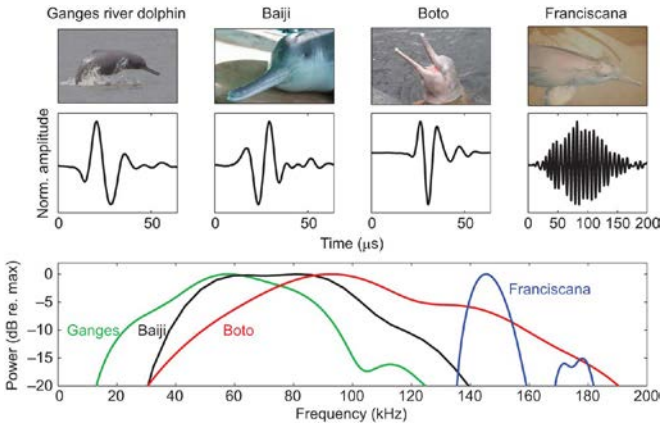
14. Want an example of sound spectrum? Below is the sound spectrum of this ->.

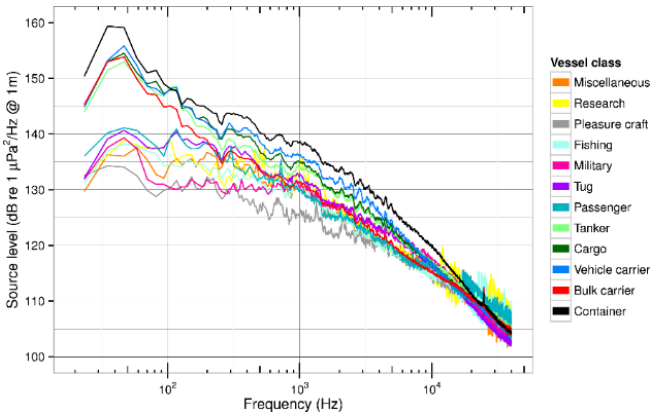




The left hand side is the spectrum on the log scale, the right hand side is the same on the linear scale and over a smaller frequency range. If you think you understand, write a note of your understanding why the spectrum (the linear one) looks as it is. If not, just skip. It won't affect your score.

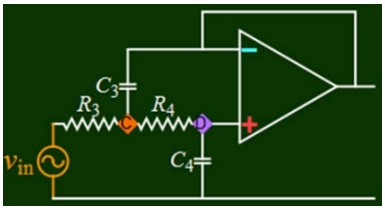
15. Below are the sonar spectra of various dolphins. On the right is the sound spectrum of various watercrafts. Supposed you are in an environment that has various watercrafts, both Baiji (extinct, but this is hypothetical) and Franciscana dolphins and if you want to detect only the latter, what type of signal filter would you use?

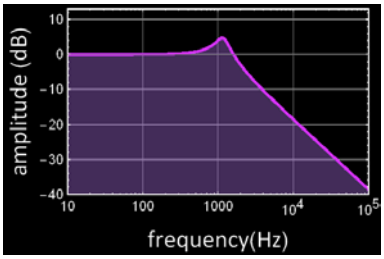




Amazon river dolphins (Inia geoffrensis) use a high-frequency short-range biosonar.
Michael Ladegaard, Frants Havmand Jensen, Mafalda de Freitas, Vera Maria Ferreira da

16. Consider this circuit on the right side that you will build, it has a plot of output phasor amplitude vs frequency (Bode plot) as shown beneath. If you input a sine wave of 5 kHz and a sine wave of 10 kHz with equal amplitude, what is the ratio of the output amplitudes of the two waves?





17. When a square wave is input into a linear circuit, if the output **is not** a square wave, something is wrong with the circuit. True or False.

18. A linear circuit can be designed to convert a sine wave into a square wave. True or false.

19. A purpose of using 2 RC circuits (2 R and 2 C), as opposed to one R and one C is to increase the circuit frequency selectivity. True or False.

20. Active circuits in Lab VI can give signal positive gain, i. e. an increase of output amplitude compared to that of input for certain frequency range. True or False.