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Introduction to Sensors, Instrumentation, and Measurement

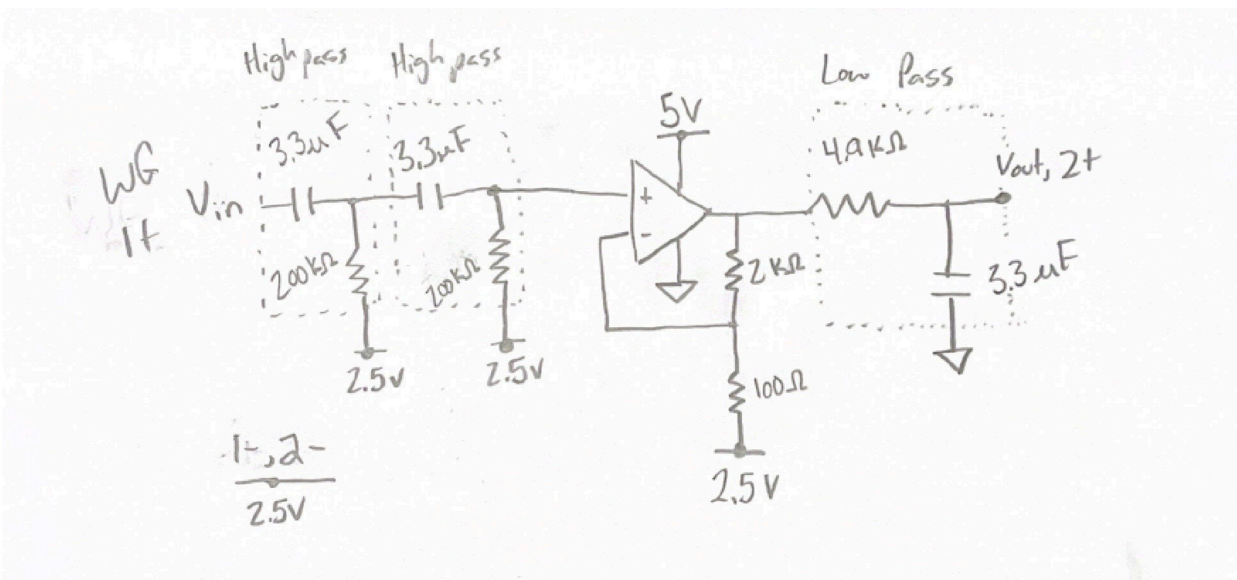
03/11/2024

Lab Six: Blood Pressure

Purpose:
Design and test a bandpass filter that can isolate a blood pressure signal.

Results:

1.) Your final filtering circuit schematic (can be drawn by hand); Denote the values of the resistors and capacitors that you chose.



2.) A very short description of the overall circuit, stating the cutoff frequencies and gain.

The circuit includes two high pass filters, an operational amplifier, and a low pass filter.

The two high pass filters are in series and create a second order high pass filter. Each high pass filter has a 200kΩ resistor and an 3.3µF capacitor. Therefore, the cutoff frequency is:

$$\textit{cutoff frequency} = 1/(2*\pi*R*C)$$
$$\textit{cutoff frequency} = 1/(2*\pi*200{,}000*0.0000033)$$
$$\textit{high pass cutoff frequency} = 0.24\ Hz$$

The operation amplifier is a voltage follower with Vs- = 0V and Vs+ = 5V. The resistors have resistances of 2kΩ and 100Ω respectively, for a gain of:

$$gain = R1/R2 + 1$$
$$gain = 2000\Omega/100\Omega + 1$$
$$gain = 21$$

Lastly, the high pass filter is connected to Vout amd has a 4.9kΩ resistor with a 3.3µF capacitor. This gives a cutoff frequency of:

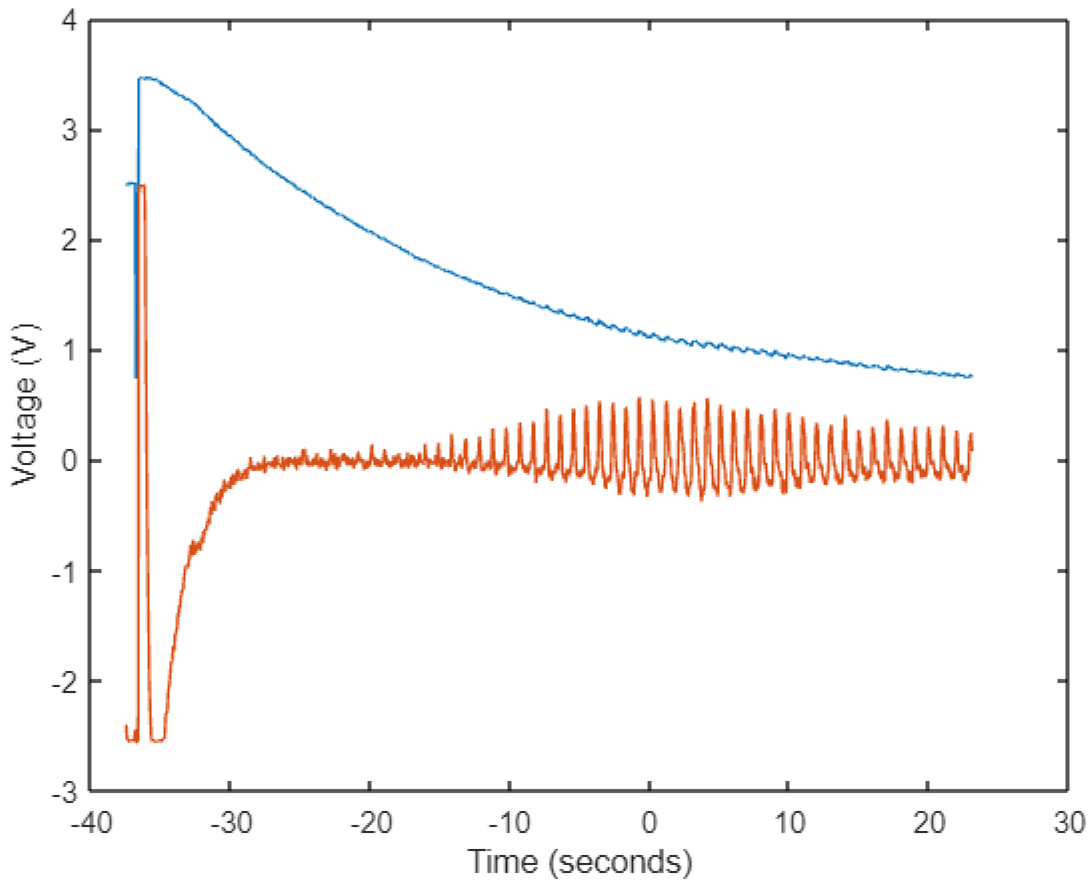
$$\textit{cutoff frequency} = 1/(2*\pi*R*C)$$
$$\textit{cutoff frequency} = 1/(2*\pi*4900*0.0000033)$$
$$\textit{low pass cutoff frequency} = 9.84\ Hz$$

This gives us a filter that theoretically cuts off frequencies below 0.24 Hz and above 9.84 Hz, and amplifies the input signal by a gain of 21.

3.) 1 point Briefly explain what advantage of 2.5 V as the reference (over 0V) for the two high-pass filters.

Using 2.5V as the reference voltage allows the sensor to pick up and amplify both positive and negative voltages. 2.5V is an ideal choice for this since the O-Scope can output voltages between 0 and 5; 2.5 is directly in the middle. If 0V was used as the reference voltage, it could only pick up and amplify positive voltages.

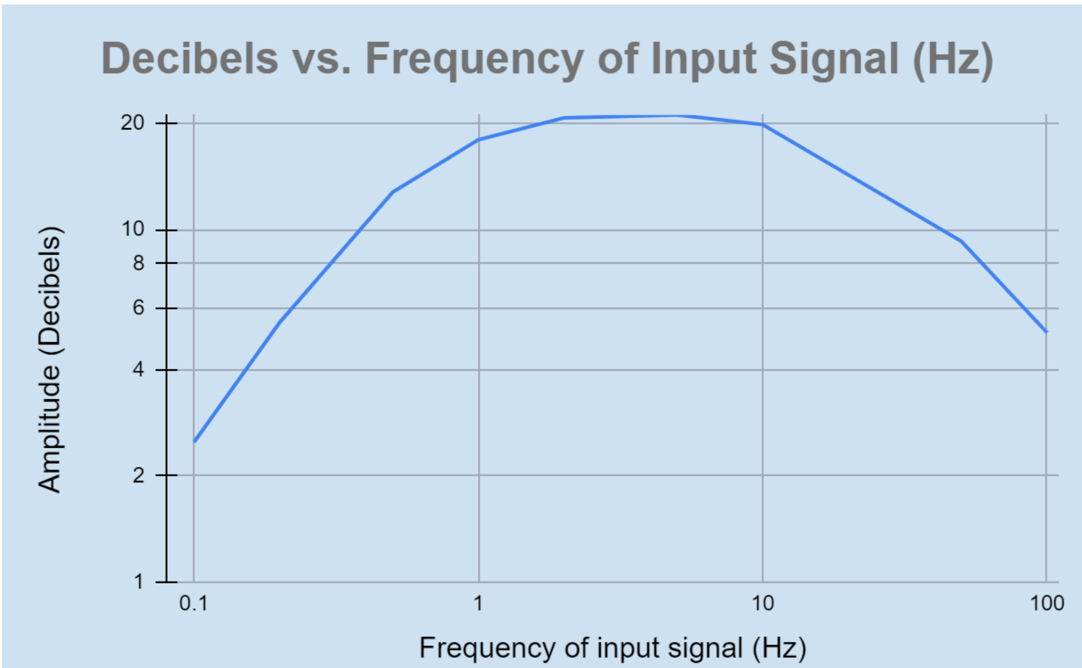
4.) 1 point Plot of the final blood pressure (BP) measurement v. time with caption. You can use the dataset (BPdata.csv) that we used for building the circuit if you like. To create a graph of pressure, you'll need the transfer function for the sensor. Make sure you label your axes.



Although this graph is in voltage, the voltage is representative of pressure. This graph was created using the preloaded data representative of an actual BP measurement from a sphygmomanometer on the Oscope. The circuit has a second order high pass filter (cutoff frequency of 0.24 Hz) , a voltage follower operational amplifier (gain of 21) , and a low pass filter (cutoff frequency of 9.84 Hz).

5.) 1 point Bode plot (amplitude only) of the circuit you designed with captions. Your amplitude Bode plot should plot amplitude of output divided by amplitude of input versus frequency. This plot will be generated from your table data – if you wish to collect more data to get a cleaner Bode plot, that is great but the table data is sufficient. Your plot should have a log-log axis. In the caption, include the cut off frequencies.

Bode Plot of Blood Pressure Filtering Circuit (Amplitude Only)



Bode Plot of a circuit with a second order high pass filter (cutoff frequency of 0.24 Hz) , a voltage follower operational amplifier (gain of 21) , and a low pass filter (cutoff frequency of 9.84 Hz). The bode plot was manually created by using the wave generator with 2.5V offset, ~100 mV Amplitude, and frequencies ranging from 100 Hz to 0.1 Hz. The generated chart of frequencies is below.

Frequency of input signal (Hz)	Vin (volts, RMS) Amplitude Ch1	Vout(volts, RMS) Amplitude Ch2	Sampling rate (100 x finput)
0.1	0.08487	0.2119	10 S/s
0.2	0.08470	0.4624	20 S/s
0.5	0.08472	1.0830	50 S/s
1	0.08395	1.5100	100 S/s
2	0.08294	1.7210	200 S/s
5	0.08330	1.7600	500 S/s
10	0.08351	1.6580	1000 S/s
50	0.08453	0.7830	5000 S/s
100	0.08459	0.4317	10000 S/s