Band Pass Filter and Thevenin Equivalent Circuit Analysis

Circuits fall 2020

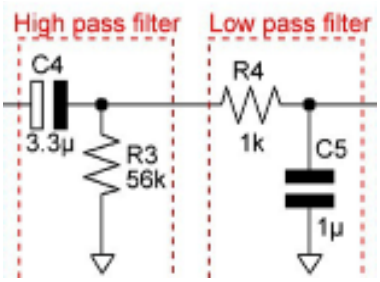

Figure 1. Band pass filter that is part of the PPG circuit to measure heart rate and blood oxygen saturation. Original design from: https://www.edn.com/simple-pulse-oximetry-for-wearable-monitor/

1. Compute the pass band frequencies for this BPF. Make an approximate sketch of G (dB) vs. log f.
2. Compute the capacitor impedance magnitude $|Z_{C4}|$ at frequencies of 1, 10, and 100 Hz
3. Do the same for C5.
4. For the HPF section, write an expression for the Thevenin equivalent impedance Z_{TH} in terms of C's and R's and angular frequency ω.
5. Compute the magnitude $|Z_{TH}|$ at frequencies of 1, 10, and 100 Hz
6. Write an expression for the R4-C5 series impedance Z_S as a function of Cs, Rs and ω.
7. Compute the magnitude of this series impedance $|Z_S|$ at frequencies of 1, 10, and 100 Hz.
8. Compute the ratio of $|Z_S|/|Z_{TH}|$ at 1, 10, 100 Hz.
9. Therefore, does this BPF work "well"? Specifically:
    a) Can we achieve $\frac{|V_{out}|}{|V_{in}|} \sim 1$ in the passband? Briefly justify with a quick calculation.
    b) Compute the Thevenin equivalent source impedance for the LPF section at 1, 10, 100 Hz. What magnitude of impedances can it safely "drive" without too much voltage division coming into play?
    c) What other design alternatives would you propose and why?