2010 EE PhD Quals: Solutions

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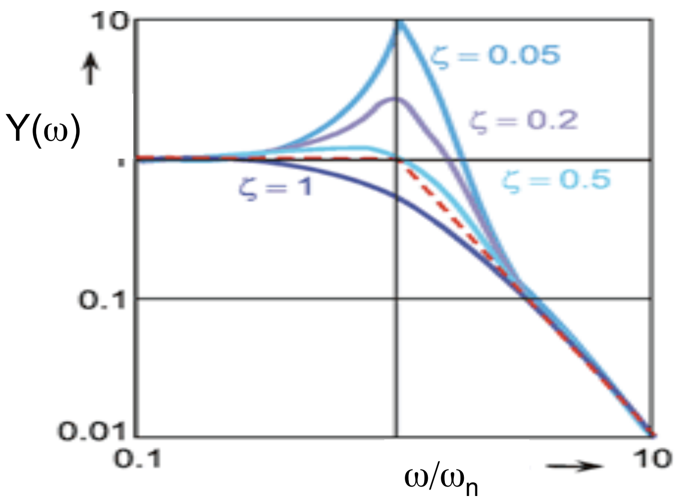
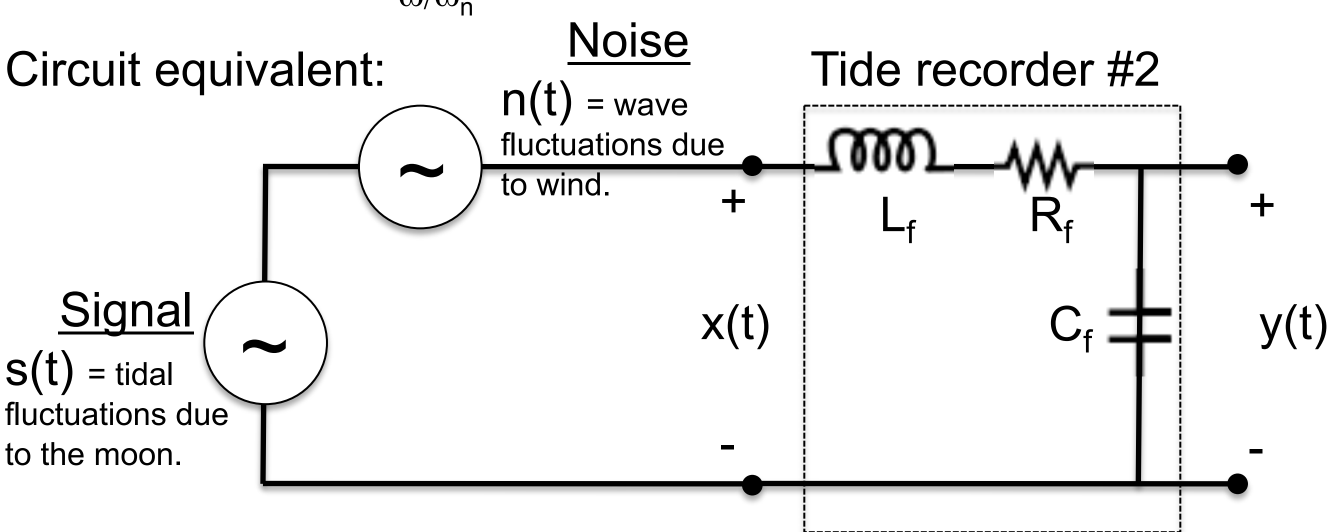
4. Device #2 is a low pass filter (equivalent to an LRC circuit). The frequency response would look something like (depending on the particular choices of A, L, and D):



In choosing A, L, and D, we want to avoid an underdamped system with a natural frequency in the range of ocean surface waves, typically on of the order of 0.1 Hz ($\omega_n = 1/\mathrm{sqrt}(L_f C_f)$ where L_f is the inertance [fluid analog of electrical inductance] and C_f is the fluid capacitance) . The damping ratio, ζ, equals $(R_f/2)\mathrm{sqrt}(C_f/L_f)$, where R_f is the fluid resistance. We want surface wave fluctuations >> ω_n and tidal variations << ω_n.

Circuit equivalent:



5a. Increasing A increases the fluid capacitance, thereby decreasing the natural frequency ω_n.

5b. Increasing L increases the fluid inertance (thereby decreasing the natural frequency ω_n) and increases the fluid resistance (thereby increasing the damping ζ).

5c. Increasing D decreases the fluid inertance (thereby increasing the natural frequency ω_n) and decreases the fluid resistance (thereby decreasing the damping ζ).