

R A Q ' s

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

How Not to Design Active Filters (Or Not Only Sharks Distract Divers)

Q. *Why does my carefully designed active filter not meet its specifications?*

A. Because much active filter software ignores “real life” amplifier behavior. I was recently on holiday diving in the Red Sea. I had left my cell phone and computer at home and forgotten all about work. But, foolishly, I carried my towel and camera to the dive boat in an Analog Devices rucksack. One of my fellow divers, Ekaterin from Russia, had just designed an active filter with ADI op amps, was having some problems, and recognized the logo. So much for a total break!

Her filter design was flawless. Spice analysis confirmed it, and the components were properly toleranced. Luckily, I did not need a computer to see why the filter did not work as expected. The design had been done with an “ideal” op amp where all the parameters are either zero or infinity. Real life is rarely so accommodating.

Voltage feedback op amps typically have high open-loop gain and a single-pole frequency response. High precision types have gain $>10^6$ but their gain-bandwidth product is rarely more than a few MHz, so their open-loop gain starts to drop at a few Hz. By 20 kHz, the top of the audio spectrum, the open-loop gain of a precision op amp may be <50 — low enough to degrade an active filter design. Furthermore, at high signal levels, slew rate also limits an amplifier's frequency response.

High-speed op amps do not have these problems, but many fast op amps oscillate with capacitive feedback. Since many active filter topologies use capacitive feedback it is unwise to design active filters with current feedback op amps.

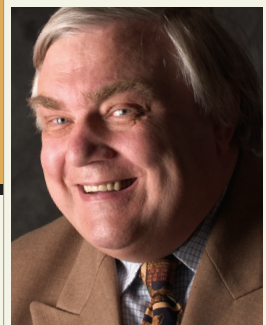


Designers often use high values resistors in order to use small, cheap precision capacitors. Bias currents flowing in high resistances will degrade the amplifier's offset voltage by the voltage drop in the resistance. The op amp's noise current will also make a greater contribution to system noise.

The resistor's (Johnson) noise can also exceed the op amp noise. Not all filter designers consider this, nor do they always remember to provide the proper high frequency supply decoupling, thus impairing the amplifier's high-frequency response.

Ekaterin's problem was due to the use of too slow an amplifier and, luckily, I was able to recommend a faster one. This, as I learned shortly after my return home, allowed her circuit to exceed its required performance comfortably. After solving the active filter problem, we both returned to the water, and the beautiful reef life, with no more distracting thoughts of work.

**To learn more about
active filters,
Go to: <http://rbi.ims.ca/5696-111>**



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