The Inverting Attenuator, G = -0.1… is it unstable?

Tweet

Unity-gain-stable op amps are stable in a gain of one or greater, but not less, right? What to do?

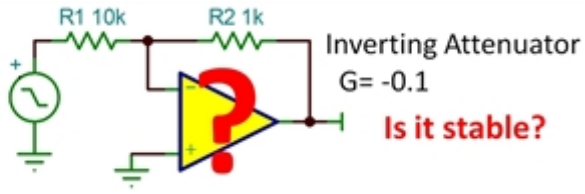

Figure 1.

This question appears on our E2E forums periodically. Okay, here's the short answer… **an inverting attenuator is stable!** You want to know why, right? There are a couple of ways to look at this issue and a quick look may add clarity to general stability issues.

Consider this: If G = -0.1 were unstable, then even lower gain should be worse, right? Let's draw a circuit—a unity-gain amplifier with a 1Ω feedback resistor, figure 2. Then consider possible circuit board leakage forming an input resistor, R1=10GΩ. This is a stray "input signal" amplified at very low inverting gain. Is it unstable? Certainly not. It's just a unity gain buffer with virtually no input. Stable.

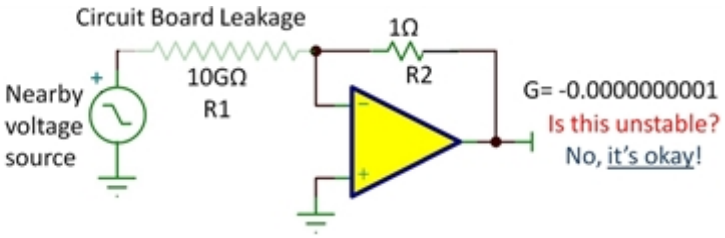

Figure 2.

Think of the stability of an op amp as related to how much output signal is fed back to the inverting input. Stability experts refer to this feedback factor as **β**, (beta). In unity gain, 100% of the output voltage is returned to the inverting input, so β is 1. The example in figure 2 is essentially the same with nearly all output signal fed back to the inverting input.

Figure 3a shows an inverting amplifier and 3b shows a non-inverting amplifier. The circuits are the same; the input signal is just applied to different nodes. Both circuits return the same amount of output signal to the inverting input so their stability behavior is the same. Beta is the same.

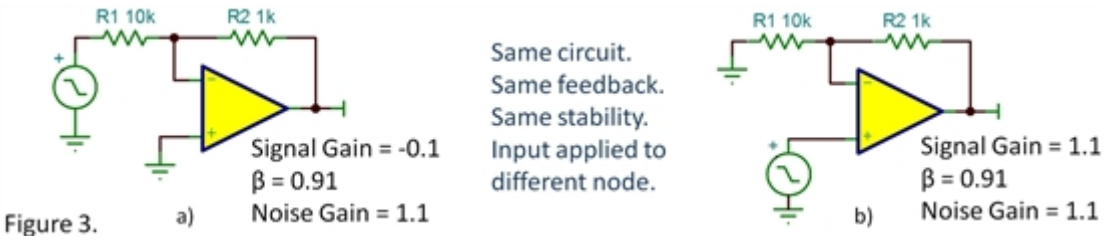

Figure 3.

Op amp wonks also use the term ***noise gain***—so-named because the op amp's voltage noise is amplified to the output by this factor. It's just another way to quantify the amount of feedback. An op amp circuit prone to oscillations or instability is incited by its own internal noise, amplified and fed back to the inverting input. The inverting amplifier, figure 3a, has the same noise gain, β and therefore the same stability behavior as its non-inverting cousin, even though the input signal gain is different.

Are there circuits with noise gains less than one? Is β ever greater than 1? **Noise gains less than unity and β greater than 1 occur when gain is included in the feedback loop**. Multiple amplifiers in a larger feedback loop such as a control system can face this issue. It also occurs when a transistor (common-emitter or common-source configuration) is included inside the feedback loop of an op amp. These circuits can have tricky stability problems.

Of course, there are other possible causes of oscillations or instability in an inverting attenuator. Capacitive load, excessively high resistor values or too much capacitance at the inverting input can cause instability but these are unrelated to the basic inverting attenuator configuration. Misconceptions about the "dangers" of the inverting attenuator persist. Relax. Simulate stability in TINA-TI or your favorite SPICE program to confirm it. And if you have doubts or problems, check with the experts on our E2E forum.

And speaking of experts, I'd like to welcome Tim Green, guru of amplifier stability issues, back to TI. Tim's article series and presentations on amplifier stability analysis are renowned and it's great to have him back on our E2E forums. You'll "see" him there.

Your comments are always welcome.

Bruce email: thesignal@list.ti.com (Email for direct communications.)

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Jonathan9420 So you disagree with this page? earmark.net/.../atten_se.htm

Bruce Trump Jonathan-- Yes, indeed, I disagree with the content in the link you reference. This fiction came from a particular engineer who contributed to portions of "Op Amps for Everyone." This book has some very good and correct content but on this point it is simply wrong. This is not a matter of varying opinion among knowledgeable experts. All real experts agree on this point. A casual op amp user might easily be uncertain on this issue and, seeking advice on the internet, find this bogus material. This was exactly the reason for writing this blog. Thanks for your question and the chance to clarify. -- Bruce

Jonathan9420 Ok, good. I found some errors in Op Amps for Everyone, too. :/