

Noise Gain vs. Signal Gain

Q: What the difference between noise gain and signal gain?



A: In the closing of RAQ 56, [Amplifier, attenuator or both?](#), I indicated that you can force the noise gain (NG) while maintaining the signal gain.

In a brief recap from op amp theory, two types of gain are associated with op amps: signal gain and noise gain. The signal gain is dependent on the amplifier configuration. With noninverting op amp configurations, the gain equation is $G = (R_F/R_G) + 1$; with inverting configurations, the gain is $G = -R_F/R_G$. The noise gain for both of these configurations is the same, and follows the same equation as the noninverting gain: $NG = (R_F/R_G) + 1$.

The amplifier's stability in a circuit is determined by the noise gain, not the signal gain. Most modern op amps are stable at unity gain, but some special-purpose amplifiers are not. Decompensated op amps can offer unique advantages, such as lower noise voltage and wider bandwidth, as compared to standard unity-gain stable op amps. So, in what situations would you need to manipulate the noise gain?

Forcing the noise gain can help in a variety of applications. For example, to take advantage of one or more of its features, you may want to use a decompensated amplifier below its minimum stable gain. Normally it wouldn't work, but if you manipulate the noise gain, you can "trick" the amplifier into thinking it is operating at a higher gain. Another great advantage of forcing a high noise gain is that it improves the amplifier's ability to stably drive capacitive loads.

Forcing the noise gain typically requires the addition of a resistor and sometimes a capacitor, depending on the situation. This could be as simple as adding a resistor between the inverting and noninverting inputs, a series RC circuit from the inverting input to ground, or components in parallel with the input or the gain resistors. It's difficult to describe in detail here, but the following references show you how easy it really is.

The benefits of forcing the noise gain may sound too good to be true but, as is usually the case, there can be some tradeoffs. Two tradeoffs that come with this approach are increased output noise and offset voltage. Still, the ability to "force" a higher noise gain may come in handy someday, making it a powerful technique to include in your arsenal of op amp tricks.

References

Charly El-Khoury, [Compensating Amplifiers That Are Stable at Gain \$\geq 10\$ to Operate at Lower Gains](#), Analog Dialogue, Volume 46, Number 4, 2012.

James Bryant, [Op Amp Issues](#), Analog Dialogue, Volume 24, Number 3, 1990.

Grayson King, [Op Amps Driving Capacitive Loads](#), Analog Dialogue, Volume 31, Number 2, 1997.

MT-049, [Op Amp Total Output Noise Calculations for Single-Pole System](#), 2009.

Walter Jung, [Op Amp Applications](#), Analog Devices, 2002, ISBN 0-916550-26-5, Also available as [Op Amp Applications Handbook](#), Elsevier/Newnes, 2005, ISBN 0-7506-7844-5.