

Current Feedback Op Amp Noise Considerations

In most applications of high speed op amps, it is the total output rms noise that is generally of interest. Because of the high bandwidths involved, the chief contributor to the output rms noise is therefore the white noise, and the $1/f$ noise is negligible.

Typical high speed op amps have bandwidths greater than 150 MHz or so, and bipolar voltage feedback (VFB) input stages have input voltage noises ranging from about 1 to 20 nV/ $\sqrt{\text{Hz}}$.

For a VFB op amp, the inverting and non-inverting input current noise are typically equal, and almost always uncorrelated. Typical values for wideband VFB op amps range from 0.5 to 5 pA/ $\sqrt{\text{Hz}}$. The input current noise of a bipolar input stage is increased when input bias-current compensation generators are added, because their current noise is not correlated, and therefore adds (in a root-sum-square manner) to the intrinsic current noise of the bipolar stage. However, bias current compensation is rarely used in high speed op amps.

The input voltage noise in current feedback (CFB) op amps tends to be lower than for VFB op amps having the same approximate bandwidth. This is because the input stage in a CFB op amp is usually operated at a higher current, thereby reducing the emitter resistance and hence the voltage noise. Typical values for CFB op amps range from about 1 to 5 nV/ $\sqrt{\text{Hz}}$.

The input current noise of CFB op amps tends to be larger than for VFB op amps because of the generally higher bias current levels. The inverting and non-inverting current noise of a CFB op amp is usually different because of the unique input architecture, and are specified separately. In most cases, the inverting input current noise is the larger of the two. Typical input current noise for CFB op amps ranges from 5 to 40 pA/ $\sqrt{\text{Hz}}$. This can often be dominant, except in cases of very high gain, when R_1 is small.

The noise sources which dominate the output noise are highly dependent on the closed-loop gain of the op amp and the values of the feedback and feedforward resistors. For high values of closed-loop gain, the op amp voltage noise will tend to be the chief contributor to the output noise. At low gains, the effects of the input current noise must also be considered, and may dominate, especially in the case of a CFB op amp.

Feedforward and feedback resistors in high speed op amp circuits may range from less than 100 Ω to more than 1 k Ω , so it is difficult to generalize about their contribution to the total output noise without knowing the specific values and the closed-loop gain.

The best way to make the noise calculations is to write a simple spreadsheet program that performs the calculations automatically, and include all the noise sources. The equations shown in Figure 1 below can be used. Note that these are the same as for a VFB op amp. Also, in most high speed op amp applications, the source impedance noise can often be neglected for source impedances of 100 Ω or less.

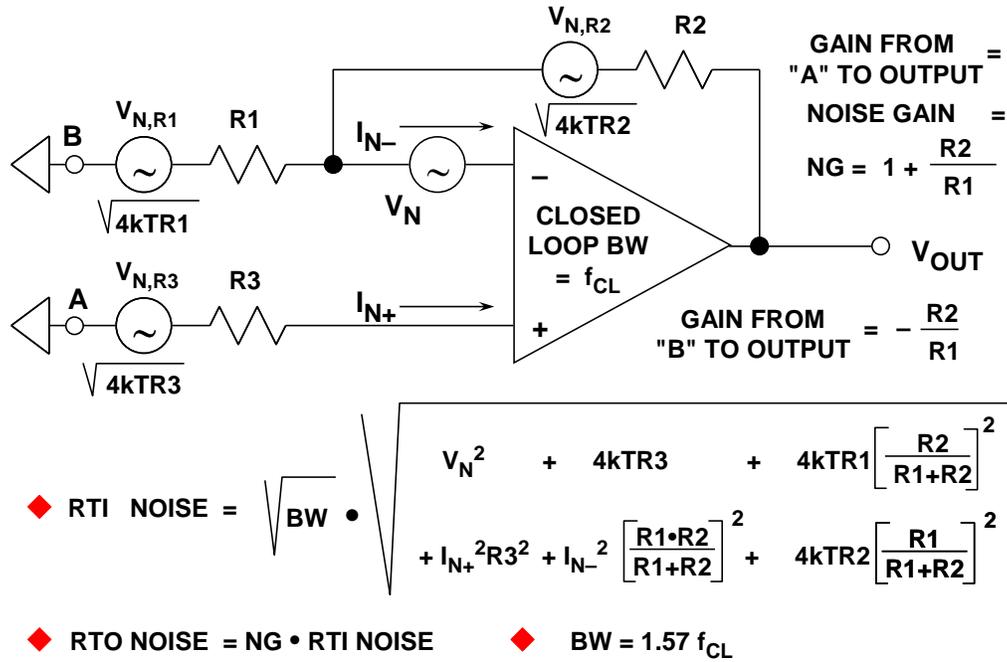


Figure 1: The Same Noise Model is Used for CFB and VFB Op Amps if there is Minimal Peaking

The above analysis neglects the effects of peaking in the closed-loop frequency response. However, more than 1 dB or so peaking in a CFB op amp can cause instability and ringing. For this reason, the above model is generally accurate enough provided peaking is minimized.

REFERENCES

1. Hank Zumbahlen, *Basic Linear Design*, Analog Devices, 2006, ISBN: 0-915550-28-1. Also available as [Linear Circuit Design Handbook](#), Elsevier-Newnes, 2008, ISBN-10: 0750687037, ISBN-13: 978-0750687034. Chapter 1.
2. Walter G. 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. Chapter 1.

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