



## Other Parts Discussed in Post: [INA116](#)

The instrumentation amplifier (IA) is an integrated combination of op amps and feedback resistors used to accurately acquire and amplify signals.

Don't know about instrumentation amps? [Get a very quick start here.](#)

A common mistake in using these versatile amplifiers is to fail to provide a path for input bias current. For 25 years we've been showing a diagram to highlight the necessary input biasing required for proper operation but designers seem to miss it. Perhaps it's the name—*instrumentation amplifier*. It sounds as if it is laboratory equipment like an oscilloscope or spectrum analyzer, complete with ready-to-use inputs. Well, that's almost true but it requires a bit more care.

Each input connects directly to the base of a bipolar transistor (figure 1a) or gate of a FET (figure 1b). The bipolar transistor requires base current to operate. The floating thermocouple voltage source does not provide a path for that current. Without this current path the input will saturate creating an invalid output voltage.

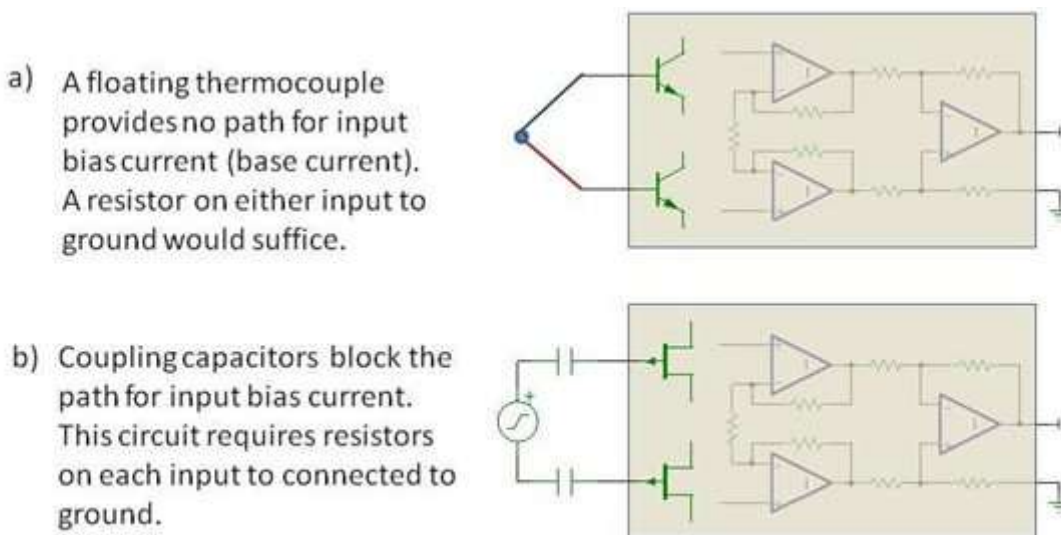


Figure 1.

Even a FET input IAs with extremely low input bias current (e.g. INA116) requires a bias current path. While the AC-coupled circuit as shown in figure 1b might appear to function properly when first powered on, the input capacitors will slowly charge from tiny input bias current and the output would appear unstable or drift away from its starting value. A resistor to ground on each input would properly bias this circuit and with the very low input bias current of a FET input, 10M $\Omega$  resistors would work well.

- Note that many circuits will not require special precautions. If the differential input voltage source can supply the input bias current and it is referenced to ground through a conduction path, no special precautions are required. See figure 2.

No additional biasing components are needed if differential and common mode sources can supply the input bias current.

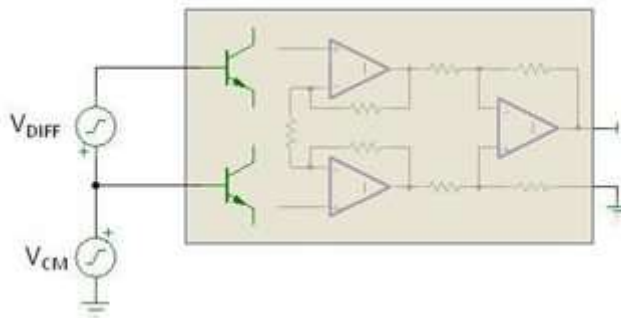
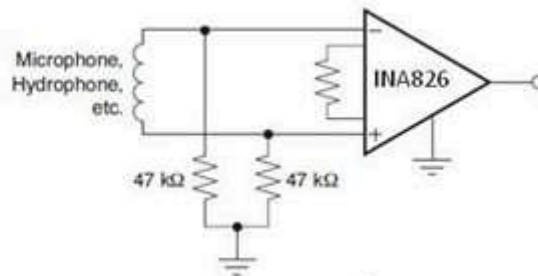


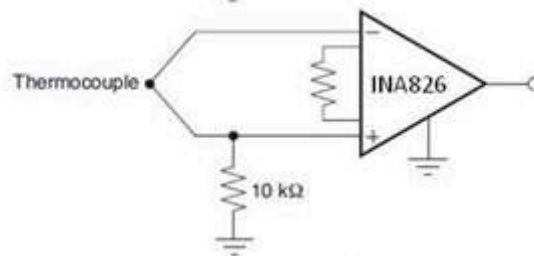
Figure 2.

Figure 3 shows three examples of how you might properly bias the inputs of an IA. The resistor values shown might vary according to the specifics of the application and the IA selected.

Very low resistance sources might be okay with one resistor. For long cable connections, keep it well balanced with two resistors.



Very low resistance sources can use a single, unbalanced biasing resistor.



Not all transformers have a center-tap. A resistor on one side to ground would be okay.

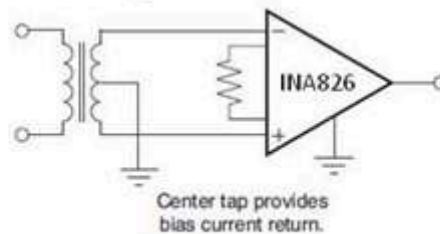


Figure 3.

There are many possible variations in how to provide this current path. Only three general cases are shown. With a little creativity you will find a way that suits your application. If you need advice our [Precision Amplifiers forum](#) is the place to go for assistance.

Again, I think the name, instrumentation amplifier, may account for the frequency of this oversight. By the way, it *is* possible to make the same mistake on the input of an op amp. I don't think that needs

- explanation, does it?

Thanks for reading,

Bruce

6 comments 0 members are here



[Abhijit Pethkar](#) *over 12 years ago*

Dear Bruce,

How do you explain for the High Pass Butterworth filter where a capacitor filter is placed at the input of the filter. Only one resistor is connected to the ground for the positive terminal where as the negative terminal has capacitors both at the input and output of the Op Amp.

Regards



[Bruce Trump](#) *over 12 years ago*

Abhijit-- Your question pertains to an op amp circuit and does not relate directly to this blog topic. An instrumentation amplifier does not have feedback from output to the inverting input. The op amp circuit I believe you are describing is a multiple-feedback high-pass filter. In this case the output of the op amp provides a bias current path for the inverting input. If you have further questions on this, I suggest that you submit to the precision amplifier forum and include a schematic.



[Jim Car](#) *over 12 years ago*

. Hi Bruce,

What a good way to bias this instrumentation amplifier circuit for single supply use (W/O a transformer).

Thank you,

Jim



[Bruce Trump](#) *over 12 years ago*

Jim-- It's necessary to get into the details of your application to answer your question. I suggest that you post a question on our precision amplifiers E2E forum. The link is below figure 3 in this blog. Postings on the forum allow sharing of schematics which cannot be done in these comments. Be sure to provide details on your input signal, power supplies, etc. -- Bruce



[Jim Carlini](#) *over 12 years ago*

Hi Bruce,

I tried for some time to leave a picture of my schematic using numerous methods. However I don't believe I was successful. Is there a trick to it?

Jim

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