

StudentZone—September 2017 Understanding Instrumentation Amplifiers— The Secret of the Diamond Plot Tool

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Instrumentation amplifiers are excellent components for various applications, such as pressure or temperature measurements. Their main tasks involve signal amplification and impedance adaptation.

In many cases, in-amps have a reference input pin. Adding a voltage at the reference pin will elevate the output signal by that voltage. This offers a simple and precise way to adjust the output of the instrumentation amplifier to the required input level of the ADC. This creates the possibility for using the complete input span of the ADC with the benefit of higher resolution. An additional advantage is a very good common-mode rejection ratio and high precision in the case of a signal with a high common rail.

Figure 1 shows the internal schematic of an instrumentation amplifier in a typical 3-op amp design. The AD8421, with its universal characteristics, is well-suited for various applications.

If you are using an instrumentation amplifier, you should be aware that the maximal output voltage is dependent on the input signal (common-mode or differential), the gain, the power supply voltage, and from a possible limitation of the internal structure. In a 3-op amp architecture, the first stage amplifier (inverting and noninverting input) amplifies the input signal with the preset gain. The second stage works as a subtraction. The output signal is built by the subtraction of the two input signals. The reference voltage will be added to the signal generating the combined output.

Based on this internal analog signal generation, different factors could now lead to internal saturation and could reduce the maximum working area.

Those factors are:

- The input voltage signal is too high for the preset gain
- The reference voltage is too high for the generated output voltage signal
- The power supply voltage is too low

Because the output voltage and the instrumentation amplifier working area are dependent on the maximum input signal, gain, reference voltage, and the limitation of the selected architecture, both are difficult to calculate. If you put these factors into a diagram, you would get a diamond-shaped graph—the so-called diamond plot. The space of the graph represents the possible working area. The calculation is not easy, as there are multiple inputs and outputs.

The Instrumentation Amplifier Diamond Plot Tool was developed by Analog Devices as an online means for such calculations. The tool automatically calculates the possible configuration for the reference, input signal, supply voltage, and gain for the required output signal. It graphically displays the possible parameter combinations for a particular output signal.

The tool contains the specifications for all Analog Devices instrumentation amplifiers, and is fast and easy to use.



Figure 1. Internal architecture on a typical instrumentation amplifier.



Figure 2. Instrumentation Diamond Plot.



Figure 3. Instrumentation amplifiers simplified schematic.



Figure 4. Recommended instrumentation amplifiers.

Figure 2 through Figure 4 show the tool's graphical user interface and the windows for its **Diamond Plot**, **Internal Circuity**, and **Recommended** tool options.

Within the first window (Figure 2), you can enter all the required parameters, calculate the diamond plot, and visualize it (possible parameters include input signal, gain, supply voltage, and the reference voltage). For the input signal, you can choose from a common-mode signal or a differential signal. In addition, the tool also lets you determine the limitations of the selected amplifier and differentiate between input-output and internal restrictions. It is now possible to estimate the working area. In general, it is recommended not to operate very close to the plot limits.

The second window of the Instrumentation Amplifier Diamond Plot tool offers the internal view of the amplifier and displays a detailed schematic (Figure 3). With this view, it is possible to see the technical details and the respective internal voltages. That's important if you need to check for possible errors in the design. A control mode is also offered to evaluate and rate the selected parameters and provide alternatives (Figure 4).

With the Instrumentation Amplifier Diamond Plot Tool, Analog Devices can help you unlock the secret of the diamond plot. With a simple user interface and 24/7 online availability, the tool enables you to select and evaluate individual instrumentation amplifiers and design more complex schematics.

And here is our quiz:

analog.com/designtools/en/diamond/

Please use a differential input for the AD8422, a gain of 100, a positive supply voltage of 15 V, and a negative supply voltage of -15 V. The reference voltage is 0. The common-mode voltage is 8 V. V_{DIFF} ranges from 100 mV to 148.5 mV. Please assume for your research that we are using the full temperature range and a load of 10 k Ω . Using the diamond plot tool and the data sheet, please explain why this setup will not work.

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