

Rarely Asked Questions

Strange stories from the call logs of Analog Devices



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Have a question involving a perplexing or unusual analog problem? Submit your question to: www.analog.com/askjames

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Measuring the DC Parameters of Op Amps

Q: Modern op amps have very high open-loop gain and very low offsets. How can one possibly measure them? Or is that a closely held secret?

A: Remarkably easily, and absolutely not!

In the very first RAQ column, I praised the restaurant "La Cognette" in Issoudun in central France. I ate there again quite recently and, not long afterwards, at what is arguably the best restaurant in Africa, "Le Quartier Français" at Franschoek in the South African winelands. At both places I had occasion to ask the chef how a dish was prepared, and at both I was willingly given all the details I could wish. The mediocre try to hide in secrecy, while the truly great wish to spread their knowledge.

Analog Devices is a world leader in analog technology. We believe that "If you cannot measure it, it's not science!" and are happy to share details of how we measure the parameters of our products.

Many textbooks include a diagram of an op amp with grounded inputs and a closed loop gain of 1–10 thousand driving a voltmeter that displays its offset amplified by 1–10 thousand. This technique works, provided care is taken to minimize thermoelectric voltages and the effects of bias currents, but it will only measure offset.

A slightly more complex arrangement, using a second op amp, allows the measurement of offset voltage, bias current, open-loop gain, common-mode rejection (CMR), and power supply rejection with minimal changes to the circuit and no low-level signal switching (which can introduce noise and errors). The addition of two more resistors and two more capacitors allows ac measurements as well. Furthermore, the second op amp need not be a high-



performance device in order to make high-accuracy measurements (e.g., to measure very small offsets and very high gains).

The basic principle behind the circuit is that the auxiliary op amp provides feedback to the device under test (DUT), causing its output to be at a potential that forces the differential voltage at the auxiliary op amp's inputs to be (close to) zero.

While it is tempting to challenge readers to work out the fine details of the circuit's operation for all the different measurements, a detailed description is contained in "Simple Op Amp Measurements."

¹In "The Door into Summer" by Robert A. Heinlein (Chapter 9), Dr. Twitchell says, "If you can't measure it, it's not science." This is an inversion of "If it's science, you can measure it." Popularly attributed to Lord Kelvin, this is a poor synopsis of what he actually said, which is nearer to Dr. Twitchell's observation. "In physical science, the first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be." [Popular Lectures & Addresses, Vol. 1 "Electrical Units of Measurement" 1883-05-03]

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