Re: How to measure really small voltages

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Jim Yanik wrote:
> alan <no−longer−valid@yahoo.com> wrote in
> news:cep0dmqgs1@news.Stanford.EDU:
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>
>>A fellow lab−mate wants to measure a DC signal in the uV or nV range,
>>while the sample is at low temperatures. That means that there are
>>going to be a few hundred pF of capacitance due to wiring, plus
>>thermo−electric offsets due to the temperature difference. He was
>>thinking of using some kind of low temperature transistors to do some
>>kind of switching at the low temperature end, and then use a lock−in to
>>measure the amplitude of the square wave. For now, assume that the
>>sample source resistance is fairly high. Is there a better way to
>>measure this small voltage?
>
>
> Keithley makes femtovoltmeters,are knowledgeable about measuring accurately
> extremely small voltages,currents,or charges.They may have publications or
> app notes about such measurements and what errors may arise.
>

One thing nobody has mentioned is the cross−correlation method. The voltage can be made AC by a variety of methods, but the additive Johnson noise is still a problem for a precise measurement.

In the cross−correlation measurement, you take two voltmeters (made e.g. from quiet high gain amps running into an A/D card), connected to the same voltage source, and form the measurement as the cross−correlation of their outputs.

Assuming that the power supplies are well isolated, the effects of the voltage noise of the two will be uncorrelated, and hence will not appear in the cross−correlation. Their current noise will add in power and show up in both outputs, but by using MOSFET buffers, this contribution can be reduced very far below sqrt(4kTB/R). There is of course a tradeoff between bandwidth, the noise (uncertainty) in the estimate, and the number of voltmeters used, but luckily the number of pairs of independent signals goes as Nsig= (Nmeters)*(Nmeters−1)/2, so you win faster than you'd expect−−with 10 MOSFETS you get 45 pairs, so your noise voltage goes down by a factor of almost 7.

This trick makes it easy to measure ac voltages far below the noise limit of the amplifiers.

The other thing is, if the measurement is being done at 100 mK, why not use a SQUID and nail the problem to the floor instead of messing around?

Cheers,

Phil Hobbs