Re: Low drift OP amp for photodiode circuit

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- *Date*: Fri, 21 Sep 2007 10:15:09 −0400

Winfield wrote:

> garnet wrote:
>
>> I'm not up to date with the latest op amp technology and was wondering what are the lowest drift op amps available now without using an oven. This is for a photodiode circuit for low level light measurement.
>
> Opamps with very low input currents have been available for a very long time; you don't really need the latest part for that task, unless you want to operate at low supply voltages, with very low supply currents, etc.
>
> One class of opamps well worth mentioning are NSC's inexpensive CMOS opamps, e.g., their LMC6001A. This one is 100% tested to insure that each chip has input leakage currents of less than 0.025 pA, or 25fA, as we like to say. These have a reasonably−low input offset voltage of 350uV max.
>
> Note, the LMC6001A was introduced at least 12 years ago (I have a 1995 datasheet in my computer's collection).
>
> Normally if you want to measure very low light levels (very small photodiode currents) you'll just use a high−value feedback resistor to develop a signal voltage above the opamp's offset voltage. For example, with a modest 100G resistor you can measure down to say 5fA and develop a 0.5mV output signal. Using the LMC6001A, which has up to 0.25mV of offset voltage and up to 2.5mV developed from input leakage current across 100G, you could improve your measurement range by noting the dark value and observing the difference when you turned on your weak light.
>
> Note, 5fA of photodiode current would mean you're observing only 10fW of light, using a 0.5A/W silicon detector rating.
>
> If you can chop your light, you can go even lower with a

> lock−in amplifier.
>
> If you're not inclined to use a high−value transresistance
> feedback resistor like 50 to 200G, but instead want to use
> say no more than 1000M, you could use a CMOS chopper−input
> opamp with 5uV or less of input offset voltage. There have
> been some interesting new parts in that area.

Since ultralow light level measurements are so slow anyway, one nice method is to use a capacitor instead of the feedback resistor, and integrate the charge coming from the PD. You can reset the cap with a MOSFET wired in parallel with it (there are other methods too−−my favourite uses LEDs).

There are lots of nice things about this method. One is that it's much much quieter at very high gains−−unlike 500G ohm resistors, capacitors don't have thermal noise. Thus the slope of the V vs T curve can be measured much more accurately than the instantaneous voltage across the feedback resistor. (*)

Another one is that you can do range switching by just changing the frequency of the reset pulses. A third is that you can add a Schmitt trigger and make an oscillator−−a current−to−frequency converter−−that will make the measurement much easier, and if you have a universal counter, there's no problem getting lots of digits on a frequency measurement.

Of course the best thing to do is to use brighter light. ;)

Cheers,

Phil Hobbs

(*) The reset process does have thermal noise, but as long as you measure the voltage just after reset and subtract that from the measurement, there's no thermal noise in the photocurrent measurement.
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