Transimpedance synchronous amplification nulls out background illumination

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Light sensors find use in a host of important applications, spanning from consumer electronics, such as ambient-light measurements and exposure control for cameras, to scientific instruments, such as optical-absorption spectroscopy, IR (infrared) detection for thermography, and two-color pyrometry. For example, in optical spectroscopy, a correct intensity measurement of the probe beam is fundamental during material and device characterization. You must eliminate any influence that dc or very-low-frequency background light induces. Also, to increase the SNR (signal-to-noise ratio), you can apply narrowband, phase-sensitive, or lock-in detection techniques to mechanically chopped or otherwise modulated probe-light sources.

In this Design Idea, the reference signal from the light chopper as a square wave of frequency, f_{CHOP}, modulates the gain of an op-amp-based inverting amplifier (**Figure 1**). The amplifier input is a voltage proportional to the photocurrent signal produced by a photodiode, which is irradiated by a modulated light beam at the same chopper frequency. In this case, because the gain and input are at the same frequency content, a dc component, which a low-pass filter can easily detect, is present at the amplifier's output.

Op amps A_{1A} and A_{1B} convert the photogenerated current into a voltage including only the ac components. You can change the value of R_1 depending on the light level you want to detect. Neglecting A_{1A}'s input capacitance, the value of C_1 strongly depends on the terminal capacitance of the input photodiode, and you must select the value to ensure the stability of the transimpedance circuit (**Reference 1**).

The heart of the system, op amp A_{1C}, includes photoresistor R_{PR}, which represents the feedback element that determines the gain of the stage. The value of R_{PR} depends on the light that D_1 emits. A_{2B}, a voltage-to-current converter, drives D_1. The converter has a fixed voltage, V_B, and a ΔV signal through A_{2A} and A_3. A_{2A} determines the dc value of R_{PR}, whereas A_{2B} and ΔR_{PR} change at the same frequency as the reference signal. The A_3 Schmitt trigger converts any TTL/CMOS level of the reference signal into a balanced ±4.6V square wave attenuated to ±0.5V to generate an LED current change of approximately 1.8 mA p-p. For the photoresistor, R_{PR}, and LED elements, a Silonex (www1.silonex.com) CdS (cadmium-sulfide) NSL-19M51 cell couples to a red LED and resides in a black box to ensure the absence of background light on the optocoupler.

To calibrate the circuit, first disconnect or obscure the input photodiode so that A_{1A} converts no ac signal. Then, switch S_1 to the "measure" position and adjust R_{T2} to null any voltage offset referred to the output voltage. When the A_{1B} buffer generates the known approximately 300-mV test voltage and S_1 is in the calibrate position, adjust R_{T1} to fix the output voltage at 0V. In such a case, V_B voltage can set the $R_{PR}/R_C=R_A/R_B$ condition.EDN

REFERENCE

1 Wang, Tony, and Barry Erhman, "Compensate Transimpedance Amplifiers Intuitively," Application Report SBOA055A, Texas Instruments, 1993, focus.ti.com/lit/an/sboa055a/sboa055a.pdf.

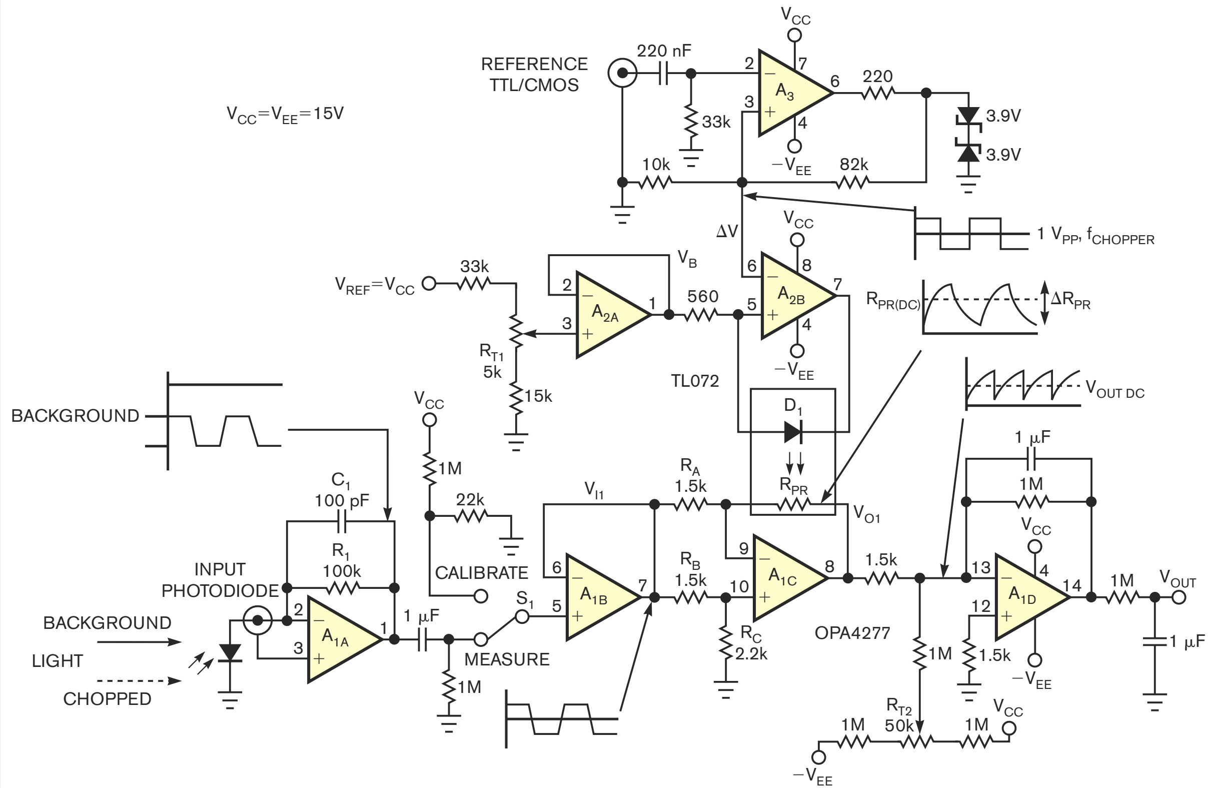

Figure 1 The reference signal from a light chopper acts as a square wave of frequency and modulates the gain of an omp-amp-based inverting amplifier.