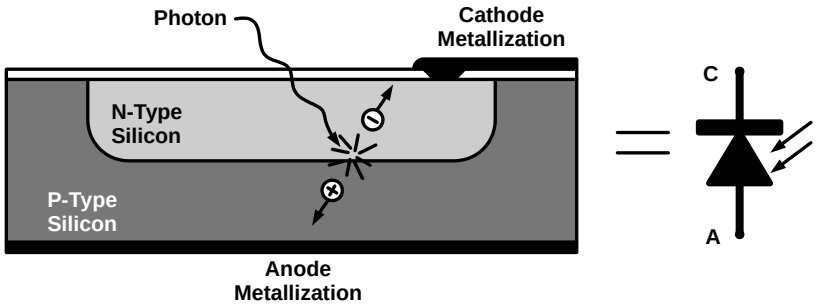
Photodiode Preamplifier

February 2001 **Circuit Solution**

Photodiodes are used in a variety of applications where one needs to detect light or measure its intensity, ranging from the light meters in cameras to fiber-optic communications systems. While there are many ways to implement a photodiode, a P-N junction such as the one shown in Figure 1, is one of the simplest structures.

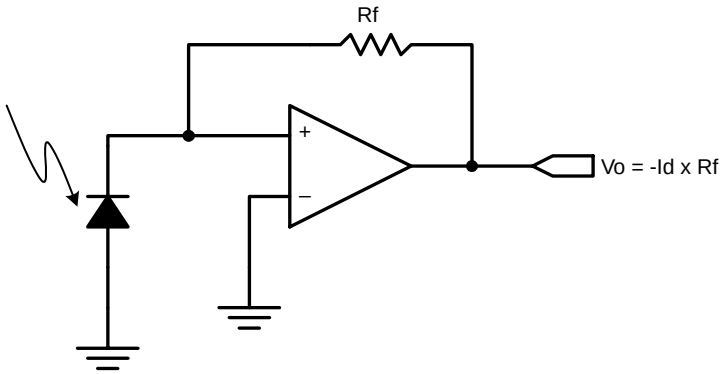
Figure 1. Structure of PN Photodiode



When an incoming photon of the appropriate wavelength is absorbed by the silicon near the junction, it can create several electron-hole pairs. The electrons migrate towards the 'N' type silicon layer, while the holes migrate toward the 'P' type layer. This results in a small electrical current which is proportional to both the wavelength and the number of photons absorbed.

Electrically, a photodiode looks much like a current source in parallel with a very high value resistor and a capacitor. The most common precision interface for a photodiode is transimpedance amplifier constructed from an opamp and a feedback resistor, as shown in Figure 2. This circuit provides a constant bias voltage (in this case '0') across the photodiode, and converts the photo-current resulting from incoming light into an output voltage. Because the input of the transimpedance amplifier looks like a short-circuit to the photodiode, it provides highly linear current-to-voltage conversion over several decades of light intensity. Because this interface uses negative feedback to present a low-impedance interface to the photodiode, a high gain and frequency response are required of the opamp for good performance.

Figure 2. Classical Transimpedance Photodiode Preamplifier

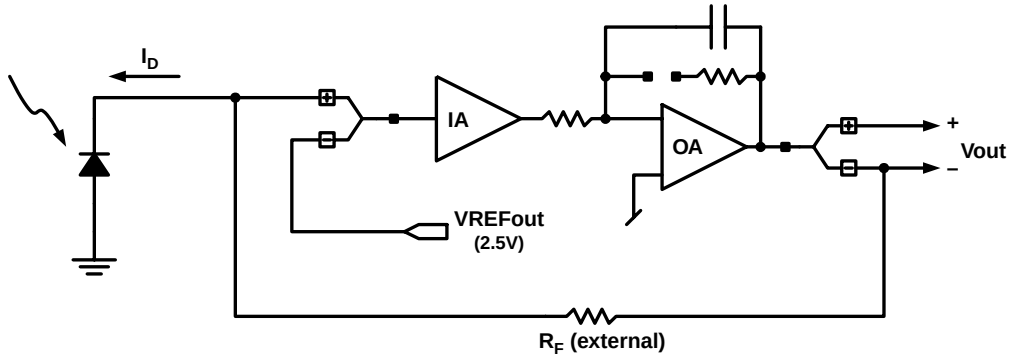


While this circuit is a good measurement solution if one has access to split power supplies, it becomes more difficult to use with a single supply. This is because a 'zero' output signal is represented by zero volts, or 'ground.' While

'rail-to-rail' output opamps can be used, their outputs will not swing exactly to ground. From an applications standpoint, not being able to accurately represent very small signals effectively reduces the dynamic range of the sensor.

The circuit of Figure 3, using an ispPAC® PACblock (available in both the ispPAC10 and ispPAC20) allows one to build a photodiode preamplifier that operates from a single +5V power supply. One external resistor is used to provide voltage-to-current conversion in the feedback loop. In this circuit, the summing junction will be biased up to 2.5 V (VREFout), reverse-biasing the photodiode. While this increases the dark current somewhat, it also provides increased frequency response for most types of photodiodes. The differential amplifier will produce a balanced output signal with a common-mode value of 2.5V, avoiding the errors associated with developing near-ground signals in single-supply systems. Another advantage of a differential output is that in the case of very small DC signals, ground-level shifts occurring between different points in a circuit will not cause any additional offset errors. If a single-ended signal is needed, it can still be obtained by just looking at either the VOUT+ or VOUT- signals. In this case, 2.5V will represent a 'zero' signal (total darkness). Note that since feedback is provided by an external resistor R_F, the PACblock's feedback link should be opened.

Figure 3. Photodiode Preamplifier Using ispPAC10 PACblock



Because only one leg of the differential output pair is fed back to the summing junction through the feedback resistor, the gain of this circuit will be twice that of the classical transimpedance amplifier, or VOUT/ID = -2RF.

Technical Support Assistance

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