

DESIGNING PHOTODIODE AMPLIFIER CIRCUITS WITH OPA128

The OPA128 ultra-low bias current operational amplifier achieves its 750A maximum bias current without compromise. Using standard design techniques, serious performance trade-offs were required which sacrificed overall amplifier performance in order to reach femtoamp ($I_A = 10^{-15}$ A) bias currents.

UNIQUE DESIGN MINIMIZES PERFORMANCE TRADE-OFFS

Small-geometry FETs have low bias current, of course, but FET size reduction reduces transconductance and increases noise dramatically, placing a serious restriction on performance when low bias current is achieved simply by making input FETs extremely small. Unfortunately, larger geometries suffer from high gate-to-substrate isolation diode leakage (which is the major contribution to BIFET® amplifier input bias current).

Replacing the reverse-biased gate-to-substrate isolation diode structure of BIFETs with dielectric isolation removes this large leakage current component which, together with a noise-free cascode circuit, special FET geometry, and advanced wafer processing, allows far higher *Difet*® performance compared to BIFETs.

HOW TO IMPROVE PHOTODIODE AMPLIFIER PERFORMANCE

An important electro-optical application of FET op amps is for photodiode amplifiers. The unequalled performance of the OPA128 is well-suited for very high sensitivity detector designs. A few design tips for photodiode amplifiers may be helpful:

- *Photodiode capacitance should be as low as possible.* See Figure 1: C_j affects not only bandwidth but noise as well. This is because C_j and the op amp's feedback resistor form a noise-gain zero (feedback pole).
- *Photodiode active area should be as small as possible so that C_j is small and R_j is high.* This will allow a higher signal-to-noise ratio. If a large area is needed, consider using optical "gain" (lens, mirror, etc.) rather than a large area diode. Optical "gain" is essentially noise-free.
- *Use as large a feedback resistor as possible (consistent with bandwidth requirements) to minimize noise.* This seems paradoxical, but remember, resistor thermal noise increases as:

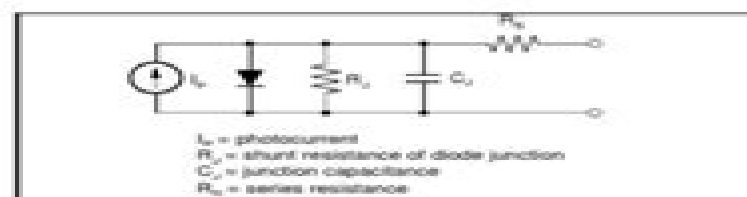


FIGURE 1. Photodiode Equivalent Circuit.

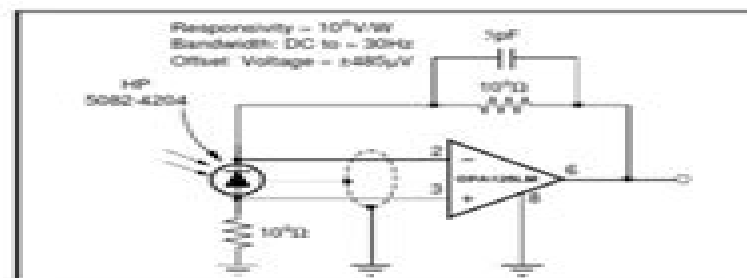


FIGURE 2. High-Sensitivity Photodiode Amplifier.

$$e_{\text{noise}} = \sqrt{4kTBR}$$

k : Boltzman's constant = 1.38×10^{-23} J/K
 T : temperature ($^{\circ}$ K)
 B : noise bandwidth (Hz)
 R : feedback resistor (Ω)
 e_{noise} : noise voltage (Vrms)

while transimpedance gain (signal) increases as:

$$e_{\text{noise}} = i(\text{signal}) R$$

Signal-to-noise improves by $\sqrt{R}$.

- *A low bias current op amp is needed to achieve highest sensitivity.* Bias current causes voltage offset errors with large-feedback resistors. Wide bandwidth circuits with smaller feedback resistors are less subject to bias current errors, but even in these circuits, bias current must be

Designing Photodiode Amplifier Circuits With Opa128

J Elliott

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Analog Electronics with Op-amps A. J. Peyton, Vincent Walsh, 1993-08-12 A reference volume of analog electronic circuits based on the op amp containing practical detail and technical advice

Design of Pulse Oximeters John G. Webster, 1997-10-23 Design of Pulse Oximeters describes the hardware and software needed to make a pulse oximeter and includes the equations methods and software required for them to function effectively The book begins with a brief description of how oxygen is delivered to the tissue historical methods for measuring oxygenation and the invention of the pulse oximeter in the early 1980s Subsequent chapters explain oxygen saturation display and how to use an LED provide a survey of light sensors and review probes and cables The book closes with an assessment of techniques that may be used to analyze pulse oximeter performance and a brief overview of pulse oximetry applications The book contains useful worked examples several worked equations flow charts and examples of algorithms used to calculate oxygen saturation It also includes a glossary of terms instructional objectives by chapter and references to further reading

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Analog Electronics for Measuring Systems Davide Bucci, 2017-05-08 Many instrumentation engineers and scientists often deal with analog electronic issues when approaching delicate measurements Even if off the shelf measuring solutions exist comprehension of the analog behavior of the measuring system is often a necessity This book provides a concise introduction to the main elements of a low frequency analog acquisition chain It aims to be sufficiently general to provide an introduction yet specific enough to guide the reader through some classical problems that may be encountered in the subject Topics include sensors conditioning circuits differential and instrumentation amplifiers active filters mainly for anti aliasing purposes and analog to digital converters A chapter is devoted to an introduction to noise and electronic compatibility This work is intended for people with a general background in electronics and signal processing who are looking for an introduction to classical electronic

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Photodiode Amplifiers: OP AMP Solutions Jerald G. Graeme, 1996 Light photons impinging upon a semiconductor material in the vicinity of a P N junction release conduction carriers to produce current flow through the photodiode effect Photodiode amplifiers convert this current to a voltage in a relationship that remains linear as long as the amplifier eliminates signal voltage swing from the photodiode For this purpose the simple current to voltage converter or transimpedance amplifier presents a virtual ground to the diode However when connected to a photodiode this simple op amp circuit displays surprising multidimensional constraints that defy conventional op amp intuition **Synthesis of Amplifier Circuits Using**

More Than One Tunnel Design Diode Richard R. Wong, 1961 *Design of OP-AMP Circuits with Experiments* Howard M. Berlin, 1988 *Designing Circuits with IC Operational Amplifiers* Robert G. Seippel, Roger Lincoln Nelson, 1975 A
Low-noise Photodiode-amplifier Circuit Kalevi Hyypä, 1993 *How to Design Op Amp Circuits, with Projects & Experiments* Delton T. Horn, 1984-01-01

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