

## 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:

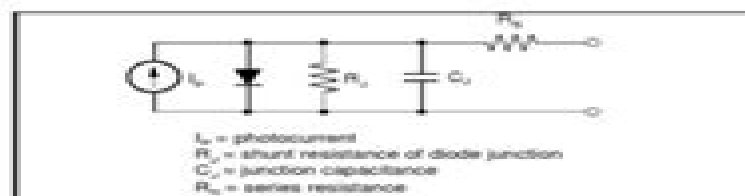


FIGURE 1. Photodiode Equivalent Circuit.

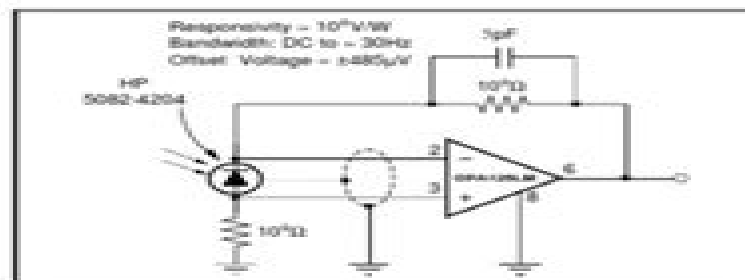


FIGURE 2. High-Sensitivity Photodiode Amplifier.

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

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

**Delton T. Horn**



## **Designing Photodiode Amplifier Circuits With Opa128:**

**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

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solutions employed in measuring instruments involving low frequency analog signal processing      Advances in Electrical and Computer Technologies Thangaprakash Sengodan,M. Murugappan,Sanjay Misra,2022-06-25 This book comprises select proceedings of the International Conference on Advances in Electrical and Computer Technologies 2021 ICAECT 2021 The papers presented in this book are peer reviewed and cover the latest research in electrical electronics communication and computer engineering Topics covered include smart grids soft computing techniques in power systems smart energy management systems power electronics feedback control systems biomedical engineering geographic information systems grid computing data mining image and signal processing video processing computer vision pattern recognition cloud computing pervasive computing intelligent systems artificial intelligence neural network and fuzzy logic broadband communication mobile and optical communication network security VLSI embedded systems optical networks and wireless communication The book is useful for students and researchers working in the different overlapping areas of electrical electronics and communication engineering      UV-Visible Reflection Spectroscopy of Liquids Jukka A. Rätty,Kai-Erik Peiponen,Toshimitsu Asakura,2013-03-20 An up to date overview of reflectometers used for optical spectroscopy of various kinds of liquids ranging from well known transparent liquids to pathological industrial liquids The book reviews and explains basic materials for anyone wanting to get to know the theory spectral analysis and modern devices needed for the measurement of refractive index and absorption of liquids Moreover the book gives an introduction to reflectivity from optically nonlinear liquids such as liquids containing nanoparticles      **Handbook of Research on Biomedical Engineering Education and Advanced Bioengineering Learning: Interdisciplinary Concepts** Abu-Faraj, Ziad O.,2012-02-29 Description based on v 2 copyrighted in 2012      **Machine Design** ,1987      **EDN** ,1987      **SiGe-based Re-engineering of Electronic Warfare Subsystems** Wynand Lambrechts,Saurabh Sinha,2016-10-19 This book provides readers a thorough understanding of the applicability of new generation silicon germanium SiGe electronic subsystems for electronic warfare and defensive countermeasures in military contexts It explains in detail the theoretical and technical background and addresses all aspects of the integration of SiGe as an enabling technology for maritime land and airborne spaceborne electronic warfare including research design development and implementation The coverage is supported by mathematical derivations informative illustrations practical examples and case studies While SiGe technology provides speed performance and price advantages in many markets to date only limited information has been available on its use in electronic warfare systems especially in developing nations Addressing that need this book offers essential engineering guidelines that especially focus on the speed and reliability of current generation SiGe circuits and highlight emerging innovations that help to ensure the sustainable long term integration of SiGe into electronic warfare systems      *Electronic Design* ,1988      Photons Plus Ultrasound ,2004      *Electronics World* ,2000      Annual Research Journal ,2005 The Dept of Electrical Engineering at the University Park Campus of Penn State University is the host of a National Science Foundation

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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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