Technical Article

Lighting up Automotive Displays with a Transimpedance Configuration

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As the sun sets on commuters driving home for the day, the displays and systems in each car gradually brighten. The manual adjustments required to brighten or dim the display in older vehicles have been replaced by intuitive lighting that adjusts without any action from the driver.

Operational amplifiers (op amps) are a simple way to provide backlighting control throughout the car to give drivers a comfortable viewing experience and save power. Using an op amp instead of a more complex light sensor also enables greater flexibility and customization.

Designing the Op Amp in a Transimpedance Configuration

Automotive display systems – the head unit, remote display, cluster or head-up display (HUD) – use the ambient light level (as detected by a circuit) to adjust the backlight brightness according to light intensity or time of day, usually through an analog-to-digital converter (ADC) or a microcontroller (MCU). A transimpedance amplifier circuit, or more specifically a photodiode amplifier circuit, can sense and respond to these changes in ambient light.

The goal of the photodiode amplifier circuit is to transform low-level current from a photodiode into a useful voltage. To do this, the op amp is designed in a transimpedance configuration, as depicted in Figure 1. The photodiode can detect many different light sources, including visible light, infrared and ultraviolet. The photodiode will produce a larger current when exposed to more light energy, increasing the circuit's output voltage.

Transimpedance in Automotive

For an automotive function, you must apply a small bias voltage to the op amp's non-inverting input so that the output does not saturate at the negative supply rail when there is no input current. Often, a resistor divider from the positive voltage supply will bias the non-inverting input above ground. This reverse bias will cause a reduced photodiode junction capacitance from the zero reverse-biased case, but the circuit will respond more quickly. Reverse bias also improves high-frequency performance. A feedback capacitor is always necessary to maintain the stability of the circuit; you can find methods for proper circuit design in the photodiode amplifier circuit application note.

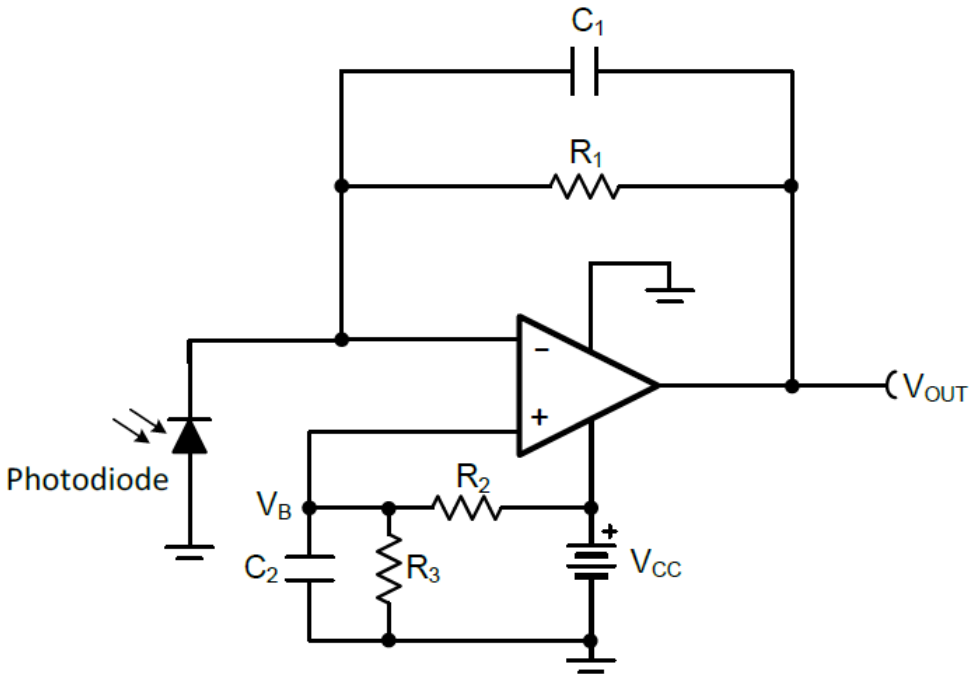

Figure 1. Transimpedance amplifier configuration with a reverse-offset bias at the noninverting input

The photodiode amplifier enables you to customize the circuit based on your needs. By strategically choosing any automotive-rated op amp or modifying the components in the circuit, you can control the gain, ensure the correct input bias current or add compensation to fix any unique stability issues. Additionally, there are many automotive-rated op amps available for each specific application. For example, TI's OPA348-Q1 is specifically designed for very low-level photodiode current at 45µA and can operate over an extended bandwidth of 1MHz.

Alternatively, TI's LM2904-Q1 consists of two independent frequency-compensated op amps with a gain-bandwidth product of 0.7MHz. Using op amps provides an economic solution to automatic adjustment: these op amps cost less than $.25 1,000-unit quantities, while an integrated circuit that performs the same function can cost $1.14 in 1,000-unit quantities with very little increase in performance.

Photodiode amplifier circuits are a simple and flexible way to automatically measure the backlighting for many automotive systems. TI's library of op amps and resources to aid in proper circuit design enable you to tailor the perfect solution for your backlight control. A transimpedance configuration in an automotive display system will lead to automatic backlight control that is simple, inexpensive and effective.

Additional Resources

- Calculate the component values using a cookbook for a photodiode amplifier circuit.
- Review the app note, "Using transimpedance amplifiers for ambient light sensing in automotive displays"
- Read Bonnie Baker's Analog Applications Journal article, "Automating circuit designs for photodiode amplifiers."
- Check out the 1MHz, Single-Supply, Photodiode Amplifier Reference Design.
- Explore TI's automotive solutions portal and op amps.

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