How to Properly Configure Unused Operational Amplifiers

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Introduction

Multi-channel operational amplifiers (op amps) are often implemented in circuits that do not require the use of all channels. Undesired behavior in an unused amplifier channel can negatively impact system performance, as well as the performance of the channels in use. To avoid degradation of both the op amp and system performance, the unused op amp channels must be configured properly.

Degradation Conditions

Improperly terminating unused op amp pins has the potential to lead to degraded the op amp or system performance. Leaving either the input or output pins floating will create unexpected voltage shifts, which leads to unpredictable behavior. Connecting a single-supply amplifier in a buffer configuration while grounding the non-inverting input will cause the output stage to saturate, potentially causing increased current consumption above the maximum quiescent current and unwanted dissipation. This configuration can also cause unpredictable signal corruption induced by crosstalk interactions between the used and unused op amps. Another consideration when configuring an unused op amp is the differential input voltage range.

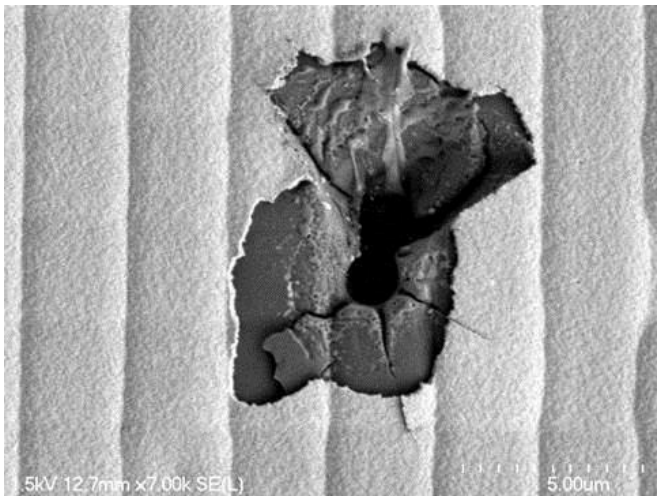

Figure 1. Scanning Electron Microscope Picture of EOS Damaged Device

An op amp typically cannot support a large differential voltage at its inputs as large as what would be seen from one supply rail to the other. Connecting the input pins together or to the supply rails can lead to device damage. If configured like this, the input stage can suffer permanent electrical overstress (EOS) damage, as shown in Figure 1.

Op Amp Specifications to Consider

The desired outcome when configuring an unused op amp in your system is to maintain linear and predictable device behavior. The op amps' specified input and output ranges, found in the product datasheet, serves as a guide to proper implementation. The input of an op amp will have a specified common mode range, and the output stage of an op amp will have a specified voltage range. Both input and output ranges must be met to prevent non-linear output behavior. In addition, negative feedback is highly recommended to achieve amplifier stability.

Implementation: Single Supply Rail

Figure 3 shows the dual-channel OPA2325 op amp powered by a single supply rail. The OPA2325 has a specified common mode voltage range of (V-)-0.1 V to (V+)+0.1 V and an output range of (V-) +0.02 V to (V+)-0.02 V.

Op amp U1A is implemented into a circuit in a basic non-inverting configuration. Op amp U1B is unused in the circuit. It is configured as a voltage follower, where the input is set by a voltage-divider from the supply rail. Selecting two equivalent resistors (R3 = R4) ensures that the input voltage will be within the common mode range by setting it to mid-supply. The output is connected to the inverting input to provide negative feedback, allowing the op amp's output to follow the input and operate in its linear region.

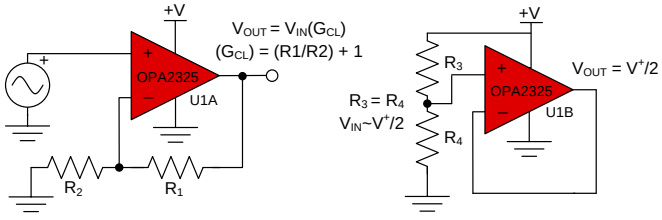

Figure 2. Proper Implementation of Unused OpAmp – Single Supply Rail

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If the implementation of extra resistors is undesirable, the non-inverting input can be connected to any reference voltage that is within the specified common mode and output ranges. This technique favors an op amp with rail-to-rail input and/or output range characteristics. Rail-to-rail devices offer a wider linear operating range, which will accept a wider range of reference voltages. Table 1 shows a couple devices that are rail-to-rail in/out and a couple that are rail-to-rail out.

Table 1. Rail-to-Rail Op Amps

Device	Rail-to-Rail
OPA2325	Input/Output
OPA388	Input/Output
OPA145	Output
OPA189	Output

Implementation: Split Supply Rails

An op amp powered by split supply rails can be implemented as shown in Figure 3 to meet the input and output specifications while maintaining stability. Op amp U2A is implemented into a circuit in a basic non-inverting configuration. Op amp U2B is unused in the circuit. The OPA2189 op amp has a specified common mode range of (V-)-0.1V to (V+)-2.5V and an output range of (V-) +0.3V to (V+) -0.3V.

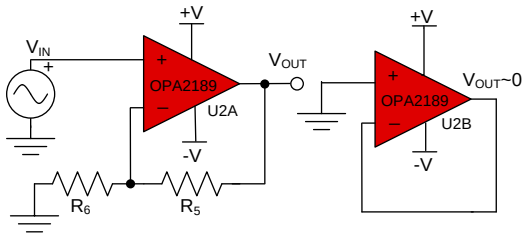

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Figure 3. Proper Implementation of Unused Op Amps - Split Supply Rail

The non-inverting input of the op amp is directly connected to ground. Connecting the non-inverting input to ground sets the voltage to mid-supply. The output is connected to the inverting input to provide negative feedback. This implementation is simple and does not require additional resistors, so it may be the most cost-effective implementation.

Summary

Unused op amps in multi-channel devices must be configured properly to avoid possible device degradation, extra power consumption and noise. These unused channels can cause undesired effects on other channels. Understanding input and output voltage limitations will guide effective configuration of unused op amps.

Table 2. Related Articles and Resources

Media	Title	Author
Article	Properly terminating an unused op amp	Todd Toporski
Video	How to terminate an unused op amp	Todd Toporski
E2E Post	The Unused Op Amp -what to do?	Bruce Trump
TIPL Video	TI Precision Labs-Op Amps: Electrical Overstress	Art Kay and Ian Williams

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