OPA564 Biasing Considerations During Enabled and Disabled States

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ABSTRACT

The OPA564 is a high-voltage, high-current, wide-bandwidth operational amplifier suitable for many applications. Among the many features available on the OPA564 is a disabled mode that is designed to be used for power savings in time multiplexed systems such as powerline communications. When using an op amp that can be placed into either the enabled state or disabled state (shutdown), it is critical to define the biasing conditions in such a manner that any disturbances are minimized when making the transition between the two states. Additionally, it is critical to keep all of the device terminals within safe operating limits under all conditions. Failure to follow the guidelines discussed here could result in poor performance and potential damage to the OPA564.

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1 Introduction

Biasing an op amp during normal operation (that is, the device is in enabled mode) is generally straightforward: the biasing is defined by the desired transfer function that is required for the signal processing task at hand. Simple examples of such transfer functions might be a noninverting gain configuration, an inverting gain configuration, or a variety of other well-known op amp configurations. During shutdown, however, the function of the amplifier is to provide no relationship between the input and output, as well as to conserve as much power as possible. A correct design is required to prevent disturbances to the signal as it transitions between the enabled and disabled states, as well as ensure that the device is placed into a condition that does not cause damage to the amplifier during extended periods in the disabled state.

2 Problem Description

When an op amp transitions between an enabled and disabled state and back again, undesirable performance anomalies can be clearly observed if the design has not taken these transitions into account. As an example, consider the powerline communications line driver circuit shown in Figure 1. Here, the op amp is in a disabled state.

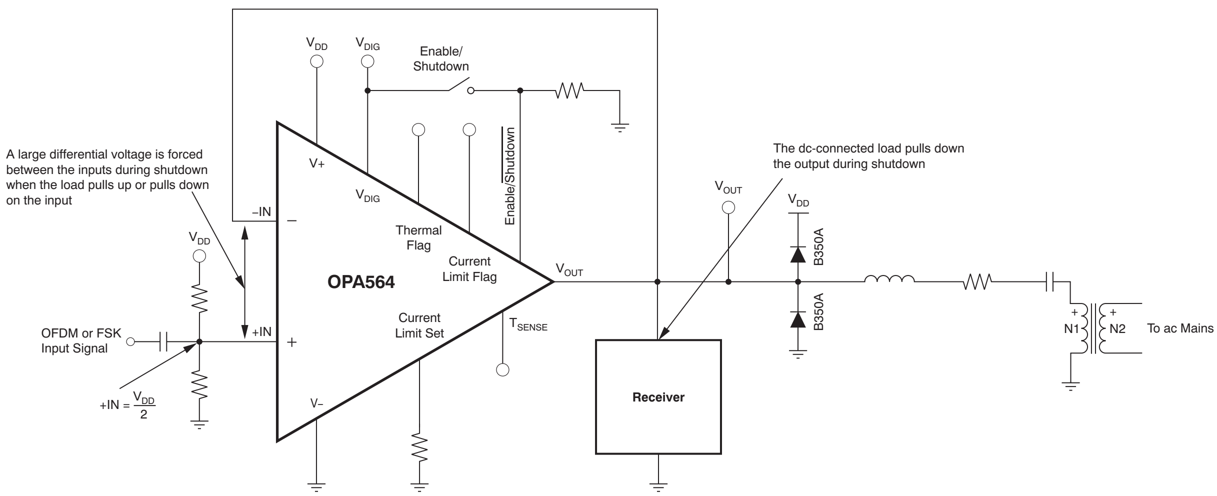

Figure 1. Unity-Gain Powerline Communications Line Driver with DC-Coupled Load

This circuit consists of the OPA564 power amplifier (PA) connected in a unity-gain power amplifier configuration. A receiver circuit connects directly to the OPA564 PA output. Connecting the receiver input impedance directly to the amplifier output creates an imbalance between the PA inputs when the PA is placed into the disabled state. Figure 2 compares the PA input and output when a large imbalance is present and when transmitting the signal.

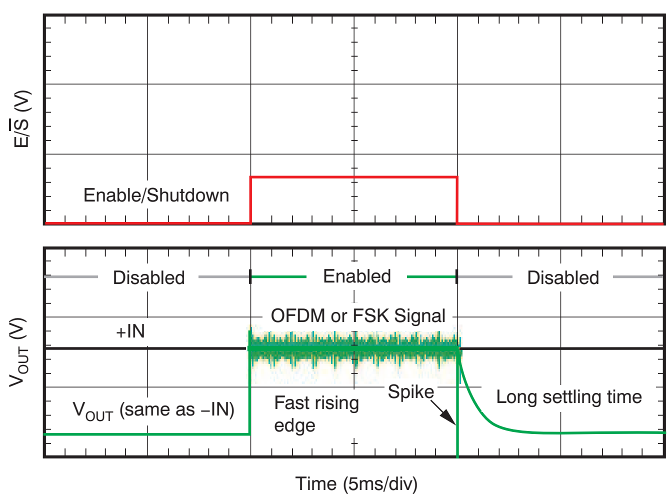

Figure 2. Output Results for Improperly Configured Circuit

The first undesirable anomaly shown in Figure 2 is a large voltage difference between the +IN and –IN terminals of the PA. Under extreme conditions, too large of an input differential voltage (greater than 500mV) during the disabled state can cause internal currents to circulate and disrupt the normal bias of the amplifier. This type of behavior may damage the device.

This large difference in voltage between the inputs must be recovered when the PA transitions to the enabled state. The fast rising edge at the beginning of the enabled state can produce higher-order harmonics in the transmitted signal spectrum. After the PA completes the signal transmission and is subsequently disabled, a spike is clearly observed when the inputs terminals are once again being driven apart by several volts. Following the spike, a delay can be seen as the high output impedance of the disabled output stage settles to its final value. Proper circuit configuration during both the enabled and disabled states is necessary to ensure proper and reliable operation of the OPA564.

3 Solutions

Fundamentally, the key to any proposed solution is to keep the +IN and –IN potentials as close to each other as practical. Doing so avoids the anomalies shown in Figure 2 and assures long-lasting, reliable device operation.

For the example in Figure 1, one simple solution is to separate the PA output and the receiver input by coupling the receiver with a capacitor. This approach is illustrated in Figure 3 for the unity-gain configuration, and in Figure 4 for an ac-coupled inverting gain configuration.

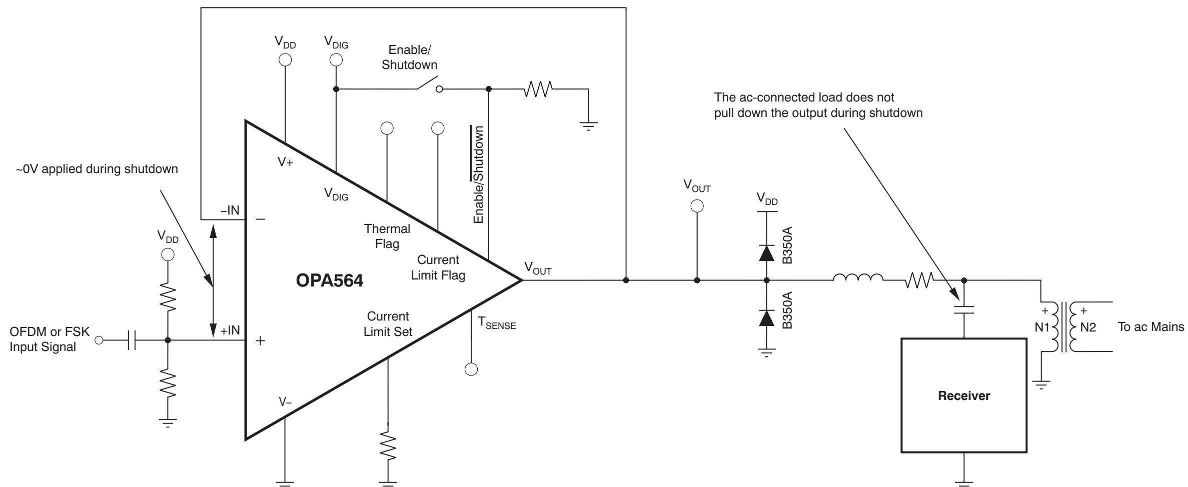

Figure 3. Unity-Gain Powerline Communications Line Driver with AC-Coupled Load

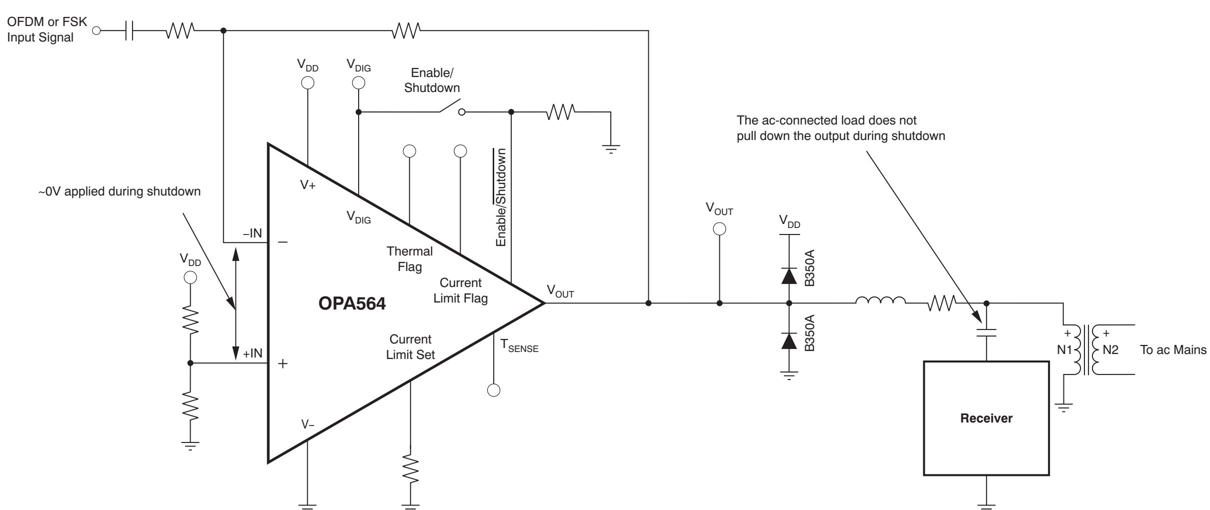

Figure 4. AC-Coupled, Inverting Gain Powerline Communications Line Driver with AC-Coupled Load

Figure 5 shows the results obtained when there are no dc paths that couple the –IN terminal to ground during the disabled state.

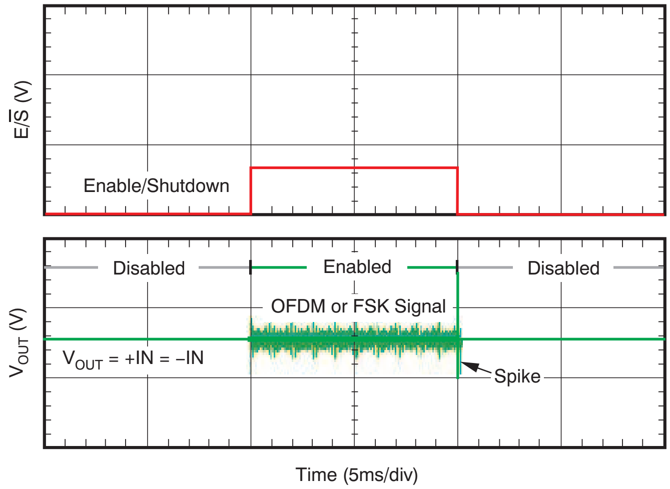

Figure 5. Output Results for Properly Configured Circuit (AC Load Only)

In Figure 5, we can see that the input differential voltage has been eliminated, and the PA transitions from a disabled state to an enabled state, and then returns to a disabled state more quickly. In this example, at the end of the transmission a much smaller spike is still present. This spike is a result of the output stage abruptly switching off and reacting with the complex impedance of the line coupling circuit and electrostatic discharge (ESD) protection diodes. This small spike can be eliminated with the addition of a voltage divider designed to set the –IN terminal equal to the +IN terminal during shutdown, as shown in Figure 6. Here, notice that the voltage divider on the PA output must match the ratio of the voltage divider that is used to create the midscale bias point at the +IN pin in order for the technique to be effective.

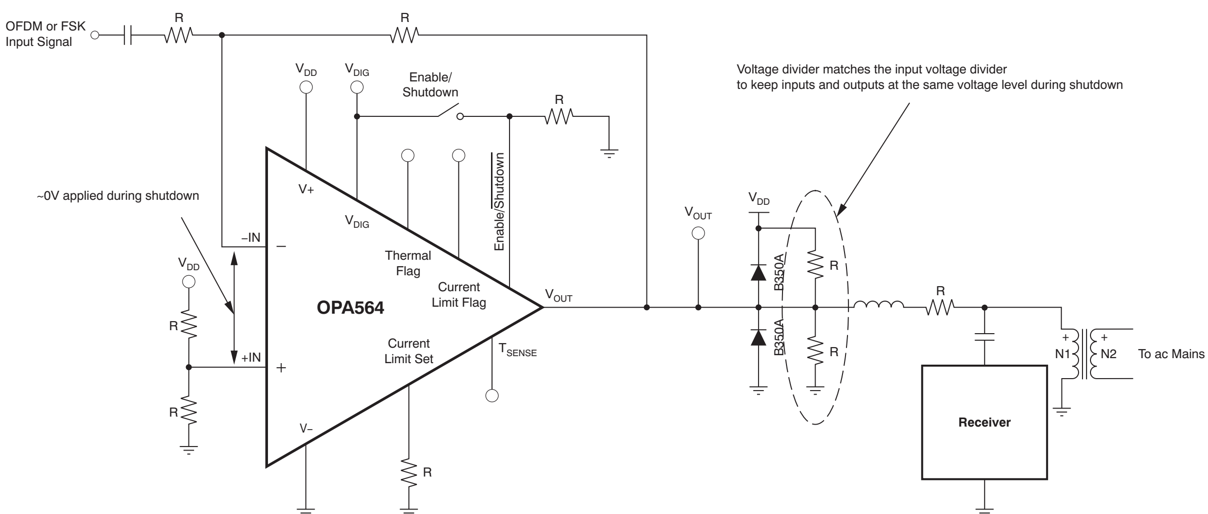

Figure 6. AC-Coupled, Inverting Gain Powerline Communications Line Driver with AC-Coupled Load and Voltage Divider

The presence of the voltage divider has very little effect during transmission because it presents only a very small additional load to the PA output. The resulting output waveforms are shown in Figure 7.

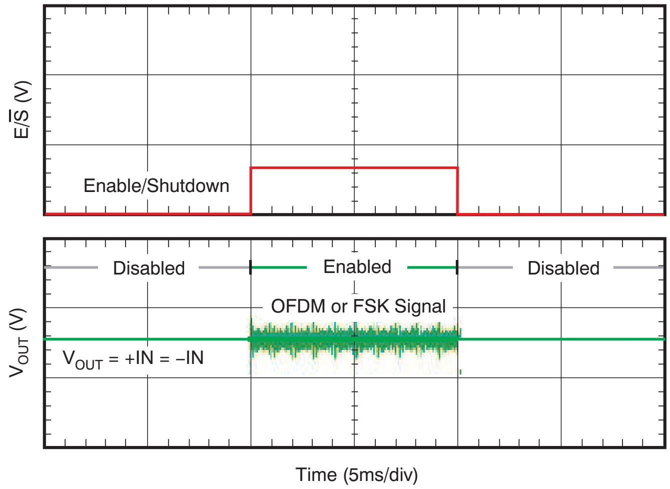

Figure 7. Output Results for Properly Configured Circuit with Voltage Divider

Other applications may require dc biasing of the load in a dual power-supply configuration, as Figure 8 shows.

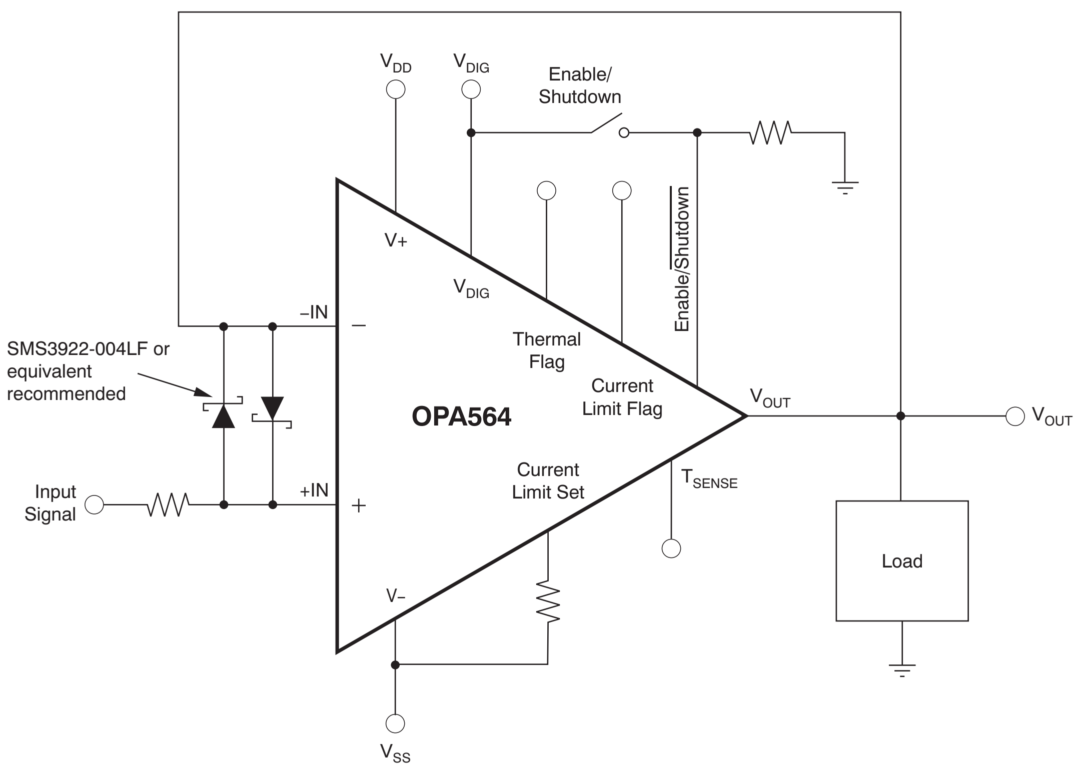

Figure 8. Dual Supply, DC-Connected Load Unity-Gain Follower

In this configuration, it may be necessary to limit the differential input voltage by placing Schottky diodes between the input terminals along with a series-connected, current-limiting resistor.

4 Conclusion

When designing an application with an amplifier that has an enable/shutdown feature such as the OPA564, care must be taken to design the amplifier configuration that allows for proper and reliable operation during both the enabled and disabled states as well as the transitions between these states. While this report presents only a few possible configurations, there are many other configurations that could be equally effective. The key to a proper design is to bias the differential inputs and output as near to the respective voltage levels that each may encounter during normal operation.

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