ADD CURRENT LIMIT TO THE BUF634

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Modern buffer amplifiers, such as the BUF634, are often used with op amps to drive high-current demand loads such as cables or electro-mechanical devices. BUF634 features internal overload protection to prevent its destruction under fault conditions. Internal current limit protects circuitry and wirebonds from excessive current. Internal over-temp shut down protects the device from excessive temperature rise by shutting down the output drive before catastrophic chip temperatures are reached (approximately 165°C).

The internal BUF634 current limit can allow output current to exceed 500mA. In some applications, it is necessary to limit the output current to a lower level to protect the load. External current limit can be added to the BUF634 with the addition of a current-sense resistor and a few other components.

Figure 1 shows the basic circuit for BUF634 external current limit. The BUF634 (A3) is connected in the feedback loop of A2 forming a precision closed-loop buffer—the output voltage of A3 is equal to the input of A2. A current-sense resistor, RCL, is connected from the buffer to the circuit output, VOUT. The buffer and resistor are enclosed in the feedback loop of A1 with a diode connected across the A2, A3 buffer. Output current produces a voltage drop across RCL. Until the voltage across RCL approaches the forward voltage drop of D1, the overall loop amplifier, A1, maintains VOUT precisely equal to VIN. As the voltage across RCL increases, drive current from A1 is diverted through D1 to the output and current limit is achieved. Output current limit is the sum of the current limit of A1 plus the forward voltage drop across D1 divided by RCL. For bipolar current limit, back-to-back diodes can be used as shown in Figure 2.

For stability, the bandwidth of A2 must be less than approximately one-fourth the bandwidth of A3, and R1 C1/(2π) must be less than approximately one-fourth the bandwidth of A2. With its bandwidth control pin unconnected, BUF634 bandwidth is 20MHz typ. Connecting the bandwidth control pin to V– increases bandwidth to approximately 160MHz.

In some cases, it may also be necessary to compensate the A2 – A3 loop as shown in Figure 3. In this case, R2 C2/(2π) must be less than approximately one-fourth the bandwidth of A3 and R1 C1 must be less than (R2 C2)/4.

FIGURE 1. Current limit can be added to the BUF634 with the addition of a current-sense resistor and a few other components. Output current produces a voltage drop across the current limit resistor, RCL. As the voltage across RCL increases, drive current from A1 is diverted through D1 to the output and current limit is achieved.

FIGURE 2. Adding a second diode to the Figure 1 circuit provides bipolar current limit. With the values shown, current limit is approximately ±100mA.

FIGURE 3. In some applications, it may be necessary to add compensation around the A2 – A3 loop.

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Current-limit can also be affected by $A_1$ input characteristics. Many BiFET op amps (Figure 4a) and lateral pnp-input op amps (Figure 4b) remain high impedance in overload. Op amps with bipolar transistor inputs often have input protection clamps (Figure 4c). In overload, current can flow directly through the diode clamps and $R_1$ and $V_{OUT}$. Select $R_1$ with this in mind.

![Image](image_url)

**FIGURE 4.** Depending on the op amp design, current can also through the op amp input pins and resistor $R_1$ to the output. The inputs of many BiFET input op amps (Figure 4a) and lateral pnp input op amps (Figure 4b) remain high impedance in overload. The inputs of other op amps, such as the npn input op amp (Figure 4c) have input protection such as the diode clamps shown.

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**FIGURE 5.** Figure 5a shows the large signal ($\pm 10V$) step response of the Figure 2 circuit into no load. Figure 5b shows the same step response into a 1$\mu$F load. Notice that the output is slew limited by the 100mA current limit into the 1$\mu$F load with good linearity over the output range.

![Image](image_url)

**FIGURE 6.** Current-Limit Response of Figure 2 Circuit Driving a 10Ω Load.

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