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 (A_3) is connected in the feedback loop of A_2 forming a precision closed-loop buffer—the output voltage of A_3 is equal to the input of A_2. A current-sense resistor, R_{CL}, is connected from the buffer to the circuit output, V_{OUT}. The buffer and resistor are enclosed in the feedback loop of A_1 with a diode connected across the A_2, A_3 buffer. Output current produces a voltage drop across R_{CL}. Until the voltage across R_{CL} approaches the forward voltage drop of D_1, the overall loop amplifier, A_1, maintains V_{OUT} precisely equal to V_{IN}. As the voltage across R_{CL} increases, drive current from A_1 is diverted through D_1 to the output and current limit is achieved. Output current limit is the sum of the current limit of A_1 plus the forward voltage drop across D_1 divided by R_{CL}. For bipolar current limit, back-to-back diodes can be used as shown in Figure 2.

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

For stability, the bandwidth of A_2 must be less than approximately one-fourth the bandwidth of A_3, and $R_1 C_1/(2\pi)$ must be less than approximately one-fourth the bandwidth of A_2. 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 $A_2 - A_3$ loop as shown in Figure 3. In this case, $R_2 C_2/(2\pi)$ must be less than approximately one-fourth the bandwidth of A_3 and $R_1 C_1$ must be less than $(R_2 C_2)/4$.
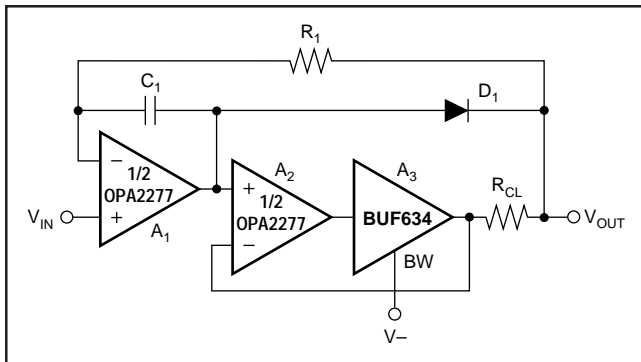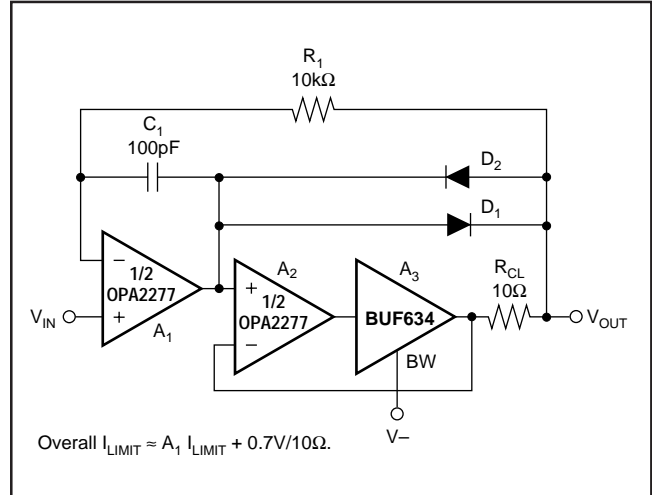

FIGURE 1. Current limit can be added to the BUF634 with the addition of a current-sense resistor and a few other components. Output current produces a voltage drop across the current limit resistor, R_{CL}. As the voltage across R_{CL} increases, drive current from A_1 is diverted through D_1 to the output and current limit is achieved.
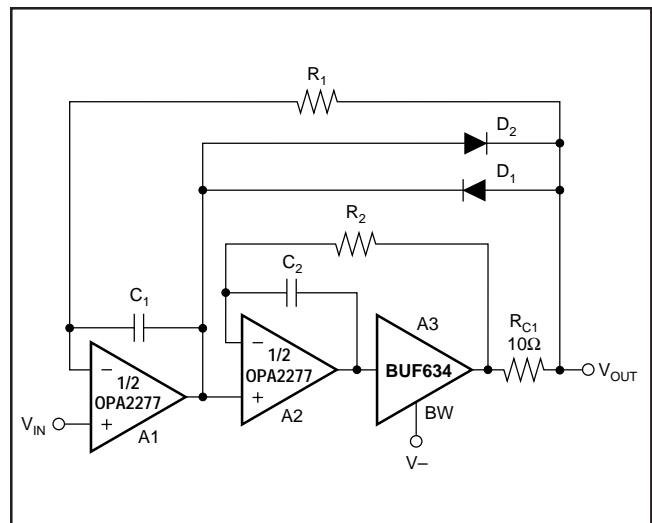

FIGURE 3. In some applications, it may be necessary to add compensation around the A_2, A_3 loop.

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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.

OPA130 Family

(a)

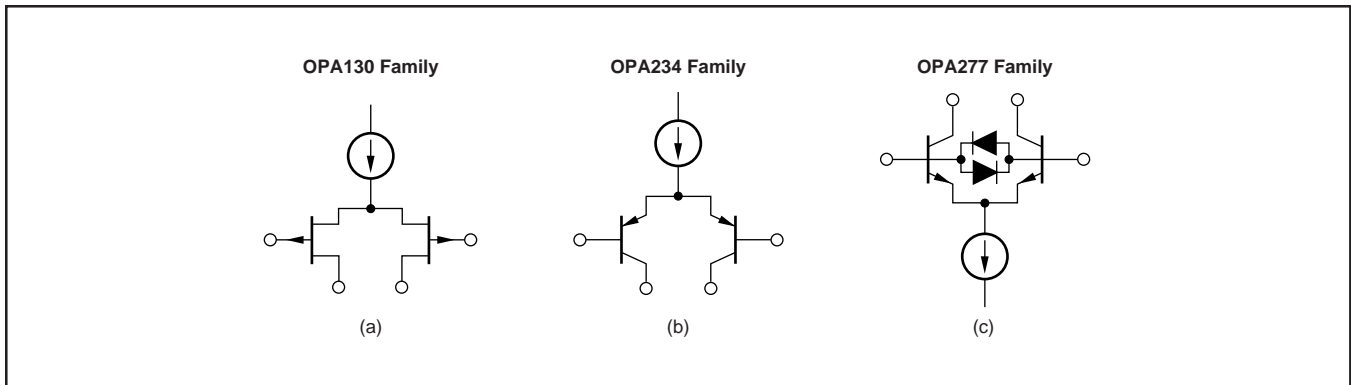**OPA234 Family**

(b)

OPA277 Family

(c)

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.
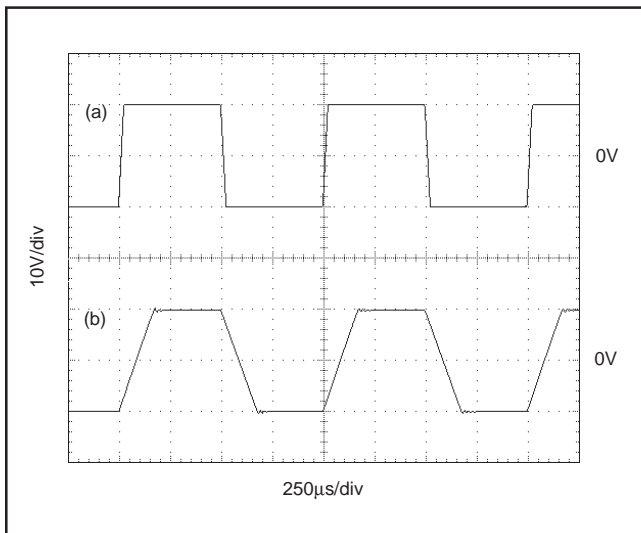

(a)

0V

(b)

0V

10V/div

250µs/div

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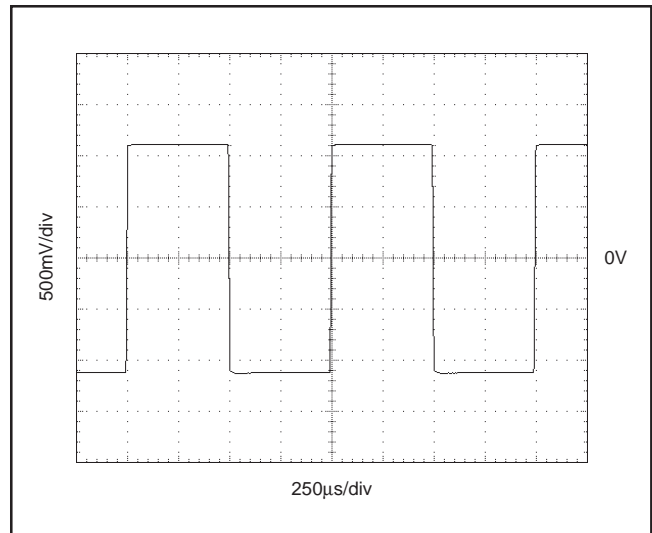

500mV/div

0V

250µs/div

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

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