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APPLICATION BULLETIN
Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706
Tel: (520) 746-1111 • Twx: 910-952-111 • Telex: 066-6491 • FAX (520) 889-1510 • Immediate Product Info: (800) 548-6132

AN EASY SOLUTION TO CURRENT LIMITING AN OP AMP

By Richard Kulavik

Many circuits today not only require voltage regulation but they also need current regulation. Some systems draw excessive current during power on, which can cause expensive system components to burn up due to improper powering of supplies. This is not the only problem associated with excessive currents. Some applications need to limit the current an op amp can provide to a specific load. This circuit can provide this type of function by making constant current sources out of simple regulators.

The REG1117 is a low cost, low drop out, adjustable regulator that can be used for both voltage and current regulation. In the normal mode of operation, applying a fixed voltage on the input pin will provide a fixed voltage between V_{OUT} and Adj. Placing a resistor across V_{OUT} and Adj will limit the amount of current delivered to the load by making the regulator appear as a constant current source.

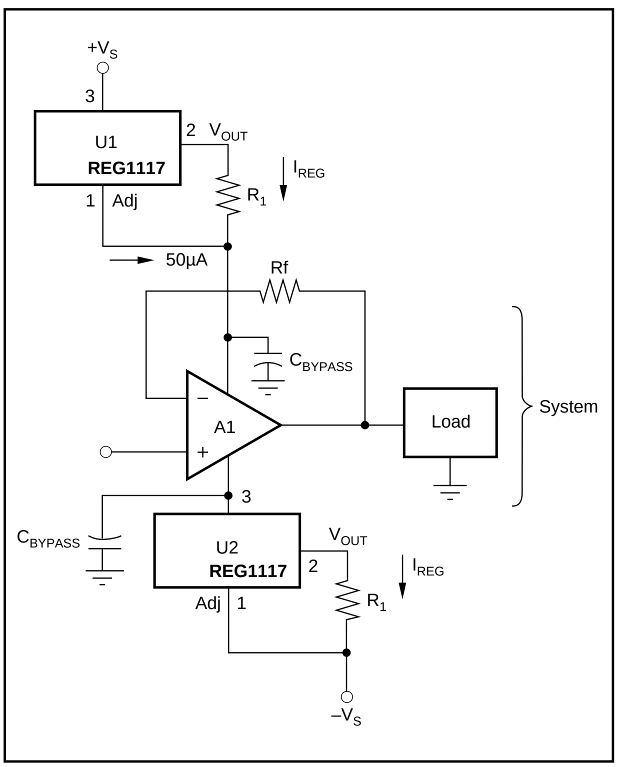

FIGURE 1. A Voltage Regulator Can Be Used as a Current Regulator and an Op Amp.

Figure 1 shows two REG1117s (U_1, U_2) with R_1, from the V_{OUT} pins to the Adj pins allowing

$$I_{REG(MAX)} = (1.25V/R_1) - 50\mu A$$

to be sources from the floating output to the system. If the system does not sink or source more than or equal to $I_{REG(MAX)}$, the regulators will be out of regulation and will drop its voltage across V_{OUT}, to Adj equalling 1.25V + I_{REG} • R_1, where I_{REG} is equal to the current demands of the system. When the current demands of the system rise and approach 1.25V/R_1, the regulator will begin to maintain its regulation and provide a maximum current, limited by R_1. At this point, the maximum voltage drop will be equal to 1.2V + 1.25V or 2.45V from V_{IN} to Adj. The supply voltage minus 2.45V will determine the compliance voltage of the current regulator. The REG1117 can source from 10mA to 800mA using the circuits shown.

Two problems can arise from creating a circuit such as the one described in Figure 1. The first problem is that the REG1117s have a transient response that will affect the output of the amplifier. Figure 2 shows the output voltage deviation in millivolts versus time from the REG1117. This voltage transient will appear as a ringing voltage to the load of the amplifier. If bypass capacitors are added on the power supply pins of an amplifier (A_1), the ringing can be reduced at the cost of greater overshoot and longer settling times. Remember that bypass capacitors are on the supply leads of

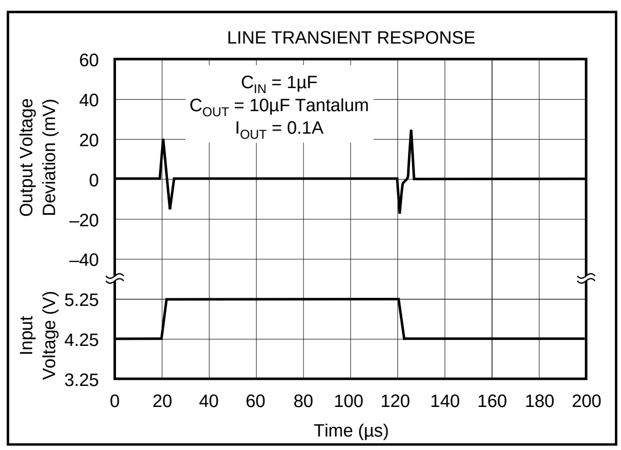

FIGURE 2. Transient Response of the REG1117.

the amplifier not only insures stability but also reduces noise and provides the amplifier with a reservoir of current for high speed requirements. The manufacturers recommended bypass capacitors from the amplifier supply pins to ground will have the capability of supplying the load with the charges from the capacitors, rendering a “soft” current limit. They can be removed from the circuit if caution is used with extensive bench testing.

Problems can also arise from placing a capacitor across the REG1117. This configuration is not advised because the regulator may be forced to sink instead of source current. The REG1117 has a tendency to oscillate under these conditions. The best alternative to this problem is to place a diode (D_2 and D_3) in series with an R || C low pass filter ($R_2 \| C_2$ and $R_3 \| C_3$) as shown in Figure 3.

A second problem is when the circuit goes into current limit, forcing the amplifier to operate in its nonlinear region. As in all current limit circuits, the amplifier is forced to do things it would not normally do. The output of the amplifier is limited from driving the load to the proper voltage. The input stage of the amplifier can not follow the load, forcing the amplifier to function as a nonlinear device. FET input amplifiers can exhibit some problems when taken outside their linear region. For instance, phase reversal is common among older FET input devices when this overload occurs. Newer FET input amplifiers, like Burr-Brown’s OPA2604 or the OPA627 have been designed to prevent this condition from occurring. Also, since the amplifier is operating in a nonlinear region, there will be a finite amount of time needed for the amplifier to recover. Often FET op amp’s overload recover time is longer than Bipolar amplifiers, such as the industry standards OPA27 or OPA1013. Care should be taken in selecting the op amp in this circuit to insure reliable operation.

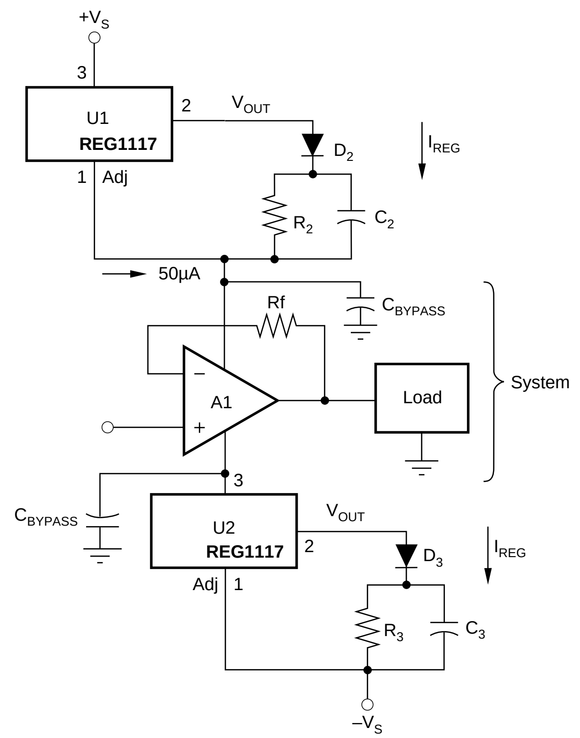

FIGURE 3. A Diode is Used to Prevent Reverse Bias Operation of the REG1117.