Extending the Input Voltage Range of Precision Current-Sense Amplifiers to 180V or Higher is Easy

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You can extend the input common-mode voltage range of high accuracy current-sense amplifiers (CSAs) to hundreds of volts by adding a general-purpose dual op amp and a few discrete components.

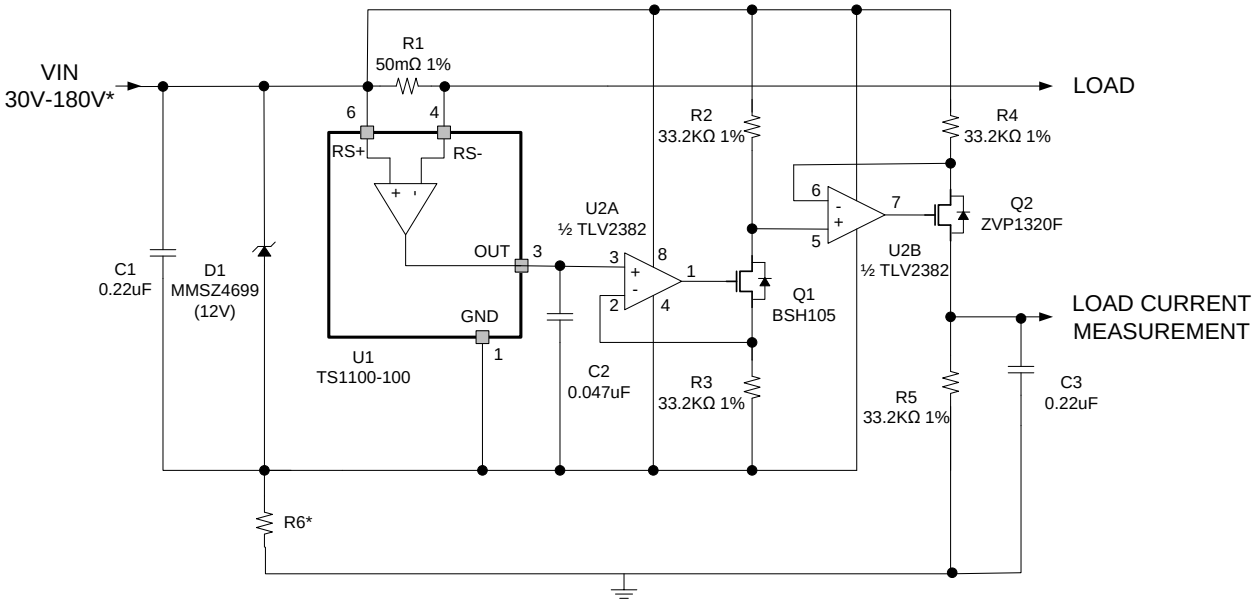
The accuracy of some CSAs is excellent, but often these CSAs are designed with battery-powered applications in mind; thus, they can't handle the high supply voltages needed for use in offline and high voltage backplane applications. The circuit of Figure 1 gets around this limitation by allowing the CSA to operate on the high side with a Zener-regulated voltage (D1), utilizing a general-purpose dual op amp, MOSFETs, and resistors to convert the CSA's output voltage to current and steering this current to a ground-referred resistor.

The core of this circuit is U1, a TS1100-100 current sense amplifier from Touchstone Semiconductor, provides an output voltage at OUT which is equal to the voltage difference between RS+ and RS- times 100 (with R1=50mΩ, OUT= 5V for 1A current) and was chosen for its ultra-low 30-µV input VOS and 1-µA supply current. To operate across Z1's terminal voltage (12V), U2A is a basic rail-to-rail op amp that servos the gate of N-channel MOSFET Q1 to force a voltage equal to OUT across R3, thereby converting the OUT voltage to a corresponding signal current through both R3 and R2. Op amp U2B servos the gate of P-channel MOSFET Q2 to set an equivalent current through R4, and sends the current through R5 which is connected to system ground. The voltage across R5 is equal to the voltage at OUT and can be measured by the system's ADC. Note that Q2 must stand off the full voltage between VIN and ground; the ZVP1320F specifies Vdsmax = 200V.

The accuracy of the load current measurement is excellent. With its ultra-low input VOS, the TS1100, enables the use of a low value sense resistor that generates a very small voltage drop across the shunt resistor R1 (a 1mV drop across RS+, RS- incurs only a +/-3% offset error, typical). The U2 op amps each contribute 0.5mV offset at the output, contributing negligible additional offset when referred to RS+/RS- (less than 1µV). In fact, any general-purpose dual op amp can be used in this circuit so long as its VOS contribution to overall offset error is small and its supply range includes Z1's terminal voltage.

Using low supply current dual op amps as complement to the TS1100 is also consistent with maintaining low power operation. Gain errors are limited by the accuracy of resistors R2-R5; for best performance, using tolerances of 0.1% should yield an error of 0.22% typical, including the gain error contributed by the TS1100.

The circuit can work for any input voltage – even several hundred volts - limited only by the choice of MOSFET Q2 which must stand off the maximum voltage at VIN.



* choose R6 according to the following: R6= (VIN-12V)/1mA

Figure 1. High-Voltage, Precision Current-Sense Amplifier

For additional information, please follow the links to the corresponding product pages:

- TS1100 Current Sense Amplifier

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