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## ISL28005, ISL28006 Unidirectional Current Sense Amplifiers

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This application note introduces the [ISL28005](#) and [ISL28006](#) family of highly integrated current sense amplifiers that can drastically simplify the design of complex current monitoring circuits. The application note explains the device internal two-amp topology with ground-sensing diagnostic features, discusses which gain to use in what type of applications, and provides an example of an optional transient protection scheme.

### Contents

<b>1. Introduction</b>	<b>2</b>
<b>2. The ISL2800x Product Family</b>	<b>2</b>
2.1 Ground-sensing Diagnostic Features	3
2.2 The Two-Amp Topology	3
2.3 Which Gain to Use?	4
2.4 Optional Transient Protection	4
2.5 Conclusion	4
<b>3. Revision History</b>	<b>5</b>

## 1. Introduction

The ISL28005 and ISL28006 are ground-sensing current sense amplifiers that amplify millivolt current signals developed across sub-1 $\Omega$  sense resistors. The simplest type of current sense amplifiers use single stage op amp circuits that take their power from the same voltage source that generates the current to be measured. These are realized using an op amp and a handful of external components to condition the amplifier to requirements of the application. As long as the measured current signal remains within the common mode voltage range of the op amp, these circuits are simple.

Applications where the amplifier operates from a different power source than the load adds complexity, particularly when the measured current is at voltage levels much higher than the op amp supply voltage. In many cases, an additional amplifier circuit is needed to perform the voltage translation to step-down the current sense signal to match the common mode input range of the current sense amplifier.

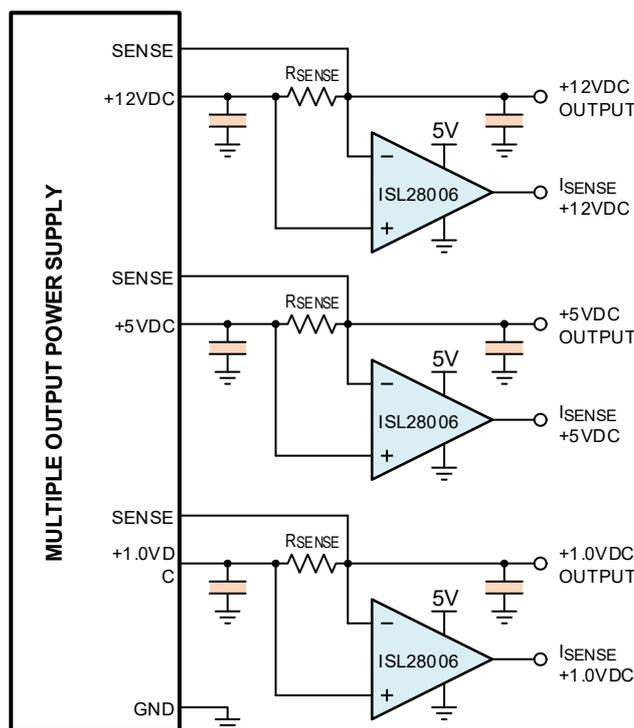


Figure 1. Typical Application Circuit

Current sensing in multi-output power supply systems (see [Figure 1](#)) is one application where one or more power supply output voltages must be measured using current sense amplifiers powered from a much lower supply voltage. The ISL2800x family of current sense amplifiers are ideal for these applications because they perform precise current sensing operating from supply voltages as low as 3.3V, while sensing from supply voltages as high as 28V. These current sense amplifiers are very simple, self-contained solutions requiring only an external current sense resistor. The space-saving SOT-23 package and low component count results in very small footprint.

## 2. The ISL2800x Product Family

Within the ISL2800x family are the ISL28005 sub-family of lower cost amplifiers for general sensing applications featuring measurement accuracies better than 4% and input offset voltages less than 500 $\mu$ V over the -40 $^{\circ}$ C to +125 $^{\circ}$ C temperature range. For greater precision, the ISL28006 sub-family offers gain accuracy and input offset voltages as low as 1% and 300 $\mu$ V over the full temperature range, depending on the device.

Within each family are pin-compatible fixed gain amplifiers in the 5 Ld SOT-23 package. The ISL2800x-20, ISL2800x-50 and ISL2800x-100 are single supply, uni-directional current sense amplifiers with fixed gains of

20V/V, 50V/V, and 100V/V, respectively. In the ISL28006 family is an additional adjustable-gain version in a 6 Ld SOT-23. The ISL28006-ADJ is a single supply, unidirectional current sense amplifier with an adjustable gain using an external resistor (see Figure 2). The ISL28006-ADJ is stable for gains of 20V/V and higher.

## 2.1 Ground-sensing Diagnostic Features

In addition to the ability to sense current from high input common mode “beyond the rail” voltages, these devices also sense currents at input voltages levels down to 0V, or ground. This ground-sensing feature adds a useful diagnostic capability to the current sensing function.

For example, during normal operation the high-side output current sense (see Figure 1) supplies common mode input voltage to the current sense amplifier equal to the supply voltage. However, in the presence of a power supply fault, (such as an output short circuit or loss of the measured output) the ground sensing feature can still measure current flow, even though the supply voltage is at 0V. In the case of an output short, the current sense will measure the abnormally high current, even though the voltage is at ground. The high current measurement capability at ground level gives the indication that a short circuit has occurred. In the case of a loss of output, a measured current near 0A and a measured voltage near 0V gives the indication that the measured supply has gone open circuit or has been disabled.

## 2.2 The Two-Amp Topology

The functional block diagram shows the current sense amplifier in Figure 2. Current sensing is performed in two stages. The input stage is a floating amplifier that translates the sense voltage across the resistor into a ground-reference sense voltage at the input to the output amplifier. The wide, 0V to +28V common mode input voltage range is achieved using a voltage sensing comparator to select one of two sense amplifiers, depending on the voltage level measured at the positive sense terminal ( $R_{S+}$ ). When the input voltage is higher than ~1.35V, the high-side sense amp is selected. This high-side input amplifier has to operate with an input voltage that is higher than the amplifier supply voltage ( $V_{CC}$ ), so this amplifier is powered from the load.

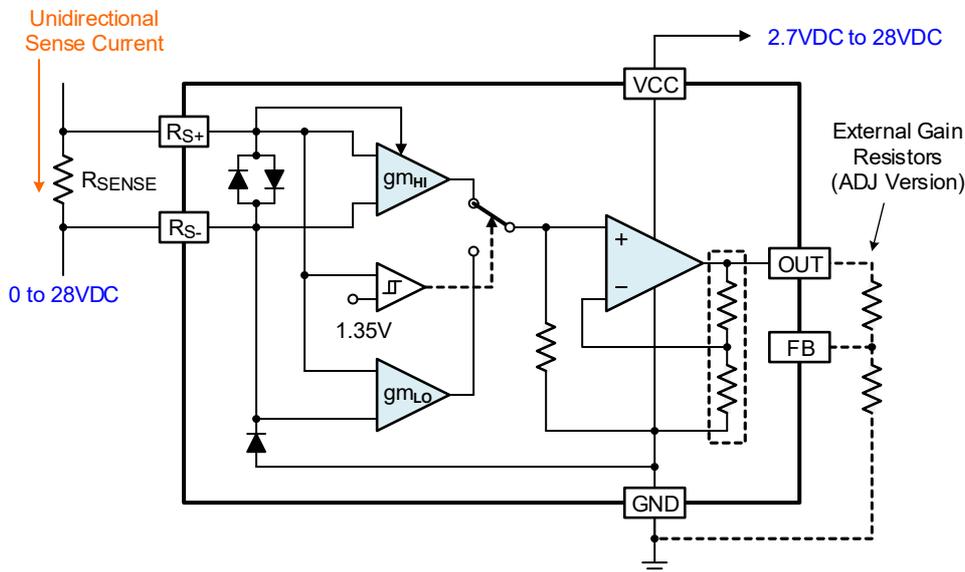


Figure 2. Functional Block Diagram

When the voltage at the sense input terminals drops below the 1.35V threshold, the lower sense amplifier is enabled and derives its power from the amplifier’s VCC pin.

The second stage contains a single supply voltage feed amplifier in the traditional non-inverting gain configuration providing a high precision buffered DC output suitable for driving A/D converters. The fixed gain X20, X50, and X100 amplifiers in the ISL28005 and ISL28006 families use internal precision thin film gain resistors for excellent

thermal tracking and gain linearity. The ISL28006 - ADJ provides an additional FB pin for the connection of external resistors in applications where other gains are required. These output amplifiers feature ground sensing inputs and rail-to-rail outputs over the 2.7V to 28VDC range.

Power supply efficiency is important, so the power consumption of the monitoring functions have to be kept to a minimum. The ISL2800x family accomplishes this in two ways. First, the supply current is kept to a low 60µA. Second, high accuracy and low VOS enable lower current sense shunt resistors for lower shunt dissipation.

### 2.3 Which Gain to Use?

The maximum full scale input voltage of all products in this family is 200mV, but a 100mV full scale input sense voltage provides the best gain accuracy and linearity. Selecting a shunt resistance that generates 100mV for the maximum current range provides additional margin for momentary current peaks, provided that the corresponding output peaks do not overload the downstream circuits. For example, a 10A full-scale (FS) current requires a 10mΩ shunt for a FS input voltage of 100mV, but can handle at least a 20A peak without overdriving the input stage.

Next, the gain of the ISL2800x amplifier can be selected to match the desired FS output voltage range. In the above 10A FS example, a gain of 20 provides a full-scale output of 2V and a max peak voltage output of 4V, which might be suitable for 5V downstream monitoring circuits.

Amplifier gain can also be used to reduce the power consumption in the shunt. In the above example, the power dissipation of the 10A FS through the 10mΩ shunt is 1W. Reducing shunt to 2mΩ reduces dissipation to 0.2W, which can reduce measurement error because of the temperature coefficient of the shunt resistor. Switching from the X20 gain to the X100 devices restores the original FS range.

### 2.4 Optional Transient Protection

For applications where the load and the power source are permanently connected, transient protection are usually not needed. Fast transients generate voltage spikes that can overdrive the amplifier, resulting in a long overload recovery time. Common mode and differential capacitors can be used to filter these spikes.

For applications where high in-rush currents are caused by hot plugging, external protection components may be needed to limit the current through the internal ESD diodes to <20mA. If the current limiting resistor is required, it needs to be placed on the  $R_{S-}$  input. Placing it on the  $R_{S+}$  input side will result in a larger error voltage because of the ISL28006 taking its supply current from the sense current in high-side applications.

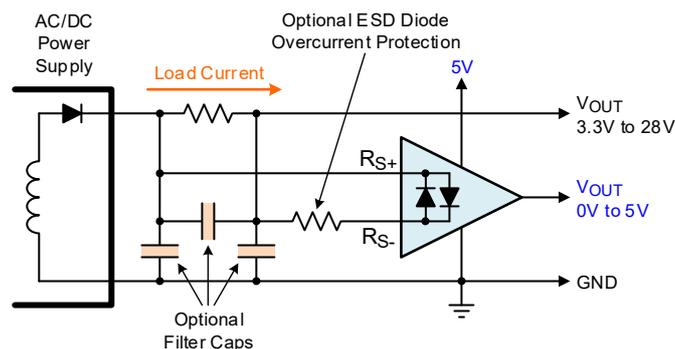


Figure 3. Functional Block Diagram using Optional Filter Capacitors

### 2.5 Conclusion

The ISL28005 and ISL28006 families of current sense amplifiers simplify the design of complex current monitoring circuits. The addition of a ground-sensing measurement capability enables a new level of fault detection that are useful in a wide range of power applications. Their unique features and wide range of gain and accuracy choices make them suitable for use in compact enclosures where high accuracy and low power dissipation are important.

### 3. Revision History

Revision	Date	Description
1.00	Feb 8, 2022	Applied New Template. Updated Figures 1-3.
0.00	May 25, 2010	Initial release.

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