

# High Side Resistive Shunt Current Sensing Using Current Shunt Monitors From Texas Instruments

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**TEXAS  
INSTRUMENTS**

**MICHIGAN STATE**  

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**U N I V E R S I T Y**

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## **Abstract**

This paper documents and explains the usage of current shunt monitors for sensing current using a resistive shunt placed on the high side. It will explain how resistive shunt current sensing works and why choosing a current shunt monitor is the best option. It will also describe how to select a part to best suit your application based on part specifications. Finally, optimal placement on a printed circuit board will be explained.

## **Introduction**

Current sensing using a resistive shunt measures a voltage drop across a small resistor and uses ohms law to determine the current being drawn from the power source to the load. Using a high side measurement places this resistor between the source and the load. Since current sensing is often used for over-current protection applications, using the high side placement is optimal since over-current can be sensed and necessary action can be triggered before current reaches the load, preventing any damage it might have caused to the circuit. High side current sensing requires an integrated circuit to measure the drop across the sense resistor and a current shunt monitor is most likely the best option available for this application.

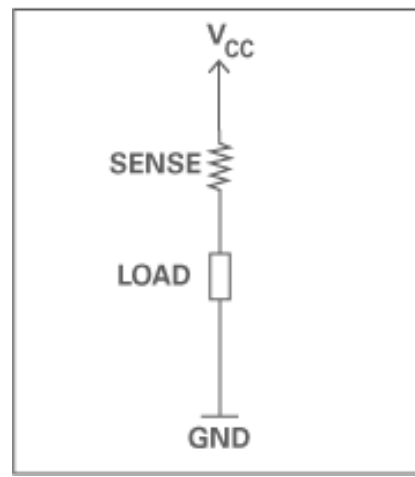


Figure 1: High Side Current Sense Resistor

<http://focus.ti.com/en/graphics/aap/general/figure4.gif>

## Why use a current shunt monitor?

Traditional high side current measurement requires the use of a differential amplifier to measure and amplify the difference between the two ends of the sense resistor. This can be very difficult to obtain an accurate reading since it requires very careful resistor matching by the designer to obtain a high common mode rejection ratio (CMRR) of the IC being used. The CMRR is a measurement of an instruments ability to reject a common mode voltage, the voltage common to both sides of a differential circuit pair. This is measured in decibels and is acceptable when it is above 90dB. If the resistors chosen deviate by 1%, the CMRR drops to around 46dB. Current shunt monitors are designed specifically for sensing applications, so the CMRR issue with high side sensing is eliminated since the resistors used for the differential amplifier are placed inside of the IC. Current shunt monitors are also more accurate since they provide an output proportional to the voltage drop across the shunt resistor. Texas Instruments currently offers more than 50 different current shunt monitors that offer a wide variety of advantages that can cater to many different applications.

## Selecting a current shunt monitor

This section explains the differences in current shunt monitors offered by TI and the specifications to consider for different applications.

### Current Output vs. Voltage Output

Current output current shunt monitors output a current signal based on the voltage drop across the current shunt monitor. This is done with the use of a bipolar junction transistor inside of the IC connected as feedback of the differential amplifier. The primary advantage of outputting current is it allows the designer to set the voltage gain with an external resistor. This can be designed using a voltage output provided in the information given by the specific IC datasheet. They also typically have a lower quiescent current.

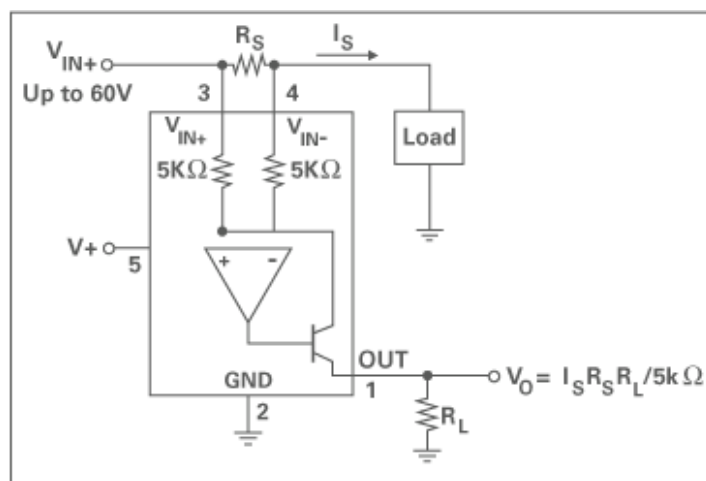


Figure 2: TI INA138 Current Output Current Shunt Monitor

<http://focus.ti.com/en/graphics/aap/general/figure6.gif>

Voltage output current shunt monitors output a voltage proportional to the voltage drop across the sense resistor and have a set voltage gain. The current shunt resistor can be selected to obtain the desired output to correspond with a specific current. Voltage outputs allow bi-directional current measurements and voltage signals are easier to use to drive an analog to digital converter. Most of the current shunt monitors offered by Texas Instruments output a voltage signal.

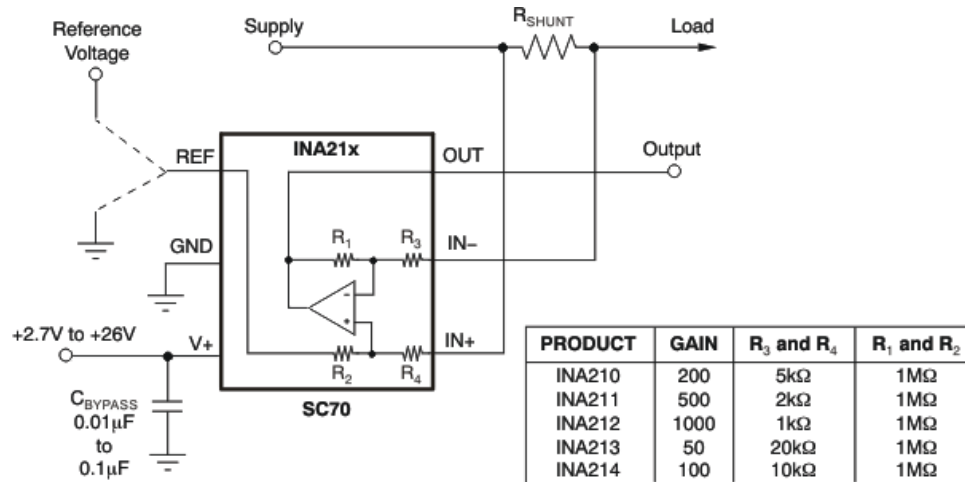


Figure 3: TI INA21X Series Voltage Output Current Shunt Monitor

[http://focus.ti.com/ds\\_dgm/thumbnails/fbd\\_sbos437b.gif](http://focus.ti.com/ds_dgm/thumbnails/fbd_sbos437b.gif)

### High Accuracy Applications

Many current sensing applications require high precision such as taking power management readings. The most important specification to consider for high accuracy applications is the input offset voltage of the current shunt monitor. Input offset voltage is the voltage required to apply between the positive and negative terminals of an operational amplifier to obtain zero volts on the output. Ideally, this is zero volts, but all integrated circuits have an offset voltage. Since the current measurements are taken between the positive and negative terminals and are a very low voltage signal, offset voltage can have a large affect on the accuracy of the output. The INA21X series has the lowest offset voltage of the current shunt monitors offered by Texas Instruments, with an offset as low as 35 $\mu$ V.

## Low Power Applications

Since many current sensing applications use power from the battery used to power the load, a current shunt monitor that draws minimal power may be desired. For these applications, one should consider the quiescent current drawn by the IC. Quiescent current is the current required by the shunt monitor to allow it to perform its expected function. The INA138/168 have the lowest quiescent current, being 25µA, though many of the shunt monitors have a quiescent current in the micro-amp range.

## Special Applications

Some current shunt monitors have features unique to only one or two devices. There are two current shunt monitors, the INA209 and INA219, designed specifically for digital applications. They are completely programmable and have an I2C interface. The INA209 also has two digital comparators and an analog comparator. The INA200-203 are analog current shunt monitors with internal comparators with an adjustable reference for one of the inputs of the comparator.

## PCB Considerations

Since current sensing requires the use of a very low resistance for the sense resistor, PCB traces and connections have more of an effect on the accuracy of the output of the IC than other applications. Special design considerations must be made when designing a PCB for a circuit that includes the use of a current shunt monitor to reduce parasitic resistance. It would be best to keep traces as close as possible to the input pins of the monitor. If the sense resistor is placed far from the monitor, on a different layer through vias, etc., the signal input could be strongly affected, therefore giving an unexpected output. Also, traces from the sides of the resistor to the input terminals of the current shunt monitor must be the same length to read the correct voltage drop across the sense resistor.

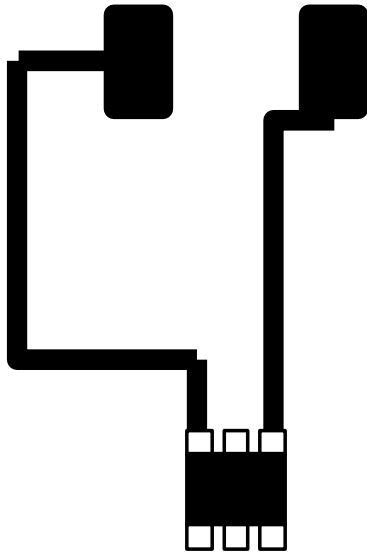


Figure 4: Poor PCB traces to the inputs of the current shunt monitor

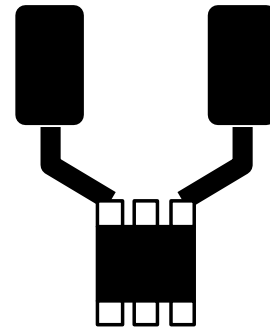


Figure 5: Recommended PCB traces to the input of the current shunt monitor

## **Conclusion**

High side resistive shunt current sensing with current shunt monitors can be used for simple and accurate current sensing. Texas Instruments offers a wide variety of current shunt monitors that have many advantages to suit any current sensing need, whether it be high accuracy for power management applications or low power for battery powered circuits. PCB traces for optimal accuracy of the output of the current shunt monitor is also a necessary consideration when designing a current sensing system.

## **References**

TI Current Sensing:

<http://focus.ti.com/analog/docs/microsite.tsp?sectionId=560&tabId=2180&micrositeId=7&familyId=426>

TI Current Shunt Monitor Portfolio Presentation: <http://www.slideshare.net/element14/current-shunt-monitors>

INA138 Datasheet: <http://focus.ti.com/lit/ds/symlink/ina138.pdf>

INA209 Datasheet: <http://focus.ti.com/lit/ds/symlink/ina209.pdf>

INA214 Datasheet: <http://focus.ti.com/lit/ds/symlink/ina214.pdf>

Quiescent Current:

<http://www.diracdelta.co.uk/science/source/q/u/quiescent%20current/source.html>

Electronics Industry Glossary: <http://www.uswi.com/glos-a-c.htm>