

MSU College of Engineering
ECE 480 Senior Design - Group 8
Jacob Mills
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Implementing a Resistive Current Sensor

Abstract

An overview of resistive current sensing and its applications. This document will focus on what current sensor to choose, how current sensors work, and what component values to choose so that the sensor is most effective.

Keywords

High side current sensor, Low Side Current Sensor, Shunt Resistor, Load Resistor

Introduction

Resistive current sensing is a key process when trying to make calculations at different points in a circuit. In many applications information needs to be calculated and stored for further analysis. Once it has that information the circuit then can be utilized for some sort of control purpose. Implementing these current sensing components can be difficult and the user must take many different factors into account when using them in a design. Throughout the course of this document the process of properly installing a current sensor will be explained and highlighted. It will cover topics like choosing the right sensor, how the sensor works, and how to choose the proper resistors for proper operation outside the sensor itself.

Choosing a Current Sensor

Current sensing is a sensitive process that requires the user to contemplate several key factors when choosing their current sensor. One of these factors is accuracy. Measurement accuracy directly impacts the result of whatever application you are using the sensor for. Normally the user will need a sensor with accuracy better than 90%. Drift is also important because it is related to how long a sensor can sustain a reading over time. Some changes can be caused by humidity, temperature, and component aging. Low drift means that the sensor has a small chance of being effected by the previously stated characteristics. Low drift is directly connected to a more stable circuit (6). Linearity is the next factor that needs to be taken into account. Linearity in a current sensor refers to its stability while the component is in full operating mode. High linearity means the sensor will provide accurate measurement for a wide range of

currents. A lot of sensors can only measure a limited range of currents which keeps them out of many applications (6). A good measurement does not only relate to accuracy and linearity in terms of amplitude but also to the phase shift that may occur. The phase shift should be as low as possible in order to measure the current properly. The final factor is also one of the most important factors when choosing the right sensor. The price of the sensor is important just as if the user was choosing any other component to their design (6). The challenge is to find the cheapest sensor that will still produce an accurate measurement. This is why most designs include a resistive type of current sensing. This method requires inserting a small resistor in the current path and measuring the voltage drop across it. The other method is by measuring a magnetic field around a conductor. Although the magnetic field method is usually more accurate, in almost all cases it is extremely hard to justify the high cost of implementing this kind of sensor.

How Resistive Current Sensing Works

Internally the current sensor contains two resistors, an op amp, and a transistor. This portion of the circuit makes up the sense amplifier. Externally the current sensor needs a voltage supply, a shunt resistor, a load, and a load resistor. The ways in which

all of these components are connected with each other determine whether it is a high side or a low side current sensor. A typical low side current sensor requires the resistor and the sense amplifier to be placed after the supply and the load (1). A simple schematic of this design can be seen in Figure 1.

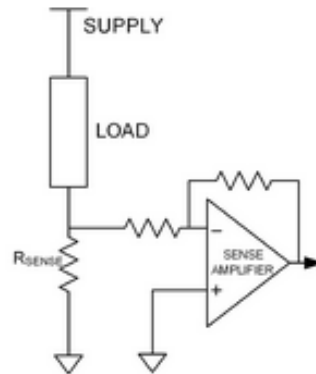


Figure 1 – Typical setup for a low side current sensor. (4)

High side current sensing utilizes a very similar setup to low side except that the resistor and sense amplifier are placed in between the supply and the load. (4) A simple schematic for a high side sensor is shown in Figure 2 below.

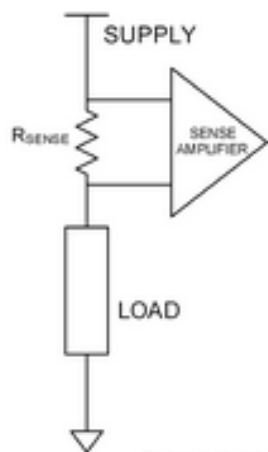


Figure 2 – Typical setup for a high side current sensor. (4)

For the most part the method for high side sensing is most effective when choosing a current sensor. In low side sensing there can be ground disturbances. This can be tolerated in some designs but high side sensing eliminates this because the sensor is not directly connected to ground. (4) Another important aspect of high side current sensing is that the sense amplifier can handle a wider range of supply voltage. This is useful for high voltage applications like automotive design. A schematic of a typical high side current sensor can be seen in Figure 3.

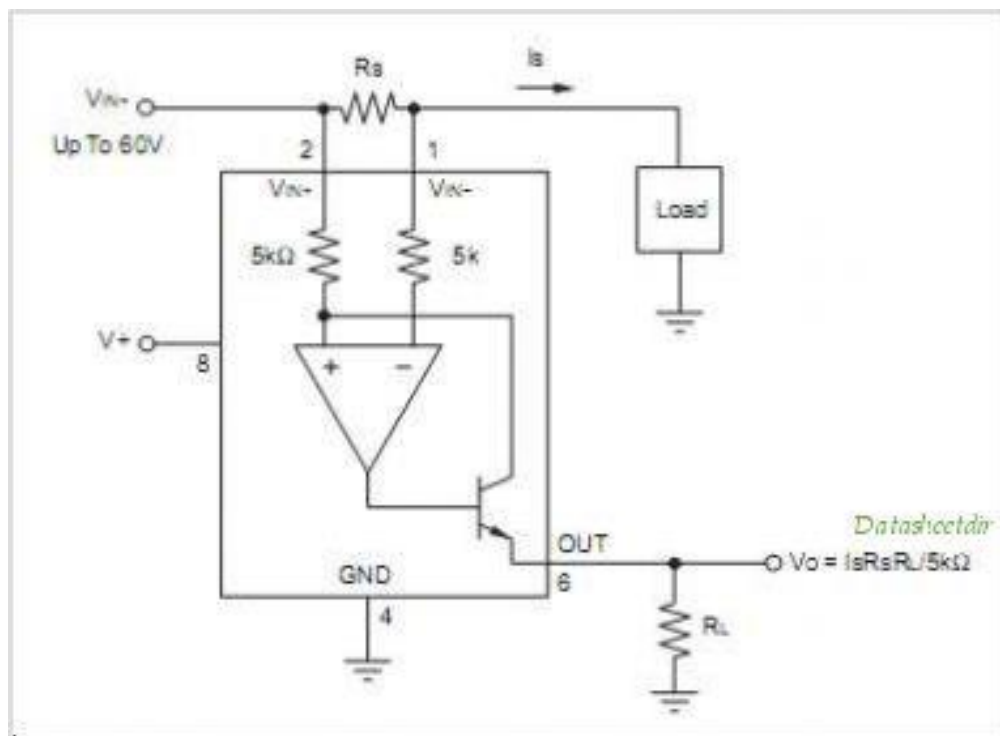


Figure 3 – In depth look at a high side current sensor (2)

The image above should give more detail as to how a high side resistor works. The high side current sensor draws a load current from the power supply through what is called a shunt resistor. The voltage drop of the shunt resistor is forced across the op amp. This then forces the current to flow into the collector of the transistor. Then the output current flows into the load resistor and it is converted to a voltage.

Selecting the Shunt Resistor

The resistance of the shunt resistor depends on the circuit you are designing. In a design that deals with a larger currents a high resistance resistor will provide the most accurate measurement. The high resistance helps with accuracy by minimizing the effects of offset (2). If a low resistance is chosen this helps minimize the voltage loss in the supply line. In most applications a low resistance is needed in order to minimize the power dissipation. The most important aspect to think about when selecting the resistor is to keep the range of the voltage in the specified range. In many cases the recommended voltage range is between 50 mV and 100 mV (2). A simple shunt resistor circuit can be seen below in figure 4.

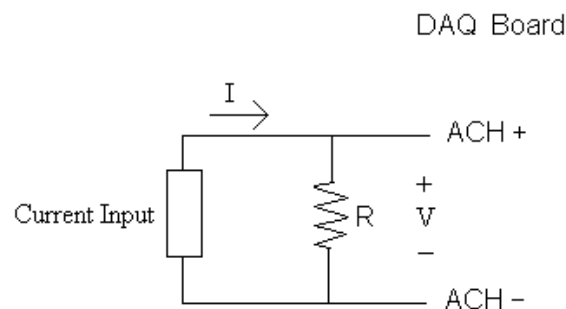


Figure 4 – simple shunt resistor example

Selecting the Load Resistor

When choosing the load resistor the desired output voltage must be taken into account. The output impedance of most sensors are high allowing for a huge range of available resistors. The user must make sure if there is any other input impedance that that impedance is higher than the load resistor to avoid degrading accuracy.

Output Voltage

The output of the current sensor is a current which is converted to a voltage by the load resistor. The maximum possible swing is limited by several factors. These factors include shunt voltage, the input common-mode, and the power-supply voltages.

Conclusion

Overall the most effective choice for a current sensor varies depending on the application for which it is being used. Although in most cases, a high side current sensor is the most effective way for monitoring current. This is due to its lower cost compared to other methods for current measurement as well as its ability to accurately measure at high voltages. When choosing a current sensor it is important to keep those very important aspects in mind but do not forget to look at other factors like drift, linearity, and phase shift.

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