Isolated Current Sensor

Team Number 73

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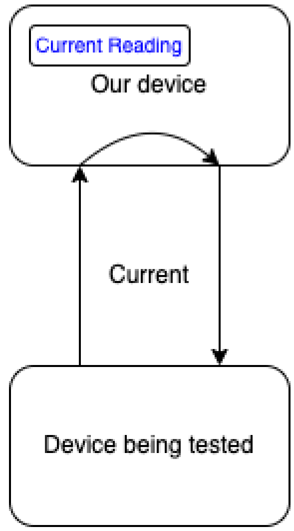
Introduction

In power electronics research, we often need to equip microcontrollers with the ability to accurately sense a high current signal. Accurately sensing the current through a circuit allows the user to gain more knowledge about the circuit and be more informed with regards to the safety precautions that may need to be in place. For example, if we are looking at situations with high current, we need to be careful with which materials we use and how we use them, as we could fry the parts and/or cause injuries to ourselves. Secondly, situations such as motor-control feedback, power-supply, or even high-side sensing require accurate measurements. The result of not having such a current sensing circuit is an inefficient use of time and effort, as this would require creating a new circuit that will manually test the current for every use case. The ability to maximize the time of the user is the main attractive feature of this product.

There are three main options in terms of how to approach creating a fully isolated current sensor: (1) the current transformer, (2) the Rogowski coil, and (3) some sort of Hall-effect device. We have decided to go with a Hall-effect current sensor over the other options for a few main reasons. The Hall-effect sensors are accurate and are able to be used on a wide range of currents. The other options offer more complications as well as restrictions in terms of how we can design our circuit.

As shown below, there are a few subsystems we have to take into consideration. First, there will have to be power supplied to all the parts. We are planning on using a battery to power each component, as the power requirements are not too high. Second, we need to feed the current we want to calculate into the hall effect current sensor. This will then output a voltage that will be fed into the analog to digital convertor. From here, we will feed the digital outputs to the microcontroller, which will then calculate a current value to be displayed using the seven segment display on the outside of our casing.

Visual Aid



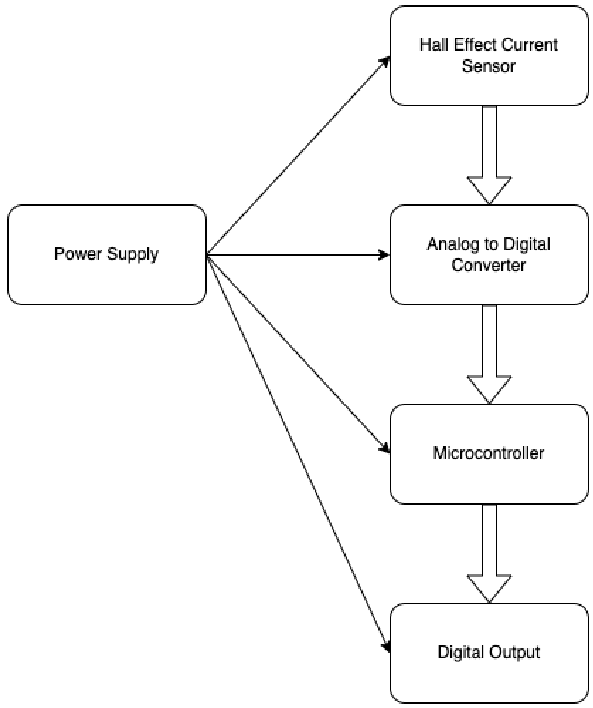
High-Level Requirements:

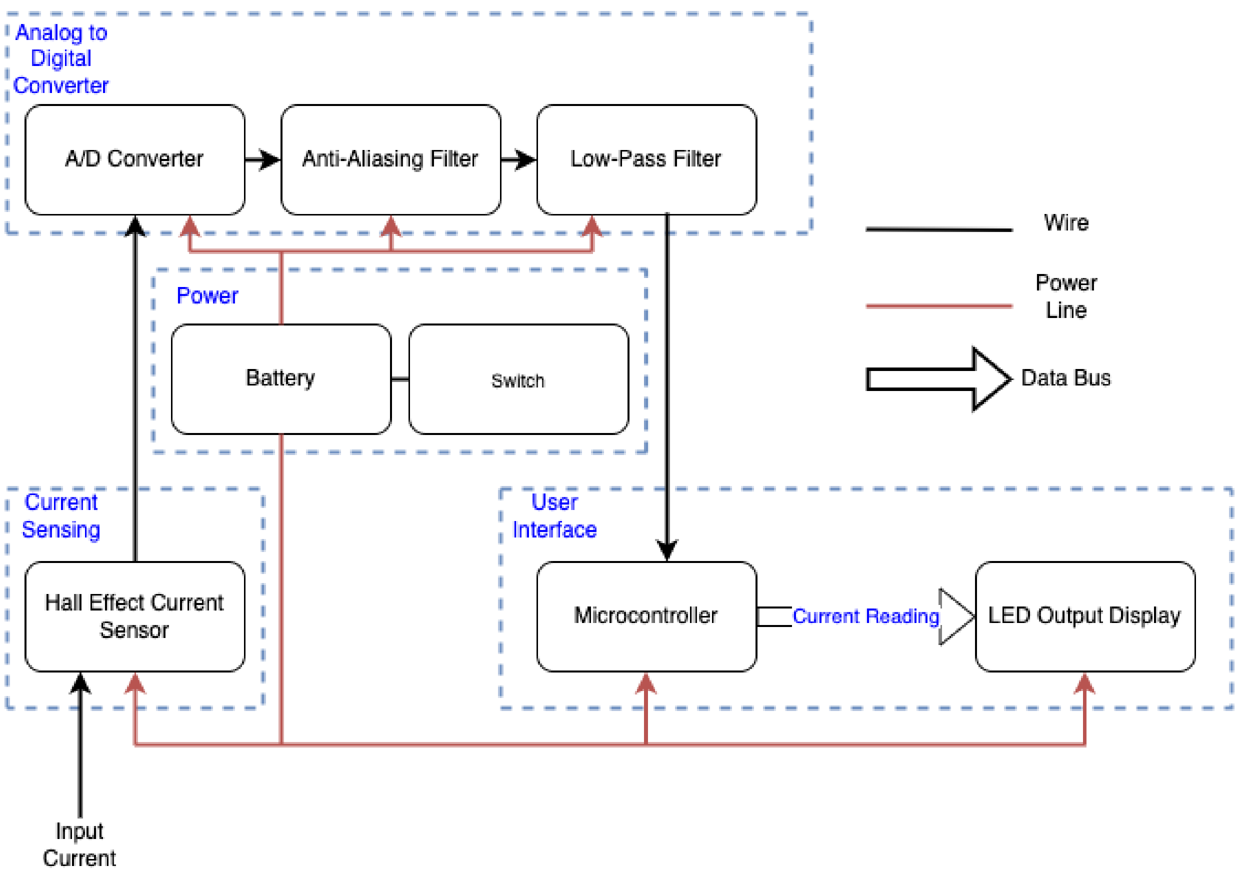
1. This product should have a reading accuracy of +/- 1% with 3 concurrent current inputs.

2. This product should have the ability to handle up to 50 KHz in bandwidth.

3. This product should have the ability to handle up to 10 Amps of current.

Block Diagrams





Subsystem Components

Hall-Effect Current Sensor:

We will utilize the Texas Instruments TMCS1100, a galvanically isolated Hall-effect current sensing IC, to accurately measure current through a system. This chip will receive the current that we want to read and output voltage to the analog to digital converter. This current detector should function between +/- 10A.

Analog to Digital Converter:

The next subsystem is the analog to digital converter. This takes the resulting analog voltage signal from the previous system, the Hall-effect sensor, and converts it into a digital signal. This signal will then be passed through an anti-aliasing filter and a low pass filter in order to get the final result. The output will connect to the microcontroller for further calculations. This subsystem must be able to take the output voltage from the current sensor and sample it at a high enough rate to achieve a bandwidth of 50kHz.

User Interface:

The final subsystem is the human interface, which will display the current reading from our device. Our system will have an ATtiny85-20SU microcontroller that takes the digital signal from the ADC and should be able to calculate the current passing through. This reading will be output to a seven segment display that should be accurate up to the hundredths decimal place, and be capable of displaying the information received from the microcontroller in real time.

Power

Our device will use a 5V battery to power each of the components. This battery will be turned on and off by a switch and should be able to power the circuit at 5 +/- 0.1V continuously.

Overall Risk:

Of all of the subsystems, the analog to digital converter poses the most risk to the completion of our project. It is the most complicated of the subsystems as it involves programming the filters onto the chip and it feeds the output needed into the microcontroller. The project also deals with 3 simultaneous current inputs, so the choice of ADC chip is crucial to ensure that all the requirements are being met.

Ethics and Safety Considerations:

In accordance with point 5 of the IEEE code of Ethics, it is important that we are honest about the claims and objectives that we achieve and hold ourselves accountable for errors and mistakes that may pop up over the course of the project. It is also important that as a group, we treat each other with respect and ensure that we abide by the IEEE code of ethics as dictated by points 7-10.

The main area of caution would be around the use of high currents. Our goal is to ensure that our device is able to handle currents up to ± 10 A, and issues may arise because of this. To prevent this we will ensure that 1) at least 2 of us are working on the project at all times, and 2) we will keep insulator objects around and put other safeguards in place to ensure no one gets hurt.