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APPLICATION NOTE

Introduction

The On Semiconductor eFuse protection devices are primarily used for limiting the system load current in the event of overload or short circuit conditions. Almost all of those eFuse protection devices provide additional features such as soft start, output voltage clamp, reverse current protection, adjustable load current limit with external resistor and so on. Some of the eFuses provide additional feature of load current monitoring which is implemented as a voltage output through an IMON pin. The user can measure the voltage at the IMON pin which would be proportional to the load current.

This application note describes the load current measurement solution for the eFuses which do not provide load current monitoring feature. Since almost all of the eFuses provide adjustable current limit functionality by utilizing an external current limiting resistor between I_{LIMIT} and Source pins, it is possible to connect a current sense amplifier across that resistor and measure the voltage drop across it which would be proportional to the load current. This method mainly requires a current sense amplifier and allows user to measure the system load current without introducing any additional resistance in series with the load path.

Schematics

A typical schematics of an eFuse configuration together with the 20 Ω RLIMIT resistor used for load current limit programming is shown in Figure 1. The load current measurement circuit implementation is shown within a dashed rectangle. Only current sense amplifier with a decoupling capacitor is required.

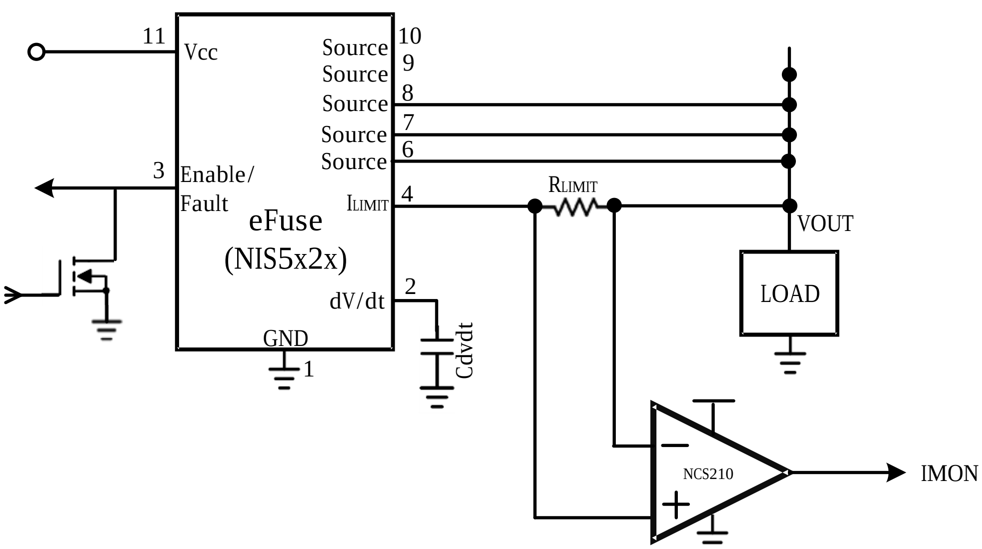

Figure 1. 12 V eFuse Configuration with Load Current Measurement Circuit

One of the most important parameters to consider when selecting a current sense amplifier are: wide common mode range, low offset voltage, low gain error, rail−to−rail input and output and a wide input supply range which exceeds the supply range of the eFuse input and output voltage.

Performance

The typical voltage drop across RLIMIT resistor versus load current for one of the ON Semiconductor 12V NIS5x2x eFuses is shown in Figure 3. For every 1 Amp of load current there is approximately 7.5 mV voltage drop across 20 Ω RLIMIT resistor, this voltage drop will depend on the value of the resistor and eFuse type, since every family of eFuse has its own proportion between the main load current and the current flowing across the RLIMIT resistor.

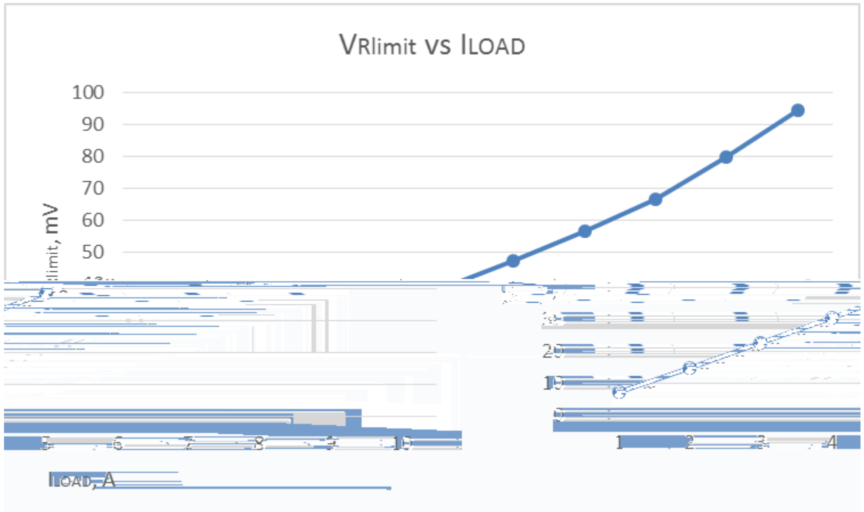

Figure 3. Voltage drop across RLIMIT versus the load current

The Figure 4 shows a schematics of two NIS5x2x eFuses connected in parallel.

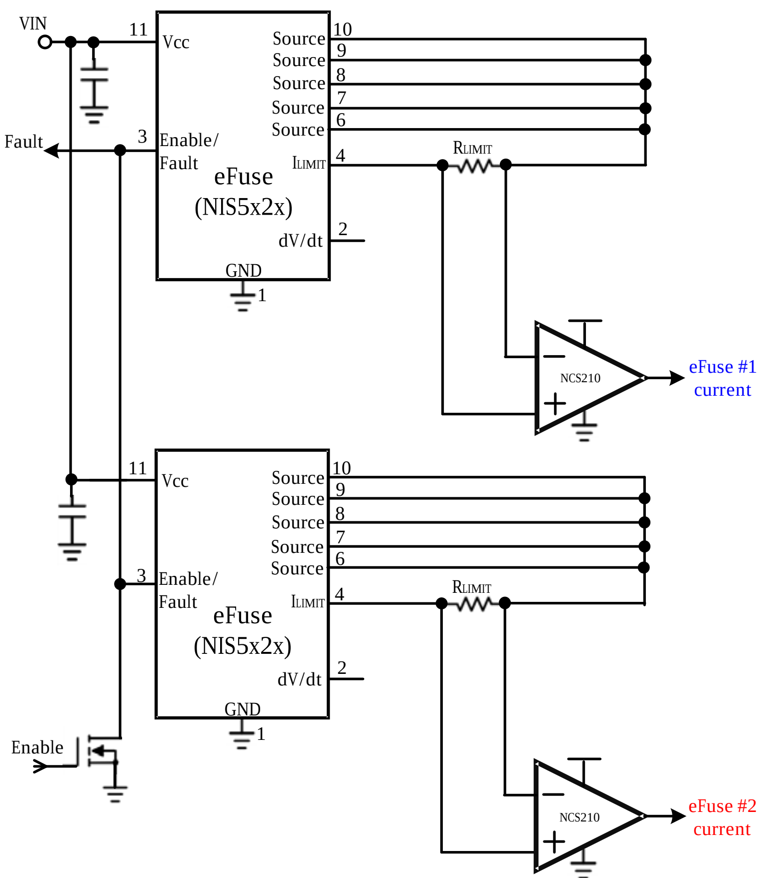

Figure 4. Parallel configuration of two NIS5x2x eFuses with individual load current monitoring

The Figure 5 shows the measurement error versus load current for the 12 V NIS5x2x eFuse. In this case one can achieve around 90% accuracy for most of the eFuse continuous current capability. The measurement accuracy would drop another 10−12% if the eFuse is operated at the maximum current rating.

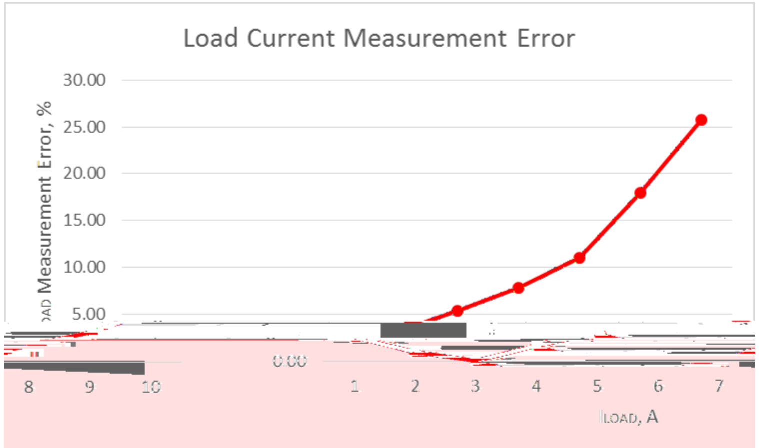

Figure 5. Load current measurement error vs Load Current

The Figure 6 shows a scope screenshot of a 20 A load hot plugged to the outputs of two NIS5x2x 12 V eFuses connected in parallel. Each eFuse in that configuration utilized a current sense amplifier across the RLIMIT resistor, the output of each current sense amplifier is connected to a scope and plotted as a red and blue traces. The purple trace shows the common connected VOUT voltage of two eFuses and the green trace shows the overall total current measured with instrumentation grade high−speed current probe. In this configuration a current sense amplifier similar to NCS210 but with a gain of 50 was used.

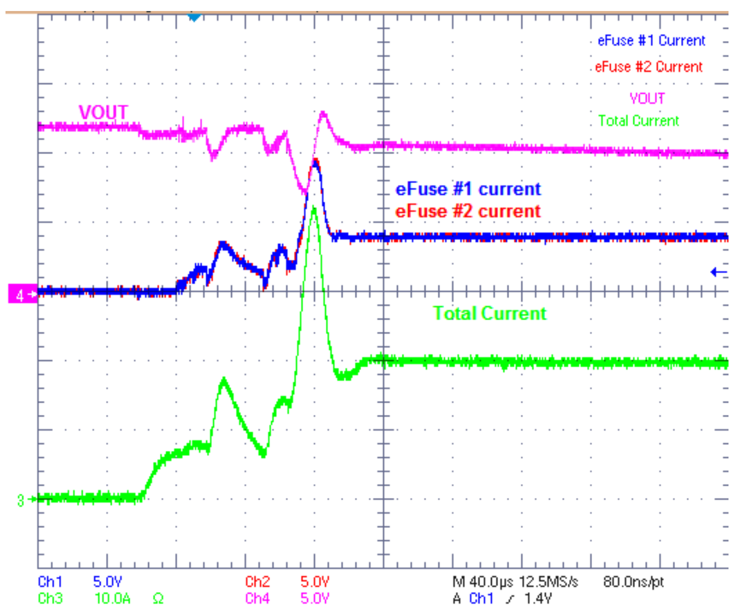

Figure 6. Hot plug to 20 A load and eFuse load current measurement

Once the hot plug event is gone the total current measured by an instrumentation current probe is settled to 20 A. Since the current is equally shared by eFuses connected in parallel, each eFuse in this case carries around 10 A current. From Figure 3, the voltage drop across 20 Ω RLIMIT resistor for this eFuse at 10 A load is around 94.3 mV, since we are using a current sense amplifier with a gain of 50, we see a voltage of around 94.3 mV x 50 = 4.7 V at the outputs of both current sense amplifiers as shown in red and blue traces in Figure 6.

The current is also perfectly shared among eFuses during a fast output load hot−plug event and properly measured by current sense amplifiers as seen from the scope shot in Figure 6, this can be achieved if current sense amplifiers are fast enough and provide 25−40 kHz 3dB bandwidth.

Conclusion

This application note demonstrated a cheap and effective way of adding a load current measurement solution to current limiting electronic fuses. The solution requires only one active device in a compact SOT−363 or UQFN10 package and minimum supporting passive components for it, such as decoupling capacitor. This solution provides measured load current not only in a static configuration but also during dynamic events.