# PROTECTING DC-DC CONVERTERS AGAINST REMOTE SENSE LINE REVERSE CONNECTION

A DC-DC converter failure can occur (1) when the remote sense lines are connected with the polarities reversed or (2) when one power line is disconnected and the load is still supplied through the remote sense lines. This Application Note describes a circuit that provides protection for the converter in such cases. A Vicor VI-J00 MiniMod is used for the data taken. The MiniMod is a family of component-level DC-DC converters that complement the higher-power VI-200 family of DC-DC converters. These "junior" converters offer up to 100W of isolated and regulated power in a board-mounted package.

A possible protection circuit is shown in Figure 1. The basic concept of this circuit is that, in case of failure, the diodes will by-pass the internal resistors of the module and keep the voltage drop on the sense pins at roughly 0.6V-0.7V. This means that the output voltage will increase to about 1.5V in the worst case. When the sense lines are reverse connected and the current is very high, the two semiconductor fuses will present a very high impedance, thus protecting the diodes. When the cause of failure is removed, the system will resume normal operation after the fuses cool.

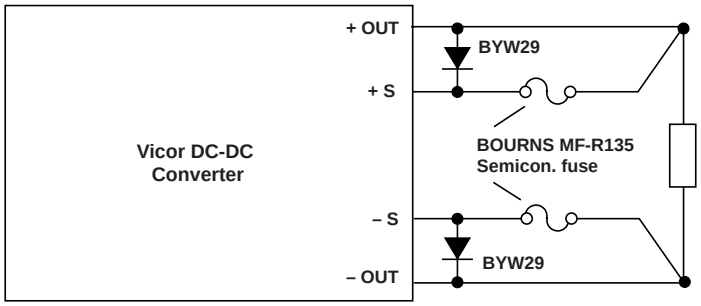


***Figure 1. DC-DC Converter Protection Circuit***

The two diodes are bipolar type instead of Schottky because, due to their high Vf, they will be completely transparent during the normal operation and will not affect remote sense regulation. Table 1 shows the sense voltage drop during normal operation. As it can be seen, this drop will never exceed 200mV, on a power line length of about 1 meter. Also, the specified remote sense compensation is 0.5V maximum. This will be below the direct drop of the diode.

| $I_L$ (A) | V +OUT/+S (mV) | V –OUT/–S (mV) |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 12.94 | 12.76 |
| 3 | 39.2 | 38.8 |
| 5 | 65.8 | 65 |
| 7 | 92 | 91 |
| 10 | 132 | 131.3 |

***Table 1. Sense Voltage Drop During Normal Operation (using a VI-J30-CY MiniMod)***

As with any other component, the semiconductor fuse has its own typical resistance that, together with the resistance of the module's internal resistor, can affect the load regulation characteristic. Table 2 shows how load regulation is affected by using the fuse or leaving the sense line directly connected to the load point.

The fuse introduces very little error to the output voltage. In most cases, it remains constant over the load range so it can be easily recovered by trimming the module if a specific set point voltage is required. The choice of a 1.35 A fuse requires a trade off between quick response time in case of fault and minimum load

| | Remote sense | | Remote sense with fuses | |
|---|---|---|---|---|
| $I_L$ (A) | $V_{out}$ (V) | $V_{Load}$ (V) | $V_{out}$ (V) | $V_{Load}$ (V) |
| 0 | 4.9877 | 4.9877 | 4.9876 | 4.9876 |
| 1 | 5.0131 | 4.9875 | 5.0139 | 4.9878 |
| 3 | 5.0656 | 4.9874 | 5.0664 | 4.9879 |
| 5 | 5.1181 | 4.9874 | 5.1191 | 4.9878 |
| 7 | 5.1711 | 4.9877 | 5.1719 | 4.9878 |
| 10 | 5.2509 | 4.9878 | 5.2524 | 4.9878 |

***Table 2. Load Regulation Characteristic (using a VI-JW2-CX MiniMod)***

regulation error. A lower current component would have a larger resistance which would introduce a larger error although the trip time and fault current are smaller.

Normally, the module short-circuit current is enough to cause the fuse to trip. However, in cases such as low power and high output voltage modules, even if the fuse doesn't trip, the diodes will act as a by-pass. Consequently, the current through them is far below their maximum rating; hence no damage will occur.

To summarize, this kind of protection allows for the DC-DC converter to be operated safely with no danger of damage due to a misconnection of the sense or output power lines. Even though a semiconductor fuse costs more than a conventional fuse, with an operating life of about 200 cycles it offers considerable economy because there is no need to replace it. The total cost of the circuit (less than $10) is an inexpensive means of protecting the DC-DC converter and its connected system.

For more information or to discuss your specific application requirements, please contact Vicor Application Engineering at 800-927-9474.