Adjustable Latching Output Overcurrent Circuit

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Introduction

Some applications employ power modules with greater output current capability than required by the load. The potential for damage to downstream PCB traces and components due to the high current source capability creates a need for an adjustable, latching, output overcurrent protection (OCP) circuit. This application note provides a simple, low component count OCP circuit that is readily adaptable for use with a wide range of Vicor DC-DC modules.

Circuit Features

The OCP circuit shown in Figure 1 is intended for use with any 48V nominal DC-DC converter module having an active "HIGH" PC or enable signal input. However, the circuit may be easily modified to function with a wide range of Vicor DC-DC products that feature a signal input pin for enable/disable control of the powertrain. As described, the OCP circuit has the following features:

- 2.5 – 60V operation, as shown
- No external, secondary power supply — sourced from module output
- Maintains SELV isolation
- User adjustable current limit — 50A as shown, higher currents achievable by adjusting current shunt and voltage reference resistive divider network
- Low component count

Theory of Operation

The circuit in Figure 1 is comprised of four essential components: a four-terminal current shunt resistor, a high side current sense amplifier, an ultralow power comparator with integral reference and an opto-TRIAC.

The current shunt resistor (R_S) is connected to the +OUT terminal of the module and is used as a current to voltage transducer for monitoring the module output current. In the example circuit, a 0.001Ω shunt is used, resulting in a voltage range of 0 – 50mV for a corresponding 0 – 50A of current flow.

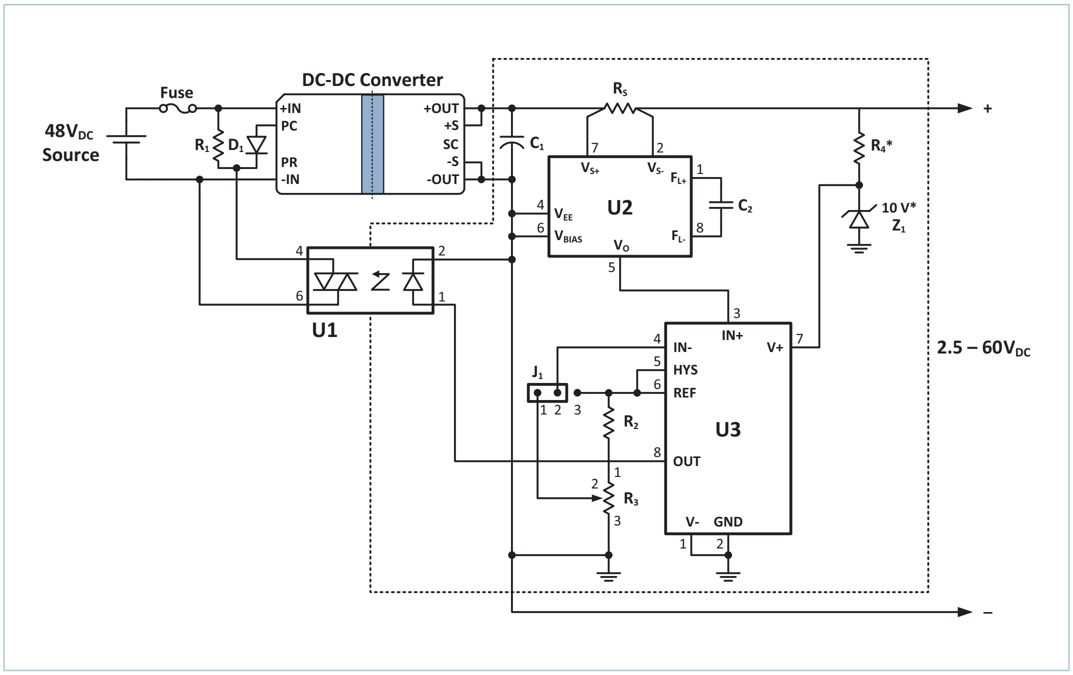
The shunt resistor voltage is supplied to a current sense amplifier (U2) that has a fixed voltage gain of 8. A wide range of precision current sense amplifiers are commonly available for applications requiring different gain and offset configurations. The amplifier output (0 – 400mV) is supplied to the non-inverting input of the comparator (U3). The inverting input of the comparator is a user adjustable voltage generated from a precision voltage reference internal to U3 (1.182V ± 1%) and a resistive divider formed by R_2 and R_3. With the provided component values, the voltage adjustment range is 0 – 0.394V. This programmable voltage reference serves as the overcurrent limit reference point. A jumper (J_1) tied to the inverting comparator input disables the OCP circuitry, allowing full current operation of the DC-DC module.

In an overcurrent condition, a voltage greater than the set reference level is applied to the non-inverting comparator input, generating a logic "HIGH" from the comparator output. This signal is used as the drive for the photodiode side of the opto-TRIAC (U1), triggering the device. Once triggered, the TRIAC typically requires just 100µA to remain latched. This latching current is provided by the combination of R_1 and D_1 connected on the module input side. The configuration shown is intended for modules having an active "HIGH" PC or enable control input pin. The TRIAC latches closed in response to a sensed overcurrent condition, pulling the PC or enable pin low and disabling module. Modules with an active "LOW" PC or enable configuration require a different arrangement of U1, R_1 and D_1.

Module input voltages up to 400V may be accommodated by modifying R_1 to ensure the recommended TRIAC latch current is supplied.

The OCP circuit is reset by cycling the input voltage. Alternatively, a suitably rated normally closed switch between R_1 and U_1 may be used to reset the circuit.

Figure 1
Adjustable Output Overcurrent Protection Circuit



Component Values:

R_S = 0.001Ω four terminal current shunt

R_1 = 72kΩ

R_2 = 10kΩ

R_3 = 5kΩ trim for 0 – 50A (for >50A increase R3)

***R_4** = 0Ω for outputs ≤ 10V, variable depending on outputs > 10V

C_1 = 100µF (consult specific module datasheet for output capacitance requirements)

C_2 = 0.1µF

***Z_1** = 10V, may be omitted if output ≤ 10V

U1 = MOC3022

U2 = LT1787HV

U3 = LTC1440

Circuit Considerations

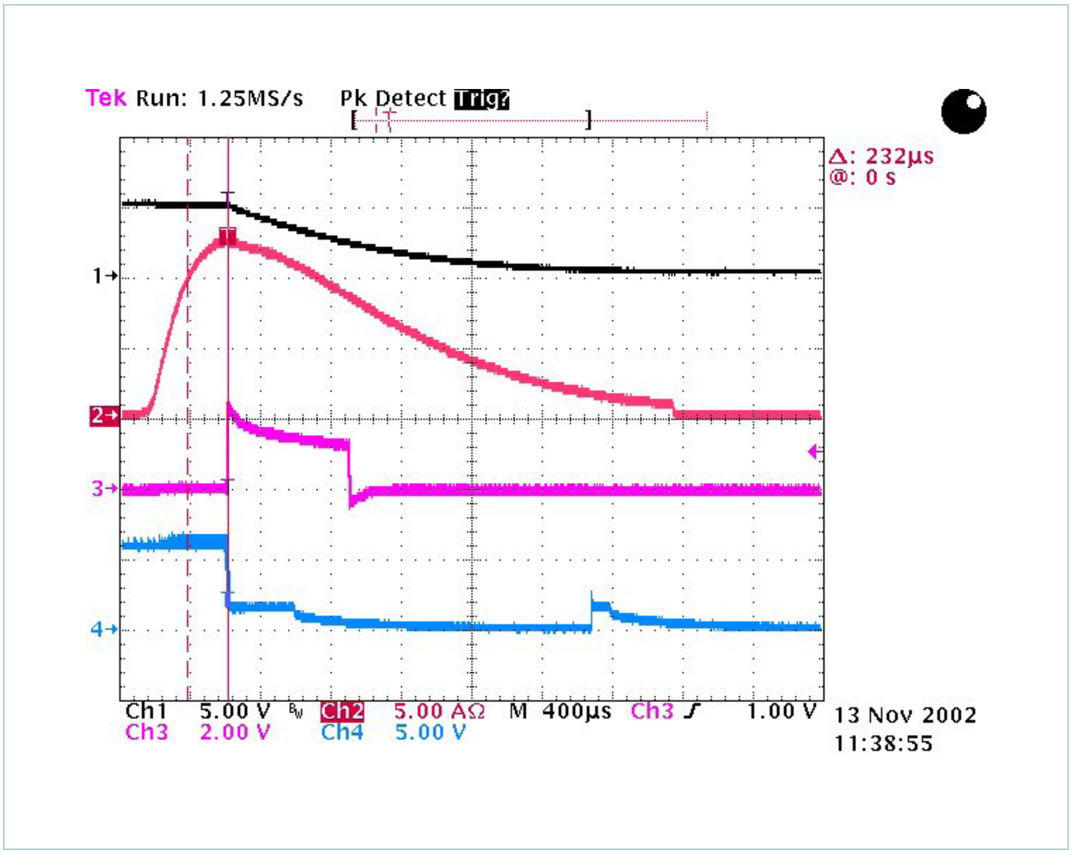
Proper operation of the OCP circuit depends on accurate module output current monitoring via the current shunt resistor. Use of a high quality, four terminal shunt resistor is strongly recommended to ensure accurate sensing of the module output current. Care should be taken to properly connect this device using Kelvin connections such that contact and/or PCB trace impedances do not degrade the current measurement and result in unintended circuit behavior. A heatsink or other thermal management system may be required given the specific environmental conditions of the application.

A short circuit occurring between the converter module and current shunt resistor will render this circuit ineffective. The circuit may also fail to operate properly if a short circuit is present upon module startup, as there may not be sufficient voltage present to supply the current sense amplifier and comparator.

Comparator U3 has an input supply voltage range of 2 – 11V. For this reason, a voltage clamp circuit should be employed when used with modules having an output voltage greater than 10V. In Figure 1, the comparator supply voltage is limited to 10V by R_4 and Z_1. Resistor R_4 is sized to limit the current through the Zener diode to an acceptable level.

Experimental Results

Figure 2
Sample Overcurrent Response Timing Waveforms, OCP Trip Set for ~10A (delay indicated)



CH1 – Output voltage of module

CH2 – Output current

CH3 – Output of comparator U3 (refer to Figure 1)

CH4 – PC pin of module

Figure 3
OCP Prototype Circuit and V48A5C400A Test Module Capable of 80A at 5V Output

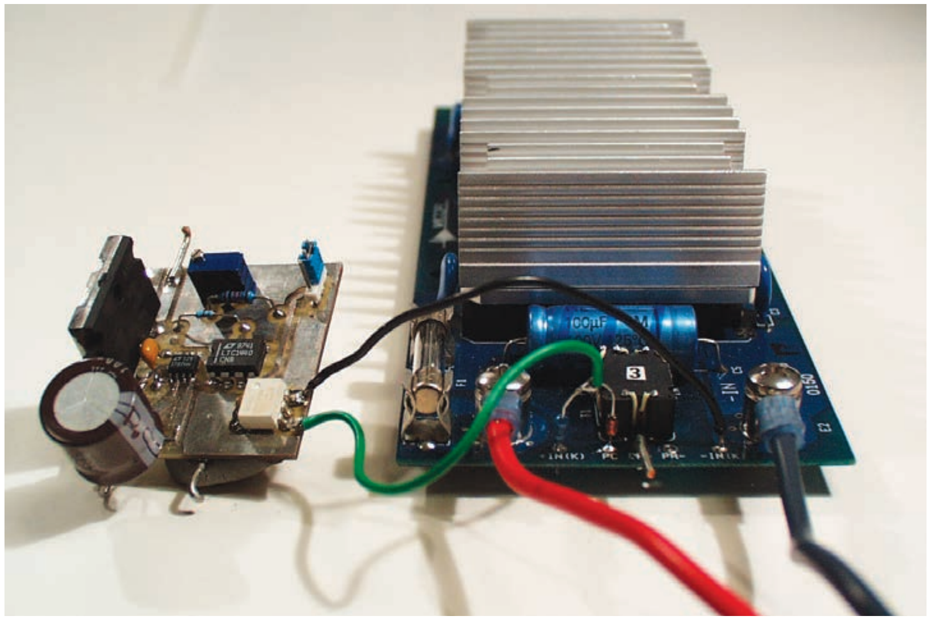
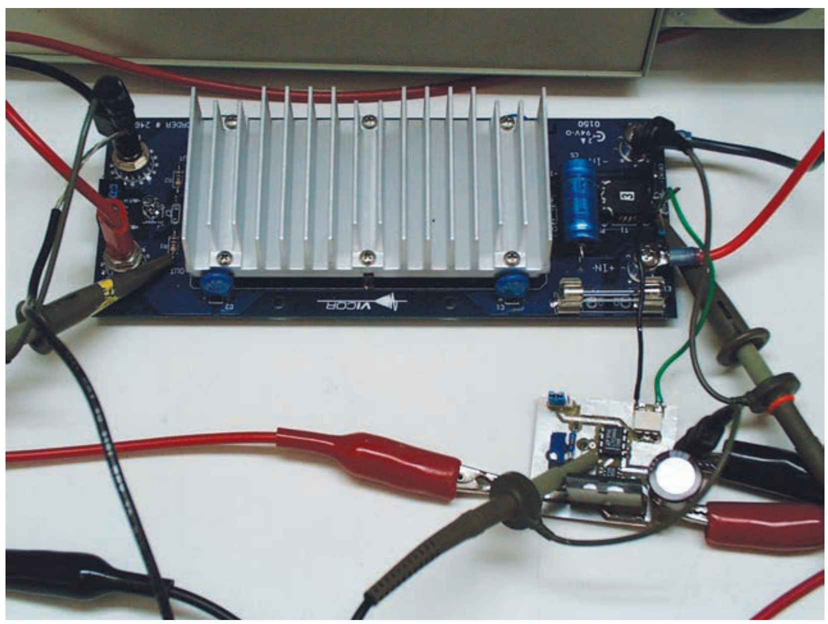


Figure 4
Circuit as Tested



Conclusion

This application note presents a simple, user-adjustable output overcurrent protection circuit for application with Vicor DC-DC converter modules. This circuit enables custom overcurrent trip levels to be easily configured for protecting downstream power components and PCB interconnects in applications where the full rated module current exceeds requirements and could be damaging if applied.

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