MIC2039 Single Input, Stack Configuration for High Current Applications

Introduction

Because processors are required to work faster with each successive generation and the consumer electronics market is expanding, the demand for compact power control circuits with high current capability is ever increasing. The MIC2039 switches feature an adjustable output current limit that is resistor programmable from 0.2A to 2.5A. To address higher current requirements, the MIC2039 can be implemented to provide 2x to 4x the maximum rated current by stacking the switches in a parallel circuit configuration using a single input supply.

Stacking multiple MIC2039 switches in parallel can provide from 5A to 10A to downstream circuits from a single input supply. The circuit in Figure 1 provides 5A using two MIC2039 ICs. Each MIC2039 is configured for the maximum current limit of 2.5A by connecting a 115Ω resistor from the ILIMIT pin (pin 5) to ground.

The MIC2039 switches also offer Kickstart, a unique feature that allows momentary high-current surges up to the secondary current limit (I_{LIMIT_2nd}) during start-up or while operating in steady state. This is useful for charging loads with high inrush currents, such as large capacitors. After an overcurrent condition is established, these switches enter into a constant current limit mode unless the die temperature exceeds the thermal shutdown specification.

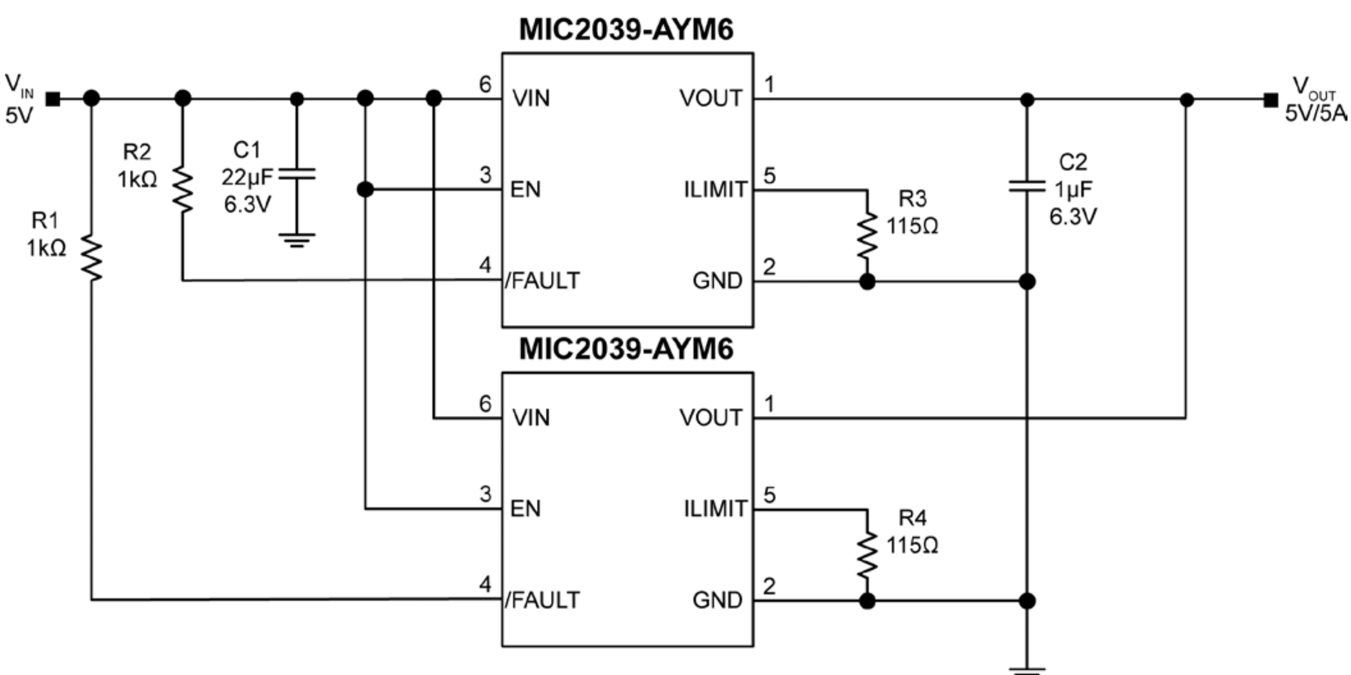

Figure 1. 5A Dual-MIC2039 Parallel Configuration

MIC2039 Basic Operation

The MIC2039 operates from as low as 2.5V to as high as 5.5V. The specification for the 2.5A current limit setting, at an input of 5V and at 25°C, ranges from 2.35A to 2.65A. At the minimum supply of 2.5V, the short-circuit current is also specified in the datasheet, ranging from 2.6A to 3.1A for the 2.5A current limit setting.

For many higher-current applications, systems often require a minimum current to be delivered while also ensuring a maximum current limit as a safeguard. With a 6% tolerance on the current limit, the MIC2039 is ideally suited to meet these systems' dual requirements.

Component Selection

The MIC2039 requires very few external components for operation. For each MIC2039 used in a stacked, or parallel, configuration, only four passive components are needed, two capacitors and two resistors.

Input Capacitor

A 1µF to 10µF ceramic input capacitor is recommended for most applications.

Place the input capacitor on the same side of the board and very close to the MIC2039 to minimize the voltage ringing during transient and short circuit conditions. Using multiple vias for each end of the capacitor to connect to the power and ground plane is also recommended.

X7R or X5R dielectric ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% and 60%, respectively, over their operating temperature ranges. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than an X7R ceramic or a tantalum capacitor to ensure the same capacitance value over the operating temperature range.

Output Capacitor

The output capacitor type and placement criteria are the same as for the input capacitor; however, larger value capacitors can be used. See the "Input Capacitor" section for a detailed description.

Enable

The MIC2039 offers either an active-high or active-low enable input (EN) that allows ON/OFF control of the switch output. The current through the device reduces to near zero when the device is shut down, with only microamperes of leakage current. The active high EN inputs of multiple ICs are tied together and may be directly tied to V_{IN} or driven by a voltage that is equal to or less than V_{IN}. For the A option (active-high), to eliminate the potential for either of the stacked devices to turn on ahead of the other(s) based on the threshold differences (small ΔV), it is recommended to drive these pins with a signal that has fast edge times, both rising and falling. For the B option (active-low), tie all of the EN pins to GND or drive similarly with a fast edge logic signal. Do not leave this pin floating.

Design Guidelines for High Current Applications

Current Limit

The MIC2039 current limit is adjustable from 0.2A to 2.5A by connecting a resistor from the ILIMIT pin to GND. The resistor can be determined from Equation 1:

$$R_{LIMIT} \cong 289 / I_{LIMIT} \qquad \text{Eq. 1}$$

where I_{LIMIT} is the typical current limit from the electrical table.

If the output current exceeds the set current limit, then the MIC2039 switch will enter constant current limit mode. The response plot in Figure 2 illustrates both the 5A (maximum) steady state load and the way V_{IN} is affected by large current loads. Sufficient bulk capacitor bypass is recommended to maintain a stable input supply. The ±1% tolerance resistor value recommended for the highest available current of 2.5A is 115Ω. For applications that have a minimum load requirement, for example 5A minimum, selecting a slightly smaller precision resistor than the recommended value in the range of 105Ω to 110Ω for each 2.5A device, is advised. Figure 3 illustrates the 10A steady state load response implemented using four MIC2039 ICs.

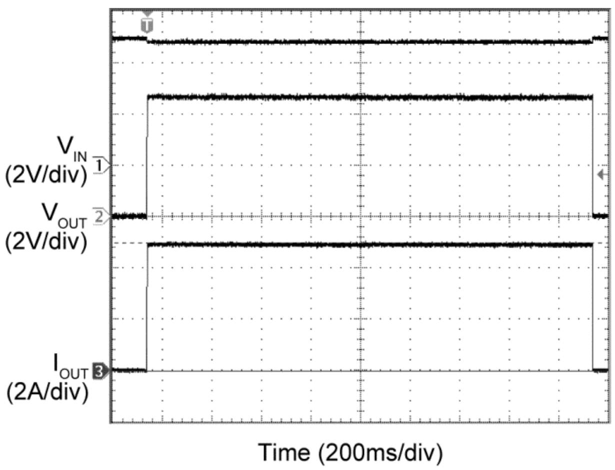

Figure 2. MIC2039 Dual-Configuration (5A)

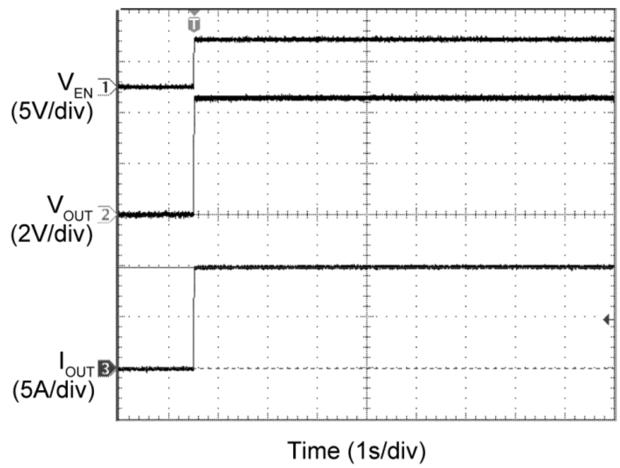

Figure 3. MIC2039 Quad-Configuration (10A)

The current-sharing of multiple, parallel MIC2039 ICs can be made very close to equivalent, in large part because process considerations produce near ideal matching of the internal power MOSFETs from IC to IC. Figure 4 and Figure 5 show that the $R_{DS(ON)}$ is 75mΩ at 25°C (with V_{IN} = 5V). With this in mind, heating effects will change $R_{DS(ON)}$ from its nominal value and may introduce error in the device matching. The maximum allowable current limit may also be less than the full specified and/or expected current if the MIC2039 is not mounted on a circuit board with sufficiently low thermal resistance.

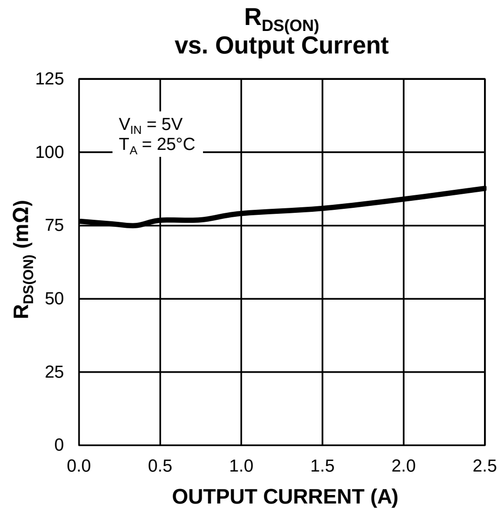

Figure 4. $R_{DS(ON)}$ at Room Temperature

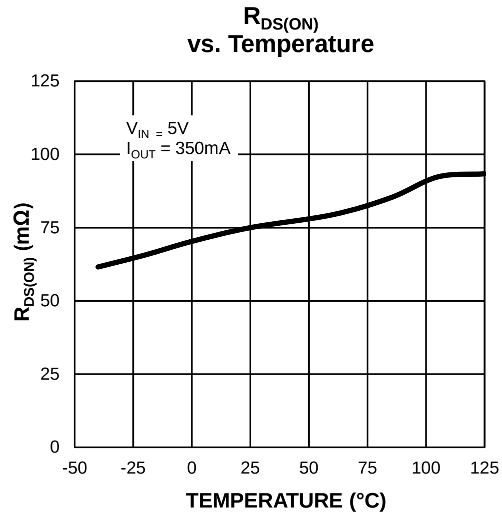

Figure 5. $R_{DS(ON)}$ vs. Temperature

Thermal Design

To help reduce the thermal resistance, the ePad (underneath the IC) should be soldered to the PCB ground and the thermal vias should be placed either underneath or near the ePad. Good thermal design requires consideration of the following application-specific parameters:

- Maximum ambient temperature (T_A)
- Package thermal resistance (θ_{JA})
- Output current (I_{OUT})
- Input voltage (V_{IN})
- Current limit (I_{LIMIT})

When the MIC2039 is in constant current limit mode, it may exceed the overtemperature threshold. If this occurs, the overtemperature condition will shut down the MIC2039 switch and the fault status flag will go active (assert low). After the switch cools down, it will automatically turn on again. The MIC2039 power dissipation can be maximized by either lowering the thermal resistance on the exposed pad (only the DFN package has an exposed pad) on the printed circuit board as mentioned earlier in this paragraph, or by limiting the maximum allowable ambient temperature.

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