by William Mai

Overview

The need for hot insertion capability has dramatically increased due to the demand of reducing system down time and portability. The effect of hot insertion is an inrush current or surge current which is produced when any uncharged capacitors are connected to a power supply. The larger the capacitors, the more energy is needed to charge them. Inrush current can cause the voltage of the power supply to droop to a level where system logic can be confused. This application note describes one of the techniques to minimize the inrush current to allow the user to utilize bulk capacitors of any size for hot insertion applications. In addition, with this solution the user does not have to wait for a long period of time between multiple insertions.

Circuit Description

Instead of charging the capacitor in a short period of time, the idea is to charge the capacitor in a long period of time by limiting the charge current. The circuit in Figure 1 uses the MIC2545A-2 and the MIC2778. The MIC2545A-2 is a programmable current limit high-side switch that is capable of having current-limit up to 2.5A. The current-limit is set by the external resistor. In this circuit, there are two current-limits, 100mA and 500mA. USB specifications limit the device current to 100mA prior to enumeration. After enumeration, a high-powered device can request no more than 500mA. This circuit will guarantee these limits are not exceeded. The MIC2778 is a voltage monitor with adjustable hysteresis and that operate down to 1.5V. The high and low thresholds are set at 4V and 2V respectively. The equation below shows how to calculate the resistors' value for the two thresholds and the two current-limits.

Thresholds

$$V_{high\ threshold} = V_{REF}\frac{R1+R2+R3}{R3}$$

$$V_{low\ threshold} = V_{REF}\frac{R1+R2+R3}{R2+R3}$$

$$V_{REF} = 1.24V$$

Set R1+R2+R3 = 1MΩ

$$V_{high\ threshold} = 4V = 1.24\frac{1M\Omega}{R3}$$

$$R3 = 310k$$

$$V_{low\ threshold} = 2V = 1.24\frac{1M\Omega}{R2+310k}$$

$$R2 = 310k$$

$$R1 = 1M\Omega - 310k - 310k = 380k$$

Current-limit

$$\text{Current limit} = \frac{230}{R_{SET}}$$

where:

Current factor = 230

$$100mA = \frac{230}{R_{SET}}$$

$$R_{SET1} = \frac{230}{100mA} \approx 2.2k$$

$$500mA = \frac{230}{R_{SET1} \| R_{SET2}}$$

(continued)

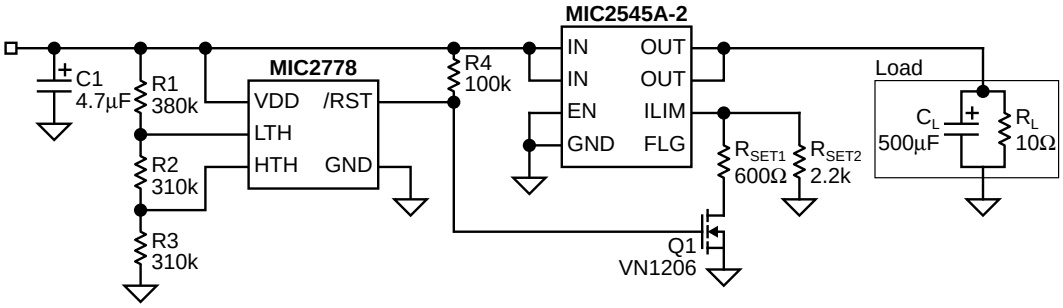

Figure 1. Dual Current-Limiting Switch

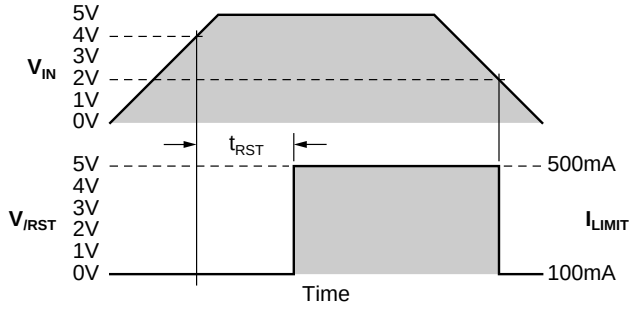

Figure 2. Timing Diagram

$$R_{SET1} \| R_{SET2} = \frac{230}{500mA} = 460\Omega$$

$$R_{SET2} \approx 0.6k$$

When V_{IN} is hot-plugged to a 5V power supply, the voltage will ramp up from 0V to 5V (Figure 2). When V_{IN} crosses 4V, the delay generator of the MIC2778 turns on allowing the $V_{/RST}$ to remains low for a minimum of 140ms. The delay feature is important in this application because it guarantees V_{IN} will be at 5V when the delay is off. It also allows the MIC2545A-2 to charge the capacitor with less than 100mA (Figure 4). Once the delay is off, the $V_{/RST}$ is pulled up to 5V. Q1 turns on to parallel the 2.2k and 600Ω to set the current limit for the MIC2545A-2 at 500mA. When V_{IN} is unplugged, its voltage will ramp down. Once the V_{IN} crosses 2V, the MIC2545A-2's current limit is reset back to 100mA.

In Figure 5, a logic control can be used to switch the current limit from 100mA to 500mA. The difference between the two circuits is that the MIC2778 allows the circuit to switch automatically.

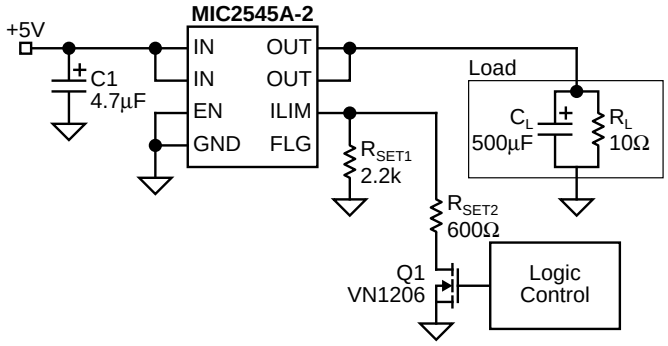

Figure 5. Logic-Controlled Current-Limit Setpoint

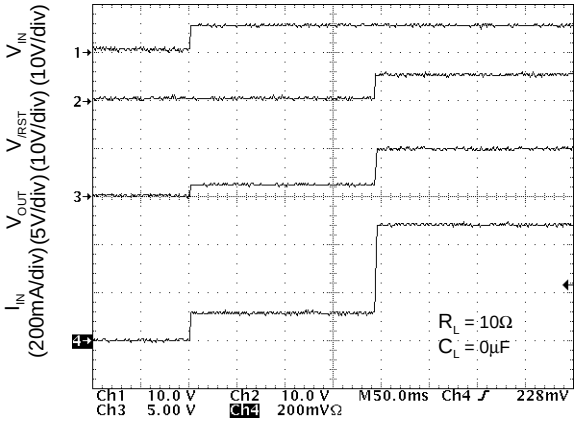

Figure 3. Dual Current Limiting

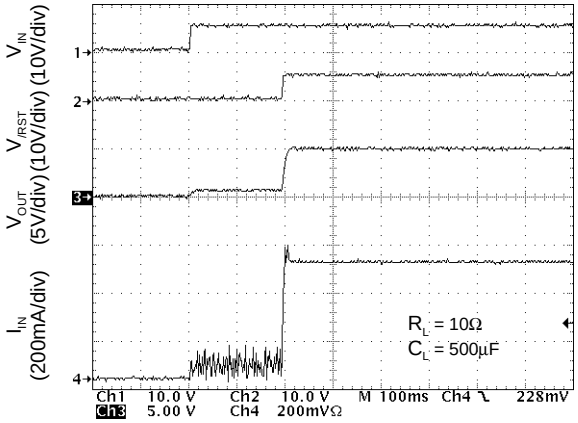

Figure 4. Inrush-Current Limiting

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