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How to Meet 24-V Hot Plug-in Test for Charge Front-End bq243xx

Mao Ye   *PMP - Battery Charge Management*

ABSTRACT

The maximum input voltage rating of the bq243xx family of ICs is 30 V. However, some customers like to perform a 24-V hot plug-in transient test to prove its high-voltage capability and reliability from a system level. It is important for system designers to properly design the charging system with correct system-level protections. Usually, a TVS (transient voltage suppression) Zener diode is used for clamping such high-pulse transient voltage so that the maximum input voltage from the charge front-end (CFE) protectors bq243xx is less than absolute maximum voltage for safe operation.

Test Setup:

Figure 1 shows the 24-V hot plug-in transient test schematic. A 1-µF input and a 1-µF output capacitors are used for CFE. First, a soft start-up with a 24-V voltage is applied to show that a slow, ramp-up input voltage does not generate any overvoltage spike. Secondly, a 24-V hot plug-in was tested to show that without the TVS Zener diode, the voltage spike can exceed the bq243xx absolute maximum voltage of 30 V. After that, a proper TVS Zener diode was added to show that it clamps the voltage to make the bq243xx devices work in a safe range.
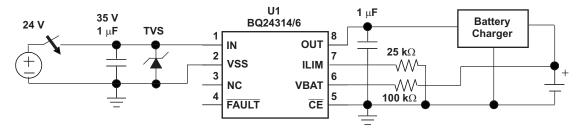

Figure 1. 24-V Hot Plug-in Transient Test Schematic

In the following test waveforms, CH3 and CH4 are represented as follows:

CH3: IN pin

CH4: input current, measured before the input capacitor, 5 A/div.

Test One: No TVS Zener Diode, 24-V Soft Start-up

Figure 2 shows the input voltage and current waveforms. Due to the soft start-up, neither voltage spike nor input inrush current occurs at input pin of the bqCFE .
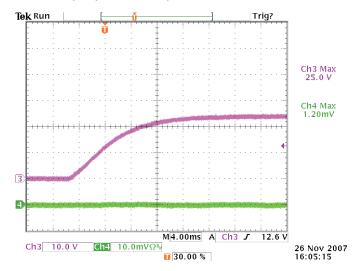

Figure 2. Soft Start-up of 24-V Input Voltage, CH3 10 V/div, CH4 5 A/div

Test Two: No TVS Zener Diode, 24-V Hot Plug-in

Due to the hot plug-in, the input pin of the bq243xx can have very high voltage due to the resonance between the cable inductance and the input decoupling capacitor of the bq243xx. Ideally, the voltage spike can be up to two times the input voltage. But the equivalent resistance of the cable and the input capacitor damp the oscillation. The practical voltage spike is approximately 1.2 to 1.8 times the input voltage as shown in Figure 3. Without any additional component, this high voltage may damage the bq243xx.
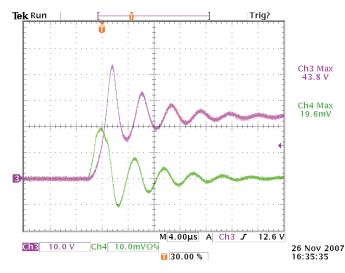

Figure 3. 24-V Hot Plug-in Without TVS Zener Diode, CH3 10 V/div, CH4 5 A/div

Test Three: Add TVS Zener Diode MMBZ27VCLT, 24-V Hot Plug-in

A SOT-23 package TVS Zener Diode MMBZ27VCLT (http://www.onsemi.com) was added at input side to clamp the voltage spike. The hot plug-in waveform is shown in Figure 4. The peak voltage spike is limited to 31 V. The clamping voltage is determined by the inrush current flowing through the Zener diode. The higher the inrush current, the higher the clamping voltage is. Select a Zener diode which has a lower clamping voltage with the same amount of inrush current.
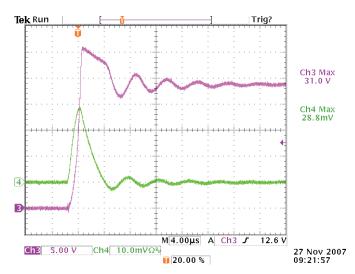
Figure 4. 24V Hot Plug-in With TVS Zener Diode MMBZ27VCLT, CH3 5V/div, CH4 5A/div

Test Four: Add TVS Zener Diode DFLT24A, 24-V Hot Plug-in

A PowerDI-123 package TVS Zener Diode DFLT24A (http://www.diodes.com) was added at the input side to clamp the voltage spike. The test result is shown in Figure 5. The peak voltage spike is limited to 29 V. This Zener diode has better performance compared with the previous one. It has lower clamping voltage under the same amount of current flowing through the Zener diode.
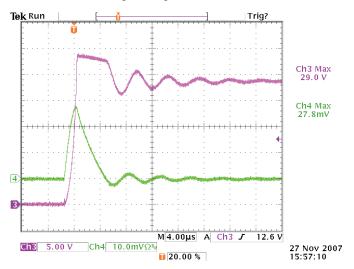

Figure 5. 24-V Hot Plug-in With TVS Zener Diode DFLT24A, CH3 5 V/div, CH4 5 A/div

Conclusion

For a 24-V hot plug-in test, use a TVS Zener diode to clamp the input voltage spike. In summary, bq243xx devices can pass the 24-V hot plug-in transient test with the setup shown Figure 1 using the recommended TVS Zener diodes.

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