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Keywords: DS2784,2784,thermal protection,temperature control,fuel gauge,gas gauge,battery monitor,lithium ion,li+,battery protection,stand-alone

#### APPLICATION NOTE 4192

# Adding Thermal Protection to the DS2784 Stand-Alone Fuel Gauge

Mar 26, 2008

*Abstract: The DS2784 stand-alone fuel gauge provides overvoltage and overcurrent protection to lithium-ion (Li+) batteries. Some newer Li+ applications, however, also necessitate thermal protection. This application note illustrates how to implement programmable temperature control by adding a MAX6506 temperature sensor and a MAX4613 analog switch to the typical DS2784 application circuit. Full functionality of the DS2784 is maintained with the additional components.*

## Introduction

The [DS2784](#) stand-alone fuel gauge provides precision voltage, temperature, and current measurements, as well as a built-in SHA-1 authentication algorithm. The integrated safety circuitry protects lithium-ion (Li+) batteries from overvoltage, undervoltage, overcurrent, and short-circuit faults. For an additional level of safety, programmable thermal protection can be added to the typical application circuit with a [MAX6506](#) dual-threshold temperature switch and a [MAX4613](#) quad SPST analog switch. **Figure 1** shows the application circuit with these additional ICs.

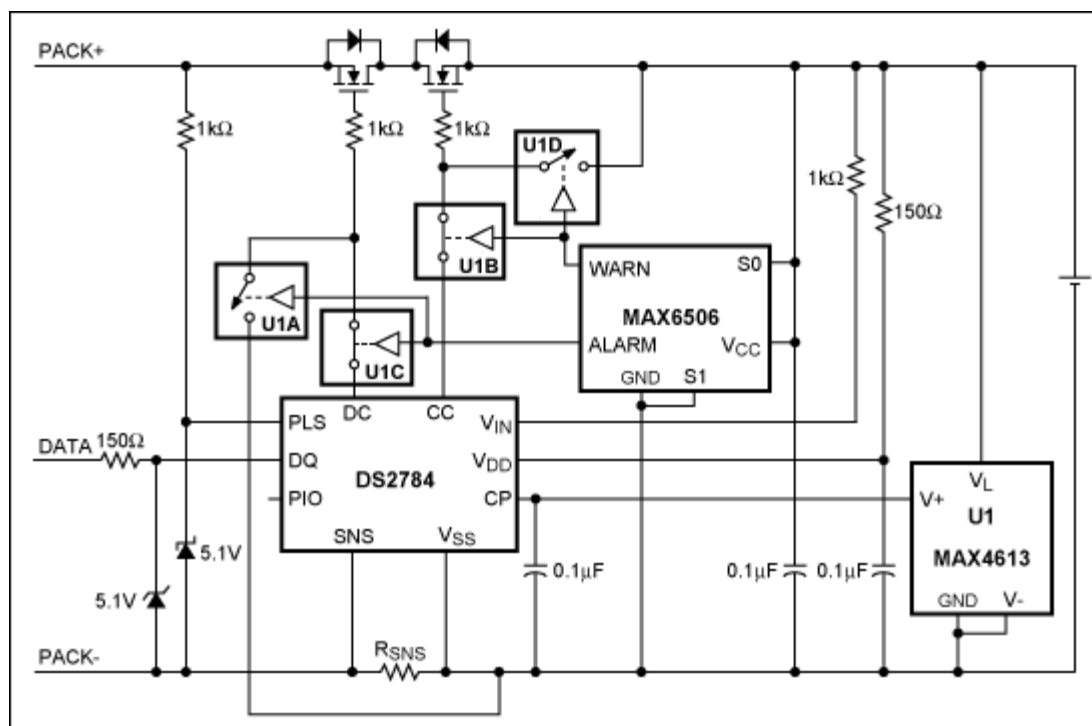


Figure 1. The MAX6506 and MAX4613 can be added to the DS2784 application circuit to provide programmable thermal protection. (Switches U1A–U1D represent the four switches inside the MAX4613.)

## Schematic Details

The MAX6506 provides two active-high, push-pull output drivers that assert when the temperature crosses their trip thresholds. The ALARM pin temperature threshold is factory programmed, while the WARN pin can be programmed by the user to a level below the ALARM threshold based on the S0 and S1 pins. The Figure 1 configuration is set-up such that WARN trips 10°C below the ALARM threshold. The MAX6506's 2.5V to 5.5V  $V_{CC}$  range and low (40μA, typ) current consumption make it perfect for single-cell applications.

The MAX4613 provides two normally open (NO) single-pole/single-throw (SPST) switches and two normally closed (NC) SPST switches. The MAX4613 supports supply voltages up to 40V. Its  $V_+$  pin must be connected to the CP pin of the DS2784 so that the analog switches can pass the high voltage gate drive from the discharge-control (DC) and charge-control (CC) pins to the protection FETs. The MAX4613's switch control signals are referenced to a separate digital logic supply pin ( $V_L$ ).  $V_L$  must be connected to the same supply as the MAX6506; thus, it is connected to the battery's positive terminal. Both the supply current and the logic current of the MAX4613 are specified at a maximum of 5μA each for a total maximum current of 10μA.

## Circuit Operation

When the temperature of the MAX6506 reaches the user-programmed trip point for the WARN level, the WARN pin drives high. This disables U1B and removes the CC high voltage drive from the CC protection FET. At the same time, the switch U1D is closed, and the CC protection FET gate is connected to the battery voltage. This keeps the CC protection FET off and sets the  $V_{GS}$  voltage to zero. The WARN pin has a factory-set typical temperature hysteresis of 5°C.

If the temperature of the MAX6506 continues to rise and reaches the factory-programmed trip point for the ALARM level, the ALARM pin drives high. This disables U1C and removes the DC high voltage drive from the

DC protection FET. At the same time, the switch U1A is closed, and the DC protection FET gate is connected to  $V_{SS}$ . This keeps the DC protection FET off. The ALARM pin has a typical temperature hysteresis of 2°C. **Figure 2** shows the circuit operation.

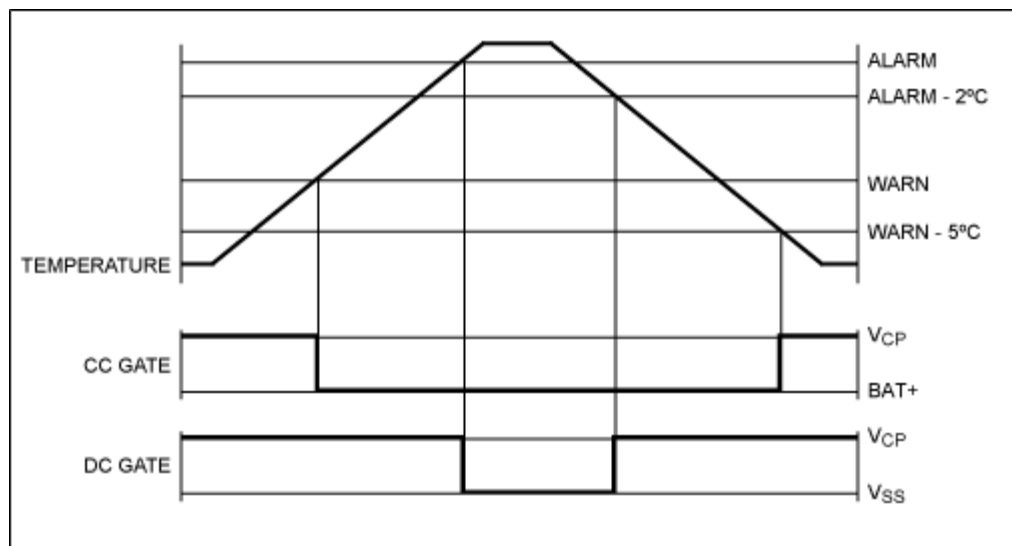


Figure 2. CC and DC gate operation over temperature.

## Conclusion

The DS2784 is a full-featured, stand-alone fuel gauge that provides precision analog measurements, protection for Li+ batteries, and SHA-1 authentication. The protection circuitry ensures complete voltage and current protection. This application note has detailed a simple method for providing programmable thermal protection with the DS2784 by simply adding two ICs to the typical application circuit. The two additional ICs allow staged temperature control of the CC and DC FETs. Full functionality of the DS2784 is retained with these additional components.

Related Parts		
<a href="#">DS2784</a>	1-Cell Stand-Alone Fuel Gauge IC with Li+ Protector and SHA-1 Authentication	<a href="#">Free Samples</a>
<a href="#">MAX4613</a>	Quad, SPST Analog Switch	<a href="#">Free Samples</a>
<a href="#">MAX6506</a>	Dual Trip SOT Temperature Switches	

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