



Keywords: DS2786, 2786, OCV, open circuit voltage, fuel-gauge, two-cell, 2-cell, multiple-cell, lithium, li-ion, battery, Li+ Aug 27, 2007

#### APPLICATION NOTE 4106

## Using the DS2786 Battery Fuel Gauge in a 2-Cell Battery Pack

*Abstract: The DS2786 stand-alone, open-circuit-voltage (OCV)-based fuel gauge has an operating range designed for a single-cell lithium-ion (Li+, Li-ion) battery pack. However, the DS2786 can also be used in a 2-cell battery pack by adding a few extra components to the typical application circuit. This application note details a circuit for using the DS2786 in a 2-cell battery pack.*

### Overview

The [DS2786](#) stand-alone open-circuit-voltage (OCV)-based fuel gauge estimates available capacity for lithium-ion and polymer batteries based on the cell voltage in an open-circuit state following a relaxation period. The OCV is used to determine relative cell capacity based on a lookup table stored in the IC. This capability makes accurate capacity information available immediately after a battery pack is inserted.

While the DS2786's operating range is designed for use with a single-cell Li+ battery pack, it can also be used in a 2-cell battery pack with the addition of a few components. This application note details a circuit that only requires two additional ICs to utilize the DS2786 in a 2-cell battery pack. This circuit allows the use of all the DS2786's features, including on-chip voltage, current, and temperature measurement; two auxiliary voltage inputs; and a two-wire interface.

### Circuit Description

**Figure 1** illustrates a circuit for using the DS2786 in a 2-cell battery pack on the cell side of the protector. The circuit shown in Figure 1 adds two additional integrated circuits to a standard DS2786 circuit: a low-dropout linear regulator (LDO) and a 2N7000 FET.



If an overcharge condition occurs, the protector's CC pin is driven low, which opens the charge FET. The open charge FET protects the LDO from experiencing any overvoltage conditions, and the DS2786 remains enabled.

## Considerations

The DS2786 provides battery pack capacity estimates based on the open-circuit voltage presented at the  $V_{IN}$  pin. Because the circuit in Figure 1 only measures the voltage on one cell, the voltage-based capacity lookup table stored in the DS2786's EEPROM must be modified appropriately. The voltage and capacity values obtained by characterizing the battery pack should be stored in EEPROM with the voltage level divided by 2. For example, if the battery pack has a capacity of 80% at 8V, the stored value should be 80% at 4V.

The current path feeding the BAT1 voltage to the  $V_{IN}$  pin of the DS2786 adds an additional small load to the BAT1 cell that BAT2 does not experience. The average load current into  $V_{IN}$  was measured in the lab to linearly increase from 5nA to 9nA when BAT1 was swept from 2.5V to 5V. The maximum 9nA results in 9nAh of capacity per hour, which is  $9\text{nAh} \times 24 = 216\text{nAh}$  per day. In a year this is  $216\text{nAh} \times 365 = 78.84\mu\text{Ah}$ ; if the user assumes a 10 year life of the pack, this is  $78.84\mu\text{Ah} \times 10 = 788.4\mu\text{Ah}$ . This amount of cell mismatch is negligible and should not harm the battery pack.

## Summary

The DS2786 is designed for a single-cell lithium-ion battery pack but can be easily adapted to a 2-cell pack. The circuit described in this application note adds only two integrated circuits and an additional current draw of 2 $\mu$ A (typ). By implementing the described circuit, the 2-cell pack is able to use all of the features of the DS2786 for stand-alone OCV-based fuel gauging.

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Application Note 4106: <http://www.maxim-ic.com/an4106>

### More Information

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### Related Parts

DS2786: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

AN4106, AN 4106, APP4106, Appnote4106, Appnote 4106

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