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APPLICATION NOTE 4799

Cell Characterization Procedure for a ModelGauge™ m3 Fuel Gauge

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Abstract: To obtain the best performance of a Maxim ModelGauge m3 fuel gauge, the battery pack must first be characterized and its performance in an application fully understood. This application note explains the recommended cell-characterization procedure. Test parameters and definitions are given, and the data necessary to generate a trustworthy reference state of charge (SOC) are listed. The MAX17047 ModelGauge m3 fuel gauge serves as the example IC.

Introduction

To obtain the best performance from a Maxim ModelGauge m3 fuel gauge, the battery pack must be characterized so that the cell's behavior in an application can be fully understood. For each characterization, Maxim recommends charging the pack at room temperature and then discharging the pack at heavy, medium, and light loads at cold, room (ambient), and hot temperatures. Additionally, a stepped discharge is recommended to observe how the pack relaxes during discharging.

Cell Characterization Parameters

The battery pack should be cycled with the charging and discharging levels that will be used in the application. The following are example values for a single-cell battery pack.

Charge current:	C rate/2
Charge voltage:	4.2V
Terminating current:	50mA
Heavy load:	C rate
Medium load:	C rate/3
Light load:	C rate/10
Empty voltage (The shutoff voltage of the system, measured	

at the pack terminals similar to the MAX17047 on the system board):	3.0V
Hot:	+40°C
Room:	+20°C
Cold:	0°C

Definitions

Charge to full is charging the battery pack at the charge current until the pack voltage reaches the charge voltage. At that time, the voltage is held at the charge voltage until the current tapers below the terminating current. It is recommended that the cell "relax" for at least 30 minutes after each charge.

Discharge is a constant-current loss of charge at the specified rate until the voltage of the battery pack drops to the empty voltage level. It is recommended that the cell relax for at least 30 minutes after each discharge.

Stepped discharge is discharging the cell at the heavy load for approximately 15% of the capacity of the battery, and then allowing the cell to relax for 40 minutes. For a 1 C discharge rate, a stepped discharge of 10 minutes is recommended. Continue these 15% discharge steps until the voltage reaches the empty voltage level.

To allow the battery to relax between the relaxed states of the first stepped discharge, a second stepped-discharge cycle should be run with a first step of 7.5% of the battery's capacity. For a 1 C discharge rate, a 5-minute discharge will provide the 7.5% offset. Continue with the original 15% discharge steps until the voltage reaches the empty voltage level.

Characterization Procedure

The following procedure is a pattern of charge/discharge cycles recommended for evaluating the performance of a fuel gauge. After each temperature change, the battery pack is kept at that temperature for 30 minutes as it relaxes while it acclimates to the new temperature.

1. Charge to full at +20°C/medium load discharge at +20°C
2. Charge to full at +20°C/medium load discharge at +20°C
   (Cycles 1 and 2 are used in the performance simulation to familiarize the fuel gauge with the battery.)
3. Charge to full at +20°C/heavy load discharge at 0°C
4. Charge to full at +20°C/light load discharge at 0°C
5. Charge to full at +20°C/heavy load discharge at +20°C
6. Charge to full at +20°C/light load discharge at +20°C
7. Charge to full at +20°C/heavy load discharge at +40°C

8. Charge to full at +20°C/light load discharge at +40°C
9. Charge to full at +20°C/stepped discharge at +20°C
10. Charge to full at +20°C/stepped discharge at +20°C offset by 7.5%
11. Charge to full at +20°C/medium load discharge at +20°C
12. Charge to full at +20°C/medium load discharge at 0°C
13. Charge to full at +20°C/medium load discharge at +40°C
14. Charge to full at +20°C

This entire cycle can take approximately 160 hours. It is important to have the test setup configured properly before starting the cycle. This is the best way to prevent having to repeat the entire process.

Charging at a Safe Temperature

Note that each step in the procedure begins with a *Charge to full at +20°C.* Maxim recommends charging at +20°C for all of these steps for several reasons. Charging at a cold temperature is sometimes dangerous and can age the battery. In some cases it will cause lithium plating to occur which, in turn, causes lost capacity and can lead to a dangerous situation. Additionally, charging at the same conditions (temperature, voltage, termination current) enables us to eliminate drift and other instrumentation issues by lining up the full events to the same full level.

Managing Inherent Instrument Error

Next, the test-system instrumentation will have some inherent error, a portion of which cannot be compensated. To better manage the error in the coulomb counter of the instrumentation, it is very valuable to have an occasional, recurring, known battery state. The battery state following a *Charge to full at 0°C* is very different from a *Charge to full at +20°C* and very different from a *Charge to full at +40°C*. Full at 0°C can occur at more than 10% lower battery state than full at +20°C. Moreover, full at +40°C can be a 2% to 3% higher battery state than full at +20°C. For example, a charge/discharge cycle of *Charge to full at +20°C/medium load discharge at +20°C* would produce different results than a cycle of *Charge to full at 0°C/medium load discharge at +20°C*, even though the discharge is the same condition.

Measurements

To generate a trustworthy reference state-of-charge (SOC) to determine error, a minimum of the following data must be collected:

Reference data:

Charge and discharge of the coulomb-counters

- These can be two registers or combined into one.
- Capacity should be measured with < 1mA coulomb-counter drift for accurate characterization and performance verification

Battery voltage Charge/discharge current Temperature Time

If reference data and silicon (MAX17047) data are collected on different systems, then the reference and silicon should both have synchronized system clocks for accurate comparison.

To prevent the data file from becoming too large while still capturing enough information, the data should be recorded once every 15 seconds.

If possible, it is also good to have fuel-gauge silicon attached during the test. The MAX17047 fuel gauge can be used as a sanity check for the reference. With the silicon, moreover, it is possible to do a performance run (verifying the silicon) instead of only a characterization run (measuring the battery). If the MAX17047 is connected, please use the MAX17047K evaluation (EV) software to log the data with the logging interval set to 15 seconds. For more information about this EV software, contact your local Maxim representative.

Conclusion

After completing this cycle, the data can be sent to your local Maxim representative, where it will be processed to determine the optimal configuration for the cell under test.

Related Parts	
MAX17047	ModelGauge m3 Fuel Gauge

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