SBS Implementers Forum

Smart Battery Data Accuracy Testing Guideline

Revision 1.0
December 11, 1998

Release Candidate A

Questions and comments regarding this specification may be forwarded to:
Email: questions@sbs-forum.org

For additional information on Smart Battery System Specifications, visit the SBS Implementer's Forum (SBS-IF) at:
www.sbs-forum.org

Acknowledgement
The Smart Battery System Implementers Forum thanks Samsung Electronics Co., Ltd. for their extensive contributions to this guideline.

Revision History

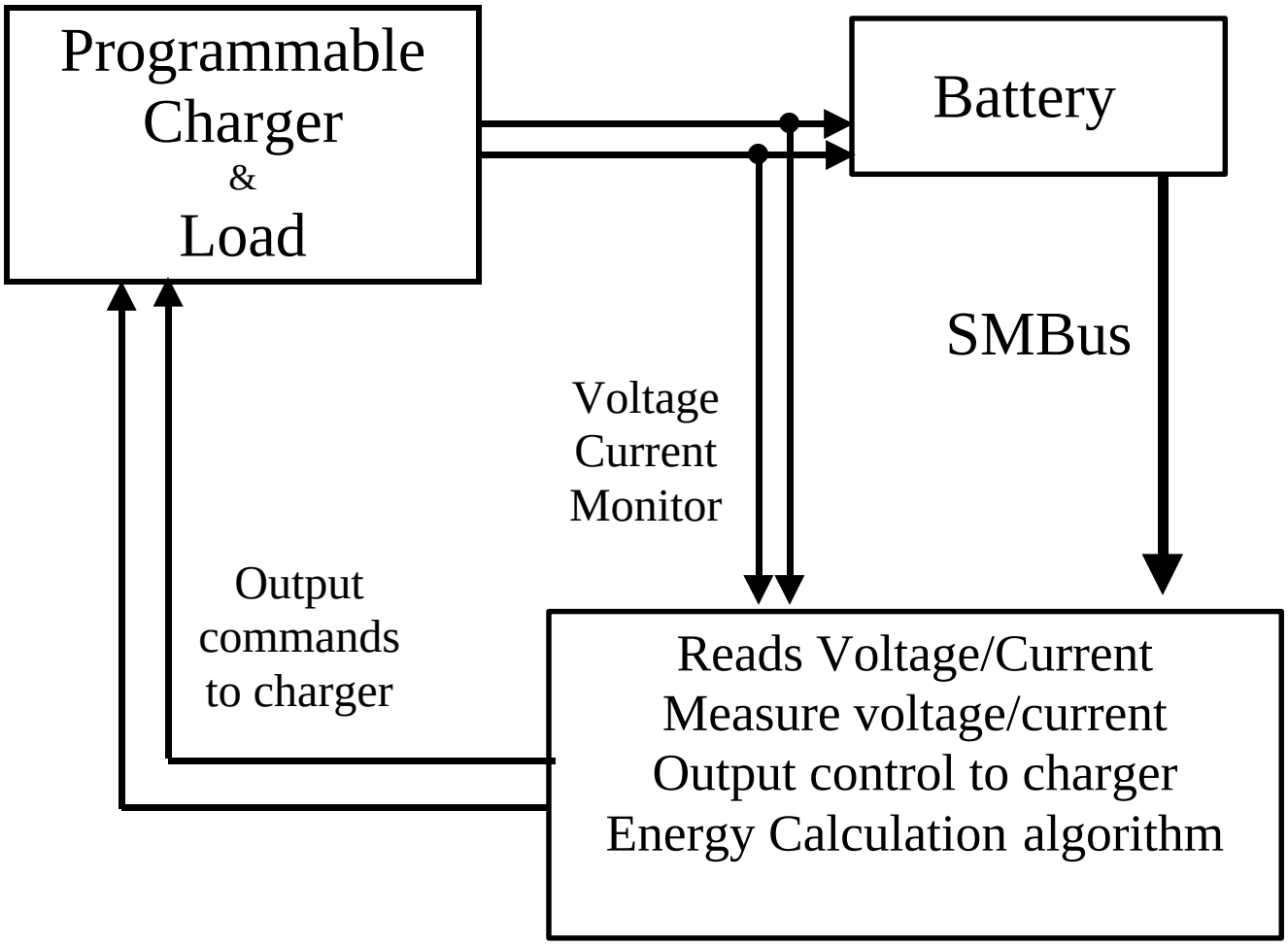
Revision Number	Date	Author	Notes
1.0	12/11/98	P. Mummah	Version 1.0 release
1.0 - A	3/5/99	R. Dunstan	Acknowledgment and Revision History added.

Introduction
to
Smart Battery Data Accuracy Measurements

The smart battery data accuracy measurements are intended to test the accuracy of the data that a smart battery reports. This information must be accurate if a smart battery powered system is to obtain maximum battery run time and maximum battery life. The Data Accuracy Measurements consists of six basic tests (some with multiple parts) that reflect how a battery is used in a typical computer laptop environment with a compliant Smart Battery design. The tests are to be done in numerical order.

The equipment necessary to complete the tests is a compliant SMBus with a connector to attach to the battery under test, a host to receive and record messages, smart charger, and a variable/programmable load. There is also a voltage and current monitor, and an integrator that records the amount of charge going into and out of the battery under test. The test results of the integrator, voltage and current data are compared to the values reported by the battery.

Block Diagram of Test Setup



Definition of Terms

Full Charge Battery **Average time = 155 min @ 0.5C**

Battery controls own charge with SMBus commands
During charging, every minute:
Measure and log voltage, current and energy put into battery.
Log reported voltage, current, RSOC, max error, remaining capacity, Battery Status
LiIon Battery
Full charge indicated when:
Battery status "Fully_Charged" bit is set, and
Charge current <= Manufacture recommended value, and
Battery voltage >= Manufacture recommended value, or
4.0 (measured) volts/cell, with charger connected in absence of manufacture data.
Time out: After 200 minutes

Full Discharge Battery **Average time = 120 min @ 0.5C**

Battery operating with load #1 until
Voltage <= Discharge end voltage as specified by manufacture
During discharge, every minute:
Log reported Voltage, Current, Remaining Capacity, Max Error, RSOC, Battery Status
Measure and log current, voltage, and energy dissipated by load.

Define load

Load #1: P/2 where P = Design capacity of battery in watt hours
Load #2: 5 min @ 0.5P, 5 min @ .0125P, 5 min @ 0.25P, 5 min @ 0.125P, repeat
Load #3: Load profile supplied by Intel (derived from a running notebook)

Calibrate battery **Average time = 480 min @ 0.5C**

Fully charge battery
Record RemainingCapacity()
Record FullChargeCapacity()
Record MaxError()
Rest battery
Record measured voltage with no load
During discharge record the following each minute:
Fully discharge battery at load #1
Record RemainingCapacity()
Record FullChargeCapacity()
Record MaxError()
Record TimeRemaining() with @ Rate set to discharge current.
Record measured capacity discharged
Record fully discharged voltage with load still attached
Record fully discharged voltage 2 minutes after load removed
Fully charge battery
During charging record the following each minute:

Record RemainingCapacity()
Record FullChargeCapacity()
Record MaxError()
Record measured charged (Voltage & Current) put into battery

Rest battery

Record measured voltage with no load

Rest battery

Leave battery disconnected 10 minutes

Measure:

Data value obtained from test equipment

Charging and Discharging:

During all charging and discharging record the following each minute:

Record RemainingCapacity()
Record FullChargeCapacity()
Record MaxError()
Record measured charged (Voltage & Current) put into battery

Reported:

Data values read from Smart Battery slave functions over the SMBus

Note(s):

1. The battery must be placed in the mode that reports capacity in 10mWH– i.e. the CAPACITY_MODE set to 1.

Tests

Test 1: (0 to 100% charge and discharge) **Avg time = 32.5 hrs**

Test done at 40 deg C

1. Calibrate battery
2. Full charge and full discharge 5 times, recording information as described above.
3. Rest battery after each full discharge and each full charge
4. Record RemainingCapacity(), FullChargeCapacity() and MaxError() after each full charge
5. Record measured capacity with test equipment after each full charge
6. Record measured voltage with no load at end of charge rest period
7. Record RemainingCapacity(), FullChargeCapacity() and MaxError() after each full discharge
8. Record measured capacity with test equipment after each full discharge
9. Record measured voltage with no load at end of discharge rest period

Tests 2: (Full charge at reduced rate, partial discharge to 35%)

Avg time = 31.5 hrs

2A:

Test done at 40 deg C

Note: For reduced charge rate, current limit charger output current to C/2.

1. Calibrate battery
2. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
3. Rest battery with no load
4. Discharge battery until RelativeStateOfCharge() = 35%
5. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
6. Rest battery with no load
7. Record measured capacity with test equipment
8. Record measured voltage with no load
9. Fully charge battery as defined above
10. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
11. Rest with no load
12. Record measured capacity with test equipment
13. Record measured voltage with no load
14. Repeat steps 4 through 13 (partial discharge and full charge) 4 times
15. Fully discharge battery
16. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
17. Rest with no load
18. Record measured capacity with test equipment
19. Record measured voltage with no load
20. Fully charge battery
21. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
22. Rest with no load
23. Record measured capacity with test equipment
24. Record measured voltage with no load

2B: **Avg time = 79 hrs**

Same as 2A except us load # 2

Test 3: (80% charge at requested rate, discharge to 30%) **Avg time = 28 hrs**

3A:

Test done at 40 deg C

1. Calibrate battery
2. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
3. Rest battery with no load
4. Discharge battery until RelativeStateOfCharge() = 30%
5. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
6. Rest battery with no load
7. Record measured capacity with test equipment
8. Record measured voltage with no load
9. Charge battery until RelativeStateOfCharge() = 80%
10. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
11. Rest with no load
12. Record measured capacity with test equipment
13. Record measured voltage with no load
14. Repeat steps 4 through 13 (partial discharge and full charge) 4 times
15. Fully discharge battery
16. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
17. Rest with no load
18. Record measured capacity with test equipment
19. Record measured voltage with no load
20. Fully charge battery
21. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
22. Rest with no load
23. Record measured capacity with test equipment
24. Record measured voltage with no load

3B: **Avg time = 70 hrs**

Same as test 3A except use load #2.

Test 4: (Current & voltage reporting accuracy) **Avg time = 0.5 hrs**

Verify battery has >= 33% reported (SMB data) charge value.

Test done at 40 deg C

1. Maintain 1C discharge rate (or manufactures maximum recommended value if less than 1C) while recording each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
2. In a single step change the discharge rate to 0.5C while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
3. In a single step change the discharge rate to 70 ma while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
4. In a single step change the discharge rate to 12 ma while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
5. In a single step change the discharge rate to 70 ma while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
6. In a single step change the discharge rate to 0.5C while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()
7. In a single step change the discharge rate to 1C rate (or manufactures maximum recommended value if less than 1C) while continuing to record each of the following every second for 5 minutes:
   a) reported Current(), b) measured current, c) reported Voltage(), d) measured voltage, e)AvgCurrent()

Plot measured current, reported Current(), measured voltage and reported Voltage() versus time.

Test 5: (Storage test) **Avg time > 1 week**

5A:

1. Calibrate battery
2. Remove load for 48 hours.
3. Store between 20 and 25 degrees
4. Record measured voltage
5. Record RemainingCapacity()
6. Record MaxError()
7. Fully discharge battery
8. Record measured charge removed from the battery

5B:

Same as 5A except step 2, store at 40 deg C.

5C:

Same as 5A except step 2, remove load for 7 days, store between 20 and 25 deg C.

Test 6: (Over discharge test)

1. Record cycle count and full charge capacity
2. Discharge battery with load 1 until:
   a. Lion: voltage at terminals is zero, Lion.
      (Battery should disconnect cells from terminals)
   b. NiMH: Cells = 0.9v/cell
3. Connect 12 volts to terminals and verify:
   A) SMBus communication begins within 5 seconds.
   B) Previous cycle count is restored
   C) Previous full charge capacity is restored

Test 7: (Prolonged suspend current) **Avg time = 12 hrs**

1. Calibrate battery
2. Rest battery with no load
3. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()
4. Discharge 20 minutes at 0.5C rate for 20 minutes while recording data
5. Discharge 10 hours at 20 milliamps
6. Fully discharge battery
7. Record RemainingCapacity(), FullChargeCapacity(), and MaxError()