# The Importance of Full Smart Battery Data (SBData) Specification Implementation

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Since the emergence of the industry standard Smart Battery Systems (SBS) Specifications approximately four years ago, designers of portable electronic devices have been building products with improved battery life and system run time through effective implementation of the specifications. The SBS Specs are the only open system level specifications available today that enable standardization of the electrical and data interfaces by defining the bus (SMBus), the smart battery data set (SBData), charger and multi-battery selector commands. The significant benefits of full compliance with the specs are outlined in this article.

Compliance with the Smart Battery Data (SBData) Specification requires full execution of the specification, not simply a sub-set of the data values or functions listed. This includes all the data values (including control bits and flags); their accuracy and granularity requirements; and the appropriate SMBus protocols and timing requirements.

Full implementation insures compatibility with the Smart Battery System (SBS) specifications for a complete power management system. Failure to comply with the individual specifications can cause inter-operability problems for the whole SBS system and affect safety, reliability, and performance. Something as simple as slightly extended bus timing can reduce communications throughput such that performance is compromised and end-user satisfaction drops significantly.

A simple example of the importance of "full implementation" is that of a Smart Charger and Smart Battery communication interface. If the Smart Battery does not support SBData broadcasts of ChargingCurrent and ChargingVoltage values, then the Smart Charger will not operate. If one Smart Battery supports these, yet another does not, the concept of interchangeability is lost, system performance is compromised, and the customer is dissatisfied.

The integrity of the standards adopted by the SBS also relies on the individual component manufacturers to implement the specifications completely and fully. Therefore, the specifications require self-policing and manufacturer integrity to insure system-wide operation. Just as traffic laws keep us all driving on one side of the road, yet still allow many different types of cars; the SBS specifications, and the Smart Battery Data specification in particular, allow all components to participate in the system while still permitting product differentiation.

## Definition of Full Implementation

Although there are many definitions of "smart batteries," there is only one definition which complies with the Smart Battery System and which affords the adopters of this system special rights and privileges.  This one definition is based on the SBS Smart Battery Data Specification, Version 1.0, originally developed by Duracell® and Intel®.  The SBS Implementers Forum (SBS-IF) is now the organization responsible for ownership of the complete set of SBS specifications.  The SBS-IF is also charged with maintaining these specifications, monitoring conformance, and enforcing "full implementation."

Full SBData Implementation is defined as:

- Execution of all 34 data value functions, including control and status flags
- Meeting the Accuracy and Granularity requirements of all 34 data value functions
- Maintaining proper SMBus timing and data transfer protocols

This definition insures a complete, safe, reliable, high-performance SBS system for power management and control.  Without compliance to the full specifications, the system would not function properly and would risk safety, reliability and performance.

Although various manufacturers may claim "full implementation," there are some which do not comply 100% with the required data representations and/or control or status flags.  Similarly, support for all modes of operation (power capacity mode, for example) is also a requirement.

## Definition: All 34 SBData Values

The Smart Battery Data Specification contains 34 data values representing the operating conditions, calculated predictions, and characteristic data of a SBS Smart Battery.  These SBData values are the core components of the specification for the Smart Battery.

Full implementation requires that each data value reports in the units required and that all associated components of a particular function be supported.  Some functions report differently depending on control and mode settings.  Some control and status flags are optional and are not required while others are specifically needed to support the full implementation guidelines stated.

Of particular importance for full implementation are the various modes of operation and data reporting. The SBData defines some capacity data to be reported in both mAmp-Hour units and 10 mWatt-Hour units. Similarly, the AtRate function can receive data in either mAmp units or 10 mWatt units. Other reported data values are also dependent on the capacity reporting units used, such as the RunTimeToEmpty and AverageTimeToEmpty data values.

The total of 34 data values can be further sub-divided into six (6) key areas of functionality. The six sub-groups are:

- Measurements
- Capacity Information
- Time Remaining
- Alarms and Broadcasts
- Mode, Status, and Errors
- Historical and Identification

These sub-groupings can also assist in the implementation of the data values since some commonality occurs within these groups.

Measurements

The direct environmental measurements of the Smart Battery are:

- Voltage (mV)
- Temperature (0.1°K)
- Current (mA)
- AverageCurrent (mA)

These measurements must occur at a rate that can insure the accuracy of the capacity information. Full implementation requires a minimum sample or integration time (based on the application), while still conserving operating power for the portable system itself. In this regard, the battery electronics designer has multiple options of multiplexing, sampling, integrating, etc.

Generally, measured data values should be reported with a delay no longer than one (1) second when in normal load or charging states, and up to four (4) seconds when at rest (no significant charge or discharge.) The question often arises concerning the responsiveness of the measured values. Full implementation requires that these values return data in a "reasonable time" that can be used by a power management system, depending on the present operational state of the Smart Battery.  Simply put, this means that if a battery is at rest (not being charged or discharged at a significant rate, such as less than 10 mA, for example), then it can report measured values at a slower refresh rate. However, when charge or discharge is occurring at an appreciable rate, the measured values must be reported and refreshed at a rate that is useful.

Capacity Information

The Smart Battery's capacity information includes state-of-charge information but also the actual capacity values in multiple representations.  The capacity values include:

- RelativeStateOfCharge (%)
- AbsoluteStateOfCharge (%)
- RemainingCapacity (mAH or 10 mWH)
- FullChargeCapacity (mAH or 10 mWH)

The capacity information is represented in either unit-less percentages or in true mAH or 10 mWH values depending on the requested data function. Granularity and accuracy values also apply to these calculated values and typically include the use of the MaxError function in the accuracy definitions.

Note that the mAH or 10 mWH representations of capacity are also rate dependent (C/5 or P/5 rates respectively) and may change based on the present charge or discharge rate.

The determination of mAH or mWH is done via the CAPACITY_MODE control flag in the BatteryMode data function.  Full implementation requires that these values be available in both units.  The reasoning for power (10 mWH) units is to simplify the representation to a Host or operating system which may not be aware of the size (voltage) of the battery.  By using power units the size is inherent in the data value and no additional translational calculation is required. Future PC operating systems and driver applications are expected to use power (capacity) reporting from the Smart Battery to simplify calculations for capacity and power available.

Time Remaining

The time remaining at present and predicted rates are calculated using the previously discussed capacity information and the Smart Battery's ability to predict when the capacity will be depleted, based on both measurements and knowledge of the battery cell's performance.  These data values are:

- RunTimeToEmpty (minutes)
- AverageTimeToEmpty (minutes)
- AverageTimeToFull (minutes)
- AtRate (mA or 10 mW)
- AtRateTimeToFull (minutes)
- AtRateTimeToEmpty (minutes)
- AtRateOK (Boolean flag)

These time remaining functions are also impacted by the CAPACITY_MODE control flag in the BatteryMode data function. Only the AtRate function is explicitly affected since the value written to AtRate may be in either mA or 10 mW depending on the mode. The other calculated time remaining values may be affected due to alterations in how the capacity values are calculated based on the CAPACITY_MODE setting.

Values written to AtRate are not assumed to be automatically converted if the CAPACITY_MODE flag is altered in BatteryMode. Therefore, before using the AtRate time functions, the original value in AtRate should be confirmed along with the present CAPACITY_MODE setting.

Granularity on all time values is set to 2 minutes although better performance is suggested. Accuracy values are dependent on the MaxError value and should represent minimum "safe" and conservative times.

Alarms and Broadcasts

The ability of the Smart Battery to respond even when not being addressed is critical to the safe and reliable operation of the complete system. Additionally, the ability to instruct a Smart Charger how to control charging voltage and current also contributes to system safety and ease of use. The broadcast data values are:

- AlarmWarning (bit flags)
- RemainingCapacityAlarm (mAH or 10 mWH)
- RemainingTimeAlarm (minutes)
- ChargingCurrent (mA)
- ChargingVoltage (mV)

The alarm functions in AlarmWarning is identical to the BatteryStatus data value except for the lower-most four (4) bits of AlarmWarning which are defaulted to high. The same four bits represent the most recent error code when read from the BatteryStatus data function. The remaining upper bits are identical in both functions.

The minimum and maximum rates of broadcasting are defined to insure safety in charging situations. Alarm broadcasts have higher rates than charging instruction broadcasts. Termination warnings may also be broadcast to multiple sources (not simply the Smart Charger, for example) to provide an additional safety notification method. In all cases, the Smart Battery may not broadcast at all during the first 10 seconds of an initialized SMBus (both lines go high).

The RemainingCapacityAlarm must permit set points represented in either mAH or 10 mWH as determined by the CAPACITY_MODE control bit in the BatteryMode data function. Initial (at time of first use after manufacture) values for RemainingCapacityAlarm must be 10% of DesignCapacity and the RemainingTimeAlarm must be 10 minutes.

Both settable alarms (RemainingTimeAlarm and RemainingCapacityAlarm) must support the zero set-point to allow the alarm to be disabled if desired. All other alarm functions may NOT be disabled.

The charging broadcasts of ChargingCurrent and ChargingVoltage may be disabled by the CHARGER_MODE control bit in the BatteryStatus function. However, when a Smart Battery is disconnected from the SMBus system (bus lines both low for more than two (2) seconds), the default state of CHARGER_MODE = 0 (broadcasts NOT disabled) must be restored.

Mode, Status, and Errors

Understanding the operational parameters and error conditions of the Smart Battery is key to maintaining a reliable system, particularly when more than one device may be involved. The Smart Battery can provide additional system information through use of the mode, status and error functions:

- BatteryMode
- CAPACITY_MODE
- CHARGER_MODE
- MaxError
- BatteryStatus
- ManufacturerAccess

The required control flags in the BatteryMode data function are listed above. The following control flags are NOT required from BatteryMode but may be used to provide additional system information. The sub-control flags shown must be supported if the "enabled" or "support" portion is available:

- CHARGE_CONTROLLER_ENABLED
- INTERNAL_CHARGE_CONTROLLER
- PRIMARY_BATTERY_SUPPORT
- PRIMARY_BATTERY

Default conditions require that the following BatteryMode control bits be cleared when a Smart Battery is disconnected from a SMBus system, both lines low for more than two (2) seconds:

- CAPACITY_MODE
- CHARGER_MODE
- CHARGE_CONTROLLER_ENABLED (if available)
- PRIMARY_BATTERY (if available)

These defaults insure that a battery inserted into a system has a defined mode of operation.

Historical and Identification

Background information and identification of the Smart Battery can be used when multiple battery systems are employed and when battery life has dropped to a point of poor performance.  Historical information can then be used by the system to determine the best moment to replace the Smart Battery for a fresh one.

The data values are:

- CycleCount (integer count)
- DesignCapacity (mAH or 10 mWH)
- DesignVoltage (mV)
- SpecificationInfo (coded)
- ManufactureDate (coded)
- SerialNumber (integer number)
- ManufacturerName (string)
- DeviceName (string)
- DeviceChemistry (string)
- ManufacturerData (string)

Some values shown above are also used in the definitions of accuracy for other data functions.

Benefits of Full Implementation

The importance of implementing the SBData specification to the definition stated previously is multi-faceted but it can offer benefits to those who adopt the set of SBS Specifications. Of primary importance is the issue of inter-operability between components, manufacturers, and systems. Following the SBS Specifications insures a safe, reliable, high-performance power management system.

Author Biography

Dan Friel is the co-author of many of the SBS Specifications, including SBData, and is the co-inventor of the Duracell and now PowerSmart, Inc. Smart Battery electronics. He is chairman of the SBS IF Smart Battery and Safety Working Groups and is a founding employee of PowerSmart Inc. Mr. Friel was previously with Duracell's Smart Battery Development Group and has also worked for Leitch, Inc. and Magnavox Electronic Systems Company. He holds a BSEE from Purdue University.

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