

## **Belt Clip Smart Charger Preliminary Specification**

### **Document Number**

DS257A205

### **Description**

Belt Clip 4-Cell Battery Smart Charger Electronics

### **Inspired Energy Part Number**

MC20501

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| Specification Number   | DS257A 4-CELL |
| Specification Revision | 1.0           |
| Prepared By            | WRL           |
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### 1. REVISION HISTORY

| Revision | Release Date | Revisions     | Issued By | Approved By |
|----------|--------------|---------------|-----------|-------------|
| 0.1      | 7/2/08       | First draft   | WRL       |             |
| 1.0      | 9/26/08      | First release | WRL       |             |
|          |              |               |           |             |

### 2. INTRODUCTION

#### 2.1. Scope

This specification describes the physical, functional and electrical characteristics of a custom Smart Battery charger produced by Inspired Energy. This specification is the interface document between Inspired Energy and its customer. It is understood that the customer may create their own internal specification. However, this specification is the master that defines the charger’s operation. The charger/control circuit produced will meet this specification.

#### 2.2. Smart Charger Overview

This specification describes the physical, functional and electrical requirements for the MC20501 Smart Charger assembly.

The MC20501 is capable of communicating with a Smart Battery through the System Management Bus (SMBus) and is fully SMBus Rev. 1.0, SBDS Rev. 1.0 and SCDS Rev. .95 compliant.

Redundant safety protection is provided by constant communications between the battery and charger and by monitoring the battery on-board thermistor.



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### 2.3. General Precautions

#### 2.3.1. Handling

- Avoid shorting.
- Do not immerse in water.
- Do not disassemble or deform.
- Avoid excessive physical shock or vibration.
- Never cover or obstruct the airflow, as this will cause overheating.

#### 2.3.2. Charge & Discharge

- Never use a charger or battery that appears to have suffered abuse.
- Only approved batteries should be charged.
- Never use a modified or damaged battery or charger.
- Specified product use only.
- Caution – during use the battery connector and charger may become warm.

#### 2.3.3. Storage

- Store in a cool, dry and well-ventilated area.

### 3. REQUIREMENTS

#### 3.1. General Requirements

##### 3.1.1. Input Power

The input power should comply with the following parameters: 9.5-24VDC, 50W minimum. The charger will turn off below 9.2 +/- .1V, and turn on above 9.7 +/- .1V.

##### 3.1.2. Operation

Operational Temperature Limits: 0°C to +50°C, ≤ 80%RH

##### 3.1.3. Storage

Storage Temperature Limits: -20°C to +80°C, ≤ 80%RH

The Smart Charger should be stored in an environment with low humidity, free from corrosive gas.



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### 3.1.4. Terminal Specifications

J4 pin assignments (also refer to the mechanical drawing for additional details).

| Terminal | Legend | Description     |
|----------|--------|-----------------|
| 1        | (+)    | 9-24V DC input. |
| 2, 3     | (-)    | DC GND input.   |

J1 (also refer to the mechanical drawing for additional details).

| Terminal | Legend | Description                       |
|----------|--------|-----------------------------------|
| 1A,1B    | (+)    | DC Positive to battery.           |
| 2A,2B    | (C)    | SMBus Clock.                      |
| 3A,3B    | (D)    | SMBus Data.                       |
| 4A,4B    | (THM)  | Thermistor connection to battery. |
| 5A,5B    | (-)    | DC Negative to battery.           |

Output terminal assignments (also refer to the mechanical drawing for additional details).

| Terminal | Legend | Description   |
|----------|--------|---|
| J2-1     | + V    | Nominal rated battery (3.6, 7.2, or 14.4V for 4-cell) voltage DC Output |
| J3-1     | GND    | DC GND input.   |

## 3.2. Charger Electronics

### 3.2.1. Overview of Operation

The Smart Charger is capable of providing all auxiliary battery functions needed to recharge a Smart Battery.

The charger is capable of communicating with battery through the System Management Bus (SMBus). The charger is fully SMBus and SBDS Revision 1.0 compliant. The charger is implemented as a SBS compliant system.

An 8-bit Reduced Instruction Set CPU (RISC) is used to process the core algorithms and perform operations required for battery monitoring, charge control and user display.

Pertinent battery parameters are constantly monitored throughout the charge cycle to ensure safe and reliable operation. The battery thermistor is monitored as an independent and redundant safety monitor. SMBus Alarms are monitored and acted upon as defined in the Smart Charger Data Specification (SCDS).

The user is notified of operational mode and fault conditions by the on-board LEDs.



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### 3.2.2. DC Specifications

| Parameter                           | Limits | Remarks                     |
|-------------------------------------|--------|-----------------------------|
| Active current consumption          | <15mA  | 12V input power is applied. |
| Battery leakage current consumption | <40uA  | Parasitic leakage           |

### 3.2.3. Pre-Regulator

To allow battery charging over a wide range of input voltages, the input voltage is first regulated to 24DVC.

### 3.2.4. Charging

During charge, the charger reads the battery status, battery mode, battery current, battery voltage, and battery temp. The battery voltage and current are then relayed to the charger control IC which has been configured to deliver up to 16.8 volts and 2 amps. The specified voltage and current of the battery is constantly read from the battery then relayed to the charge control chip every second. Normal charge termination occurs when the battery reaches full charge and begins requesting 0 current and issues the TERMINATE\_CHARGE\_ALARM Warning.

Once fully charged, if the battery is left in the charger, the charger will re-initiate charge as requested by the battery. Typically, the battery will either request a trickle current, or will begin requesting current following a predetermined amount of self-discharge. The battery may be left in the charger indefinitely.

### 3.2.5. Charge Regulation/Measurement Accuracy

#### 3.2.5.1. Charge Voltage

The charge voltage is measured and regulated to  $\pm 0.8\%$  of the battery requested value, up to 16.8V.

#### 3.2.5.2. Charge Current

The charge current is measured and regulated to  $\pm 6\%$  of the battery requested value, up to 2A.

### 3.3. Control Electronics

#### 3.3.1. Output Voltage

There is no output voltage regulation, therefore the output voltage will depend on the battery voltage, which will depend on battery charge state. At higher currents, cable voltage losses can be significant. The output voltage will drop substantially due to both hardware and software current limiting, if the rated current is exceeded.

Refer to the battery specification for pertinent battery parameters.

#### 3.3.2. Output Current

The MC20501 is fused at 6A with a non-user replaceable slow-blow fuse. It is important that the MC20501 have adequate free air circulation when operating at high currents. The unit must be allowed to dissipate ~2 watts of heat. If excessive current is being demanded from the battery, the battery output protection circuit will be activated.



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### 3.3.3. LED Status Indication

The charger/control electronics provides a green status LED to inform the user of the charger mode and fault conditions:

LED flashing: battery is being charged

LED on steady: input power is on and battery reports it is fully charged

LED off: input power is off or error condition is preventing charging

Error conditions include either the charger microprocessor cannot communicate with the Smart Battery, or cannot communicate with the internal battery charger unit. The batteries compatible with this charger contain a fuel gauge to indicate the relative state of charge of the battery.

### 3.4. SMBus and SBDS Parameters

#### 3.4.1. Overview of Operation

The Smart Charger is fitted with a microprocessor and associated circuitry for communication with the Smart Battery. Reference should be made to the following specifications when reading this section:

- System Management Bus Specification (Rev 1.0, Feb 15, 1995)
- Smart Battery Data Specification (Rev 1.0, Feb 15, 1995)
- Smart Battery Charger Specification (Rev 0.95a, Feb 15, 1995)

#### 3.4.2. SMBus Logic Levels

| Symbol | Parameter                     | Limits |     | Units |
|--------|-------------------------------|--------|-----|-------|
|        |                               | Min    | Max |       |
| Vil    | Data/Clock input low voltage  |        | 0.6 | V     |
| Vih    | Data/Clock input high voltage | 1.4    | 5.5 | V     |
| Vol    |                               |        | 0.4 | V     |

#### 3.4.3. Communication Protocol

SMBus Interface complies with SBS Specification Version 1.0. The charger includes a simple bi-directional serial data interface similar to I<sup>2</sup>C. The charger processor uses the interface to access various battery pack registers.

#### 3.4.4. Initialization Procedure

The interface uses a command-based protocol, where the charger processor sends the battery address command byte to the battery pack. The command directs the battery pack to either store the next data received to a register specified command byte or output the data specified by the command byte.



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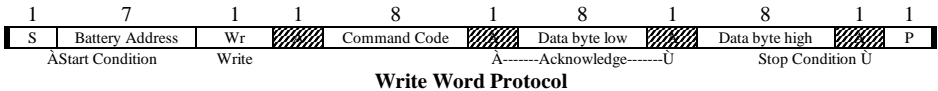
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The Charger communicates with the battery pack using one of three protocols:

- Write Word
- Read Word
- Read Block

### 3.4.4.1. Write Word

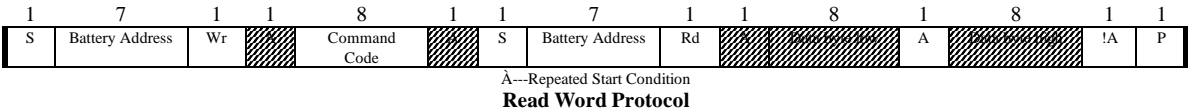
The first byte of a Write Word access is the command code. The next two Bytes are the data to be written. In this example the master asserts the slave device address followed by the write bit. The device acknowledges and the master delivers the command code. The slave again acknowledges before the master sends the data word (low byte first). The slave acknowledges each byte according to the I<sup>2</sup>C specification, and the entire transaction is finished with a stop condition.



### 3.4.4.2. Read Word

Reading data is slightly more complex than writing data. First the host must write a command to the slave device. Then it must follow that command with a repeated start condition to denote a read from that device's address. The slave then returns two bytes of data.

Note that there is not a stop condition before the repeated start condition, and that a "Not Acknowledge" signifies the end of the read transfer.





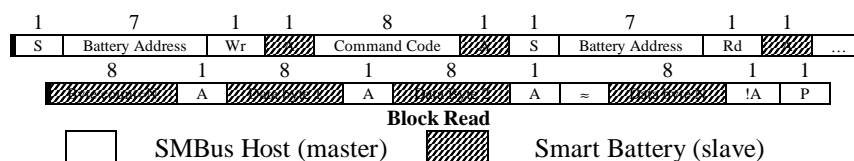


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### 3.4.4.3. Block Read

The Block Read begins with a slave address and a write condition. Then it must follow that command with a repeated start condition to denote a read from that device's address. After the repeated start the slave issues a byte count that describes how many data bytes will follow in the message. If a slave had 20 bytes to send, the first byte would be the number 20 (14h), followed by the 20 bytes of data. The byte count may not be 0. A Block Read can transfer a maximum of 32 bytes.



### 3.4.5. Charger to Battery Messages

The Charger microprocessor acting in the role of a bus master, uses the read word, write word, and read block protocols to communicate with the Battery, operating in slave mode.

#### Charger-to-Battery Messages

| Function             | Command Code | Description  | Unit      | Access |
|----------------------|--------------|--|-----------|--------|
| BatteryMode()        | 0x03         | Battery Operational Modes.   | Bit flags | r/w    |
| Temperature()        | 0x08         | Returns the pack's internal temperature.   | 0.1 °K    | r      |
| Voltage()            | 0x09         | Returns the battery's voltage (measured at the cell stack)   | mV        | r      |
| Current()            | 0x0a         | Returns the current being supplied (or accepted) through the battery's terminals.                  | mA        | r      |
| RemainingCapacity()  | 0x0f         | Returns the predicted remaining battery capacity.  | mAh       | r      |
| FullChargeCapacity() | 0x10         | Returns the predicted battery capacity when fully charged.   | mAh       | r      |
| AverageTimeToFull()  | 0x13         | Returns the rolling average of the predicted remaining time until the battery reaches full charge. | minutes   | r      |
| ChargingCurrent()    | 0x14         | Returns the battery's desired charging rate.   | mA        | r      |
| ChargingVoltage()    | 0x15         | Returns the battery's desired charging voltage.  | mV        | r      |
| BatteryStatus()      | 0x16         | Returns the battery's status word.   | Bit flags | r      |
| ManufacturerName()   | 0x20         | Returns a character array containing the manufacture's name.                                       | string    | r      |
| DeviceName()         | 0x21         | Returns a character array that contains the battery's name.  | string    | r      |
| DeviceChemistry()    | 0x22         | Returns a character array that contains the battery's chemistry.                                   | string    | r      |
| ManufacturerData()   | 0x23         | Returns data specific to the manufacture.  |           | r      |

### 3.4.6. Battery to Charger Messages

The Battery, acting in the role of a bus master, uses the write word protocol to communicate with the Charger, operating in slave mode. If the CHARGER\_MODE bit in BatteryMode() is clear, the Battery will broadcast Charger request information at 15-second intervals.

#### Battery-to-Charger Messages

| Function          | Command Code | Description   | Unit | Access |
|-------------------|--------------|---|------|--------|
| ChargingCurrent() | 0x14         | Sends the desired charging rate to the battery charger    | mA   | W      |
| ChargingVoltage() | 0x15         | Sends the desired charging voltage to the battery charger | mV   | W      |



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### 3.4.7. Critical Messages

Whenever the Battery detects a critical condition, it takes the role of a bus master and sends AlarmWarning() message to the Charger. The Battery broadcasts the AlarmWarning() message at 10 second intervals until the critical condition(s) has been corrected.

#### Battery Critical Messages

| Function       | Command Code | Description  | Unit           | Access |
|----------------|--------------|--|----------------|--------|
| AlarmWarning() | 0x16         | This message is to the host and/or charger to notify them that one or more alarm conditions exist. | Formatted word | W      |

#### Alarm Bit Definitions

| Hex  | Battery Status            | Status | Definition  |
|------|---------------------------|--------|---|
| 4000 | TERMINATE_CHARGE_ALARM    | ON     | Set when the battery detects that one or more of its charging parameters are out of range.              |
|      |                           | OFF    | Cleared when the parameters fall back within range.   |
| 1000 | OVER_TEMP_ALARM           | ON     | Set when the battery detects that its internal temperature is greater than allowed.                     |
|      |                           | OFF    | Cleared when the battery temperature falls back within acceptable range.                                |
| 800  | TERMINATE_DISCHARGE_ALARM | ON     | Set when the battery determines that it has supplied all the charge it can without being damaged.       |
|      |                           | OFF    | Cleared when the battery reaches a state-of-charge sufficient for it to once again safely supply power. |

#### Status Bit Definitions

|    |                  |     |  |
|----|------------------|-----|--|
| 80 | INITIALIZED      | ON  | Always   |
|    |                  | OFF |  |
| 40 | DISCHARGING      | ON  | Battery "Current()" is not positive  |
|    |                  | OFF | Battery "Current()" is positive  |
| 20 | FULLY_CHARGED    | ON  | Set when the battery determines that it has reached a full charge termination point. |
|    |                  | OFF | Cleared when the battery determines that it can be charged again.                    |
| 10 | FULLY_DISCHARGED | ON  | Set when the battery determines that it has supplied all the energy it can.          |
|    |                  | OFF | Cleared when "RelativeStateOfCharge()" $\geq$ 20%.                                   |



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### 3.5. Mechanical Specifications

#### 3.5.1. Weight

Approximately 7.5 ounces (214 gm).

#### 3.5.2. Mating Connector

Mating DC barrel input connector measures 3.3mm OD x 1.3mm ID x 9.5mm long.

#### 3.5.3. Date/Revision Stamp

A code is stamped on the plastic shell. See mechanical drawing below. The format is in the form of an 8-digit alphanumeric code:

ZZ YYWW XX  
Manufacturing site \_\_\_↑ \_\_\_↑ \_\_\_↑ \_\_\_Revision  
Manufacturing date \_\_\_\_\_|

Manufacturing site: IE

Manufacturing date: the 2-digit year and 2-digit week of manufacture

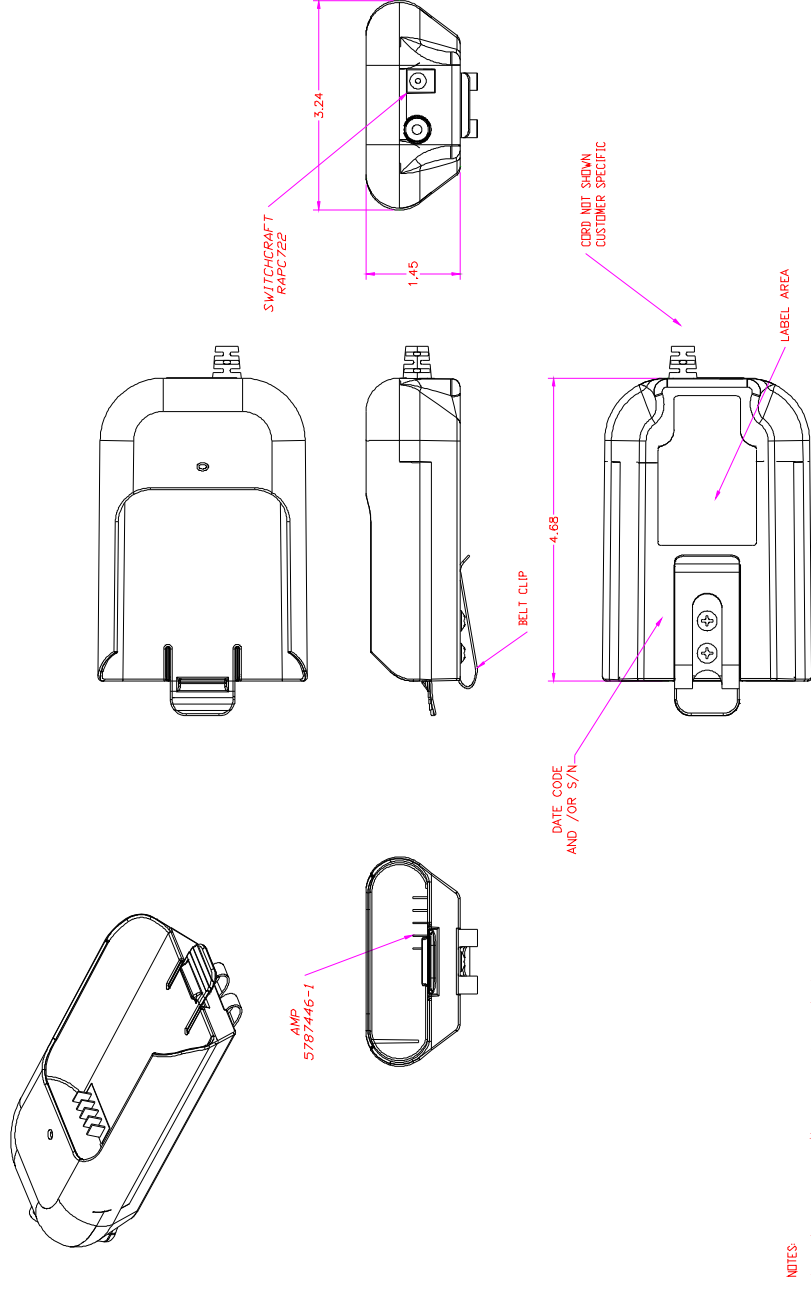
Revision: two digit revision, starting with 01



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### 3.5.4. Mechanical Drawing (Preliminary)





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### 3.6. Environmental/Safety Specifications

#### 3.6.1. EMC and Safety

MC20501 has been tested to meet the requirements of:

- CE [EN550022 (ITE Class B), EN55024 (ITE, ESD Level 2)]
- FCC Part 15 Class B
- EN60950

### 3.7. Reliability

#### 3.7.1. Warranty

A high quality standard is maintained by Inspired Energy. All products are warranted against defects in workmanship, material and construction. The warranty period is one (1) year from the date of shipment from Inspired Energy.