

Smart Charger Preliminary Specification

Document Number

DS262A

Description

High Power Smart Charger Electronics

Inspired Energy Part Number

PH4000

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1. REVISION HISTORY

Revision	Release Date	Revisions	Issued By	Approved By
0.1	7/8/08	First draft.	WRL	

2. INTRODUCTION

2.1. Scope

This specification describes the physical, functional and electrical characteristics of a lithium ion smart charger supplied by Inspired Energy. This specification is the interface document between Inspired Energy and its customers. 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 produced will meet this specification.

2.2. Smart Charger Overview

This specification describes the physical, functional and electrical requirements for the PH4000 Smart Charger assembly. It will handle lithium ion (only) batteries rated up to 28.8V (8 cells).

The PH4000 is capable of communicating with 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. In addition, the charger has passive over-current protection and active monitoring of current reported by the battery compared to the current being sourced from the charger.



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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 across the case, as this will cause overheating.

2.3.2. Charge & Discharge

- Never use a charger or battery that appears to have suffered abuse.
- Only approved lithium ion batteries should be charged.
- Never use a modified or damaged battery or charger.
- Specified product use only.

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: 36VDC, 100W.

3.1.2. Power-On-Reset

All LEDs will flash on for 2 seconds on charger power up.

3.1.3. Operation

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

3.1.4. Storage

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

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



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3.1.5. Terminal Specifications

Hard-wired input power supply (also refer to the mechanical drawing for additional details).

Terminal	Legend	Description
--	(POS)	36V DC input.
--	(NEG)	DC GND input.

J3 pin assignments (also refer to the mechanical drawing for additional details).

Terminal	Legend	Description
A1	(+)	DC Positive to battery.
2	(C)	SMBus Clock.
3	(D)	SMBus Data.
4	(THM)	300 ohm "thermistor" connection to battery.
A2	(-)	DC Negative to battery.

The SMBus Clock and data lines will be pulled up by the charger to a nominal 5V Vdd. A 15K Ω pull-up resistor is used, but please refer to the SMBus Specification for additional information.

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 level III 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/calibration control and user display.

Pertinent battery parameters (including battery temperature) are constantly monitored throughout the charge/calibration cycle to insure safe and reliable operation. 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	<70mA	36V input power is applied (no battery).
Battery leakage current consumption	<30uA	Parasitic leakage current from the battery when input power has been removed from the charger.

3.2.3. 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 passed on to the charge control circuitry which has been configured to deliver up to 33 volts and 4 amps. The present voltage and current of the battery is constantly read from the battery then used to adjust the charge voltage and current every second. Normal charge termination occurs when the battery reaches full charge, begins requesting 0 current and issues the TERMINATE_CHARGE_ALARM Warning.

When a 300 ohm resistor is detected on the 'T' battery pin, an 80mA wake-up current is provided until the battery broadcasts the desired charge voltage and current. If the battery does not respond within 220 seconds, the charger shuts off the wake-up current and indicates an error condition. The battery is charged at constant current until the battery voltage is near the final charge voltage, 4.2V times the number of lithium cells in series. The charger then switches to constant voltage charging. If either the voltage reported by the battery differs from that measured in the charger by more than 6%, or the current reported by the battery or measured by the charger exceeds the max current requested by the battery by more than 12% for more than 20 seconds, the charger will shut down and indicate an error condition.

Once fully charged, if the battery is left in the charger, the charger will re-initiate charge as requested by the battery. The battery will begin requesting current following a predetermined amount of self-discharge. Batteries can be left connected to the charger indefinitely without harm.

3.2.4. Calibration

If the battery is in need of fuel gauge recalibration, the red charger LED will flash upon insertion of the battery, as well as the green charge LED flashing.

The flashing red LED indicates a calibration cycle is needed for the battery to relearn its capacity, thereby providing more accurate data to host device. The calibration cycle consist of both charge and discharge cycles sequenced in a manner to allow the battery to relearn its capacity. The PH4000 does not provide a calibration cycle.

3.2.5. Regulation/Measurement Accuracy

3.2.5.1. Voltage

The charge voltage is measured and regulated to $\pm 1.5\%$ of the battery requested value.

3.2.5.2. Current

The charge current is measured and regulated to $\pm 5\%$ of the battery requested value.



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3.2.6. LED Indication

The charger provides LED display to inform the user of operation mode and fault conditions.

Off:	No Battery
GREEN Flashing:	Charge in process
GREEN Solid:	Charge complete
RED Flashing:	Battery requesting calibration
RED:	Error

Error Conditions:

Smart Charger: Unsuccessful internal communications, voltage or current delivered is different from that reported by battery.

Battery: No Battery Communications w/i timeout.

3.3. SMBus and SBDS Parameters

3.3.1. Overview of Operations

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)

3.3.2. 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

3.3.3. Communication Protocol

SMBus Interface complies with SBS Specification Version 1.0. The charger includes a simple bi-directional serial data interface. The charger processor uses the interface to access various battery pack registers.

3.3.4. 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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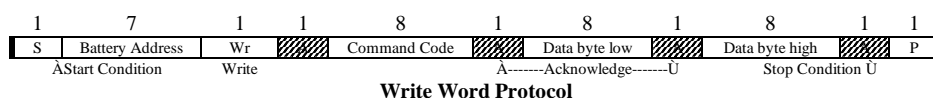
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The Charger communicates with the battery pack using one of three protocols:

- Write Word
- Read Word
- Read Block

3.3.4.1. Write Word

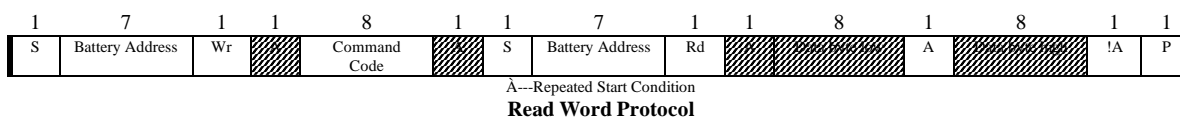
The first byte of a Write Word access is the command code. The next two Bytes are the data to be written. In this example the master asserts the slave device address followed by the write bit. The device acknowledges and the master delivers the command code. The slave again acknowledges before the master sends the data word (low byte first). The slave acknowledges each byte according to the I²C specification, and the entire transaction is finished with a stop condition.



3.3.4.2. 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.

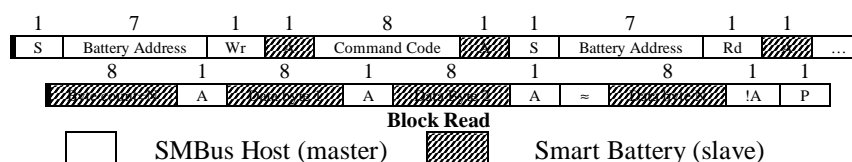


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3.3.4.3. Block Read

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.



3.3.5. Charger to Battery Message

The Charger 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

3.3.6. 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	mV	W



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3.3.7. 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%.



3.4. Mechanical Specifications

Approximately 1.9 lb. (0.85Kg), including 36V “brick” power supply.

The recommended interconnection mating connectors to the charger are:

Amphenol p/n L177TWA7W2SMP3SV4RRMM6, Inspired Energy p/n 619018

Amphenol L177TWA7W2S male connector shell with female signal pins

Amphenol L17DM53744-1 40A female solder cup inserts (2 required)

Amphenol L17DTZK15K optional protective backshell

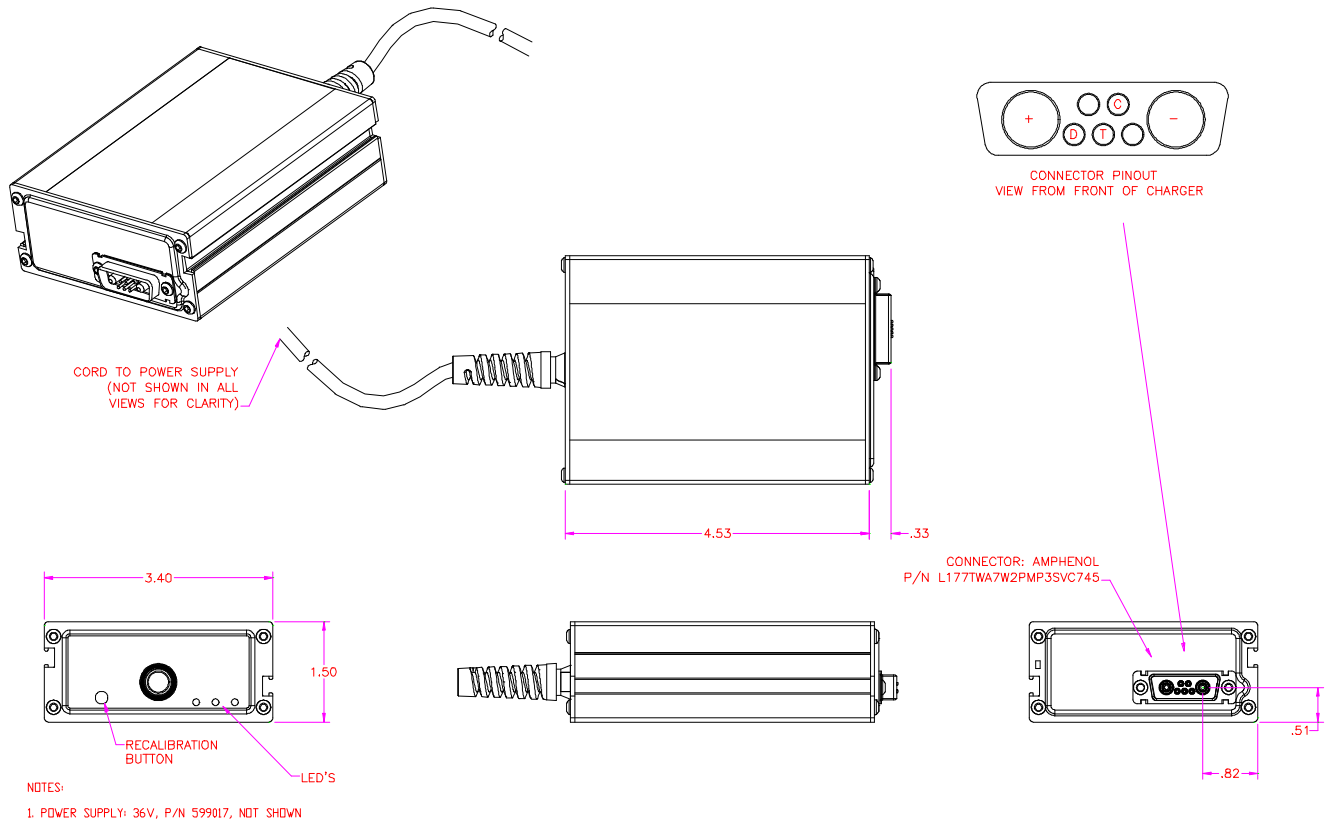
A date code is stamped on the back of each charger. The format is in the form of an 8 digit alphanumeric code

Manufacturing site ZZ YYWW XX Charger Revision
 Manufacturing date _____ ↑

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3.4.4. Mechanical Drawing





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3.5. Environmental/Safety Specifications

3.5.1. EMC and Safety

The Smart Charger *will have* the following approvals and *will be* labeled accordingly:

- FCC
- CE
- EN60950 Safety

3.6. Reliability

3.6.1. 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.