Dual Smart Charger/Calibrator Specification

Document Number

DS249A

Description

Dual Smart Charger/Calibrator Electronics

Inspired Energy Part Number

CH5050

Statement of Confidentiality

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1. REVISION HISTORY

Revision	Release Date	Revisions	Issued By	Approved By
0.1	6/20/08	First draft	WRL	
1.0	8/11/08	First release	WRL	

2. INTRODUCTION

2.1. Scope

This specification describes the physical, functional and electrical characteristics of a dual smart charger/calibrator 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/calibrator's operation. The charger/calibrator produced will meet this specification.

2.2. Smart Charger/Calibrator Overview

This specification describes the physical, functional and electrical requirements for the CH5050 Dual Smart Charger/Calibrator assembly.

The CH5050 is capable of communicating with each of two batteries through separate System Management Bus (SMBus) communications 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 each battery and the charger and by monitoring the battery on-board thermistor. In addition, the charger has passive over-current protection and active current monitoring of current to the battery as well as the current being sourced at its input.

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/block the fan exhaust 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/calibrated.
- Never use a modified or damaged battery or charger.
- Specified product use only.
- Caution – during recalibration the battery connector and base of the charger will 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 to the following parameters: 24VDC, 60W.

3.1.2. Power-On-Reset

The LEDs will flash for 1 second on power up, for each of the two chargers.

3.1.3. Operation

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

3.1.4. Storage

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

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

3.1.5. Terminal Specifications

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

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

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

Terminal	Legend	Description
1A,1B	(+)	DC Positive to battery1.
2A,2B	(C)	SMBus Clock 1.
3A,3B	(D)	SMBus Data 1.
4A,4B	(THM)	Thermistor connection to battery 1.
5A,5B	(-)	DC Negative to battery 1.

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

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

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

3.2. Charger/Calibrator Electronics

3.2.1. Overview of Operation

The Smart Charger/Calibrator is capable of providing all auxiliary battery functions needed to recharge and recalibrate one or two Smart Batteries.

The charger is capable of communicating with each battery independently 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 are constantly monitored through out the charge/calibration cycle to insure 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.

3.2.2. DC Specifications

Parameter	Limits	Remarks
Active current consumption	<20mA	24V input power is applied.
Battery leakage current consumption	<40uA	Parasitic leakage current from each battery when input power has been removed from the charge control board.

3.2.3. Charging

During charge, for each battery the charger reads the battery status, battery mode, requested battery current, requested battery voltage, and battery temp. The requested battery voltage and current are then passed on to the charge control chip which has been configured to deliver up to 16.8 volts and 3 amps. The specified voltage and current of the battery read from the battery every second then relayed to the charge control chip. 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 a 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 else will begin requesting current following a predetermined amount of self-discharge.

The difference between the Primary and Secondary battery positions is that the Primary has priority, and will always charge at the maximum desired rate, drawing up to 2.5A from the input source. The Secondary position receives any excess current available from the input source (up to 2.5A) that the Primary does not require.

3.2.4. Calibration

The calibration cycle is needed for a battery to relearn its capacity, thereby proving more accurate data to host device.

The calibration cycle consist of both charge and discharge cycles sequenced it a manner to allow the battery to relearn its capacity.

The charge cycle is controlled as described above. The final step in the calibration cycle is to fully charge the battery.

During discharge, each battery is discharged through a constant 16 ohm resistance. Discharge cycles are terminated when the battery issues the TERMINATE_DISCHARGE_ALARM. The charger may get quite warm if two batteries are being discharged simultaneously.

If a battery is in need of fuel gauge recalibration, the red LED will flash upon insertion of the battery.

> *This indicator provides feedback to the user on the accuracy of the fuel gauge and avoids unnecessary battery calibration cycles.*

The user has the option to calibrate the fuel gauge and charge the battery, or to only charge the battery.

> *This option is given because a recalibration cycle is longer than a charge cycle.*

To recalibrate the battery, press the calibrate button for this battery position.

> *No user action is required if only a recharge is required, as the charger will automatically begin to charge the battery.*

The blue calibration LED will flash to indicate that the battery is undergoing the recalibration cycle.

> *There may be a short delay before the calibration begins. During calibration the discharge resistors will heat up and the fan will operate to maintain temperature within acceptable limits.*

At the end of this procedure the blue LED will stay on constantly, indicating a fully charged, fully calibrated battery.

If the charger fails to calibrate the battery correctly, the blue LED will light solid and the red LED will flash.

If the battery is removed, or the charger powered down, the calibration cycle must start again from the beginning.

3.2.5. What is recalibration & why is it needed?

The fuel gauge in the battery uses a highly accurate voltmeter, ammeter and time clock to measure actual charge in & out of the battery pack. In addition there are algorithms to compensate for the effects of discharge rate, discharge temperature, self-discharge and charging efficiency etc.

All this combines to provide a highly accurate fuel gauging system. What is also required is the means to ensure the continued reliability of this system throughout the life of the battery pack.

Even with all this technology, the only time at which the battery is absolutely certain of its real capacity is when it is either completely full or completely empty. Anywhere in between is a calculated estimate - albeit a highly accurately calculated one.

Also, as the battery ages, the amount of available capacity shrinks - so each cycle the "full" point gets a little bit lower. Imagine if the fuel tank in your car got smaller as your car got older – you'd need to occasionally recalibrate your car's fuel gauge too.

What's more, if the battery only sees partial charges and discharges during its application, then it may not get the benefit of a "full" or "empty" reference point for some time and must rely more and more on its calculated figure. So the fuel gauging system may be subject to drift during use.

In use, as the fuel gauge mathematically works out the battery's remaining capacity. It will also work out an estimated accuracy figure known as the "Max Error". This keeps track of the overall accuracy of the system. In this way the battery can tell the device not only how much capacity is remaining, but also how reliable this estimate is. When an Inspired Energy battery achieves a max. error of 10% the recalibration bit is set.

Some devices use this recalibration bit to trigger a note on the device screen to tell the user to recalibrate their battery. Other systems simply put a note in their instruction manual to recalibrate the battery every so often.

So the recalibration is used to re-set the fuel gauge algorithms, re-establish the full and empty points, and re-calculate the actual capacity in the battery. In this way, even as the battery ages and things change, the accuracy and reliability of the fuel gauge can be retained throughout the life of the battery.

Now in order to carry out a full recalibration the following must occur:
- Fully charge the battery (this tells the system how much charge has been put into the battery to take it to 100% charged, and establishes the current "Full" point.)
- Fully discharge the battery (This tells the system how much of the full charge input is available for discharging, and re-sets the Max Error)

At this point the battery is calibrated, but it is also empty - so it needs a full recharge to return it to use.

3.2.6. Regulation/Measurement Accuracy

3.2.6.1.Voltage

The charge voltage is measured and regulated to ±0.8% of the battery requested value.

3.2.6.2.Current

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

3.2.7. LED Indication

The charger/calibrator 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
BLUE Flashing:	Calibration in process
BLUE Solid:	Calibration complete
RED Flashing:	Battery requesting calibration
RED:	Error

Error Conditions:

Smart Charge:	Unsuccessful Charger communications within 210 second timeout.
Battery:	No Battery Communications within 210 second timeout.

3.3. SMBus and SBDS Parameters

3.3.1. Overview of Operations

The Smart Charger/Calibrator 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.

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.

1	7	1	1	8	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	Data byte low	A	Data byte high	A	P

ÀStart Condition   Write   À-------Acknowledge-------Ù   Stop Condition Ù

Write Word Protocol

☐ SMBus Host (master)   ▨ Smart Battery (slave)

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.

1	7	1	1	8	1	1	7	1	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A	Data byte low	A	Data byte high	!A	P

À---Repeated Start Condition

Read Word Protocol

SMBus Host (master)   Smart Battery (slave)

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.

1	7	1	1	8	1	1	7	1	1	
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A	…

8	1	8	1	8	1		8	1	1
Byte count=N	A	Data byte 1	A	Data byte 2	A	≈	Data byte N	!A	P

Block Read

SMBus Host (master)   Smart Battery (slave)

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 charger	mV	W

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()" ≥ 20%.

3.4. Mechanical Specifications

3.4.1. Weight

Approximately 0.80 lbs. (0.36kg) for the charger, 0.65 lbs (0.30kg) for the DC power supply brick

3.4.2. Mating Connector

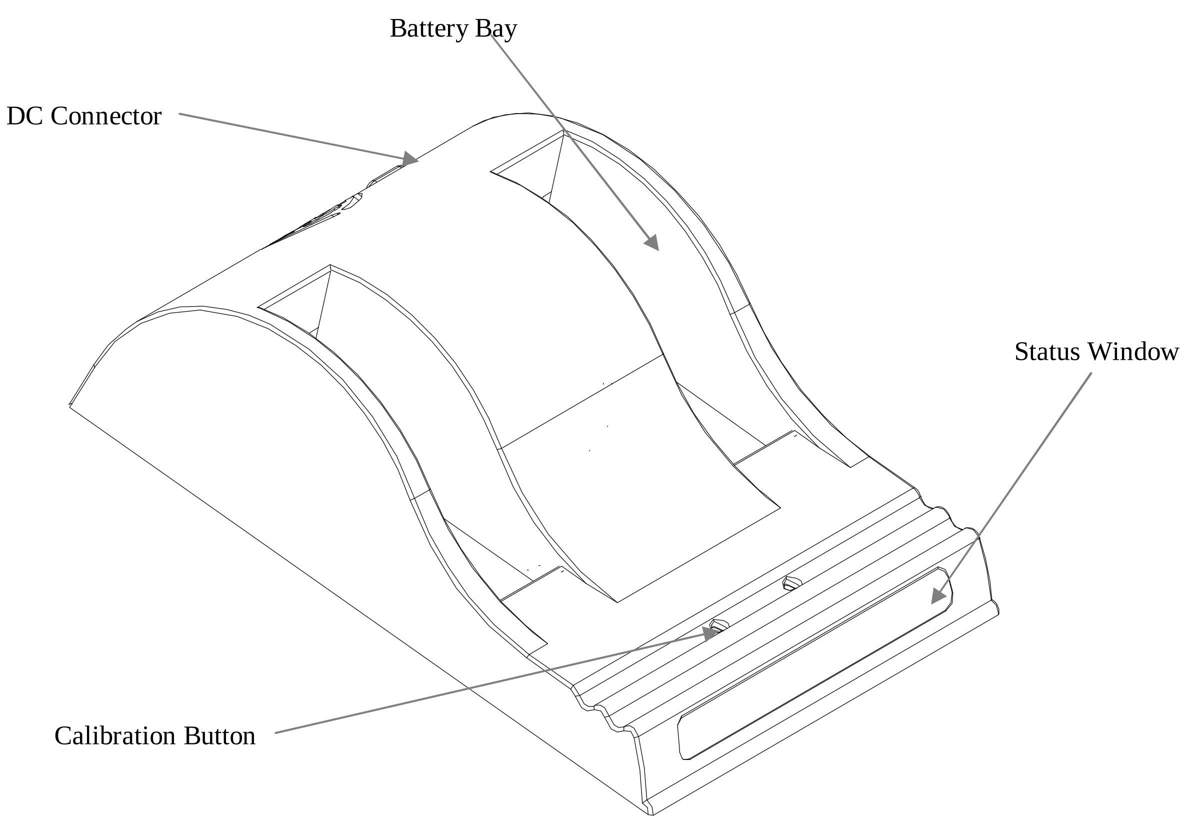
The recommended interconnection mating connectors are AMP/TYCO 787615-1, 787614-1 and 787613-1,

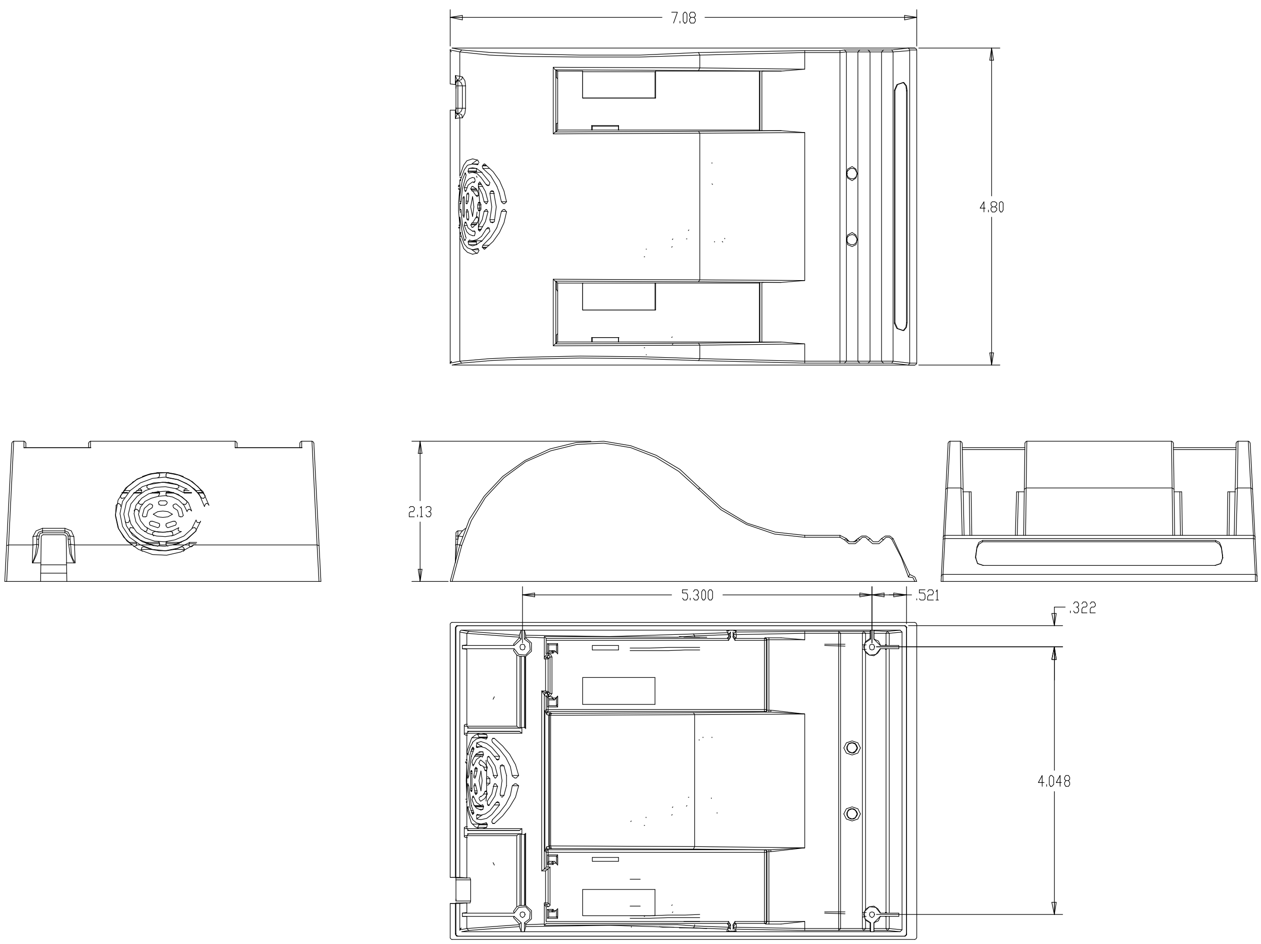
3.4.3. Date Code

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

ZZ YYWW XX
Manufacturing site___↑ ↑____Charger Revision
Manufacturing date________↑

3.4.4. Mechanical Drawing





7.08
4.80
2.13
5.300
.521
.322
4.048

3.5. Environmental/Safety Specifications

3.5.1. EMC and Safety

The Smart Charger/Calibrator has the following approvals and will be labeled according:

- CE [EN550022 (ITE Class B), EN55024 (ITE), ESD Level 4]
- FCC Part 15 Class B
- IEC60950 (ITE)

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.

3.7. Packaging

3.7.1. Single unit per carton

3.7.2. Bulk Packaging