

3-Battery Li-Ion Smart Charger System with 24V Output Specification

Document Number

DSCR03H205

Description

196Wh 3-Battery Li-Ion Charging System with up to 150W 24 Volt (Boosted) Battery Output and Pass-Through

Inspired Energy Part Number

CR03H205

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Specification Number	DSCR03H205
Specification Revision	1.0
Prepared By	DK & KP
Issue date	2/25/21

TABLE OF CONTENTS

1. INTRODUCTION	3
1.1. SCOPE.....	3
1.2. DEVICE OVERVIEW.....	3
1.3. GENERAL PRECAUTIONS.....	4
1.3.1. Handling	4
1.3.2. Charge & Discharge.....	4
1.3.3. Storage.....	4
2. REQUIREMENTS	4
2.1. GENERAL REQUIREMENTS.....	4
2.1.1. Input Power	4
2.1.2. Operation.....	4
2.1.3. Storage.....	4
2.1.4. Terminal Specifications	5
2.2. CHARGER ELECTRONICS.....	5
2.2.1. Overview of Operation.....	5
2.2.2. DC Specifications	6
2.2.3. Charging.....	6
2.2.4. Charge Regulation/Measurement Accuracy	6
2.2.4.1. Charge Voltage	6
2.2.4.2. Charge Current.....	6
2.3. CONTROL ELECTRONICS.....	7
2.3.1. LED Status Indication.....	7
2.3.2. Output	7
2.4. SMBUS AND SBDS PARAMETERS	8
2.4.1. Overview of Operation.....	8
2.4.2. SMBus Logic Levels.....	8
2.4.3. Communication Protocol.....	8
2.4.4. Initialization Procedure.....	8
2.4.4.1. Write Word	9
2.4.4.2. Read Word	9
2.4.4.3. Block Read.....	10
2.4.5. Charger to Battery Messages.....	10
2.4.6. Battery to Charger Messages.....	10
2.4.7. Critical Messages	11
2.5. MECHANICAL SPECIFICATIONS.....	12
2.5.1. Weight.....	12
2.5.2. Mating Connector	12
2.5.3. Date/Revision Stamp.....	12
2.5.4. Power Sources	12
2.5.5. Mechanical Drawing	13
2.5.5.1. Product Label:.....	14
2.6. ENVIRONMENTAL/SAFETY SPECIFICATIONS	14
2.6.1. EMC and Safety	14
2.7. RELIABILITY	14
2.7.1. Warranty.....	14



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Revision History

Revision	Release Date	Revisions	Issued By	Approved By
1.0	5/8/20	Production Release	DK & KP	JB, DH
1.1	2/25/21	EMC and Safety update	KP	JB

1. INTRODUCTION

1.1. Scope

This specification describes the physical, functional and electrical characteristics of a 3-bay Li-Ion Smart Battery charger with battery output 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.

1.2. Device Overview

This specification describes the physical, functional and electrical requirements for the CR03H205 system. The CR03H205 will house and charge three Inspired Energy NH2054xxxx 14.4V batteries from a 24V, 160W input. An output of up to 150W, 24V is provided through a 2ft output cable by battery power through boost circuitry. There is also a pass-through feature which allows the 24V input to pass through to the output cable. Battery power can supply up to 196Wh with three fully charged Inspired Energy NH2054xx34 batteries.

There are a total of four internal PCBs: three individual battery charger PCBs and a motherboard which ties the charger boards together and manages the total output, 150W pass-through and 24V boost circuitry. An external rocker switch located on the side of the enclosure is used to disable the batteries, and will place the battery output/charger circuitry into a low-power state. The device enclosure is made from aluminum 5052-H32 with black powder coating and is rated as IP50 (dust ingress protected).

The CR03H205 is capable of communicating with a Smart Battery through the System Management Bus (SMBus) and is fully SMBus Rev. 1.0, SBDS Rev. 1.1 and SCDS Rev. 1.1 compliant.

Safety protection is provided by a 25A Fast blow output fuse, and an on-board circuit breaker IC monitoring current. Redundant safety protection is provided by constant communications between the battery and charger and by monitoring the battery reported temperature, voltage and current.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
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1.3. General Precautions

1.3.1. Handling

- Avoid shorting.
- Do not immerse in or allow device to come in contact with water.
- Do not disassemble or deform.
- Avoid excessive physical shock or vibration.
- Never cover or obstruct the airflow, as this will cause overheating.
- Keep door shut when in operation

1.3.2. 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 device enclosure may become warm.

1.3.3. Storage

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

2. REQUIREMENTS

2.1. General Requirements

2.1.1. Input Power

The input power supply (599034) should comply with the following parameters: 24VDC, 160W. The input has reverse polarity protection, and is fused at 8A slow-blow. Charger will shut off for input voltages below 18VDC.

2.1.2. Operation

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

2.1.3. 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.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.1.4. Terminal Specifications

Card Edge Connectors - Charger PCB to Motherboard Connections (also refer to the mechanical drawing for additional details).

Terminal	Description
J1	Card edge connector 1.
J2	Card edge connector 2.
J2	Card edge connector 3.

Output Cable Pin Assignments (also refer to the mechanical drawing for additional details).

Terminal	Pin	Legend	Description
J5-1, J5-2	1 (Female)	(+)	24VDC output or +Vbattery DC output. This is reverse-current protected.
J5-3, J5-4	2 (Male)	(-)	DC GND output.

Battery Enable/Disable Rocker Switch Pin Assignments (also refer to the mechanical drawing for addition details).

Terminal	Pin	Legend	Description
J6-1	1	(-)	DC GND.
J6-2	2	(BD)	Battery Disable.

Input Connector Pin Assignments (also refer to the mechanical drawing for additional details).

Terminal	Pin	Legend	Description
J4-1, J4-2	1 (Male)	(+)	24V DC input.
J4-3, J4-4	2 (Female)	(-)	DC GND input.

2.2. Charger Electronics

2.2.1. 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 Revision 1.0 and SBDS Revision 1.1 compliant. The charger is implemented as an 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.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.2.2. DC Specifications

Parameter	Limits	Remarks
Operating current consumption	<25mA	24V input power is applied.
Battery operating current consumption	<6mA system total, <2mA per battery	Parasitic leakage current from the batteries when input power has been removed from the charge control board. Processor is on. Output Boost on.
Shutdown current consumption	<200uA system total, <60uA per battery	Parasitic leakage current from the batteries when input power has been removed from the charge control board. Processor is off. Battery disable switch is in off position.

2.2.3. Charging

During charge, each 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 4 amps (30Watt max each or 90Watts Total), but not more than the input voltage. The specified voltage and current of the battery are 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.

2.2.4. Charge Regulation/Measurement Accuracy

2.2.4.1. Charge Voltage

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

2.2.4.2. Charge Current

The charge current is measured and regulated to -14% +6% or to $\pm 50\text{mA}$, whichever is greater, of the battery requested value, up to 4A that is limited to 30 watts each or 90 watts total.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.3. Control Electronics

2.3.1. LED Status Indication

The charger/control electronics provides a green status LED to inform the user of the charger mode and a red status LED to inform the user of fault conditions or if calibration is required:

Off:	Switched off, No/Low Battery, or Input voltage less than 18VDC.
GREEN Flashing:	Charge in process
GREEN Solid:	Charge complete
RED Solid:	Error Condition(s)
BLUE Solid:	24Volt Output on

Error conditions include:

- the charger microprocessor cannot communicate with the Smart Battery, or
- the charger microprocessor cannot communicate with the internal battery charger engine.

The batteries compatible with this charger contain a fuel gauge to indicate the relative state of charge of the battery. The battery LCD flashes to indicate charging.

There will be one Blue LED for the CR03H205 to indicate the 24Volt Output in on.

2.3.2. Output

As a pass-through design, the higher voltage of either the input from J4 or the batteries are connected to the output connector J5. If there is no input and the batteries are all reporting FULLY_DISCHARGED status, or removed, then there will be no output at J5. When operating on batteries the FULLY_DISCHARGED status will not clear until they have charged to 20% state of charge. This output enable delay is to prevent power on/off glitches. 20% allows for enough runtime to be able to perform most actions required.

When an input >18V is present, the output is enabled by processor--even when no battery is present. Each battery connector is fused at 10A slow-blow, while each battery charger input connector is fused at 8A slow-blow. To prevent overloading the input source, each charger will reduce the charge current as required to keep the input at 1.25A max, although the load may exceed 1.25A. The CR03H205 is capable of delivering a total of 30A from the batteries (10A each). The Boosted Output is capable of 24Volt 6.25Amps (150 Watts continuous). The Output is circuit breaker protected at 7.5amps with a response time of 8μSec and a retry time frame of 550mSec.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.4. SMBus and SBDS Parameters

2.4.1. 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 1.1, Dec 11, 1998)
- Smart Battery Charger Specification (Rev 1.1, Dec 11, 1998)

2.4.2. 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	3.3	V
Vol			0.4	V

2.4.3. Communication Protocol

SMBus Interface complies with SBS Specification Version 1.0. The charger includes a simple bi-directional serial data interface similar to I²C. The charger processor uses the interface to access various battery pack registers.

2.4.4. 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.

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

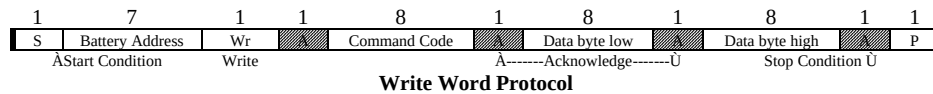
- Write Word
- Read Word
- Read Block

3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
Prepared By	DK & KP
Issue date	2/25/21

2.4.4.1. Write Word

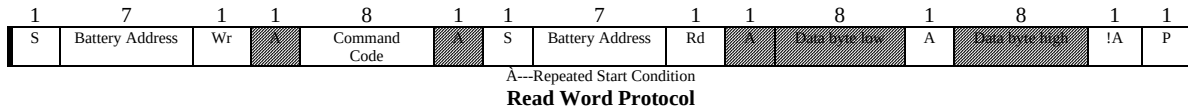
The first byte of a Write Word access is the command code. The next two Bytes are the data to be written. In this example the master asserts the slave device address followed by the write bit. The device acknowledges and the master delivers the command code. The slave again acknowledges before the master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



2.4.4.2. 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.

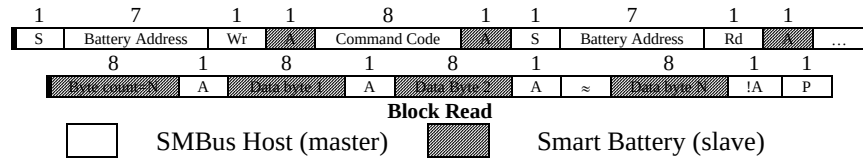


3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.4.4.3. 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.



2.4.5. 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

2.4.6. 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

3-Battery Li-Ion Smart Charger System with 24V Output Specification

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2.4.7. 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%.



3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.5. Mechanical Specifications

2.5.1. Weight

Single Unit without batteries: Approximately 4.1 lbs (1.86 kg)
Single Unit with batteries: Approximately 7.01 lbs (3.18 kg)
Shipping Weight, Single Unit: Approximately 6.59 lbs (2.99 kg)
Shipping Weight, Three Units: Approximately 21.12 lbs (9.58 kg)

2.5.2. Mating Connector

Output Cable Mate: Lemo ERA.1S.302.CLL

Input Connector Mate: Lemo FFA.1S.302.CLAC62Z

2.5.3. Date/Revision Stamp

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

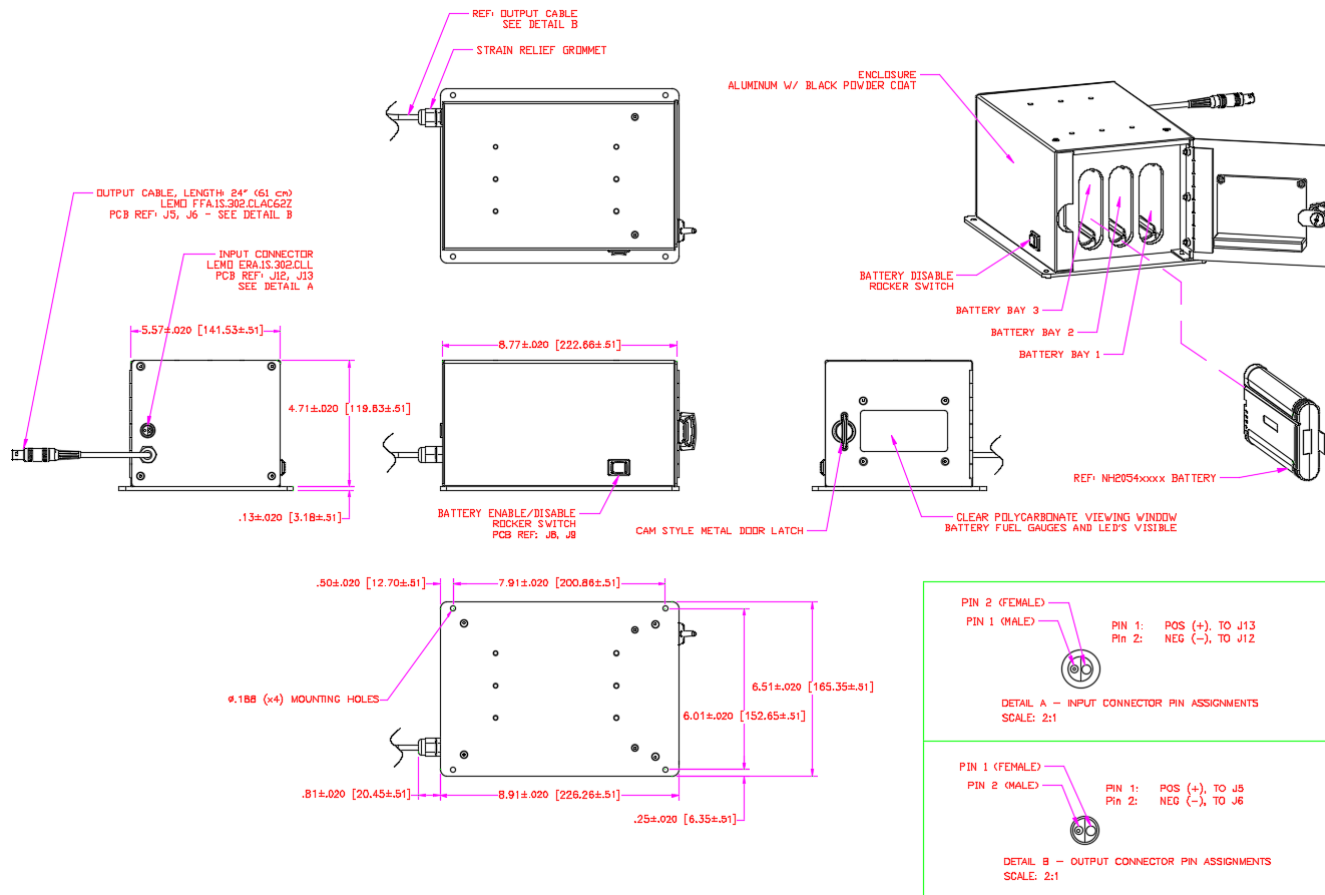
2.5.4. Power Sources

Power Supply: 160W 24VDC 6.67A, Level VI Efficiency, P/N: 599034

3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.5.5. Mechanical Drawing

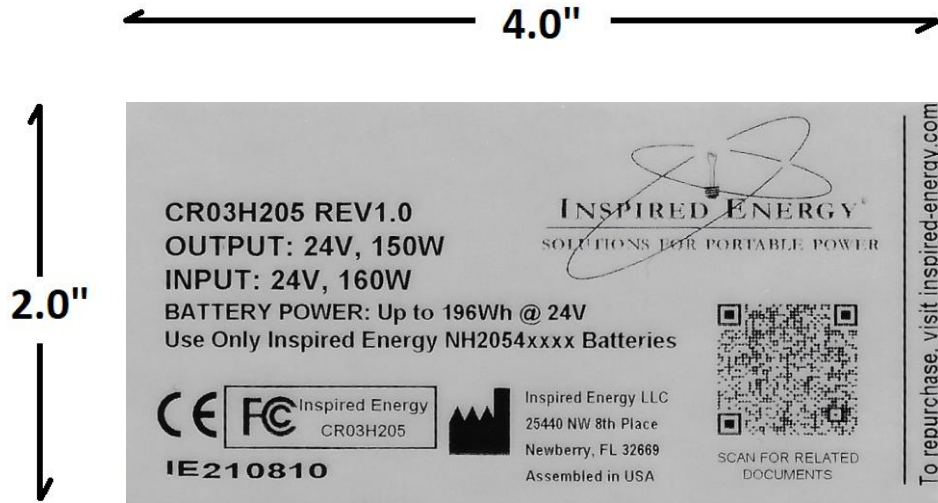




3-Battery Li-Ion Smart Charger System with 24V Output Specification

Specification Number	DSCR03H205
Specification Revision	1.0
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2.5.5.1. Product Label:



2.6. Environmental/Safety Specifications

2.6.1. EMC and Safety

CR03H205 has been tested to meet the requirements of:

The Smart Rack Charger has the following approvals and is labeled accordingly:

- EMC Directive
- WEEE Directive
- RoHS2 Directive
- EU Regulation (EC) REACH

Tested to:

- EN 55032
- EN 55024
- FCC Title 47 CFR, Part 15 Class B

2.7. Reliability

2.7.1. 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.