ICL & RC Series Battery Chargers Installation & Design Guide

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Table of Contents

1 Safety Notes

This section provides important safety information when installing and using all of the ICL & RC Series battery chargers. Read and comprehend this document fully before handling or working with ICL & RC Series battery chargers.

1.1 High Voltage Safety

WARNING: This product can contain potentially lethal levels of voltage. Exercise extreme care when working with the equipment.

WARNING: DO NOT open the case of the charger. No serviceable parts are contained inside the unit.

1.2 Electrical Safety Information

Danger: Risk of electric shock. Connect charger power cord to an AC outlet that has been properly installed and grounded in accordance with all local codes and ordinances. A grounded AC outlet is required to reduce the risk of electric shock. **Do not use ground adapters or modify the plug**. Do not touch uninsulated portions of the output connector or uninsulated battery terminals. Disconnect the AC supply before making or breaking the connections to the battery. Do not open or disassemble the charger. Do not operate this charger if the AC supply cord or DC output cord is damaged or if the charger has received a sharp blow, been dropped, or is damaged in any way. Refer all repair work to the manufacturer or qualified personnel. This charger is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities, or lack of experience and knowledge on electrical systems and battery charging, unless they have been given supervision or instruction concerning use of the charger by a person responsible for their safety. Children should be supervised to ensure they do not play with the charger.

1.3 Battery Safety Information

WARNING: Use the charger only with an algorithm that is appropriate to the specific battery type and capacity. Other usage may cause personal injury and damage. Lead acid batteries may generate explosive hydrogen gas during normal charging. Keep sparks, flames, and smoking materials away from batteries. If this charger is used with lithium-ion type batteries, an integrated battery management system (BMS) must be used. The BMS must ensure that, in all operating modes, the battery cells are protected from inappropriate levels of voltage, current, temperature, and state of charge. Do not operate charger in a closed-in area or restrict ventilation. Never charge a frozen or non-rechargeable battery. Observe all battery manufacturers' precautions (e.g., maximum charge rates and if cell caps should be removed while charging).

1.4 Precautions

Hot Surfaces: During charging, the surface of the charger may become hot to the touch, especially in higher ambient temperatures. This is normal. Avoid touching the surface of the charger.

Extension Cord Rating: Extension cords used with the charger must have appropriate safety approvals for the country in which it is used (e.g., Nationally Recognized Testing Laboratories (NRTL) approval in the United States). Wire gauge must be appropriate for the input current of the charger.

2 Regulatory Notes

2.1 North America

This equipment has been tested and found to comply with the limits for Class B digital devices, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

All ICL & RC Series chargers are fully compliant with safety regulatory requirements in Canada and the United States, as indicated by the C before and the US after the UL or RU mark.

All ICL & RC Series chargers are fully compliant with California Energy Commission (CEC) standards for efficiency, and are marked with the CEC compliance symbol.

2.2 Europe, Asia, Middle East, Africa

The ICL & RC Series chargers are approved for use in Europe and other countries that accept CE requirements. Each charger has a CE mark, supported by a CB Test Report. ICL & RC Series chargers comply with the limits of CISPR 14-1 & 14-2 when appropriately filtered COMM cords are installed. Contact Delta-Q Technologies for details on this filtering.

2.3 United Nations Economic Commission for Europe (UNECE)

The ICL & RC Series 48V chargers are compliant with the UNECE Regulation 10 requirements for electrical/electronic sub-assembly (ESA) when appropriately filtered cord sets are installed. Contact Delta-Q Technologies for details on this filtering (pending).

2.4 Australia & New Zealand

The ICL & RC Series chargers are certified for use in Australia and New Zealand, and labelled with the Regulatory Compliance Mark (RCM) symbol.

2.5 South Korea

The RC 900 and 1200 36V model chargers are certified for use in South Korea and labeled with the regulatory KC mark.

2.6 Other Standards or Requirements

Every effort has been made to ensure ICL & RC Series chargers are fully compliant with most worldwide regulations. If a particular region does not accept the regulatory approvals for these products, contact Delta-Q Technologies for further information and assistance. Copies of all approvals are available upon request.

3 ICL & RC Series Model Overview

There are many models of the ICL & RC Series chargers, with differing combinations of features and options; contact Delta-Q Technologies for more information. The table below lists some of the standard models of the ICL & RC Series.

Figure 1: RC900 W/UI, RC1200 W/UI and ICL1200 Battery Chargers

Table 1: ICL & RC Series Models

Part Number	Product Description	Nominal Voltage	Max Current	Max Power
ICL900 Models				
947-0001	ICL900	36-54V	27.0A	900W
ICL1200 Models				
943-0001	ICL1200	36-54V	33.3A	1200W
RC900 Models				
944-0001	RC900 36V	36V	28.0A	900W
944-0002	RC900 48V	48V	21.0A	900W
944-0003	RC900 36V W/UI	36V	28.0A	900W
944-0004	RC900 48V W/UI	48V	21.0A	900W
RC1200 Models				
945-0001	RC1200 36V	36V	36.7A	1200W
945-0002	RC1200 48V	48V	27.5A	1200W
945-0003	RC1200 36V W/UI	36V	36.7A	1200W
945-0004	RC1200 48V W/UI	48V	27.5A	1200W

4 ICL & RC Series Charger Operation

ICL & RC Series battery chargers are intelligent, programmable power devices designed to reliably charge your machine's batteries in the harshest of environments. They are intended to be installed on-board or off-board and, if desired, can be fully controlled by your own machine control module. The charger also provides electrical protection to help maintain the integrity of your vehicle's electrical system and protect your users.

As advanced power conversion devices, ICL & RC Series chargers efficiently provide clean DC output in a very compact package. They do this using small, lightweight, high-frequency switching technology, and also incorporate a utility-friendly power factor correction stage. The overall design is optimized for maximum ruggedness and reliability to provide many years of service.

Note: If the charger is used to charge lithium-ion type batteries, an integrated battery management system (BMS) MUST be used. The BMS must ensure that, in all operating modes, the battery cells are protected from inappropriate levels of voltage, current, temperature, and state of charge.

4.1 Isolation

The ICL & RC Series chargers use a system of isolation boundaries to separate the charger's advanced features into three galvanically-isolated electrical domains:

1. AC Domain: the input to the charger.
2. Battery/DC Domain: contains all the charger's outputs except the CAN bus
3. Isolated CAN Domain: CAN bus signal and ground pins

Each domain is isolated from the others and from the charger's case. The case is directly connected to the AC ground pin of the AC input connector.

4.2 User Interface

RC Series chargers are available as Base or W/UI (with user interface) models. The difference between the two is the inclusion of a status LED and push-button on the W/UI models. Both models can be configured for on-board or off-board use.

Figure 2: RC900 Series W/UI Model (rear view)

Figure 3: ICL1200 Series Base Model (rear view)

4.3 Normal Operation for Lead Acid Battery Charging (RC Series Only)

To begin charging, the battery pack must be within the voltage operation range of the selected charge algorithm and the AC input voltage must be within the specified range for the charger. The RC Series chargers can operate in an on-board configuration (charge on AC detect) or an off-board configuration (charge on battery detect). Once the battery pack is fully charged – and if the charger, battery pack, and AC input all remain connected – the charger will continue to monitor and maintain the battery.

Notes:

- If AC power is interrupted, and then restored, the charger resumes operation without hazard to the user or damage to the batteries.
- When not being controlled externally (e.g., via CAN bus), the ICL & RC Series chargers are designed to charge batteries only during the times when the machine is off.
- Unlike the Delta-Q Technologies IC Series chargers, RC Series battery chargers do not continue operation when AC power is disconnected.
- The chargers are not designed to be used as power supplies (i.e., to provide power to loads other than batteries). Unsatisfactory operation may occur if loads, other than batteries, draw current from the charger, which may include under- or over-charging, and/or an increase in Electromagnetic Interference (EMI).

4.3.1 On-Board Configuration: Charge on AC Detect

The charger is permanently connected to the battery pack. Charging begins when AC input is applied to the charger and will continue until the batteries are fully charged. The charger enters Monitor/Maintain mode when charging is complete and remains in this mode while connected to AC input.

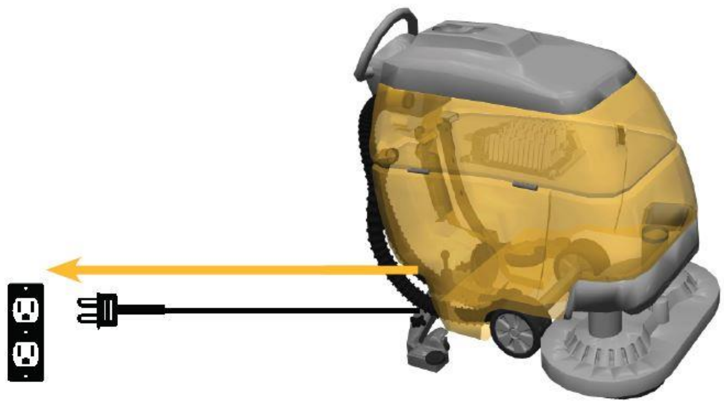


Figure 4: On-Board Configuration

4.3.2 Off-Board Configuration: Charge on DC (Battery) Detect

The charger is permanently connected to AC power. Charging begins when the battery pack is connected to the charger and will continue until charging is complete. The charger enters Monitor/Maintain mode when charging is complete and remains in this mode while connected to the battery pack.

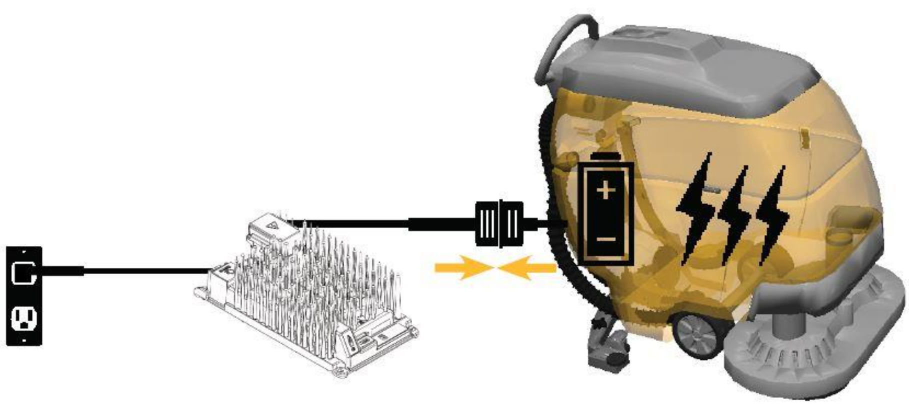


Figure 5: Off-Board Configuration

4.3.3 Monitor/Maintain Mode

This mode becomes active when charging is complete, AC power is present, and the battery pack is connected. The charger's DC output is disabled and the charger monitors the batteries. If the batteries fall below set thresholds or beyond set time limits for the charge algorithm, the charger takes action to maintain the capacity and health of the batteries. Typically, charging will restart after 14 days or 1.80 V/cell for lead acid batteries.

4.4 Normal Operation for Lithium Battery Charging with BMS Control

The charger may be configured for remote controlled operation over CAN bus. In this mode, the charger accepts voltage and current requests that, together with an appropriate algorithm, allow a suitable battery monitor/controller (e.g., a BMS) at another node on the CAN bus to control the charger's output. There are several requirements that must be met for remote operation to work properly.

1. The charger must be configured for remote operation with an appropriate algorithm. Your Delta-Q Technologies Applications Engineer can provide assistance.
2. Before the charger accepts voltage and current requests, three steps must be followed:
    a. The charger must periodically receive a heartbeat from the battery monitor node. The charger detects the heartbeat by node ID. By default, the charger is configured to recognize node ID 1 (0x1) as the battery monitor. The charger's default heartbeat timeout is 2 seconds. This means the battery monitor must transmit its heartbeat with a period of less than two seconds (e.g., 1 second).
    b. Once the heartbeat is established, the charger must receive a battery status object (0x6000) indicating the battery is NOT ready to charge (0). The battery status will only be accepted if the heartbeat has been established. This signals the battery monitor is ready to take control and puts the charger in a known, safe state.
    c. The charger must receive a battery status object (0x6000) indicating the battery is ready to charge.
3. After establishing the heartbeat and battery status ready, the charger accepts voltage (0x2271) and current (0x6070) request objects. Both requests must be received by the charger at least once before it produces any output.

The charger uses the lower of the limits specified by the algorithm and those supplied remotely.

- The charger receives a battery status object (0x6000) of zero:
    - Reset the voltage request object (0x2271) to zero.
    - Reset the current request object (0x6070) to zero.
    - Reduce the output to zero.
- The charger detects a loss of heartbeat:
    - Reset the voltage request object (0x2271) to zero.
    - Reset the current request object (0x6070) to zero.
    - Reset the battery status object (0x6000) to zero.
    - Reduce the output to zero.
    - If charging, transmit an emergency (EMCY) message indicating loss of heartbeat (CANopen error code 0x20808130).
- The charger is configured to detect missing Process Data Objects (PDOs) and a PDO timeout occurs:
    - Reset the voltage request object (0x2271) to zero.
    - Reset the current request object (0x6070) to zero.
    - Reset the battery status object (0x6000) to zero.
    - Reduce the output to zero.
    - Transmit an emergency (EMCY) message indicating loss of PDO (CANopen error code 0x20808130).
- Following the loss of heartbeat, or any other abnormal termination, charging can only resume after repeating steps 2 & 3.
- The charger receives an NMT application reset command (129):
    - Reset the current request object (0x6070) to zero.
    - Reset the battery status object (0x6000) to zero.
    - Reduce the output to zero.
- The charger loses power (AC and DC), the following objects are reset on restart:
    - Voltage request object (0x2271)
    - Current request object (0x6070)
    - Battery status object (0x6000)

- The charger loses power (AC and DC), the following objects are reset on restart:
  - Voltage request object (0x2271)
  - Current request object (0x6070)
  - Battery status object (0x6000)

To maintain reliable operation, Delta-Q Technologies recommends periodically transmitting the battery status (0x6000), voltage request (0x2271), and current request (0x6070) objects. In software version 5.6.0 or greater, this can be enforced using timeouts on received PDOs which can stop charging and indicate an alarm.

In addition, the charger status object (0x6001), or equivalently bit 5 in the extended charger status object (0x2006), may be used by the battery monitor to determine whether the charger is ready and able to charge. The charger is ready to charge if all of the following conditions are met:

- The charger is NOT in algorithm selection mode.
- The user is NOT attempting to enter algorithm selection mode.
- The charger is NOT performing a self-test (during start-up).
- An algorithm is configured.
- AC (main) power is qualified.
- The charger's power conversion circuitry is functioning properly.
- The battery is not connected to the charger with battery cable wired in reverse polarity.
- There are NO alarms or faults that could prevent charging.

PDOs can help automate the periodic resending of the battery status (0x6000), voltage request (0x2271), and current request (0x6070) objects. Transmission and reception of PDOs can be enabled by putting the charger into the CANopen bus state *operational mode* and disabled by putting it back into a *pre-operational mode*.

Note:

- The chargers CANopen software can only receive PDOs while in *operational mode* and not in *pre-operational mode*.
- The charger can be configured as a self-starting slave, which automatically enables the charger into an *operational mode* and would, therefore, start PDO transmission without any external enabling.

The operation/pre-operational mode of the charger does not have any direct effect on remote mode; it is only the receiving of the battery status (0x6000), voltage request (0x2271), and current request (0x6070) objects within the PDOs that affect the current and voltage behavior.

Note: As above, even with PDOs, the charger still requires reception of the heartbeat from the BMS before any of the battery status (0x6000), voltage request (0x2271), and current request (0x6070) commands will be processed and acted upon.

If the charger loses AC power, the charger's CANopen state is reset on restart to *boot* followed by *pre-operational* (unless self-starting slave is configured). It is up to the BMS to command the charger back into *operational* mode if PDOs are required.

For further information regarding particular CANopen objects, refer to the following documents:

- CAN in Automation, *CiA 301: CANopen Application Layer and Communication Profile*, V4.2.0 or later, 2011/02/21
- Delta-Q Technologies, *IC Series CANopen Interface Specification*, CANopen V2.0 or later

4.5 Normal Operation for Lithium Battery Charging without BMS Control

The charger may be configured with an appropriate algorithm for Lithium-ion battery charging. An external controller, such as a BMS, may remotely control the charge algorithm operation (e.g., using an enable/disable signal via pin 4 of the Signals & Control Connector). Contact Delta-Q Technologies for further information and assistance.

To begin charging, the battery pack must be within the voltage operational range of the selected charge algorithm and the AC input voltage must be within the specified input range for the charger.

The ICL & RC Series chargers can operate in an on-board configuration (charge on AC detect) or an off-board configuration (charge on battery detect). Once the battery pack is fully charged – and if the charger, battery pack, and AC input all remain connected – the charger will continue to monitor and maintain the battery.

Lithium Considerations:

- A BMS is required.
- The algorithm MUST specifically match the BMS and battery requirements.
- The BMS may enable/disable the charger's DC output depending on the algorithm features.
- Maintenance mode is algorithm dependent.
- The minimum voltage to start charging varies by algorithm but is generally much higher than lead-acid batteries.
- Typically, lithium algorithms will not have a *finish* phase and the charger will not indicate this phase of charging.

4.6 Battery Capacity

This table provides recommendations on the maximum Amp-Hour capacity rating (based on a 20-hour discharge rate) of batteries which each charger model may be used with, assuming the desired maximum charging time is 8 hours. Batteries with higher capacities are supported but the charging times would be longer than 8 hours. There is also a minimum battery capacity to meet California Energy Commission (CEC) regulation for each model.

Table 2: Maximum Battery Capacity for 8-Hour Charge

Model	36V (Lead Acid)	48V (Lead Acid)	48V (Lithium)
RC900	240 Ah	180 Ah	150 Ah
RC1200	320 Ah	240 Ah	200 Ah
ICL900	-	-	150 Ah
ICL1200	-	-	200 Ah

5 User Interface

On W/UI models, the **Charge Status** indicator shows the status of charging and any faults or errors, using a variety of colours and flashing/steady patterns. The **Charger** button is used to identify the current algorithm or select another algorithm from those stored on the charger. See *Charger* for details on how to use the button and see *Appendix E: Using the Charger Button (W/UI Models)* to learn how to make changes to the algorithm.

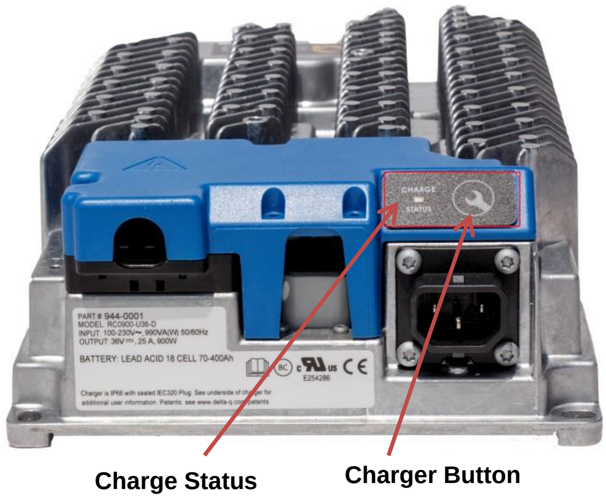


Figure 6: RC 900/1200 W/UI Models Interface

5.1 Standard Remote LED

On RC Series Base model and all ICL Series model chargers, an optional Remote LED can be used (PN 900-0147). The LED shows the status of charging and any faults or errors; the label (which is included in the LED kit) can be attached to the panel where the LED is mounted, and provides a graphical guide to the status information indicated by the LED colours & flashing/steady patterns.

Table 3: Remote LED Operation

Status	LED Operation
No AC	OFF
Charging: battery at low state of charge	Slow GREEN breathing (1s on; 0.2s off)
Charging: battery at high state of charge	Fast GREEN breathing (0.4s on; 0.1s off)
Charge Complete	Solid GREEN
Error	Rapid AMBER flashing (0.5s on; 0.5s off)
Fault	Solid RED

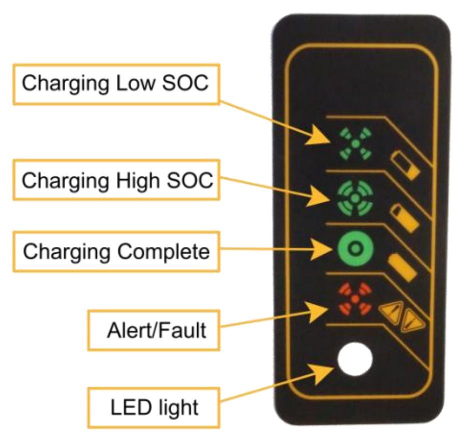


Figure 7: Remote LED Label

6 Installation

Though the chargers operate reliably in any orientation, insufficient cooling may prevent the charger from operating at full output power. Other important considerations in the installation are as follows:

- Keeping the charger clear of debris and dirt which can hinder conduction cooling.
- Providing access to the AC, DC, and signal connections for maintenance.
- Ensuring visibility of the charger interface if a remote LED is not used.
- Having mounting points that provide a secure installation.

6.1 Cooling

The amount of heat generated by the ICL & RC Series chargers, while charging batteries, is approximately 10% of the output power. At full output power, the ICL900 and RC900 generate approximately 90W while the ICL & RC 1200 generate approximately 120W of heat. The air around the charger moves the heat away from the immediate vicinity of the charger and eventually conducts that heat to the air outside of the equipment.

6.1.1 Fan Cooled Chargers

The ICL1200 and RC1200 chargers use forced air cooling. That is, a fan mounted on the case moves air over the surfaces of the charger. The charger should be installed so the air can exhaust to the rear (connector) side of the charger.

Use the following tips as a guide to ensuring the charger will be sufficiently cooled:

- Allow sufficient space around the charger for cooling air to flow around the charger. More space is better.
- The required clearance around the charger can be reduced to as little as 1 inch.
- The charger should be oriented so the fan is able to exhaust the air from the equipment in the most effective directions. See Figure 8 ICL1200 & RC1200 Forced Air Flow Simulation
- Do not place objects directly on top of the fan grill. This blocks the air intake and results in poor cooling performance.

The ICL1200 and RC1200 Forced Air Flow Simulations (shown on the following page) were produced assuming the worst-case operating conditions. That is, a charger attached to a thermally non-conductive surface, enclosure within one inch gap from the charger, high ambient temperature at 40°C, and operation at the maximum power output. Under nominal conditions, the charger temperature rise will be less than that shown in the diagrams.

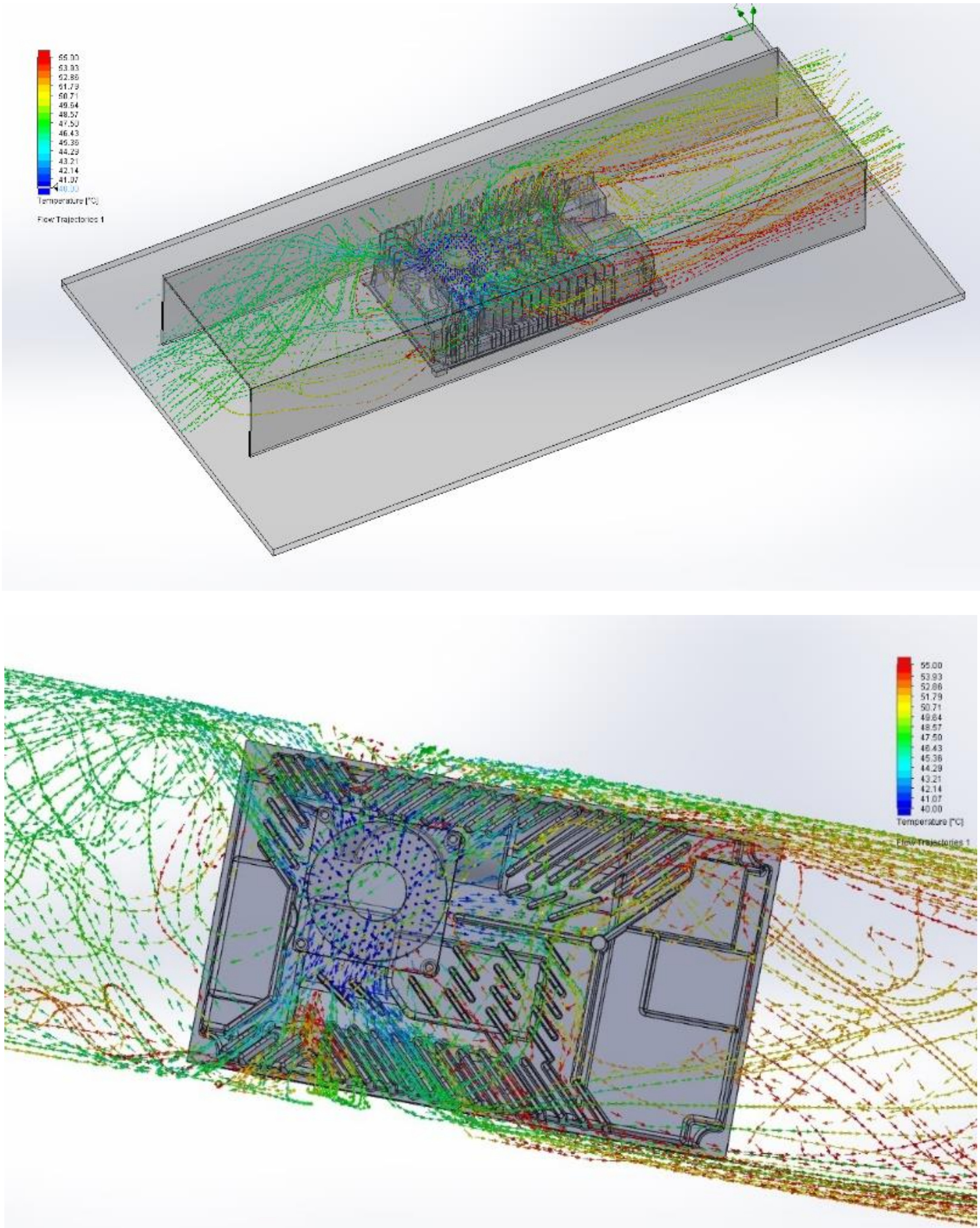


Figure 8: ICL1200 & RC1200 Forced Air Flow Simulation

6.1.2 Convection Cooled Chargers

The ICL900 and RC900 use convection cooling which uses the natural upward movement of warm air over the surfaces of the charger and draws in new cold air to carry the heat away from the charger.

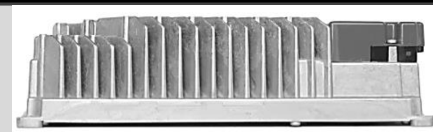
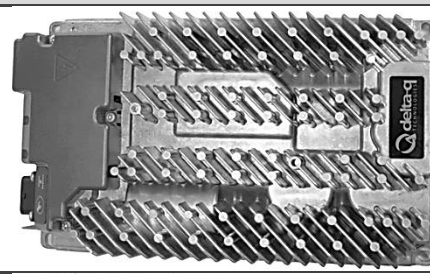
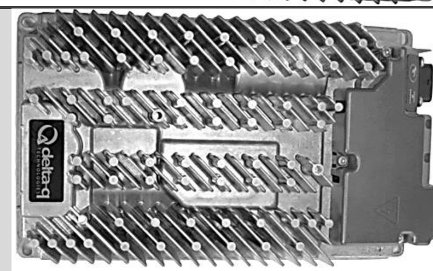
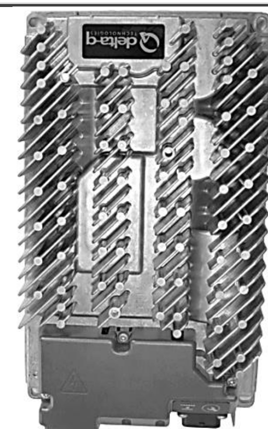
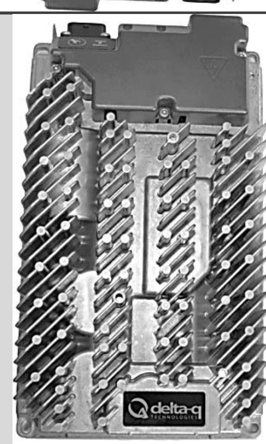
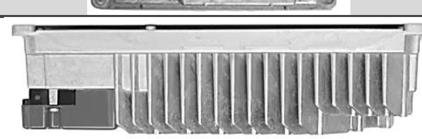
Figure 9: Convection Cooled ICL & RC Series Charger

Use these tips to ensure the charger will be sufficiently cooled:

- Mount the charger away (as much as possible) from other sources of heat, such as batteries.
- Provide 2 to 6 inches clearance around the charger to allow free air movement to and from the charger.
- When installed in an enclosed space, there must be a path for the heat to escape from an enclosed space at the top and for cool air to enter at the bottom.
- Allow for as large as possible openings, vents, and/or louvers to allow cool air to enter and hot air to escape.
- The ICL900 and RC900 Convection Air Flow Simulation diagrams show the air flow path for charger orientations and provide indications for the critical areas where to optimally place the air input and output openings.
- A variety of mounting orientations are possible with varying degrees of cooling effectivendss. See Table 4 for recommendations and tips.
- The best orientation for cooling the charger is to mount it on a horizontal surface with the cooling fins pointing upwards. Mounting the charger with the heat sink fins facing downward is not recommended. Trapped hot air may prevent the charger from operating at maximum output power.
- Due to the small contact area around its feet, the charger is insignificantly dependent on conduction cooling.

Note: The ICL900 and RC900 Convection Air Flow Simulations (shown on the following pages) were produced assuming the worst-case operating conditions. That is, a charger attached to a thermally non-conductive surface, high ambient temperature at 40°C, low input voltage at 100 Vac, low output voltage at 36Vdc, and operation at the maximum power output. Under nominal conditions, the charger temperature rise will be less than that shown in the diagrams.

Table 4: Convection Charger Orientation and Cooling Performance

Orientation	Cooling Performance	Illustration
Horizontal	Charger orientation presenting the best cooling performance.	
Side (AC connector at the bottom)	Charger orientation presenting the next best cooling performance. This orientation is particularity advised versus the one below when AC power voltage is 120VAC or lower.	
Side (AC connector at the top)	Charger orientation offering slightly less thermal performance than the above orientations.	
Vertical (Connectors side at the bottom)	The charger output power may de-rate under worst-case conditions. It is recommended the connector side of the charger be placed at the bottom so the power cables don't get heated by the hot air rising to the top of the charger.	
Vertical (Connectors side at the top)	The charger output power may de-rate under worst-case conditions. The power cables may heat up in this orientation due to rising hot air.	
Downward	This orientation is not recommended. Trapped hot air may prevent the charger from operating at its maximum output power.	

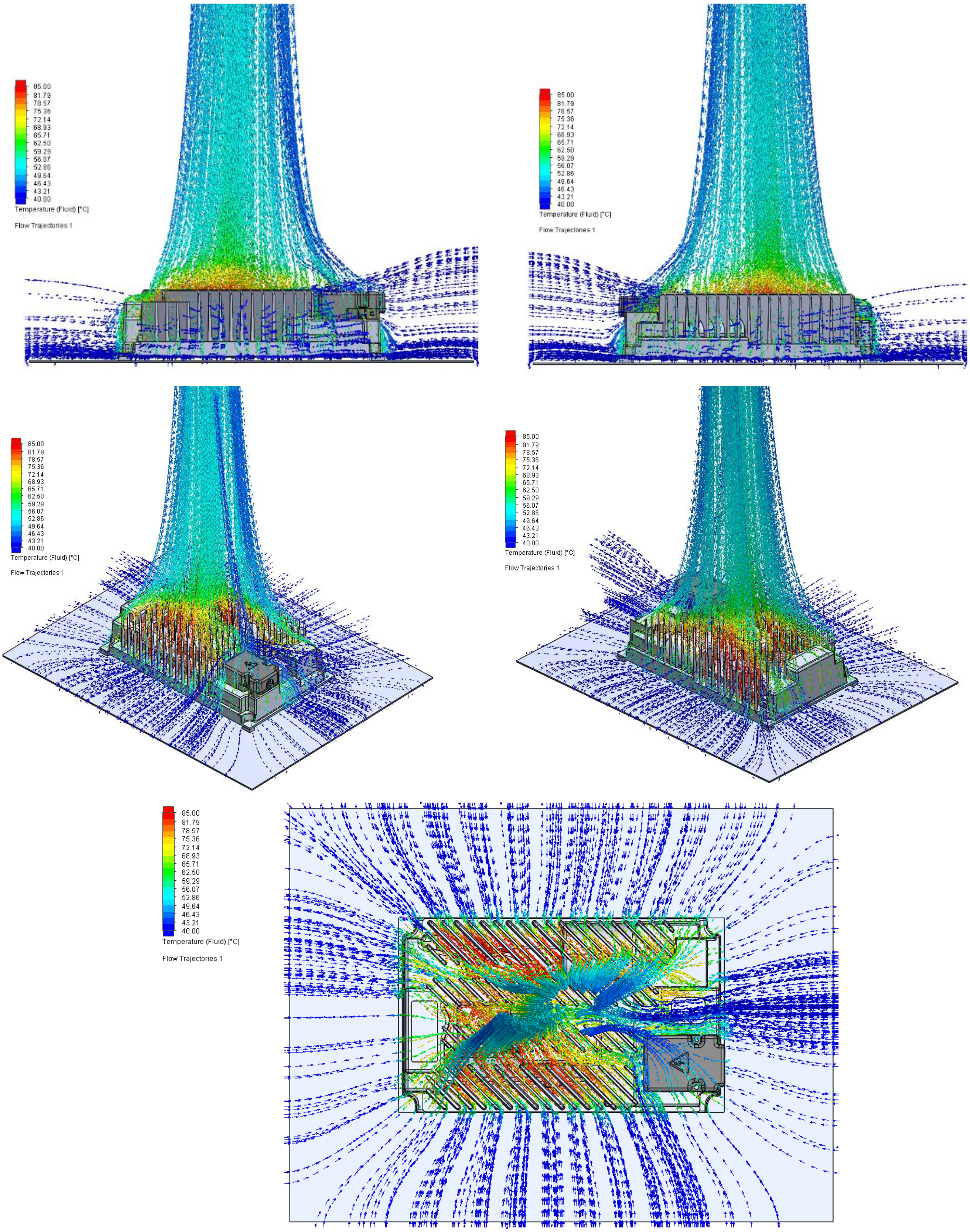


Figure 10: ICL900 & RC900 Convection Air Flow Simulation - Horizontal Orientation

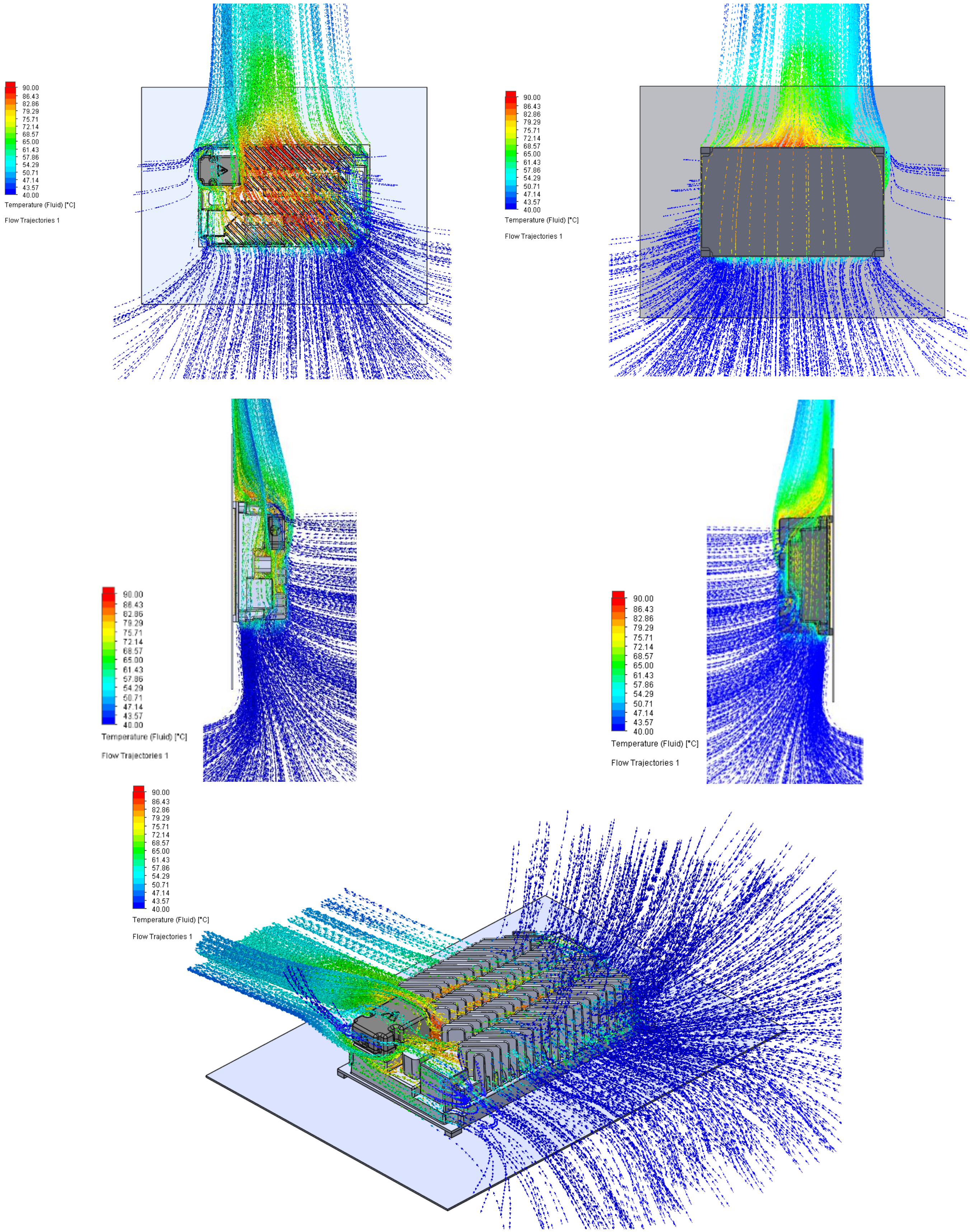


Figure 11: ICL900 & RC900 Convection Air Flow Simulation - Side Orientation

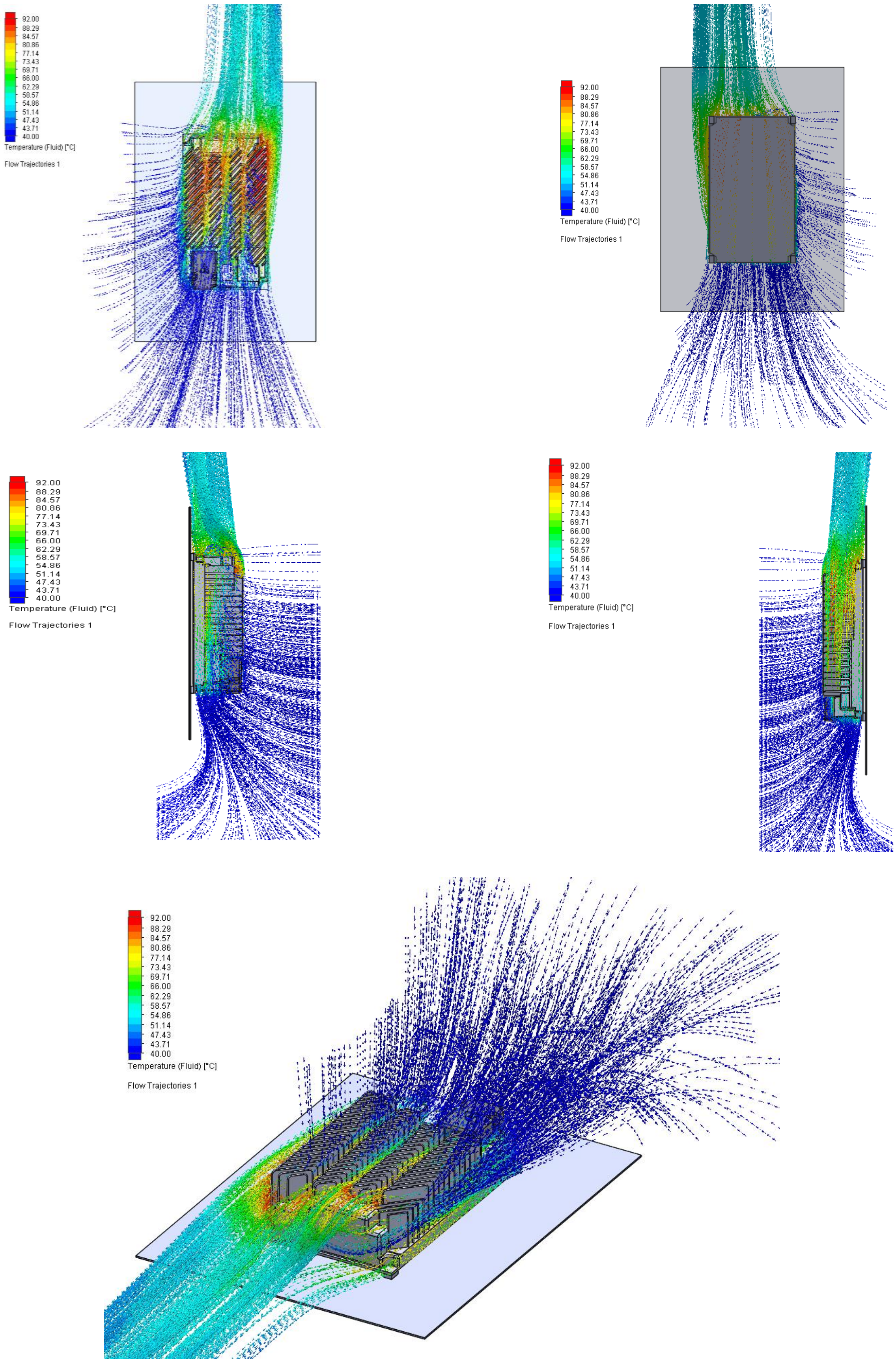


Figure 12: ICL900 & RC900 Convection Air Flow Simulation - Vertical Orientation

6.1.3 Testing the Charger Cooling Effectiveness of the Mounting Location

As no model or guide can predict real-world usage, it is strongly recommended to test the charger in the application at full power to determine if the temperature rise will cause the charger to reduce power. There are too many variables because of the infinite combinations of materials near the charger, the size of the mounting area, the clearances around the charger, the mounting orientation, and the ambient temperatures. Therefore, it is essential to test the proposed mounting location before it is finalized.

The following test procedure allows you to assess the cooling effectiveness of the proposed charger mounting location:

- Install the charger and batteries, as intended.
- Fully discharge the batteries.
- Proceed with a full battery charge while measuring and recording the output voltage and current of the charger over time.
- Alternatively, the IC Data Analysis Tool or CAN bus monitoring could be used to review the charger voltages and currents without the need to directly perform measurements.
- It is best to conduct this test at the maximum ambient temperature at which the charger is expected to operate.
- The measured voltage and current data can be analyzed to validate full power output.
- If the output current, during bulk charging, reaches the maximum current for at least 1 hour then the charger is confirmed to be performing at its optimum operation in this configuration.
- If the measured current falls below the expected output current of the charger, during bulk charging, the output current is being automatically reduced by the charger in response to elevated temperature. This is an automatic safety feature of the charger, ensuring the internal temperatures do not become excessive. The reduced output will result in extended battery charge times.

The reduced output current is an indication the heat generated by the charger is not being removed quickly enough. Increasing the size of the air input and output openings may help improve this situation. Otherwise, with the ICL900 and RC900 chargers, an auxiliary fan may be needed to cool them if sufficient natural passive cooling cannot be achieved.

6.2 Charger Surface Temperatures

While the ICL & RC Series chargers do meet regulatory temperature limits, they can get hot to the touch when operating. The hotter areas are around the bottom base of the charger on the left and right sides. Under the worst-case scenarios, these areas may reach up to 80°C on the ICL1200 and RC1200 chargers and 90°C on the ICL & RC 900 chargers. Under nominal conditions, at room normal temperature, all surfaces typically stay below 65°C.

CAUTION: Many cables, wires, and electrical/electronic components & modules are often rated only to a maximum temperature of 85°C. Care should be taken to avoid the hottest locations on the surfaces of the charger.

The following figures show the chargers surface temperature distribution during normal operation (at room temperature).

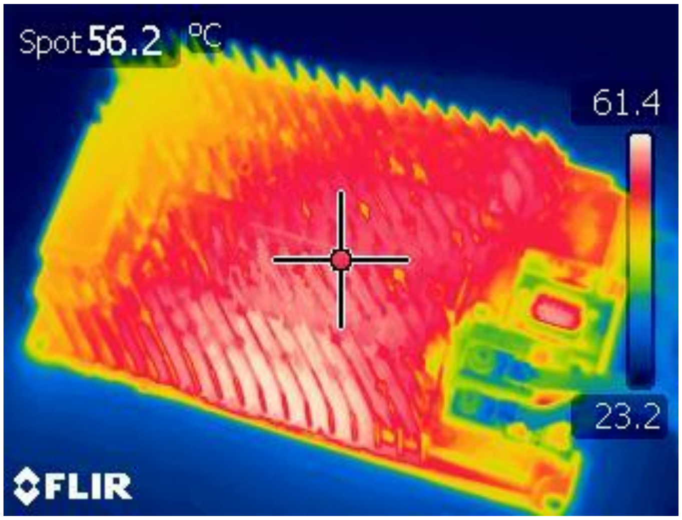


Figure 13: ICL900 & RC 900 Right Side

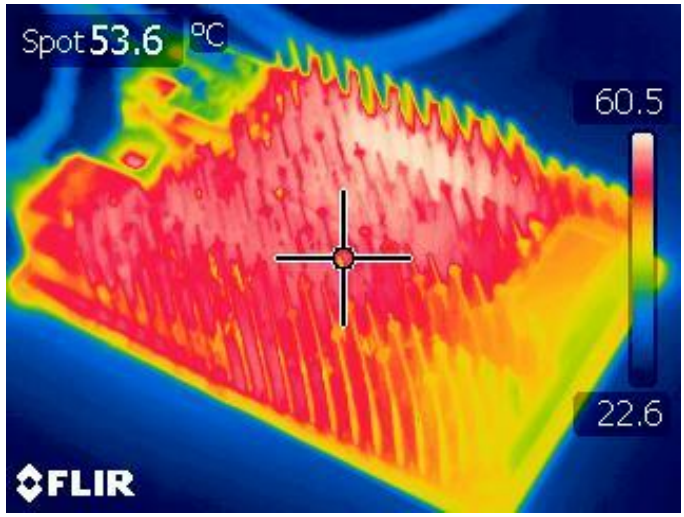


Figure 14: ICL900 & RC900 Left Side

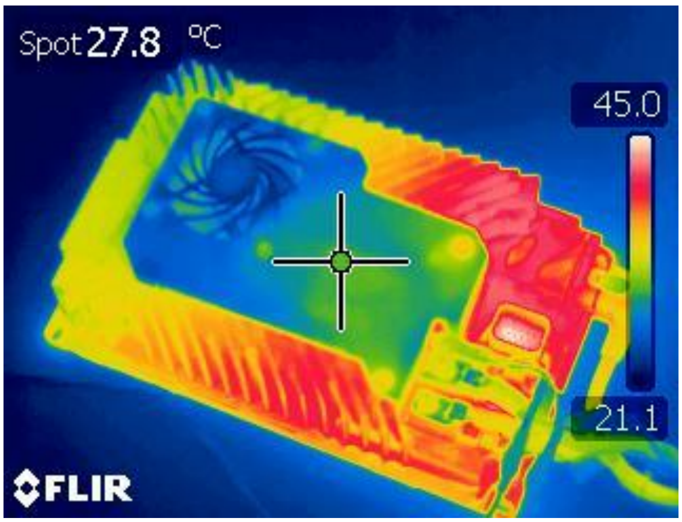


Figure 15: ICL1200 & RC1200 Right Side

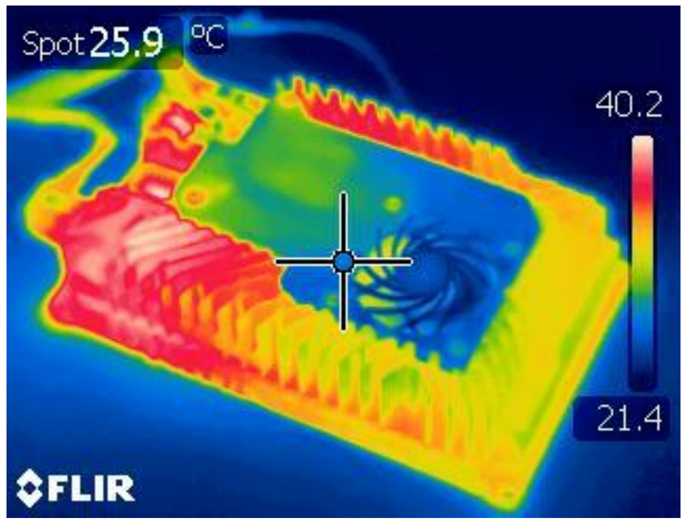


Figure 16: ICL1200 & RC1200 Left Side

6.3 Mechanical Installation

Robust mounting points are cast into the charger's aluminum enclosure. At each corner are slots for M6 or 1/4" fasteners arranged to allow ample tolerance when mating with standoffs or pre-drilled holes in a machine.

If mounting the charger on a vehicle or machine frame that may be prone to flexing, it is recommended to mount the charger using only three of the mounting points to prevent the charger case and internal components from being subjected to undue stress and torsional loads.

- Mount the charger securely using the mounting points shown in this section.
- A bracket may need to be fabricated, particularly if there is insufficient cooling air flow.
- Do not drill holes in the charger.

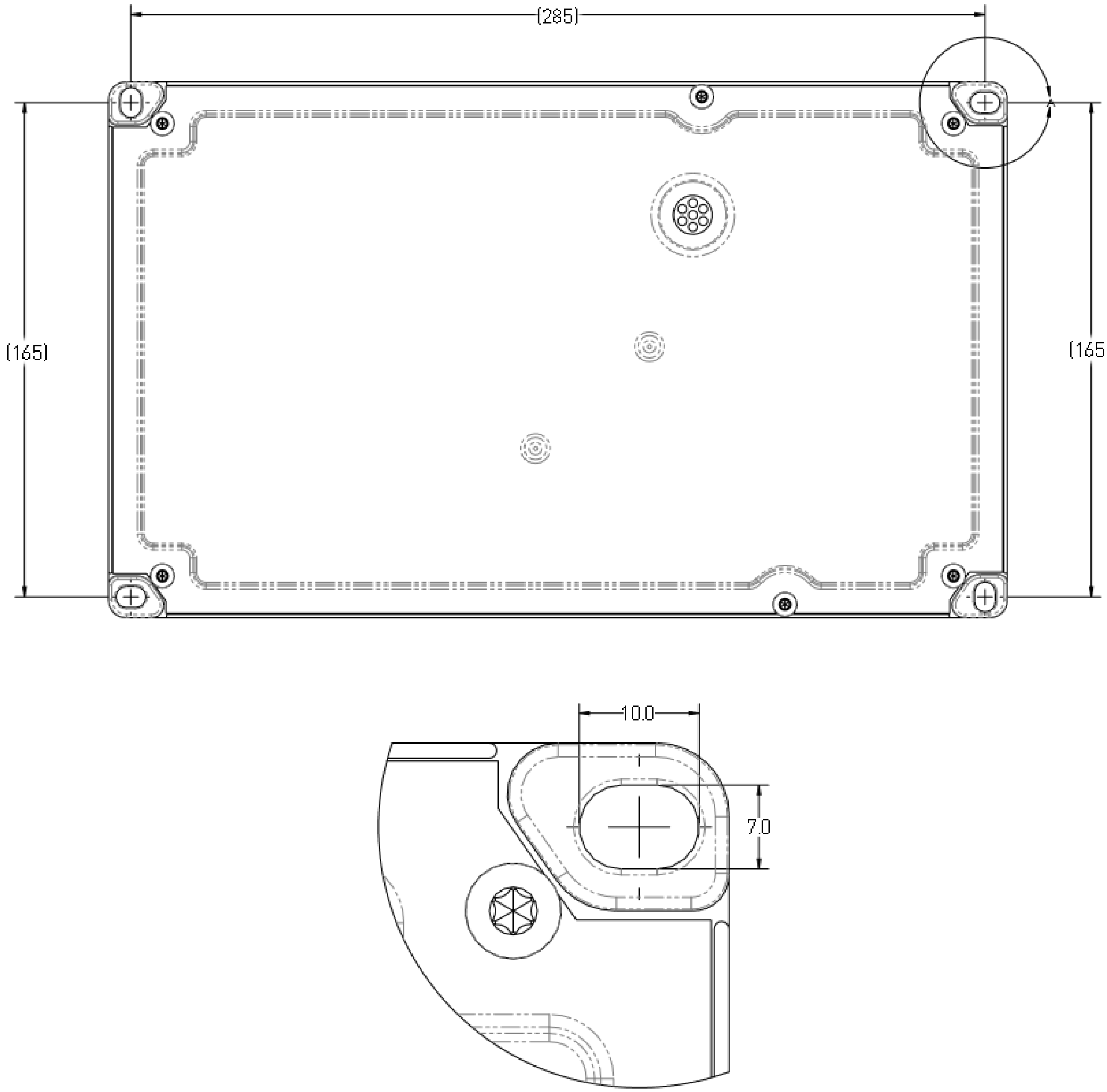


Figure 17: ICL & RC Series Charger Mounting Points (*Dimensions in mm*)

7 Electrical Installation

The ICL & RC Series charger has three connectors on the rear panel: AC Input, DC Output Block, and Signals & Control.

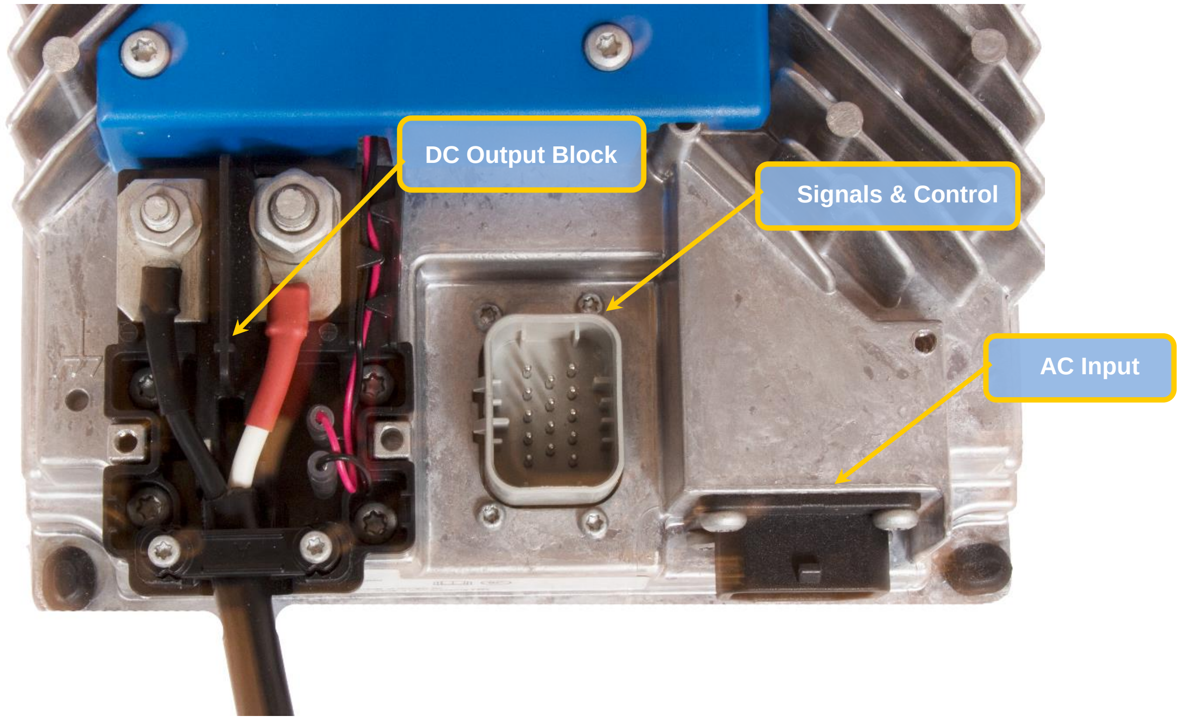


Figure 18: ICL & RC Models Rear Panel

7.1 General Considerations for Machine Wiring

To reduce electromagnetic interference (EMI) issues, avoid routing power and communications cables together. If they must cross, it should be at right angles, to minimize EMI coupling. If these cables must be run together, keep the cable lengths as short as possible. Also, the greater the distance between the data and power cables, the less EMI coupling there will be between them.

Ideally, communications cables should use twisted pair wiring so any AC or DC noise coupled to the data cable will be balanced on each wire and will be cancelled out in the receiving circuit.

For battery cables, see the tables in the following sections for minimum recommended cable sizes. Wire lengths should be kept as short as is practical. For best performance, the positive and negative cables should run alongside each other. Avoid cable loops.

Battery overcurrent protection is highly recommended, even if it is not required by the specific safety regulations for the vehicle or equipment. Fuses and disconnects should be sized to protect the wiring in the system. Install the overcurrent protection as close to the battery as possible, to provide adequate protection. ICL & RC Series chargers have built-in overcurrent protection (non-replaceable fuses) on both the AC input and the DC output.

7.2 AC Input

7.2.1 AC Cable Requirements

Connector Type: Standard IEC60320/C14
Recommended Connector Type: Delta-Q IP66 sealed AC cord
Alternate Mating Connector: Standard IEC60320/C13

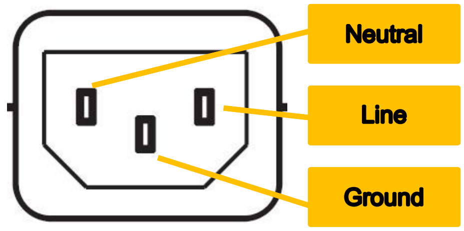


Figure 19: AC Input Connector

Table 5: AC Input Connector Pin Configuration

Pin No.	Wire Colour Code	Description
L	Brown	AC Line
G	Green/Yellow	AC Ground
N	Blue	AC Neutral

For industrial applications where the AC cord may be exposed to hard usage and moisture, Delta-Q Technologies recommends a heavy duty cable such as SJTW or SJT, 105°C (221°F), and 300V rating (or equivalent).

Recommended world-wide AC cords:

- **North America (and other 120V AC regions):** 3-conductor UL Listed/CSA approved detachable cord set at least 1.8m in length (≥ 6 feet), minimum 16AWG and rated SJT, 105C min, and terminated with 300V, 13A or greater connector.
- **Japan:** 3-conductor PSE approved detachable AC cord set, 105C min, terminated with 100V, 15A or greater connector.
- **Rest of World (220-240VAC regions):** a 3-conductor safety-approved cord set, with 1.5mm² conductors (min.), rated appropriately for industrial use. The cord must be terminated on one end with a grounding type input plug appropriate for use in the country of destination; both plug and connector should be rated 250V, 10A or greater.

7.2.2 AC Cabling Installation Instructions

Use of the Delta-Q Technologies sealed, locking AC power cable is recommended. It seals the AC inlet against water and dirt ingress, ensures the charger meets IP66 specifications, and locks the cable to the charger. No tools are required to connect or disconnect the Delta-Q Technologies locking AC power cable.

Figure 20: Red Gasket

Figure 21: Locking Clips

ICL & RC Series chargers allow any country-specific IEC60320/C14 AC cable to be used with the charger's standard IEC60320/C14 mating connector. This allows an OEM to source AC cables depending on demand in different countries.

Tips when using a non-sealed AC connector:

- The AC plug and connector must be protected against moisture, dirt, and other contamination.
- The plug and connector must be periodically inspected to ensure the contacts are clean and dry.
- Secure the cable to the charger using cable ties. This prevents accidental disconnection.

7.2.3 AC Extension Cords

Use a heavy gauge extension cord rated for the charger's maximum input current. Do not use a light-duty indoor extension cord. Per UL guidelines, at 120VAC, extension cords must be 3-wire cord no longer than the following:

- 30m (100ft) at 10 AWG/6.0 mm^2
- 15m (50ft) at 14 AWG/2.5 mm^2
- 7.5m (25ft) at 16 AWG/1.5 mm^2

7.3 DC Output

Output Cable Recommendation:

- Use DC output cables that are listed, outdoor rated, water, acid and oil resistant, with two 14 AWG minimum conductors, rated for DC currents, and sized appropriately for the rated output current of the charger.
- Examples: Type SJTW, SJOOW, SJO, or DLO.
- The DC cord may include additional conductors for up to three optional signals form the Signal and Control connector.
- The cables must have a minimum temperature rating of 90°C and 300V insulation rating.

7.3.1 RC 900 or RC 1200 or ICL 1200 DC Output

The ICL & RC Series battery cable terminals feature a Poka-Yoke design (*mistake-proof*) by using different screw sizes, (M6 for the negative and M8 for the positive termination), to prevent inadvertent reverse polarity battery cable installation.

A DC cable clamp is designed to provide optimum compression for cable diameters from 6.5mm to 12mm.

A DC terminal block cover is provided to protect the user from contact with the DC terminals.

Table 6: DC Terminal Block Fastener Information

Fastener	Screws	Recommended Torque Value
Battery Negative (B-)	10mm M6 Hex Nut	4.5Nm +/-5%
Battery Positive (B+)	13mm M8 Hex Nut	6.0Nm +/-5%
DC Cord Cable Clamp	Torx T10 screws (x2)	0.6Nm +/-6% (DO NOT OVERTIGHTEN)
DC Terminal Block Cover Screws	Torx T20 screws (x2)	1.8Nm +/-6%

The ICL & RC Series chargers also have tabs for the fan power on the ICL & RC 1200 models. The tabs accept FASTON™ or equivalent 0.110” single-wire female receptacles.

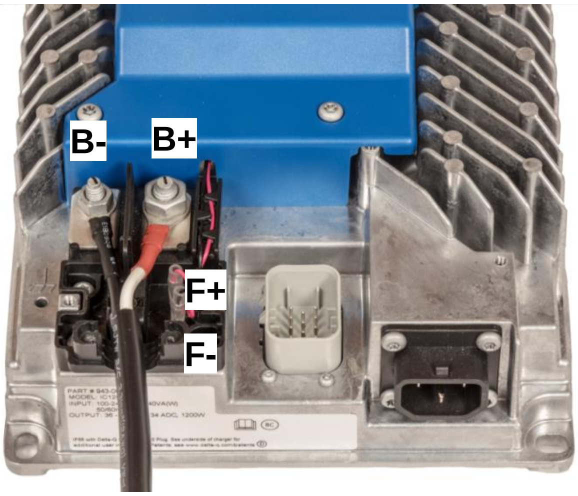


Figure 22: RC1200 Charger DC Output Terminals

Table 7: Recommended Maximum DC Cable Length

Maximum DC Cable Length (in meters)			AC Cable: 3m-16 AWG				
			Wire Gauge (AWG/mm^2)				
Charger	**Voltage (V)**	**Max Current (A)**	**14/2.5**	**12/4.0**	**10/6.0**	**8/10.0**	**6/16.0**
RC900	36	28	1.3	2.1	3.4	-	-
RC900	48	21	1.8	2.8	4.2	-	-
RC1200	36	36.7	-	1.5	2.5	3.8	-
RC1200	48	27.5	1.3	2.2	3.5	-	-
ICL900	48	27	1.3	2.2	3.5	-	-
ICL1200	48	33.3	-	1.2	1.9	3	-

** Cable length is the length of one of the battery wires and assumes both are of equal length.*

Notes:

- The recommendations ensure compliance with safety and California Energy Commission (CEC) efficiency requirements.
- The maximum cable length is the total length of the cable from the charger to the battery terminals.
- The shaded cells indicate the AWG gauge is not supported for that specific charger either because the ampacity is too high for the wire or the cable length is not practical.
- The DC connectors and termination used must be rated for the maximum current of the charger used.

7.4 Signals & Control Connector

This is a 14-pin AMPSEAL™ connector made by TE Connectivity™. In combination with the matching plug & contacts, it is a heavy-duty, automotive-grade, waterproof, polarized connector system. Delta-Q Technologies offers various standard signal wiring harnesses which mate with the AMPSEAL connector.

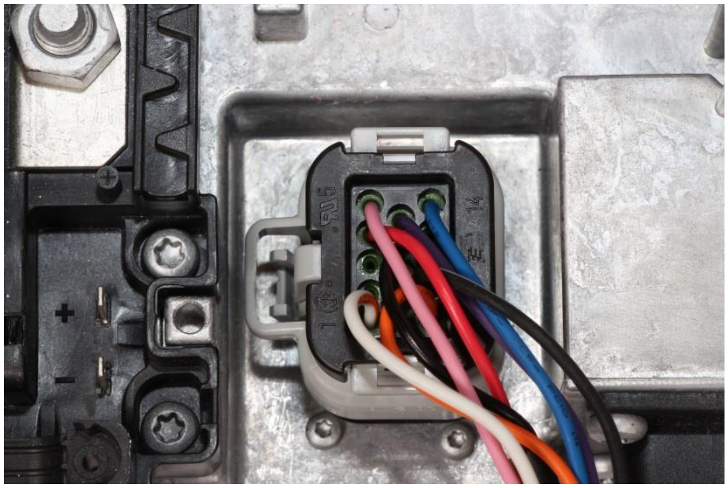


Figure 23: Signals & Control Connector

Table 8: TE Part Numbers

Description	TE Part Number	Delta-Q Part Number
Charger Header ***(for reference only, not user-replaceable)***	776262-4	410-0450
Cable Plug *(body only)*	776273-4	410-0451
Contacts *(loose piece)*	770854-1	410-0388
Contacts *(strip form)*	772520-1	N/A

Note: Pin numbers 1, 5, 6, 9, 10, and 14 are labeled on the connector's inside face, next to the pins. On the mating plug, the same pin numbers are embossed on the top of the body. The recommended wire for all pins is 16-20 AWG (1.0-0.50 mm^2), 300V rated (UL3266 or equivalent). Wire colours listed in the following tables are suggestions – the same as used on various *All Wires* cables available from Delta-Q Technologies (e.g., PN 475-0513).

Table 9: Wire Colours & Signals for All ICL & RC Models

Wire Colour	Pin No.	Description	Details
White/Orange	1	CAN Low	Isolated CAN Low signal. (See *CAN Communications)*
N/A	3, 7	Factory port	Factory use only.
Pink	5	Interlock-NO	Dry Contact Interlock relay: Normally open contact. (See *Interlock)*
White/Black	6	CAN GND	Isolated reference ground for CAN signals. (See *CAN Communications)*
Black ①	8	Signal Ground	Do not connect to Battery Negative.
Violet	9	Interlock-Common	Dry Contact Interlock relay: Common contact. (See *Interlock)*
Orange	10	CAN High	Isolated CAN High signal. (See *CAN Communications)*
Blue	14	Interlock-NC	Dry Contact Interlock relay: Normally closed contact. (See *Interlock)*

Table 10: Wire Colours & Signals for ICL Models

Wire Colour	Pin No.	Description	Details
White	2, 11	CAN Termination (Low, High)	Connect Pins 2 & 11 to enable internal CAN bus termination (See *CAN Communications)*
Brown	4	For future use	Can be configured for various customer requirements (e.g., charge current control using an analog or digital signal). Contact Delta-Q Technologies for more information.
Green	12	Remote LED Green +ve	For a Remote LED: Pin 12 goes high with respect to Pin 13 to light the Remote LED green, and vice versa to light the LED red
Red	13	Remote LED Red +ve	

Table 11: Wire Colours & Signals for RC Models

Wire Colour	Pin No.	Description	Details
White	2	Unused or Button Input	RC Base models: not used RC W/UI models: Control Panel button input
Black ①	11	Unused or Control Panel Ground	RC Base models: not used RC W/UI models: Control Panel Ground reference
White/Red	4	Battery Temperature Sensor +ve	*SeeBattery Temperature Sensing*
Green	12	Panel or Remote LED Green +ve	RC Base Models: for an optional Remote LED: - Pin 12 goes high with respect to Pin 13 to light the LED green, and vice versa to light the LED red RC W/UI models: for the Control Panel LED: - Pin 12 goes high with respect to Pin 11 to light the LED green - Pin 13 goes high with respect to Pin 11 to light the LED red
Red	13	Panel or Remote LED Red +ve	

① Pin 8 is the ground reference for Pins 3, 4 & 7 on all ICL & RC models (and also for Pins 12 & 13 in some Remote LED installations). Pin 11 is the ground reference for the Control Panel on RC W/UI models. Both are electrically connected, via a low-impedance resistor/inductor circuit, to the Battery Negative terminal on the DC block.

NEVER connect Pin 8 or Pin 11 in the RC models directly to the Negative terminal of the battery, nor to the Negative terminal in the DC block.

7.4.1 Signals & Control Connector Pin Configurations

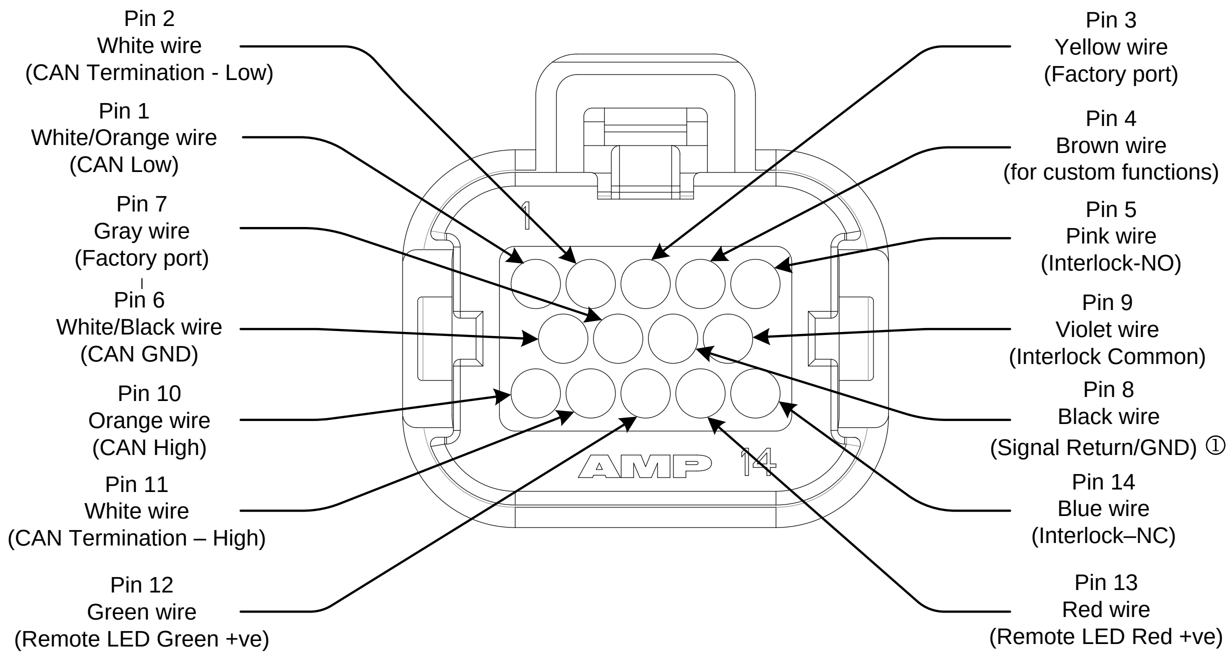


Figure 24: ICL Series Signals & Control Connector – Pin Signal Reference

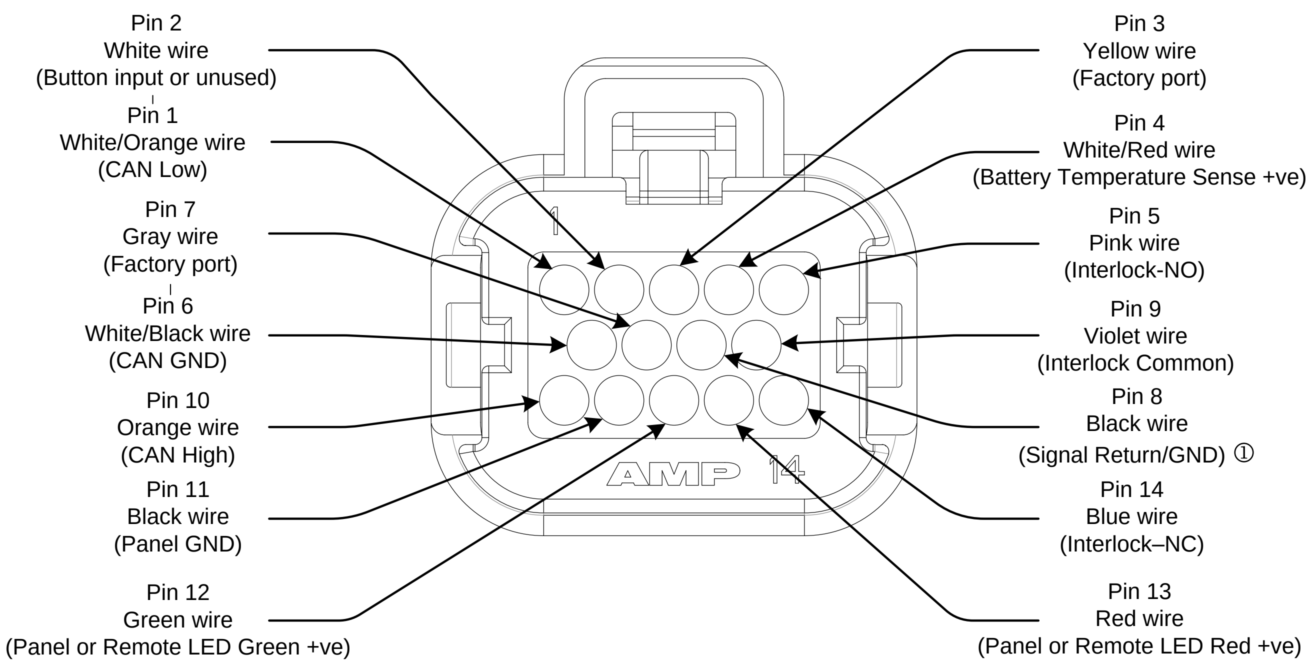


Figure 25: RC Series Signals & Control Connector – Pin Signal Reference

7.4.2 Class B and CISPR-14 EMI Compliance Recommendations

EMI reducing beads may be required to be installed in certain configurations over all the wires connected to the Signals & Control connector. Refer to *Electromagnetic Interference (EMI)* for guidelines. The required part numbers for the configurations tested are shown in the following table. The installation of the bead is shown in Figure 26.

Table 12: Bead Part Numbers

Configuration	Bead Part Number	Detail
4-core cable combining two DC power wires and two CAN signal lines	-	No bead needed.
CAN, Interlock and thermistor (8 wires) or Interlock and thermistor (5 wires twisted) connected to the Signals & Control connector	Fair-rite Products Corp 2631626402	Install one bead over all wires connected to the Signals & Control connector, 68mm (2.67") from the body of the connector. The bead can be covered with heat shrink tubing.
CAN signal (3 wires) connected to the Signals & Control connector	Fair-rite Products Corp 2631626402	Install one bead over all wires connected to the Signals & Control connector, 68mm (2.67") from the body of the connector. All wires need to run twice through the core (2 turns). The bead can be covered with heat shrink tubing.
Other configurations with up to -12 wires connected to the Signals & Control connector	Fair-rite Products Corp 2631102002	Install one bead over all wires connected to the Signals & Control connector, 68mm (2.67") from the body of the connector. The bead can be covered with heat shrink tubing.

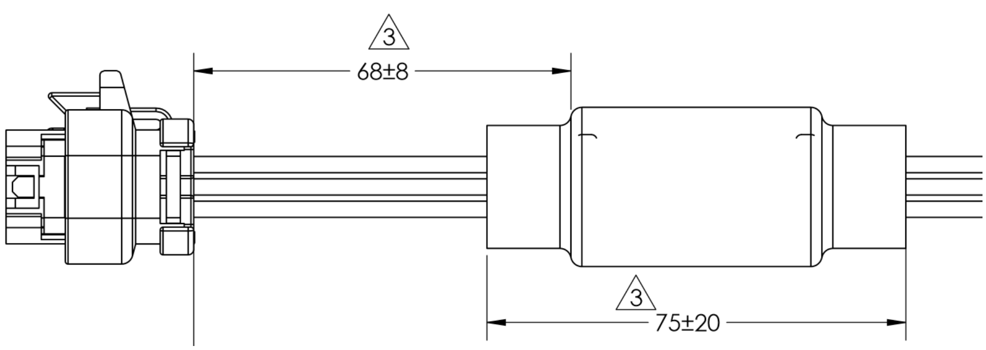


Figure 26: Installing a Ferrite Bead on the Wires from the Signals & Control Connector

7.5 Remote LED Installation

RC Base and all ICL models allow connecting an optional Remote LED to the Signals & Control connector.

Various Signal cables with a Remote LED are available; contact Delta-Q Technologies for more information. A 3-metre remote LED cable can be made using Delta-Q Part Number 900-0147 (Accessory Remote LED 3M IC Series COMM).

1. For an existing ICL/RC Series Signal cable which does not have any remote LED wiring (i.e., no wires in Pins 12 & 13):
   a. Open the AMPSEAL plug.
   b. Insert the LED cable's black wire contact into Pin 13 of the AMPSEAL plug.
   c. Insert the LED cable's white wire contact into Pin 12 of the AMPSEAL plug.
   d. Close the AMPSEAL plug.
2. If there is no existing ICL/RC Series Signal cable, follow the steps in Step 1 above, using a new AMPSEAL plug.

Figure 27: Remote LED Cable for RC & ICL Series Chargers

Another option is to make a custom cable of the desired length, to provide a remote LED (and any other required signals) using an AMPSEAL plug & contacts (see Table 8). For the LED, use the parts suggested in Table 13, or similar.

Table 13: Recommended Parts for Custom Remote LED Cables

Description	Recommended Provider & Part Number
Remote LED	5mm T1-3/4, 10- 20 mA nominal • Everlight/Fairchild MV5491A • Lite-On LTL-293SJW Other 2-lead bipolar LEDs which work with ~6-9 mA forward current can be used but may not produce bright amber colour.
LED Holder/Bezel	Lumex SSH-LX5091 and SSH-LX5090 or similar (maximum 1.5mm panel) Bivar CR174 for 0.8 – 3.2mm panels Bivar CR-174L for 1.5 – 6.4mm panels
Cable	16-20 AWG 2-conductor
Maximum Length Recommended	7.5m (25')
LED Polarity	LED green anode/red cathode connected to Pin 12 LED red anode/green cathode connected to Pin 13

7.6 Interlock

7.6.1 Interlock Usage

The Interlock function is provided primarily as an optional safety measure, a way to prevent the equipment or vehicle from moving when it would be unsafe to move the vehicle/equipment. For example, in an on-board configuration (See *On-Board Configuration: Charge on AC Detect*), the charger's AC connector and/or the AC cable could be damaged if the vehicle/equipment moved while the cable was plugged in the charger. Similarly, in an off-board configuration, the DC cable could be damaged if the vehicle moved while the charger was connected to the battery pack.

Alternatively, the Interlock function can be used to indicate to some other element of the vehicle/equipment's control system that the charger, AC power, and battery pack are all connected.

The Dry Contact Interlock pins (2, 3 and 4) are connected to the floating contacts of a relay. The term *dry* means there is no voltage or current from the charger's circuitry in any of these contacts. The relay's coil is energized when there is AC Voltage connected to the charger, and so the Interlock Common and Normally Open (NO) pins are connected, and the Normally Closed (NC) pin is unconnected. The relay de-energizes when the charger does not have AC power: Interlock Common and NC pins are connected; NO pin is unconnected. The contacts are isolated from all other circuits in the charger.

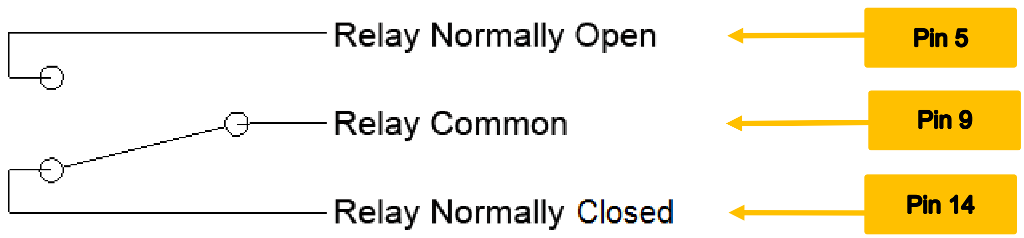


Figure 28: Internal Schematic of Interlock Relay Contacts

7.6.2 Protecting the Interlock Relay

A suitable fast blow fuse sized to match the desired voltage/current switching capacity, and within the maximum limits of the circuit as detailed below, should be installed in series with the connection. Examples include the following:

- 0.25" x 1.25" 3AG and 5mm x 20mm M205 glass/ceramic cartridge types.
- Auto style blade fuses (e.g., ATC-1) may also be an option, though most are rated at only 32 VDC and may not be suitable for your application.
- Mini auto style blade fuses; 58V versions of this fuse are available.

7.6.2.1 Resistive loads on Interlock Connections

For resistive loads, the maximum current is 1A up to 30Vdc, 0.3A from 30V up to 110Vdc, and 0.5A up to 125Vac; 100,000 cycles. The circuit protecting fuse should be sized accordingly. The minimum current is 1 mA.

7.6.2.2 Inductive Kickback on Interlock Connections

Voltage spikes (kickbacks) occur if the load is inductive, such as a relay or motor. This kickback may damage the Interlock circuits in the ICL & RC Series chargers. Therefore, some means of minimizing the kickbacks is required. A free-wheeling diode, a metal oxide varistor (MOV), or a transient voltage suppressor (TVS) all will work. Contact Delta-Q Technologies for more information about preventing inductive kickback from damaging the charger.

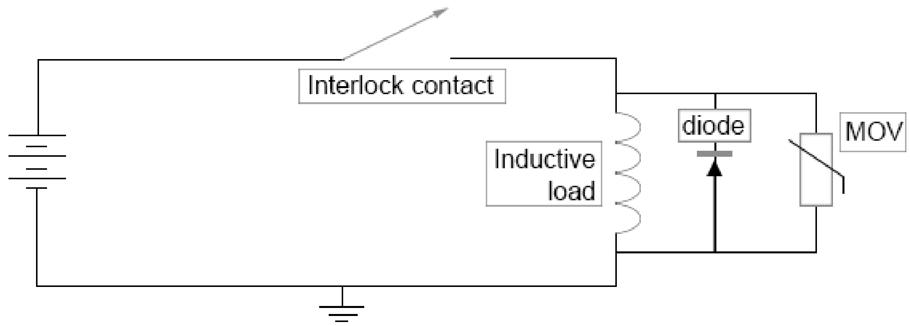


Figure 29: Interlock Contacts Protected from Inductive Load

7.6.2.3 Surge Loads on Interlock Connections

Many loads (e.g., motors, light bulbs, and electronic equipment) often have an inrush or surge current when first connected to power. Relays can easily be damaged by this surge. Symptoms of surge damage can include welding of the relay terminals (i.e., the relay contacts no longer open or close) and/or poor or no connection. This condition cannot be repaired if it occurs. So, when there is a risk of surge damage, protective measures need to be taken to ensure satisfactory operation.

Because inrush is both prevalent and poorly documented, most loads connected to the interlock should be tested to ensure satisfactory operation. This test is typically performed with an oscilloscope and a current sensor. A multimeter cannot measure inrush unless it is specially designed to do so.

Delta-Q Technologies recommends installing a resistor in series with the load to reduce the surge, with values chosen so it does not affect operation. The resistance, type, and power rating of this resistor vary from load to load.
Delta-Q Technologies can help you select this resistor.

7.7 Battery Temperature Sensing

7.7.1 Battery Temperature Theory

Most battery chemistries require the charging to be adjusted to take account of temperature. Some algorithms are designed to automatically adjust for temperature changes while others require the use of a temperature sensor to charge correctly. So, if the machine is used in a range of temperatures, it is recommended to either use an algorithm designed to auto adjust, or to add a temperature sensor and use a suitable algorithm that can compensate for the changing temperature. Some, but not all, Delta-Q Technologies charging algorithms use temperature compensation.
Contact Delta-Q Technologies for help choosing an appropriate algorithm.

Installation: Most Delta-Q Technologies battery temperature sensors are in an electrically-insulated ring terminal that can be attached to any battery terminal or mounting bolt; the sensors have a cable or wire pair for connection to the charger. We recommend you install the sensor near the middle of the battery pack where the temperature will be hottest.

Figure 30: Battery Temperature Sensor

RC Series: Connect the sensor (non-polarized) to Pins 4 and 8 of the Signals & Control connector.

ICL Series: There is no connection for a battery temperature sensor. Instead, any temperature-based adjustments to the charger's output voltage and/or current are determined by the Battery Management System (BMS), which commands the charger to make the required changes over the CAN bus.

7.7.2 Hardware

The recommended battery temperature sensors for use with the charger's temperature sensor input are as follows:

- Part No. 900-0059: Isolated Temp Sensor 140mm Bare Wires
- Part No. 900-0028: Isolated Temp Sensor 200mm Bare Wires (250pcs)
- Part No. 900-0060: Isolated Temp Sensor 1.2m Bare Wires
- Part No. 900-0056: Isolated Temp Sensor 3m Shielded Bare Wires

AMPSEAL contacts may need to be crimped to the wires of these sensors for connecting to the Signals and Control connector. Other part numbers may also be available. For more information, contact Delta-Q Technologies.

Do not connect the negative lead of any temperature sensor to the Battery Negative terminal (B–) in the DC Output Block.

For customers wishing to construct their own temperature sensors, the following part can be used with the RC Series chargers. The current through the sensor is less than 10mA.

- Vishay BCC 238164063103, NTC 10k 5% Thermistor, B25/85 = 3977K

7.8 Electromagnetic Interference (EMI)

Nearly all electronic and electrical devices create some form of electromagnetic emissions. These emissions, if they are of high magnitude and at certain frequencies, can interfere with the operation of other nearby devices. Because of this, most countries have regulations that limit the magnitude of EMI emissions at certain frequencies, for many products.

Delta-Q Technologies ICL & RC Series chargers meet many of the different regulations throughout the world. Contact Delta-Q Technologies to discuss your specific requirements.

7.8.1 Guidelines for Reducing EMI

The characteristics of an installation can amplify, focus, or channel electromagnetic waves in unpredictable ways leading to unexpected results. Delta-Q Technologies provides the following guidelines for EMI reduction:

- Keep wires away from emission-causing components, and route them as directly as possible. Wires routed alongside emission-causing components pick up and conduct these emissions.
- Avoid loops in wiring. *Loops act as antennas.* The bigger the physical area of a loop, the greater the risk it will emit and/or pick up EMI.
- Install all of the required emission-reducing devices required for each component of your system. Refer to the user manual provided by the manufacturer for each of these components. Many Delta-Q Technologies charger versions require emission-reducing components that are external to the charger to be installed in/on the wiring harness. Refer to the *Installation* section of this guide for details about installing these components.
- If wires must be routed near the emission-causing components, shielding the wire usually reduces the pickup of emissions by that wire. Regulations often allow the shield of the wire to be connected to any point, but it is usually most effective when connected to a chassis or circuit ground point. Similarly, emissions from wires can often be contained by a grounded shield. Shields should usually be grounded at only one point which is often at the source of the signals in the wire(s).
- During testing, long cords, extension cords, and ground fault circuit interrupters (GFCI) can detrimentally affect emissions. Most EMI regulations specify a minimum cord length for testing, and shortening of wires to meet these requirements is usually allowed. The regulations often allow shortening by trimming or by folding the cord back upon itself multiple times. Remember to avoid creating loops and do not coil the cord(s).
- If the equipment has a metal frame, the emissions can change if the chassis of the emission-causing component is electrically connected to the frame. Emissions may be reduced by making this connection.
- Filters can be added to reduce emissions. Inline filters for the AC input such as Epcos B84112G0000B110, Schaffner FN2030-10-06, and Delta 10DSCG5 have been found to be effective in many cases. Be sure to select a filter designed for the application and one that meets local requirements.
- Ensure the AC cord is of the correct type and gauge. Choosing the incorrect cord can adversely affect emissions.
- The ICL & RC Series chargers are tested for worst-case radiated emissions by using a fully populated -12-wires on the Signals and Control connector. An EMI reducing bead is installed over all of the wires connected to the Signals & Control connector to meet the requirements of radiated emission. However, it is recommended to determine whether the ferrite bead is required or not in the end application while performing EMC testing on the entire system/vehicle. There is a good chance the ferrite bead may be reduced (in size) or not be required in cases where only a few wires are used on the Signals and Control connector, or where the signal wires are shielded or partially shielded by the application's housing/chassis. Refer to *Class B and CISPR-14 EMI Compliance Recommendations* for details.

8 CAN Communications

ICL & RC Series chargers support advanced functions accessible via the Controller Area Network (CAN) Bus using the CANOpen protocol. For more information, contact Delta-Q Technologies for the most recent version of the *IC Series CANopen Interface Specification*.

8.1 CAN Version

ICL & RC Series chargers are compliant with the CAN in Automation (CiA) 418, and 419 device profiles. These standards define most of the interface, including all of the first six layers (Physical, Data Link, Network, Transportation, Session, and Presentation) of the OSI model, and most of the seventh layer (Application). In addition to the standard protocol, the charger has support for a range of other data as specified in the *IC Series CANopen Interface Specification*.

Table 14: CAN Configuration

Item	Configuration/Specification
Charger Role	Slave of the master/slave model
CAN Termination	RC models: 120 Ohm, factory terminated (option: unterminated) ICL models: internal 120 Ohm, which may be activated via a jumper wire on the Signals & Control connector's AMPSEAL plug.
Number of Bits in Identifier	11 bits
Bit-rate	125 kbps (configurable)
Node ID of the Charger	10 (configurable)
Node ID of the Battery Node	1 (configurable)
Use Dynamic SDO and SDO Manager	FALSE (configurable)
SDO COB-ID	0x60A (Rx) and 0x58A (Tx) Use Dynamic SDO is FALSE
PDO COB-ID	Always requested from the battery module via SDO (configurable)

8.2 Delta-Q Standard PDO Mapping

This table shows the COB-IDs for the charger and battery module. See the *Delta-Q IC Series CANopen Simplified* or the *CANopen Interface Specification IC Series* tutorials for more details.

Table 15: Delta-Q Standard PDO Mapping

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
RPDO0	200h	0							
RPDO1	300h	7	6010h *Battery Temperature LSB*	6010h *Battery Temperature MSB*	6081h *Battery State of Charge*	6060h *Battery Voltage LSB*	6060h *Battery Voltage*	6060h *Battery Voltage*	6060h *Battery Voltage MSB*
RPDO2	400h	7	6070h *Charger Current Request LSB*	6070h *Charger Current Request MSB*	6000h *Battery Status*	2271h *Voltage Limit Request LSB*	2271h *Voltage Limit Request*	2271h *Voltage Limit Request*	2271h *Voltage Request MSB*

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
TPDO0	180h	0							
TPDO1	280h	4	6001h *Charger Status*	6080h *Charger State of Charger*	6010h *Battery Temperature LSB*	6010h *Battery Temperature MSB*			
TPDO2	380h	5	6001h *Charger Status*	2005h-1 *Elapsed Time LSB*	2005h-1 *Elapsed Time MSB*	2009h-1 *Ah Returned in Present Cycle LSB*	2009h-1 *Ah Returned in Present Cycle*	2009h-1 *Ah Returned in Present Cycle*	2009h-1 *Ah Returned in Present Cycle MSB*
TPDO3	480h	6	2002h *Charger Current LSB*	2002h *Charger Current MSB*	2101h *Battery Voltage LSB*	2101h *Battery Voltage MSB*	2006h *Extended Charge Status LSB*	2006h *Extended Charge Status MSB*	

9 Charger Software Features

9.1 Charge Algorithms

The ICL & RC Series chargers can store up to 25 charging algorithms in internal memory. Consult with your Delta-Q Representative to select from the large library of lead-acid and lithium algorithms to be loaded on your charger. These algorithms can be specific to each manufacturer and model of battery. The default charge algorithm can be set in two ways:

- Via a CAN message
- Via the **Charger** button (W/UI Model)

See *Appendix E: Using the Charger Button (W/UI Models)* to learn how to make changes to the algorithm.

9.2 Charger Reprogramming

ICL and RC Series chargers can only be reprogrammed via CAN. See the *IC Series CANopen Interface Specification* or contact your Delta-Q Technologies Application Engineer for more details. A PC tool is available which can be used with Peak Systems PCAN-USB interface to reprogram the chargers.

9.2.1 Charger Data Log

All ICL & RC Series chargers record charge data which can be very useful in vehicle or machine diagnostics. Some data recorded includes the following:

Cumulative Data (lifetime)

- Total Amp-hours
- Total charge cycles
- Total maintenance cycles

Cycle Data (~3 years of data; accessible via CAN)

- Charge hours
- Charge Amp-hours
- Max voltage
- Min voltage
- Time between charges

Detailed Data (~3 months; must be downloaded)

- Battery voltage
- Charge current
- Battery temperature
- AC voltage

9.2.2 Custom Configuration

In addition to algorithms, numerous other settings on the charger are configurable. Some examples include:

- CAN Charger Node ID
- CAN Bus Speed
- CAN Battery Node ID
- CAN PDO Map
- Cable resistance compensation
- Temperature Sensor Not Detected Error

Contact a Delta-Q Technologies Applications Engineering team to discuss your requirements.

9.3 Charge Data Retrieval

Cumulative and Cycle Data: Retrieve via CAN Objects. See the *IC Series CANopen Interface Specification*.

All data: Retrieve via CAN SDO Block Transfer. See the *IC Series CANopen Interface Specification* or contact your Delta-Q Technologies Application Engineer for more details. A PC tool is available which can be used with Peak Systems PCAN-USB to download data from the chargers

9.4 Charge Data Analysis

The Delta-Q IC Data Analysis Tool enables parsing and viewing the charger data logs. The Simple Version displays the charge cycles records while the Full Version additionally graphically plots the data and enables detailed analysis of charge cycle data. Contact your Delta-Q Technologies Application Engineer for more details.

Figure 31: IC Data Analysis Tool – Simple Version

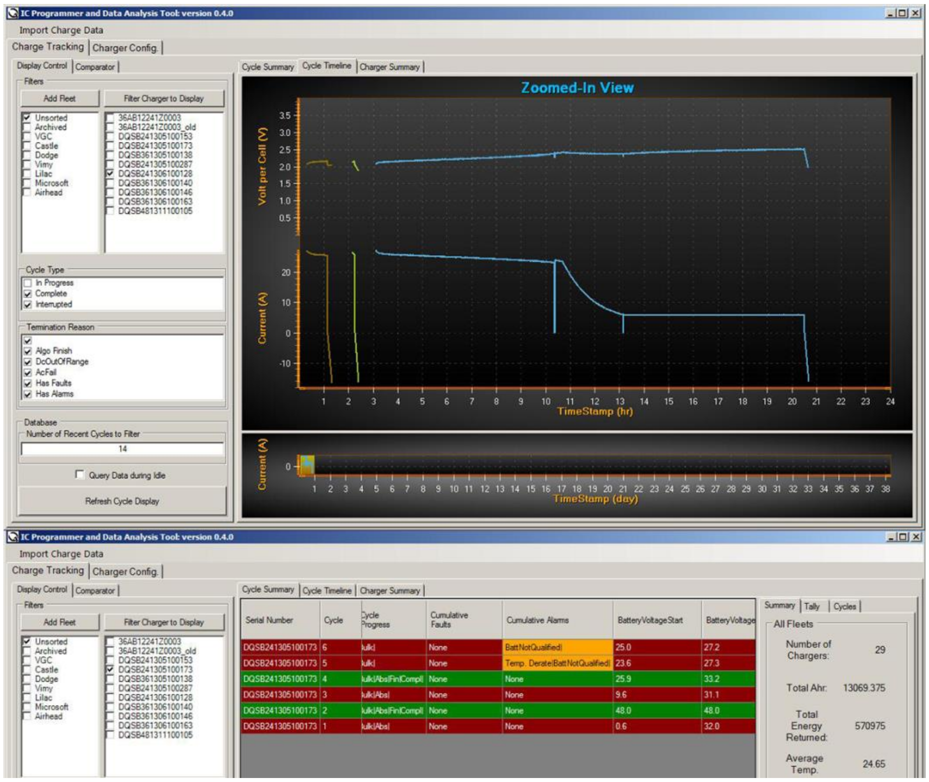


Figure 32: IC Data Analysis Tool – Full Version

10 Adverse Operation and Performance Charts

This section provides details on the high and low ambient temperatures, high and low AC input voltages, power limit, and DC-only operation and related performance levels.

10.1 High Ambient Temperature

At ambient temperatures above approximately 40°C (104°F), the charger automatically de-rates its output in order to regulate its maximum internal temperatures. This de-rating is approximately linear until 0% output power at over 80°C (176°F) ambient temperatures. As with any thermodynamic system, there are many variables to consider, such as the volume and speed of airflow, ventilation, air currents, and emissivity effects that all influence the thermal performance of the charger. Thorough thermal testing is recommended in the final installation to determine actual performance.

10.2 Low Ambient Temperature

The charger is capable of operating at full power at extremely low ambient temperatures. The charts illustrate the approximate ambient temperature performance.

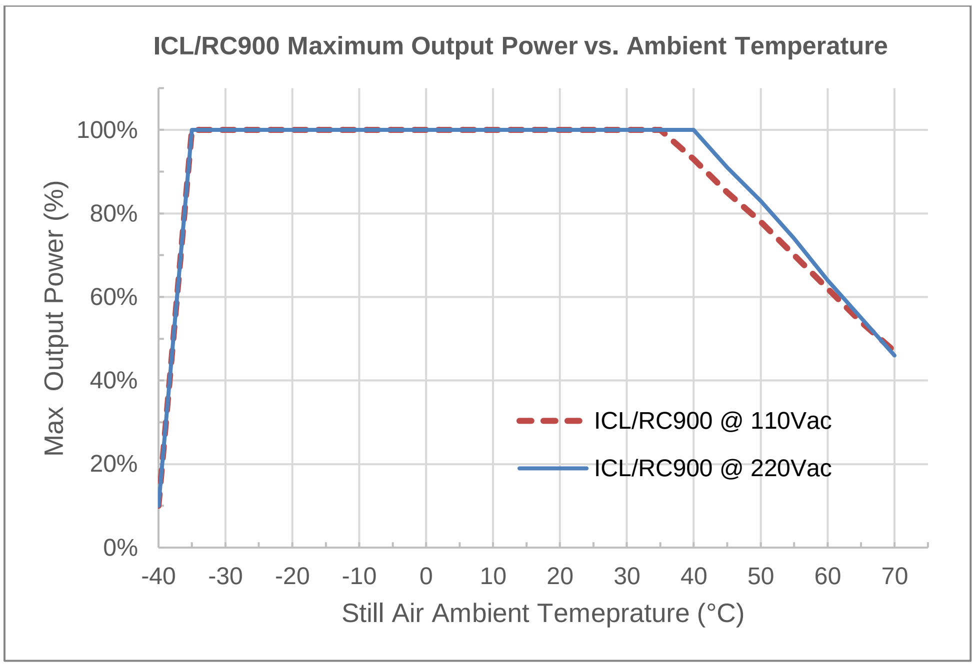


Figure 33: Ambient Temperature Derating for the ICL & RC 900 Chargers

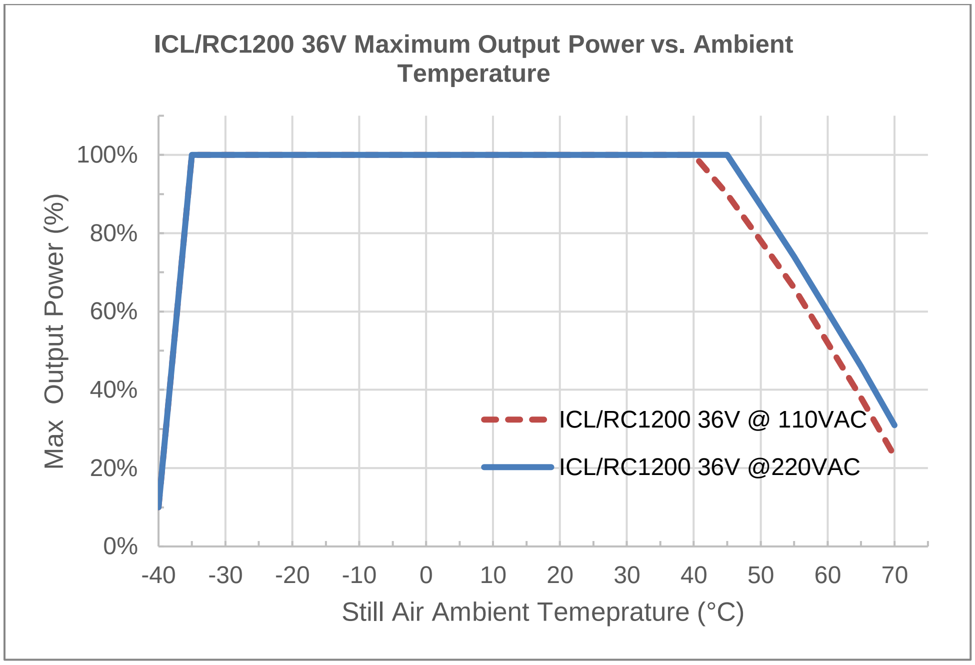


Figure 34: Ambient Temperature Derating for the ICL & RC 1200 Chargers @ 36V

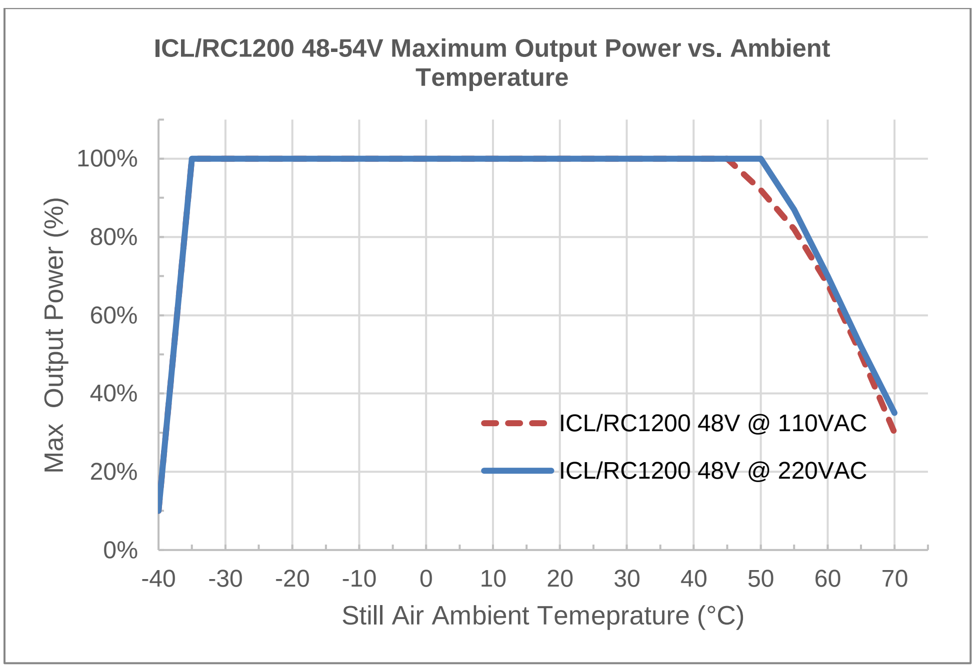


Figure 35: Ambient Temperature Derating for the ICL & RC 1200 Chargers @ 48-54V

10.3 Low AC Voltage

Universal Input Models: If input voltage falls below 100V AC, the ICL & RC chargers reduce their output power to protect themselves from damage and stay within the components safety limits. The power is progressively reduced until the charger turns off at around 80V AC. The following figure shows the available output power across the AC voltage range.

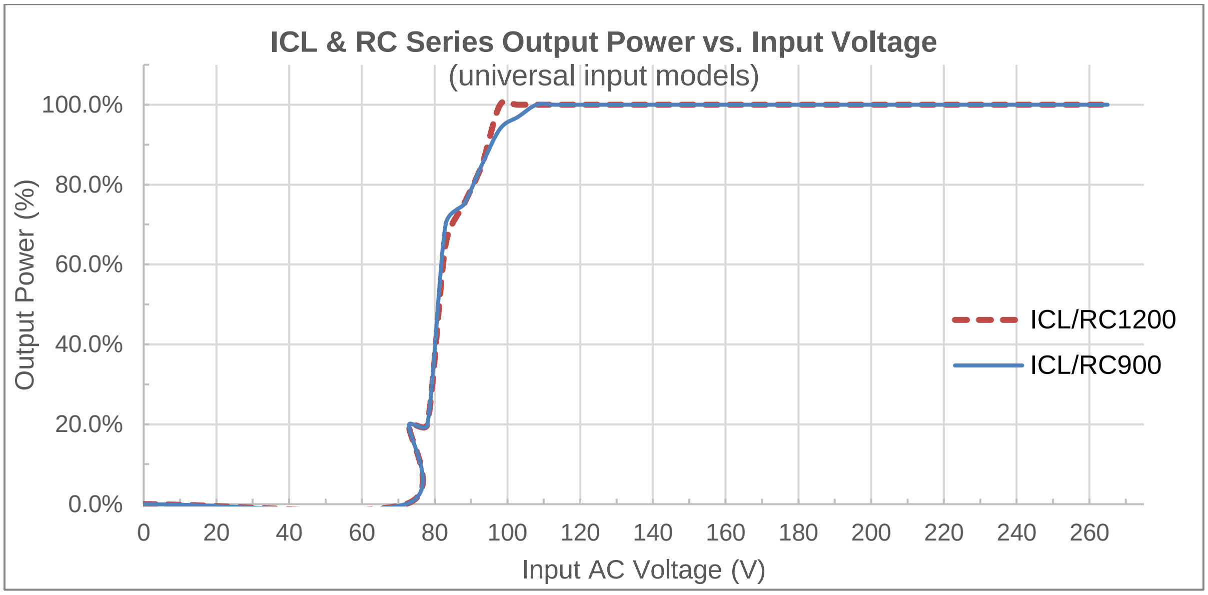


Figure 36: Output Power vs. AC Input Voltage for the ICL & RC Series Chargers (Universal Input Models)

10.4 High AC Voltage

When its input voltage rises above 270V AC, the charger shuts off to protect itself from damage. It will not turn on until the voltage falls below 265V AC.

Note: AC voltages over 300VAC will damage the charger permanently.

10.5 Power Limited

At charging voltages below 2.0V/lead acid cell or equivalent, such as those found on excessively discharged or damaged battery packs, the charger is able to supply its maximum DC output current at voltages as low as 0.1V/ lead acid cell or equivalent. The selected charging algorithm may restrict output current under these conditions. When the output voltage is low, the resulting output power is lower than expected.

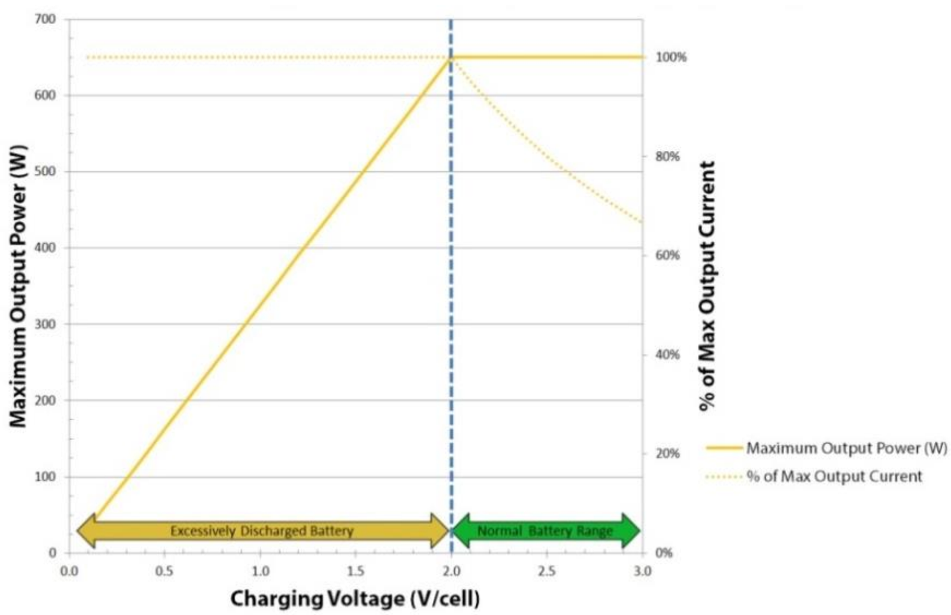


Figure 37: Maximum Output Power vs. Charging Voltage

11 Acronyms

The following table provides acronym definitions used within this guide.

Term	Definition
AC	**Alternating Current**
AWG	**American Wire Gauge**
BMS	**Battery Management System**
CAN	**Controller Area Network**
CAN-ID	**CAN Identifier**
CFM	**Cubic Feet Per Minute**
CiA	**CAN in Automation**
CEC	**California Energy Commission**
COB-ID	**CAN Object Identifier**
DC	**Direct Current**
DSP	**Digital Signal Processor**
ELV	**Extra Low Voltage**
EMI	**Electromagnetic Interference**
ESA	**Electrical/Electronic Sub-Assembly**
GFCI	**Ground Fault Circuit Interrupter**
HV	**High Voltage**
HW	**Hardware**
ID	**Identifier**
KB	**Kilobyte**
kW	**Kilowatt**
LED	**Light Emitting Diode**
LV	**Low Voltage**
MB	**Megabyte**
MCU	**Microcontroller (*also abbreviated uC or µC)***
MOV	**Metal Oxide Varistor**

Term	Definition
NMT	Network Management
NRTL	Nationally Recognized Testing Laboratories
OEM	Original Equipment Manufacturer
PC	Personal Computer
PDO	Process Data Objects
PFC	Power Factor Correction
RCM	Regulatory Compliance Mark
SDO	Service Data Objects
SJTW	Hard Service Cord
SW	Software
TBD	To Be Determined
TVS	Transient Voltage Suppressor
UL	Underwriters Laboratories
USB	Universal Serial Bus
V	Volt
VAC	Volts Alternating Current

Appendix A: DC Cabling Installation Instructions

To attach DC cabling to the ICL & RC chargers, you will need the following items:

- 1 Torx T40 screwdriver
- 1 Torx T30 screwdriver
- 1 Torx T10 screwdriver
- 1 Torx T30/M6 screws (provided)
- 1 Torx T40/M8 screws (provided)
- 2 or 3 longer Torx T10 screws (provided)
- 2 shorter Torx T10 screws (provided)
- 1 DC cable with ring terminals for attachment into the DC block
- 1 DC block cover (provided)
- 1 DC cable clamp (provided)

1. Remove the DC terminal block cover by lifting it vertically off the charger. Remove the bag of parts that contains the cable clamp, 2 longer Torx T10 screws, and 2 shorter Torx T10 screws.

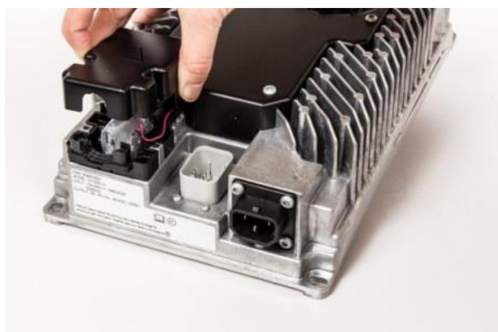


Figure 38: Removing the DC Block Cover

2. Remove the positive and negative battery fasteners (M8 and M6 screws).
3. Attach the negative ring terminals of the B- wires to the terminals of the charger and secure with T30/M6 screws to a recommended torque of 4.5Nm +/-5%.
4. Attach the positive ring terminals of the B- wires to the terminals of the charger and secure with T40/M8 screws to a recommended torque of 6.0Nm +/-5%.
5. Secure the DC cable and/or wire(s) in place using the supplied cable clamp. Fasten with the two longer Torx T10 screws to a recommended torque of 0.6Nm +/-6%.

Figure 39: Secure DC Wire

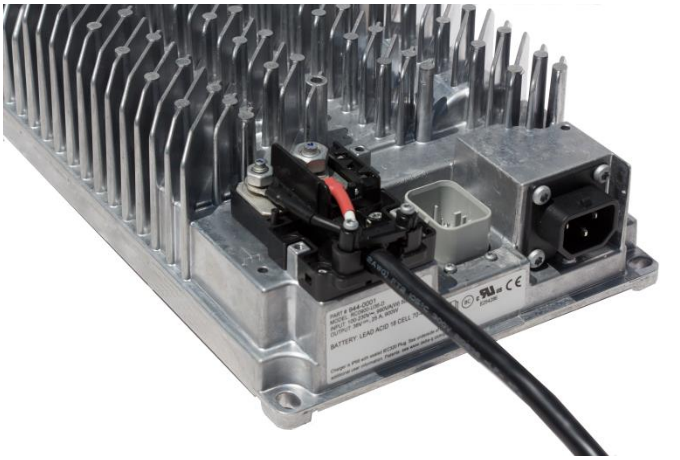


Figure 40: Using the Cable Clamp

6. Replace the DC terminal block cover and use the 2 shorter T10 screws to secure the cover in place.

Note: Replacement instructions for the ICL & RC 1200 fans are provided in Appendix C: Fan Replacement Instructions

Appendix B: Signals & Control Connector Cabling Instructions

No tools are required to install or remove the AMPSEAL plug.

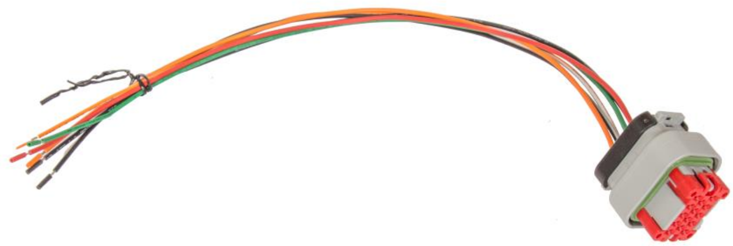


Figure 41: An Example Communications Harness

1. Insert the AMPSEAL plug into the Signals & Control connector with the locking mechanism facing toward the DC Block of the charger.

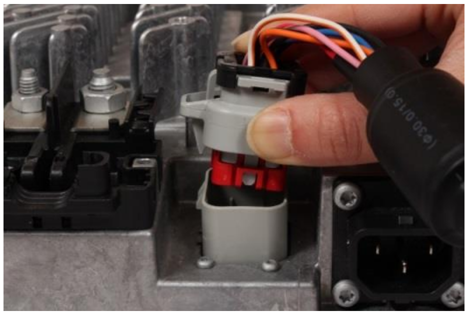


Figure 42: Inserting the AMPSEAL Plug

2. Apply pressure until you hear an audible click as the plug locks into position.

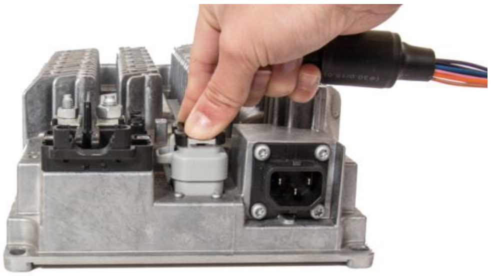


Figure 43: Plug Locking

To disconnect a communications harness, pull out the plastic catch of the plug locking mechanism, while pulling the harness out of the charger. Be sure to pull using the plug body, not the wires.

Appendix C: Fan Replacement Instructions

If the IC1200 or RC 1200 charger fan fails or is accidentally disconnected, the charger displays a fan error on its status display. Under this condition, the charger continues to operate but at reduced output. The fan and/or fan shroud can be easily replaced.

1. Take the DC terminal block cover off the battery charger.

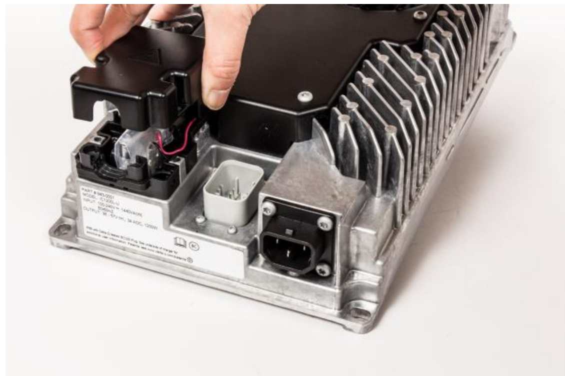


Figure 44: Remove DC Block Cover

2. Unscrew the six screws on the fan shroud.

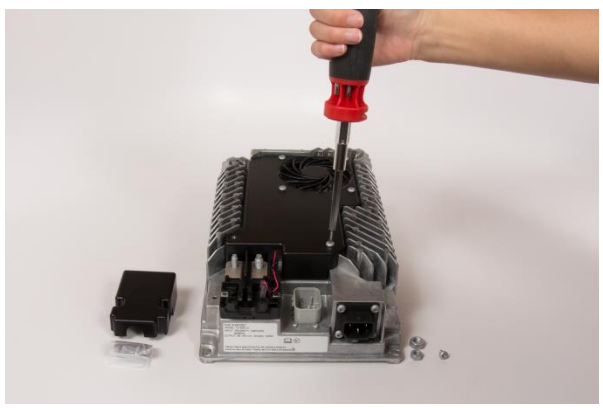


Figure 45: Remove 6 Screws

3. Lift the fan shroud from the charger. The fan may remain on the charger or stay with the shroud.

Figure 46: Lift Fan Shroud off the Charger

4. Turn the shroud upside down. The two screws at the rear will fall out. Set them aside. The four screws for the fan should stay with the shroud, held in place by rubber grommets. Detach the fan's red & black wires from the clips holding them to the shroud. Lift the fan away from charger and shroud.

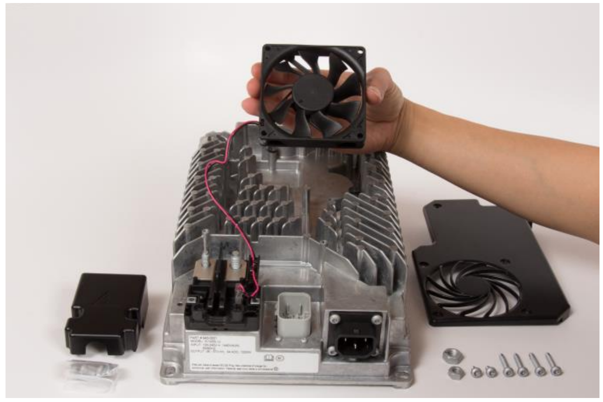


Figure 47: Lift Fan

5. Be sure to disconnect the red and black fan wire quick-connects from the terminal tabs and remove the fan.

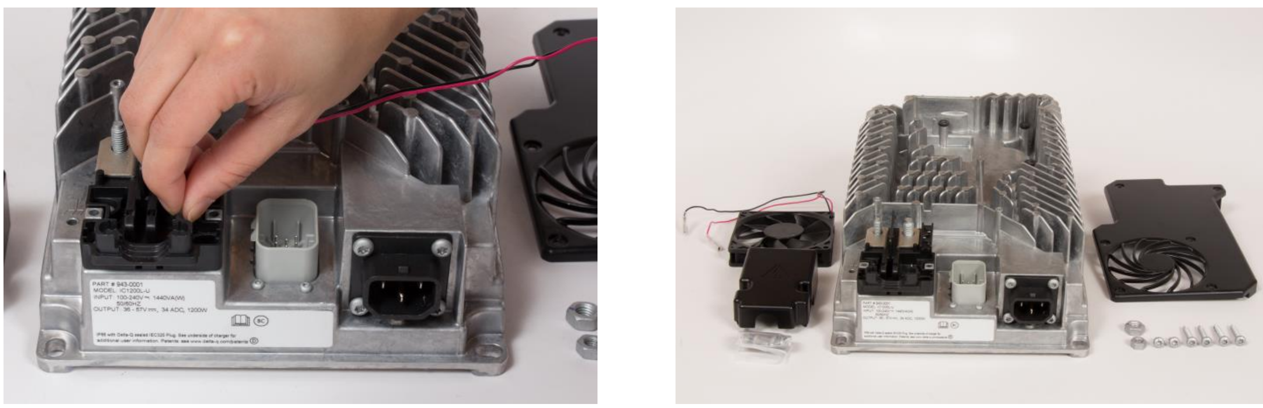


Figure 48: Disconnect Wires and Remove Fan

6. Place the new fan onto the fan shroud so the red & black wires are located as shown in the figure below, with the four mounting holes in its corners over the four screws. Then, push it all the way down on the rubber grommets. Make sure the fan's air flow indicator (an arrow symbol) on the outside edge of the fan is pointing away from the shroud, so the airflow will be downward onto the charger's case after the fan is re-installed. If the fan is installed backwards, the charger my reduce charging performance.

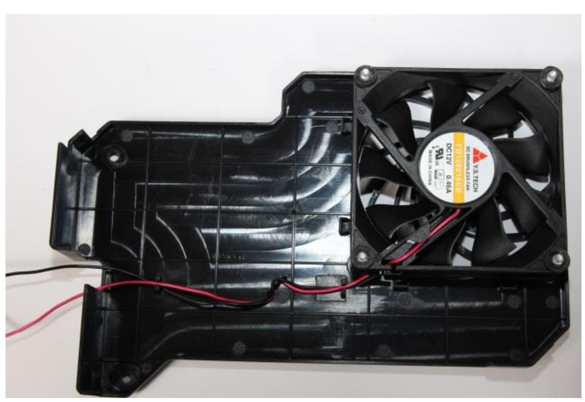


Figure 49: Place New Fan in Fan Shroud

7. Run the red & black wires from the fan through the two clips and the 3-post strain relief in the shroud. Holding the fan to the shroud with your fingers, turn the shroud top side up.

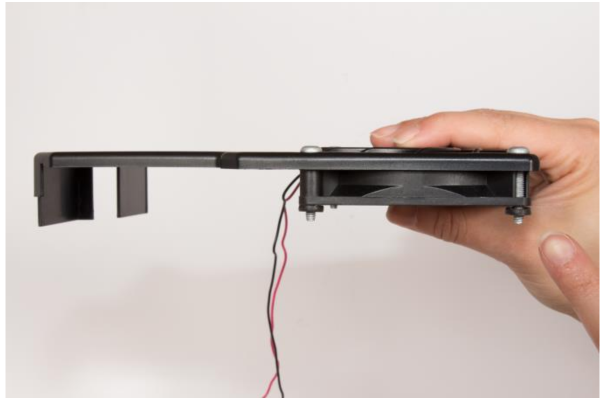


Figure 50: Shroud with Fan, top side up

8. Align the fan and shround on the battery charger and drop in place.

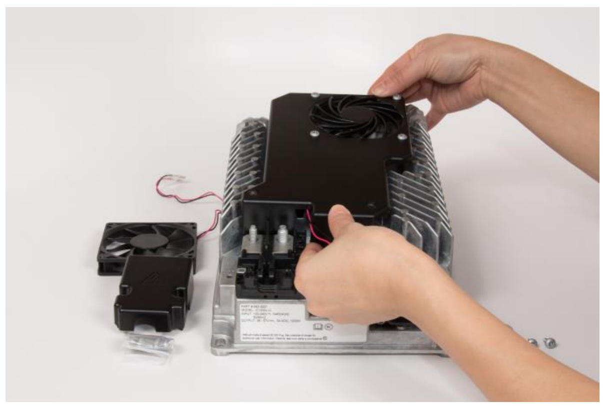


Figure 51: Install New Fan

9. Run the red & black fan wires through the channel for them in the DC block, under the triangular prongs. Make the electrical connections in the DC terminal block. Connect the red wire to the positive quick connect tab (F+) and the black wire to the negative quick connect tab (F).

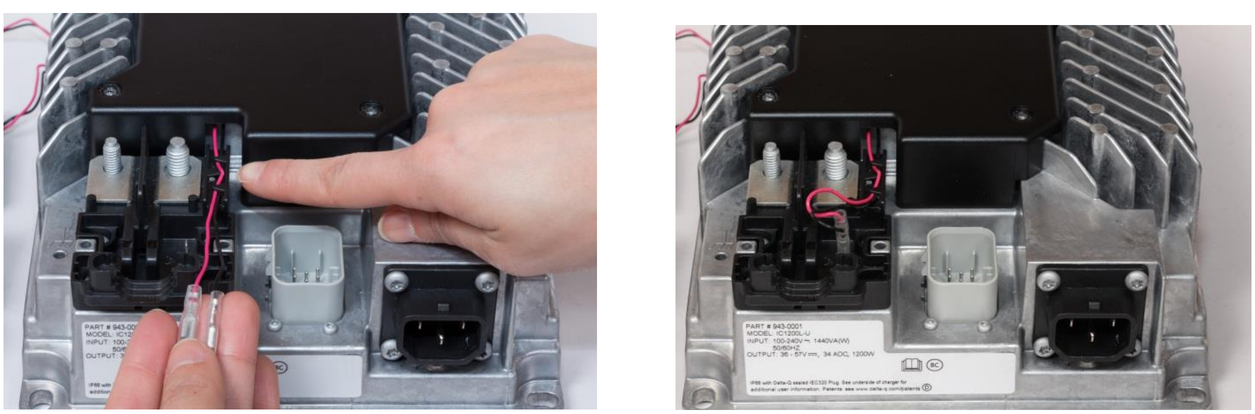


Figure 52: Wiring and Electrical Connection

10. Replace the two screws in the rear of the shroud. And, then screw in all six screws. Do not overtighten (recommended torque 2.7Nm).

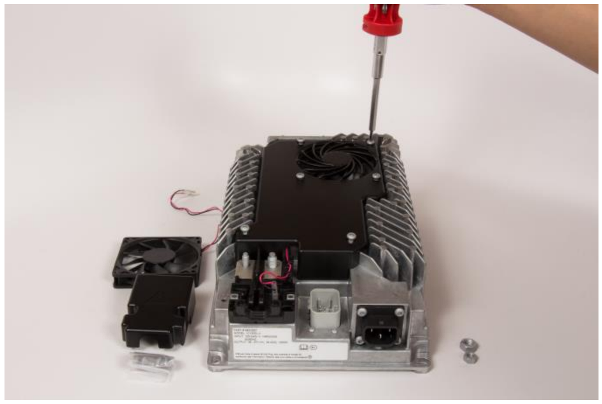


Figure 53: Secure Fan/Fan Shroud

11. Replace the back cover.

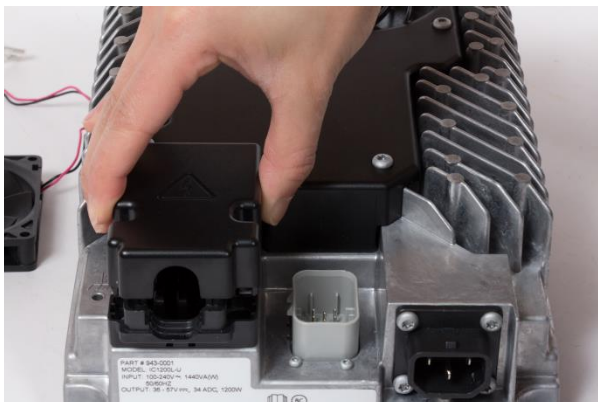
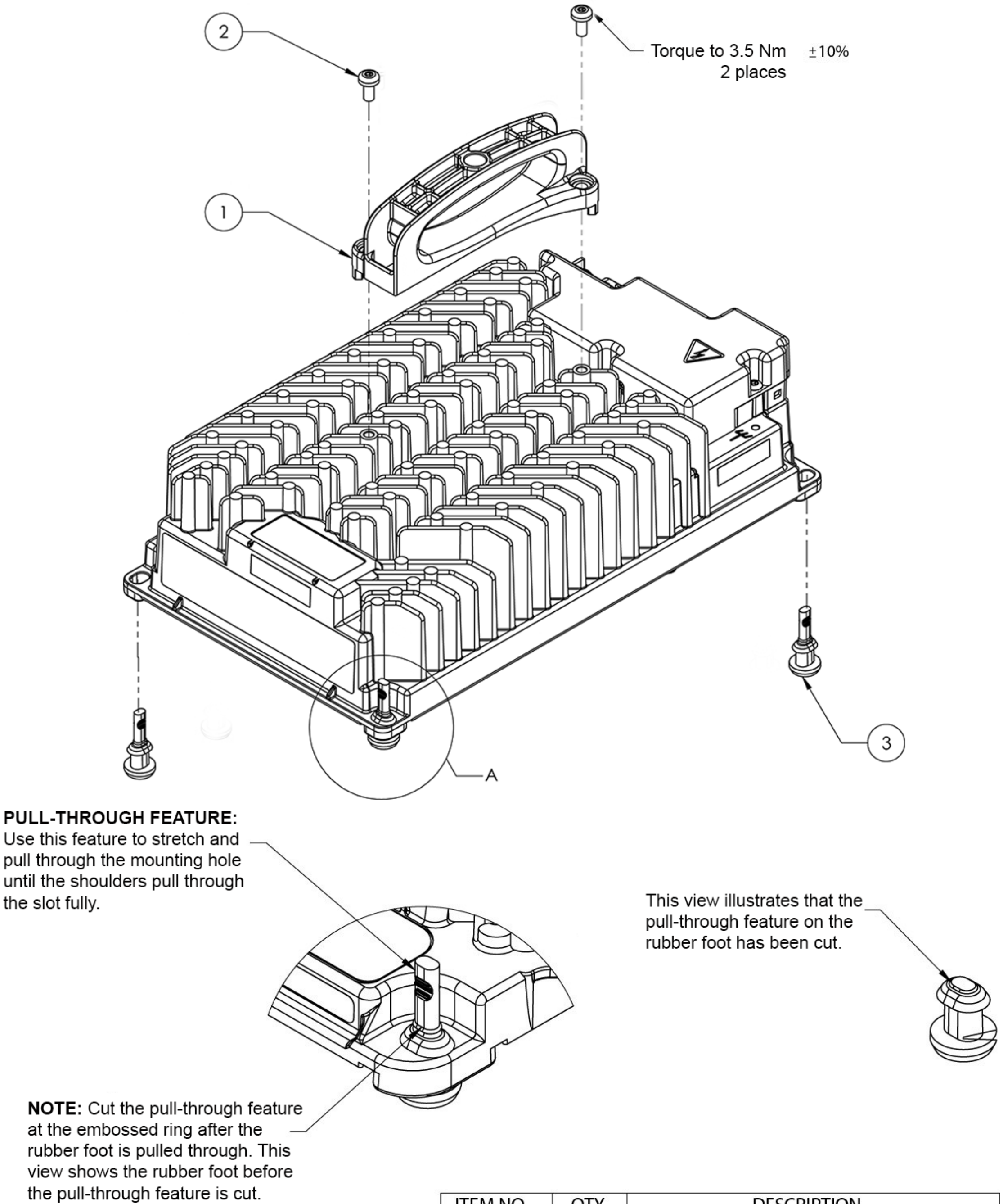


Figure 54: Replace Back Cover

Appendix D: Portable Use

The diagram shows how to install the IC Series Accessory Kit PN 900-0111, which includes a handle and rubber feet for the ICL & RC 900 chargers. This kit provides portability, safe charger handling, and prevents scratches to surfaces on which the charger is placed. The ICL & RC 1200 chargers have an option for a built-in handle on the fan shroud.



ITEM NO.	QTY	DESCRIPTION
1	1	HANDLE IC SERIES
2	2	SCREW M5 x 16 TAPTITE TORX
3	4	FEET IC SERIES

Figure 55: Charger Handle and Feet Installation

Figure 56: RC900 with Add-On Handle

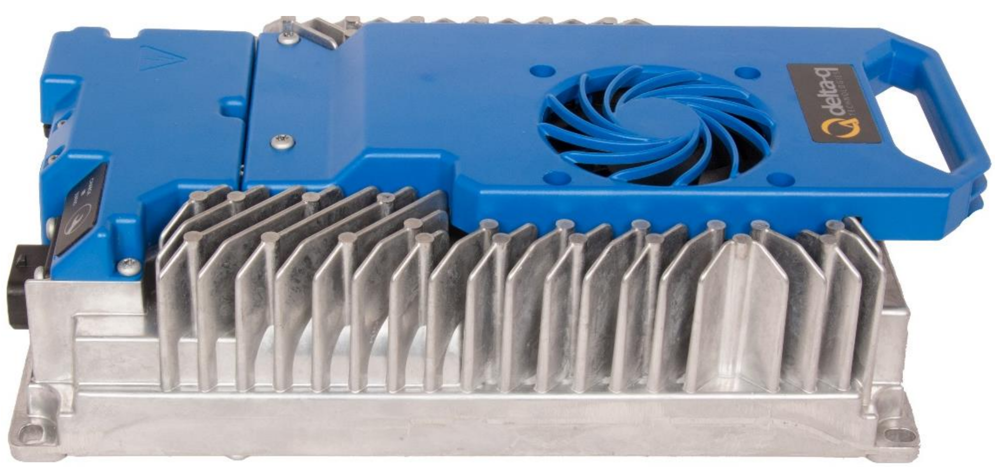


Figure 57: RC1200 with Built-In Handle

Appendix E: Using the Charger Button (W/UI Models)

Nearly every model of battery has different charging requirements. For Delta-Q Technologies chargers, these requirements are used to create a charge algorithm specific to each battery. Therefore, the appropriate charge algorithm (often referred to as a charge profile) must be selected. Most models of the RC Series chargers come with a default set of pre-loaded standard charge algorithms. Up to 25 selectable algorithms may be stored on the RC Series chargers. It is also possible to load different algorithms, via CAN.

Regardless of which and/or how many algorithms are installed, selecting the algorithm to be used on the W/UI model chargers can be done by following the steps outlined below.

Identifying the Charging Algorithm in Use

Follow these steps to identify the charging algorithm in use on the RC Series W/UI model charger:

1. On a powered charger, press and release the **Charger** button, to display the charging algorithm currently in use. The **Charge Status** indicator shows the algorithm (also called:"profile"), in a sequence of fast **Red** flashes and slower **Green** flashes of the LED; the algorithm number is equal to the number of **Green** flashes. This sequence is repeated twice.

   Algorithm 7 = 

   Algorithm 7 = **Red** flashes **Green Green Green Green Green Green Green**

2. An algorithm number ten or greater is displayed in the same way, but with a pause between the Green flashes for the first and second digits of the algorithm number. This sequence is repeated twice.

   Algorithm 33 =  || 

   Algorithm 33 = **Red** flashes **Green Green Green** **||** **Green Green Green**

Selecting a New Charging Algorithm

1. Press and hold the **Charger** button to enter the Algorithm Select mode. After five seconds, a sequence of fast **Red** flashes and slower **Amber** flashes appears on the **Charge Status** indicator, confirming the charger is in this mode.

2. Release the **Charger** button.

3. The **Charge Status** indicator shows the charging algorithm currently in use, similar to *Identifying the Charge Algorithm in Use,* but with **Amber** flashes to indicate the algorithm instead of **Green** flashes. This is repeated four times.

   Algorithm 33 =  || 

   Algorithm 33 = **Red** flashes…**Amber Amber Amber** || **Amber Amber Amber**

4. To display the next algorithm available in the charger, press the **Charger** button anytime during the four cycles. The sequence in the previous step starts again, but shows the next algorithm available in the charger. If there is only one algorithm in the charger, the old algorithm is still shown.

5. When your desired algorithm is showing, press and hold the **Charger** button for seven seconds to select that algorithm. The LED changes to a steady **Red** and after the seven seconds have elapsed, the new algorithm is displayed in **Green**. This repeats for two cycles, with **Red** flashes in the middle to indicate the end of a cycle.

   Algorithm 7 = 

   Algorithm 7 = **Green Green Green Green Green Green Green**

   If the **Charger** button is released before seven seconds, the **Charge Status** indicator reverts to displaying the last algorithm in **Amber** to signify the button was released too soon, and therefore the new algorithm was not selected.

6. Press the **Charger** button to confirm the desired algorithm has been selected.

Appendix F: Replacement Parts List

This is a partial list of available items. Contact Delta-Q Technologies for a current list of available accessories and cables.

Table 16: Replacement Parts List

Item	Part No.	Description
ICL 1200 Complete Fan with Handle and DC Terminal Replacement Kit	900-0150	Kit includes: black fan with handle, black DC cover and mounting accessories
ICL 1200 Complete Fan without Handle and DC Terminal Replacement Kit	900-0153	Kit includes: black fan without handle, black DC cover and mounting accessories
RC 1200 Fan with Handle Replacement Kit	900-0155	Kit includes: blue fan with handle and mounting accessories
RC 1200 Complete Fan without Handle Replacement Kit	900-0154	Kit includes: blue fan without handle and mounting accessories
ICL DC Terminal Kit	900-0152	Kit includes: black DC cover, M6 and M8 nuts, cable clamp, and clamp/cover screws
RC DC Terminal W/UI Kit	900-0151	Kit includes: bleu DC cover W/UI, AMPSEAL connector, M6 and M8 nuts, cable clamp, and clamp/cover screws
ICL Handle & Rubber Feet Kit (ICL & RC 900 only)	900-0111	Plastic handle to carry the charger and four rubber feet to prevent scratches to surfaces on which the charger is placed.
Rubber Mounting Foot	400-0366	Rubber feet to prevent scratches to surfaces on which the charger is placed.