IC Series Battery Chargers
Installation and Design Guide

IC650 **IC900** **IC1200**

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1 Introduction

This document is intended for engineers and technologists of original equipment manufacturers (OEMs) to aid them in incorporating IC Series battery chargers into their products.

It details mechanical and electrical installation, provides guidelines for charger operations and configuration, and outlines the various communications protocols associated with the IC Series. As well, there are several detailed drawings and figures that provide a variety of views of the various battery chargers.

The guide includes a listing of fault codes and error codes in the troubleshooting section that help engineers take steps quickly to resolve issues. As well, there is a partial list of replacement parts, should they be required.

2 Safety Notes

This section provides important safety information when using all of the IC Series battery chargers. Read and comprehend this document fully before handling or working with IC Series battery chargers. Important safety, operation, and installation instructions are included.

2.1 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.

2.2 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

2.3 Battery Safety Information

WARNING: Only use the charger with a charging profile that is appropriate to the specific battery type. 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. Do not operate charger in a closed-in area or an area with restricted ventilation. Never charge a frozen or non-rechargeable battery. Observe all battery manufacturers' precautions (e.g. maximum charge rates and temperature compensation).

2.4 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.

3 Regulatory Notes

3.1 North America

This equipment has been tested and found to comply with the limits for Class A digital devices, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in an industrial environment. 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. Operation of this equipment in a residential area is likely to cause harmful interference; in which case, the user will be required to correct the interference at his/her own expense.

All IC 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. Additionally, the IC650 charger also carries the CSA mark. All IC Series chargers are fully compliant with California Energy Commission (CEC) standards for efficiency, and are marked with the CEC compliance symbol.

3.2 Europe, Asia, Middle East, Africa

The IC 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. PSE/CISPR version of the IC650 24V and 36V chargers comply with the limits of CISPR 14-1 & 14-2 when appropriately filtered AC and COMM cords are installed. Contact Delta-Q Technologies for details on this filtering.

3.3 Japan

PSE/CISPR versions of the 24V and 36V IC650 chargers are certified for use in Japan when appropriately filtered AC and COMM cords are installed. Contact Delta-Q Technologies for details on this filtering.

3.4 South Korea

The IC650 chargers are certified for use in South Korea and labeled with the regulatory KC mark.

3.5 Australia & New Zealand

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

3.6 Other Standards or Requirements

Every effort has been made to ensure IC 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.

4 IC Series Model Listing

These tables have basic details for the battery chargers. See *IC Series Drawings and Photos* for detailed information.

Figure 1: IC650, IC900, and IC1200 Battery Chargers

Table 1: IC650 Details

Part No.	Product Description	Voltage	Max Current	Power
940-0001	IC650 24V BASE	24V	27.1A	650W
940-0002	IC650 36V BASE	36V	18.1A	650W
940-0003	IC650 48V BASE	48V	13.5A	650W
940-0004	IC650 24V COMM	24V	27.1A	650W
940-0005	IC650 36V COMM	36V	18.1A	650W
940-0006	IC650 48V COMM	48V	13.5A	650W
940-0036*	IC650 24V BASE PSE/CISPR 14	24V	27.1A	650W
940-0037*	IC650 36V BASE PSE/CISPR 14	36V	18.1A	650W
940-0038*	IC650 24V COMM PSE/CISPR 14	24V	27.1A	650W
940-0039*	IC650 36V COMM PSE/CISPR 14	36V	18.1A	650W

* PSE (Japan) and CISPR 14.1 & 14.2 compliant models. These models are not typically stocked by Delta-Q Technologies and may require special orders.

Table 2: IC900 Details

Part No.	Product Description	Voltage	Max Current	Power
942-0001	IC900 24V BASE	24V	37.5A	900W
942-0002	IC900 36V BASE	36V	25.0A	900W
942-0003	IC900 48V BASE	48V	20.0A	900W
942-0008	IC900 24V COMM	24V	37.5A	900W
942-0009	IC900 36V COMM	36V	25.0A	900W
942-0010	IC900 48V COMM	48V	20.0A	900W

Table 3: IC1200 Details

Part No.	Product Description	Voltage	Max Current	Power
941-0001	IC1200 24VBASE	24V	50.0A	1200W
941-0002	IC1200 36V BASE	36V	33.3A	1200W
941-0003	IC1200 48V BASE	48V	25.0A	1200W
941-0008	IC1200 24V COMM	24V	50.0A	1200W
941-0009	IC1200 36V COMM	36V	33.3A	1200W
941-0010	IC1200 48V COMM	48V	25.0A	1200W

5 IC Series Charger Operations

IC 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, IC Series chargers efficiently provide clean DC output in a very compact package. They do this using small, lightweight, high-frequency switching circuitry, 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.

5.1 Isolation

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

1. **AC Input:** 0-270 VAC
2. **DC Output & Charger Control/Status Signals:** range depends on voltage model: 0-3 V/cell and 0-5 VDC
3. **Universal Serial Bus (USB)**: 0-5 VDC
4. **CAN bus:** 0-5 VDC

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.

5.2 Configurations

Two configurations of each model are available: BASE and COMM. The difference between the models is the inclusion of a communication port on the COMM model for advanced control. Both can be configured for on-board or off-board use. For more details, see *Electrical Installation*.

Figure 2: COMM: CAN Bus and Several Control/Status Signals Available

Figure 3: BASE Model Connections to the Battery and Controller Interlock

5.3 Normal Operation

Nearly every model of battery has different charging requirements. For Delta-Q chargers, these requirements are used to create a charge algorithm specific to each battery. To begin charging in an on-board or off-board configuration, 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. For details of CAN bus controlled charging, see *CAN Communications*.

The IC Series charger operates in an on-board configuration (charge on AC detect) or off-board configuration (charge on battery detect). Once the battery pack is fully charged (and if the charger, battery pack, and AC input remain connected) the charger will continue to monitor and maintain the battery.

When not being controlled externally, the IC Series chargers are designed to charge batteries during the times when the machine is off. They are not designed 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 overcharging, or an increase in Electromagnetic Interference (EMI). If AC power is interrupted, and then returns, the charger will start and continue to operate without hazard to the user, or damage to the batteries.

5.3.1 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 the charger remains connected to AC input. The button can be used to turn the charger off in this mode when powered in DC only.

Figure 4: On-Board Configuration

5.3.2 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 the charger remains connected to the battery pack.

Figure 5: Off-Board Configuration

5.3.3 Monitor/Maintain Mode

This mode becomes active when charging is complete, AC power is present, and the battery pack is connected. The charger 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. Depending on the selected algorithm and version of the charger, charging restarts after either 30 days or when the battery voltage drops to 2.08 V/cell, or after 14 days or 1.80 V/cell.

5.4 Battery Capacity

The table below provides recommendations on the maximum Amp-Hour capacity rating (based on a 20-hour discharge time) of batteries which each 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 4: Maximum Battery Capacity for 8-Hour Charge

	24V	36V	48V
IC650	260 Ah	175 Ah	130 Ah
IC900	360 Ah	240 Ah	180 Ah
IC1200	480 Ah	320 Ah	240 Ah

6 Charger Interface

All IC Series chargers share the same user interface to improve usability.

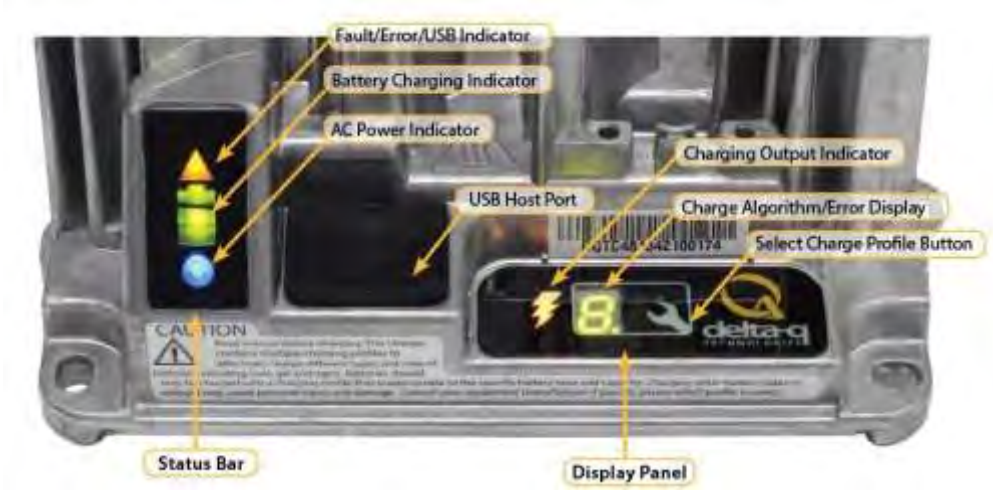


Figure 6: Charger Interface

- When you first plug into AC power, the **AC Power Indicator** illuminates solid blue to indicate AC power is present.

Solid Blue = AC power available

- The Battery Charging Indicator has four states.

Breathing Green = Low state of charge
Solid green = High state of charge

Breathing Green = High state of charge
Solid Green = Charge completed

- The **Fault/Error/USB Indicator** indicates faults, errors, and USB activity. See the Error Display for the code and find the error description in the *Charger Fault Codes* and *Charger Error Codes*.

Solid Red = Charger fault; See display panel for details

Flashing Amber = External error condition – Caution
See display panel for details

Flashing Green = USB port active
Solid Green = Safe to remove USB flash drive

- The **Charging Output Indicator** is solid yellow when the charger output is active. Take appropriate actions while handling the charger, as there is a risk of electric shock and energy hazard. The indicator flashes if the charger is disabled by an external signal (in some charge algorithms).

- The **Charge Algorithm/Error Display** shows the current charge algorithm or the resting phase of some algorithms or the fault/error code the charger is currently experiencing. It displays one of four possible codes to indicate different conditions:
    - F codes mean an internal fault condition has caused charging to stop.
    - E codes mean an external error condition has caused charging to stop.
    - P codes mean the charger programming mode is active.
    - C and S codes are related to software display.
    - USB code means the USB port is active and the flash drive should not be removed.

  The E, F, and P codes are followed by three numbers and a period to indicate different conditions (e.g., E-0-0-4.). See *Charger Fault Codes* or *Charger Error Codes* for details on these conditions and their solutions. P codes indicate the active charging profile number.

- The **Select Charge Profile** button, when pressed, shows the currently active charging algorithm. It is also used to select a new charge algorithm from those loaded on the charger. Up to 25 charge algorithms can be stored. See *Using the Select Charge Profile Button* for instructions.

  From charger software version 4.3.3 and later, the button has additional features:

    - Long Press (5 seconds): Shows software version, checksum, algorithm, and algorithm version as follows:

      ```
      S 4. 3. 3 C a b 1 2 P 0 1 1 r 1. 3 2
      ```

      Where:

      ```
      SW: v4.3.3
      Checksum: ab12
      Algorithm: 11 v1.32
      ```

    - Very Long Press (10 seconds): Off mode. This turns off all charger functions, while not charging, to save energy while connected only to batteries. This is only applicable for off-board applications when connected to DC only. If AC power is present the charger just turns back on again.

- The **USB Host Port** on an IC Series charger is used when configuring or retrieving data from the charger. The **USB Host Port** accepts standard USB 2.0 flash drives available at office supply or electronic stores. Data retrieved from a charger can be transferred to and viewed on a Windows-based computer by running the Delta-Q Technologies IC Data Analysis Tool software. See *Charger Data Logging* for more information.

Figure 7: USB Host Port

A USB flash drive can also be configured to program charger settings and update the charger algorithms and/or software. See *Charger Algorithms and Configuration* for more information. This allows easy updates of the charger on a production line or in the field.

A rubber cover seals this USB port against the elements. The port's connector is sealed against water and dust ingress to an IP67 rating. See *Using a USB Flash* Drive for more information.

IMPORTANT: Only USB 2.0 flash drives (single partition, formatted as FAT16 or FAT32) are compatible with the USB Host port. Do not connect other USB devices.

USB power may be drawn from the port to the limits in the table below.

Table 5: USB Port Specifications

IC Series Charger	Max USB Current Rating
IC650	**200 mA**
IC900	**500 mA**
IC1200	**500 mA**

- Remote LED Behavior

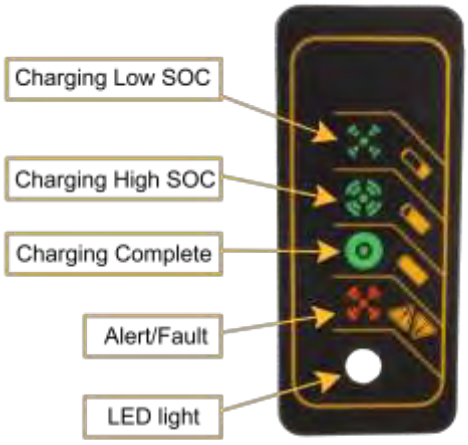


Table 6: LED Operation

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

7 Installation

The most important consideration for the IC Series chargers is cooling. Though the chargers operate reliably in any installation, insufficient cooling may prevent the charger from operating at full output power. Other important considerations in the installation are as follows:

- Keeping electrical connections clean and dry
- Providing access to the AC, DC, and signal connections for maintenance
- Ensuring visibility of the charger interface if a remote LED is not used
- Providing access to the USB Host port for maintenance
- Having mounting points that provide a secure installation

7.1 Cooling

Every battery charger generates heat while charging. That heat must be able to escape to the air outside of the equipment in which the charger is installed. For Delta-Q Technologies chargers, 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.

IC Series chargers are cooled by either forced air or convection cooling. The IC1200 chargers use forced air cooling. This means there is a fan mounted on the top of the case to mechanically move air over the surfaces of the charger, extracting heat from the charger and moving that heat to the air around the charger. The charger should be oriented so the fan is able to exhaust the air from the equipment in the most effective directions. The IC650 and IC900 use convection cooling which uses the natural upward movement of warm air over the surfaces of the charger and draw new cold air to carry the heat away from the charger.

Note: In both cases, the charger transfers its heat to the air around it. And, in both cases, a pathway is required to carry that heat from the air around the charger to the air outside of the equipment. The IC Series chargers do not benefit much from conduction cooling. Though cooling via conduction is not significant, the conduction cooling can be maximized by ensuring good thermal contact under each foot to a metal surface.

Figure 8: Convection Cooled IC Series Charger

IC Series chargers require clearance for airflow around the charger to allow for maximum performance.

The IC Series chargers achieve the best transfer of heat to the surrounding air when mounted horizontally, with the cooling fins pointing up. Mounting the chargers on their sides is nearly as effective, but mounting the chargers with the cooling fins pointing down may give unsatisfactory results. The charger location is important for optimum cooling of the system because heat from the charger may be detrimental to batteries and other heat sensitive parts.

Regardless of which charger is chosen for an application, the same principles apply. Delta-Q Technologies can provide recommendations to customers who are fitting chargers into their vehicles/machines to allow for enough airflow over the chargers. As fully sealed power electronics devices, IC Series chargers require different considerations for cooling than open, ventilated, or conduction cooled devices.

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. For the fan-cooled IC1200 charger, this clearance can be reduced to as little as one (1) inch. The IC650 and IC900 chargers require two to six inches above them to allow hot air to rise away from the charger.
- A variety of mounting orientations are possible but mounting on a horizontal surface with the cooling fins pointing upwards is best.
- If the heat sink is facing downward, trapped hot air may prevent the IC650 and IC900 chargers from operating at maximum output power.
- An auxiliary fan may be used to cool an IC650 or IC900 enclosure if sufficient passive cooling cannot be achieved.
- There must be a path for the heat to escape from an enclosed location. Allow for openings, vents, and/or louvers at both the top and bottom to allow hot air to escape (at the top) and cool air to enter (at the bottom).

7.1.1 Testing the Cooling Effectiveness of the Mounting Location

The amount of heat generated by the IC Series chargers is approximately 10% of the output power. Therefore, at full output power, the IC650 charger generates approximately 65W of heat, the IC900 generates approximately 90W of heat, and the IC1200 generates approximately 120W of heat. Unfortunately, it is nearly impossible to calculate the resulting temperatures in an application. 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.

To test the proposed mounting location, install the charger and batteries as intended. Fully discharge the batteries and measure the output voltage and output current of the charger during a full charge cycle. If this test is conducted at the maximum ambient temperature at which the charger is expected to operate, the measured voltage and current data can be analyzed to confirm full output current and, therefore, optimum charger operation.

Note: Alternatively, the IC Data Analysis Tool could be used to review the charger voltages and currents without the need to directly perform measurements.

After the test is complete, the voltage and current should be plotted against time as shown in Figure 9. If the output current appears like the output current shown in the solid green line, the charger is operating at full output power. If the current falls below the expected output current of the charger during bulk charging, as shown by the dashed line, the output current is being automatically reduced by the charger in response to the elevated temperature. This is an automatic safety feature of the charger, ensuring the internal temperatures do not become excessive. If the output current is reduced in this way, it indicates the heat generated by the charger is not being removed quickly enough and additional cooling may be required to achieve satisfactory results.

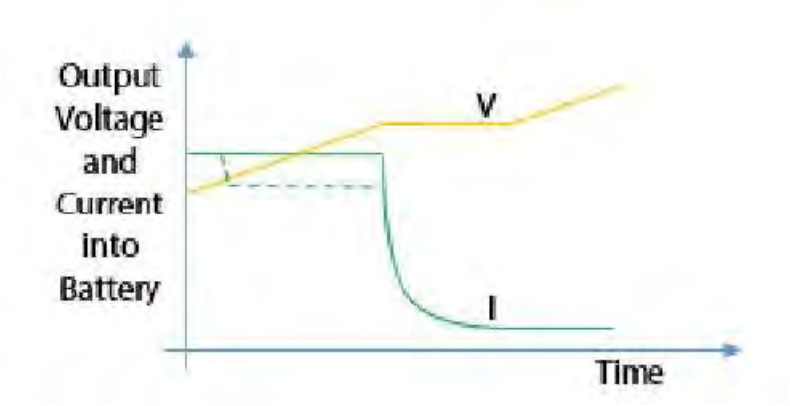


Figure 9: Voltage, Current, and Time Plot to Illustrate Derating

Reduced output current due to high temperatures will result in extended charge times. In these circumstances, it is necessary to evaluate whether the increase in charge time is acceptable. To estimate how much longer the charge time may be when output current is reduced, use the following formula:

```
Increase = Treduced ((Imax/Ireduced) – 1)
```

Where:

Increase is how much longer the charge cycle will take.
Treduced is how much time the charger spends at reduced current during the charge cycle.
Imax is the maximum output current of the charger at the beginning of the charge cycle.
Ireduced is the reduced output current.

7.2 Battery Heating

Because the battery charger is usually installed near the batteries, in addition to considering the heat generated by the charger, the heating of the batteries should also be considered. A battery typically causes approximately 10°C temperature increase over a charge cycle but excessive heating reduces the longevity of the batteries. Thus, the battery temperature should be measured during the testing of the charger to ensure the heat from the charger is not being transferred to the battery pack. If the batteries appear to be heating more than expected, try moving the charger to reduce the heat transfer. The following tips may help reduce the transfer of heat:

- Avoid putting the charger directly against the batteries or wall of the battery box.
- Avoid putting the charger directly below the batteries.
- Provide a thermal break between the surface the charger is mounted on and the battery box.

7.2.1 Charger Surface Temperatures

While the IC Series chargers do meet regulatory temperature limits, they can get hot to the touch when operating. Care should be taken to keep any heat sensitive components in the system away from the charger especially if the components can come in contact with hotter areas of the charger. High temperature components, such as wires, rated at 105°C can be safely put anywhere and will not be damaged by the charger.

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 IC Series chargers during normal operation (at room temperature). Hotter areas can be identified and therefore avoided, if required.

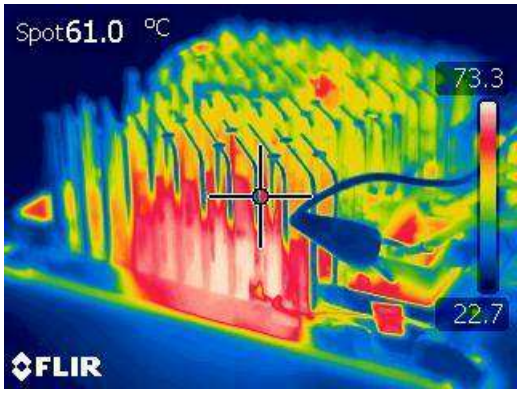


Figure 10: IC650 Right Side

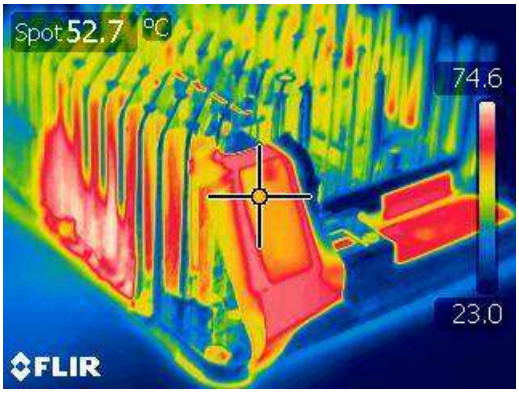


Figure 11: IC650 Left Side

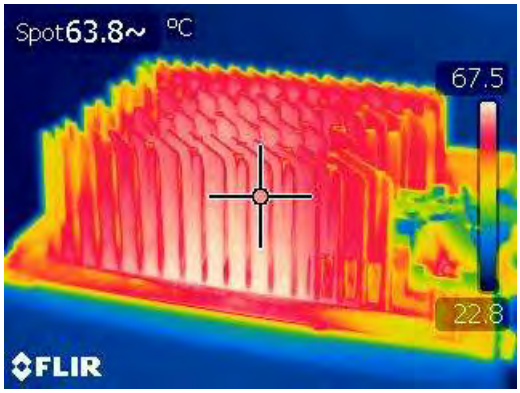


Figure 12: IC900 Right Side

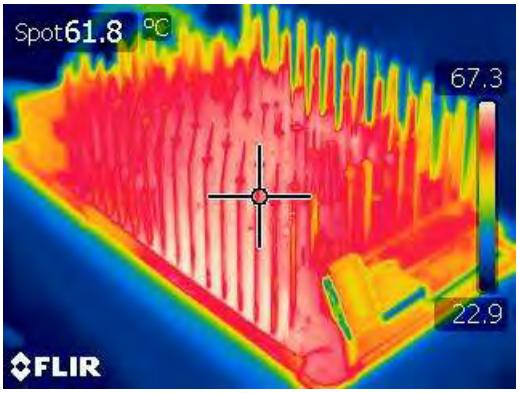


Figure 13: IC900 Left Side

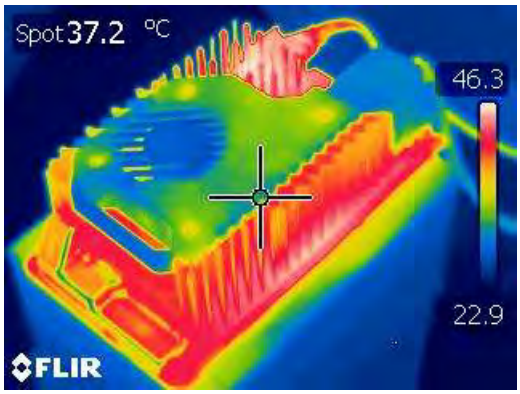


Figure 14: IC1200 Right Side

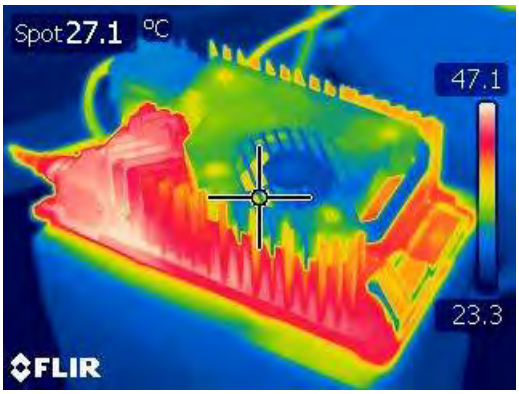


Figure 15: IC1200 Left Side

7.3 Mechanical Installation

Robust mounting points are cast into the charger's aluminum enclosure. At each corner are 6.3mm (1/4") diameter slots, arranged to allow ample tolerance when mating with standoffs or pre-drilled holes in a machine. In addition, a keyhole slot has been provided in the back of the charger so it can be hung vertically on a wall or secured to a shelf. When using the keyhole slot, remember to add at least one additional securing screw, to prevent the charger from falling.

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.

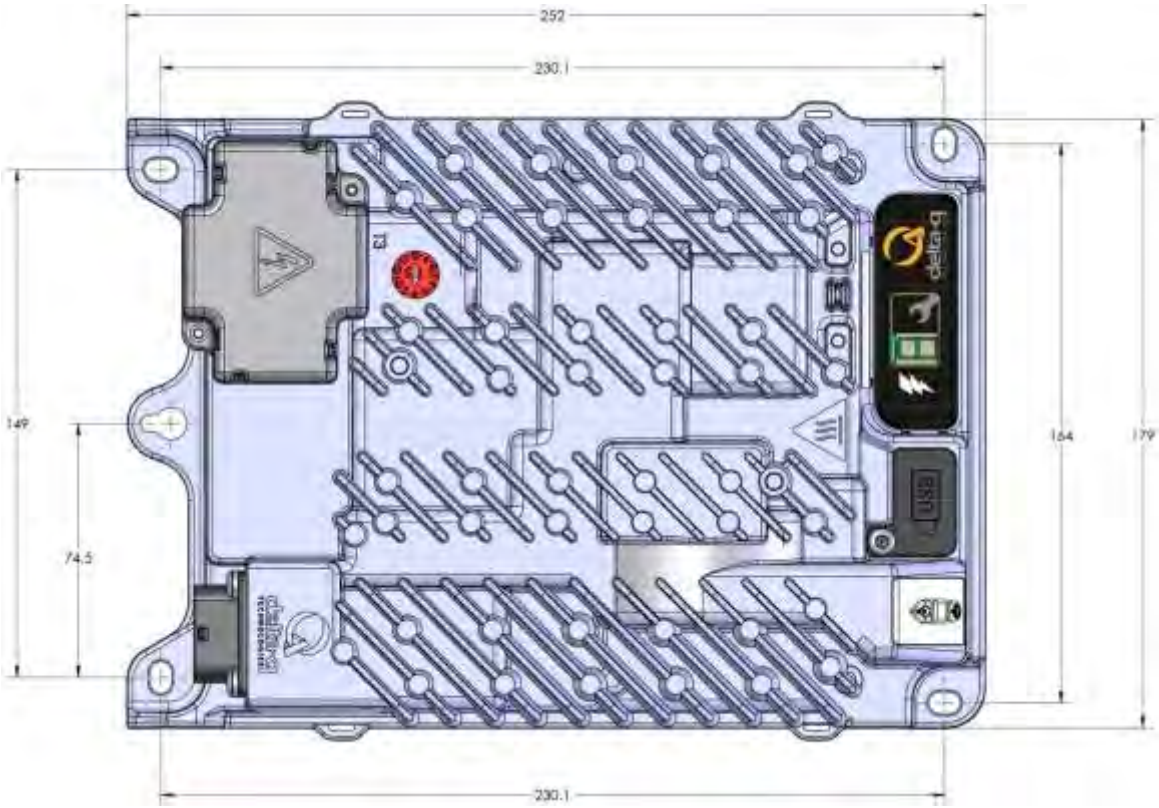


Figure 16: IC650 Charger Mounting Points

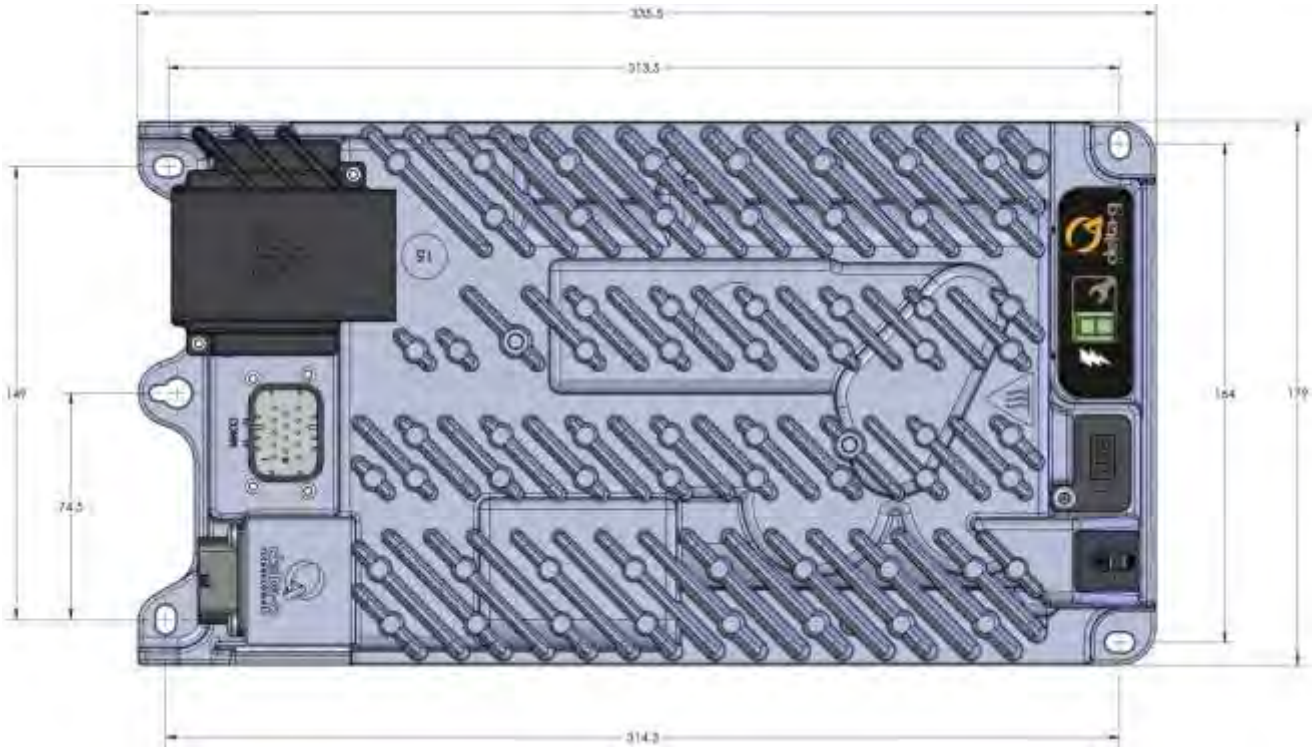


Figure 17: IC900 Charger Mounting Points

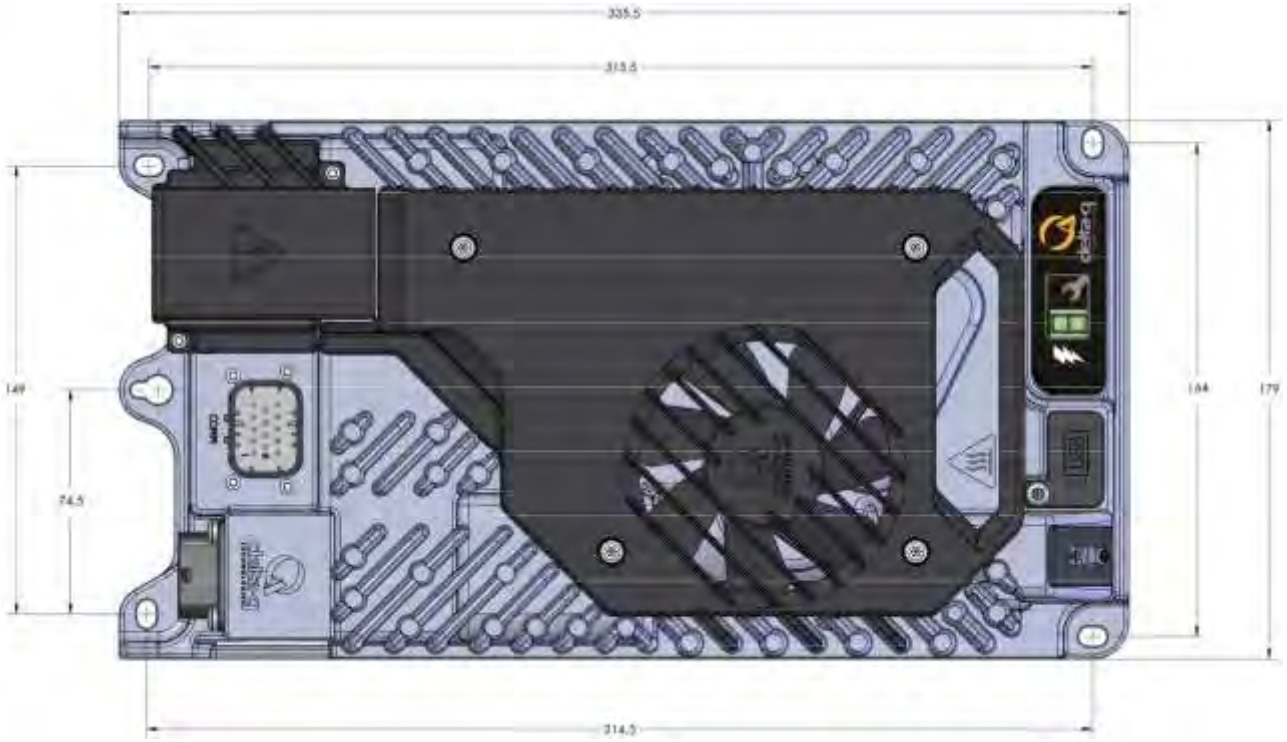
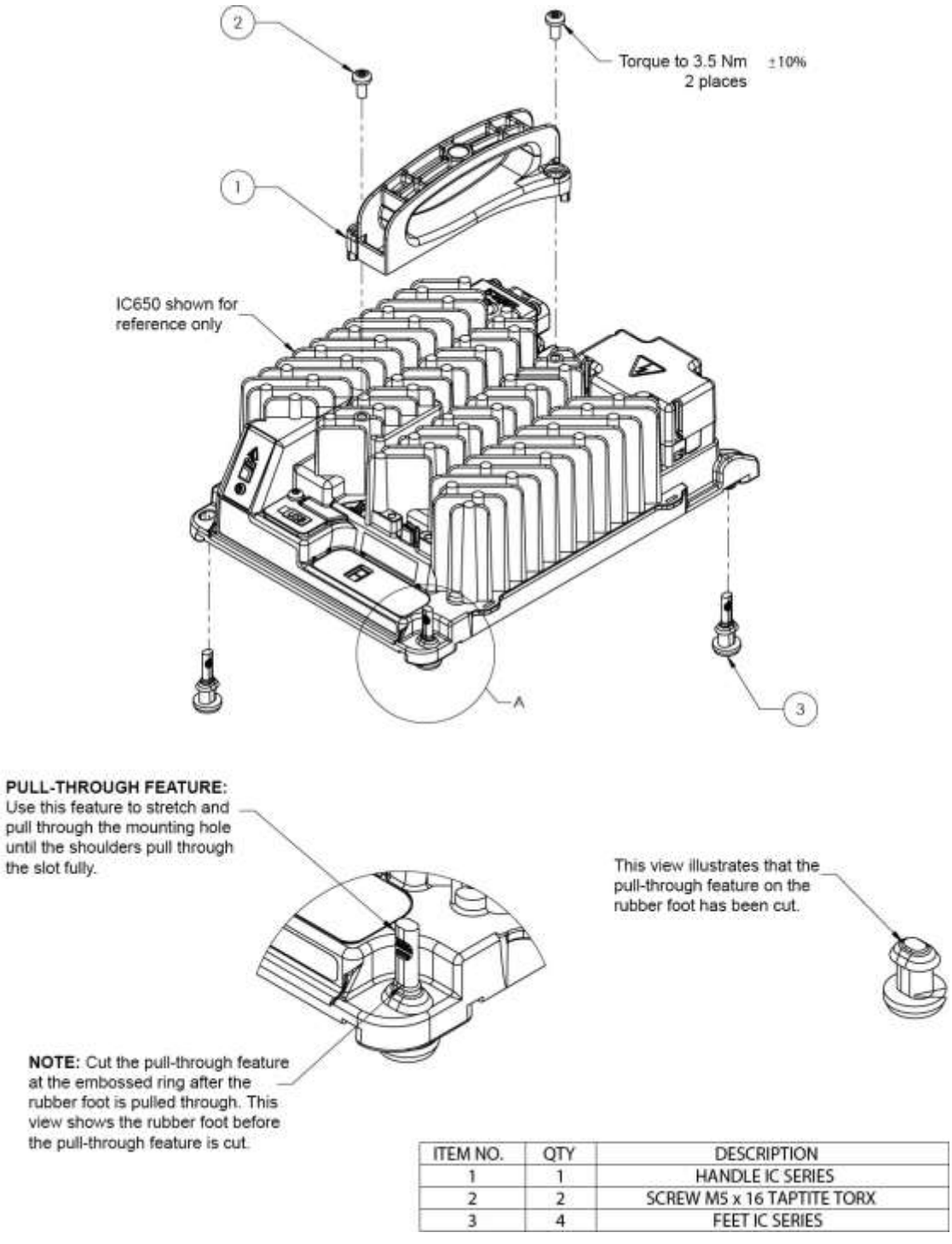


Figure 18: IC1200 Charger Mounting Points

7.4 Portable Use

The diagram below shows how to install the Kit 900-0111, which includes a handle and rubber feet for the IC650 and IC900 chargers. This kit provides portability, safe charger handling, and prevents scratches to surfaces on which the charger is placed. The IC1200 has a built-in handle on the fan case.



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

Figure 19: Charger Handle and Feet Installation

8 Electrical Installation

The charger has either two or three connectors on the rear panel depending on the model. The COMM model with all connectors is shown below. The BASE model does not have a Signals & Control Connector.

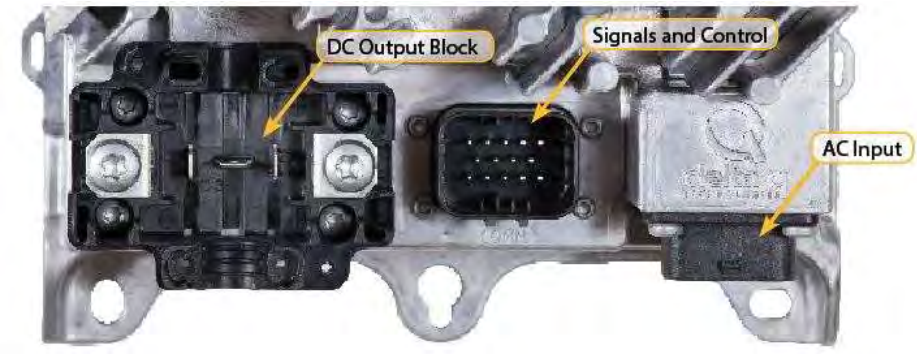


Figure 20: IC650 COMM Model Rear Panel

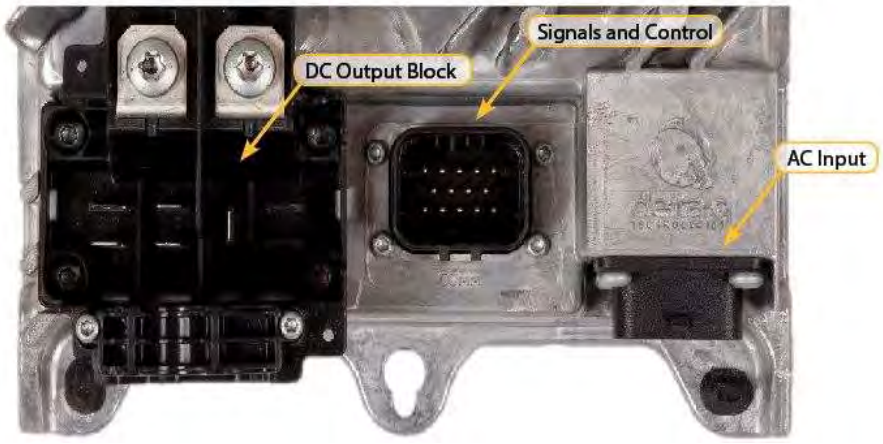


Figure 21: IC900 COMM Model Rear Panel

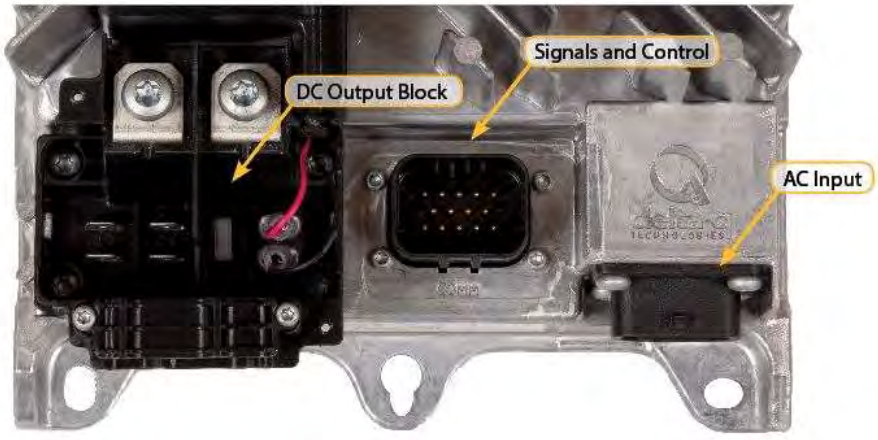


Figure 22: IC1200 COMM Model Rear Panel

8.1 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. IC Series chargers have built-in overcurrent protection on both the AC input and the DC output.

8.2 Cable Dressing

It is recommended AC, DC, and signal cables be secured especially in applications where there are high vibration and shock loads. Cables and cords used to secure cables should be rated to at least 105°C (221°F). Delta-Q Technologies offers cable clamps and sealed, locking AC cables to provide improved system robustness.

Figure 23: Example of Cable Routing on the IC650 Charger

The IC650 charger provides a channel between the heat sink fins to thread the DC Cabling through the front side of the charger and clamp the cable in place.

8.3 AC Input

8.3.1 AC Cable Requirements

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

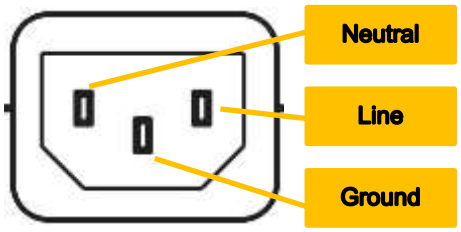


Figure 24: AC Input Connector

Table 7: AC Input Connector Pin Configuration

Pin	Wire Color 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).
Delta-Q Technologies can supply cables with most required ratings.

- In North America (and other 120V AC regions), the AC cord must be a 3-conductor UL Listed/CSA approved detachable cord set at least 1.8m in length (≥ 6 feet), minimum 16AWG and rated SJT; terminated with 3000V, 13A or greater connector.
- In Japan, the AC cord must be a 3-conductor PSE approved detachable AC cord set terminated with 100V, 15A or greater connector.
- In 220-240VAC regions, the AC cord must be 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.

8.3.2 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 cable.

Figure 25: Red Gasket

Figure 26: Locking Clips

IC 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. If a standard unsealed connector is used, 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. Also Delta-Q Technologies recommends securing the cable to the charger using cable ties. This prevents accidental disconnection.

Note: IC650 PSE/CISPR-14 models require EMI reducing beads be installed over the AC input cable. Refer to *Electromagnetic Interference (EMI)* for guidelines. Two recommended part numbers for the beads are shown in the following table. An example of installation is shown for reference in the following figure.

Table 8: Bead Part Numbers

Option	Bead Part Number	Details
1	Laird Technologies 28B0734-000	Install two beads over the AC wire, 35mm +/- 15mm from the IEC320/C14 connector. These beads are solid cores types.
2	Laird Technologies 28A2913-0A2	Install two beads over the AC wire, 35mm +/- 15mm from the IEC320/C14 connector. These beads are clamp on cores types.

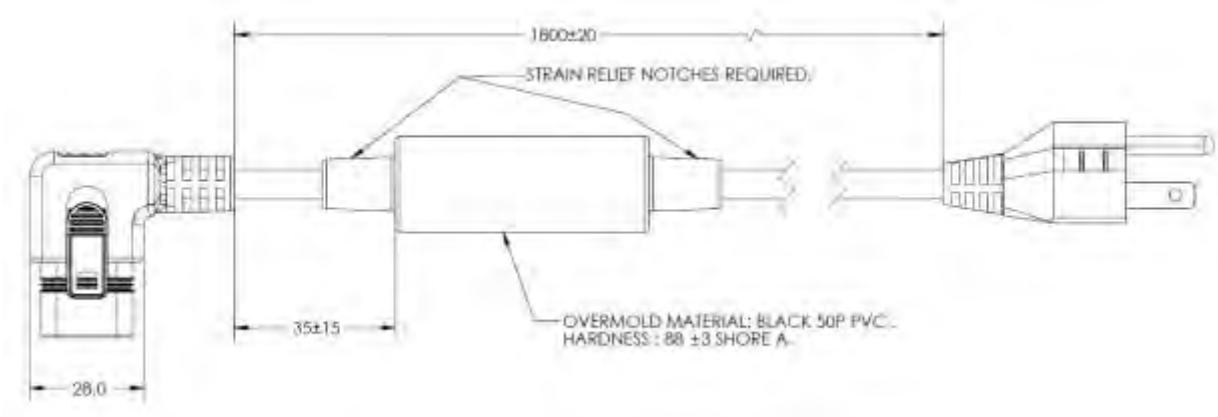


Figure 27: Installation Example of Laird 28B0734-000 on the AC Power Cable

8.3.3 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:

- 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

8.4 DC Output

Delta-Q Technologies recommends using DC output cables that are listed outdoor-rated, water, acid and oil resistant, with two 16 AWG minimum conductors, rated for DC currents, and sized appropriately for the rated output current of the charger. Such cables include type SJTW, SJOOW, or SJO. The DC cord may include additional conductors for signaling or data transmission using up to three optional data connections integral to the DC terminal block. The cables must have a minimum temperature rating of 90°C and 300V insulation rating.

8.4.1 IC650 DC Output

The DC terminal block on the IC650 charger is designed to allow a DC cable to be attached leading to the front or to the back of the charger. A DC cable clamp secures the DC cord to the terminal block using two Torx T10 screws. The DC cable clamp is designed to provide optimum compression for cable diameters in the 9 to 11mm range. A DC terminal block cover is provided to protect the user from contact with the DC terminals. After final connections are made to the terminals, the cover is snapped in place and secured with at least one screw.

Table 9: IC650 DC Recommended Torque Values

Screws	Recommended Torque Value
DC Terminal Block B+ and B- Connections	4.5Nm +/-5%.
DC Cord Cable Clamp Torx T10 Screws	0.6Nm +/-6%
DC Terminal Block Cover Screws	0.6Nm +/-6%.

The DC Output connector block also contains quick-connect tab-style terminals for a battery temperature sensor and an Interlock signal. The tabs accept FASTON™ or equivalent 1/4" single-wire female receptacles.

Figure 28: IC650 Charger DC Output Terminals

WARNING: Be careful not to allow battery voltage to be applied to the blade terminals (C1, C2, C3), as it will result in permanent damage to the charger.

Table 10: IC650 Pin Configuration

Pin	Recommended Wire Size (AWG/mm²)	Description	Notes
-	12/4.0	Battery negative	Each accepts a 1/4" or larger ring terminal Fastener: Torx T30 screw, M6 nut. Recommended Torque: 4.5Nm +/-5%
+	12/4.0	Battery positive	
C1	20/0.5	Battery temperature sense negative	Each is a 1/4" quick-connect terminal. See *Battery Temperature Sensing*.
C2	20/0.5	Battery temperature sense positive	
C3	20/0.5	Interlock Signal	1/4" quick-connect terminal; normally closed to battery positive. Open when the charger output is active. 1.5A maximum. See *C3 Signal* Interlock.

Table 11: IC650 Recommended Minimum Wire Gauge

Cable Length*	Recommended Minimum Wire Gauge for DC Connections		
	24V (AWG/mm²)	36V (AWG/ mm²)	48V (AWG/ mm²)
<2m	12/4.0	12/4.0	14/2.5
2-3m	10/6.0	10/6.0	12/4.0
3-5m	8/10.0	8/10.0	10/6.0
5-8m	6/16.0	6/16.0	8/10.0

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

8.4.2 DC Cabling Installation Instructions for the IC650 Charger

To attach DC cabling to the charger, you need the following items:

- 1 Torx T30 screwdriver
- 1 Torx T10 screwdriver
- 2 Torx T30/M6 screws (provided)
- 3 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 inserting the head of the Torx T30 screwdriver into the gap on the lower left side of the DC block fixture. Pull up on the same side of the cover.

Figure 29: Removing the DC Block Cover

2. Insert the head of the Torx T30 screwdriver into the gap on the lower right side of the DC terminal block cover and push the screwdriver in while pulling up on the cover to release the right side of the cover.

Figure 30: Releasing the Cover

3. Lift the cover and remove the bag of parts.

Figure 31: Removing the Cover

4. Remove the positive and negative battery fasteners (M6 screws).
5. Fix the DC cable in place using the supplied cable clamp.
6. Fasten with the two longer Torx T10 screws (supplied) to a recommended torque of 0.6Nm +/-6%.

7. Attach the positive and negative leads to the positive and negative terminals using the Torx T30 screwdriver and Torx T30/M6 screws, with a recommended torque of 4.5Nm +/-5%.

Figure 32: Attaching the DC Cable

8. Replace the DC terminal block cover and use the third, shorter T10 screw (supplied) to secure the cover with a recommended torque of 0.6Nm +/-6%.

8.4.3 IC900 and IC1200 DC Output

The DC terminal block is designed to allow a DC cable to be attached to the back of the charger. A DC cable clamp secures the DC cord to the terminal block using two Torx T10 screws. The DC cable clamp is designed to provide optimum compression for cable diameters from 6.5mm to 12mm. Care must be taken to prevent overtightening these screws. A DC terminal block cover is provided to protect the user from contact with the DC terminals. After final connections are made to the terminals, the cover must be secured with the provided screws.

Table 12: IC900 and IC1200 DC Recommended Torque Values

Screws	Recommended Torque Value
DC Terminal Block B+ and B- Connections	4.5Nm +/-5%.
DC Cord Cable Clamp Torx T10 Screws	0.6Nm +/-6%
DC Terminal Block Cover Screws	0.6Nm +/-6%.

The DC Output connector block also contains quick-connect tab-style terminals for a battery temperature sensor, a remote status LED and an Interlock signal. The IC1200 also has tabs for the fan power. The tabs accept FASTON™ or equivalent 1/4” single-wire female receptacles.

Figure 33: IC900 and IC1200 Charger DC Output Terminals

WARNING: Be careful not to allow battery voltage to be applied to the blade terminals (L1, L2, C1, C2, C3, F+, F-), as it will result in permanent damage to the charger.

Table 13: IC900 and IC1200 Pin Configuration

Pin	Recommended Wire Size (AWG/mm²)	Description	Notes
-	Refer to Table 14	Battery negative	Each accepts a 1/4" or larger ring terminal Fastener: Torx T30 screw, M6 nut Recommended torque: 4.5Nm +/-5%
+		Battery positive	
L1	22/0.5 (2-conductor cable)	Remote LED red anode/green cathode	Each is a 1/4" quick-connect terminal. See *Remote LED Installation*. L2 goes high with respect to L1 to light the remote LED green, and vice versa to light the remote LED red.
L2		Remote LED green anode/red cathode	
C1	18/1.0 (2-conductor cable)	Battery temperature sense negative	Each is a 1/4" quick-connect terminal. See *Battery Temperature Sensing*.
C2		Battery temperature sense positive	
C3	12/4.0	Interlock Signal	1/4" quick-connect terminal; normally closed to battery positive. Open when the charger output is active. See *C3 Signal Interlock*.
F+	N/A	Fan power/control; 0-12 VDC (IC1200 only)	1/4" quick-connect terminals
F-		Fan power/control return; 0-12 VDC (IC1200 only)	

Table 14: Maximum DC Cable Length

Maximum DC Cable Length (in meters)			AC Cable: 3m-16 AWG					AC Cable: 2m-14 AWG				
			Wire Gauge (AWG/mm²)					Wire Gauge (AWG/mm²)				
Charger	Voltage (V)	Max Current (A)	14/2.5	12/4.0	10/6.0	8/10.0	6/16.0	14/2.5	12/4.0	10/6.0	8/10.0	6/16.0
IC900	24	37.5		1.2	2.0	3.1	4.8		1.4	2.2	3.4	5.5
IC900	36	25	1.4	2.4	3.7			1.6	2.6	4.0		
IC900	48	20	1.6	2.5	4.0			1.8	2.8	5.0		
IC1200	24	50			1.3	2.0	3.2			1.5	2.4	3.7
IC1200	36	33.3		1.8	3.0	4.5			2	3.2	5	
IC1200	48	25	1.4	2.4	3.7			1.6	2.6	4.0		

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

With the IC1200/24V charger, for example, using 10 AWG (6 mm^2**)** wire, the maximum DC cable length is 1.3 meters. Longer DC cables would require higher gauge wires. The recommendation above would ensure compliance with safety and California Energy Commission (CEC) efficiency requirements.

The first half of the table provides recommendations assuming a 3 meter AC cable is being used. Using shorter AC cables (i.e., 2 meters instead of 3 meters) allows you to extend the DC cable and still meet CEC requirements. This is shown in the right side of the table.

The maximum cable length is the total length of the cable from the charger to the battery terminals. If a DC cable is terminated with ring terminals, it is assumed it would terminate on the battery posts. Therefore, this cable may be as long as the maximum values indicated in the table. However, if the DC cable has a connector at its end, we should assume it would connect to a battery harness of approximately 0.6-1 meter. As a rule of thumb, the max DC cable length with connector should be kept to the max value from the table below minus at least 0.6 meter.

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.

Note: The DC connectors and termination used must be rated for the maximum current of the charger used.

8.4.4 IC900/IC1200 DC Terminal Blocks

To switch between the cable clamp configurations, unscrew the screws on either side of the cable clamp and rotate it 180°.

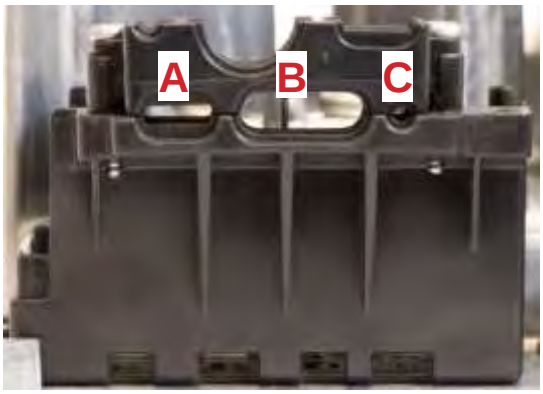


Figure 34: Cable Clamp Configuration 1
Recommended for Use with a Multi-Conductor Cable

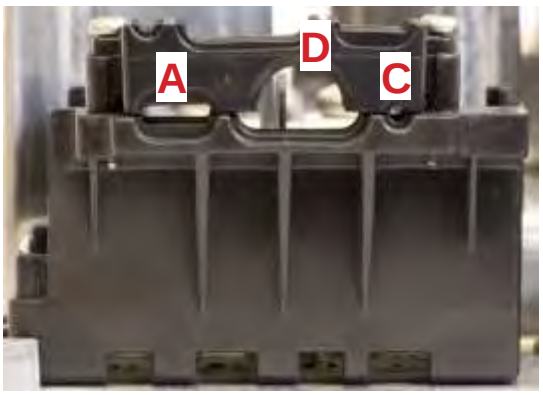


Figure 35: Cable Clamp Configuration 2
Recommended for Use with a Sleeved Battery Cable

Table 15: Terminal Block Mechanical References

Reference	Description	Minimum Outside Diameter	Maximum Outside Diameter	Minimum/Maximum AWG
A	Remote LED and/or temperature sensor	3.2 mm	5.2 mm	2 Conductor, 18-22 AWG (0.34-1.0 $mm^{2)}$
B	Battery cable 2x single conductor	6.5 mm	8.5 mm	6-8 AWG (10 -16 $mm^{2)}$
C	Interlock wire	2.0 mm	3.5 mm	12-18 AWG (1- 4 $mm^{2)}$
D	Multi-conductor cable (battery +/-, temp sensor, interlock)	10.0 mm	12.0 mm	Depends on cord (accepts 4 conductor -12 AWG, and 2 conductor -10 AWG cord)

** Consult Delta-Q Technologies for wire sizes that fall outside of this range.*

8.4.5 DC Cabling Installation Instructions for the IC900 and IC1200 Chargers

To attach DC cabling to the IC900 and IC1200 chargers, you need the following items:

- 1 Torx T30 screwdriver
- 1 Torx T10 screwdriver
- 2 Torx T30/M6 screws (provided)
- 2 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 36: Removing the DC Block Cover

2. Remove the positive and negative battery fasteners (M6 screws). Attach the ring terminals of the wires to the terminals of the charger and secure with the T30/M6 screws to a recommended torque of 4.5Nm +/-5%.
3. Secure the DC 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 37: Secure DC Wires

Figure 38: Using the Cable Clamp

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

Note: Replacement instructions for the IC1200 charger fan are provided in *Fan Replacement Instructions*.

8.5 Signals & Control Connector

This is only present on COMM models. It uses 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.

Table 16: TE Part Numbers

Description	TE Part Number	Delta-Q Part Number
Charger Header (for reference only, not user-replaceable)	776262-1	410-0352
Cable Plug (body only)	776273-1	410-0386
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 are suggestions, as used on various *all wires* cables available from Delta-Q Technologies (e.g., PN 475-0358).

Table 17: Wire Colours & Signals

Wire Color	Pin	Description	Detail
White/Black	1	CAN GND	Isolated reference ground for CAN signals. See *CAN Communications.*
Blue	2	Interlock-NC	Dry Contact Interlock relay: Normally closed contact. See ***Remote** LED Installation*.
Purple	3	Interlock-Common	Dry Contact Interlock relay: Common contact. See ***Remote** LED Installation*.
Pink	4	Interlock-NO	Dry Contact Interlock relay: Normally open contact. See ***Remote** LED Installation*.
White/Red	5	Battery temperature sense +ve	See *Battery Temperature Sensing.*
Orange	6	CAN High	Isolated CAN high signal. See *CAN Communications*.
Black ①	7	Signal Ground	Do not connect to Battery Negative.
Brown	8	For future use	Can be configured to meet various customer requirements. Contact Delta-Q Technologies for more information.
Yellow	9	IC650: unused IC900/IC1200: APO	IC650: Pin is unused IC900/IC1200: Accessory Power Output (+5VDC, 250 mA max); not isolated from the DC Output voltage domain.
White/Orange	10	CAN Low	Isolated CAN Low. See *CAN Communications*.
Grey	11	Factory port	Factory use only
Green	12	Remote LED Green +ve	For Remote LED. Pin 12 goes high with respect to Pin 13 to light the Remote LED green, and vice versa to light the Remote LED red.
Red	13	Remote LED Red +ve	
White	14	Battery temperature sense -ve	See *Battery Temperature Sensing.*

Note: Pin 7 is the Ground reference for Pins 8, 9, and 11; also for Pins 12 and 13 in some Remote LED installations. It is electrically connected, via a low-impedance resistor/inductor circuit, to the Battery Negative terminal on the DC block.

NEVER connect Pin 7 directly to the Negative terminal of the battery, nor to the Negative terminal in the DC block.

8.5.1 Signals & Control Connector Pin Configurations

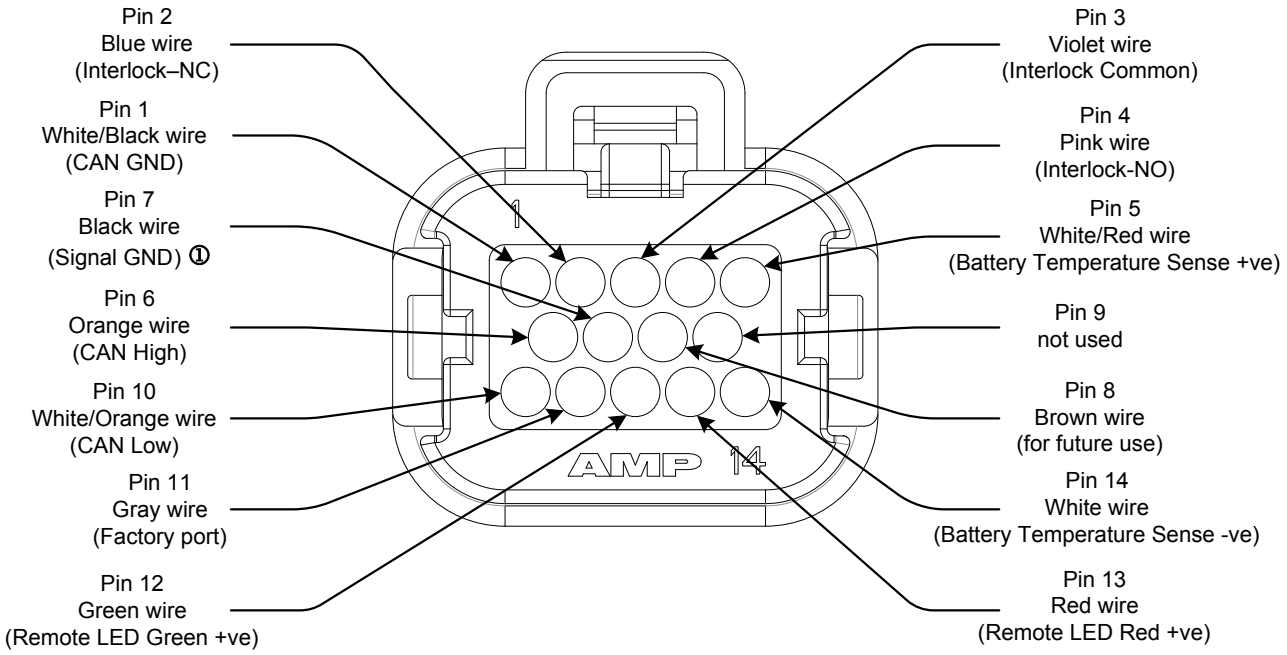


Figure 39: IC650 Signals & Control Connector: Pin Signal Reference

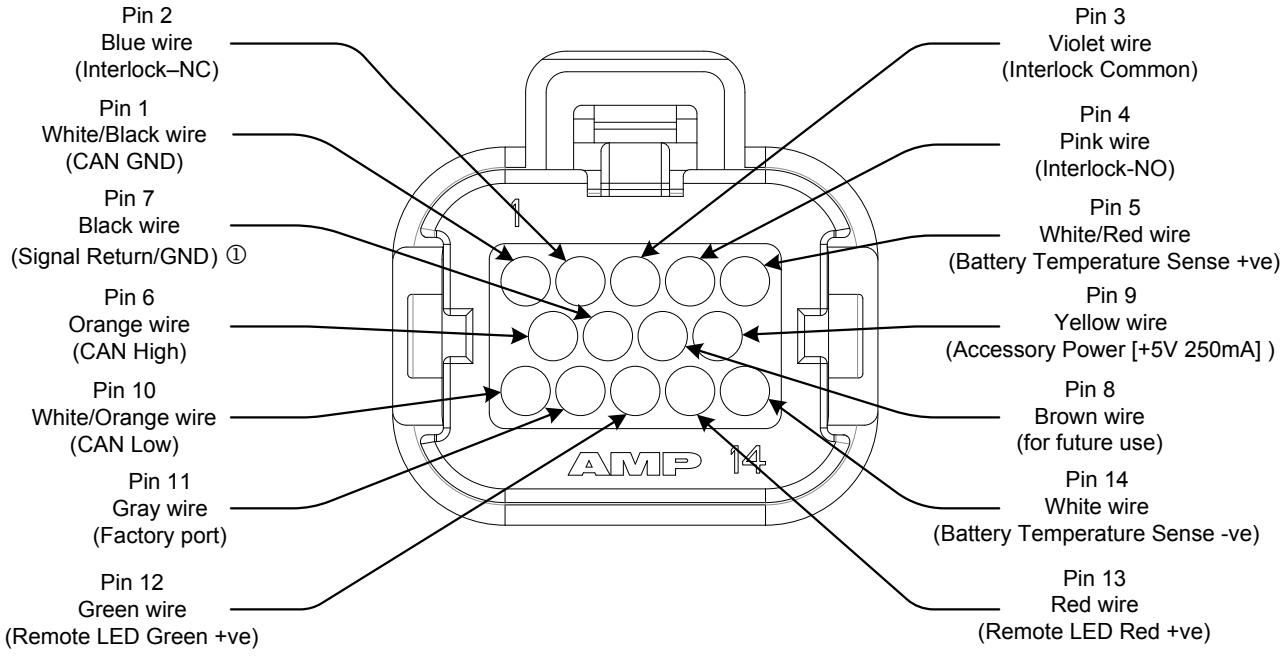


Figure 40: IC900/IC1200 Signals & Control Connector: Pin Signal Reference

8.5.2 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 outer edge 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.

Note: EMI reducing beads may be required to be installed over all of the wires connected to the Signals & Control Connector. Refer to *Electromagnetic Interference (EMI)* for guidelines. The required part numbers are shown in the following table and the installation of the bead is shown in the following figure.

Table 18: Bead Part Numbers

Model	Bead Part Number	Detail
IC650	Laird Technologies 28B1020-100	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, if desired.
IC900/IC1200	Laird Technologies 28B1020-100	Install two beads 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, if desired.

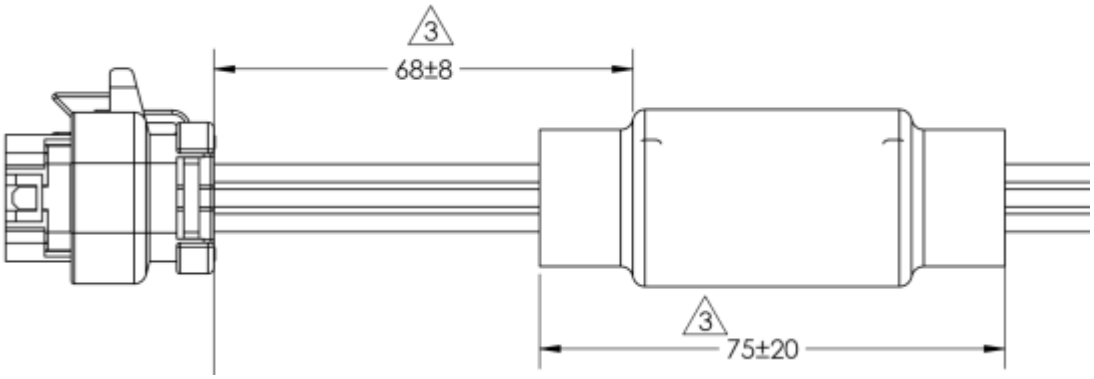


Figure 44: Installing a Ferrite Bead on the Wires from the Signals & Control Connector

8.6 Remote LED Installation

IC Series COMM model chargers allow connecting an optional remote LED to the Signals & Control Connector. Alternately, all IC900/IC1200 chargers permit connecting a remote LED directly on terminals L1 and L2 of the DC Output Block.

8.6.1 Remote LED Indicator for COMM Models

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 IC Series Signal cable which does not have any remote LED wiring (i.e., no wires in Pins 12 and 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 IC Series Signal cable, follow the steps in item 1 above, using a new AMPSEAL plug.

Figure 45: Remote LED Indicator for IC Series COMM Model 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 16). For the LED, use the parts suggested in Table 19, or similar.

Table 19: Recommended Parts for Custom Remote LED Cables

Part Type	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, as desired.
LED Holders/Bezels	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

8.6.2 Remote LED Installation on the DC Output Block (IC900/IC1200 only)

The remote LED cable recommended for the IC900/IC1200 charger's DC Output Block is Delta-Q Technologies Part Number 900-0138. This option enables connection to a remote LED without using the Signals & Control Connector. Connect the black wire (red anode/green cathode) to L1 and the white wire (green anode/red anode) to L2.

Figure 46: Remote LED Indicator for IC900/1200 Charger DC Output Block

8.7 Interlock Options

The Interlock function is provided as a means to prevent the equipment or vehicle from moving when it is plugged in. There are two interlock options available on the IC Series chargers:

1. The **C3 Signal Interlock** in the DC Output connector block: Battery positive is connected to the C3 terminal when the charger is not plugged into AC. This is typically used as a signal, or supply voltage, which enables the equipment/vehicle to operate.
2. The **Dry Contact Interlock** pins in the Signals Connector on COMM models: These are the contacts of a relay which is energized when the charger is plugged into AC; the contacts are isolated from all other circuits in the charger.

If you wish to use the interlock signal to wake-up a Battery Management System (BMS), contact Delta-Q Technologies to ensure compatibility with your system.

8.7.1 C3 Signal Interlock

IC Series chargers are supplied with one quick-connect terminal in the DC terminal block, marked C3, which is internally connected to battery positive when the charger is not plugged into AC.

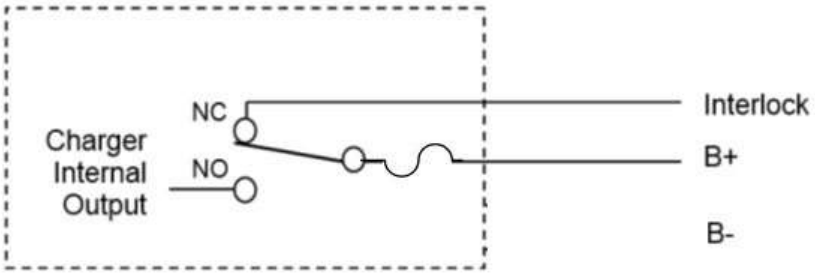


Figure 47: Simplified Internal Diagram of the Charger's Interlock Output

This interlock can be used to inhibit the equipment either by connecting it directly to the appropriate signal on a motor controller, or to an external relay. This Interlock option may not operate correctly to inhibit the equipment if the charger is in a fault state or if the charger does not sense battery voltage.

CAUTION: Avoid shorting the interlock connection to battery negative. Doing so will damage the charger.

IMPORTANT: Install a suitably-rated inline fuse to avoid damage to internal circuitry.

Table 20: IC650 C3 Signal Interlock Current Range

	Maximum Current	Minimum Current
24 V	1.5 A	0.1 A
36 V	1.5 A	1.0 A
48 V	1.5 A	1.0 A

Table 21: IC900/IC1200 C3 Signal Interlock Current Range

	Maximum Current	Minimum Current
24 V	10.0 A	0.1 A
36 V	2.0 A	0.1 A
48 V	0.5 A	0.1 A

8.7.2 Dry Contact Interlock

The optional Dry Contact Interlock connections are connected to the floating contacts of a relay. The term *dry* means there is no power on any of these contacts. The relay is typically closed (relay wiper and relay Normally Open are connected, Normally Closed is disconnected) when there is AC Voltage connected to the charger. Most models of the IC Series chargers that have the Signals & Control Connector have this option.

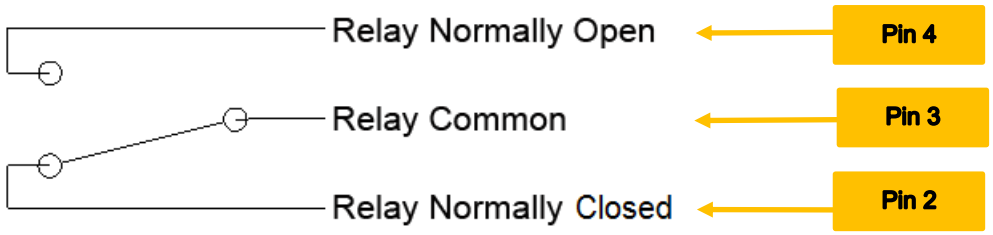


Figure 48: Internal Schematic of Interlock Relay Contacts

A suitable fast blow fuse sized to match the switching capacity 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.

The maximum current is 1A at 30V and 0.5A at 100V. The minimum current is 1 mA. Once this interlock has been used to conduct a current over 100mA, it can no longer be relied upon to conduct currents under 100mA.

8.7.3 Interlock Connection Recommendations

This section provides details on the various interlock connections.

8.7.3.1 Inductive Kickback on Interlock Connections

Inductive spikes or kickbacks occur if the load is inductive, such as a relay or motor. This kickback will damage the Interlock connection(s) in the IC Series chargers. Therefore, some means is required to prevent kickback. A free-wheeling diode, MOV, or TVS will all work. Contact Delta-Q Technologies for more information about preventing inductive kickback from damaging the charger.

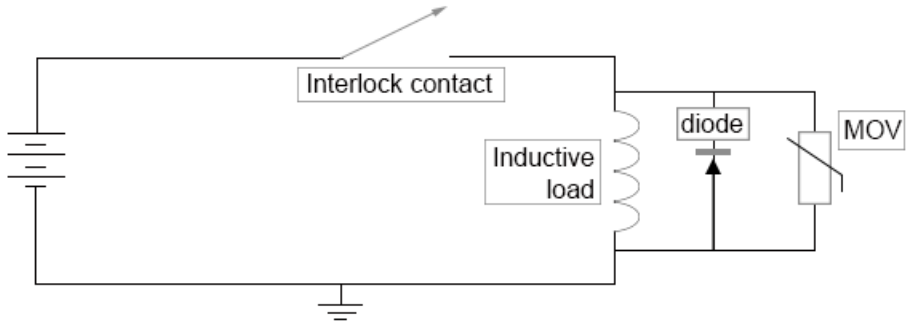


Figure 49: Interlock Contacts Protected from Inductive Load with a Diode or an MOV

8.7.3.2 Surge Loads on Interlock Connections

Many loads (e.g., motors, light bulbs, and electronic equipment) often have an inrush or surge when connected to power. Relays can easily be damaged by this surge. Symptoms of surge damage can be 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 to select this resistor.

8.7.3.3 Interlock Minimum Current Requirements

If the minimum current specification is not met every time the relay contacts close, the relay contacts may become intermittent or faulty over time. Because this problem usually develops over months or years, testing the application is not sufficient to ensure satisfactory operation if the current is less than the required minimum.

If the load does not meet the minimum current requirements, a momentary surge load may be created with the following circuit. This circuit is typically needed for the C3 Signal Interlock and for the Dry Contact Interlock if the current is less than 100mA for part of the time.

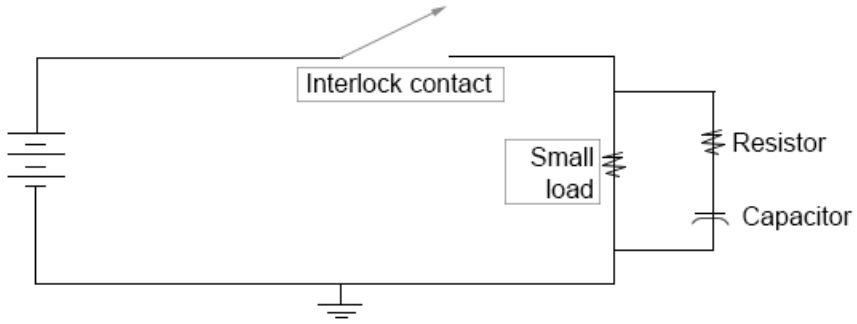


Figure 50: Resistor and Capacitor Meet Minimum Load Requirements for Interlock Contacts

Table 22: Resistor and Capacitor Values for Minimum Current

	Minimum Current	Resistor*	Capacitor**
24 V	1 A	15 Ω	100 μF
36 V	1 A	22 Ω	100 μF
48 V	1 A	30 Ω	47 μF

* The resistor must have a surge rating sufficient for the application.
** The capacitor must have a voltage rating appropriate for the maximum expected voltage.

8.8 Battery Temperature Sensing

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 with a suitable algorithm that can compensate for the changing temperature. Contact Delta-Q Technologies for help choosing an appropriate algorithm.

There are two options for connecting a battery temperature sensor to the IC Series chargers. The sensor can be connected to the C1 and C2 connections in the DC terminal block OR the sensor can be connected to Pin 5 and Pin 14 of the Signals & Control Connector. The temperature sensing end of the standard Delta-Q Technologies battery temperature sensor is an electrically-insulated ring terminal that can be attached to any battery terminal.

Figure 51: Battery Temperature Sensor

Typically, the batteries at the center of the battery pack will be hotter, and thus the sensor is best connected to these batteries. Some, but not all, Delta-Q Technologies charging algorithms use temperature compensation.

8.8.1 Hardware

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

- Part 900-0059: Isolated Temp Sensor 140mm Bare Wires
- Part 900-0028: Isolated Temp Sensor 200mm Bare Wires (250pcs)
- Part 900-0060: Isolated Temp Sensor 1.2m Bare Wires
- Part 900-0056: Isolated Temp Sensor 3m Shielded Bare Wires
- Part 900-0064: Isolated Temp Sensor 140mm Fast-on Tab/Plug

Other part numbers may also be available. For more information, please contact Delta-Q Technologies.

Note: Do not connect the negative lead of any temperature sensor to the battery negative terminal in the DC Output Block.

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

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

8.9 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 IC Series chargers are available to meet many of the different regulations throughout the world. Contact Delta-Q Technologies to discuss your specific requirements.

The specific EMC regulations that apply to a standalone battery charger must usually be met by equipment in which the battery charger is installed. Unfortunately, a piece of equipment may not meet these regulations even though it contains components (e.g., a battery charger, a motor controller, electronic controller, LED lights, etc.) that each separately meet the requirements. This can be especially true if there are many components operating at the same time.

In general, the characteristics of an installation can amplify, focus, or channel electromagnetic waves in unpredictable ways leading to unexpected results. Delta-Q Technologies has found that by observing the following guidelines, electromagnetic emissions can be reduced.

- 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 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 IC Series chargers are tested for worst case radiated emissions by using a fully populated 14-wires on signal 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 few wires are used on the Signal and Control Connector, or where the signal wires are shielded or partially shielded by the application's housing/chassis.

9 CAN Communications

The versions of the IC Series chargers, with the Signals & Control Connector, support advanced functions accessible via the Controller Area Network (CAN) interface using CANOpen protocol. For more information, contact Delta-Q Technologies for the most recent version of the IC Series CANopen Interface Specification (Document Number 710-0148).

9.1 CAN Version

IC Series chargers are compliant with the CAN in Automation (CiA) 301, 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 later in this document.

Table 23: CAN Configuration

Item	Configuration/Specification
Charger Role	Slave of the master/slave model
CAN Termination	Permanent 120 ohm
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	60A (rx) and 58A (tx); Use Dynamic SDO is FALSE
PDO COB-ID	Always requested from the battery module via SDO (may be configured at Delta-Q Technologies factory)

9.1.1 Recommended Timeouts

The charger is configured with a 2-second heartbeat consumer timeout and 1-second heartbeat producer period.

Table 24: Recommended Timeouts

Parameter	Timeout Value	Notes
Boot-up	5000 ms	
NMT	2000 ms	
SDO	2000 ms	2000 ms functions correctly
PDO Cycle Time	- ms	Specified by the system designer with respect to how long before they detect the charger has stopped communicating. The minimum time depends on the actual PDO message as they have different rates. A suggested value would be five times the message transmit rate.
Objects 1010h/1011h	2000 ms	
SYNC Cycle Time	N/A	Charger does not support SYNC function
Charger Monitoring Heartbeat Timeout	2000 ms	Charger produces HB messages every 1000 ms

9.1.2 Default PDO and SDO COB-IDs

This table shows the default 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 25: Default PDO and SDO COB-IDs

PDO/SDO	Object Index	Object Sub-Index	Base COB-ID	Charger w/Node ID COB-ID	Battery Module w/Node ID COB- ID
Server SDO: Client>Server	1200h	1	600h	60Ah	601h
Server SDO: Server>Client	1200h	2	580h	58Ah	581h
Client SDO: Client>Server	1280h	1	580h	58Ah	581h
Client SDO: Server>Client	1280h	2	600h	68Ah	681h
RPDO 0	1400h	1	200h	20Ah	201h
RPDO 1	1401h	1	300h	30Ah	301h
RPDO 2	1402h	1	400h	40Ah	401h
RPDO 3	1403h	1	500h	50Ah	501h
TPDO 0	1800h	1	180h	18Ah	181h
TPDO 1	1801h	1	280h	28Ah	281h
TPDO 2	1802h	1	380h	38Ah	381h
TPDO 3	1803h	1	480h	48Ah	481h
TPDO 4	1804h	1	481h	48Ah	482h

10 Charger Algorithms and Configuration

The IC Series chargers can be configured to work in an application in different ways.

- The charge algorithm can be changed with the **Select Charge Profile** button.
- The chargers can be configured by plugging in a USB Flash Drive containing configuration files.
- The chargers can be ordered with a customer specific configuration
- The chargers can be configured using CAN

10.1 Using the Select Charge Profile Button

Nearly every model of battery has different charging requirements. For Delta-Q 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 IC Series chargers come with a default set of pre-loaded standard charge algorithms. Up to 25 selectable charging profiles may be stored on the IC Series chargers. It is also possible to load different algorithms, via a USB flash drive. Regardless of which and/or how many algorithms are installed, selecting the algorithm to be used can be done by following the steps outlined below.

Note: The procedure will time out and the algorithm will remain unchanged if any of the following occur:

- There are 15 seconds of inactivity.
- An algorithm number is allowed to display three times.
- AC power is disconnected and re-connected.

10.1.1 The Procedure

1. Disconnect AC and the battery from the charger. Wait 30 seconds.

Figure 52: Disconnecting AC Input

2. Press and hold the **Select Charge Profile** button.

3. Reconnect the AC while continuing to hold **Select Charge Profile** button.

Figure 53: Reconnect the AC While Holding the Select Charge Profile Button

4. Continue to hold the **Select Charge Profile** button until the Error Indicator illuminates amber and the Battery Charging Indicator is flashing green (wait maximum 22 seconds).
5. Release the **Select Charge Profile** button.
6. Momentarily press and release the **Select Charge Profile** button to advance through the charging algorithms. The selected charging profile will be displayed up to three times (e.g., P-0-1-1 for Profile 11).

Figure 54: Press the Select Charge Profile Button to Advance Through the Charge Algorithms

7. Once the desired charging algorithm is displayed, press and hold the **Select Charge Profile** until the Error Indicator turns off, the Battery Charging Indicator turns off, and the AC Power Indicator remains lit (approximately 10 seconds) to confirm the selection and to return to normal operation.
8. Momentarily press the **Select Charge Profile** button to check the desired algorithm is selected.

10.2 Using a USB Flash Drive

It is possible to use a USB flash drive to install new charge algorithms, to select a different algorithm, to update the charger's software, and to modify many additional settings to customize the charger for nearly any application. If there is enough disk space (~ 2 MB), the charger normally writes charge tracking data to the USB flash drive after all other changes/updates are completed.

1. Contact Delta-Q Technologies to obtain the required algorithm/software/settings configuration file(s) for your batteries & charger model.
2. Copy the provided file(s) to a blank USB 2.0 flash drive, formatted as FAT16 or FAT32, according to the instructions received with the file(s).
3. Insert the USB flash drive in the USB connector on the charger when the charger is connected to the battery and/or AC (but preferably not while the battery is charging).
4. The Fault/Error/USB Indicator flashes green during reading and writing.
5. If the drive contains compatible configuration files, the charger load thems.
6. The charger may briefly reset, one or more times. During these resets, the display may be off for multiple seconds at a time.
7. Remove the drive when the Fault/Error/USB indicator lights a steady green for at least 10 seconds.

Figure 55: Inserting the USB Flash Drive

Troubleshooting

- If the alarm indicator flashes amber, note the error code and retry the update.
- Check the charger either has AC power and/or a charged battery is connected. If both AC and a battery are connected, the charger may attempt to start charging during the upgrade process.
- Connect AC to the charger if USB operation does not automatically start when connected to the batteries.

10.2.1 Confirming a Software Update

After using a USB flash drive to update the charger firmware, the update can be confirmed by pressing **Select Charge Profile** button for 5 seconds. If successful it should show the software version, checksum, algorithm, and algorithm version as in the example below:

```
S 4. 3. 3 C a b 1 2 P 0 1 1 r 1. 3 2
```

Where:

```
SW: v4.3.3

Checksum: ab12

Algorithm: 11 v1.32
```

Alternatively, the IC Series Data Analysis Tool, available from Delta-Q Technologies, can be used to identify which software and charging algorithms were used for each charge cycle that has been performed.

Software versions 4.3.3, and later, can display the software version on the display panel. See *Charger Interface* for details.

10.2.2 Ordering a Custom Configuration

Please contact Delta-Q Technologies Applications Engineering team to discuss your requirements.

11 Charger Data Logging

All IC Series chargers record data, such as Amp-Hours returned, the success of a charge cycle, and the charge algorithm used. This data can be very useful in vehicle or machine diagnostics. It can be viewed using the IC Series Data Analysis Tool, available by contacting Delta-Q Technologies. To retrieve this data, follow these steps:

1. If neither a battery nor AC power is connected to the charger, connect AC power.
2. Insert a USB 2.0 flash drive (formatted as FAT16 or FAT32) with at least two megabytes of free space into the charger's USB connector.
3. The Fault/Error/USB Indicator will flash green while the charger writes the data to the USB flash drive. This may continue for many minutes, depending on how much data is stored in the charger, and the speed of the USB drive.
4. After the data is written to the USB flash drive, the Fault/Error/USB Indicator stops flashing and starts indicating solid green.
5. Remove the USB flash drive from the charger.

If you plan to download data from a large number of chargers, having more free space on your USB flash drive is recommended. If you want to update the software on only some of your chargers, it is recommended you use separate USB flash drives for updating and downloading the data.

12 Troubleshooting

The IC Series charger is continuously monitoring itself and its environment for unusual conditions. There are a few indications that may require the user's attention.

Table 26: Symptoms

Symptom	Recommended Action
No indicator lights	Check AC voltage and connection to wall power
Only blue AC light on	Charger is connected to AC and is waiting for a battery to be connected, or for CAN remote control commands. Battery voltage must rise over 0.1V/cell before charging will begin. Some charging algorithms require a higher battery voltage to begin.
Solid red Fault/Error/USB Indicator	Read fault code (e.g., F-0-0-1) number on the Charge Algorithm/Error Display and refer to the fault code table.
Flashing amber Fault/Error/USB Indicator	Read error code (e.g., E-0-0-1) number on the Charge Algorithm/Error Display and refer to the error code table.

12.1 Charger Fault Codes

This table describes each fault code and recommended customer actions.

Table 27: Fault Codes

Fault Code	Description	Troubleshooting/Customer Actions
F-0-0-1	DC-DC Failure: LLC excessive leakage fault	Internal charger fault. Disconnect AC and battery from charger for a minimum of 30 seconds. If it fails again, contact the manufacturer of your equipment or Delta-Q Technologies.
F-0-0-2	Power Factor Correction (PFC) Failure: PFC excessive leakage fault	
F-0-0-3	PFC has taken too long to boost	
F-0-0-4	The charger has been unable to calibrate the current offset.	
F-0-0-5	The voltage drop across the DC relay is too high while the relay is closed.	
F-0-0-6	Large difference between internal DC-DC and battery sense currents	

12.2 Charger Error Codes

This table describes each error code and recommended customer actions.

Table 28: Error Codes

Error Code	Description	Solution
E-0-0-1	Battery voltage over limit in software. Typically 2.5V/cell. At the start of a charger cycle only and only for lead acid batteries. It is acceptable for the voltage to go above this during charging and when charging Lithium batteries.	• Check the battery voltage and cable connections. • Check charger voltage model is appropriate for batteries. • This error automatically clears once the condition has been corrected.
E-0-0-2	Battery voltage too low to start a charge cycle. Algorithm dependent. Typically 0.1V/cell.	• Check the battery voltage and cable connections. • Check the charger is the correct voltage for the batteries it is connected to. • Check battery size and condition. Batteries may be over-discharged. Use another charger to bring the batteries above the minimum voltage. • This error automatically clears once the condition has been corrected.
E-0-0-3	Charge time limit reached. Algorithm dependent.	• Charger output reduced due to high temperatures. Operate at lower ambient temperature. • Charger output reduced due to low AC voltages. Check AC voltage. • Check for shorted or damaged cells. • Poor battery health. Replace the battery. • Batteries too large for the charger. Replace batteries. • Very deeply discharged battery. Retry charge. • Battery connections are loose or corroded. Check connections. • Extra loads. Turn off other devices running on the battery • This error automatically clears once the charger is reset by cycling DC or by loss of AC for over 10 minutes.
E-0-0-4	Battery could not be trickle charged up to the minimum voltage. May also be used for other battery-related errors depending on the algorithm.	• Check for shorted or damaged cells. • Poor battery health. Replace the battery. • Check DC connections. • May be caused because of output reduced due to high temperature. • Some new batteries may trigger these alarms as there voltage dips when charging starts before it goes onto rise.

Error Code	Description	Solution
E-0-0-7	Charge amp-hour Limit reached. Algorithm dependent.	• Charger output reduced due to high temperatures. Operate at lower ambient temperature • Charger output reduced due to low AC voltages. Check AC voltage. • Check for shorted or damaged cells. • Poor battery health. Replace the battery. • Very deeply discharged battery. Retry charge. • Battery connections are loose or corroded. Check connections. • Extra loads. Turn off other devices running on the battery • This error automatically clears once the charger is reset by cycling DC or by loss of AC for over 10 minutes.
E-0-0-8	Battery temperature out of range. Algorithm dependent.	• Cool or warm batteries as needed. • Check temperature sensor and connections. • This error automatically clears once the condition has been corrected.
E-0-1-1	Charge disabled by external command	• Charger has been disabled by an external controller over the CANbus network. • This error automatically clears once the command has been removed.
E-0-1-2	Reverse polarity	• Battery is connected the wrong way around. Check the battery connections. • This error automatically clears once the condition has been corrected.
E-0-1-3	Battery does not take current	• Check for an electrical component or loose connection between the charger and the battery. • When charging lithium batteries, ensure the charger is properly connected to the battery and battery management system. • This error automatically clears once the charger is disconnecting DC or AC.
E-0-1-6 **E-0-1-8**	Software upgrade failed	• Ensure the USB flash drive is properly formatted and not corrupted. • Ensure the USB flash drive does not draw excessive current. • Copy the install files to the USB flash drive again. • Retry the update by reinserting the USB flash drive in the charger. • If software updates continue to fail, contact Delta-Q Technologies.

Error Code	Description	Solution
E-0-1-7	USB mount/unmount error	• Remove and reinsert the USB drive. • Ensure the USB flash drive is properly formatted and is not corrupted. • Ensure the USB flash drive does not draw excessive current. • If the condition persists, disconnect AC and battery for a minimum of 30 seconds and retry. • If the problem persists, contact Delta-Q Technologies.
E-0-1-9	Hardware build does not support software version	• The charger hardware does not support the new software version. • Existing SW is left running. Contact Delta-Q Technologies.
E-0-2-0	No active algorithm selected	• Reprogram the charger with its original software, algorithms, and settings. • Use the wrench button to select the correct algorithm if still available on the charger. • The problem clears automatically when an available algorithm is set on the charger, as default.
E-0-2-1	High battery voltage while charging. Algorithm dependent. Typically 2.8V/cell.	• When already charged, some new batteries may exhibit this error. Disconnect the battery connection and wait for the battery voltage to fall. Reconnect the batteries to see if the condition reoccurs. • Check battery size and condition. Batteries in poor condition, with a high internal resistance, may cause this error. New batteries, if charged when already full, may also cause this error. Disconnect and reconnect the batteries a few times. • Check the battery voltage and cable connections. • This error automatically clears once the condition has been corrected.
E-0-2-2	Low battery voltage while charging. Algorithm dependent. Typically 0.1V/cell.	• Another device may be drawing current from the battery. • Check the battery voltage and cable connections. • Check battery size and condition. Batteries may be over-discharged. Use another charger to bring the batteries above the minimum voltage. • This error automatically clears once the condition has been corrected.
E-0-2-3	High AC voltage error (>270 VAC)	• AC voltage is too high. Connect charger to an AC source that has a stable AC voltage between 85 and 270 VAC/45-65 Hz. • In newer software versions this does not prevent charging. • This error will automatically clear once the condition has been corrected.
E-0-2-4	Charger failed to turn on properly	• Disconnect AC input and battery for 30 seconds. If the error persists, contact Delta-Q Technologies.

Error Code	Description	Solution
E-0-2-5	AC voltage has dipped below 80 VAC 3 times in 30 seconds	• AC source is unstable. This could be caused by an undersized generator and/or input cables that are too long or too small. • Connect the charger to an AC source with a stable AC voltage between 85 and 270 VAC/45-65 Hz. • This error will automatically clear once the condition has been corrected.
E-0-2-6	One or more USB script commands failed	• Ensure the USB flash drive is properly formatted. • Ensure the right update package is being used. • Delete all files on the USB flash drive and copy the configuration files to the USB flash drive again. • Retry the update by removing and reinserting the USB flash drive in the charger. • If software updates continue to fail, contact Delta-Q Technologies.
E-0-2-7	USB overcurrent fault	• USB hardware overcurrent protection has been tripped. Remove and reinsert USB flash drive. If condition persists, try using a different USB flash drive.
E-0-2-8	Attempt to select algorithm incompatible with this software	• Update charger software, continue to use existing algorithm***** or select a different charging algorithm that is compatible. * **Notes** • If selecting a different algorithm, the existing algorithm will remain in the charger. • If upgrading an existing algorithm, the existing algorithm will be deleted. Contact Delta-Q Technologies for a software upgrade to run the new algorithm.
E-0-2-9	Cannot transmit on CAN bus	• Check the physical CAN connector, electrical bus conditions, and other CAN modules for correct functioning. For example, check that termination resistance is approximately 60 ohms.
E-0-3-0	CAN heartbeat timeout on Battery module	• May be caused by a missing heartbeat message. Check the CAN bus battery module for correct function. • This error automatically clears once the condition has been corrected.
E-0-3-1	The Vref for the ADC measurements has triggered an alarm	• Internal charger error. Disconnect AC and the battery for a minimum of 30 seconds and retry. • If the problem persists, contact Delta-Q Technologies. • This error automatically clears once the condition has been corrected.

Error Code	Description	Solution
E-0-3-2	CAN Heartbeat Lost	• An error was detected with the CAN heartbeat communications with a registered node being guarded. • Check the networked CANbus device(s) for correct functioning. • This alarm does not display or get logged on the charger but does appear on the CAN bus via an emergency message.
E-0-3-6	Battery temperature sensor is missing or shorted	• Check sensor connections. • The charger behavior when this fault occurs can be configured. OEMs may contact Delta-Q Technologies for more information. • This error automatically clears once the condition has been corrected.
E-0-3-7	CANopen reprogramming failed	• Retry. • Reprogram using a USB flash drive. • This error automatically clears once reprogramming has completed successfully.
E-0-3-8	Fan will not turn	(Fan-equipped models only) • Check fan connections. • Check to ensure the fan turns freely and is not obstructed. • This error automatically clears once the condition has been corrected.
E-0-4-0	Fan voltage pulled low	(Fan-equipped models only) • Check to ensure the fan turns freely.
E-0-4-5	Battery disconnected	• Battery disconnected • Reconnect the battery or check the wiring
E-0-4-6	Invalid PDO Length	• Check to ensure all PDOs are valid length. This error automatically clears once the condition has been corrected
E-0-4-7	Platform overvoltage alarm	• A battery or some other source has been connected to the charger that exceeds the hardware's design limits.

13 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.

13.1 High Ambient Temperature

At ambient temperatures above approximately 40°C (104°F) (above 35°C (95°F) for IC650-24), the charger will automatically de-rate 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.

13.2 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.

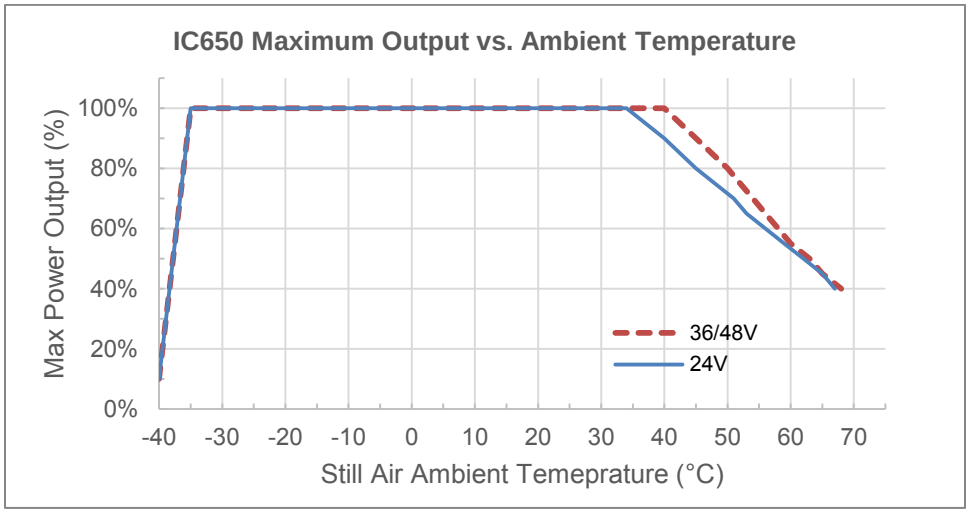


Figure 56: Ambient Temperature Derating Performance for the IC650 Charger

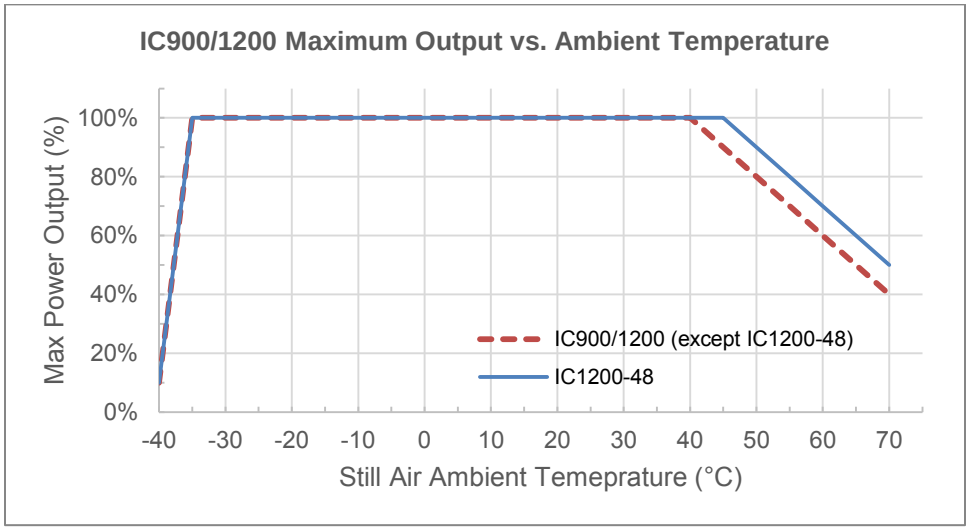


Figure 57: Ambient Temperature Derating Performance for the IC900 and IC1200 Chargers

13.3 Low AC Voltage

If input voltage falls below 100V AC, the IC650 charger reduces its output power to protect itself from damage. The power is reduced 1% per volt below 100V AC until the charger turns off at 80V AC. When the voltage rises above 85V AC, the power will resume. The 24V model de-rates at 0.5% per volt below 120V AC. The following figure shows the available output power across the AC voltage range for an IC650 charger.

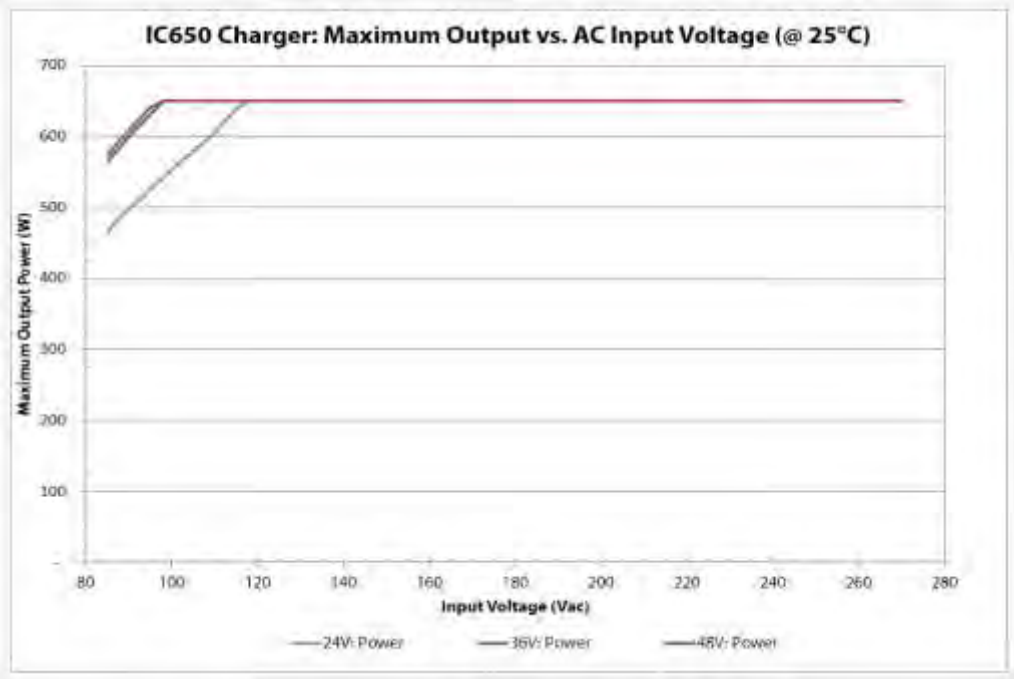


Figure 58: Output Power vs. AC Input Voltage for the IC650 Charger

If input voltage falls below 100V AC, the IC900 and IC1200 chargers reduce their output power to protect themselves from damage. 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 for an IC900 and IC1200 chargers.

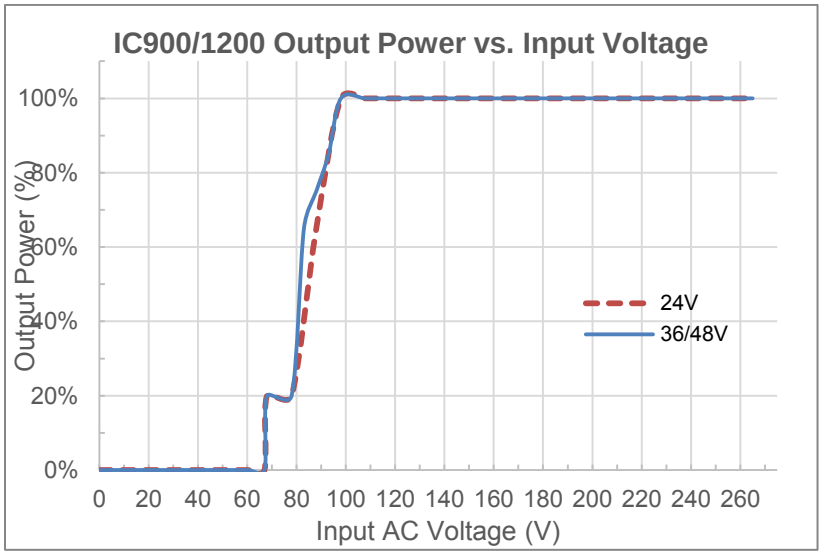


Figure 59: Output Power vs. AC Input Voltage for the IC900 and IC1200 Chargers

13.4 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.

13.5 Power Limited

At charging voltages below 2.0V/cell, 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/cell. 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.

Note: In software version 4.5.2 or later, the charger starts derating only below 1.0V/cell.

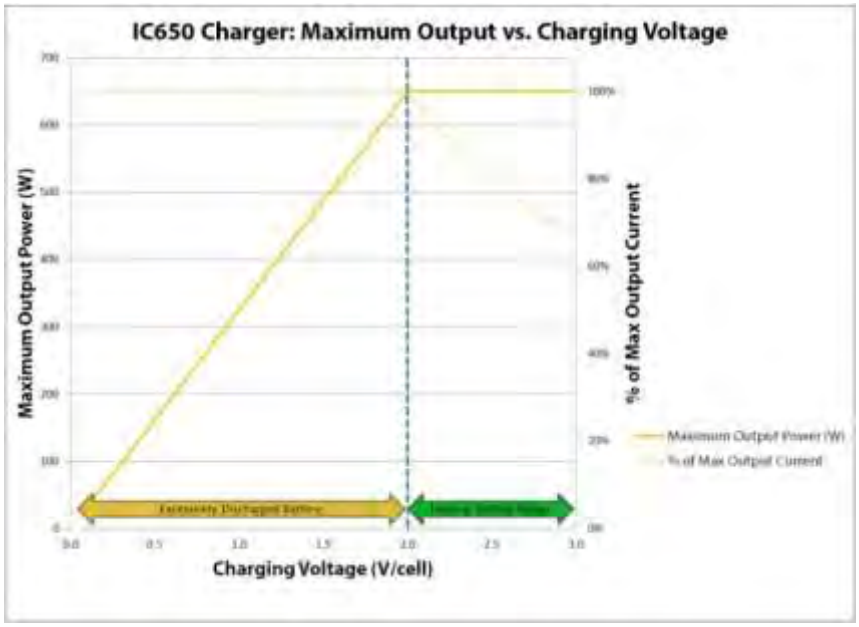


Figure 60: Maximum Output Power vs. Charging Voltage

13.6 DC Only Operation

IC Series chargers are able to maintain communications on DC voltage from the batteries after being disconnected from AC. CAN and some monitoring functions are active until a pre-set turn-off time or a voltage threshold is reached. In this mode the charger may be turned off anytime by pressing the **Select Charge Profile** button for 10 seconds.

Standard turn-off time: 18 days
Standard turn-off voltage: 1.75V/cell (except 940-0023 and 940-0032)

For the IC650 chargers, the AC must be connected first before it will operate from the battery supply alone.

Minimum DC battery voltage to turn on: 24V DC

14 Maintenance and Replacement Parts

This section provides information on various replacement parts as well as maintenance/replacement of the battery fan.

14.1 Replacement Parts List

Here is a partial list of items available from Delta-Q Technologies. Contact Delta-Q Technologies for the current list of all available accessories and cables.

Table 29: Replacement Parts List

Part	Part No.	Description
USB Port Dust Cover	400-0371	Covers USB Host port from dust/liquid ingress
IC650 DC Terminal Block Cover	400-0300	Covers DC terminal fixtures to protect terminals from being shorted by foreign objects
IC650 DC Cable Clamp	400-0303	Secures DC wires in place at the point of exit out of the DC terminal block
Torx T30/M6 Bolts	410-0365	Bolts for DC positive/negative terminals
IC650 M6 Square Nut	400-0305	Nuts for DC positive/negative terminals
IC1200 Complete Fan Replacement Kit	900-0123	Kit includes the IC1200 fan, DC Terminal Block and all their accessories
IC900/IC1200 Complete DC Terminal Kit	900-0130	Kit includes DC Cover, M6 Bolts, Cable Clamp and Clamp/Cover Screws for IC900/1200
IC650 Complete DC Terminal Kit	900-0145	Kit includes DC Cover, M6 Bolts, Cable Clamp and Clamp/Cover Screws for IC650
IC900/IC1200 DC Terminal and Signal Connector Cover	400-0451	Plastic cover to protect both the DC Terminal and Signal Connector
IC650 DC Terminal and Signal Connector Cover	400-0369	Plastic cover to protect both the DC Terminal and Signal Connector
IC650/IC900 Plastic Handle	900-0111	Plastic handle to carry the charger
Rubber Mounting Foot	400-0366	Rubber feet prevent scratches to surfaces on which the charger is placed

14.2 Fan Replacement Instructions

If the IC1200 charger fan fails or is accidentally disconnected, the charger will display a fan error on its status display. Under this condition, the charger will continue to operate but at reduced output.

The fan and/or fan shroud can be easily replaced; you need a 3mm Hex key (Allen key).

1. Using the Hex key, remove the four screws on the fan shroud.

Figure 61: Remove Fan Screws

2. With the four screws removed, lift the fan shroud from the charger. Be sure to disconnect the red and black fan wire quick-connects from the terminal tabs.

Figure 62: Lift Fan Shroud

3. Remove the four screws securing the fan.

Figure 63: Remove Fan Screws and Fan

4. Ensure all rubber isolation washers on the fan screws are retained.

Figure 64: Isolation Washers

5. Install new fan, fastening it to the charger with four of the Hex screws (with the isolation washers in the same positions shown in Figure 64). Do not overtighten (recommended torque 2.7Nm). Ensure the arrow on the fan (A) is pointing towards the DC block at the back of the charger. Weave the two wires (B) around the three pins to provide strain relief. Ensure the rubber grommet is placed in the plastic holder of the DC block (C).

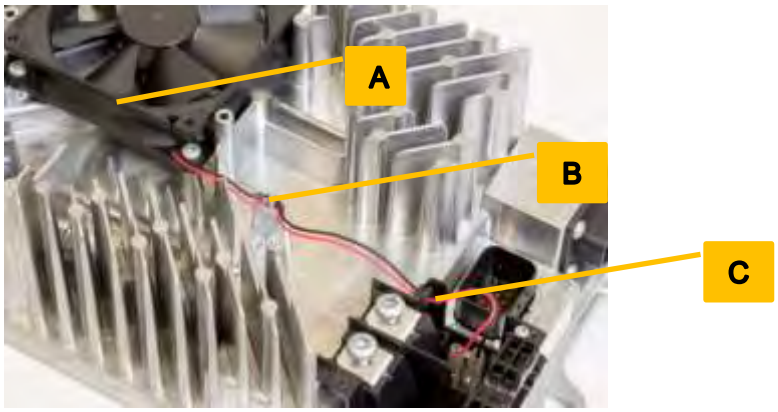


Figure 65: Install New Fan

6. Make the electrical connections in the DC terminal block. The red wire is connected to the positive quick-connect terminal (F+) and the black wire is connected to the negative quick-connect terminal (F-).

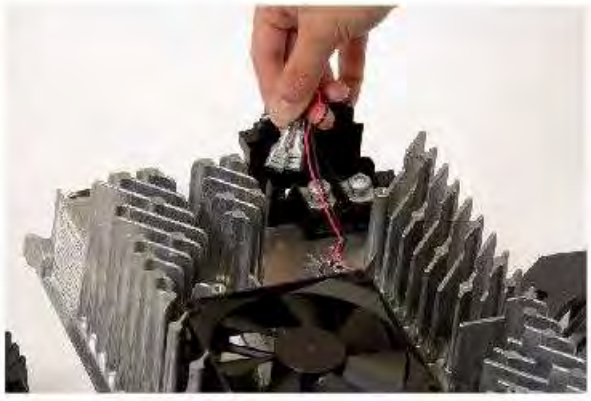


Figure 66: Electrical Connections

7. Replace the fan shroud and secure it with four Hex screws. Do not overtighten (recommended torque 2.7Nm).

Figure 67: Replace Fan Shroud

15 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 Identifiers
DC	Direct Current
DSP	Digital Signal Processor
ELV	Extra Low Voltage
EMI	Electromagnetic Interference
GFCI	Ground Fault Circuit Interrupter
HV	High Voltage
HW	Hardware
ID	Identification
kW	Kilowatt
LED	Light Emitting Diode
LIN	Local Interconnect Network
LV	Low Voltage
MB	Megabyte
MCU	Microcontroller - also abbreviated uC or µC
NMT	Network Management
NRTL	Nationally Recognized Testing Laboratories

Term	Definition
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
UL	Underwriters Laboratories
USB	Universal Serial Bus
V	Volt
VAC	Volts Alternating Current

16 IC Series Drawings and Photos

This section contains several drawings and photos of the IC Series Battery Chargers

16.1 IC650 Charger

The figures in this section show different views of the IC650 Charger.

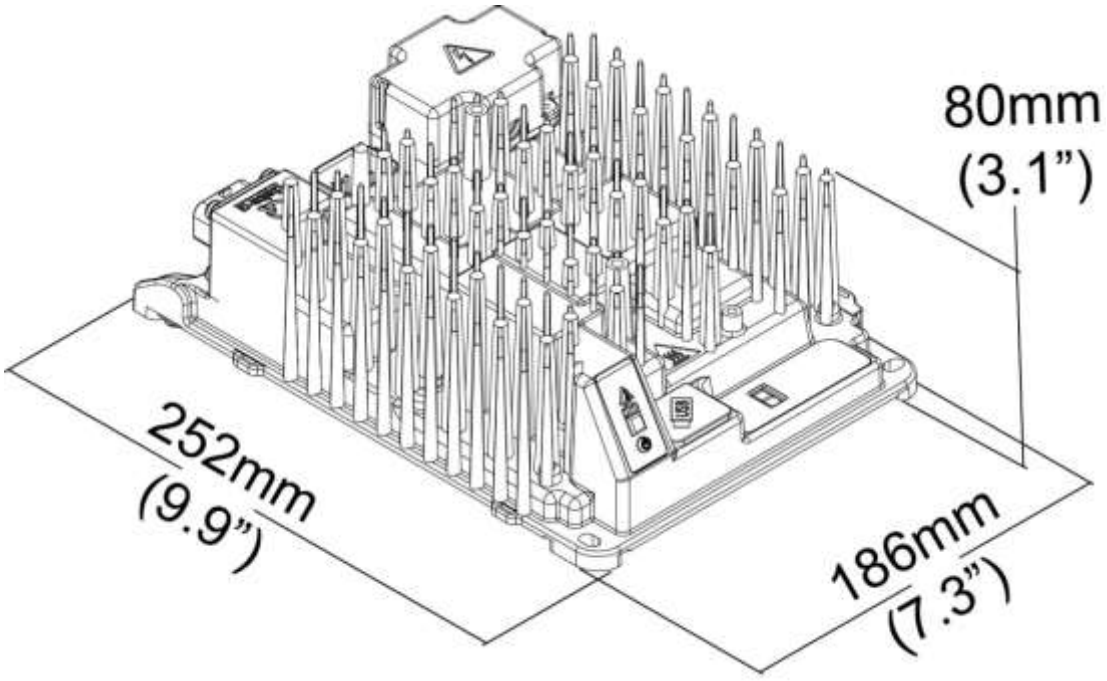


Figure 68: IC650 Charger Isometric View and Dimensions

Figure 69: IC650 Charger Front View

Figure 70: IC650 Charger Right Side View

Figure 71: IC650 Charger Left Side View

Figure 72: IC650 Charger Top View

Figure 73: IC650 Charger Rear View (BASE Version)

16.2 IC900 Charger

The figures in this section show different views of the IC900 Charger.

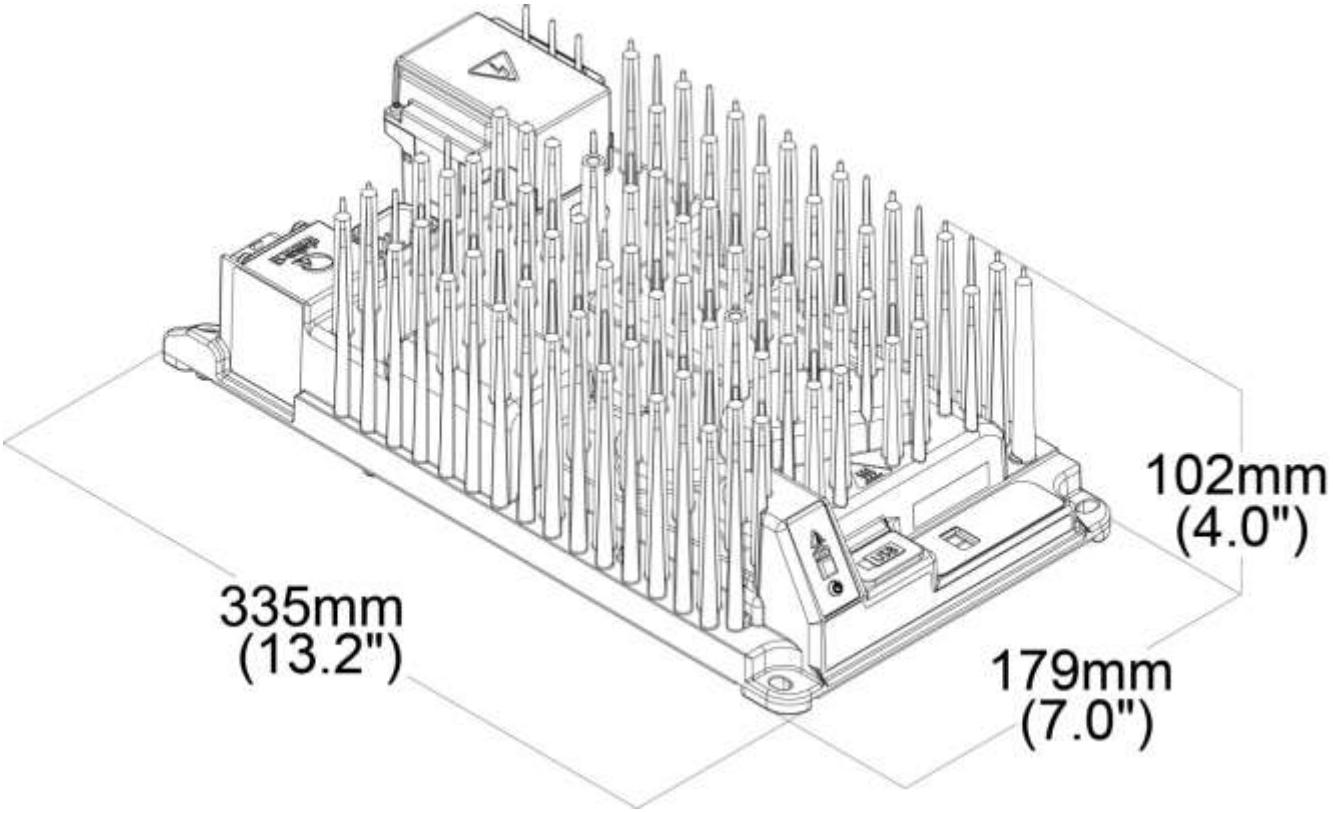


Figure 74: IC900 Isometric View and Dimensions

Figure 75: IC900 Charger Front View

Figure 76: IC900 Right Side View

Figure 77: IC900 Left Side View

Figure 78: IC900 Charger Top View (COMM Version)

Figure 79: IC900 Charger Rear View (COMM Version)

16.3 IC1200 Charger

The figures in this section show different views of the IC1200 Charger.

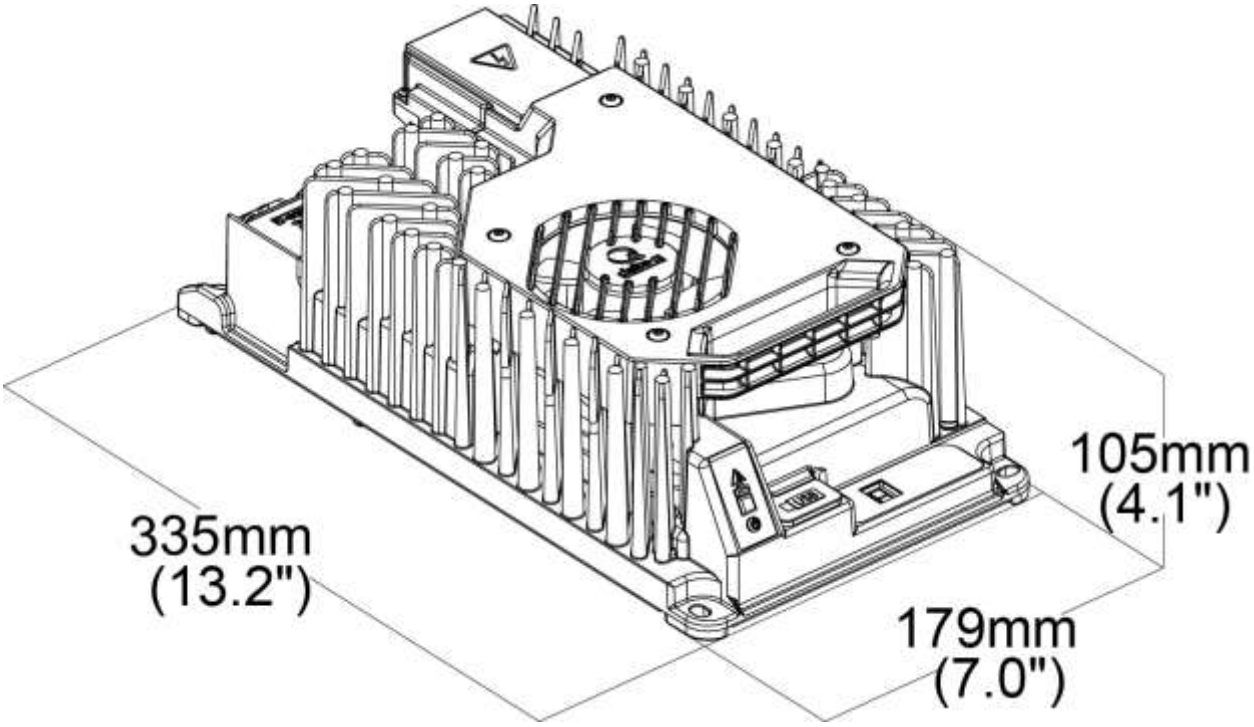


Figure 80: IC1200 Charger Isometric View and Dimensions

Figure 81: IC1200 Charger Front View

Figure 82: IC1200 Charger Right Side View

Figure 83: IC1200 Charger Left Side View

Figure 84: IC1200 Charger Top View (COMM Version)

Figure 85: IC1200 Charger Rear View (COMM Version)