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.

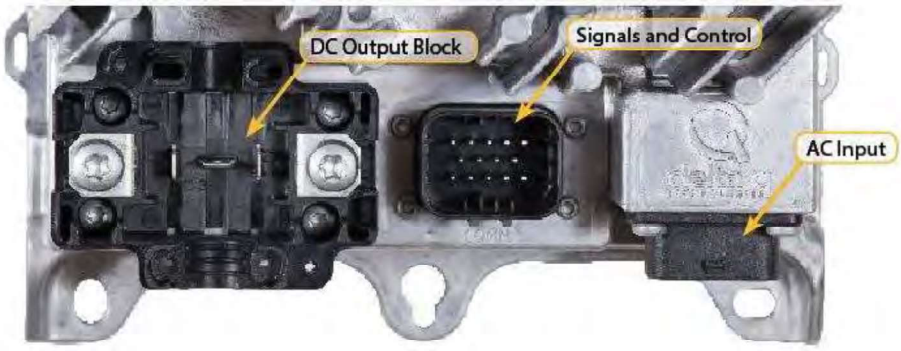


Figure 20: IC650 COMM Model Rear Panel

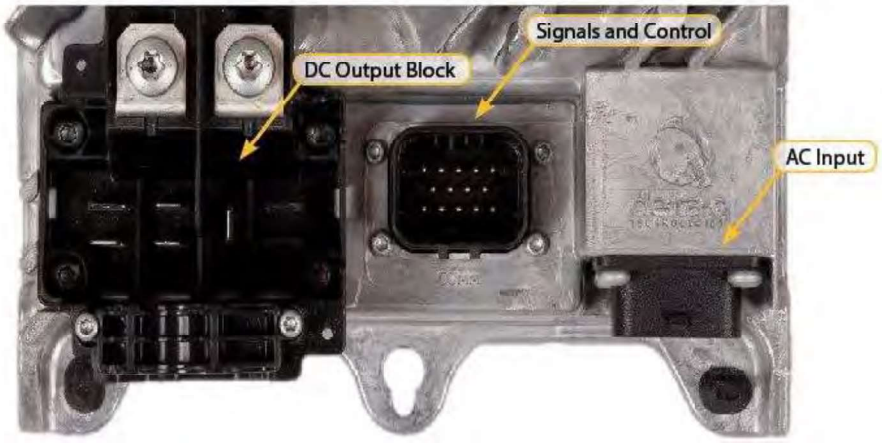


Figure 21: IC900 COMM Model Rear Panel

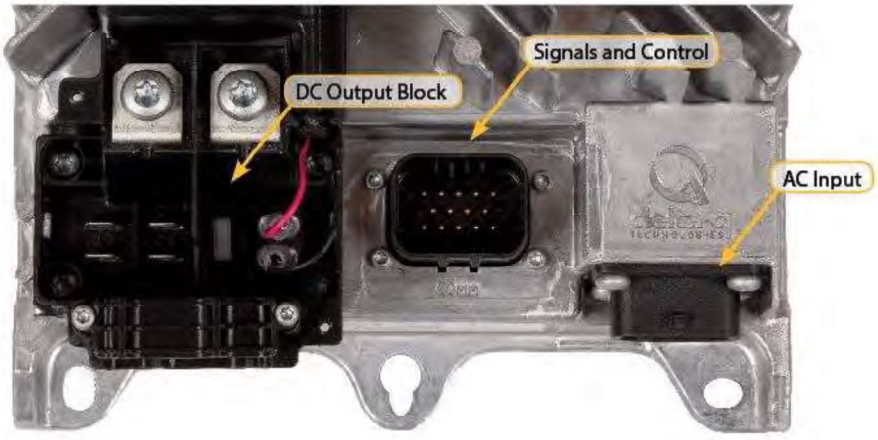


Figure 22: IC1200 COMM Model Rear Panel

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

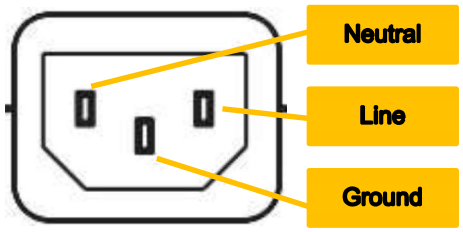


Figure 24: AC Input Connector

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.

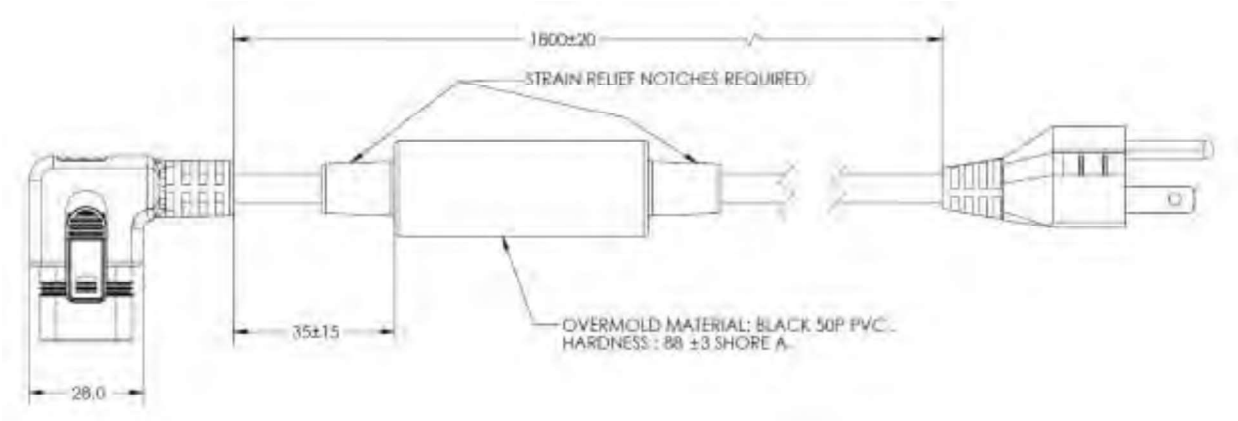


Figure 27: Installation Example of Laird 28B0734-000 on the AC Power Cable

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°.

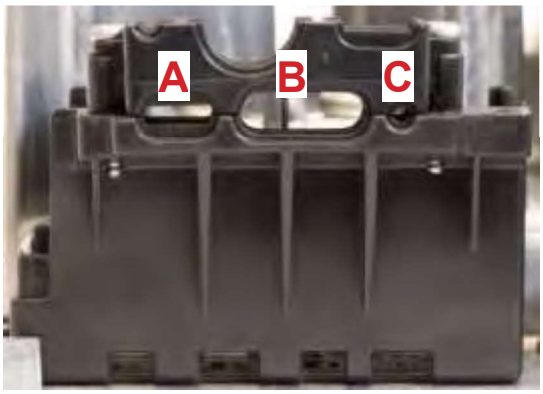


Figure 34: Cable Clamp Configuration 1
Recommended for Use with a Multi-Conductor Cable

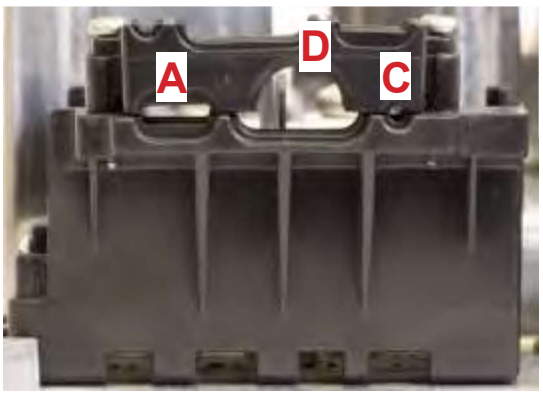


Figure 35: Cable Clamp Configuration 2
Recommended for Use with a Sleeved Battery Cable

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%.

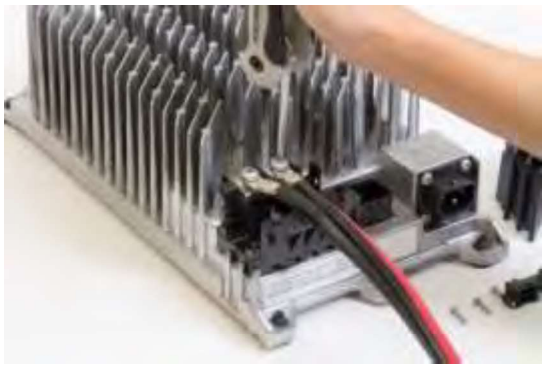


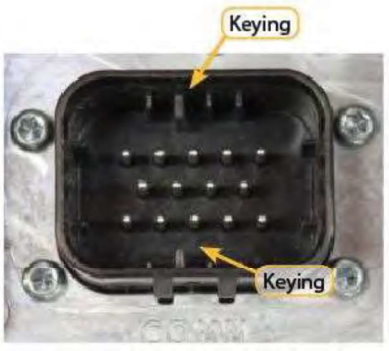
Figure 37: Secure DC Wires

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

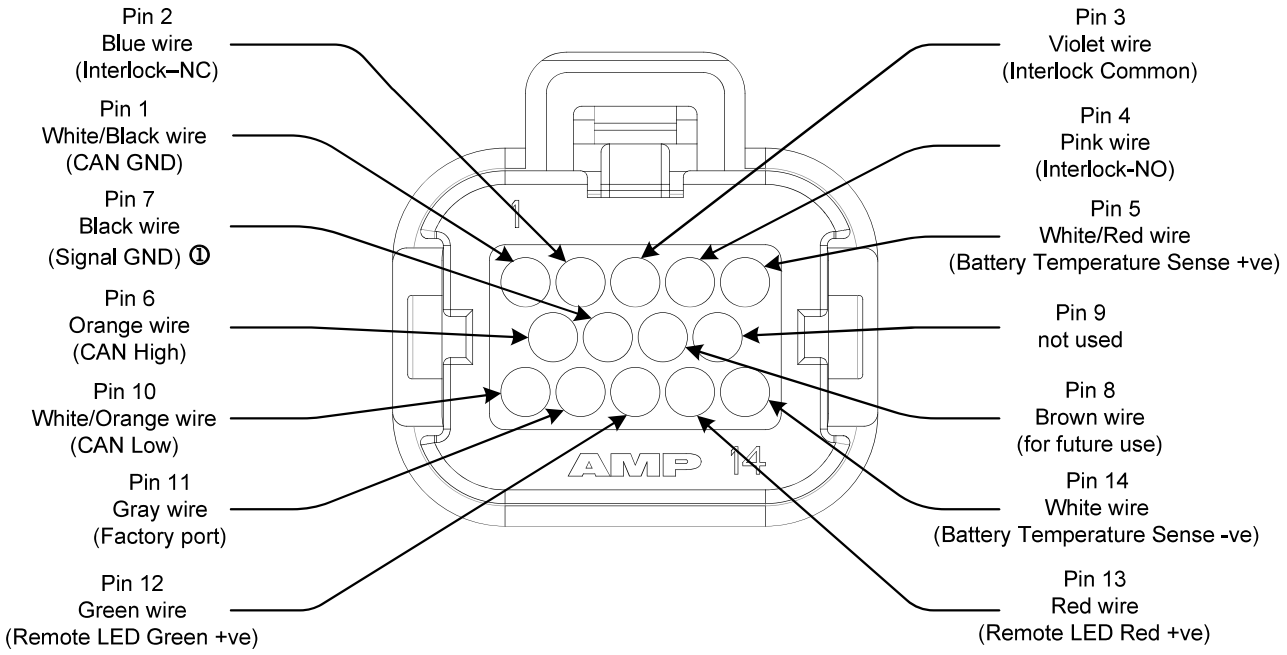


Figure 39: IC650 Signals & Control Connector: Pin Signal Reference

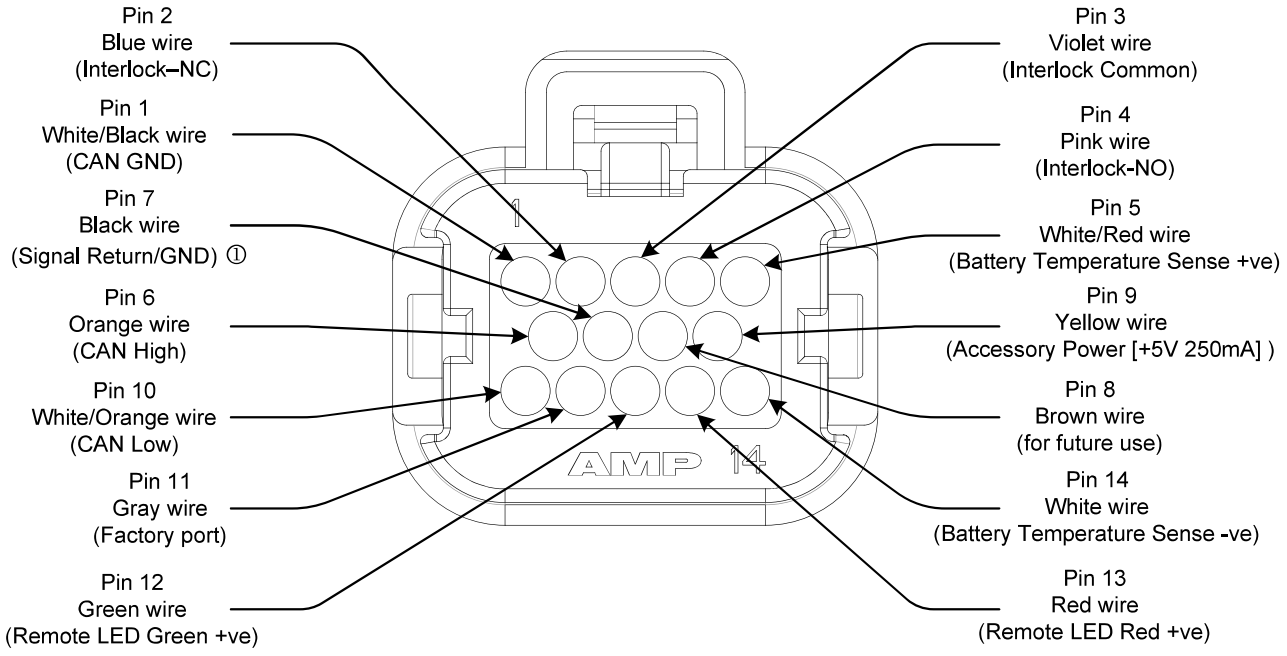


Figure 40: IC900/IC1200 Signals & Control Connector: Pin Signal Reference

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.

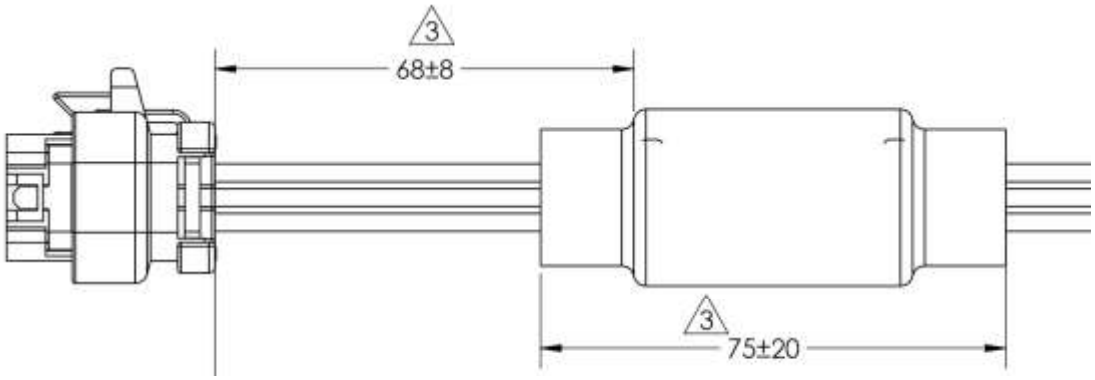


Figure 44: Installing a Ferrite Bead on the Wires from the Signals & Control Connector

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.

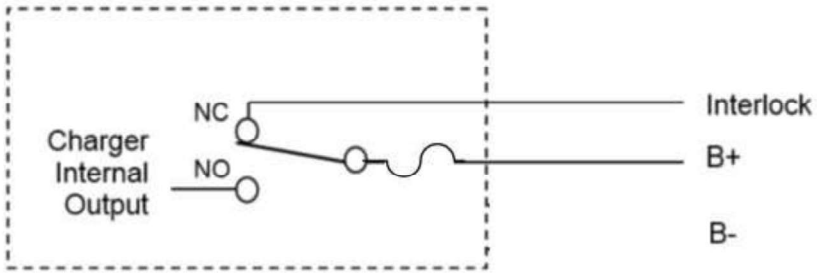


Figure 47: Simplified Internal Diagram of the Charger's Interlock Output

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.

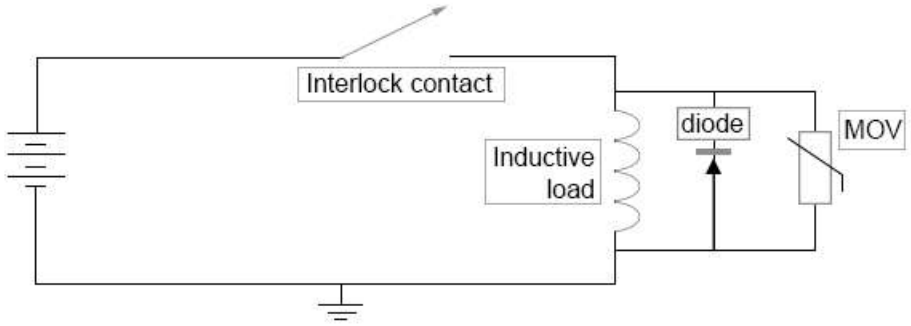


Figure 49: Interlock Contacts Protected from Inductive Load with a Diode or an MOV

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.

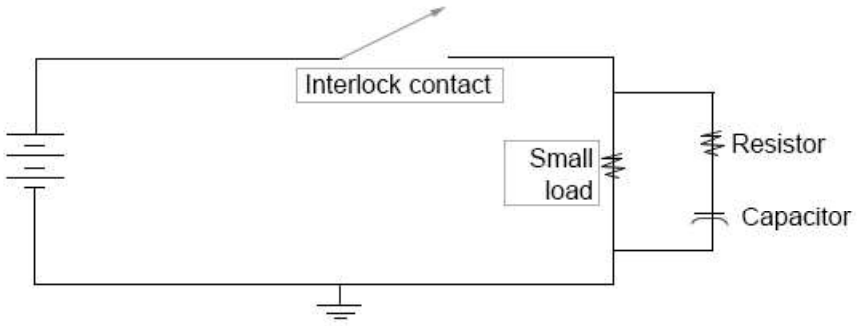


Figure 50: Resistor and Capacitor Meet Minimum Load Requirements for Interlock Contacts

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.