Critical Installation & Setup Guide

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CROSSFIRE Critical Installation Manual

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1. Introduction

The LCO CROSSFIRE's patented design optimizes power by regulating the 24VDC signal, driving efficiency across the system. However, maintaining proper VFD wiring is crucial to ensure this optimization works effectively. Specifically, the cable must be limited to a maximum of 60 feet with #10 AWG wire due to the following factors:

1. **Voltage Drop**: Longer cable runs increase resistance, which leads to voltage drops that can reduce motor efficiency. Using #10 AWG minimizes resistance and ensures the motor receives stable voltage.
2. **Signal Integrity and Harmonics**: Extended cable distances can introduce signal distortion and harmonics, impacting the VFD's ability to control motor speed and torque. Limiting the distance to 60 feet helps maintain clear signal transmission and reduces harmonics.
3. **Current Handling**: #10 AWG wire is necessary to handle the current demands of the system without overheating or risking performance issues.

By keeping these limits, we ensure our power optimization works seamlessly with the VFD technology for reliable and efficient operation.

Important Installation Notes:

- Maximum cable distance between the controller and pump is ~60 feet. This refers to the actual length of the cable, not the straight-line distance.
- The pump is certified as Explosion Proof, Class 1 Div 1, meaning it is limited to a maximum current of 10 Amps for safety reasons.

Key Electrical Relationships:

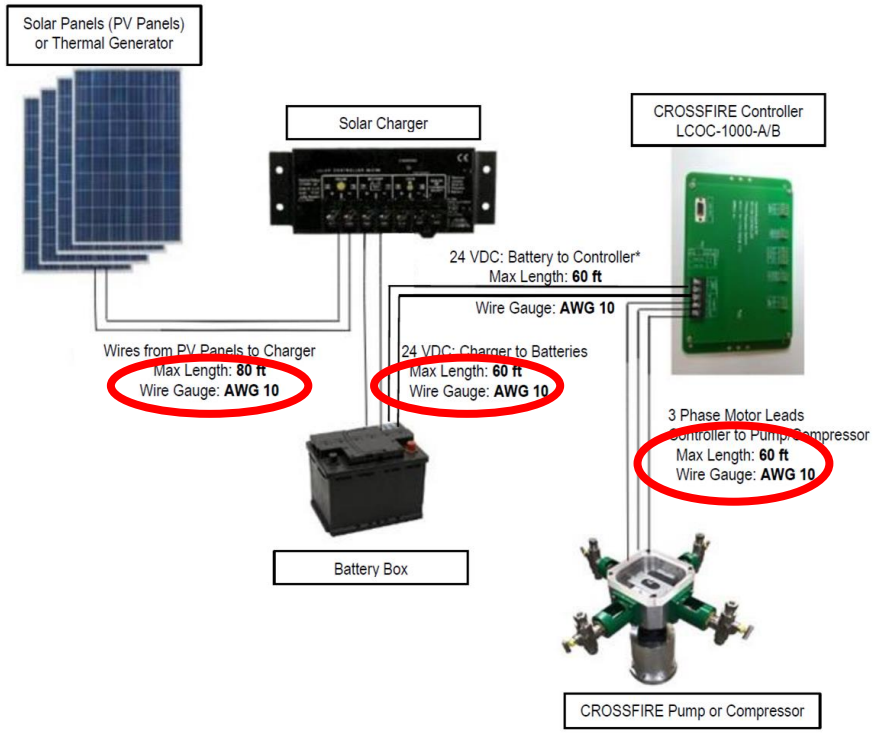
- Voltage (V) = Power Supply Voltage (~24 VDC)
- Current (I) is influenced by resistance (R)
- Resistance is determined by cable length, wire gauge (AWG), and proper grounding

Voltage = Current (I) × Resistance (R)

As resistance increases, current also increases.

This is not a technological limitation but a requirement for CSA certification compliance.

Failure to follow these guidelines can lead to damage to the controller, resulting in repair charges.



2. Expected Installation Requirements

To ensure the proper installation of the CROSSFIRE system, the following wiring and distance guidelines must be strictly followed:

Wires between Solar Panels and Charger:

- Maximum length: 80 feet
- Wire gauge: 10 AWG

Wires from Charger to LCO Controller:

- Maximum length: 60 feet
- Wire gauge: 10 AWG

Wires from LCO Controller to CROSSFIRE Pump, Air Compressor, or VRU:

- Maximum distance: 60 feet
- Wire gauge: 10 AWG
- *Note*: This distance refers to the actual length of the cable, not the straight-line distance ("as the crow flies"). Measure along the cable tray or conduit where the cable is laid.

3. Installation Variation Examples

Example 1: Impact of Different Wire Gauges on Resistance and Current

Different wire gauges have varying resistance per meter, which can influence the current in the system. For example:

- A 10 AWG wire has a resistance of approximately 0.00328 Ohms per meter.
- A 12 AWG wire has a resistance of approximately 0.00521 Ohms per meter.

Using a 12 AWG wire instead of the recommended 10 AWG over a 60-foot run (18 meters) increases resistance, leading to higher current draw, which can exceed the controller's limits.

Example 2: Effect of Poor Grounding on Resistance and Current

Poor grounding can increase system resistance, causing erratic behavior. A poor ground connection that adds just 0.1 Ohms of resistance can significantly increase current draw and lead to overcurrent protection triggers.

Example 3: Voltage Drop Due to Weak Batteries Under Load

Weak batteries can cause a significant drop in voltage, affecting the entire system. For example, if the battery voltage drops from 28V to 24V under load, the CROSSFIRE controller will draw more current to compensate, potentially leading to a blown fuse.

4. Conductor Wire Length, Wire Gauge, and Installation Requirements

It is critical to reduce power loss on cable runs so there is enough voltage and current to power the motor. In addition, it is important to recognize that the LCO controller is a Variable Frequency Drive (VFD), which can be sensitive to transient voltage spikes induced by the inductance of long cable runs. Components of the power system must be properly placed on-site to minimize the length of cables throughout the entire system to reduce cable inductance and resistance.

Key Guidelines:

- Minimize cable runs to reduce voltage loss, inductance, and resistance.
- Always follow the American Wire Gauge (AWG) guide for wire size and resistance (see **Attachment 1**). If the wire resistance deviates from the AWG guide, reduce the maximum cable length proportionally.
    - For example, if the cable has three times the resistance listed in the AWG guide, the maximum wire length should be reduced to one-third.
- Use stranded copper conductors (AWG 20-24) with proper ferrule terminations.

Resistance Checks:

- Long cable runs or poor electrical contact at terminals can increase overall resistance, negatively affecting the system’s performance.
- Use the LCO Technologies configuration software (under the "terminal" tab) to check resistance values at startup. Ensure that neither “Resistor A” nor “Resistor B” exceeds 0.3 Ohms.
- If either resistance value is higher than 0.3 Ohms, check all power wire connections, ensure they are properly tightened, and consider shortening the cable runs if necessary.

Note: If your installation site does not allow you to meet the specified wire lengths, please contact LCO Technologies for alternative solutions.

5. Open Circuit Voltage: Voltage Suppression Requirements

When installing a CROSSFIRE product, open circuit voltage may require special installation instructions depending on the site and power conditions. Solar panels generate a transient voltage spike when the charger turns on to route current to the batteries and the CROSSFIRE controller. This spike can damage the controller if it exceeds 40V.

Where:

- L1 = Cable length from PV panels to the charger.
- L2 = Cable length from the charger to the batteries.
- VOC = Open circuit voltage at the PV panels.
- VC = Maximum voltage the CROSSFIRE controller can withstand (40V).
- VB = Battery charging voltage (28V).

Voltage Spike Control Formula:

$$Maximum\ L2 = \frac{VC - VB}{VOC - VC} x\ L1$$

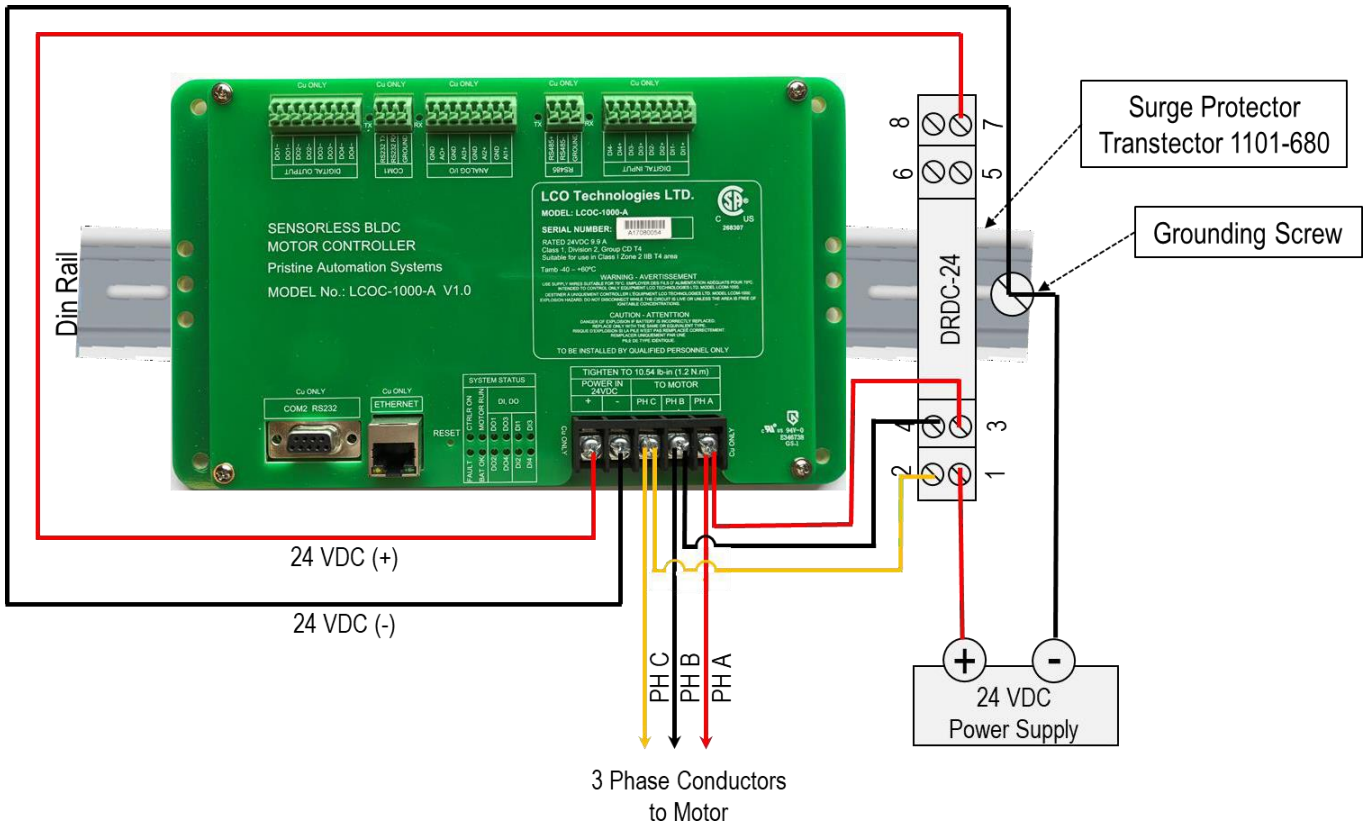
6. Surge Protection Devices

If transient voltage spikes cannot be mitigated by cable length adjustments, surge protection must be installed to safeguard the CROSSFIRE controller.

Non-Hazardous Areas:
Install a low-cost bi-directional surge suppression diode (TVS 5KP33CA) across the 24VDC line.
Hazardous Areas (Class 1 Div. 2):
Use a Transtector 1101-680 surge protector following the provided wiring diagram.

Note: The TVS diode is effective but not CSA-certified for hazardous locations.

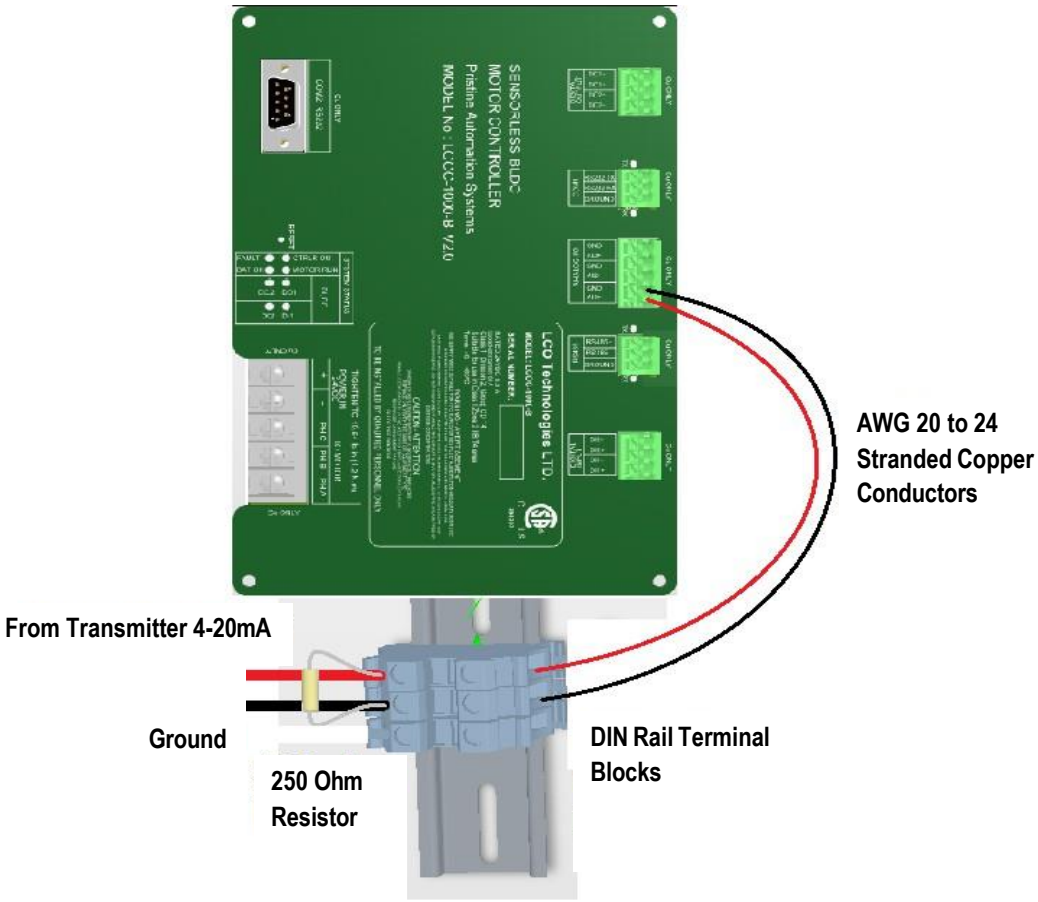
Transtector 1101-680 Surge Protector



Wiring Diagram for Installation of Transtector Surge Protector (Model # 1101-680)

7. Resistor Wiring Requirements (Instrument Air Compressor)

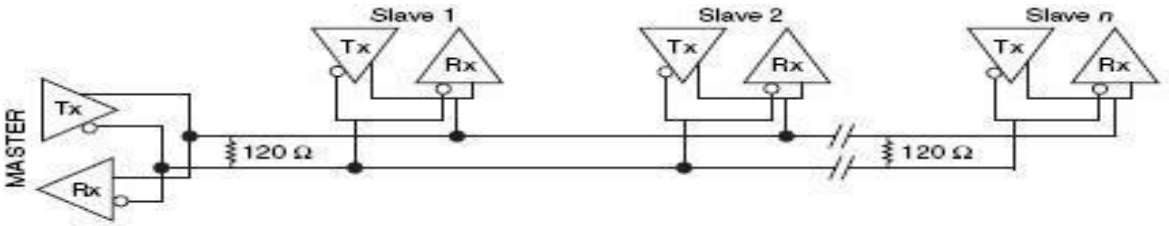
For the CROSSFIRE instrument air compressor, a 250 Ohm resistor is required for reverse proportional pressure control in the 4-20mA signal loop. The resistor must be installed on the terminal blocks inside the control or instrument panel and **not directly** on the CROSSFIRE controller's AI1 terminals, which could damage the terminal or void the warranty.



8. RS-485 Modbus Communication

CROSSFIRE products support Modbus communication over an RS-485 bus. To ensure proper communication:

- Both ends of the RS-485 trunk must be terminated with 120 Ohm resistors.
- The GROUND terminal on the RS-485 port serves as a signal ground reference. This terminal should only be connected to the RTU's RS-485 port GND, not to chassis ground.



2-Wire Multidrop Network Using Terminating Resistors

9. Understanding Voltage and Current (V=IR)

Understanding how voltage, current, and resistance interact is critical for ensuring proper installation and preventing damage.

- **Low Voltage**: Causes higher current draw, leading to potential performance issues.
- **High Resistance**: Increased wire or contact resistance leads to higher current consumption.
- **Current Load**: Current draw rises in proportion to how hard the unit is working mechanically, independent of voltage and resistance.

CROSSFIRE controllers are protected by an internal 9.9 Amp fast-blow fuse. To protect the controller and associated equipment, external fusing should be limited to 8 Amps.

10. Troubleshooting Guide

Before troubleshooting, review the specific product's user manual and use the **LCO Smart Application** (available on iOS, Android, and Windows) for incremental error codes and diagnostics.

Common Issues and Solutions:

1. **System Will Not Start**
   - Verify voltage and check the external 8A fuse.
   - If the internal 9.9A fast-blow fuse has blown, the controller must be returned to LCO Technologies for evaluation. The fuse cannot be replaced in the field.
2. **Controller Shuts Down After Operation Begins**
   - Check for excessive current draw and use the LCO Smart App to diagnose the issue.
   - Verify wire length, gauge, and resistance.
3. **Communication Failure (RS-485)**
   - Ensure proper RS-485 bus termination with 120 Ohm resistors and correct wiring of the signal ground.
4. **High Current Draw**
   - Check wire gauge, connections, and grounding. Measure the voltage under load to ensure proper power supply.
5. **Voltage Spikes or Fluctuations**
   - Recheck cable lengths and ratios between the solar panels, charger, and batteries. Install surge protection if needed.
6. **Internal Fuse Blown**
   - The 9.9A fast-blow fuse cannot be replaced in the field. Return the controller for evaluation and repair. Ensure external fusing is rated at 8 Amps.

Attachment 1: AWG Guide

AWG gauge	Conductor Diameter Inches	Conductor Diameter mm	Conductor cross section in mm^2	Ohms per 1000 ft.	Ohms per km	Maximum amps for chassis wiring	Maximum amps for power transmission	Maximum frequency for 100% skin depth for solid conductor copper
0000	0.46	11.684	107	0.049	0.16072	380	302	125 Hz
000	0.4096	10.40384	84.9	0.0618	0.202704	328	239	160 Hz
00	0.3648	9.26592	67.4	0.0779	0.255512	283	190	200 Hz
0	0.3249	8.25246	53.5	0.0983	0.322424	245	150	250 Hz
1	0.2893	7.34822	42.4	0.1239	0.406392	211	119	325 Hz
2	0.2576	6.54304	33.6	0.1563	0.512664	181	94	410 Hz
3	0.2294	5.82676	26.7	0.197	0.64616	158	75	500 Hz
4	0.2043	5.18922	21.1	0.2485	0.81508	135	60	650 Hz
5	0.1819	4.62026	16.8	0.3133	1.027624	118	47	810 Hz
6	0.162	4.1148	13.3	0.3951	1.295928	101	37	1100 Hz
7	0.1443	3.66522	10.6	0.4982	1.634096	89	30	1300 Hz
8	0.1285	3.2639	8.37	0.6282	2.060496	73	24	1650 Hz
9	0.1144	2.90576	6.63	0.7921	2.598088	64	19	2050 Hz
10	0.1019	2.58826	5.26	0.9989	3.276392	55	15	2600 Hz
11	0.0907	2.30378	4.17	1.26	4.1328	47	12	3200 Hz
12	0.0808	2.05232	3.31	1.588	5.20864	41	9.3	4150 Hz
13	0.072	1.8288	2.63	2.003	6.56984	35	7.4	5300 Hz
14	0.0641	1.62814	2.08	2.525	8.282	32	5.9	6700 Hz
15	0.0571	1.45034	1.65	3.184	10.44352	28	4.7	8250 Hz
16	0.0508	1.29032	1.31	4.016	13.17248	22	3.7	11 k Hz
17	0.0453	1.15062	1.04	5.064	16.60992	19	2.9	13 k Hz
18	0.0403	1.02362	0.823	6.385	20.9428	16	2.3	17 kHz
19	0.0359	0.91186	0.653	8.051	26.40728	14	1.8	21 kHz
20	0.032	0.8128	0.519	10.15	33.292	11	1.5	27 kHz
21	0.0285	0.7239	0.412	12.8	41.984	9	1.2	33 kHz
22	0.0253	0.64516	0.327	16.14	52.9392	7	0.92	42 kHz
23	0.0226	0.57404	0.259	20.36	66.7808	4.7	0.729	53 kHz
24	0.0201	0.51054	0.205	25.67	84.1976	3.5	0.577	68 kHz
25	0.0179	0.45466	0.162	32.37	106.1736	2.7	0.457	85 kHz
26	0.0159	0.40386	0.128	40.81	133.8568	2.2	0.361	107 kHz
27	0.0142	0.36068	0.102	51.47	168.8216	1.7	0.288	130 kHz
28	0.0126	0.32004	0.080	64.9	212.872	1.4	0.226	170 kHz
29	0.0113	0.28702	0.0647	81.83	268.4024	1.2	0.182	210 kHz
30	0.01	0.254	0.0507	103.2	338.496	0.86	0.142	270 kHz
31	0.0089	0.22606	0.0401	130.1	426.728	0.7	0.113	340 kHz
32	0.008	0.2032	0.0324	164.1	538.248	0.53	0.091	430 kHz
Metric 2.0	0.00787	0.200	0.0314	169.39	555.61	0.51	0.088	440 kHz
33	0.0071	0.18034	0.0255	206.9	678.632	0.43	0.072	540 kHz
Metric 1.8	0.00709	0.180	0.0254	207.5	680.55	0.43	0.072	540 kHz
34	0.0063	0.16002	0.0201	260.9	855.752	0.33	0.056	690 kHz
Metric 1.6	0.0063	0.16002	0.0201	260.9	855.752	0.33	0.056	690 kHz
35	0.0056	0.14224	0.0159	329	1079.12	0.27	0.044	870 kHz
Metric 1.4	.00551	.140	0.0154	339	1114	0.26	0.043	900 kHz
36	0.005	0.127	0.0127	414.8	1360	0.21	0.035	1100 kHz
Metric 1.25	.00492	0.125	0.0123	428.2	1404	0.20	0.034	1150 kHz
37	0.0045	0.1143	0.0103	523.1	1715	0.17	0.0289	1350 kHz
Metric 1.12	.00441	0.112	0.00985	533.8	1750	0.163	0.0277	1400 kHz
38	0.004	0.1016	0.00811	659.6	2163	0.13	0.0228	1750 kHz
Metric 1	.00394	0.1000	0.00785	670.2	2198	0.126	0.0225	1750 kHz
39	0.0035	0.0889	0.00621	831.8	2728	0.11	0.0175	2250 kHz
40	0.0031	0.07874	0.00487	1049	3440	0.09	0.0137	2900 kHz