

CROSSFIRE CHEMICAL INJECTION PUMP

Ultra-Low Power Instrument Air Compressor **LCOD-LSI-COMPRESSOR**

Installation and Operations Manual
Version 2.0

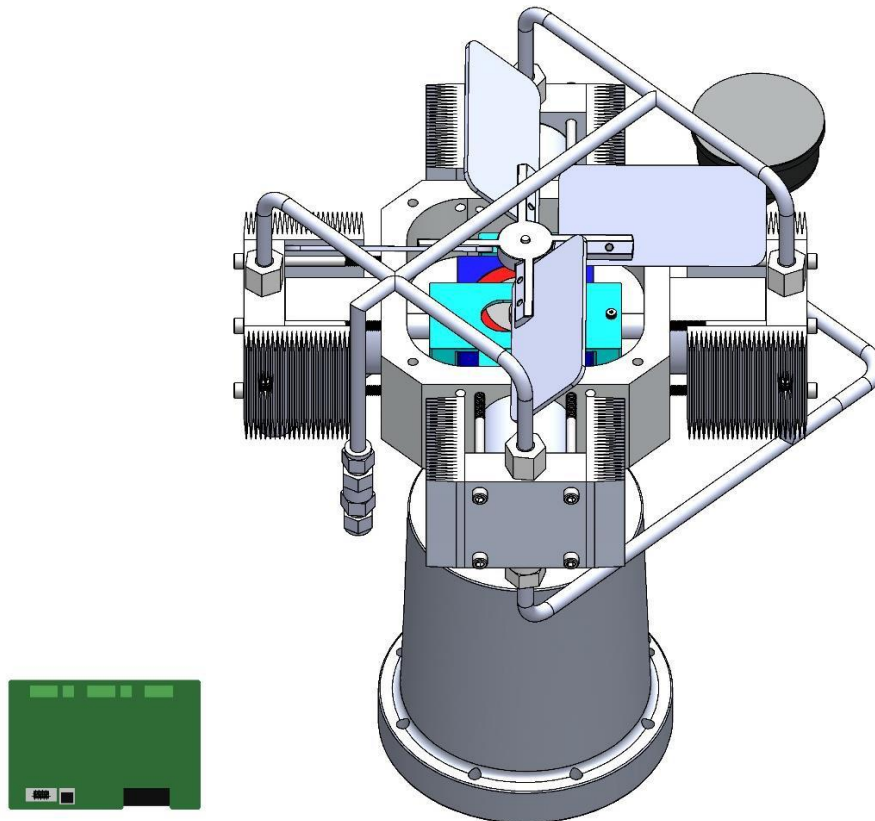


Table of Contents

CSA Requirements and Installation Requirements	3
CROSSFIRE Installation Guide	7
Installation Requirements – Summary Diagram	13
CROSSFIRE Compressor Start Up	13
Wireless Option	13
Interface Guide	15
Motor Control Tab.....	18
System Status Tab	20
System Setup Tab	21
System I/O Tab	24
Automation Tab	25
Terminal Tab	25
Frequently Asked Questions: Automation & MODBUS	26
Fault Codes	28
Controller Troubleshooting	30
COM Port Issues	31
Other Miscellaneous Issues	31
CROSSFIRE Maintenance	32
Diagram: Assembled CROSSFIRE Instrument Air Compressor with Fan Cover.....	34
Diagram: Assembled CROSSFIRE Instrument Air Compressor without Fan Cover	35
CROSSFIRE Compressor Troubleshooting	36
CROSSFIRE Return and Repairs.....	40
Repairs.....	40
Replacement	40
Warranty Exceptions.....	40

CSA Requirements and Installation Requirements

IMPORTANT SAFETY CONSIDERATIONS

WARNING

AVERTISSEMENT

EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS
MAY IMPAIR SUITABILITY FOR INSTALLATION IN HAZARDOUS LOCATIONS
RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS
PEUT RENDRE CE MATÉRIEL INACCEPTABLE POUR LES
EMPLACEMENTS DANS DES ENDROITS DANGEREUX (CLASSE 1, DIVISION 2).

WARNING

AVERTISSEMENT

EXPLOSION HAZARD - DO NOT REPLACE COMPONENTS
UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS
KNOWN TO BE NON-HAZARDOUS.
RISQUE D'EXPLOSION - COUPER LE COURANT OU
S'ASSURER QUE L'EMPLACEMENT EST DÉSIGNÉ NON
DANGEREUX AVANT DE REMPLACER DES COMPOSANTS.

WARNING

AVERTISSEMENT

EXPLOSION HAZARD - DO NOT CONNECT OR DISCONNECT EQUIPMENT
UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS
KNOWN TO BE NON-HAZARDOUS.
RISQUE D'EXPLOSION - AVANT DE DÉBRANCHER
L'ÉQUIPEMENT, COUPER LE COURANT OU S'ASSURER
QUE L'EMPLACEMENT EST DÉSIGNÉ NON DANGEREUX

WARNING

AVERTISSEMENT

THE CONTROLLER ASSEMBLY IS FOR USE IN CLASS I, DIVISION 2, GROUPS C AND D, AND OR
NONHAZARDOUS LOCATIONS ONLY.
L'APPAREIL DU CONTRÔLEUR CONVIENT À L'UTILISATION DANS LES EMBLEMES
DE CLASSE 1, DIVISION 2, GROUPES C ET D, OU NE CONVIENT
QU'À L'UTILISATION DANS DES EMBLEMES DÉSIGNÉS NON DANGEREUX.

WARNING

AVERTISSEMENT

THE MOTOR ASSEMBLY IS FOR USE IN CLASS I, DIVISION 1, GROUPS C AND D, AND OR
NONHAZARDOUS LOCATIONS ONLY.
L'APPAREIL DU MOTEUR CONVIENT À L'UTILISATION DANS LES EMBLEMES
DE CLASSE 1, DIVISION 1, GROUPES C ET D, OU NE CONVIENT
QU'À L'UTILISATION DANS DES EMBLEMES DÉSIGNÉS NON DANGEREUX.

AGENCY CERTIFICATION

Controller Assembly

(Must be placed in a Cabinet/Enclosure that provides a minimum Ingress Protection of NEMA 4/IP54)

Class 1, Division 2, Groups C and D, or nonhazardous.

Temperature Code: T4, Tamb: -40 to 60 Deg. C.

Suitable for Zone 2, IIB.

Motor Assembly

(Motor is for indoor or protected environment use only)¹

Class 1, Division 1, Groups C and D, or nonhazardous.

Temperature Code: T6, Tamb: -40 to 60 Deg. C.

Suitable for Zone 1, IIB.

Models:

Explosion Proof Motor Assembly Model LCOM-1000

Controller Model LCOC-1000-A and Model LCOC-1000-B

IMPORTANT: Conditions of Certification

- ✓ The Controller must be installed within an enclosure suitable for the environment and requiring a tool or key to open. Controller models LCOC-1000-A and LCOC-1000-B are intended for use in a Pollution Degree 2 environment.
- ✓ The RS232 connector must be retained with two screws on the mating connector.
- ✓ The Ethernet RJ45 connector must be retained with its original locking tab to withstand a 15 Newton pull force once engaged.
- ✓ Model LCOM-1000 and Model LCOC-1000 must be used together to form a Certified Brushless DC (BLDC) Motor System. No substitutions of motor types are permitted.

Controller

The controller input voltage rating is 24 VDC. The battery power supply must be capable of supplying 24 VDC to ensure reliable operation and motor start-up. For average current draw based on application and help with solar sizing, please contact LCO Technologies directly. Current draw on most applications in steady state is around 0.7-2.0 A, however the rated maximum current draw for the controller is 9.9A.

The Controller must be protected by external over current protection in keeping with CEC and NEC practices supplied at the time of installation.

EXTERNAL CONNECTORS

The controller features several external connectors. These are labelled as followed:

- Power In: Connectors are used to connect the 24VDC power supply.
- To Motor: Connectors are used for Phase A, Phase B and Phase C of BLDC. These connections are not phase sensitive.

¹ Note: Protected environment means the motor must be under a shelter and off the ground to protect the motor from moisture (such as rain, snow, ice etc.)

Use only copper conductors on supply and motor load terminal blocks

“TIGHTEN TO 10.54 pound-inches (1.2 N•m)”. Or Equivalent

It is a CSA requirement to use #10 straight or ring lugs with **10 AWG wiring**, when connecting to the Power and Motor connectors. The Controller data connectors can accept 20 to 24 AWG stranded wire.

All wiring and connections must be in line with accepted wiring practices as outlined by the Canadian Electrical Code (Canada) and the National Electrical Code (USA) and installed by qualified personnel only (use copper conductors only.)

There are two patterns of mounting holes on the Controller unit. The four corner mounting positions are for a direct fastening to the enclosure using # 6 screws. The two patterns of 3 holes are for DIN Rail mounting brackets. Installer must supply screws and brackets as applicable.





It is required that a cutoff switch is installed on the +24 VDC power rail, between the controller and supply. This allows for safe servicing of the controller, and eliminates any arcing caused by manual connection or disconnection of the supply rail. Failure to do so may result in personal injury or damage to the controller.

Motor

Accurate mechanical lineup is essential for successful operation. Mechanical vibration and roughness in running the motor may be an indication of poor alignment. It is recommended that the lineup be checked when installed.

For direct coupled applications, use flexible couplings when possible. Use of a sealed fitting at the motor wiring entrance point is required with a minimum of 5 full thread engagement to maintain the Class I, Division1 rating of the motor when installed in a Hazardous Area.

The 3-Phase conductors and the Earth ground must be terminated in an approved Class I, Division 1 junction box. The green Earth lead must be grounded to the ground screw in the junction box.

WARNING: Motor, Control and Grounding must be in accordance with Canada - Canadian Electrical Code and/or USA – National Electrical Code and consistent with Local requirements and practices. Use Ground lug on exterior of Motor enclosure and Ground lead provided to ensure proper Grounding of the Motor.

See below for Safe Operating Area Curves (SOAC) for the Motor

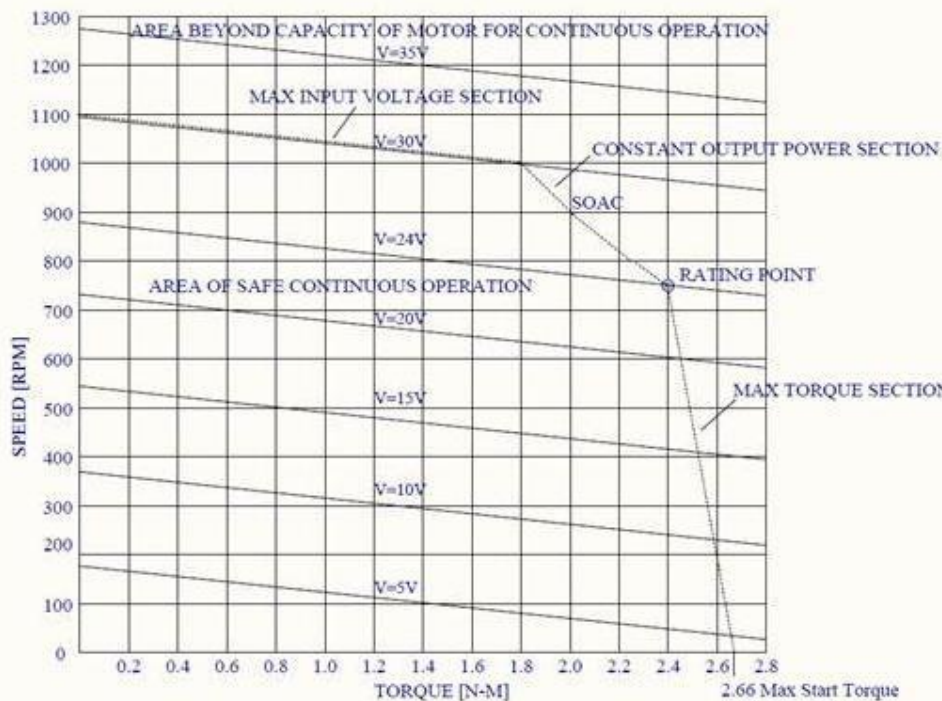


Figure 1: Safe Operating Area Curves (SOAC)

CROSSFIRE Installation Guide

Step 1: Open Shipment

- Confirm the following parts are present
 - LCOD-LSI-COMPRESSOR Package
 - LCOD-LSI-COMPRESSOR mounted on an accumulator volume bottle, complete with pressure transmitter and other accessories ordered
 - Complete with tubing from the compressor to the accumulator volume bottle and clear acrylic tubing for oil catch
 - ISO 46 Weight Hydraulic Oil² – 7 Fluid Oz
 - Oil provided for one fluid fill of the compressor
 - Re-useable squeeze bottle for easy oil changes
 - Smart Controller: Part Number # LCOC-1000-A
 - Shipped loose or pre-installed in a C1D2 panel as per customer requirement
- Check to ensure no parts were damaged during shipment
 - Contact the shipment carrier and file a claim if any damage has been identified
 - If replacement parts are required, please contact your supplier

Step 2: Mount the compressor

- Find a desired location for installation
 - A location that can accommodate compressor package dimensions
 - Ensure the compressor is in a protected environment and out of the elements
 - For example, inside the skid building
 - Avoid direct exposure to catalytic heaters if present in the building
 - The compressor generates its own heat and will run more efficiently when cool
 - Install near the utility gas distribution system
- Set the compressor package down
 - Recommendation: Secure the compressor package to the floor; use prefabricated holes in the base frame to bolt down or weld to attach materials

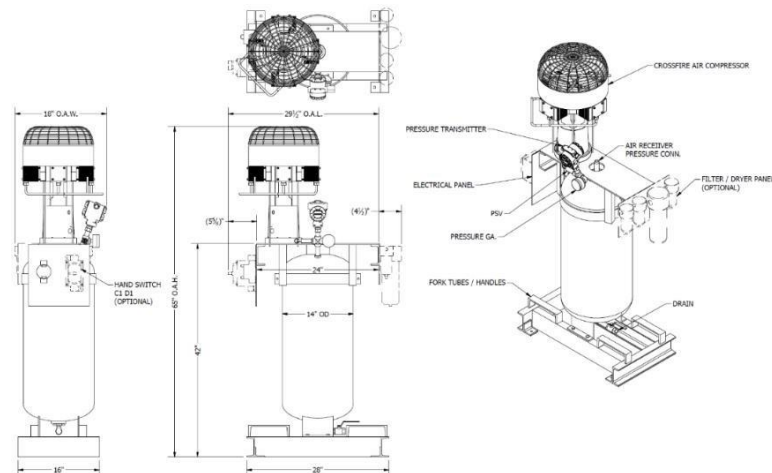


Figure 2: CROSSFIRE Compressor Package

² Hydraulic Oil: Recommended Brand “Certified – Hydraulic Oil, ISO 46 Weight”



Warning: The Compressor is mounted and attached on top of the air accumulator volume bottle to ensure any moisture present at discharge flows into the accumulator and not back towards the compressor valves. In addition, the tubing from the compressor outlet to the accumulator is completed already to ensure moisture can easily drain. Do not adjust this set up or configuration. Any modifications may affect compressor performance and will impact product warranty.

Step 3: Tube the compressor

- Remove the air filter and female connector fitting (PFC-06-08-SS) from the Compressor inlet
 - Keep the filter attached to the PFC-06-08-SS
- Tube the attached filter and PFC-06-08-SS outside the skid building
 - Tube the filter out the top of the building so it is outside of the C1D1 environment
 - Confirm the air intake is from a fresh air source and located away from any fuel gas or combustible gas lines that may be venting
 - Ensure the filter is under the building overhang to protect from rain or snow accumulation
 - Face the filter downwards at a 45-degree angle
- Place an oil catch can under the compressor and insert the two segments of clear acrylic tubing in the can
 - This will be the catch can for any oil leaks



Note: Use clean, dry, tubing for the air intake lines. Tubing transported on truck racks with no protection must be cleaned onsite prior to use. Trash in the tubing can cause compressor failure and will not be covered by warranty.

Warning: Filter must be protected from rain and snow accumulation and installed at a 45-degree angle. If insufficient cover from building overhang, water and liquids will be introduced to the compressor and may affect compressor performance.

- Tube a “dirt pocket” into the system in between the filter and the compressor inlet to allow for dirt and moisture capture. Attach a ball valve or mini valve or solenoid or back pressure regulator for control.
- Tube a “dirt pocket” on the accumulator tank outlet and then tube to instruments

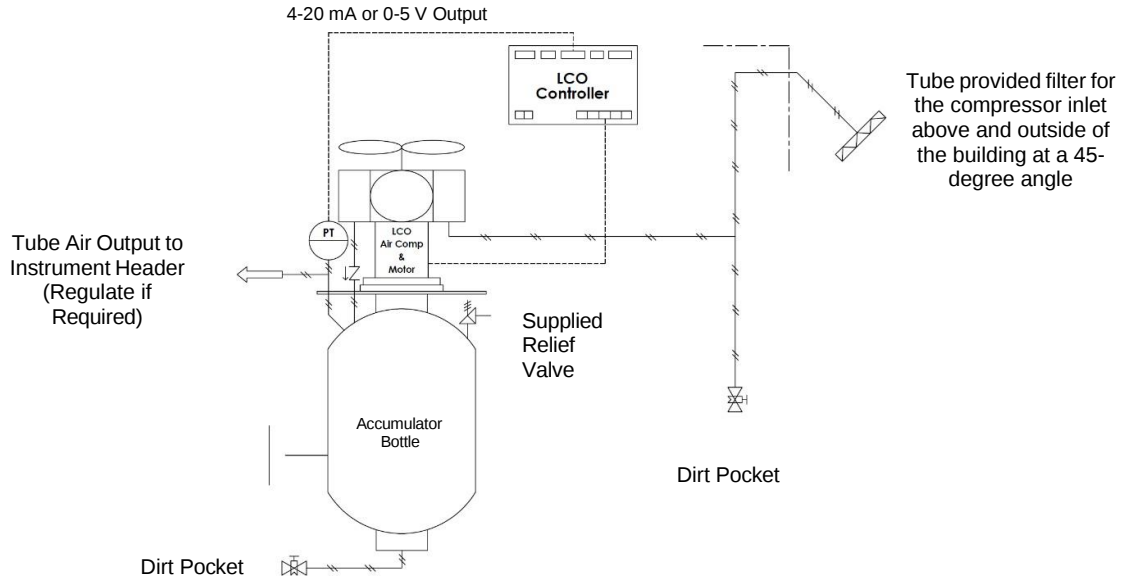


Figure 3: CROSSFIRE Compressor Installation P&ID

Step 4: Fill the LSI Top Works with Oil

- Locate the provided bottle of ISO 46 Weight Hydraulic Oil
- Locate the piece of tubing at a 90-degree elbow connected to the ball valve
 - Open the ball valve
 - Ensure the elbow is pointing upwards
- Dispense the entire bottle of oil into the tubing (7 Fluid Oz) as shown below
 - The oil will slowly move from the elbow and up into the square top works
 - Look through the clear cover and ensure the oil has entered the top works. The oil fill line should cover approximately half of the thrust rods.
 - Close the ball valve
- Ensure there are no leaks present in the system

Picture: How to fill oil in compressor

Step 5: Install the Smart Controller (LCOC-1000-B)

- Mount the Controller in a Nema 4 Enclosure as per CSA requirements (page 3 to 6)
- Wire the controller to a 24 VDC power supply
 - Connect the **2 conductor, 10 gauge tech cables** with appropriate environmental and classification seals to the controller
- Attach the three conductor cables from the motor to the controller. The green ground wire can be terminated at any ground. The conductor cables must be terminated in a Class 1, Division 1 junction box at the motor.
 - The three conductor cables will be terminated in the controller at termination points marked phase A, phase B, and phase C (PH A, PH B, PH C)
 - The wires must be attached in a specific order to ensure the fan spins in the correct direction. Attach the **red wire to PH A**, the **black wire to PH B**, and the **yellow wire to PH C**.
 - Cables are **gauge 10** and can be a maximum length of **60 ft**



Warning: If the resistance in the gauge 10 wires does not meet AWG standards, the distance must be reduced proportionately.



Warning: All conductor cables must be attached with proper end ferrule connectors and clamped down properly with the appropriate tools. Double check that all screw terminals are tightened down to avoid any electrical connection issues. Similarly, if two wires must be spliced together, please use a proper splicer connector, clamp down sufficiently, and do not use electrician twist caps.

Note: Wiring instructions are per device. Multiple CROSSFIRE units cannot be wired off a single cable run. Any deviation can affect CROSSFIRE performance. Please consult LCO Technologies directly for assistance prior to deviation, if required at site.

Step 6: Install Pressure Transmitter

- A pressure transmitter is already installed on the volume accumulator bottle with the compressor package. This transmitter allows the *CROSSFIRE* smart controller to automatically control the motor speed to maintain a set pressure in the accumulator bottle to maximize energy efficiency
- The pressure transmitter should be scaled to 0-50PSI³
- Wire the pressure transmitter to the AI¹⁺ port on the *CROSSFIRE* smart controller according to the wiring diagrams below
 - Use Gauge 20-24 AWG Tech Cable for the AI¹⁺ Terminal

Note: Wiring diagrams are designed for the pressure transmitter that comes standard with the Compressor Package (Rosemount 2088). Diagrams may be applied to other models requested outside of the package, however LCO Technologies does not guarantee this. The use of other models may affect compressor performance and is not recommended without the consultation of LCO Technologies.

Note: Please use Gauge 20, single strand wires for all terminals on the smart controller.

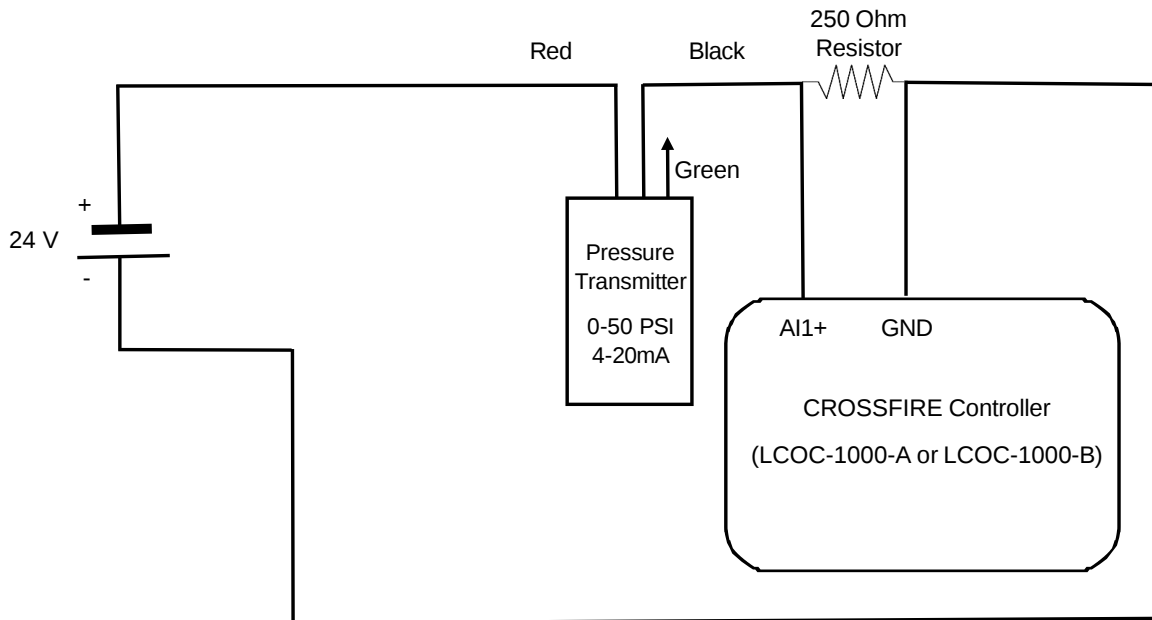
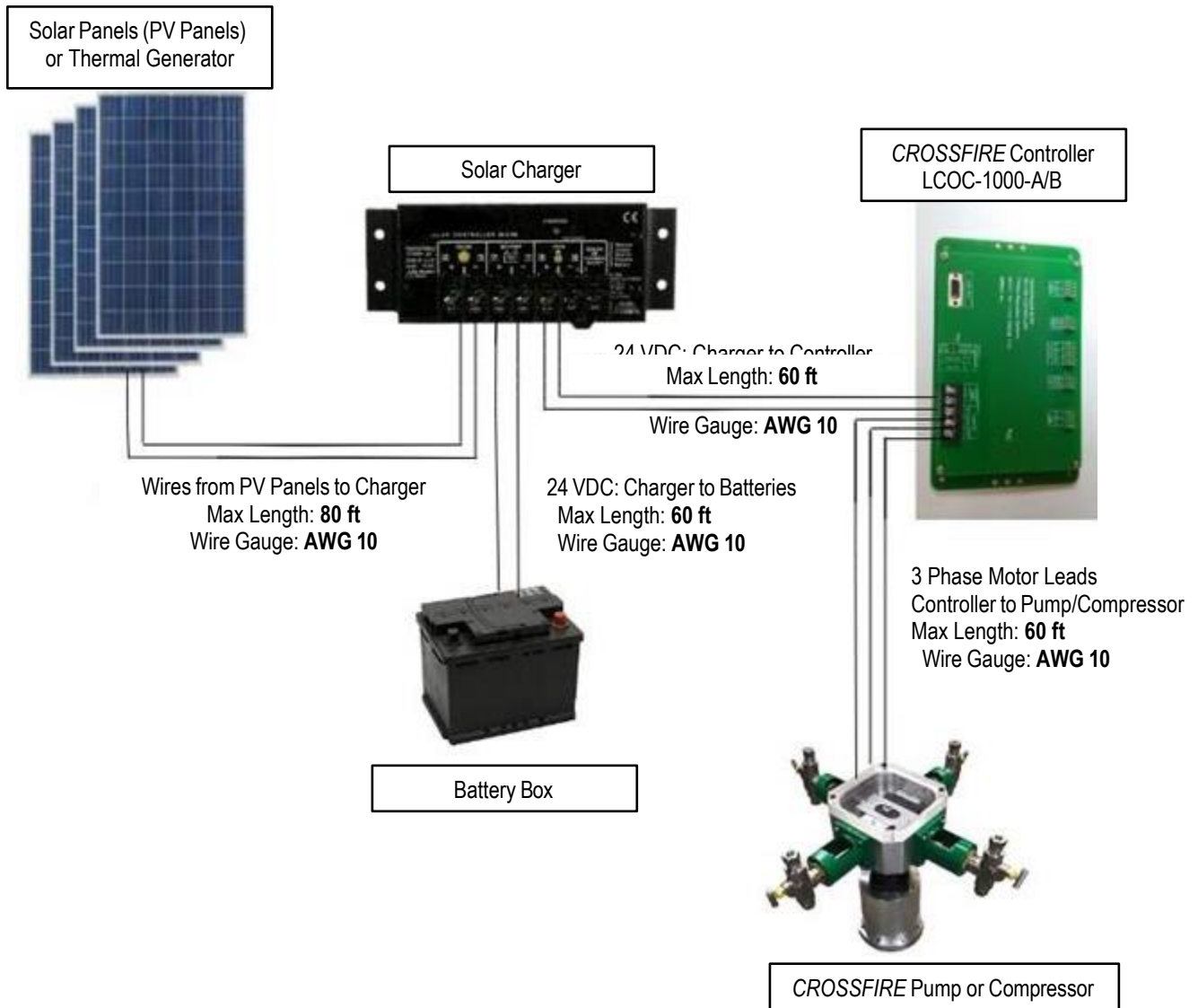


Figure 4: Wiring Diagram for 0-50 PSI, 4-20 mA Pressure Transmitter

³ Exception: If using a special-order high-pressure compressor, the pressure transmitter must be scaled to 0-100PSI. Contact LCO Technologies directly for specific instructions on the high pressure unit.

Installation Requirements – Summary Diagram



Note: Wiring instructions are per device. Multiple CROSSFIRE units cannot be wired off a single cable run. Any deviation from the above diagram can affect CROSSFIRE performance. Please consult LCO Technologies directly for assistance prior to deviation if required.

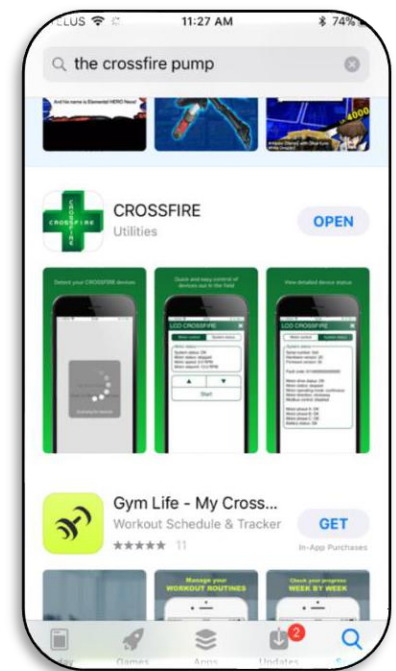
CROSSFIRE Compressor Start Up

Step 1: Download the configuration software

- Go to www.lcotechnologies.com
- Click on the resources tab
- Click on download button and follow all prompted instructions
- ZIP file password: **crossfire2017**
- The Interface is compatible with the following operating systems:
 - Windows 7
 - Windows 8.1
 - Windows 10
- Both the operator and technician tabs are password protected.
 - Operator Password: **Pristine**
 - Technician Password: **Automatio**

Wireless Option:

- In addition to the full computer software, there is a wireless communication option to the computer software or to a mobile phone or tablet
- Required Parts:
 - BT5-SAI
 - Optional: BT5-USB for laptop connection only
- Download mobile App on **Apple App Store** or **Android App Store**
 - Search “CROSSFIRE” or “LCO CROSSFIRE”
 - Alternative: go to the LCO website and click on the App store link listed under the “Resources” tab
- Both the operator and technician tabs are password protected
 - Operator Password: **Pristine**
 - Technician Password: **Automatio**
- If using BT5-SAI with a laptop for wireless connection, go to <https://lcotechnologies.com/resources.html> and download the device driver (Drivers for USB->Bluetooth adapter)
 - No password required
- For any other information regarding wireless Bluetooth communication and installation details, please refer to the Bluetooth Product Spec Sheet found at: <https://lcotechnologies.com/resources.html>



Step 2: Start the Compressor

- Connect an RS 232 cable to the controller and computer
- Ensure the acrylic top plate and fan enclosure are on the compressor
- Start up the compressor as per the operator interface instructions listed on page 15.
 - Log in as “*Technician*”
 - Go to the “*system setup*” tab
 - Configure device operating mode to “Compressor” by choosing one of the four control curve options:
 - Compressor – stop at @ 36 PSI
 - Compressor – stop @ 50 PSI
 - Compressor – custom curve (0-50PSI)
 - Set up curve based on custom application prior to starting unit
 - Software will automatically prompt with a graphical interface to configure the custom curve
 - Compressor – custom curve (0-100PSI)*
 - *Note: this curve is for the special high-pressure compressor only, standard LCOD-Compressor is not designed for 100 PSI*



Warning: Pinch Hazard. Always keep the clear acrylic top plate and the fan cover on the unit while the compressor is running

Note: The hydraulic oil in the top works will turn black within a few hours of run time. This is a normal reaction and not a sign of contaminants in the system.

Step 3: Observe proper scaling of the pressure transmitter

- Once the compressor is running, isolate the instrument air distribution system and allow the pressure in the accumulator tank to climb to the set maximum pressure.
 - As the pressure increases, the motor speed will decrease
- Open all valves connecting the compressor to the instruments on site and allow compressed air to flow throughout the system.
- As instruments use the pressurized air, the compressor will automatically modulate the motor speed up and down to maintain the set pressure in the accumulator bottle.



Optional Step – MODBUS Communications: The CROSSFIRE Compressor can be connected to a local SCADA/RTU System and communicate via MODBUS. Consult LCO Technologies for the latest MODBUS maps and for further instructions on integration.

Interface Guide

The LCO Technologies *CROSSFIRE* Configuration Software is a tool used to easily monitor and configure the controller that drives the *CROSSFIRE* pump or compressor with a RS232 serial connection. Additionally, a mobile version of the software for cell phones and tablets is available using Bluetooth Low Energy communications.

There are two distinct logins for the interface – technician and operator. Operators have viewing access to all tabs, however, can only make changes within the [motor control](#) and [system status](#) panels. Technicians have access to all panels and can make changes to all settings. As the *CROSSFIRE* is both a chemical pump and an air compressor, the interface will default to pump mode. Once configured as an air compressor, the fluid end settings in the configuration panel (region # 3) will disappear.

Interface Overview

The *CROSSFIRE* configuration software is divided into three regions:

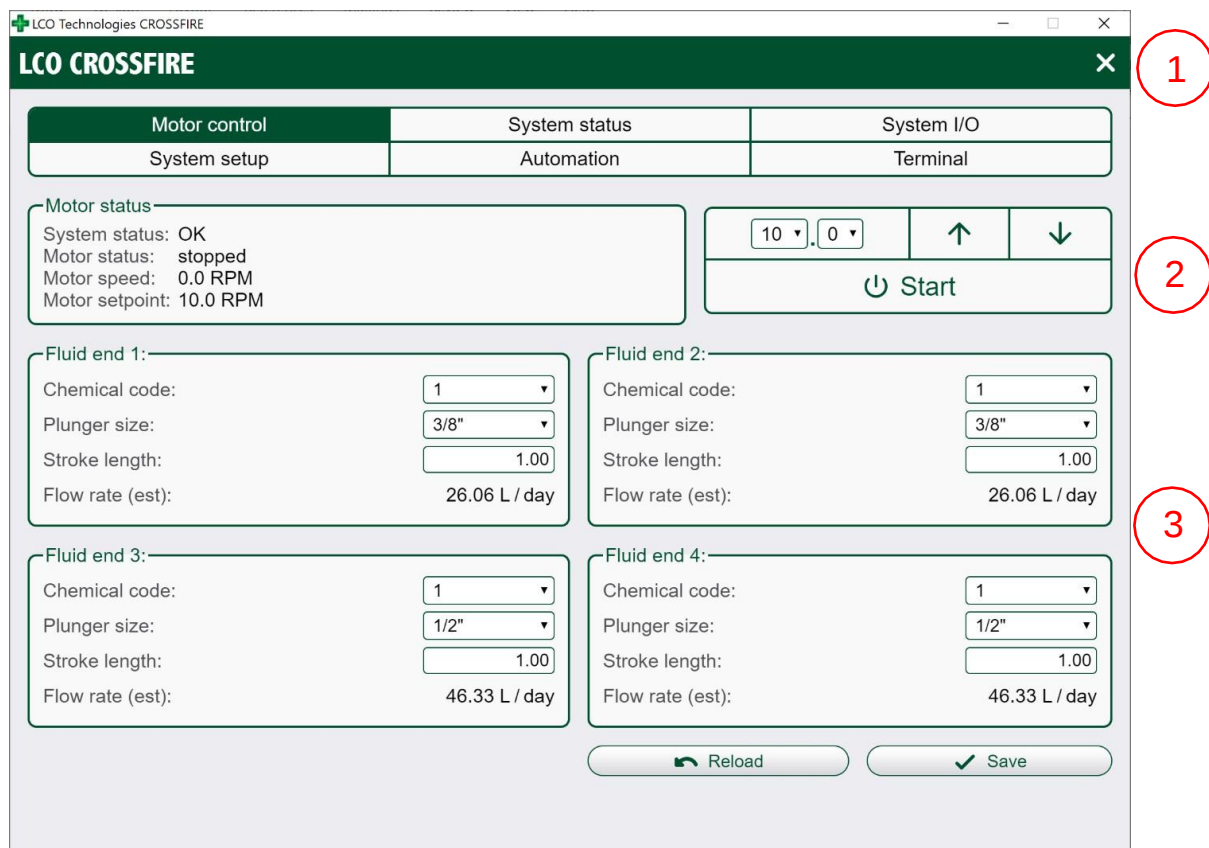


Figure 5: *CROSSFIRE* Configuration Software main window

- 1) Main menu bar: Used to connect and disconnect from the *CROSSFIRE* controller and switch between operation tabs.
- 2) Motor control panel: Shows motor status and is used to start/stop the motor and set motor speed (available for both operators and technicians). Additionally, will display automation mode instead of speed settings if configured.
- 3) Configuration panel: Used to view and edit the configuration data stored on the *CROSSFIRE* controller (ex. plunger size, and chemical injected)

Main menu

Connect to Controller:

The main screen is used to scan for devices and connect to the *CROSSFIRE* controller and compressor. Ensure the pump is powered on and click [Scan for Devices](#) and select the appropriate COM Port.

- See: Troubleshooting – COM Port Issues if needed



Figure 6: Computer Interface Main Page – Connecting to a CROSSFIRE Controller



Log into the Controller:

- 1) Login as: Select operator, or technician. Operators only have access to change basic settings; Technicians have access to change all settings, including advanced configuration options.
- 2) Password: Enter the correct password to log in to the controller as operator or technician.
 - Operator Password: **Pristine**
 - Technician Password: **Automatio**

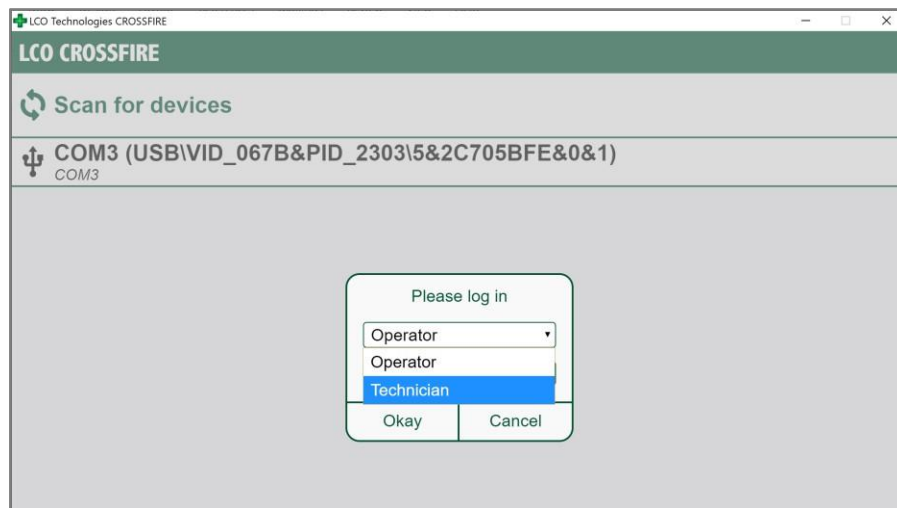


Figure 7: Computer Interface Main Page – Log in as Operator or Technician

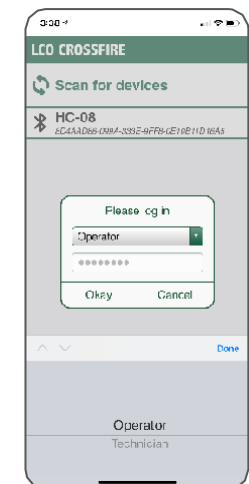


Figure 8: Mobile App Login

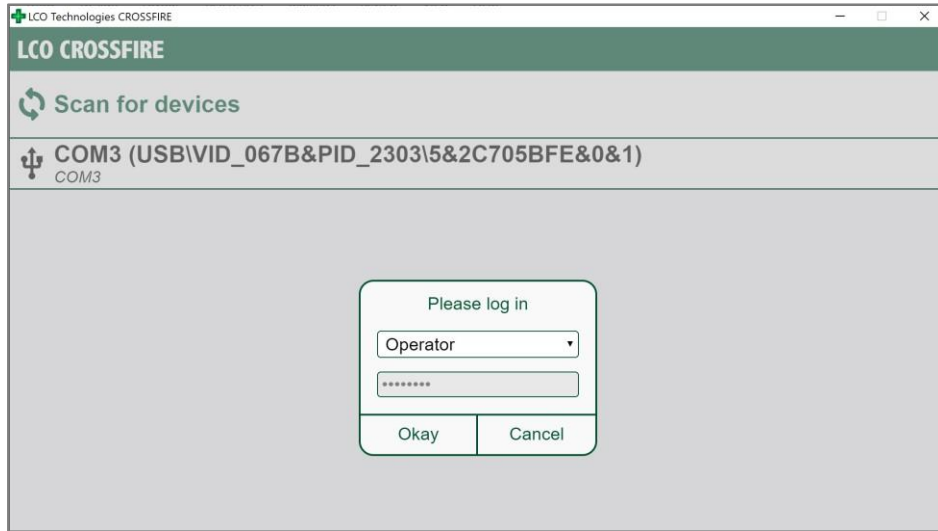


Figure 9: Computer Interface Main Page – Log in as Operator or Technician

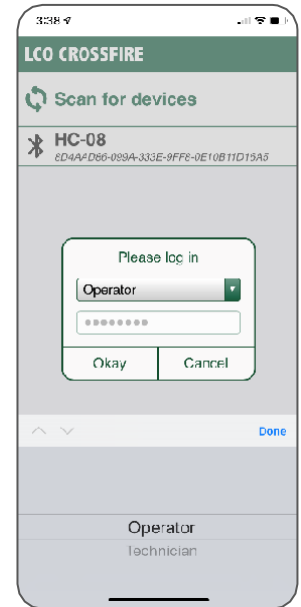


Figure 10: Mobile App Login

If connecting to the controller succeeds, the configuration and status panels will be enabled and will begin showing data from the *CROSSFIRE*. If the attempt to connect fails, an error message will be displayed (see: Troubleshooting – Connection Errors).

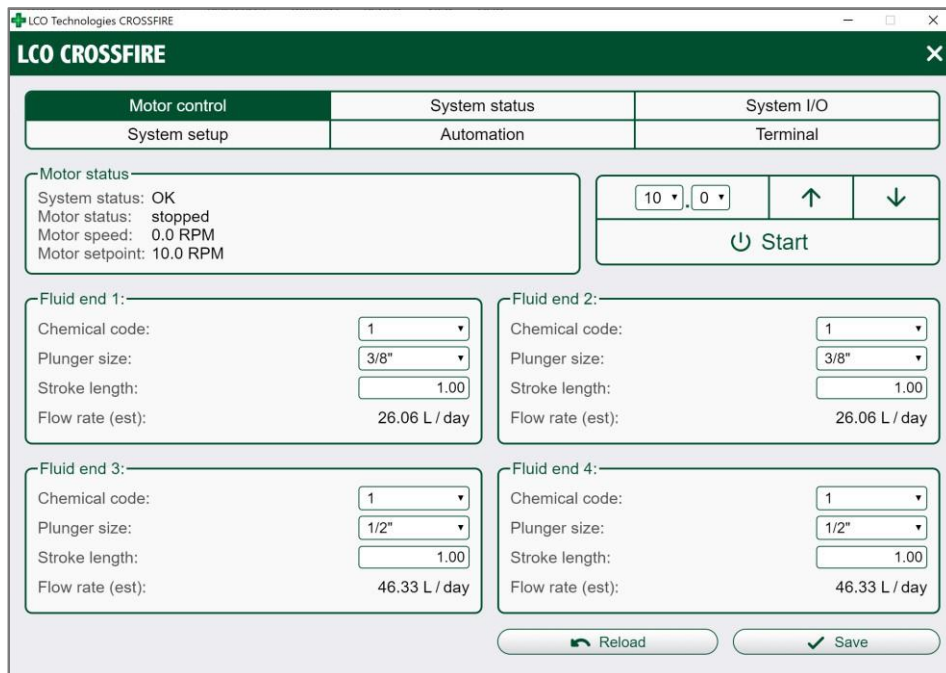


Figure 11: Computer Interface Main Page – Successful Login

Disconnect from Controller:

To disconnect from the controller, click the white X in the top right-hand corner.

Motor Control Tab

The *CROSSFIRE* can be configured either as a chemical injection pump, or an instrument air compressor. The software is default to the chemical injection pump. Therefore, upon initial log in, the motor control tab displays all pump and fluid end settings. Go to the “[system setup](#)” tab and change the “[device operating mode](#)” to compressor. For more details and screenshots from the “[system setup](#)” tab, refer to page 20.

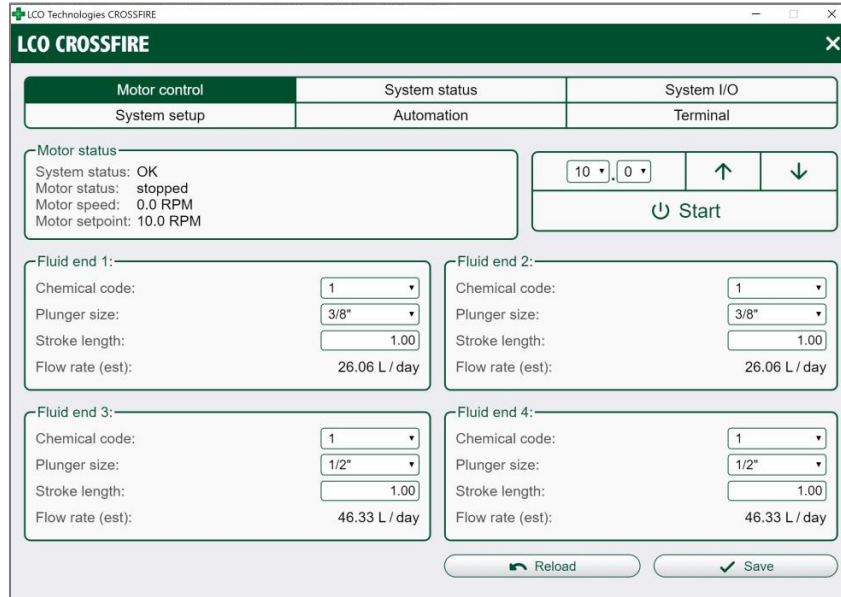


Figure 12: Computer Interface Main Page – Default Chemical Pump View

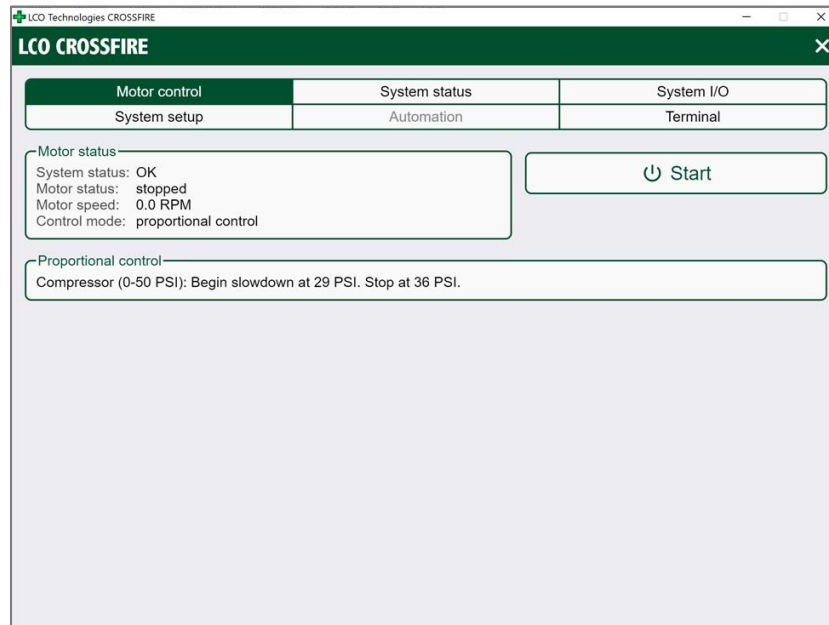


Figure 13: Computer Interface Main Page – Compressor Configuration View

Motor Status Panel

The motor status panel is used to check the status of the drive motor and control mode engaged. Once a compressor configuration is active; the control mode will read “proportional control”.



Figure 14: Motor Control Tab - Motor Status Panel – Compressor Configuration

Note: Once the compressor is in active proportional control mode, the auto restart function is automatically engaged. If the system loses power, the compressor will auto-restart once 24 VDC of power is available again.

Proportional Control Panel

The proportional control panel is used to break down the active proportional control mode engaged on the compressor. Changes to the proportional control mode must be done in the [system setup](#) tab, so this panel is for viewing and information only.

Note: Only users logged in as Technician can change the proportional control mode in the [system setup](#) tab. Operators do not have that functionality and can only view the tab.

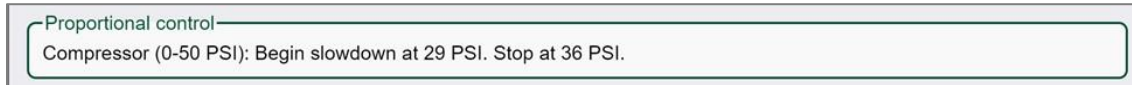


Figure 15: Motor Control Tab - Proportional Control Panel – Compressor Configuration “Stop @ 36 PSI” Selection

Start or Stop

The start or stop button is used to start or stop the compressor. Once the button is pushed, the motor status in the “motor status” panel will update accordingly.



Figure 16: Motor Control Tab – Start or Stop Button

Note: Any unsaved changes made to the settings will be lost.



System Status Tab

The [system status](#) panel provides detailed status and diagnostic information about the motor and controller:

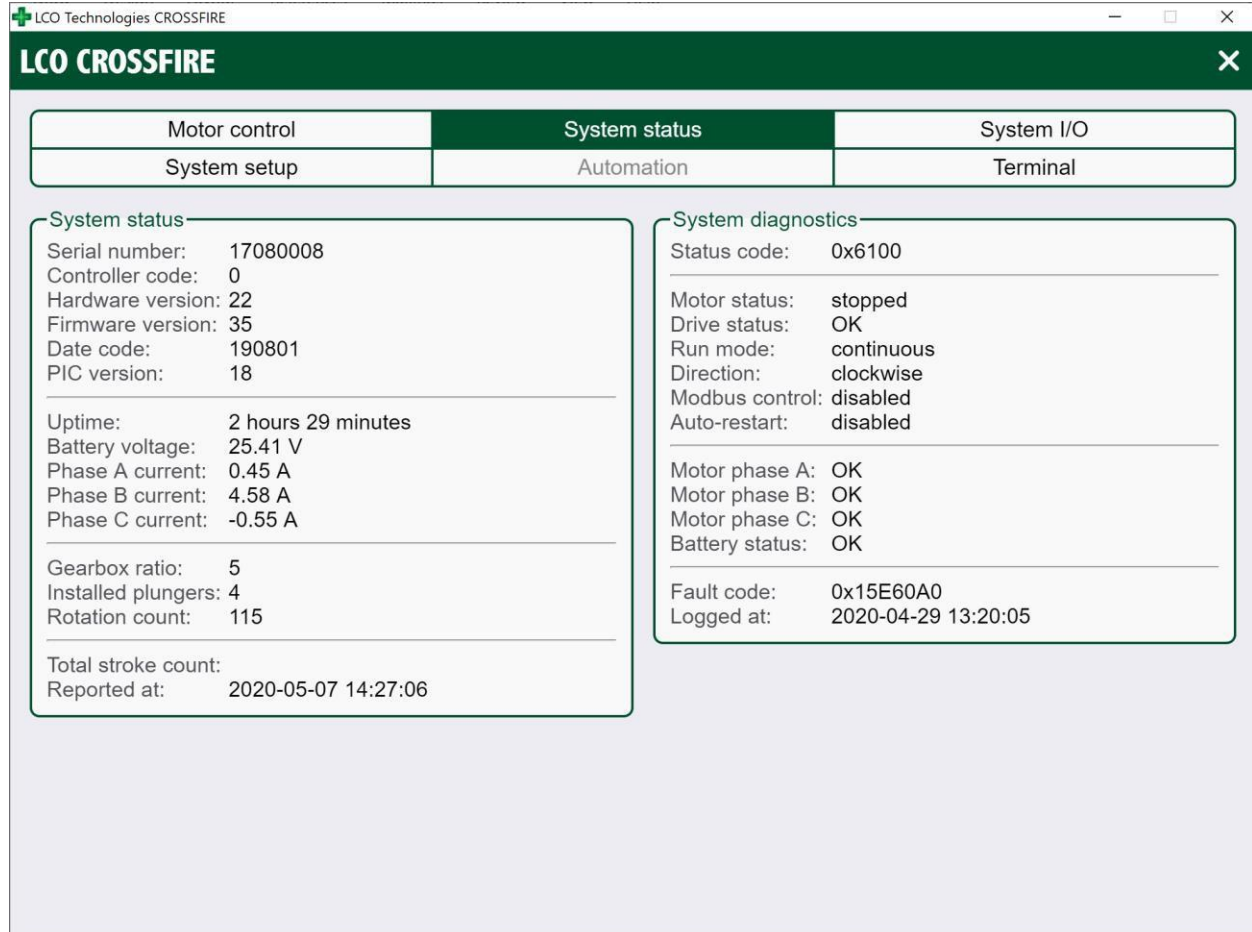


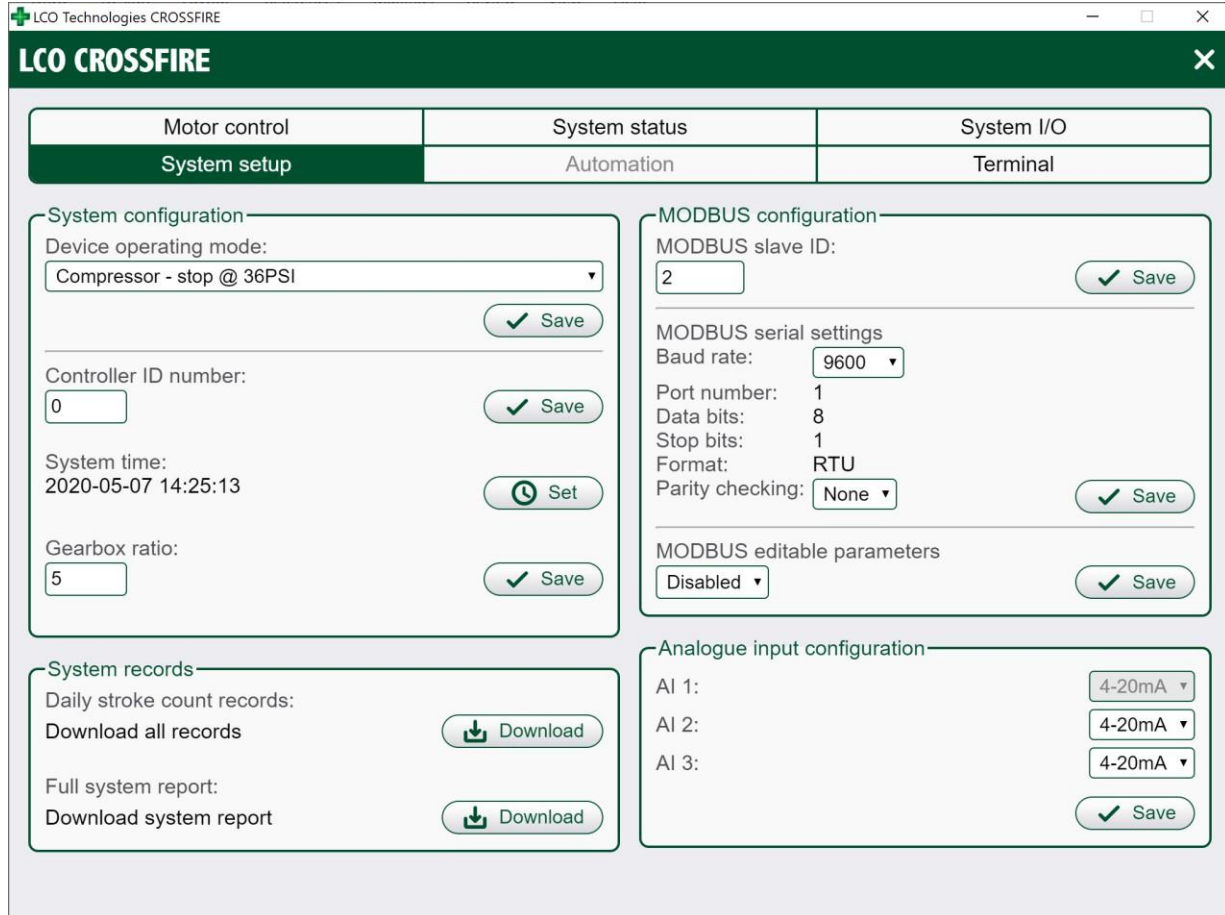
Figure 17: System status tab

[System status](#) shows the controllers unique serial number, hardware, firmware, uptime of the connected controller and the configured state of the compressor hardware. It also shows the total rotation count and total stroke count for the device.

[System diagnostics](#) displays the current system status code; underneath, a detailed breakdown of the code will describe system condition any detected faults if applicable. This information is updated every few seconds. The most recent fault record is listed below if applicable.

System Setup Tab

The [System setup](#) tab allows for setup and configuration of advanced controller features, download of record and system reports, and is divided into four regions:



The screenshot shows the LCO CROSSFIRE web interface. At the top, there's a navigation bar with 'Motor control', 'System status', and 'System I/O'. Below this, a sub-navigation bar highlights 'System setup' and includes 'Automation' and 'Terminal'. The main content area is divided into four sections:

- System configuration:** Includes 'Device operating mode' (set to 'Compressor - stop @ 36PSI'), 'Controller ID number' (set to '0'), 'System time' (set to '2020-05-07 14:25:13'), and 'Gearbox ratio' (set to '5'). Each has a 'Save' button.
- MODBUS configuration:** Includes 'MODBUS slave ID' (set to '2'), 'MODBUS serial settings' (Baud rate: '9600', Port number: '1', Data bits: '8', Stop bits: '1', Format: 'RTU', Parity checking: 'None'), and 'MODBUS editable parameters' (set to 'Disabled'). Each has a 'Save' button.
- System records:** Includes 'Daily stroke count records' and 'Full system report', each with a 'Download' button.
- Analogue input configuration:** Includes 'AI 1:', 'AI 2:', and 'AI 3:', each set to '4-20mA', with a 'Save' button.

Figure 18: System Setup Tab

- 1) System configuration
- 2) MODBUS configuration
- 3) System records
- 4) Analogue input configuration

Note: Operators will only have viewing access to this tab. In order to make changes to any configuration settings, the user must be logged in as Technician.



The [system configuration](#) settings are used to set the main operating device mode and reset or change controller parameters.

- [Device operating mode](#) is used to select between pump or compressor modes. The four compressor modes available include:
 - Compressor – stop @ 36 PSI
 - Compressor – stop @ 50 PSI
 - Compressor – Custom Curve (0-50 PSI)
 - Compressor – Custom Curve (0-100 PSI)
- Select the appropriate mode based on your application
 - *Compressor stop @ 36 PSI* and *Compressor stop @ 50 PSI* are the two standard curves with no additional configuration required
- *Compressor custom curves* require additional configuration to set the pressures at which the compressor should slow down and stop at (see figure 20)
- Press [save](#) to apply changes and activate device operating mode

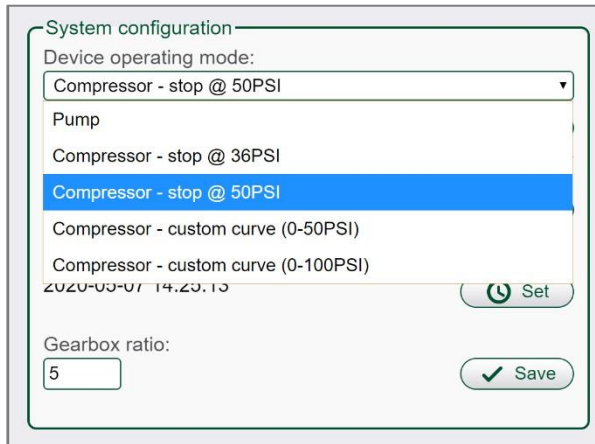


Figure 19: System Setup Tab – System Configuration Panel

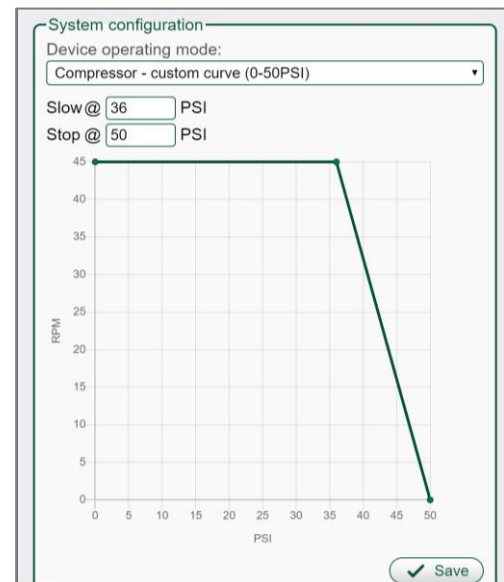
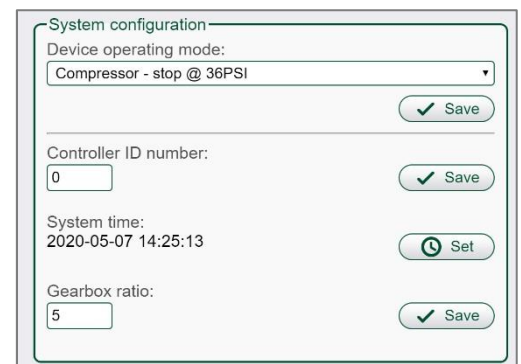


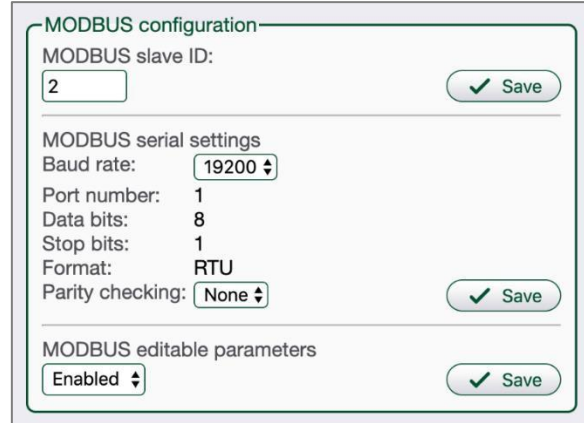
Figure 20: System Setup Tab – System configuration panel with custom compressor curve

- [Controller ID number](#) can be used to assign a number to the controller (any value between 0 to 255)
- [System time](#) sets the controller's system clock to the current date and time
- [Gearbox ratio](#) specifies the gear ratio of the installed gearbox on the motor (compressor ratio is 5:1)



Note: Compressor – Custom curve (0-100 PSI) is only available for users with a special-order high-pressure compressor. In this case, the pressure transmitter must be scaled to 0-100 PSI. Contact LCO directly with any questions and for special instructions prior to selecting this curve.

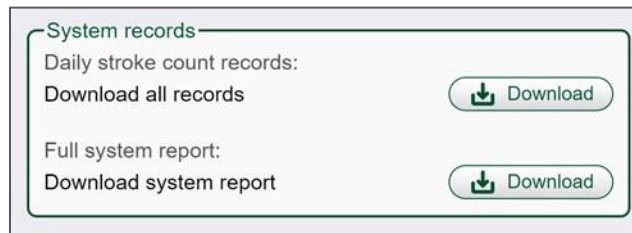
The **MODBUS configuration** settings are used to view and change the settings of the controller's MODBUS port, in order to properly integrate it with your SCADA system. Configurable options include **MODBUS slave ID**, **parity checking** and **baud rate**. **Port number**, **data bits**, **stop bits**, and **format** are automatically determined according to the MODBUS standard. The **Save** button will save the settings to the controller.



The screenshot shows the 'MODBUS configuration' window. It has three sections: 'MODBUS slave ID' with a text input field containing '2' and a 'Save' button; 'MODBUS serial settings' with dropdowns for Baud rate (19200), Port number (1), Data bits (8), Stop bits (1), Format (RTU), and Parity checking (None), with a 'Save' button; and 'MODBUS editable parameters' with a dropdown set to 'Enabled' and a 'Save' button.

Figure 21: System Setup Tab – Modbus Configuration Section

The **Systems record** section allows users to download a daily stroke count record log and full system report. By clicking download, the report will automatically save to your desktop computer.

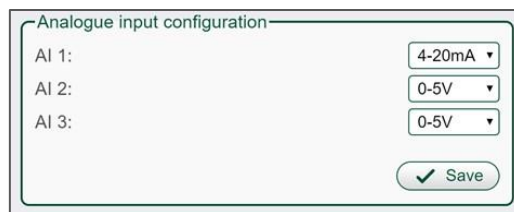


The screenshot shows the 'System records' section. It contains two rows: 'Daily stroke count records' with a 'Download all records' button, and 'Full system report' with a 'Download system report' button. Both buttons have a download icon.

Figure 22: System Setup Tab – System Record Section

Note: For mobile users, the app has an option to email or save the downloaded records. For iPhone users, the app will automatically save a copy of the file to the device, which can be found in the iOS system files app under “On My iPhone > CROSSFIRE > SystemReports”.

The **Analogue input configuration** section is used to set the Analogue inputs to 4-20mA or 0-5V. Once selected, press **save** to apply changes.



The screenshot shows the 'Analogue input configuration' window. It has three rows for AI 1, AI 2, and AI 3, each with a dropdown menu. AI 1 is set to 4-20mA, AI 2 is set to 0-5V, and AI 3 is set to 0-5V. There is a 'Save' button at the bottom right.

Figure 23: System Setup Tab – Analogue Input Configuration Section

Please note that all compressor curves will respond appropriately to a 4-20 mA pressure transmitter when wired with a 250 Ohm resistor, or a 0-5 V pressure transmitter. Ensure the pressure transmitter is scaled to 0-50 PSI and the correct analogue input is selected in the software. Refer to page 10 for wiring diagrams.

System I/O Tab

The [System I/O](#) panel is used to view the state of the controller's discrete input, discrete output, analogue input, and analogue output pins. Inputs will auto-populate when connected to the controller however, all I/O configuration for outputs must be done in the terminal tab. Specific control applications can be exercised under the [Terminal](#) tab, which will allow configuration of a wide variety of logic parameters. Please contact LCO Technologies directly for assistance with I/O configuration.

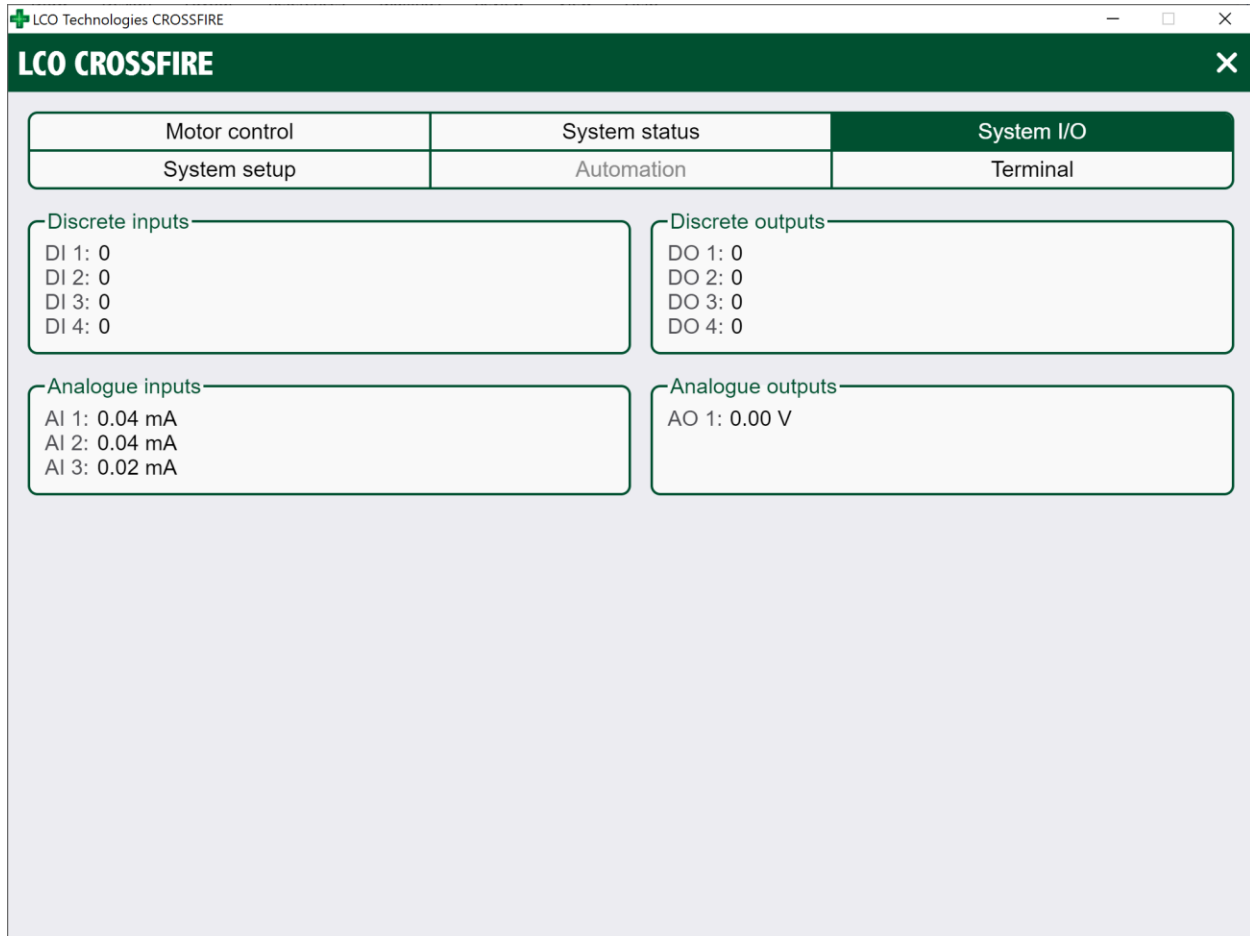


Figure 24: I/O Config Tab

Note: Monitored values are automatically refreshed every few seconds that the System I/O tab is open.

Automation Tab

The [automation](#) tab is only required for *CROSSFIRE* pumps and is not available when operating in compressor mode. The compressor is only controlled by the transmitter on the accumulator; therefore, the Automation tab is greyed out.

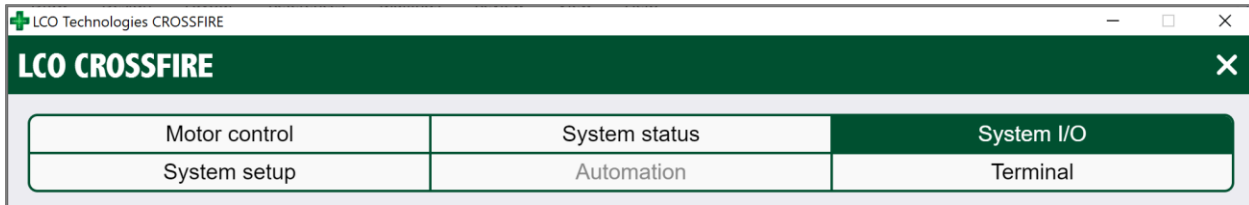


Figure 25: Automation Tab

Terminal Tab

The Terminal tab is available to Operators and Technicians however, the commands will be limited when logged in as Operator. This tab allows users to by-pass any software selections and speak directly to the controller. This tab can be used for troubleshooting to determine if communication errors exist on the controller or software and can also be used for more advanced configuration such as I/O commands specific to applications. For a full list of applicable commands contact LCO Technologies directly.

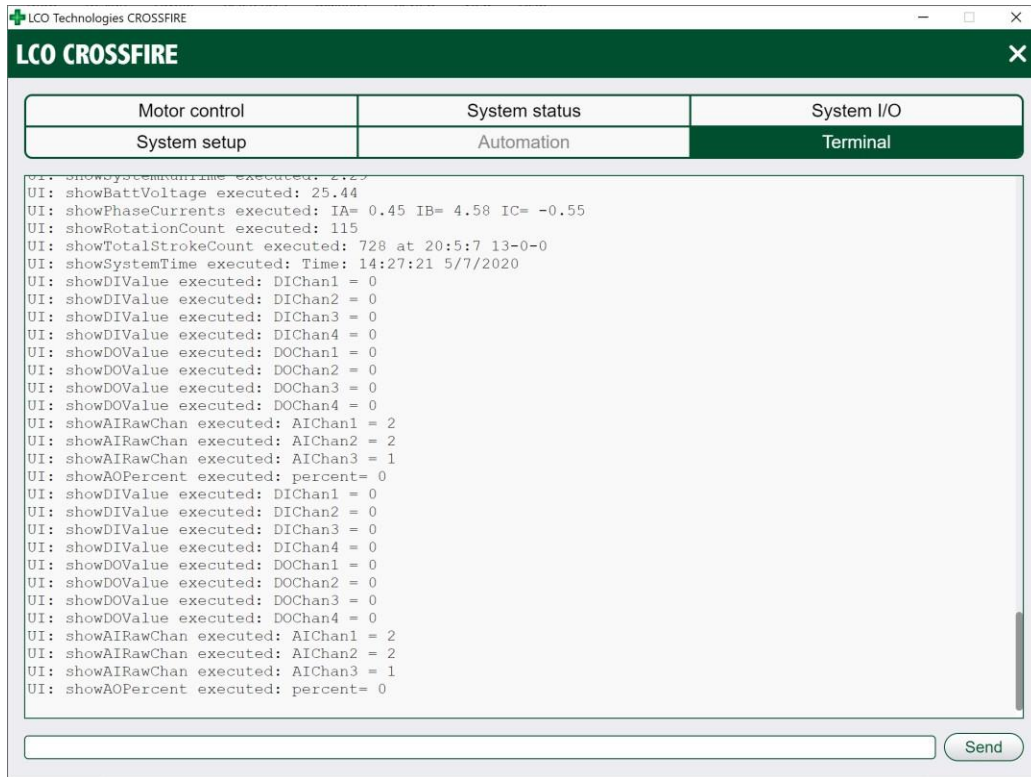
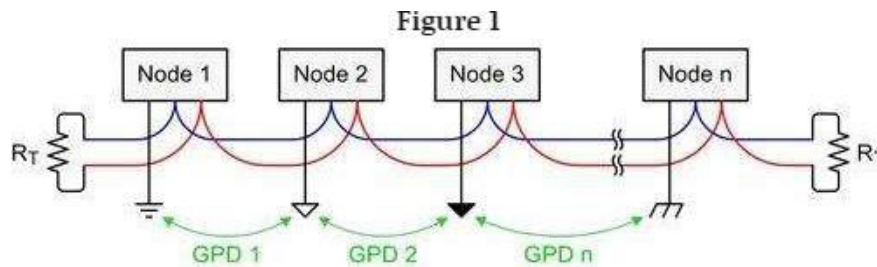


Figure 26: Terminal Tab

Frequently Asked Questions: Automation & MODBUS

- Q: Can you tie multiple CROSSFIRE controllers on the same RS485 Modbus
 - A: Yes, you can daisy chain multiple CROSSFIRE controllers on the same Modbus even with other devices set up as Modbus slaves. Every slave must have a unique Modbus Slave ID, from 1 to 247. 0 is reserved for the master. Default slave ID is 2 for the CROSSFIRE Controller.
- Q: Do you need to connect the GND terminal on the RS485 port?
 - A: No, connecting GND terminal is not mandatory for the 2-Wire RS485 bus. If the Modbus has multiple slaves and the site is electrically noisy, connecting all the slaves' RS485 GND to the master RS485 GND may help to improve Modbus communication. Ensure the RS485 GND should never be connected to the power supply ground or the safety ground.
- Q: Does the Modbus need to be terminated?
 - A: Yes, the trunk of this RS485 based Modbus should be terminated on both ends with a 120 Ohm resistor across RS485+/A+ and RS485-/B-. This usually means the master or RTU and the last slave at the end of this RS485 bus.



- Q: What are the valid baud rates and serial com settings?
 - A: Default is 9,600. Other choices are 14,400 and 19,200. 8 data bits, no parity, 1 stop bit and no flow control.
- Q: How often can you poll a CROSSFIRE controller?
 - The CROSSFIRE controller can be polled every 500ms
- Q: Can you poll all the registers provided by the CROSSFIRE Controller?
 - Yes, you can poll all 300+ registers **but we do not recommend this** as it will severely slow down Modbus communication due to the heavy traffic on the RS485 bus. There is no reason to poll all the registers, most sites require 40 registers or less to fully control and monitor a pump or a compressor onsite. We recommend you choose the registers most important to monitor the CROSSFIRE. **In an effort to reduce power consumption we have limited the maximum number of read or write registers to eight (8) per poll.**
- Q: Where can I get the Modbus register map?
 - You can get the latest Modbus register map from LCO Technologies.

- Q: Do you need to put the controller in remote control mode in order to read its registers?
 - A: No, you can read any register in both local and remote modes.
- Q: How do you know the current status of the pump or the compressor?
 - Connect with the computer or app interface software and select the “System Status” tab. This tab provides detailed status and diagnostic information.
- Q: If a pump or compressor has faulted and stopped for an unknown reason, how can I find out the fault code to troubleshoot if it doesn’t show up as an active fault in the “system status” panel?
 - Depending on which version of the software you are using, the systems status tab will display the most recent fault record, under systems diagnostics, if available.
 - Alternatively, as the CROSSFIRE controller records the last fault code in the non-volatile memory, it can be accessed through the Terminal Tab as well. Select the “terminal” tab to send commands to the controller directly. Enter "**showFaultRecord**" and click the send button. The controller will respond with a time tag and a 6 digits hex number. The last two digits of the hex number is the fault flag.
 - 01: Motor stalled due to mechanical jam
 - 02: Motor overload causing over-current or under-voltage
 - 04: Over-current detected by firmware
 - 08: Battery/power supply under-voltage
 - 10: Battery/power supply over-voltage
 - 20: Motor phase A wire is discounted
 - 40: Motor phase B wire is discounted
 - 80: Motor phase C wire is discounted
 - 6X: Motor driver ASIC is damaged (where X is any single digit hex number)
 - Example: faultRecord: 20:4:15 13-11-23: 0x6460**08**

Fault Codes

Fault Code	Details	Suggested Troubleshooting
Motor phase A disconnected Fault Code: 20	Conductor wire from motor to Phase A has been disconnected	Field repairable – Reconnect conduit wire to controller – If conductor wire is broken, please replace as need be
Motor phase B disconnected Fault Code: 40	Conductor wire from motor to Phase B has been disconnected	Field repairable – Reconnect conduit wire to controller – If conductor wire is broken, please replace as need be
Motor phase C disconnected Fault Code: 80	Conductor wire from motor to Phase C has been disconnected	Field repairable – Reconnect conduit wire to controller – If conductor wire is broken, please replace as need be
Battery over voltage Fault Code: 10	Battery voltage is over 32 V	Field Repairable – Adjust power supply to ensure 24 V is available to the <i>CROSSFIRE</i> – Ensure you have a check valve installed in between the compressor outlet and the accumulator tank to prevent back pressure
Battery under voltage Fault Code: 08	Battery voltage is under 18 V	Field Repairable – Adjust power supply to ensure 24 V is available to the <i>CROSSFIRE</i> – Check that all conductor cables are correctly attached to the controller (reference page 9 for more information)
Motor Status: Fault Detected Fault Code: 02 ² or 04 ²	Motor has stalled, due to: – Operating outside compressor design parameters – Insufficient voltage or current – Mechanical obstruction	Field Repairable – Ensure the maximum torque requirements are within the motor limits – Clear any mechanical obstruction that is preventing motor rotation – Check power supply/battery voltage and current capacity – Check that all conductor cables are correctly attached to the controller (reference page 9)

Motor drive status: faulted, motor overload, or controller needs repair Fault Code: 01⁴	Motor overload due to mechanical obstruction or insufficient power supply Or Controller is damaged and requires repair	Field Repairable – If overload is caused by mechanical obstruction or insufficient power supply, this is field repairable – Clear any mechanical obstruction that is preventing motor rotation – Ensure the power supply has sufficient current capacity at the maximum load so that supply voltage will not drop below the required 24 VDC – Check that all conductor cables are correctly attached to the controller (reference page 9 for more information) Not Field Repairable – If the problem persists after following the suggested troubleshooting steps as listed above, your controller may require repair or replacement – Talk to your supplier for further instructions – Go under “System setup” tab, press “Download full system report” and a spreadsheet will automatically save to your computer desktop. The supplier may request this.
Motor drive status: faulted Fault Code: 30 or 3X	Two phases (such as phase A and phase B) read as broken, one phase (such as phase C) OK	Not Field Repairable – This fault code indicates that the IC Component on the controller had been damaged by excessive voltage – This damage can be confirmed in the software terminal tab – Start the compressor and read the generated values listed in the terminal tab – The line of interest will be “Motor Start: Resistor A” and “Motor Start: Resistor B” If either of these values exceed 0.5ohm or read “INF” the IC is damaged

⁴ Please note that fault codes 01, 02, and 04 may have similar symptoms and resolutions

Controller Troubleshooting

Connection Errors

When attempting to connect to the controller, a connection error may occur. The following table lists common errors, and solutions:

Error Message	Description & Solution
Error: Password must not be blank	To successfully login to the controller, the password must be entered. <i>Possible solutions:</i> 1) Retry connection and enter password (password is case sensitive)
Could not connect to controller: No response	When attempting to connect to the controller, the software received no response. <i>Possible solutions:</i> 1) Ensure that the serial cable or Bluetooth serial adapter used to connect to the controller is inserted securely into both the computer and the <i>CROSSFIRE</i> controller. 2) If you are connecting using a Bluetooth serial adapter, you may be out of signal range or near a radio interference source. Move closer to the controller. 3) Ensure the correct COM port is listed (see: Troubleshooting – COM Port Issues). 4) Ensure the <i>CROSSFIRE</i> controller is powered on
Could not connect to controller: Unknown response	When attempting to connect to the controller, the software received an unrecognized response. <i>Possible solutions:</i> 1) Ensure that the serial cable or Bluetooth serial adapter used to connect to the controller is inserted securely into both the computer and the <i>CROSSFIRE</i> controller. 2) Ensure the correct COM port is listed (see: Troubleshooting – COM Port Issues). 3) Ensure the BAUD rate listed is correct (default – 115200) 4) If the problem persists, try connecting with an alternate RS232 cable or Bluetooth serial dongle.

Could not connect to controller: Incorrect password	When attempting to connect to the controller, the wrong password was provided. <i>Possible solutions:</i> 1) Retry connection and ensure you have the correct password (note: the password is case sensitive) 2) Ensure you are connecting under the right user (operator or technician) that corresponds to the correct password
Disconnected: Login session with controller expired	For security reasons, the login session with the controller is automatically terminated after one hour. This can be configured to customize an alternate logout time period if requested. <i>Possible solutions:</i> 1) Reconnect and log back in to the controller.
Disconnected: Communication with controller lost	The software lost connection to the <i>CROSSFIRE</i> controller for unknown reasons. <i>Possible solutions:</i> 1) Check that the RS232 serial cable or Bluetooth serial adapter has not come loose either from the computer or from the <i>CROSSFIRE</i> controller. 2) If connecting using a Bluetooth serial adapter, the connection may have been lost due to signal interference or from moving too far away from the <i>CROSSFIRE</i> controller. Move closer to the controller and away from any radio sources. 3) The <i>CROSSFIRE</i> controller may have lost power. Check that the controller is powered on and that the system voltage level is adequate.

COM Port Issues

If the software continues to have trouble connecting to the *CROSSFIRE* controller, it may be caused by the serial link to the controller.

- 1) Select a different COM port in the connection window
- 2) Close all other software that could be using the serial connection
- 3) Close and reopen the *CROSSFIRE* software
- 4) Restart the computer

Other Miscellaneous Issues

If the software is having trouble saving configurations, or showing other miscellaneous problems or inconsistencies, please ensure you have the most up-to-date software version by visiting www.lcotechnologies.com/resources.html and downloading the software (zip file password: crossfire2017). The top menu bar within the software will indicate the version number for your reference. If these problems persist after downloading the most recent software version, please contact your supplier.

CROSSFIRE Maintenance

The *CROSSFIRE* requires minimal maintenance. Below is a list of recommended maintenance practices. The recommended time frame is estimated and may need to be adjusted based on usage.



Warning: Customers must exercise standard lockout procedures for electrical equipment prior to servicing any component on the *CROSSFIRE*



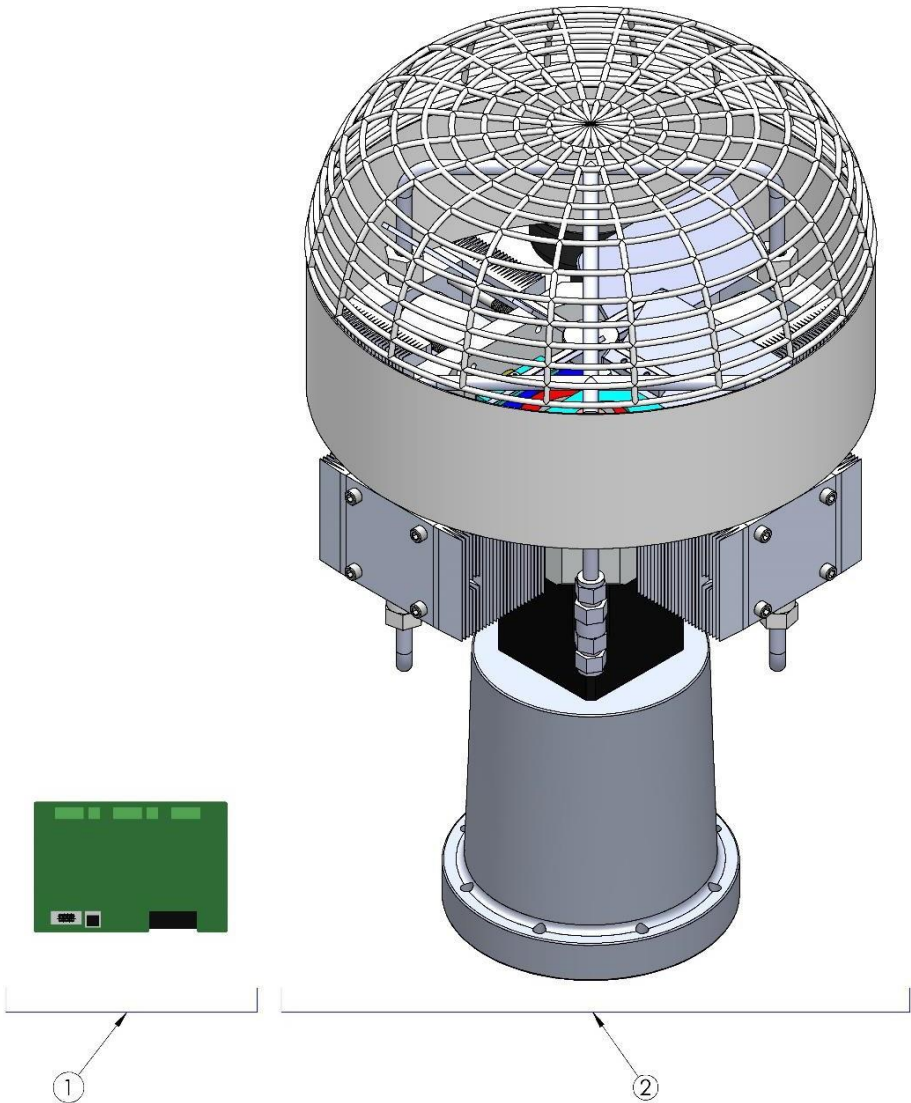
Warning: It is critical when completing inspections and required maintenance, to take appropriate safety protocols and take all precautions to keep compressor components clean. The introduction of small particles, dirt, or even Teflon tape scraps from tubing may affect compressor performance and cause internal scoring of the cylinder which may impact the airtight seal. Damage from improper maintenance will not be covered by product warranty.

Maintenance Required & Recommended Time Frame	Instructions
Open and Drain Drip Pockets (Daily to Monthly–Automate)	– At minimum, Monthly – Open all needle valves and/or ball valves that are drip valves in your system ○ Drain any moisture or dirt captured – Close valves once finished – Adjust frequency of task as per site requirement
Change Oil in Top Works (Every 2 Months)	– Complete an oil change monthly, or every two months as required – Complete if the oil level gets low ○ Oil should normally cover about half of the thrust rod – Oil Drain: Rotate the 90-degree elbow connected to the oil drain ball valve so it is pointing down – Open the ball valve and drain the oil into a container – dispose appropriately – Complete a visual check of moving components – ensure all parts visible appear to be in good working order with no damage – Rotate the 90-degree elbow so it is pointing up – tighten nut/ferrule – Oil Fill: Locate oil squeeze bottle and fill with 7 fluid oz of hydraulic oil ○ Recommended: Hydraulic Oil - ISO Weight 46 ○ Squeeze the new oil into the tubing to fill the top works back up ○ When finished, close ball valve – Check for any oil leaks <i>Photo Demonstration on Next Page</i>

	 <i>Oil Drain</i>	 <i>Oil Fill</i>
Internal Soft Goods Maintenance (Every 6 months to Annual)	– Depending on usage and load, the compressor soft goods components must be replaced as a part of <u>regular maintenance</u> – Please contact LCO Technologies directly for parts and instructions	
Air Filter Replacement (Annual)	– Remove the old air filter from tubing – Replace with a new filter ○ Part Number: LCOF-8477259 ○ The use of other filter types is not recommended as they may increase current draw – Ensure the filter is protected from rain/snow accumulation and re-installed at a 45-degree downwards angle	

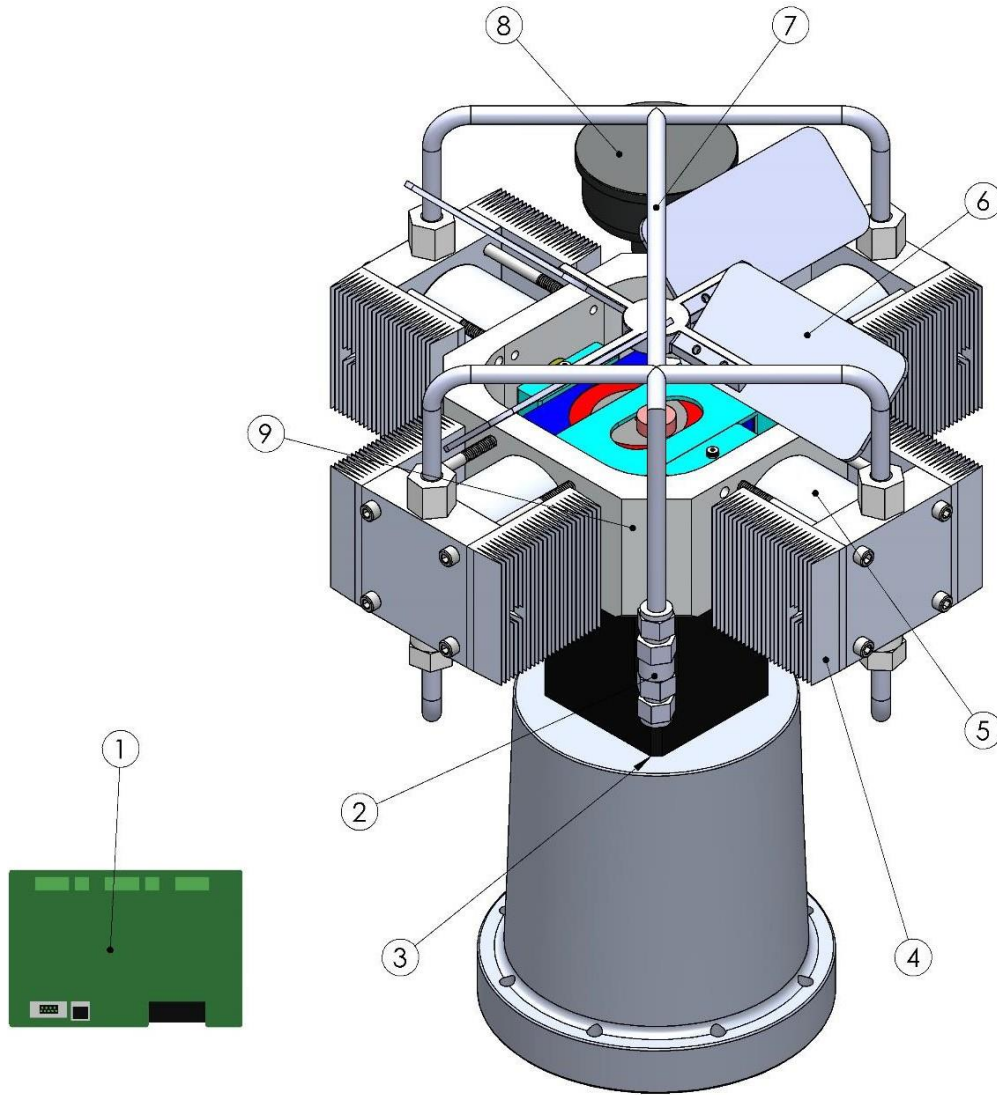
CROSSFIRE Instrument Air Compressor Technical Drawings

Assembled CROSSFIRE Instrument Air Compressor with Fan Cover:



Item	Part Number	Part Description
1	LCOC-1000-B	CROSSFIRE Basic Controller
2	LCOD-Compressor	CROSSFIRE Instrument Air Compressor Complete with Fan, PANAM Check Valve, Tubing, and Filter

Assembled CROSSFIRE Instrument Air Compressor without Fan Cover:



Item	Part Description	Material
1	Smart Controller (Part Number: LCOC-1000-B)	Fiber glass top plate
2	PANAM Check Valve (PCV-06-SS-OD)	316 Stainless Steel
3	Gear Box and Motor	Aluminum and Steel
4	Heat Sink	Aluminum
5	Cylinder with Enclosed Piston	Stainless Steel
6	Fan	Aluminum
7	Tubing	316 Stainless Steel
8	Filter (LCOF-8477259)	Metal/Plastic
9	Common Base	Aluminum

CROSSFIRE Compressor Troubleshooting

Issue	Suggested Resolution
Software Connection Issue	– Reference Page 29 for a full list of suggested troubleshooting steps – Ensure you are using the most up-to-date software ○ Version indicated on the top menu bar of the software for reference – Download on www.lcotechnologies.com/resources.html – (Zip File PSW: crossfire2017)
Compressor Stall – Fault code on controller flashing red – Compressor not running	Option 1: – Open and connect to <i>CROSSFIRE</i> interface software – Click on the system status panel – Check for fault code (reference page 27) and troubleshoot as recommended Option 2: – Check battery voltage on system status panel in <i>CROSSFIRE</i> Interface Software – Connect data logging Multi Meter and check battery voltage before start-up and during start-up ○ Compressor requires 24V of power supply ○ If available voltage on site is below 18V or above 32V the compressor will stall to prevent system and solar infrastructure damage Option 3: – Turn compressor off and ensure power supply is off – Remove the custom fan cover and place a socket over the hex nut on the fan ready rod (M5 or M6) – Manually turn the socket to in turn, rotate the motor – Feel for any irregularities or barriers ○ If there are any irregularities, contact your supplier for a top work replacement kit Option 4: – Ensure a check valve is installed on the outlet of the compressor ○ This ensures that no back pressure from the accumulator bottle is acting upon the compressor – Reference page 8 for drawings Option 5: – Check that all conductor cables are attached with proper end ferrule connectors and clamped down appropriately – Double check that all screw terminals are tightened down sufficiently

Motor not spinning as expected – Detected by: Software motor status reads “running” however motor and compressor is not spinning – Potential Fault Code listing two motor phases broken, and one ok (such as phase A and phase B broken, phase C ok)	– Go to the “system status” tab and look at the system diagnostics section ○ Read the fault code ○ If fault code indicates two phases broken, other one ok, the controller IC component may be damaged from power surge on site – Go to the “terminal” tab, start motor and read generated motor start values – Two lines of interest: ○ MotorStart: Resistor A ○ MotorStart: Resistor B – If the resistor value listed is reading a numerical value below 0.5 ohms, the IC component is not damaged – If the resistor value listed is above 0.5 ohms, or reads “INF” for infinite, the IC component has been damaged – Contact LCO Technologies for more assistance – Controllers with damaged IC components can be repaired at the factory for a small fee
Poor Compressor Performance – Delivering less air than expected – Not keeping up with demand	Option 1: – Open and drain all dirt pockets ○ There may be extra moisture or particles present in your system – Check the filter and ensure there is no blockage ○ Replace the filter if necessary (page 32) Option 2: – Contact your supplier for a top works replacement kit or soft goods rebuild kit – The internal valve or cylinder components may require maintenance or replacement Option 3: – Turn off compressor and isolate lines to the instruments and accumulator bottle – Hook up a Nitrogen bottle to the inlet on the compressor ○ Push compressed Nitrogen at a set pressure through the system ○ Listen for any leaks ○ Check pressure to see if there is a drop-in pressure indicating a leak ○ Check that all tubing is tight and fully seated Option 4: – Check battery voltage on system status panel in <i>CROSSFIRE</i> interface software – Hook up data logging multi meter and check battery voltage before motor start-up and during start-up – The motor requires 24V of power supply ○ If available voltage drops above or below that point, the compressor may have decreased performance

Not modulating pressure with transmitter	– Confirm that all electrical wiring is attached and installed correctly ○ See page 10 for wiring diagrams – Check for any wires that may have become disconnected or broken – Ensure you have properly selected the compressor mode in the <i>system setup</i> tab and the analogue input is selected correctly as either 4-20mA or 0-5V ○ Check that your transmitter is scaled (0-50PSI standard) and responding as expected ○ Replace the transmitter if required
Fan Blade Issue – Unscrewed over time – Hitting fittings or fan enclosure	Loose Fan Blades: – If the fan blades have become loose, turn off the compressor and ensure the power supply is off – Remove the fan cover and use a socket to remove the M5 or M6 hex nut and ready rod holding the fan blades on – Apply 2-3 drops of Loctite⁵ to the ready rod and re-screw the rod and fan into place – Place the fan cover back on Blades Hitting Fittings or Enclosure: – Turn off the compressor and ensure the power supply is off – Remove the fan cover – Bend the thin Aluminum fan blades back to its original form ○ Use industrial scissors to trim the blade edges if need be – Manually turn to rotate the fan blades to confirm they do not hit the fittings or enclosure anymore
Loose Gearbox Collar – Detected by: motor seems to be running, but the compressor and fan blades are not turning	– A clamp in the gearbox grips the output shaft of the motor (called gearbox collar) – Access the collar through two plastic plugs on the side of the gearbox. – Remove plug and reach in with a 4mm Allen key to spin the collar until the Allen bolt is facing straight out through the plug hole. – Tighten the Allen bolt. – There are two Allen bolts that are 180 degrees opposite to one another; tighten both ○ Note: Some gear boxes will have two plugs, but only one bolt to tighten the Gearbox collar. This is normal; tighten the one bolt as needed.

⁵ Recommended Brand: Loctite ® 242 – Medium Strength Nut & Bolt Threadlock

Motor or gearbox out of alignment – Detected By: rubbing sound, excessive grinding or noise coming from gearbox or motor	– Remove the compressor top works from the gearbox motor drive system ○ Remove the fan cover and use a socket to remove the M5 or M6 hex nut and ready rod holding the fan blades on ○ Remove the four M8 bolts connecting the top works from the gearbox ○ Pull the top works up and off the gearbox ○ Start the compressor (gearbox and motor still connected) and observe – Remove the gearbox from the motor ○ Remove the two plugs on either side of the gearbox ○ Reach inside the gearbox plug hole with a 4mm Allen key and loosen the collar bolt ○ Repeat on the other side of the gearbox; there are two Allen bolts holding the collar in place ○ <i>Note: Some gear boxes will have two plugs, but only one bolt to tighten the Gearbox collar. This is normal; tighten the one bolt as needed.</i> ○ Remove the four M6x40mm bolts holding the gearbox on the motor ○ Pull the gearbox up and off the motor ○ Start the motor and observe – By removing and running the motor separate from the gearbox and top works, this will help identify which component is causing the excessive noise – Consult the LCO factory for further assistance and relay test results
Worn out top works components Detected By: Slack or movement between the white load block and trunnions, thrust rod and trunnions, or any other component in the top works	– If any movement between components can be identified, contract LCO Technologies for assistance ○ Video and photo's may be requested to help identify which components are damaged – Replacement parts are available for purchase
Undetected issue – Controller or Interface is not responding	– Go through all interface troubleshooting steps and the above compressor troubleshooting steps – If no resolution, reset and reboot the controller and computer – Reset controller by pressing a pin into the reset button on the controller
WARNING: Pressing the reset button on the controller will reset all data logged including stroke count and will permanently erase the stored values. Proceed with extreme caution.	



CROSSFIRE Return and Repairs

The below list dictates which parts can be repaired in the field and which parts constitute a return and replacement if under warranty.

Note: When repairing a unit or disassembling to be sent back for replacement, please take every step to ensure the safety of people and environment. Follow all protocols as set out by your company and ensure all employees are properly trained prior to disassembly.



Warning: It is critical when completing all repairs, to take precautions to keep all compressor components clean. The introduction of small particles, dirt, or even Teflon tape scraps from tubing may affect compressor performance and cause internal scoring of the cylinder which may impact the airtight seal.

Repairs

- Compressor Top Works
 - Top works require maintenance and replacement of soft goods on a regular basis
 - Minimum frequency every 6 Months, or determined by performance
 - Purchase top works replacement or soft good rebuild kit
 - If components outside of standard soft goods are damaged by improper maintenance or debris, individual components can be purchased from your supplier

Replacement

- Motor/Gearbox
 - If the motor or gearbox stops working out in the field, this will constitute a replacement if under warranty
- Controller
 - If the controller stops working, and it is not due to a troubleshooting error, this will require a complete replacement unit if under warranty

Warranty Exceptions:

- Compressor Top Works, Motor, and Gearbox
 - Damage from improper compressor maintenance or the introduction of debris/dirt during repairs will not be covered by warranty
 - Full warranty evaluations can be performed by the factory if the cause of damage is unknown
 - Rebuild components can be purchased for cost effective repair
- Controller
 - Damage from improper installation, voltage surges, or poor power conditions will not be covered by warranty
 - Controllers can be repaired for a fee, contact LCO factory for more details

LCO Technologies

#115, 1829 54 Street SE
Calgary, AB T2B 1N5

1-403-860-9899
info@lcotechnologies.com
www.lcotechnologies.com