LOFA EM500 Operation and Troubleshooting

Introduction

This document provides general information on LOFA Industries EM500 control systems operation and troubleshooting. The EM500 allows the operator to see the electronically governed diesel engine status at a glance featuring LOFA's powerful First Fault Diagnostics (FFD). After the ECU (Engine Control Unit) pinpoints a failure, FFD stores it in memory and alerts the end user via a single bright LED. FFD directly monitors battery charge and, if reported by the ECU, low oil pressure, high temperature, coolant level, fuel pressure and diagnostic blink code. The microprocessor-based solid-state design uses high power semiconductors instead of outdated electromechanical relays to ensure reliable high current switching.

Note

Most problems with ECU controlled engines can be pinpointed via the ECU diagnostic messages. Use the DPG or ECU diagnostic tool to view fault codes.

All engine state information and diagnostic codes displayed by the EM500 are provided by the ECU.

The EM500's integral throttle control requests the ECU adjust the engine speed via voltage (potentiometer simulation), Pulse Width Modulation (PWM) or CANbus. A single momentary toggle switch adjusts the throttle speed request within the configurable engine speed limits. When teamed with LOFA Auto Start/Stop controls, the EM500's flexible throttle control and configurable throttle ramp time makes an ideal automatic start/stop control system. Alternately, the EM500 can be programmed to operate in dual speed mode via a toggle switch or external input.

Standard VDO Cockpit International analog gauges display current operating parameters reported by the ECU, including RPM, engine temperature and oil pressure. Additional gauges can be installed for other measurements. With the addition of the optional Diagnostic Program Gauge (DPG), virtually any SAE J1939 parameter or diagnostic code can be monitored.

The DPG features a backlit LCD display with three push buttons in a 2" gauge. Additionally, three bright LEDs indicate Preheat, Service Due and Auxiliary input. The LCD is clearly readable in both bright sunlight as well as total darkness. The DPG allows each system to be field configured to suit the customer's unique requirements. After initial configuration, the DPG can be removed in cost sensitive applications.

Some of the EM500 configurable features include:

- Engine brand (Caterpillar, Deutz, John Deere, Perkins, etc.)
- Throttle type (Voltage, PWM or CANbus)
- High idle speed
- Throttle ramp time
- Charge indication mode (lamp input or system voltage)

The standard system terminates to a sealed Deutsch weatherproof plug. This wiring solution offers a robust connection that performs well in harsh environments and allows simplified installation. The design allows efficiently installing custom plug-and-play engine wiring harnesses as well as standard harness extensions.

Warning

When replacement parts are required, LOFA Industries recommends using replacement parts supplied by LOFA or parts with equivalent specifications.

Failure to heed this warning can lead to premature failure, product damage, personal injury or death.

Important Safety Information

The warnings in this publication are not all inclusive.

LOFA Industries cannot anticipate every potential hazard.

Appropriate safety rules and precautions should be followed with any tool, work method or operating procedure.

Improper procedures, tools and materials may cause damage or make the equipment unsafe to operate.

Only persons with appropriate training, skills and tools should perform these functions.

Improper operation, maintenance or repair of this product can be dangerous and may result in injury or death.

Do not operate or perform any maintenance or repair on this product until all operation, maintenance and repair information is read and understood.

The information, specifications, and illustrations in this publication are based on information available at the time of publication.

All items are subject to change at any time without notice.

Operation

Turning the control system key to the run position starts a self-test which causes all LEDs to illuminate once, the analog gauges (temperature and pressure) to calibrate and energizes the ECU. After self-test, the LEDs indicate the state of the faults they monitor. The normal indication before starting is battery charge in most applications. If the LED is not illuminated at this time it may indicate the inputs are not properly connected.

If the ECU is preheating when the key switch is turned to the run position, the Preheat LED is illuminated. Preheat time varies with atmospheric and engine conditions. After waiting for the Preheat LED to extinguish, the engine is cranked by turning and holding the key switch in the start position until the engine starts.

Note

The ECU will not preheat unless conditions warrant. If necessary, starting the engine may be attempted by turning the key to the start position without waiting for preheat to expire.

The key switch is spring loaded to return automatically to the run position when released.

Note

The key switch is equipped with a mechanical start locking device.
An attempt to re-crank the engine can only be made by turning the key switch to the off position to reset the start locking mechanism.

Indicators

Battery LED (Red)

A solidly illuminated Battery LED indicates a battery charge failure. A battery charge failure may be caused by a faulty alternator, broken drive belt or the alternator not excited. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly. Irregular blinking of the Battery LED may indicate a failing charge circuit. The system can be configured for indication via charge lamp (D+) circuit of the alternator or battery voltage as reported by the ECU.

Oil Pressure LED (Red)

A blinking Oil Pressure LED indicates low oil pressure warning reported by the ECU. A solidly illuminated LED indicates the ECU is reporting oil pressure failure.

Note

ECU programming determines the response to warnings and failures.
Typically the ECU can be programmed to shutdown, derate or run to failure.
The EM500 only displays ECU reported conditions.

Warning

Low oil pressure is not an indication of low oil level.

For best possible protection LOFA recommends using our solid-state oil level shutdown switch.

Temperature LED (Red)

A blinking temperature LED indicates high temperature warning reported by the ECU. A solidly illuminated LED indicates the ECU is reporting high temperature failure.

Note

ECU programming determines the response to warnings and failures.
Typically the ECU can be programmed to shutdown, derate or run to failure.
The EM500 only displays ECU reported conditions.

Warning

If the temperature sensor is not in contact with coolant due to coolant loss the engine is not protected from overheating.

For best possible protection, LOFA recommends using our solid-state coolant level shutdown switch.

Coolant Level LED (Red)

A blinking coolant level LED indicates a low coolant level warning reported by the ECU. A solidly illuminated LED indicates the ECU is reporting low coolant level failure.

Note

ECU programming determines the response to warnings and failures.
Typically the ECU can be programmed to shutdown, derate or run to failure.
Coolant level monitoring is not supported by all engine configurations.
The EM500 only displays ECU reported conditions.

Fuel PSI LED (Red)

A blinking fuel PSI LED indicates a fuel pressure warning reported by the ECU. A solidly illuminated LED indicates the ECU is reporting fuel pressure failure.

Note

ECU programming determines the response to warnings and failures.
Typically the ECU can be programmed to shutdown, derate or run to failure.
Fuel pressure monitoring is not supported by all engine configurations.
The EM500 only displays ECU reported conditions.

Fault Code LED (Red)

The Diagnostic Code LED displays the blink code as provided by the ECU. Simple diagnostics are provided via a pattern of fast and slow blinks by some ECUs to identify a general error. There is no standard definition of blink codes. Some ECUs only generate blink codes when an input is received. Refer to ECU documentation for correct interpretation of blink codes.

Note

Blink codes are not supported by all ECUs.
The EM500 only displays ECU reported conditions.

Preheat LED (On DPG)

A solidly illuminated Preheat LED is the system preheat indication. When the LED extinquishes the preheat period is complete and the engine may be cranked.

Note

The EM500 only reports when the ECU is requesting preheat.
Cold starting aids are not installed in all engine configurations.

Service Due LED (On DPG)

The service due LED is illuminated when the ECU output is active. Refer to ECU documentation for service interval and reseting information.

Note

Service due indication is not available in all ECUs.

Auxilary LED (On DPG)

The auxilary LED is not currently used.

Gauges

Voltmeter

The voltmeter is connected to the key switch accessory terminal. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly.

Tachometer

The tachometer indicates engine RPM using a frequency signal derived from the ECU. The tachometer is factory calibrated to correctly indicate the engine speed reported by the ECU.

Note

Failure of panel gauges to read correct values and/or the DPG to display Engine Hours Not Used indicates the CANbus connection between the panel and ECU has failed. See the troubleshooting section to diagnose and repair this error.

Oil Pressure Gauge

The oil pressure gauge indicates engine oil pressure derived from the ECU. The oil pressure gauge calibrates each time the panel is energized.

Note

Failure of panel gauges to read correct values and/or the DPG to display Engine Hours Not Used indicates the CANbus connection between the panel and ECU has failed. See the troubleshooting section to diagnose and repair this error.

Warning

Low oil pressure is an indication of engine wear,
not an accurate indication of low oil level.

Temperature Gauge

The temperature gauge indicates engine coolant temperature derived from the ECU. The temperature gauge calibrates each time the panel is energized.

Note

Failure of panel gauges to read correct values and/or the DPG to display Engine Hours Not Used indicates the CANbus connection between the panel and ECU has failed. See the troubleshooting section to diagnose and repair this error.

Warning

If the temperature sensor is not in contact with coolant due to coolant loss
the gauge will not accurately indicate engine temperature.

Additional Gauges

Additional gauges can be added by removing blind covers and installing the gauge. Power connections are provided but sender wiring is typically installed by the panel installer.

Note

The EM500 provides constant 12V supply for gauges even on 24V systems.
The use of 24V powered gauges is unnecessary and not supported.

Harness

The provided sealed weather proof plug includes a locking collar which must be turned counter clockwise to separate the connectors.

Warning

LOFA does not recommend using dielectric grease or sealant.
These chemicals may cause seal damage and allow water entry.

Use LOFA provided cavity plugs to reseal the connector if wires are removed.

The minimum routing of radius of the wiring harnesses should be at least two times the diameter of the wiring harness. Bends should be avoided within 1 inch (25 mm) of any connector in order to avoid seal distortion allowing moisture to enter the connector.

Battery Circuit Requirements

Battery Positive Connection

The electronic control system operates on either a 12 VDC or 24 VDC electrical systems. The unswitched battery positive connection to the control system is made at the weather proof connector. The control system provides switched positive battery protected by a 15 Amp fuse (12 V or 24 V system).

Protection for the unswitched battery positive circuit is dependent on specific equipment configuration. The overload protection should not exceed 125% of the sum of all output currents plus 5 Amps for the control system. Powering the control system through dedicated circuits with appropriate overload protection reduces the possibility of system damage.

Circuit breakers are preferred over in-line fuses for circuit protection. Over current protection devices should ideally be located in a central location. If automatic reset circuit breakers are used, consideration of the environment of the breaker is critical and may affect the trip point. The trip point of some circuit breakers can be significantly reduced below the rated trip point if the circuit breaker is exposed to high temperatures.

Warning

Disconnecting the battery while the engine is running
may damage electrical components.

When using a battery disconnect switch, LOFA recommends using a
2 pole switch to disconnect both the battery and alternator output.

Battery Negative Connection (Grounding)

Warning

Improper grounding can cause electrical noise, unreliable operation and may damage the control system or other components. All ground connections must be free from foreign materials, including paint, which may interfere with proper grounding.

A reliable ground must be provided for the control system.
LOFA recommends the ground connection be made directly to the battery negative.
Grounding through frame members is not recommended.

All ground paths must be capable of carrying any likely fault currents.

Do not reverse the battery polarity. Attempting to crank the engine when the polarity of the battery connections is reversed may damage the control system.

Note

A maximum of three ring terminals should be connected to a ground stud in order to ensure integrity of the ground connection. The use of more than three terminals can cause the connection to become loose.

Voltage Drop

If control system voltage drops below 6 volts for more than one tenth of a second, the control system may reset causing the self test to reactivate and the engine to shutdown after 10 seconds. Resetting the control

system is equivalent to quickly turning the key switch to off and back to run without starting the engine. Since the control system did not sense a start signal, the fuel run/stop solenoid deactivates after 10 seconds. Voltage drops can be caused by transients from external equipment, improper wire sizes, faulty wiring or nearby lightning strikes. In the absence of a LOFA Power Box, relays may be needed for long wire runs.

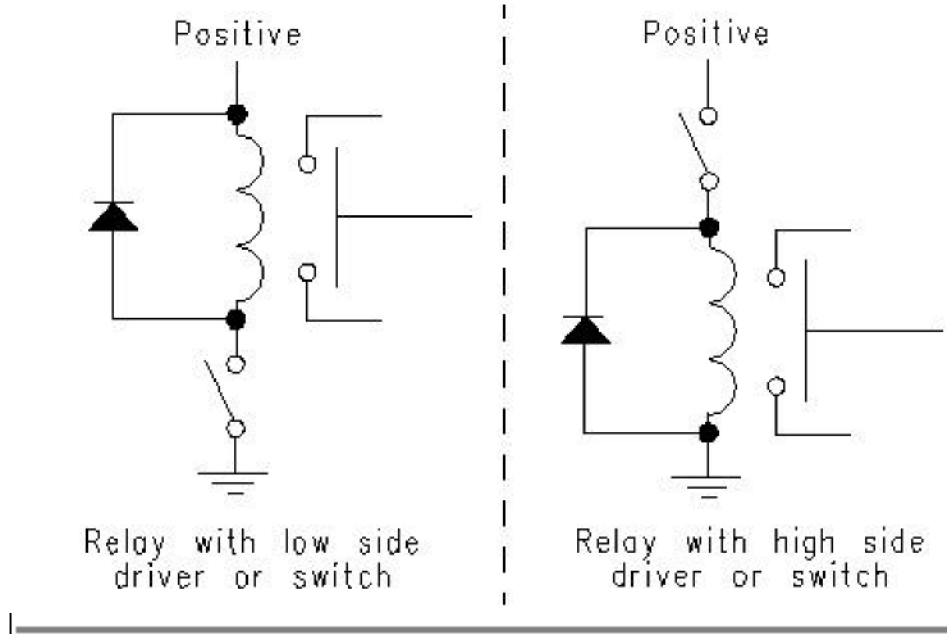
Suppression of Voltage Transients (Spikes)

Warning

The installation of voltage transient suppression at the transient source is required.

LOFA follows SAE recommended electrical environment practices.

Inductive devices such as relays, solenoids and motors generate voltage transients and noise in electrical circuits. Unsuppressed voltage transients can exceed SAE specifications and damage electronic controls.



Relays and solenoids with built-in voltage transient suppression diodes are recommended whenever possible. Refer to the illustration for proper installation of diodes when built-in voltage transient suppression is not available.

Locate inductive devices as far as possible from the components of the electronic control system. When using electric motors it may also be necessary to add isolation relays to eliminate voltage transients, noise and prevent back feed.

Welding on Equipment with Electronic Controls

Proper welding procedures are required to avoid damage to electronic controls, sensors, and associated components. The component should be removed for welding if possible.

The following procedure must be followed if the component must be welded while installed on equipment with electronic controls. This procedure will minimize the risk of component damage.

Warning

Do not ground the welder to electrical components such as the control ground or sensors. Improper grounding can cause damage to electrical components

Clamp the ground cable from the welder to the component being welded. Place the clamp as close as possible to the weld to reduce the possibility of damage.

1. Stop the engine. Turn the key switch to the OFF position.
2. Disconnect the negative battery cable from the battery.
3. Open any installed battery disconnect switch.
4. Unplug the control system if possible.
5. Connect the welding ground cable as close as possible to the area to be welded.
6. Protect the wiring harness from welding debris and spatter.
7. Use standard welding methods to weld the materials.

General Troubleshooting

For additional information, refer to engine manufacturer troubleshooting guide.

No response from starter motor

Possible Cause	Possible Remedy
No battery voltage to starter	Verify wiring and battery connection (power and ground)
Battery discharged	Charge or replace battery, verify alternator charging
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No signal from control system	No power to control system (see Control System Troubleshooting below)
Defective starter solenoid	Replace starter solenoid
Defective starter motor	Replace starter motor

Engine will crank but not start

Possible Cause	Possible Remedy
Engine not getting fuel	Check fuel level, filter, fuel pump, verify no air in fuel lines
Fuel run/stop solenoid not engaged	See Fuel Solenoid Run/Stop Troubleshooting (below)
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No preheat (cold condition)	See Preheat Troubleshooting

Engine runs and shuts down

Possible Cause	Possible Remedy
ECU shutdown	Use DPG to view ECU diagnostic codes, use ECU diagnostic tool for more detailed information
Circuit overload protection tripped	Correct overload, keep control system from overheating (over 185° F/85° C)
Voltage transients (spikes)	Add suppressor diodes, protect from nearby lightening strikes, shield induced spikes from other equipment, add electric motor control relay
Defective control system	See Control System Troubleshooting (below)

Alternator not charging battery

Possible Cause	Possible Remedy
Broken or slipping alternator drive belt	Adjust or replace alternator drive belt
Alternator not excited	Verify excitation circuit connected, replace faulty regulator
Alternator output not connected	Install charge wire
Alternator not grounded	Clean or add ground connection
Alternator faulty	Replace faulty alternator

Engine Troubleshooting

Note

Most problems with ECU controlled engines can be pinpointed via the ECU diagnostic messages. Use the DPG or ECU diagnostic tool to view fault codes.

All engine state information and diagnostic codes displayed by the EM500 are provided by the ECU.

ECU programming determines the response to warnings and failures. Typically the ECU can be programmed to shutdown, derate or run to failure.

ECU does not power-up

Possible Cause	Possible Remedy
No power to ECU	Locate reason for lack of power and correct (Circuit overloaded? Failed suppressor diode? Faulty wiring?)
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
Faulty ECU	Replace ECU
Optional e-stop engaged	Disengage e-stop

Engine not getting fuel

Possible Cause	Possible Remedy
Empty fuel tank	Fuel engine
Clogged filter	Replace filter
Air in fuel lines	Bleed fuel lines
Low fuel pressure	Replace faulty fuel pump and/or clogged filter
Faulty fuel pump	Replace fuel pump, correct wiring fault (electric fuel pump)

Preheat Troubleshooting

Engine is hard to start in cold conditions

Possible Cause	Possible Remedy
Start attempt before preheat complete	Wait for preheat time to elapse, crank as soon as time elapses
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct ECU configuration
Faulty control system	Repair or replace ECU

Engine produces excessive white smoke after starting

Possible Cause	Possible Remedy
Afterglow not enabled	Reconfigure ECU
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct ECU configuration
Faulty control system	Repair or replace ECU

Control System Troubleshooting

Note

Most problems with ECU controlled engines can be pinpointed via the ECU diagnostic messages. Use the DPG or ECU diagnostic tool to view fault codes.

All engine state information and diagnostic codes displayed by the EM500 are provided by the ECU.

ECU programming determines the response to warnings and failures. Typically the ECU can be programmed to shutdown, derate or run to failure.

Control system does not perform self test

Possible Cause	Possible Remedy
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
Faulty connection to battery	Correct battery connections (see Battery Circuit Requirements above)
Faulty control system	Repair or replace control system

Control system performs normal self test, engine cranks, runs and shuts down

Possible Cause	Possible Remedy
Only Battery LED illuminated	Correct battery charge failure (see Battery not charging above)
Only Oil Pressure LED Illuminated	Correct low oil pressure condition, use ECU diagnostics
Only Temperature LED Illuminated	Correct overheating condition, use ECU diagnostics
Only Aux LED Illuminated	Correct fault condition (i.e. coolant level) , use ECU diagnostics
All LEDs illuminate for one second (control system reset)	Add suppressor diodes, protect from nearby lightening strikes, shield induced spikes from other equipment, add electric motor control relay

Testing a Warning or Shutdown

Shutdown simulation with ECU controlled engines requires using the ECU diagnostic tool. Refer to the diagnostic tool documentation to simulate a warning or shutdown.

Testing CANbus

Most information provided to the EM500 is sent by the ECU via the CANbus. CANbus is an international data bus used to support SAE J1939. If this connection is broken or improperly terminated, the EM500 can not display ECU parameters such as engine hours, oil pressure and diagnostic codes. This test procedure helps identify the problem location.

1. Disconnect the battery.

Warning

This test should be completed with the battery disconnected!

Failure to disconnect the battery may cause ECU, panel or test equipment damage!

2. Identify the engine diagnostic plug. Connect an ohmmeter across the CANbus pins of the diagnostic plug.

3. A reading of 120 Ω indicates only one end of the bus is terminated. Identify the CANbus terminator on the engine harness and remove it.

    a. An ohmmeter reading of 120 Ω indicates the bus to the terminator in the panel is complete and the problem is on the harness between the panel and the engine terminator.

    b. An open circuit ohmmeter reading indicates the bus to the engine terminator is complete and the problem is between the panel and engine harness.

4. A reading of 60Ω indicates both end of the bus are terminated and the bus is intact.

5. Reinstall the terminator resistor and reconnect the battery.

    a. If the ECU diagnostic tool is available, use it to verify the ECU is transmitting CANbus data. Refer to ECU documentation to identify and correct the error.

    b. If another panel is available for testing, replace the panel to determine if the error is in the panel.

Diagnostic Codes

ECUs typically report faults via Suspect Parameter Number (SPN) and Fault Mode Indicator (FMI) pair. SPN identify the fault and the FMI identifies the precise fault identified.

Typical SPNs

Standard SPN codes are defined by SAE J1939-71. Not all standard codes are provided by ECUs. In addition manufacturers may add additional SPN codes. Refer to ECU documentation for complete list of SPN codes.

SPN	Description
51	Throttle Position
91	Accelerator Pedal Position
94	Fuel Delivery Pressure
98	Engine Oil Level
100	Engine Oil Pressure
110	Engine Coolant Temperature
111	Coolant Level

FMI

FMI codes are defined by SAE J1939-71. Refer to ECU documentation for correct interpretation of FMI codes.

FMI	Description
0	Data valid but above normal operational range
1	Data valid but below normal operational range
2	Data erratic, intermittent or incorrect
3	Voltage above normal or shorted high
4	Voltage below normal or shorted low
5	Current below normal or open circuit
6	Current above normal or grounded circuit
7	Mechanical system NOT responding properly
8	Abnormal frequency, pulse width or period
9	Abnormal update rate
10	Abnormal rate of change
11	Failure mode NOT identifiable
12	Bad intelligent device or component
13	Out of calibration
14	Special instructions
15	Data valid but above normal operational range (least severe)
16	Data valid but above normal operational range (moderately severe)
17	Data valid but below normal operational range (least severe)
18	Data valid but below normal operational range (moderately severe)
19	Received network data in error
20 thru 30	Reserved for future assignment
31	Not available or condition exists

Blink Codes

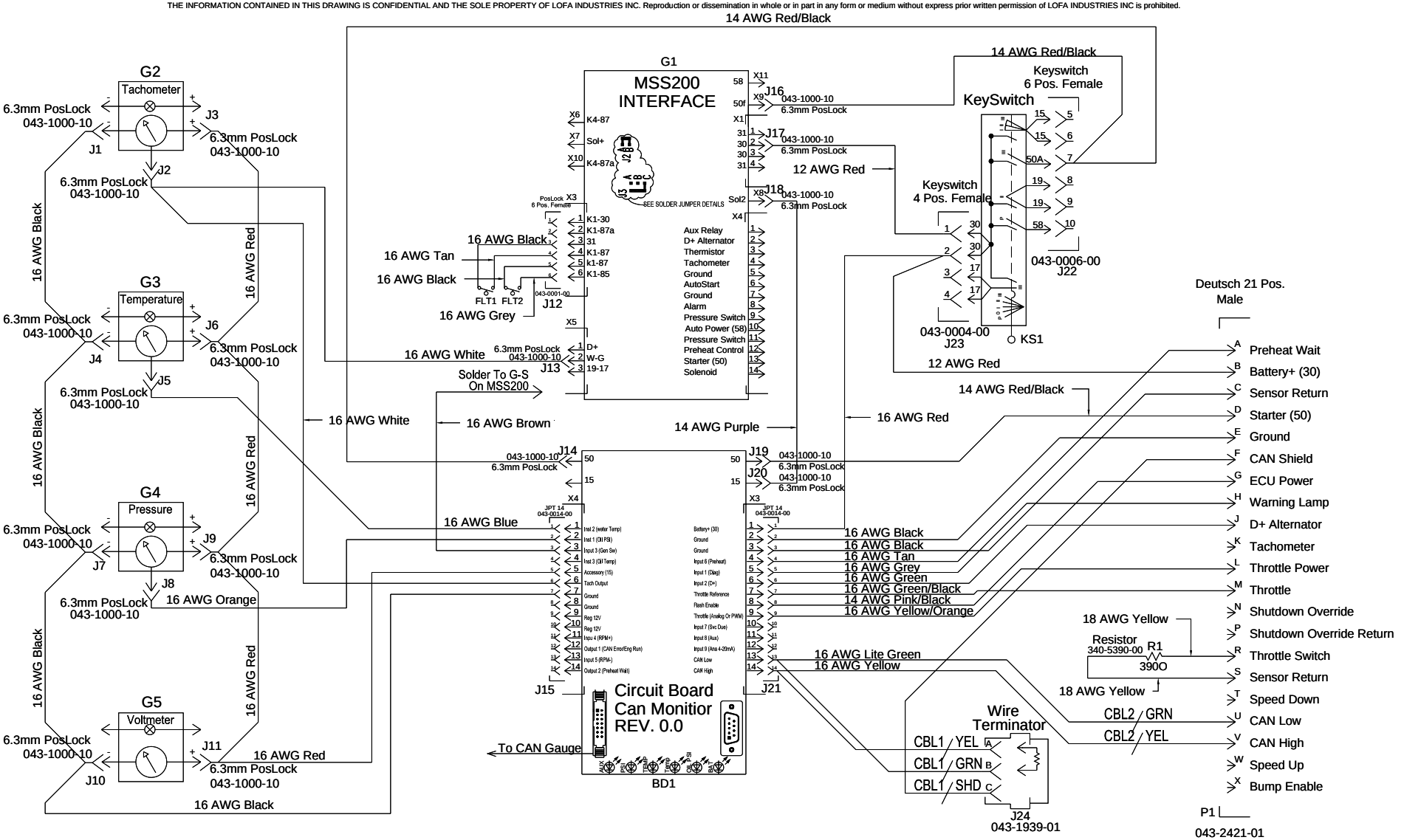
Simple diagnostics are sometime provided via a pattern of fast and slow blinks that identify a general error. The Diagnostic Code LED displays the blink code as provided by the ECU. There is no standard definition of blink codes. Refer to ECU documentation for correct interpretation of blink codes.

Typical Schematic

The following page shows a typical schematic.
Details vary from installation to installation.
See the specific schematics for installation for details.

Revision Information

Initial Release: 22-May-2006.



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Part Number: Panel EM500-G6A CAT 24V							
	Rev	Drawn By: MThiam	Date: 02-17-06		Sheet 1 of 1		
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