WOODWARD

L-Series Position Controller with CAN Capability

Software: 5418-6084, 5418-6638, 5418-7022

Installation, Programming, & Troubleshooting Manual

Contents

Illustrations and Tables

Acronyms/Abbreviations

AUX	auxiliary
EEPROM	electrically-erasable programmable read-only memory
EMC	electro-magnetic compatibility
GUI	graphic user interface
I/O	inputs/outputs
Isoch	isochronous
ITB	integrated throttle body
L-Series	Woodward electronic engine governor that contains both a rotary actuator and a controller circuit board
MPU	magnetic pick up
OEM	original equipment manufacturer
PWM	pulse-width modulated
rpm	revolutions per minute
RS-232	a communications standard
TPS	throttle position sensor

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  DeviceNet (Open DeviceNet Vendor Association, Inc.)

Warnings and Notices

Important Definitions

⚠️ This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠️**WARNING** **Overspeed / Overtemperature / Overpressure**	The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage. The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.
⚠️**WARNING** **Personal Protective Equipment**	The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to: • **Eye Protection** • **Hearing Protection** • **Hard Hat** • **Gloves** • **Safety Boots** • **Respirator** Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.
⚠️**WARNING** **Start-up**	Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.
⚠️**WARNING** **Automotive Applications**	On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

| NOTICE

Battery Charging Device	To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

| NOTICE

Electrostatic Precautions	Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts: • Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control). • Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards. • Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices. To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715, Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules.*

Follow these precautions when working with or near the control.
1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   • Do not touch any part of the PCB except the edges.
   • Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   • When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

EMC Directive: Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)

Regulatory Compliance

European Compliance for CE Marking:
These listings are limited only to those units bearing the CE Marking.

EMC Directive:	Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)

Other European Compliance:
Compliance with the following European Directives or standards does not qualify this product for application of the CE Marking.

Machinery Directive:	Compliant as partly completed machinery with Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on machinery.

North American Compliance:
These listings are limited only to those units bearing the CSA agency identification.

CSA:	CSA Certified for Class I, Division 2, Groups A, B, C & D, T3C at 105 °C Ambient for use in Canada and the United States. Certificate #1380416
	This product is certified as a component for use in other equipment. The final combination is subject to acceptance by CSA International (or UL) or local inspection.

The L-Series is suitable for use in Class I, Division 2, Groups A, B, C, D per CSA for Canada and U.S. or non-hazardous locations only.

Wiring must be in accordance with North American Class I, Division 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Field wiring must be suitable for at least 105 °C.

The actuator should be protected from exposure to sunlight and rain.

⚠ **WARNING**	**EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division or Zone applications.**

⚠ **AVERTISSEMENT**	**RISQUE D'EXPLOSION—Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.** **La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, applications Division ou Zone.**

Chapter 1.
General Information

Purpose and Scope

This manual provides the necessary background information for applying the L-Series control to gas/gasoline reciprocating engines. This manual is intended primarily for OEMs, who may find it useful to copy some of the information from this manual into their application user manuals.

This manual does not contain instructions for the operation of the complete engine system. For engine or plant operating instructions, contact the plant-equipment manufacturer.

This version of the manual applies to all CAN-capable L-Series Position Control models with software 5418-6084, 5418-6638, or 5418-7022. The software version can be identified on the Identification tab of the Service Tool.

How to Use This Manual

The following summarizes how to install an L-Series actuator into a new or existing system:
- Unbox and inspect the hardware.
- Mount and wire the hardware following the procedures and recommendations in Chapter 3.
- Optionally configure the control using the Service Tool (Chapter 4).
- Optionally stroke the valve and verify dynamics and functionality.
- Troubleshooting guidelines are provided in Chapter 5.
- Specifications are provided in Appendix B.

Intended Applications

The L-Series control is designed for various industrial applications, including but not limited to generator sets, welders, portable refrigeration units, irrigation pumps, chipper shredders, and mobile industrial gas or gasoline reciprocating engines. Key environmental characteristics of these applications include extended industrial operating temperatures (–40 to +105 °C/–40 to +221 °F), Industrial EMC Requirements, electrical transients, and lower operating voltages (12/24 V).

Introduction

The L-Series provides a building-block approach to total engine management. The modular bi-directional actuator design easily attaches to fuel pumps, mixers, or throttle bodies. For information on Woodward throttle body applications, refer to manual 26249 (ITB and LC-50).

Woodward also offers a non-CAN position control version and L-Series versions for Speed Control applications (manual 26250) and Process Control applications (manual 26251).

The L-Series position control accepts a position command and drives the 0–60 degree output shaft to the commanded position based on an internal shaft position sensor. The high-efficiency torque motor delivers 0.34 N·m (0.25 lb-ft) nominally over 60° travel range to operate fuel or air control devices (see specifications in Appendix B for torque performance over the full product temperature range).

The L-Series position control accepts either a PWM command, a CAN command, or a 0–5 V command for output positioning. The command signals are issued by the appropriate supervisory engine management system, and the L-Series must be set up properly in software to expect the correct signal for the application. The position command input can also be set up with a primary and a backup input, providing redundancy.

For status purposes, a relay driver output is available that changes state whenever a fault or error condition is experienced by the L-Series controller.

If the system so requires, the L-Series provides a direct position output signal in the form of a dc voltage. The TPS (throttle position sensor) output represents full counterclockwise (CCW) to clockwise (CW) rotation of the actuator shaft, and thus gives the operator an external position indication after installation and while the unit is operating.

⚠ **WARNING**	**When included with an ITB (integrated throttle body), the actuator depends solely on the return spring inside the throttle body assembly to drive toward minimum fuel when not powered. Therefore other positive shutdown devices like fuel shut-off solenoids are recommended to ensure shutdown upon loss of signal to the control system. Also, separate overspeed trip devices are always mandatory.**

Programmable Features

Control setup and tuning is accomplished through the use of a PC (personal computer), Woodward Service Tool software, and a programming harness. The features identified below are described in Chapters 2 and 4. Briefly, the programmable features include:
- General Setup Parameters
  - Position Demand Select (Primary/Backup; CAN, PWM or Analog)
  - Fail Position
  - Min Position Direction (CCW or CW)
  - Actuator Curve Selection (Linear or Non-linear)
  - CAN Setup
- PWM Setup Parameters
  - PWM Drive Select (Push-Pull, High-Side Drive or Low-Side Drive)
  - PWM Offset
- Valve Position Control Parameters
- Non-Linear Actuator Settings
  - Position Request (5 curve input points)
  - Actuator Position (5 curve output points)
- Discrete Output Settings
  - Output's Non-Fault Condition (ON or OFF)
  - Fault Selections as Discrete Output Indications
- Fault Settings
  - Latching or Non-Latching Fault Indications
  - Position Error Magnitude & Delay
  - Fault Selections as Alarms or Shutdowns

Service Tool Software

The L-Series Service Tool software is a Microsoft Windows based GUI (graphic user interface). The Service Tool Software gives the OEM the ability to:
- Configure product settings based on application requirements
- Tune the control with the engine running during application development
- Create configuration files for downloading into multiple controls
- Download configuration files
- Extract and view fault codes for field diagnosis
- Update control dynamics during field service
- Calibrate the control for user stops

Detailed descriptions of software installation are available in Chapter 4.

Chapter 2.
System Description/Application Overview

System Operation

On power-up, the L-Series actuator will establish its identity based on the CAN ID inputs and ensure that service tool communications are not active prior to initializing CAN communications. The actuator will immediately drive to maintain the position commanded by the supervisory control.

Optionally, a Run Enable input can be used to activate or de-activate the L-Series output. This input can also be used to reset shutdown fault conditions.

Upon an engine shutdown command, the independent engine shutdown solenoid or solenoid valve in the fuel supply should be de-activated and the power supply disconnected from the speed control. This shutdown signal should be sent directly from the engine control panel and should be independent and separate from the L-Series controller.
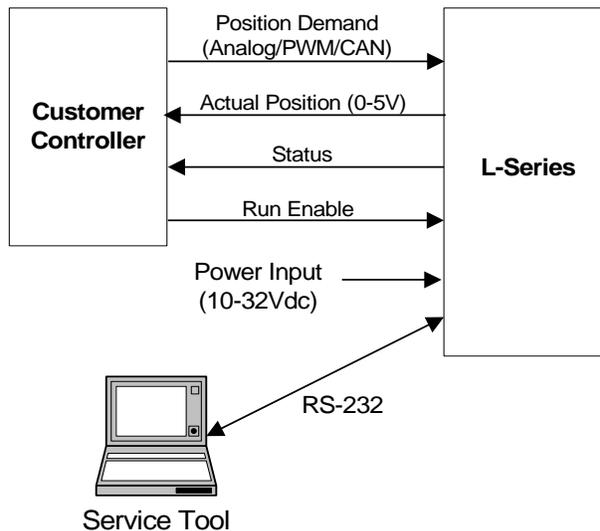
Figure 2-1. System Overview

Driver Input Power

The L-Series will handle a voltage range of 10 to 28 Vdc at full specified torque. The actuator is functional in the range of 8 to 32 Vdc, but accuracy and/or torque can be diminished at the extreme ends of this range.

The supply voltage failure levels are below 6.25 V and above 33 V. The unit can be configured to either alarm or shut down upon detection of a supply voltage fault.

L-Series Position Control Functional Overview
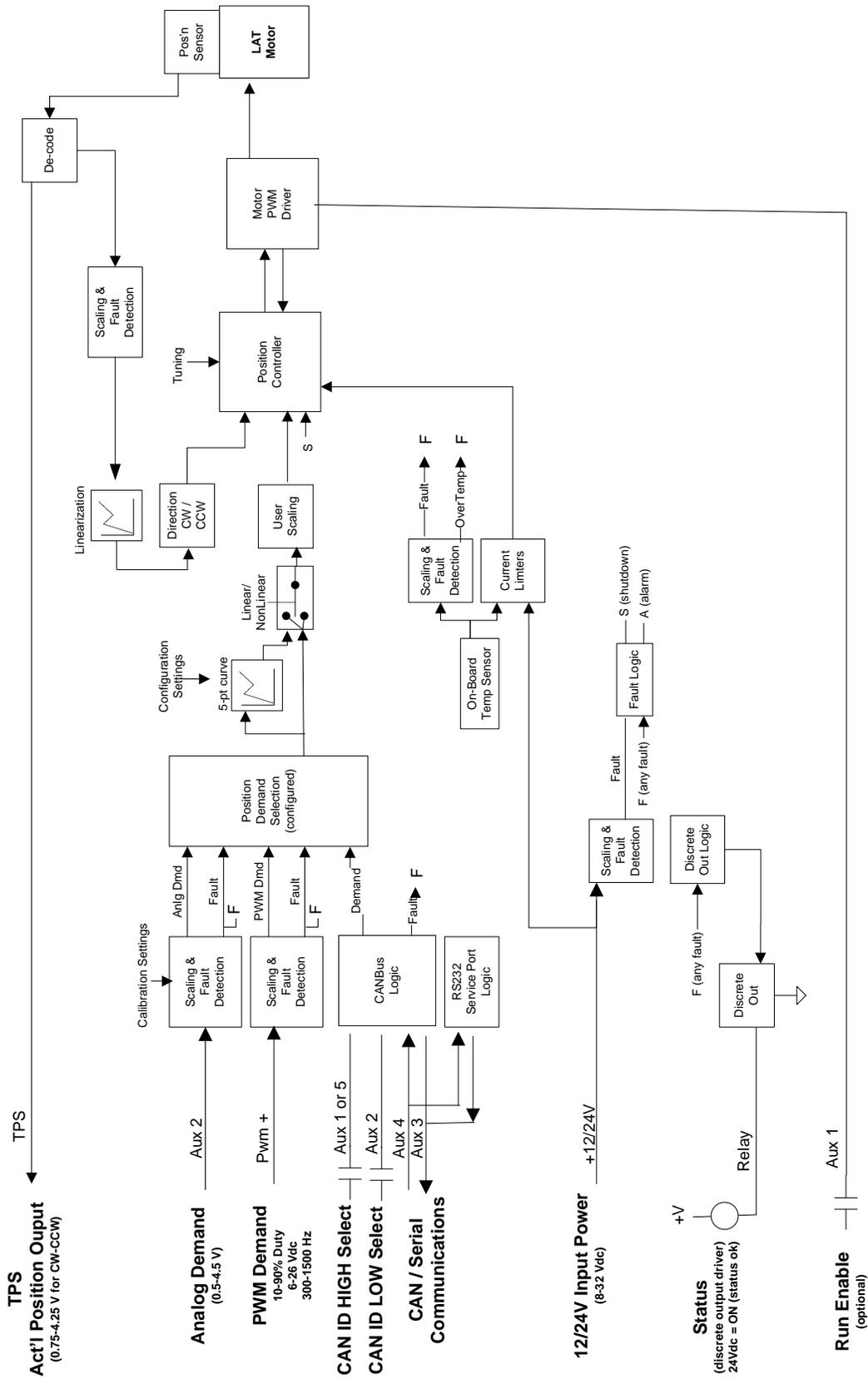
Figure 2-2. Functional Overview

Position Command Signal

The L-Series can accept either a single position command or a redundant position command. A redundant command uses two position commands, one as the primary command and one as a backup. If the primary fails, the unit can continue to run using the backup command (see Figure 2-3). The command source can be sent over CAN, as a PWM command signal input, or an analog 0–5 Vdc command signal input, depending on how the software application is configured.

Init

(Primary Demand Fault AND Backup Demand OK)

Use Primary Demand

(Backup Demand Fault AND Primary Demand OK)
OR
(Primary Demand OK for > 10 sec AND Tracking OK)

Use Backup Demand

Primary Demand Fault
AND
Backup Demand Fault

Backup Demand Fault
AND
Primary Demand Fault

Primary Demand OK
AND
Reset*

Backup Demand OK
AND
Primary Demand Fault
AND Reset*

Demand Failed

*Reset not required if configured as non-latching

Figure 2-3. Position Demand Logic

PWM Position Command

The PWM will function with various types of input sources, including high-side, low-side open collector, and push-pull—depending on the configuration. It will handle a PWM frequency range from 300 to 1500 Hz at amplitudes ranging from 5 V up to battery voltage. Normal operating range is from 10% to 90% duty cycle, representing the hard stops in the actuator (Figure 2-4). The input can be optionally set to a non-linear mode which provides a 5-point curve relationship between position signal and desired position (Figure 2-5).

The input failure levels are below 3% and above 97% duty cycle. The unit can be configured to either alarm or shut down on detection of a position command failure. The shutdown failsafe position is also user-configurable and can be set to any point between 0% and 100%.

A user-configurable offset is available to adjust the input duty-cycle reading, as needed.
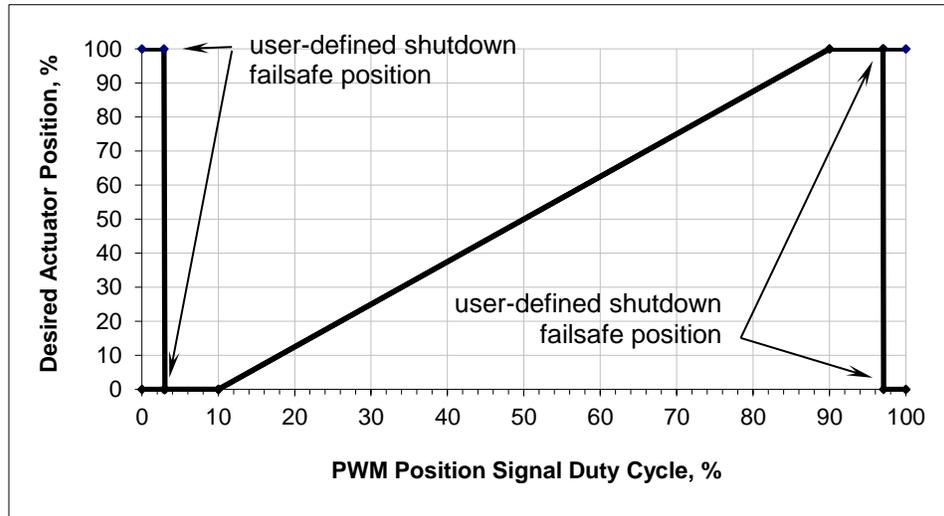
Figure 2-4. PWM Linear Demand to Position
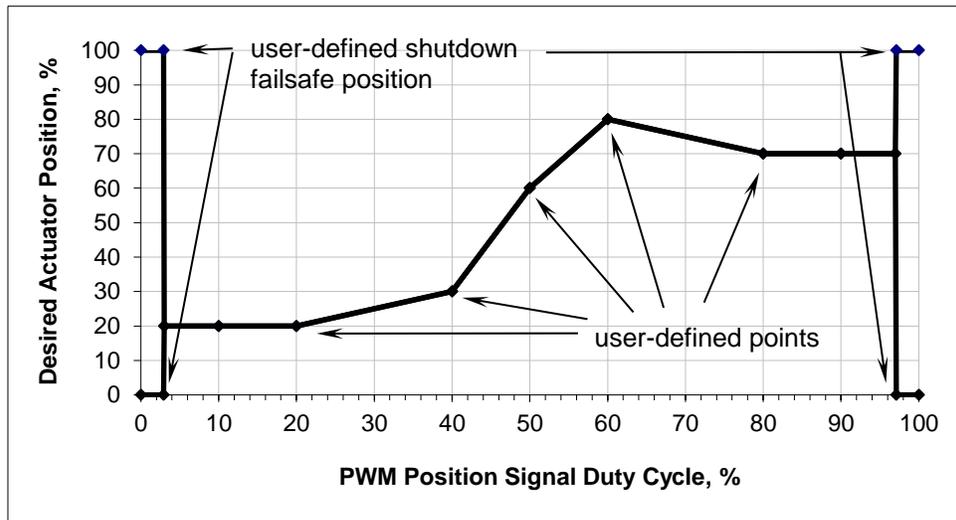
Figure 2-5. PWM Non-Linear Demand to Position

Analog (0–5 V) Position Command

The 0–5 V input uses a different pin in the connector, and it has a usable range of 0.5 to 4.5 V to command the throttle from minimum to maximum position (Figure 2-6). The input can be optionally set to a non-linear mode which provides a 5-point curve relationship between position signal and desired position (Figure 2-7).

The input failure levels are below 0.2 V and above 4.8 V. The units can be configured to alarm or shut down on detection of a position command failure (loss of all position command inputs). The shutdown failsafe position is also user-configurable and can be set to any point between 0% and 100%.
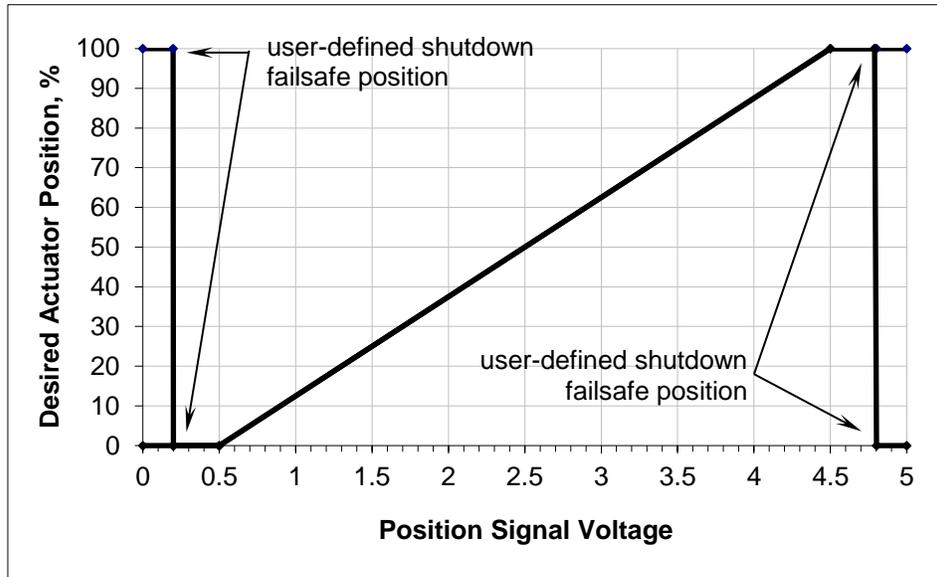
Figure 2-6. Analog 0–5 V Linear Demand to Position
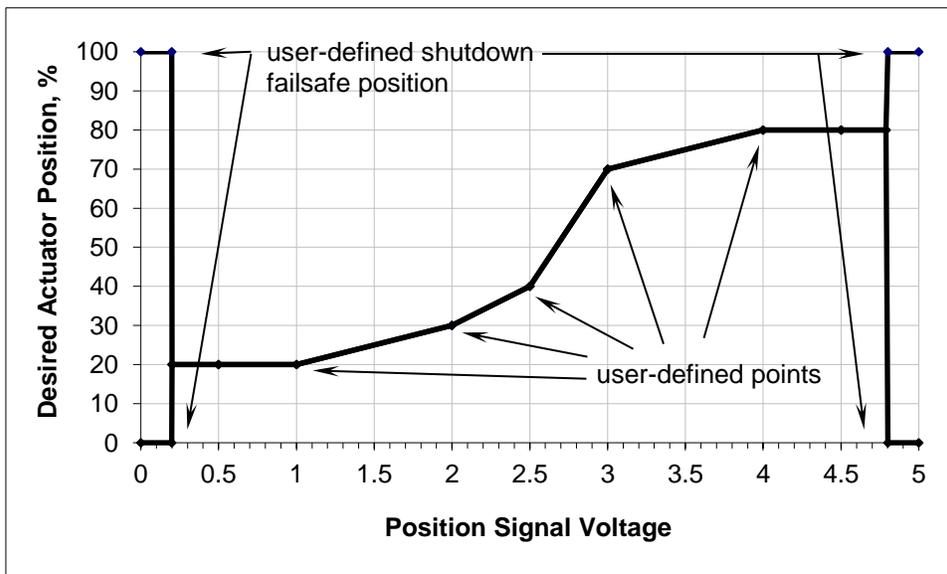
Figure 2-7. Analog 0–5 V Non-Linear Demand to Position

CAN Position Command

CANbus can be used to monitor unit status and/or control the commanded position. The CAN messaging is selectable between J1939 and CANopen. CAN details are provided later in this chapter.

When used as a position command, a minimum update rate is expected or a CAN fault will be issued. This update rate is user-configurable. The L-Series can be configured to alarm or shut down on detection of a position command failure (loss of all position command inputs). The shutdown failsafe position is also user-configurable and can be set to any point between 0% and 100%.

Discrete Output

A discrete output is provided to serve as a status indicator. This switchable discrete output is a closure to ground capable of sinking 250 mA with an output voltage rise of less than 1.5 V, and it is available to power external relays for devices such as alarms or fuel shutoff solenoids. The circuit is protected internally against overcurrent and inductive spikes, so external clamping is not necessary.

This output can be configured as either normally on/open (preferred failsafe setting) or normally off/closed. In addition, the faults that drive the relay status can be configured individually. For details, refer to Chapter 4 (Service Tool).

There are two conditions that will prevent the discrete output from operating correctly:
- If battery positive is accidentally connected to the discrete output;
- If the discrete output is shorted to ground.

The circuit will protect itself in the event of a miswire, but it will hold the output open (floating) until the fault is removed.

Run Enable Discrete Input

An optional Run Enable discrete input can be configured for use. The Run Enable operation provides a closed-to-run function which, when open, forces the shaft controller into a low-current "limp" mode. The Run Enable can also be used to clear a latching shutdown condition since a closure of the input will issue a reset command.

Actual Position Feedback (TPS)

The L-Series provides a 0–5 V signal representing actual shaft rotational position, where 0.75 V and 4.25 V correspond to full counterclockwise to clockwise rotation, respectively. This signal is fed directly off the position sensor to ensure no delays are introduced by the processor. However, this signal is also uncorrected, so the difference between this signal and actual position can vary up to ±10% over the operating temperature range.

Additional Inputs/Outputs

Auxiliary Inputs—There are four auxiliary inputs on the L-Series controller, all of which are capable of both analog and discrete functions. They can all be functionally defined for purpose in the software application. Although they are very flexible, two of them are shared with the serial and CAN communications, so will be unavailable if the L-Series is connected to the Service Tool or when CAN is used. More detail concerning the auxiliary inputs is provided in Chapter 3 (Installation).

5 V Output—A 5 Vdc output has been provided on the L-Series actuator to power external sensors, if necessary. The 5 V output is limited to 10 mA, but this is sufficient for most light-duty ratiometric sensors.

Temperature Sensing

The L-Series has an on-board temperature sensor to monitor board temperatures and protect the unit from overtemperature. This temperature is monitored and a fault is annunciated if the set point is exceeded.

Current Limiting based on Temperature

The controller provides actuator current limiting based on the electronics temperature. Depending on actuator and circuit board thermal models, the software reduces current as necessary to avoid conditions that would damage the device due to extreme temperatures.

Current limiting based on temperature begins when the combined current and temperature environment causes board temperatures greater than 117 °C. The limit curve is a linear derate from full current at 117 °C down to zero current at 125 °C. At 117 °C, an Over Temperature fault is annunciated. Depending on the current (actuator torque) and ambient operating temperatures, the unit may never reach a reduced level.

RS-232 Communications

RS-232 communications are available on the L-Series when used with an external transceiver connected to pins 4 and 6. Serial communications allow for the use of a service and configuration tool with the L-Series actuator. The simplest way to establish this interface is to use Woodward kit # 8923-1061.

Functions available through this port include tuning, monitoring, and configuration of the position controller. Detailed driver status information is also available.

Any RS-232 wiring must meet the requirements in the EIA RS-232 Standard document. The RS-232 standard states that the length of the RS-232 cable between the driver and the PC must be less than 50 ft (15 m) with a total capacitance less than 2500 pF. The RS-232 data rate is fixed at 19.2 kbps. The communication port is non-isolated and susceptible to both EMI noise and ground loops related to PC connections and typical industrial environments.

IMPORTANT	The service port is not isolated and is not intended to function while the prime mover is in normal operation. The service port is provided for configuration and setup only.

CAN Communications

To use CAN (Controller Area Network), the L-Series version that supports CAN must be purchased. The L-Series Position Control can provide either J1939 or CANopen, based on the CAN Protocol setting in the Service Tool. AUX3 and AUX4 inputs are not available for other I/O options since they are used for CAN communications.

Parameter Format

The L-Series uses a little-endian format when handling multiple-byte parameters (i.e. a position demand of 50% is $FF0F, not $0FFF). All parameters must use this format unless otherwise specified.

CAN Fault Indication

When a CAN position command is configured, if new position updates from CAN are not received within the configured CAN Fail Timeout, a CAN Demand Fault is annunciated. Additionally in J1939 mode, a CAN fault is activated if address claiming is not successful. Faults are globally configured as either latching or non-latching. An option is available to latch-in the CAN fault, to ensure a CAN fault is annunciated over the CAN link when configured as non-latching.

Position Tamper Fault

A position tamper fault can be configured to ensure the primary demand matches the backup CAN demand. The criteria for matching is defined by the CAN Tracking Error Maximum and Delay settings (found on the Alarm/Shutdown tab in the Configuration Editor). If the difference between the primary demand and the CAN backup is greater than the Maximum for the Delay time, a Position Tamper Fault is issued, and the primary demand is no longer used—the CAN demand is used instead. To use this fault, CAN must be configured as the backup demand, and the position tamper fault must be enabled (Setup tab of Configuration Editor). This fault is disabled if CAN is failed (no signal or updates too slow).

J1939

This section describes the communication that will take place over the J1939 Data Link when the optional CAN communication link is used and configured for J1939. For details, see SAE J1939/11. The L-Series uses CAN 2B with 29-bit identifiers.

Device Identifier

The device source address is a Service Tool configurable parameter (CAN Device Identifier). The L-Series has an allowed range of 18 to 21 (12 to 15 hex), allowing multiple L-Series controllers on a single CAN link. The configured Device Identifier affects the PDU Specific portion of the incoming position demand message.

Support for up to 4 L-Series devices on one bus is provided with firmware 5418-6638 and 5418-7022 (2 devices with firmware 5418-6084). Unique device identifiers are selectable through discrete inputs, CAN ID LOW, and CAN ID HIGH. When used, the device identifier is based on the state of these discrete inputs at power-up.

CAN ID HIGH input	CAN ID LOW input	Selected Device Number
Open / low	Open / low	1
Open / low	Closed / high	2
Closed / high	Open / low	3
Closed / high	Closed / high	4

A discrete input selection configured as 'Not Used' is interpreted as Open.

J1939 Message Overview

The following information is continuously sent over the CAN:
- L-Series Data (position, position setpoint, and temperature)
- L-Series Fault Status (Alarms and Shutdowns)

The following information is sent over the CAN upon request:
- Software Version Number, Parameter File name, Serial Number, and Address Claimed.

The L-Series Position Controller optionally receives the following information over CAN:
- Position Demand
- DM13

PGN 60928 Address Claimed (ACL) message
Address Claimed / Cannot Claim Message

Message
Update rate:	on startup. on request, response to Address Claimed
Data length:	8 bytes
Data page:	0
PDU format:	238
PDU specific:	0
Priority:	6
PGN:	60928 (0xEE00)

Data
Bytes 1.1 - 3.5: (21 bits) Identity Number, SPN 2837
Bytes 3.6 - 4.8: (11 bits) Manufacturer Code, SPN 2838
Byte 5.1: (3 bits) ECU Instance, SPN 2840
Byte 5.4: (5 bits) Function Instance, SPN 2839
Byte 6.1: (8 bits) Function, SPN 2841
Byte 7.1: (1 bit) Reserved
Byte 7.2: (7 bits) Vehicle System, SPN 2842
Byte 8.1: (4 bits) Vehicle System Instance, SPN 2843
Byte 8.5: (3 bits) Industry Group, SPN 2846
Byte 8.8: (1 bit) Arbitrary Address Capable, SPN 2844

The Address Claimed message will be sent out shortly after power has been applied to the L-Series. The Address Claimed message will also be sent out in response to a Request for Address Claimed. The Request for Address Claimed can be sent to a specific Address or to the Global Destination Address, 255. The L-Series will respond to a specific query, or one to the Global Destination Address, 255.

The Source Address for the L-Series is configurable uniquely using the service tool. Since Dynamic Addressing is not supported, the L-Series will only try to claim the configured address. If a higher priority device claims the configured address, the L-Series will stop communicating as defined per SAE J1939.

The Address Claimed Message will also be sent out if the L-Series receives an Address Claimed message from the same Address as the receiving node and a lower priority (higher value) NAME. The entire 8-byte value of the NAME is used for arbitration with the Arbitrary Address Capable Field as the Most Significant Bit.

The Cannot Claim Address message will be sent out if the L-Series receives an Address Claimed message with the same Source Address as the receiving node and with a higher priority (lower value) NAME. The entire 8-byte value of the NAME is used for arbitration with the Arbitrary Address Capable Field as the Most Significant Bit.

The Cannot Claim Address will also be sent out in response to a Request for Address Claimed if the address was unsuccessfully claimed. The Cannot Claim Address message is identical to the Address Claimed message in all aspects except that the Source Address of the L-Series is replaced with 254.

If the L-Series cannot claim an Address, a status bit will be set and any position demand value from CAN will be forced to zero (this may cause a shutdown depending on demand source settings).

L-Series NAME fields:
Arbitrary Address Capable:	0 / Disabled
Industry Group Field:	0 / Global
Vehicle System Instance:	0 / First Instance
Vehicle System Field:	0 / Non-specific System
Function Field:	15 / Fuel System
Function Instance Field:	0 / First
ECU Instance Field:	0 or 1 (for Device 1 or 2 if CAN ID is used)
Manufacturer Code Field:	153 / Woodward Governor Industrial Controls
Identity Number Field:	Unique

PGN 65532 Valve Data Message

Data message transmitted by the L-Series. Note that actual and desired valve position are transmitted separately in both a 1-byte and 2-byte format.

Message
Update rate:	0.1 sec
Data length:	8 bytes
Data page:	0
PDU format:	255
PDU specific:	252
Priority:	7
PGN:	65532 (0xFFFC)

Data
Byte:		
	1	Actual valve position (8 bits)
	2	Desired valve position (8 bits)
	3	Electronics Temperature
	4	Reserved
	5...6	Actual valve position (2 bytes)
	7...8	Desired valve position (2 bytes)

Actual valve position—Measured position. A value of 0% represents min and a value of 100% represents max.
Data length:	1 byte
Resolution:	1/2.56 % / bit, 0 offset
Range:	0 to 100% (scaled from 0 to FF hex)
Error Indicator set if:	None

Desired valve position—Desired position. A value of 0% represents min and a value of 100% represents max.

Data length:	1 byte
Resolution:	1/2.56 % / bit, 0 offset
Range:	0 to 100% (scaled from 0 to FF hex)
Error Indicator set if:	None

Electronics Temperature—internal temperature of the L-Series electronics. A value of 0% represents min and a value of 100% represents max.

Data length:	1 byte
Resolution:	1 °C / bit, –40 °C offset
Range:	–40 to +210 °C (scaled from 0 to FA hex)
Error Indicator set if:	Temperature sensor failed

Actual valve position—Measured position. A value of 0% represents min and a value of 100% represents max.

Data length:	2 bytes
Resolution:	1/81.92 % / bit, 0 offset
Range:	0 to 100% (scaled from 0 to 1FFF hex)
Error Indicator set if:	None

Desired valve position—Desired position. A value of 0% represents min and a value of 100% represents max.

Data length:	2 bytes
Resolution:	1/81.92 % / bit, 0 offset
Range:	0 to 100% (scaled from 0 to 1FFF hex)
Error Indicator set if:	None

PGN 65533 Diagnostics from L-Series Valve

Diagnostics message transmitted by the L-Series. The L-Series transmits the current status of its diagnostics, regardless of the fault mapping used (i.e. Alarm vs Shutdown). The diagnostics status indications are bit mapped to indicate the active or in-active state. Two bits are used for every fault condition to indicate the status (see Bit Code Legend section).

Bytes 1-4 of the diagnostic message are set to indicate their current status and bytes 5-6 indicate historical (logged) value status. The logged diagnostics are retained in non-volatile memory. They provide an indication of the events that occurred since the last time they were cleared/reset.

Message

Update rate:	0.1 sec
Data length:	8 bytes
Data page:	0
PDU format:	255
PDU specific:	253
Priority:	6
PGN:	65533 (0xFFFD)

Data

Byte:	1..4	Diagnostics (current)
	5..8	Diagnostics (logged)

Bit code legend
The following diagnostics and events status will be sent by the L-Series actuator in a sequence.

Bit code	Description
00	Inactive
01	Active
10	Reserved
11	Not Available

Bit position in a byte is "8 7 6 5 4 3 2 1"
Bit position 0 is least significant bit.
Example: Bit position 2 is "1" and all others bits are "0", byte value is 2.

Diagnostic codes
The following diagnostics will be sent by the L-Series actuator.

Diagnostics	J-1939 data frame bit position
Watch Dog Reset	1,2
Brown Out Reset	3,4
EEPROM Fail	5,6
Position Sensor Fail	7,8
Temperature Sensor Fail	9,10
Voltage Sense Fail	11,12
Relay Short Fail	13,14
All Position Demands Failed	15,16
OverTemp	17,18
Position Error	19,20
Position Tamper Fault	21,22
Spare — sent as "11" (firmware 5418-6084) CAN Stop Command (firmware 5418-6638)	23,24
Analog Demand Failed (input out of range)	25,26
PWM Demand Failed (duty cycle out of range)	27,28
CAN Demand Failed	29,30
Stop Command from Run Enable Input	31,32

PGN 65298-65301 Valve Position Command
Position command received by the L-Series, determined by the device identifier. For example device 18 (12h) will only accept proprietary PGN 65298.

Message
Update rate:	between 5 and 100 ms
Data length:	2 bytes
Data page:	0
PDU format:	255
PDU specific:	DA (L-Series Source Address*)
Priority:	1
Supported PGNs:	65298-65301 (0xFF12 ... 0xFF15)

*Note: L-Series is limited to values of 18, 19, 20, and 21.

Data
Byte: 1...2   Valve Position Demand
       3   Command Bits (only supported in 5418-6638 firmware)
       4...8   Reserved/Not Used

Valve position demand — CAN commanded position setpoint.

    Data length: 2 bytes
    Resolution: 1/81.92 % / bit, 0 offset
    Range: 0 to 100% (scaled from 0 to 1FFF hex)

Command bits (byte 3) – 5418-6638 firmware only
Data length: 1 byte
   Bits 1-2: Reset Active Diagnostics
      00 No action
      01 Reset action *
      10 Reserved
      11 Not supported
   Bits 3-4: Reset Logged Diagnostics
      00 No action
      01 Reset action *
      10 Reserved
      11 Not supported
   Bits 5-6: Operation Control (Run/Stop)
      00 No action
      01 Shutdown (limp, same as keyswitch input)
      10 Reserved
      11 Not supported
   Bits 7-8: RESERVED/NOT USED

* A reset action must be preceded by a no action command or the device will not perform the requested action—the bits cannot remain in a '01' state. The reset action occurs only upon the transition from 00 to 01.

Reset Active Diagnostics

When the Reset action bit pattern is received on bits 1–2 of byte 3, the device will clear the diagnostics that are no longer active in the device. Diagnostics are displayed on the service tool and are sent as bits 1–32 (bytes 1–4) on PGN 65533. This command is only valid (needed) when latching faults are configured. When configured as non-latching, faults are automatically cleared (no reset is required).

Only the Reset Action bit pattern (01) will activate a reset. All other commands are interpreted as no action. The reset action requires a rising edge, meaning the signal must go to another value and then back to 01 before another reset will be performed.

Reset Logged Diagnostics

When the Reset action bit pattern is received on bits 3–4 of byte 3, the device will clear the Logged diagnostics history stored in the device. These logged diagnostics are displayed on the service tool and are sent as bits 33–64 (bytes 5–8) on PGN 65533.

Only the Reset Action bit pattern (01) will activate a reset. All other commands are interpreted as no action. The reset action requires a rising edge, meaning the signal must go to another value and then back to 01 before another reset will be performed.

Operation Control (Run/Stop)

When the Shutdown bit pattern (01) is received on bits 5–6 of byte 3, the device will be put in a limp mode, the same as opening the RunEnable discrete input (coil current off). It also triggers a diagnostic (CAN Stop Commanded) which is available on both the service tool and over J1939 for troubleshooting purposes and as an option for the discrete output.

Only the Shutdown bit pattern (01) will activate the CAN Stop Command. All other commands will be interpreted as 'Run'.

PGN 59904 Requested Messages

PGN request received by the L-Series. The software version number, parameter filename, serial number and address claimed messages can be requested using the request message below. Requests for serial number utilize RTS/CTS or BAM transport protocol to accommodate the data length (>8 bytes).

Message

Update rate:	on request	
Data length:	3 bytes	
Data page:	0	
PDU format:	234	
PDU specific:	DA	
Priority:	6	
PGN:	59904 (0xEA00)	

Data:

Byte: 1..3   requested data PGN* (byte 3 is msb)
        4..8   reserved

*Supported PGNs: 60928, 65242, 65259, and 65496.

PGN 65242 Software Identification (SOFT) message

The software identification message is provided only upon request. One field is sent with 6 bytes of data representing the software version as follows: 2 bytes for major revision, 2 bytes for minor revision, and 2 bytes for bug fix version.

Message

Update rate:	on request	
Data length:	8 bytes	
Data page:	0	
PDU format:	254	
PDU specific:	218	
Priority:	6	
PGN:	65242 (0xFEDA)	

Data:

Byte 1: Number of Software Identification Fields, SPN 965

Data length:	1 byte
Resolution:	1 /bit, 0 offset
Range:	0 to 250 (0x00 to 0xFA)
Actual value:	1 (will always report 1)

Bytes 2-7: Software Identification, SPN 234

Data length:	6 bytes
Resolution:	ASCII, 0 offset
Range:	0 to 255 per byte
Actual value:	varies**

Byte 8: Delimiter, SPN 234

Data length:	1 byte
Resolution:	ASCII, 0 offset
Range:	0 to 255
Actual value:	42 (0x2A)
Character:	*

**Data actual value for firmware 5418-6084 NEW is '020000' (for major rev '2')
   Data actual value for firmware 5418-6638 NEW is '020100' (minor rev '1')
   Data actual value for firmware 5418-7022 NEW is '030000' (for major rev '3')

PGN 65259 Component Identification (CI) message

The component identification message is provided only upon request and is used to query the serial number of the device. Requests for this message utilize transport protocol to accommodate the data length (>8 bytes). See SAE J1939-21 and the example below. The optional make, model, and unit number fields of this message are not used.

Message

Update rate:	on request
Data length:	Variable
Data page:	0
PDU format:	255
PDU specific:	235
Priority:	6
PGN:	65259 (0xFEEB)

Data:

Byte 1-2: Delimiter, SPN 234

Data length:	1 byte
Resolution:	ASCII, 0 offset
Range:	0 to 255
Actual value:	42 42 (0x2A 0x2A)
Character:	* *

Byte 3-10: Serial Number field, SPN 588

Data length:	1 byte
Resolution:	1 /bit, 0 offset
Range:	0 to 250 (0x00 to 0xFA)
Actual value:	varies

Byte 11-12: Delimiter, SPN 234

Data length:	1 byte
Resolution:	ASCII, 0 offset
Range:	0 to 255
Actual value:	42 42 (0x2A 0x2A)
Character:	* *

Note: data is basically **cccccccc** sent in 2 messages, where c is the 8-byte serial number representation.
Data1: 01 2A 2A (first 5 bytes of serial number)
Data2: 02 (last 3 bytes of serial number) 2A 2A FF FF

Example sequences with ECM requesting Component ID (serial number) where SA=18 (12h)

Specific Request

Action	Message	Actual (hex)
ECM-to-L-Series request	RQST SOFT, 65259	EA1200 (EB FE 00)
L-Series-to-ECM RTS	TP.CM_RTS, 16,14,0,2,2,65259	EC0012 (10 OE 00 02 02 EB FE 00)
ECM-to-L-Series CTS	TP.CM_CTS,17,2,2,0,0,65259	EC1200 (11 02 02 00 00 EB FE 00)
L-Series-to-ECM data1	TP.DT, 1, data 1-7	EB0012 (01 2A 2A 31 31 31 31 31)
L-Series-to-ECM data2	TP.DT, 2, data 8-14	EB0012 (02 31 31 31 2A 2A FF FF)
ECM-to-L-Series EndOfMsg	TP.ACK, 19,14,2,2,0,65259	EC1200 (13 FF 00 02 00 EB FE 00)

Global Request

Action	Message	Actual (hex)
ECM-to-L-Series request	RQST SOFT, 65259	EAFF00 (EB FE 00)
L-Series-to-ECM BAM	TP.CM_BAM, 16,14,0,2,2,65259	ECFF12 (20 OE 00 02 FF EB FE 00)
L-Series-to-ECM data1	TP.DT, 1, data 1-7	EBFF12 (01 2A 2A 31 31 31 31 31)
L-Series-to-ECM data2	TP.DT, 2, data 8-14	EBFF12 (02 31 31 31 2A 2A FF FF)

PGN 65496 Settings Filename message

This proprietary message is provided only upon request (global or specific) and is used to query the filename of the configuration settings stored in the device. The value transmitted corresponds to that displayed on the Identification tab of the Service Tool.

Message

Update rate:	on request
Data length:	8 bytes
Data page:	0
PDU format:	255
PDU specific:	216
Priority:	6
PGN:	65496 (0xFFD8)

Data:

Byte: 1...8   Parameter file identifier. 8-bytes, 1 character/byte.

PGN 57088 DM13 Stop Start Broadcast message

The SAE J1939-73 DM13 Start/Stop broadcast messaging capability is available in the L-Series and can be used to stop or start broadcast messages or to suspend loss of communication diagnostics. The intent of this message is to minimize network traffic as well as eliminate nuisance diagnostics. The L-Series supports Start/Stop and Suspend/Resume functions. DM13 should only be used when the engine is stopped.

Start/Stop

The L-Series will respond to the Start and Stop Broadcast commands for the 'Current Data Link' and supports the Hold Signal to maintain the Stop state for another 6 seconds. In addition to ceasing message broadcasts, the L-Series suspends loss of communications diagnostics during a DM13 Stop state.

Suspend/Resume

The suspend function turns off the loss of communication diagnostics in the L-Series. An example usage would be when an ECM reflash is initiated. Loss of communication diagnostics will resume upon receipt of a DM13 resume signal, upon receipt of a position command (normal ECM communication resumes) or a device power cycle. Indefinite suspension is supported, temporary suspension is not supported.

Message

Data length:	8 bytes
Data page:	0
PDU format:	223
PDU specific:	DA
Priority:	6
PGN:	57088 (0xDF00)

Data

Byte: 1 bits 8-7 Current Data Link (Start/Stop)
              bits 6-1 (not supported)
Byte: 2-3 (not supported)
Byte: 4 bits 8-5 Hold Signal
              bits 4-1 Suspend Signal (Suspend/Resume)
Byte: 5-6 Suspend Duration (not supported)
Byte: 7-8 SAE Reserved

Start/Stop bit interpretation (SPN1230)

Bit Code	Description
00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)

Suspend Signal bit interpretation (SPN 2618)

Bit Code	Description
0000	Indefinite suspension of all broadcasts
0001	Indefinite suspension of some messages
0010	Temporary suspension of all broadcasts (not supported)
0011	Temporary suspension of some messages (not supported)
0100-1101	SAE Reserved
1110	Resuming normal broadcast pattern
1111	Not Available

Hold Signal bit interpretation (SPN 1236)

Bit Code	Description
0000	All Devices
0001	Devices whose broadcast state has been modified
0010-1110	SAE Reserved
1111	Not Available

PGN 55808 Reserved for ISO 15765*

The L-Series can communicate and be reflashed via UDS using a third party tool. This is implemented per OEM proprietary requirements. Woodward does not provide a method in the L-Series service tool to allow reflash. Prior to reflash, the engine must be off and the L-Series in a stopped position, since the actuator is uncontrolled through the whole reflashing process.

*Available only in 5418-7022

⚠ **WARNING**	**Prior to reflash, engine must be off and valve in stopped position since valve is uncontrolled through the whole reflashing process.**

CANopen

Overview

CANopen is a networking system based on the CAN serial bus. CANopen assumes that the device's hardware has a CAN transceiver and CAN controller as specified in ISO 11898. The CANopen specification covers both application layer and communication profile. The CANopen profile family specifies standardized communication mechanisms and device functionality. It is maintained by an international users' and manufacturers' group called CAN in Automation (CiA).

The L-Series CANopen Data Link is functional when the optional CAN communication link is used and the CAN Protocol is configured for CANopen. For details on the CANopen protocol, refer to CiA DS301 Version 4.02.

Initially only one L-Series was going to be on a single CAN link. This requirement has recently changed and some areas of this document will also change as a result.

CAN Bit Timing

In CANopen mode, the L-Series bit timing provides a data rate of 250 kbps only.

Device Identifier

The Device Identifier is a Service Tool configurable parameter, allowing multiple L-Series controllers on a single CAN link. Allowed values for the Device Identifier are from 1 to 127.

The configured Device Identifier affects the COB-ID of the incoming message. COB-IDs follow the predefined connection set as defined on page 78 of DS301.

Heartbeat

The L-Series heartbeat message is transmitted at the user-defined Heartbeat Producer Time set using the Service Tool.

Network Management (NMT) States

The NMT state machine is implemented per the DS301 standard. When the L-Series powers up, it will transfer through the Initialization state to the Pre-Operational state where it will remain until commanded into the Operational state.

The following are not supported:
- Synchronization (SYNC) object
- Node Guarding
- Service Data Objects (SDOs) -- (except for the Identity object, Device Type, and Error Register)
- Time Stamp Object
- Emergency Object

In the Pre-Operational State:
- Module Control Services (NMT commands) are handled
- Heartbeat is functional
- SDOs (those supported) are functional

In the Operational State:
- All communication objects are handled including PDOs (Process Data Objects)

In the Stopped State:
- Module Control Services (NMT commands) are handled
- Heartbeat is functional

The following Module Control (NMT Zero) services are supported:
- Start Remote Node
- Stop Remote Node
- Enter Pre-Operational mode
- Reset Node
- Reset Communication

Requested Messages

The software version number, parameter filename, and serial number messages can be obtained using a request of the Identity Object. The Identity Object is accessed via SDO upload at OD Index 0x1018.

The Identity Object supports 4 sub indexes:
- The Vendor ID for Woodward is 0x170
- The Product Code for Position Control is 0x1
- The Revision Number is defined to be the firmware number plus rev (i.e. firmware 5418-6084 rev NEW would be '541860840')
- The Serial Number is a unique identifier set at the factory.

Received Messages

The L-Series receives only one input command from CAN, the position demand setting. To use this input, either the primary or backup position command signal must be set for 'CAN'. The maximum message receive frequency that the L-Series can respond to is 9 ms. The minimum receive rate, prior to an annunciated fault, is determined by the CAN Fault Timeout setting in the Service Tool.

PDO1 (Rx) - Message size is 2 bytes

Byte	Parameter	Scaling
1 -2	**Position Demand** (Low byte first)	0 to 100% (scaled from 0 to 1FFF hex)

Transmitted Messages

The transmitted parameters are shown in Table 1. These parameters are transmitted at a frequency of one per second.

PDO1 (Tx) - Message size is 8 bytes. Unused bytes will be set to FF

Byte	Parameter	Scaling
1	**Actual Position**	0 to 100% (scaled from 0 to FF hex)
2	**Desired Position**	0 to 100% (scaled from 0 to FF hex)
3	Diagnostics 1 Bit0 – Watchdog Reset Bit1 – Brownout Reset Bit2 – EEPROM Fault Bit3 – Position Sensor Fault Bit4 – Temperature Sensor Fault Bit5 – Supply Voltage Fault Bit6 – Discrete Out / Relay Fault Bit7 – Position Command Fault	Bit field
4	Diagnostics 2 Bit0 – Over temperature Bit1 – Position Error Bit2 – Position Tamper Fault Bit3 – (spare) Bit4 – Analog Posn Command Fault Bit5 – PWM Fault Bit6 – CAN Fault Bit7 – Run Enable Fault	Bit field
5	**Internal Temperature**	–40 to +215 °C, –40 offset (scaled from 0 to FF hex)
6	**Reserved**	
7	**Historical Diagnostics 1**	Bit field
8	**Historical Diagnostics 2**	Bit field

Faults

Faults are separated into two categories: Logged Faults and Current Faults. The Current Faults are volatile and reset every time power is applied. Current Faults are detected faults that are presently active; they may latch or not latch depending on the fault. All latching Current Faults are reset by a power cycle or Service Tool reset. All logged faults are latched and written to the EEPROM. They must be cleared through the Service Tool.

A fault can have three effects on the control:
- Change the discrete output state (Alarm);
- Shutdown–drive to fail direction and change the discrete output state (Alarm); or
- Shutdown–go limp and change the discrete output state (Alarm).

A parameter is available to configure the fault to either an alarm or a shutdown. The shutdown action performed (go limp or drive to fail position) is fault-dependent. Some faults are dedicated shutdowns and cannot be configured—they are identified as such below. A "go limp" command overrides a "drive to fail position" if more than one fault is set.

Faults can be configured as either latching or non-latching. This is a general setting that applies to all faults, unless otherwise noted. When configured as

non-latching, a Reset is not needed. If latching mode is configured, a Reset or power-cycle is required to clear the fault and resume positioning.

Watchdog Reset

Watchdog Reset is true if a watchdog timer timeout occurred which resulted in a reset of the microprocessor. This is a hard-coded alarm. If detected, the control will attempt to continue normal operation.

Brownout Reset

Brownout Reset is true if CPU Voltage drops below 4.2 V but not below 1 V. The brownout detect circuit will reset the CPU. This is a hard-coded alarm. If detected, the control will attempt to continue normal operation.

EEPROM Fail

EEPROM Fail indicates failure or corruption of the internal non-volatile memory. If the CRC is not correct for the EEPROM data, this fault will be set true. This is a hard-coded internal shutdown. If detected, the control output will go limp. A power cycle is required to clear this fault.

Position Sense Fail

This indicates a failure of the internal Position Sensor. This is a hard-coded internal shutdown. If detected, the control output will drive to the Shutdown Position using current control. This fault latches and requires a reset or power cycle to clear.

Failure levels: >4.75 V and < 0.25 V
Persistence: 650 ms

Voltage Sense Fail

Indicates an out-of-range signal on the input power. Could indicate input power out of range or a fault in the supply voltage sense circuitry.

Failure levels: >33 V and <6.25 V
Persistence: 650 ms

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using current control) if this fault is detected. If configured as an alarm, the control will internally default to an assumed 32 V power supply voltage (decreased torque at lower actual voltages) and attempt to continue normal operation if this fault is detected. The value displayed on the Service Tool will show sensed value, not default.

Temp Sense Fail

Indicates a failure of the internal on-board Temperature Sensor.

Failure levels: >150 °C and <–45 °C
Persistence: 650 ms

Hysteresis: 5 °C (<145 °C or >–40 °C to clear)

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected.

OverTemp

If the on-board temperature sensor reads above 117 °C, this error will be set, which is the temperature at which current limiting begins. At 125 °C, the temperature-based current limiting will effectively make the output "limp" by reducing the drive current to zero.

Failure levels: >117 °C
Persistence: 650 ms
Hysteresis: 5 °C (<1120 °C to clear)

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will go limp if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Position Error

Position Error detection logic will indicate a difference between commanded position and actual position exceeded for longer than the set delay. The error magnitude and duration are customer-configurable parameters.

Failure levels: Set by customer variable, Error > |PosErrorMax|
Persistence: Set by customer variable, Position Error Delay.
Hysteresis: none
Override: Whenever the current is being limited to a factor of 1/2 normal maximum or less. This would be because of high temperature (see section on Temp Sensing and Current Limiting) or a shutdown that causes the output to go "limp".

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Relay Output Shorted

The relay driver is thermally protected against wiring errors. If incorrectly wired, the output will turn off and then set the Error Bit.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

PWM Input Failed

Indicates the PWM position command input (PWM Demand) is out of range. This indication is only active when the position demand is configured for 'PWM'.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Failure levels: >97% Duty and < 3% Duty
Persistence: 250 ms
Hysteresis: 1% (<96% or >4% to clear)

Analog Demand Failed

Indicates the AUX2 position command input (Analog Demand) is out of range. This indication is only active when the position demand is configured for 'Analog'.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Failure levels: >4.8 V and < 0.2 V
Persistence: 650 ms
Hysteresis: 0.05 V (<4.75 V or >0.025 V to clear)

CAN Fault

Indicates the address was not successfully claimed (J1939) or the position command over CAN is stopped or the detected CAN position command updates are too slow. The command failed detection is only active when the position demand is configured for 'CAN'. If new position updates from CAN are not received within the configured CAN Fail Timeout a CAN Fault is annunciated.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Position Demand Failed

Indicates all position demand signals are failed. When configured for redundant inputs, both the primary and the backup signals must be out of range to activate this fault.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Run Enable Shutdown

The Run Enable discrete input is opened. The shutdown is only active when Run Enable is configured for use. This is a hard-coded shutdown. The control will go limp if this condition is detected.

CAN Stop Commanded (not available in 5418-6084 firmware)

Indicates a Stop Command was issued over CAN. This is a hard-coded shutdown. The control will go limp if this condition is detected.

Tamper Fault

CAN command failed is only active when the backup position demand is configured for 'CAN' and Tamper Fault is enabled.

Indication that the primary position command does not match the CAN position command. When this condition is detected the primary command will be "faulted" and the backup (CAN) command will be used.

Can be configured as an alarm or shutdown. If configured as a shutdown, the control will drive to Shutdown Position (using position control) if this fault is detected. If configured as an alarm, the control will attempt to continue normal operation.

Failure levels: Set by customer variable, |Error| > CAN Tracking Error Max
Persistence: Set by customer variable, CAN Tracking Error Delay
Override: Fault is disabled for CAN Fault

Chapter 3.
Installation

Introduction

This chapter provides instructions on how to mount and connect the L-Series controller into a system. Hardware dimensions are provided for mounting the device to a specific application.

⚠ WARNING	**EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.**
	Substitution of components may impair suitability for Class I, Division or Zone applications.

⚠ WARNING	**External fire protection is not provided in the scope of this product. It is the responsibility of the user to satisfy any applicable requirements for their system.**

⚠ WARNING	**Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.**

⚠ CAUTION	**Due to typical noise levels in turbine or engine environments, hearing protection should be worn when working on or around the L-Series.**

⚠ CAUTION	**The surface of this product can become hot enough or cold enough to be a hazard. Use protective gear for product handling in these circumstances. Temperature ratings are included in the specification section of this manual.**

NOTICE	**Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagrams (Figure 3-4).**

General Installation, Operation Notes and Requirements

⚠ WARNING	**Woodward strongly recommends use of the following devices. Failure to use any of these devices can cause personal injury or property damage:**
	• **Use an independent device for positive shutdown, such as a fuel shut-off valve.**
	• **Use an external spring to return to minimum fuel.**
	• **Use a predicted min fuel shutdown procedure.**

Unpacking

Be careful when unpacking the actuator. Check the unit for signs of damage, such as bent or dented panels, scratches, and loose or broken parts. Notify the shipper and Woodward if damage is found.

Mechanical Installation

Mounting Location

Locate the L-Series control a distance from sources of extreme radiant heat, such as exhaust manifolds or turbochargers. The operating temperature range of the control is –40 to +105 °C (–40 to +221 °F). In spark-ignited applications, make sure the L-Series is located away from the ignition coil, and that harness wires are not routed next to the spark plug wires.

Mounting Orientation

While it is not a requirement, it is good practice to orient the connector feature on the control in a horizontal or downward orientation to minimize fluid accumulation between the enclosure and the mating connector's gasket.

Actuator Configuration

The L-Series actuator utilizes a 2-inch (50.8 mm) square mounting bolt pattern and is intended to fit within an envelope of 2.618 x 2.618 x 2.540 (66.50 x 66.50 x 64.52 mm) with the short dimension along the shaft axis. Two shaft seal configurations are available, an internal lip seal and an external lip seal with spring backup (Figure 3-2). In addition, six independent output shaft configurations are available (Figure 3-3). Consult Woodward Applications Engineering for the application appropriate seal and shaft configuration.

Mounting Hardware

Use #10 or M5 fasteners to attach the L-Series control to the mounting bracket. The bracket and attaching hardware must be designed to hold the weight and to withstand the vibration associated with prime mover mounting. Use the appropriate fasteners for securing the mounting bracket to the engine.
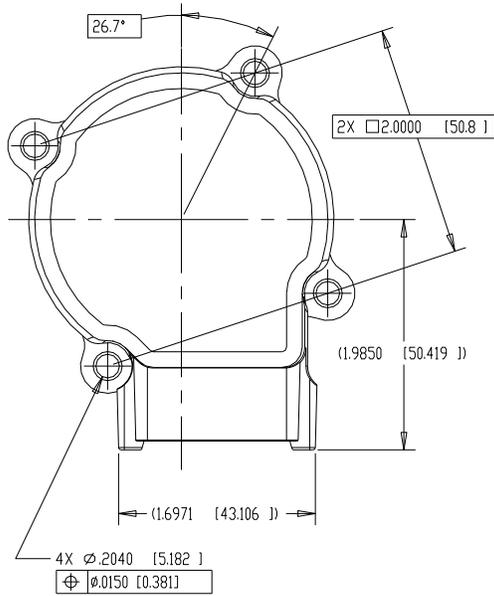
NOTES:

1. MOUNTING HARDWARE TO BE SOCKET HEAD CAP SCREWS
    -- #10(.190)-24, M5, OR EQUIVALENT.
    NO WASHERS TO BE USED.
    RECOMMENDED SCREW TORQUE = 35 IN-LB [4 N-M].

2. FOR BRACKET-MOUNT APPLICATION, A BRACKET OUT-OF-
    FLATNESS OF .010 [0.25] MAXIMUM IS RECOMMENDED.

3. FOR CONNECTOR INFORMATION, REFER TO CONNECTOR
    TABLE AND APPROPRIATE WIRING DIAGRAM.

4. USE OF INTERNAL ACTUATOR STOPS IN APPLICATION NOT
    RECOMMENDED. TORQUE AGAINST STOPS NOT TO EXCEED
    200 IN-OZ.

5. DIMENSIONS ARE SHOWN IN INCHES [MM].

6. DETAILS SHOWN HERE ARE COMMON TO ALL ACTUATOR
    ASSEMBLIES. HENCE, NEITHER COVERS NOR SHAFTS ARE
    SHOWN IN THESE VIEWS. SEE COVER AND SHAFT DETAILS
    ELSEWHERE IN THIS MANUAL.

INTEGRATED DEUTSCH CONNECTOR (REF: DT04-12PA)		
ITEM	RECOMMENDED	OPTIONAL
MATING CONNECTOR	DT06-12SA-P012	DT06-12SA
SECONDARY LOCK	W12S-P012	W12S
SOCKETS	0462-201-16141	0462-201-16141
WIRING HARNESS STRESS RELIEF SUPPORT	WITHIN 16 INCHES FROM CONNECTOR	

NOTE: IN THE EVENT A WIRE IS NOT USED FOR EACH OF THE 12 PINS ON
        THE CONTROL, A DEUTSCH 114017 PLUG MUST BE USED IN PLACE
        OF EACH MISSING WIRE TO ENVIRONMENTALLY SEAL THE CONTROL.
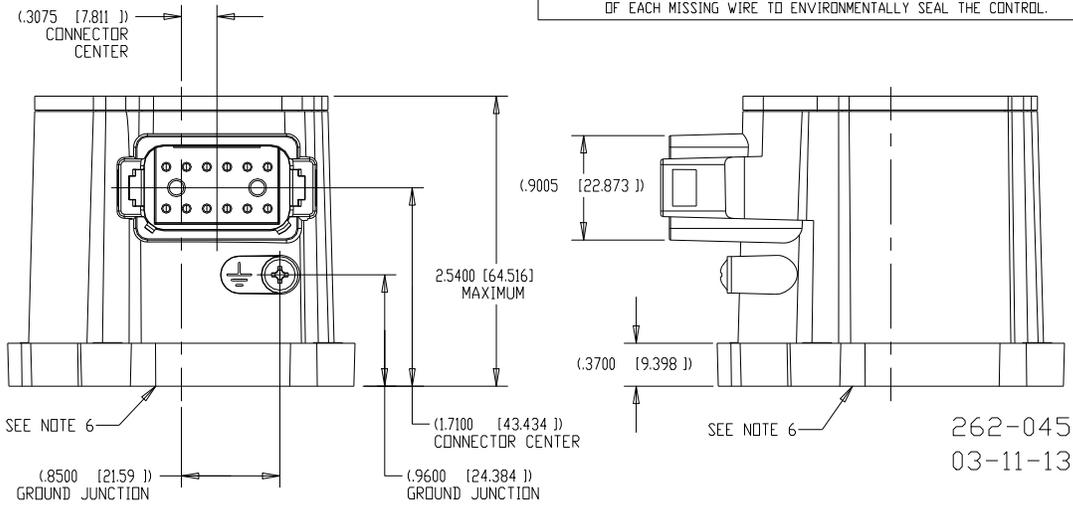
262-045
03-11-13

Figure 3-1. L-Series Outline Drawing

COVER TYPE 1
INTERNAL LIP SEAL
SHAFT TYPE 1 PHANTOM / INCHES [MM]

COVER TYPE 2
EXTERNAL SPRING-LOADED LIP SEAL
SHAFT TYPE 1 PHANTOM / INCHES [MM]

.0590 -.0670
[1.499 -1.701]

.2450 -.2530
[6.223 -6.426]

.1540 -.1620
[3.912 -4.114]

.0390 -.0450
[0.991 -1.143]

.3250 -.3350
[8.255 -8.509]

(Ø.4800   )
[12.192]

Ø.7720 -.7780
[19.609 -19.761]

Ø.8590 -.8650
[21.819 -21.971]

Ø1.0230 -1.0290
[25.985 -26.136]

Ø1.1850 -1.1920
[30.099 -30.276]
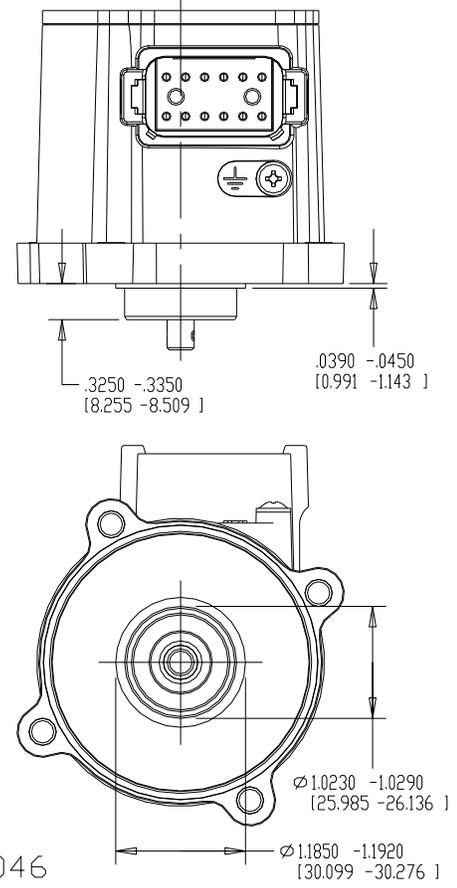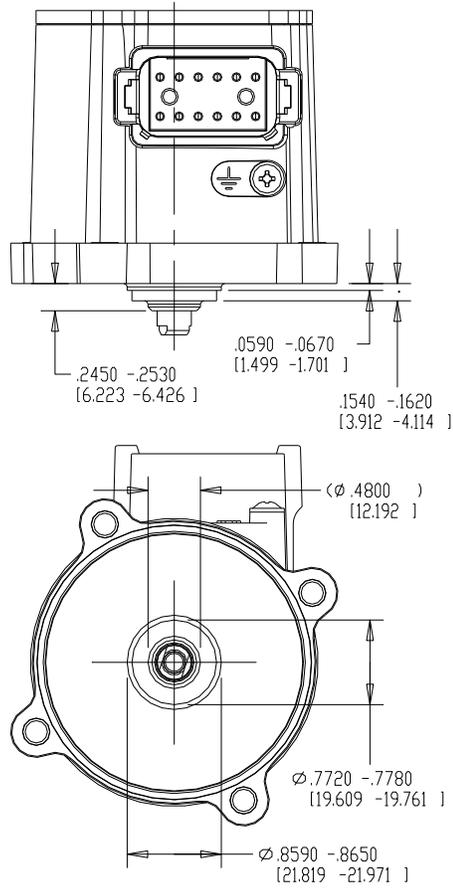
262-046
03-11-13

Figure 3-2. L-Series Cover Types

SHAFT TYPE 1
2X FLATS, THREADED AXIAL HOLE
COVER TYPE 1 PHANTOM / INCHES [MM]
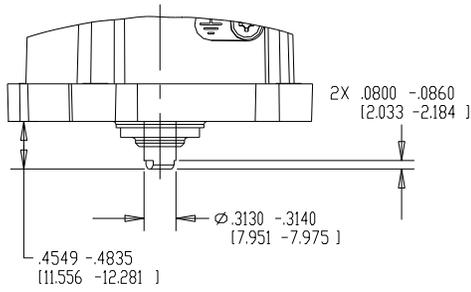
SHAFT TYPE 2
Ø.2480, 1X CROSS HOLE
COVER TYPE 2 PHANTOM / INCHES [MM]

2X .0800 -.0860
[2.033 -2.184]

Ø.3130 -.3140
[7.951 -7.975]

.4549 -.4835
[11.556 -12.281]

.1210 -.1370
[3.074 -3.479]

X   X

Ø.2470 -.2490
[6.274 -6.324]

.5919 -.6205
[15.035 -15.761]

COUNTER-CLOCKWISE
INTERNAL STOP

.2135 -.2165
[5.423 -5.499]
ACROSS FLATS

60° ±2°
TRAVEL BETWEEN
INTERNAL STOPS

CLOCKWISE
INTERNAL
STOP

M5X0.8 THREAD
↧.3310 MIN

134.8° ±3.5°
FLATS RELATIVE TO
THE MOUNTING HOLE

SECTION X-X

Ø.0620 -.0650
[1.575 -1.651]

COUNTER-
CLOCKWISE
INTERNAL
STOP

60° ±2°
TRAVEL BETWEEN
INTERNAL STOPS

81.4° ±3.5°
SHAFT CROSS HOLE
RELATIVE TO THE
MOUNTING HOLE

CLOCKWISE
INTERNAL
STOP

262-047
03-11-13

Figure 3-3a. L-Series Shaft Types

SHAFT TYPE 3
Ø.3095, 1X CROSS HOLE
COVER TYPE 1 PHANTOM / INCHES [MM]

SHAFT TYPE 4
Ø.2480, 1X CROSS HOLE
COVER TYPE 1 PHANTOM / INCHES [MM]

.1170 -.1330
[2.972 -3.378]

X   X

Ø.3090 -.3100
[7.849 -7.874]

.6119 -.6405
[15.543 -16.269]

.0990 -.1150
[2.515 -2.921]

X   X

Ø.2470 -.2490
[6.274 -6.324]

1.4119 -1.4405
[35.863 -36.589]

SECTION X-X

Ø.0925 -.0935
[2.350 -2.374]

CLOCKWISE
INTERNAL
STOP

60° ±2°
TRAVEL BETWEEN
INTERNAL STOPS

0.0°±3.5°
SHAFT CROSS HOLE
RELATIVE TO THE
MOUNTING HOLE

COUNTER-CLOCKWISE
INTERNAL STOP

SECTION X-X

COUNTER-CLOCKWISE
INTERNAL STOP

Ø.0620 -.0650
[1.575 -1.651]

60° ±2°
TRAVEL BETWEEN
INTERNAL STOPS

97.8° ±3.5°
SHAFT CROSS HOLE
RELATIVE TO THE
MOUNTING HOLE

CLOCKWISE
INTERNAL
STOP

262-048
03-11-13

Figure 3-3b. L-Series Shaft Types

SHAFT TYPE 5
Ø.2480, 1X CROSS HOLE
COVER TYPE 1 PHANTOM / INCHES [MM]

SHAFT TYPE 6
Ø.2480, 2X CROSS HOLE
COVER TYPE 1 PHANTOM / INCHES [MM]

X   X

.0980 -.1140
[2.490 -2.895]

NOTE:
THIS SHAFT
IDENTICAL TO
SHAFT TYPE 5
PLUS EXTRA
CROSS HOLE

X   X

.7440 -.7560
[18.898 -19.202]

Ø.2470 -.2490
[6.274 -6.324]

1.8819 -1.9105
[47.801 -48.527]

SECTION X-X

Ø.0620 -.0650
[1.575 -1.651]

SECTION X-X

Ø.0610 -.0670
[1.550 -1.701]

CLOCKWISE
INTERNAL
STOP

0.0°±3.5°
SHAFT CROSS HOLE
RELATIVE TO THE
MOUNTING HOLE

COUNTER-CLOCKWISE
INTERNAL STOP

60° ±2°
TRAVEL BETWEEN
INTERNAL STOPS

262-049

03-11-13

90° ±3°
INNER CROSS HOLE
RELATIVE TO OUTER
CROSS HOLE

Figure 3-3c. L-Series Shaft Types

Electrical Installation

Figure 3-4 shows a wiring pin-out of the L-Series control, as viewed by looking into the control's connector feature. Typical connections to external devices are also shown.

The L-Series has an operating voltage range of 8 to 32 Vdc with nominal voltages of 12 or 24 Vdc. The power supply is reverse polarity protected, and consumes 32 W maximum power at a peak current of 1 A (32 V) assuming 4 Ω stator resistance at 25 °C. These assumptions are based on the fact that the software limits the power to the rotary actuator to 25 W at any given time and input voltage (in the valid range). The control system should be protected with a 6 A slow-blow fuse in the voltage supply lines. Typical max average current is 2.1 A, or max 25 W at 12 V. The application should be configured to turn on power to the actuator when the engine is first cranked.

NOTICE	Centralized load suppression is required when using an L-Series. The L-Series power supply input is not designed to withstand transient events typical of industrial or automotive environments (alternator load dump or power line surge). The centralized suppression must limit transient events to less than 45 V at the L-Series input power terminals.

Electrical Connections

⚠WARNING	EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous. Substitution of components may impair suitability for Class I, Division or Zone applications.

Prior to installation, refer to the wiring diagrams and the representative I/O interfaces schematic in this chapter. Also, review the hardware I/O specifications in Appendix B.

NOTICE	The control will only meet ingress protection specifications while the Deutsch connector is installed in the unit. As such, the unit should not be exposed to operating environments unless the mating connector is installed. In addition, if a wire is not used for each of the 12 pins on the control, a Deutsch 114017 plug must be used in place of each missing wire. Failure to adhere to these guidelines may result in product failure or decreased life.

Use 16 to 18 AWG (1 to 1.5 mm²) stranded copper wire with insulation that meets temperature requirements in the harness design. A wiring harness stress relief within 16" (406 mm) of the control's connector is recommended. Limit all I/O and signal lines to less than 30 m (98 ft). Also limit input power (B+/B−) connections to an earth grounded battery or conditioned power interface to less than 10 m (33 ft) from the L-Series product.

IMPORTANT	A conditioned power interface is an interface which offers equivalent common mode and differential mode conditioning of that of a grounded 24 V lead acid battery.

Dress the harness with wire loom to contain it in a single bundle. Use grommets when passing the harness through metal panels.

Connector

The following Deutsch connector components are recommended for harness designs:

	Recommended	Optional
Mating Connector	DT06-12SA-P012	
Secondary Lock	W12S-P012	
Sockets	0462-201-16141	1062-16-0122
Crimp Tool	HDT-48-00	DTT-16-00
Sealing Plug	114017	

For convenience, Woodward part number 8928-396 is a kit that provides all the necessary Deutsch components (crimp tool *not* included).

> **IMPORTANT**   **Crimping methods for the Deutsch connector pins must be followed as prescribed by the manufacturer. Woodward is not responsible for damage or loss of performance resulting if any other method of crimping is used. Use of the listed part numbers of Deutsch connector components is strongly recommended.**
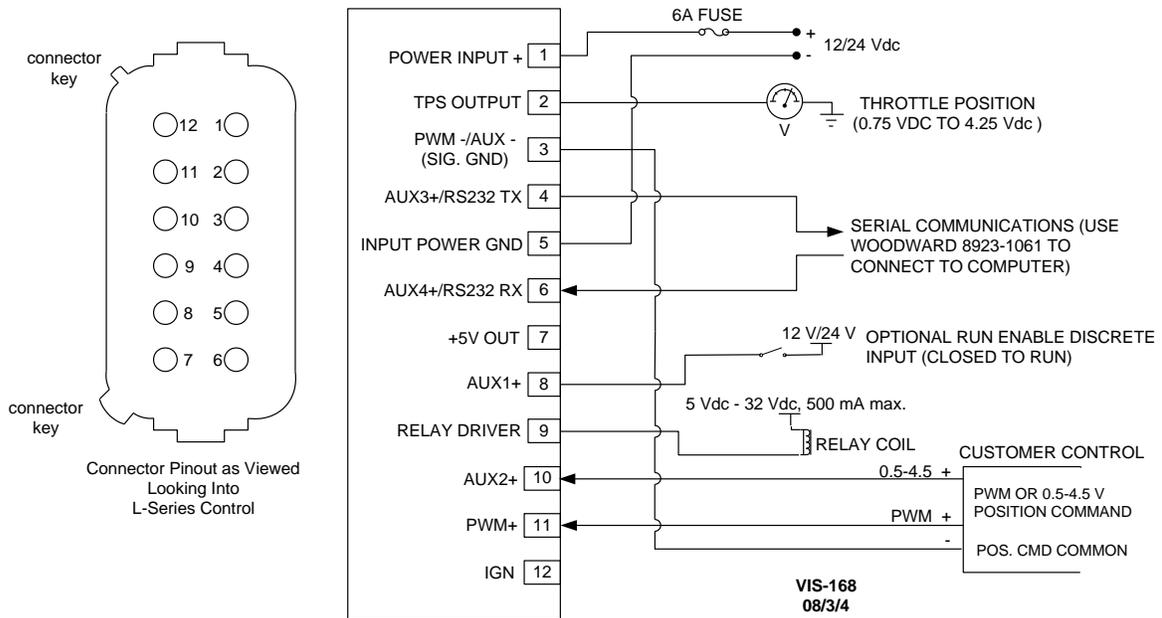
Figure 3-4. Typical L-Series Position Control Application Wiring

Connector Pin #	Description	Comment
1	+12 V/24 Vdc Input Power	Supply power
2	TPS Signal Output	Direct position feedback output indication
3	PWM – / AUX –	Ground for the PWM or AUX command signal common
4	RS-232 transmit / CAN H	For use with the service tool and CAN
5	Input Power Ground	Ground for the 12 V/24 V input power
6	RS-232 receive / CAN L	For use with the service tool and CAN
7	5 V Out	Power for external sensors (10 mA max)
8	Aux Input 1	Optional Run Enable or CAN ID discrete input
9	Relay Driver Output	Status / fault detection output
10	Aux Input 2	Optional 0–5 V command input or CAN ID selector
11	PWM + / Aux Input 5	Optional PWM command input or CAN ID discrete input
12	Ignition Input	Not used—Leave open

Description of Electrical I/O

Representative circuitry for the L-Series inputs/outputs is provided in Figure 3-5 below.

Power Supply Input (+12 Vdc/24 Vdc at pin 1, ground at pin 5)—The L-Series is configured for 12 or 24 V nominal operation, although it will handle 8–32 V. The power supply terminals are reverse polarity protected, and in the case that a reverse polarity condition exists, the L-Series actuator will not power-up and will remain at the minimum stop if attached to a throttle body with an internal return spring.

Woodward recommends using a 6 A slow-blow fuse on the power supply line feeding pin 1 of the L-Series actuator.

⚠ **WARNING**	**The input power must be fused. Failure to fuse the L-Series could, under exceptional circumstances, lead to explosion, personal injury, or damage to the control valve.**

PWM Command Input (+PWM at pin 11, PWM ground at pin 3)—This actuator can be configured to handle a PWM signal from a high-side or low-side open-collector or open-drain source, as well as from a push-pull (customer pull-up) source. The necessary pull-up and pull-down voltages to accommodate the open-collector sources are handled within the L-Series actuator. Nominally, the frequency of PWM is 1 kHz, but it will handle the full range of 300 to 1500 Hz. See Figure 3-5 below, which describes the possible input types and configurations for the PWM input.

This input (pin 11) can also be used as a CAN ID HIGH discrete input, referred to as Aux5. This feature only applies to J1939 and is not available in firmware 5418-6084.

IMPORTANT	**This actuator can also be commanded using an analog signal of 0–5 V. See the description below for the auxiliary input pins. AUX2 is used as the analog command input. The PWM and AUX2 input pins should not be tied together.**

TPS Output (pin 2, referenced to either pin 3 or pin 5)—This pin feeds the output of the Hall effect position sensor to the terminal wiring. The output range of this pin should be approximately 0.75 Vdc when the actuator is full counterclockwise (when viewed at the end of the shaft), and approximately 4.25 Vdc when the actuator is at full clockwise. This gives the end user an indication of throttle position.

⚠ **WARNING**	**Woodward recommends that the TPS output be used to externally verify that the position command and subsequent actual position matches the command signal sent. In addition to a positioning error validation, the TPS signal should be monitored to detect out-of-range errors on the TPS output. Failure to comply with this recommendation can result in undetected system faults, and in extreme cases, can cause personal injury and/or property damage.**

IMPORTANT	**This output is meant for an approximate indication of shaft position only. The unconditioned output accuracy must be considered when using this signal externally. Refer to the specification for TPS accuracy.**

For this type of PWM Source...   ...the L-Series PWM Input looks like...
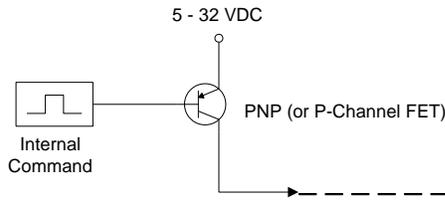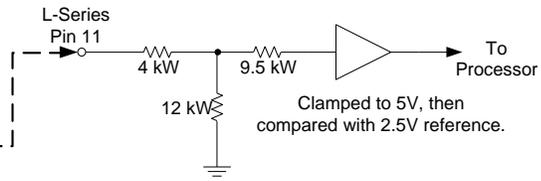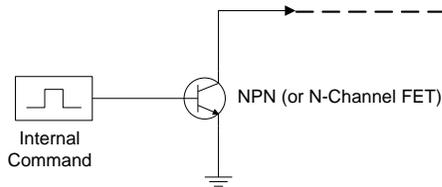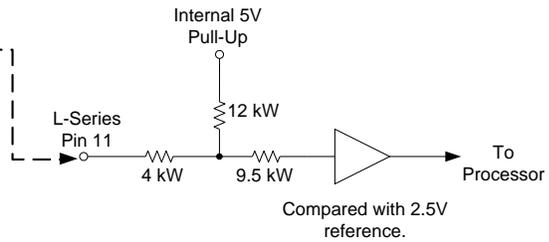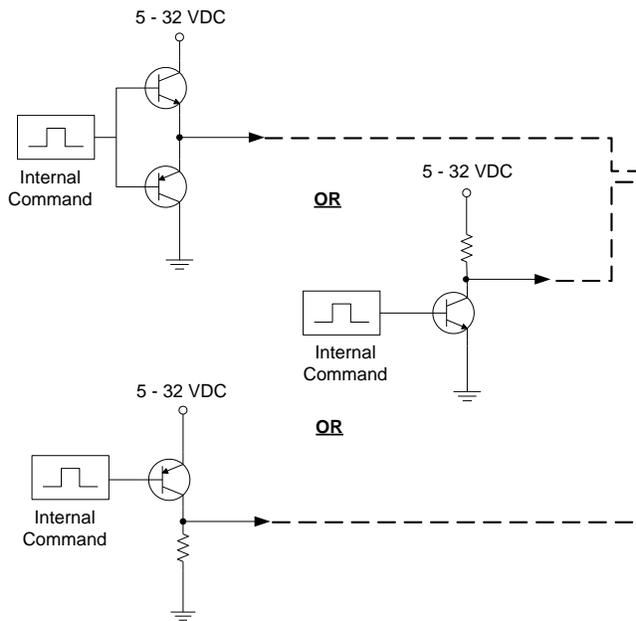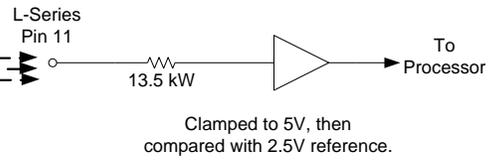
Figure 3-5. Acceptable PWM Input Types

RS-232 Connections (pin 4 and pin 6)—These pins are for serial communication with the L-Series actuator. An external RS-232 transceiver is necessary to make communications possible with the Woodward L-Series Service Tool. A connectivity kit can be purchased from Woodward to accomplish this. Further instructions for using this connectivity kit are provided in Chapter 4. See also the description below on Auxiliary Inputs.

Relay Driver Output (pin 9)—This pin provides the end user with a means for detecting a fault or shutdown condition that is experienced by the L-Series actuator. It is a low-side driver capable of sinking 250 mA (not to exceed 500 mA) through an external load such as a lamp or relay. This circuit is internally protected against over-current conditions and inductive flyback, such as from a relay coil. By default, this circuit will be configured in a failsafe manner, meaning it will be active (conducting) when no fault exists, but if power is lost or a fault is detected by the L-Series actuator, the circuit will open. See Figure 3-6 below for typical usage of this feature.

> ⚠️**WARNING**   **Woodward recommends that the Relay Output be configured for the failsafe 'Normally On' mode, to ensure maximum fault protection and annunciation. Failure to follow these guidelines could, under exceptional circumstances, lead to personal injury and/or property damage.**
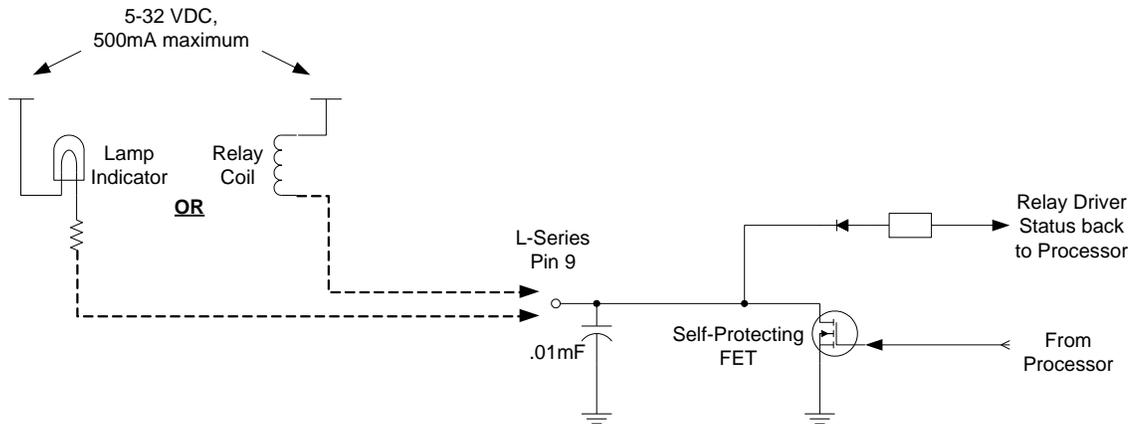

Figure 3-6. Relay Driver Output

5 V Output (pin 7, referenced to pin 3)—The +5 Vdc Power Output is intended to power any external transducer that depends on a steady 5 V source. The maximum output current is 10 mA.

Auxiliary Inputs (pins 4, 6, 8, and 10)—The L-Series has three dedicated digital inputs (AUX2, AUX3, and AUX4) used to activate various features of the control. Shorting an auxiliary input pin to battery voltage activates it. Removing battery voltage from an input pin or shorting the pin to ground deactivates the input. If it is decided not to use battery voltage with the auxiliary digital inputs, Woodward recommends that at least 3 V be present on an input pin in order to change its state from inactive to active. All discrete inputs will be the same voltage as the system power supply and will be active only while the input is in a high state. For AUX2, AUX3, and AUX4, greater than 2.5 Vdc is considered high, and less than 0.8 Vdc is considered low. For the AUX1 discrete input only, the input must exceed 3 V to activate the discrete state. AUX3 and AUX4 are also used for digital communications such as RS-232 (service tool) or CAN (If the CAN option was purchased). RS-232 and CAN will NOT run simultaneously.

An additional CAN ID HIGH discrete input (AUX5, pin 11) can be configured to support up to four J1939 devices on a single bus.

AUX1 can be configured as a run enable or CAN ID LOW discrete input (J1939 mode only). This configuration must be specified in the configuration of the device using the Service Tool. If AUX1 is selected to perform the run enable function, then 5 V (5–32 V) applied to pin 8 will allow the control to run normally. When this input is opened, the actuator will be in stand-by mode. When in stand-by, the actuator driver will be disabled, and the shaft will be limp.

AUX2 can be used as either a 0–5 V position command signal or as a CAN ID discrete input (J1939 mode only). The software must be configured to recognize the input's function. When configured as a CAN ID LOW discrete input, the input is monitored on power-up to determine which ID to use. Device 1 is selected if closed/high and device 2 is selected if open/low.

See Figure 3-7 below for typical usage of AUX1 and AUX2 when the L-Series is configured as an analog position control.

IMPORTANT	This actuator can also be commanded using a PWM signal. See the description above in the PWM Command Input section. The PWM and AUX2 input pins should not be tied together.

IMPORTANT	All connector pins are short-circuit protected to ground and power except pins 3 and 5, which are not protected against shorts to battery positive. Installation of a fuse on the power ground wire to pin 5 would provide protection to these pins but does not mean one is not needed in the power connection. Pin 1 (B+) still needs protection against a short to ground.
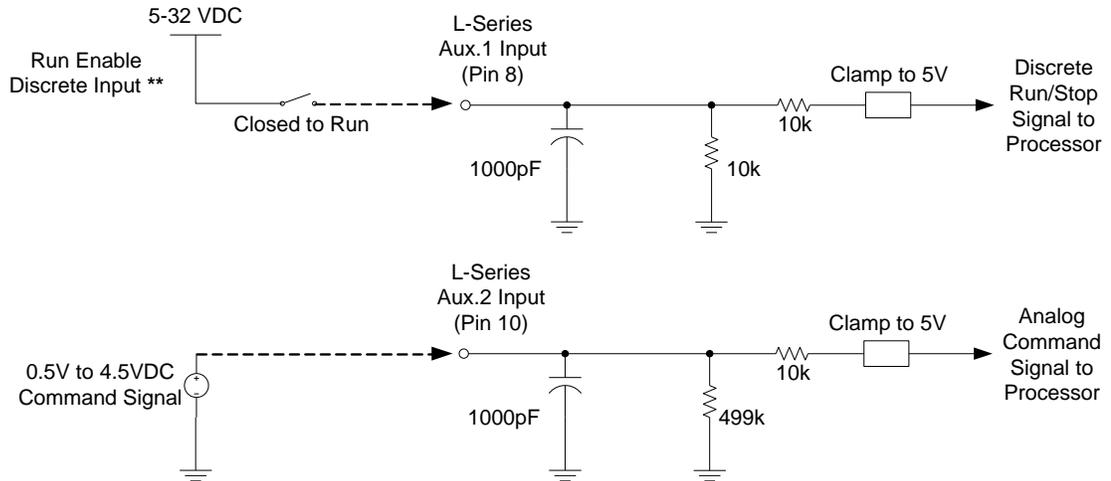
** if optional external Run Enable is chosen during L-Series configuration, Aux. 1 can be used to enable or
disable the actuator output shaft torque.

Figure 3-7. Typical AUX1 and AUX2 Usage

NOTICE

When using a CAN-enabled L-Series actuator, if AUX3 or AUX4 are used as discrete inputs, do not tie pin 4 or pin 6 directly to the BAT+ input (pin 1). Doing so can damage the control. If it is desired to use AUX3 and/or AUX4 as discrete input(s) instead of CAN, connect to the supplied 5 V output (pin 7), or use an independent power source of less than 10 Vdc.

Communications

The L-Series can communicate using CANbus protocol or serially using RS-232. CAN is an optional feature that requires additional hardware and a CAN-capable processor. For protocol details, refer to the CAN section in chapter 4 of this manual.

RS-232 communications are available on the L-Series when used with an external transceiver connected to pins 4 and 6. Serial communications allow for the use of a service and configuration tool with the L-Series actuator. The simplest way to establish this interface is to use Woodward kit # 8923-1061.

On CAN-capable units, both CAN and RS-232 share the same I/O pins. The L-Series performs a check on these pins in power-up to determine if the Service Tool is attempting to communicate with the unit. If not, CAN is initialized and used. When finished with the Service Tool functions, disconnecting the RS-232 communications and cycling the input power will re-establish CAN communications.

RS-232/Service Tool Connections (pin 4 and pin 6)
These pins are for serial communication with the L-Series actuator. An external
RS-232 transceiver is necessary to make communications possible with the
Woodward L-Series Service Tool. A connectivity kit can be purchased from
Woodward to accomplish this. Further instructions for using this connectivity kit
are provided in Chapter 4.

Woodward recommends that the OEM or packager provide a breakout cable that
is connected to the L-Series service port and run to an easily accessible area on
the engine. The service port is absolutely necessary to set up and troubleshoot
the L-Series.

Any RS-232 wiring must meet the requirements in the EIA RS-232 Standard
document. The RS-232 standard states that the length of the RS-232 cable
between the driver and the PC must be less than 50 ft (15 m) with a total
capacitance less than 2500 pF. The RS-232 data rate is fixed at 19.2 kbps. The
communication port is non-isolated and susceptible to both EMI noise and
ground loops related to PC connections and typical industrial environments.

Functions available through the Service Tool include tuning, monitoring, and
configuration of the position controller. Detailed driver status information is also
available. For details, refer to the Service Tool chapters of this manual.

IMPORTANT	The service port is not isolated and is not intended to function while the prime mover is in normal operation. The service port is provided for configuration and setup only.

CAN Connections (pin 4 and pin 6)
As a general rule for CAN networks, use the following and refer to the table
below.
- Wiring length restrictions depend on the baud rate used. The L-Series only
  supports 250 kbps in CANopen mode and 250 or 500 kbps in J1939 mode.
- The "Trunk" is the length between the two units at the physical ends of the
  network; or the two termination points if the end units have a drop cable.
- The "Cumulative Drop" is the added length of all drop wires from the trunk to
  the devices.
- The "Maximum Drop" is the maximum allowed for any 1 drop.

The limits below are the maximum allowed by the CAN standard, when isolated.
Shorter lengths in practice are highly recommended in order to maintain a high
level of reliability.

IMPORTANT	Since the L-Series CAN communications is not isolated, a distance of 40 meters should not be exceeded without adding an isolator.

Baud Rate	Trunk Length	Cumulative Drop	Maximum Drop
250 kbps	250 m (820 ft)	78 m (256 ft)	6 m (20 ft)

CAN Network Termination
CAN networks must be terminated with a 121 Ω ±1% differential resistance at each end of the network. It is necessary to terminate the network to prevent interference caused by signal reflections. Depending on length, many CAN networks will not operate at all without the proper termination. Generally it is a good idea not to build the termination into a node since CAN is intended to be a plug-and-play type network with RIUP (remove and insert under power). However, no specific restrictions are placed on the inclusion of termination resistors in a node.

Termination resistors must be installed only at the physical ends of the network. Terminating other midpoint units can overload the network and stop all communications. As a rule, no matter how many units are on a network, there should never be more than two terminations installed.

If termination resistors are provided within a node, the EMC test should be conducted both using and not using the termination network to validate that both wiring versions provide acceptable results. This assumes the termination network can be disabled which is generally true.

Termination is a simple 121 Ω, ¼ watt, 1% metal film resistor placed between CAN high and CAN low terminals (differential termination) on or near the two end units.

CAN Network Construction
While there are different ways to physically connect devices on a network, the most reliable method for multi-drop networks is a "daisy chain" configuration, also called a "zero drop length" connection. A "backbone with stubs" is also acceptable, but will require more attention to wiring for reliable performance. In a daisy chain, wires are run from device one to device two to device three, etc. In a backbone with stubs, a main trunk line is run between the two devices that are physically farthest apart, and then stub lines are run from the intermediate devices to the trunk line. Stubs should be kept as short as possible and may never exceed 6 m (20 ft). See wiring example below for a graphical representation.

In most applications, a ground wire is needed between all units on the network. The preferred method for isolated ports is to include a separate wire in the CAN cable. This keeps the communications and ground reference at the same potential at all times. For this reason the recommended cable types below are DeviceNet cables, which include an extra wiring pair.

Non-isolated nodes may not have a signal ground available for connection. If a signal ground is not available, use the alternate wiring scheme of connecting the CAN ground wire from the isolated nodes to the B- terminal at a non-isolated node (this is typically the signal reference for CAN if isolation is not provided).
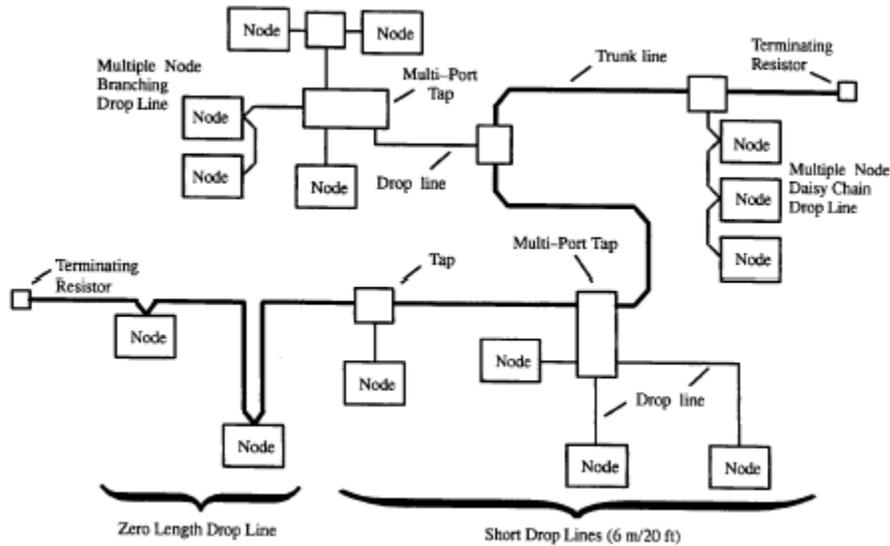
Figure 3-8 CAN System Wiring Example

CAN Cable Recommendations
Use only recommended shielded cabling for a CAN network. Correct cable is available from Belden, Lapp Cable, or other suppliers providing an equivalent cable.

Here are the cable specifications from the DeviceNet standard, a good source for CAN requirements.

Data pair impedance	120. ±10% at 1 MHz
Cable capacitance	12 pF/ft at 1 kHz (nominal)
Capacitive unbalance	1200 pF/1000 ft at 1 kHz
Propagation delay	1.36 ns/ft (maximum)
DC Resistance	6.9 Ω / 1000 ft @ 20 °C (maximum)
Data Pair	19 strands, 1.0 mm² corresponds to 18 AWG, individually tinned, 3 twists/foot
Power Pair	19 strands, 1.5 mm² corresponds to ~16 AWG, individually tinned, 3 twists/foot
Drain / Shield Wire	19 strands Tinned Copper shielding braid or shielding braid and foil
Cable type	twisted pair cable. 2x2 lines
Bend Radius	20 x diameter during installation or 7 x diameter fixed position
Signal attenuation	0.13 dB/100 ft @ 125 kHz (maximum)
	0.25 dB/100 ft @ 500 kHz (maximum)
	0.40 dB/100 ft @ 1000 kHz (maximum)

"DeviceNet" cable is a good example of CAN cable, but use caution as most DeviceNet cables are not rated for on-engine temperatures.

When using DeviceNet cables, only use the "Thick" or "Trunk" cable. The advantage of "Thick" cables is the conductor size. Larger gauge conductors fare much better in high vibration environments.

Below are two example DeviceNet CAN cables that are suitable for on-engine use if the wiring area stays below 75 °C. Other cables may exist.

Part Number	Description
Belden 3082A	PVC, 18 AWG shielded data pair, 15 AWG shielded power pair. 300 V insulation.
Belden 7896A	PVC, 18 AWG shielded data pair, 16 AWG shielded power pair. 600 V insulation.
Lapp Cable 2710-250	Halogen free, 18 AWG shielded data pair, 15 AWG shielded power pair. 300 V insulation

CAN Shielding

Shielded cable is required for industrial applications. Only very cost sensitive automotive applications attempt to use unshielded cable for communications. Unshielded cables and improperly shielded cables are likely to cause communication problems and unreliable control operation. The standard for CAN networks is that each device will have an ac-coupled (connected through a 0.01 µF coupling capacitor) shield connection and a single shield ground location will be provided. The ground location does not have to be at a unit connector, it can be any convenient place in the system but should be the same ground as used for the system power.
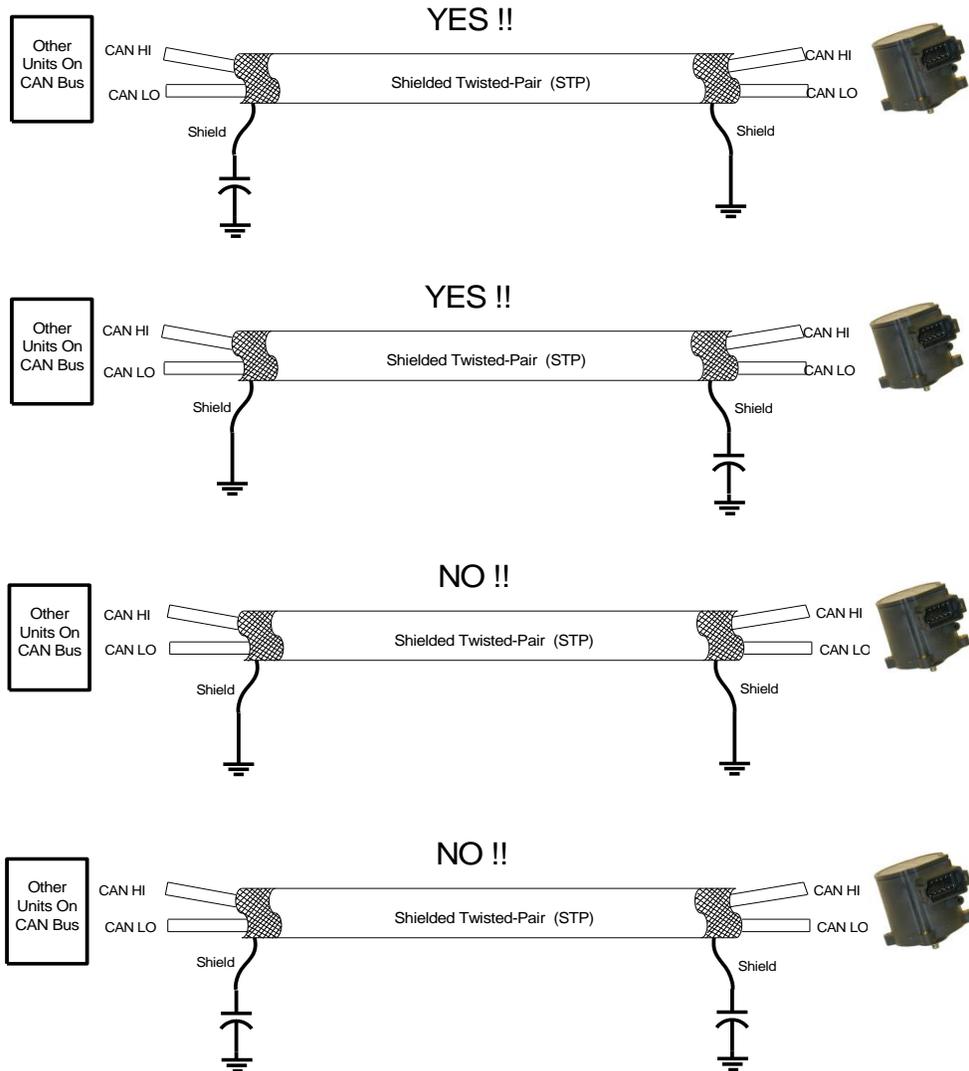
Figure 3-9. CAN Shielding

Ground Junction (see Figure 3-10)—This grounding junction is provided for joining external ground wires. THERE IS NOT AN INTERNAL CONNECTION TO CIRCUIT GROUND. Terminal pins 3 and 5 must be used for access to the circuit ground. This junction point is completely electrically isolated from the L-Series actuator's electronics, and is solely for convenience during installation.
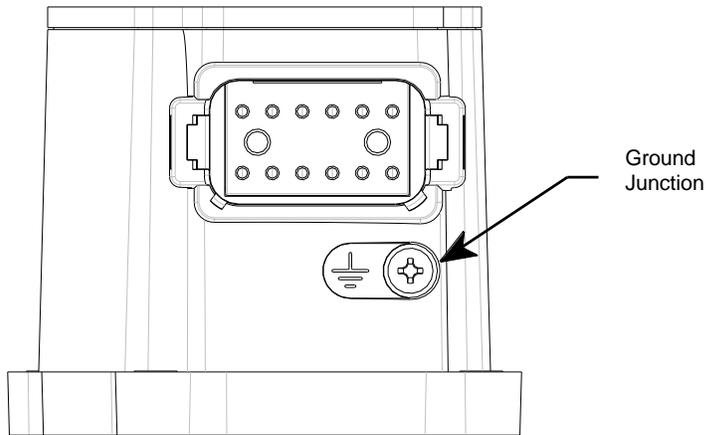

Figure 3-10. Ground Junction Point

Chapter 4.
Service Tool

Introduction

This chapter covers tuning, configuring, calibrating, and servicing the control via the L-Series Service Tool. The control should already be installed on the engine.

IMPORTANT	**Many applications are delivered pre-configured, calibrated, and tuned. These units do not require the use of the Service Tool.**

Description

The Service Tool software is used to configure, tune, and troubleshoot the L-Series controller. This chapter identifies the parameters available that can be viewed and provides detailed information on configuring and setting up the L-Series to the customer-specific field application.

The Service Tool software resides on a PC (personal computer) and communicates to the L-Series through connector pins 4 and 6. An external RS-232 transceiver is necessary to make communications possible with the Woodward L-Series service tool. A connectivity kit (Woodward # 8923-1061) can be purchased from Woodward to accomplish this.
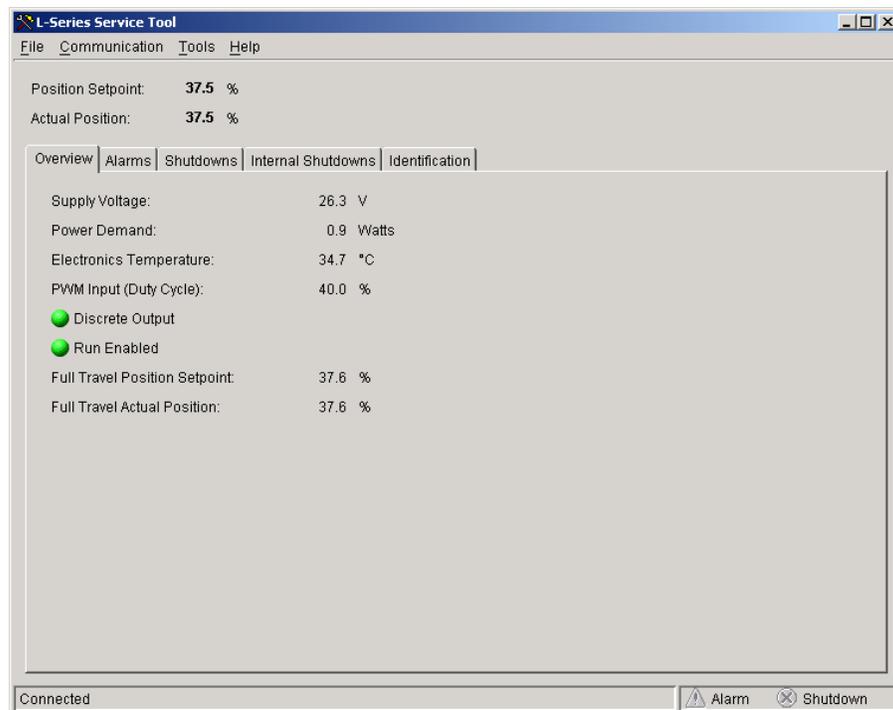
Figure 4-1. Example Service Tool Screen

The following hardware is required to work with the L-Series control:
- PC-compatible laptop or desktop computer with at least one available serial communications port, and Windows 2000, XP, NT 4.0, Vista, Win 7 (32- and 64-bit) as the operating system.
- Programming/datalink harness as shown in Figure 4-2.

In addition to the hardware, the following are the distributions of tool software needed to communicate with the control:
- Woodward part number 9927-1222, L-Series Service Tool

NOTICE	There is a potential for serial port damage when communicating with the L-Series control. This is caused by a difference in ac voltage between neutral and earth ground. If the PC RS-232 port ground is referenced to ac neutral, and the L-Series control is referenced to battery ground (ac earth ground), a large amount of current can be experienced. To avoid this situation, we strongly recommend placing an isolation transformer between the ac outlet and the PC.
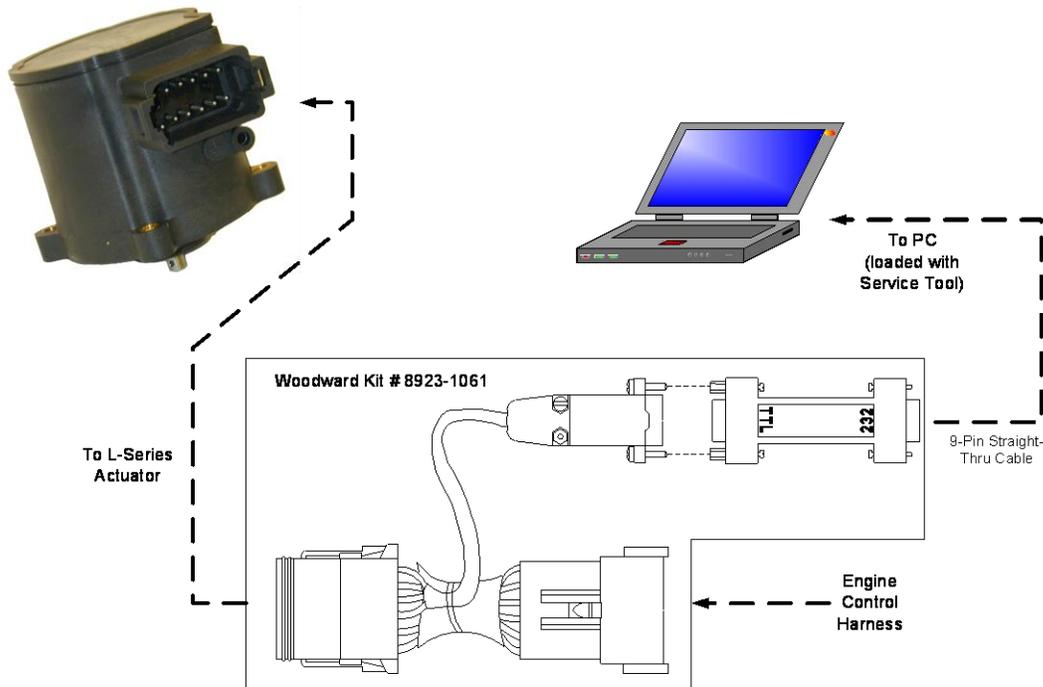
Pinouts Viewed Looking into Control Connector and Computer Connector

Figure 4-2. Typical Programming Datalink Harness Wiring

Getting Started

Installation Procedure

The Service Tool software can be downloaded and installed from the Woodward internet site (**www.woodward.com/software**).

What to do next

After the software is installed, connect a serial communications cable between the RS-232 connections on the L-Series control and an unused serial port on

your computer. Run the Service Tool program and select the appropriate comm port. Once connected to the control, the status bar will display 'connected' and the Service Tool screen will populate with monitor parameters.

On CAN versions, the Communication/Connect command must be issued prior to powering-up the L-Series. Since the same I/O pins are used for both Service Tool and CAN communications, the only time the Service Tool is enabled is on power up. If a Service Tool connect is detected, CAN will be disabled and the Service Tool communications will remain active.

⚠️ **WARNING** — **An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.**

Service Tool Help

More help on using Service Tool is available and included with the installation of the Service Tool product. Service Tool Help can be accessed from the Service Tool 'Contents' drop-down window selection under the Help menu located on the Main Window.

Software Version Identification

The Service Tool software version can found by selecting 'About' under the Help menu. The L-Series software version can be found on the right-most tab sheet (Identification) of the Service Tool screen. The Service Tool and Control must be connected to view this information. Refer to this version information in any correspondence with Woodward.

Configuration Password

If a password has been saved in the configuration file, the file cannot be opened without first entering the password. Once a configuration with a password has been loaded into the L-Series driver, the control configuration cannot be opened without the password. All other service tool functions do not require a password including: writing over a password protected file configuration, writing over a password protected control configuration, using the Position Calibration Tool, and using the Edit Position PID.

L-Series Configuration

The L-Series can be configured either on-line or off-line. On-line configuration can only be performed when the Service Tool is connected to and communicating with the L-Series control. Off-line configuration can be done at any time; however, settings will not take effect until they are loaded into the control.

IMPORTANT — **If using non-linear mode, control power must be cycled after loading a new configuration.**

The current L-Series control configuration settings can be viewed at any time when connected to the control by opening the Configuration Editor (File/Open Control Configuration). See Figure 4-3.

A Configuration Summary worksheet is provided in Appendix of this manual to allow documentation of application configuration settings.

OEM Configuration File Data

The OEM can save configuration file specific data with the service tool by selecting Properties under the File menu pull down. This is a text field and can be used to store data such as:
- Customer
- Engine Type
- Application Type
- Notes

Configuring the Unit—On-Line

Unit configuration is summarized as follows:
- Open the Configuration Editor Dialog by selecting 'File/Open Control Configuration'.
- Edit the configuration settings.
- Load the configuration to the L-Series control.

IMPORTANT	**As changes are made to Configuration parameters, they are not used by the driver until a 'load' command is issued. Selecting the 'Close Window' box/button closes the Configuration Editor and does not make any changes to the driver.**

Configuring the Unit—Off-Line
Unit configuration is summarized as follows:
- Open the Configuration Editor Dialog using the File/New or File/Open options.
- Edit the configuration settings.
- Save the configuration to a file. At a later date simply open the configuration and load it into the control.
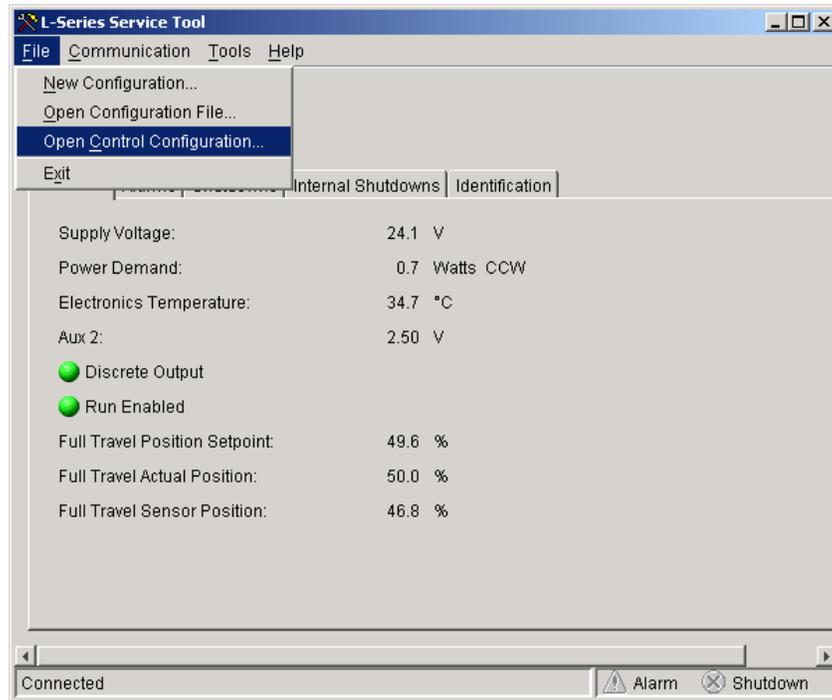
Figure 4-3. Configuration Selection Options

Configuration Parameters

There are five tab sheets that contain all the configuration settings: Overview, Setup, Discrete Output, Alarm/Shutdown and Security.

Overview Tab Sheet

The Overview tab (Figure 4-4) contains general positioning settings for the application. A description of each configuration parameter and its adjustment range is also available in the contents of the Service Tool Help.
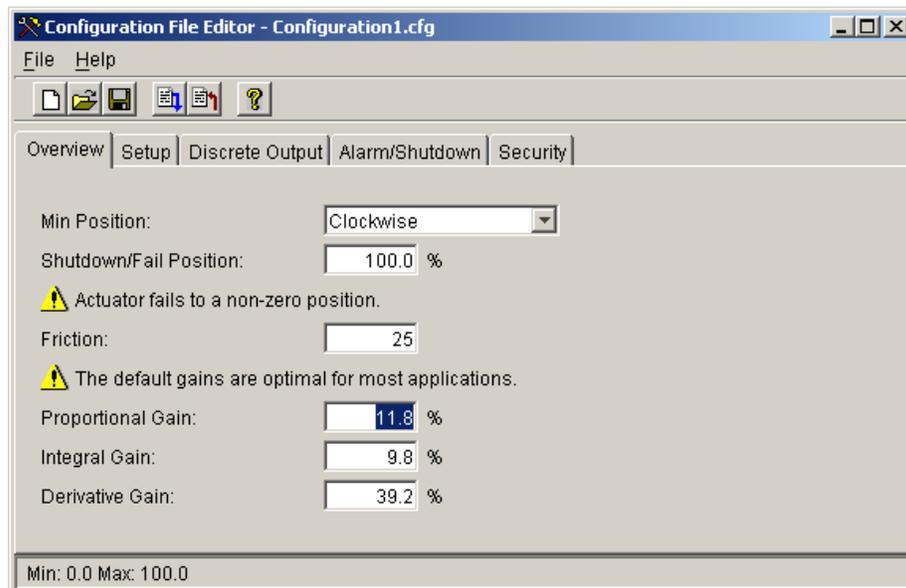
Figure 4-4. Configuration Editor—Overview Tab

Min Position
Sets the position controller direction. Allowed values: CW and CCW.

Shutdown/ Fail Position
Sets the position controller position, in percent, when a shutdown condition is detected. Allowed values: 0-100%.

Note: If the Shutdown/Fail Position is not set to '0.0', the 'Actuator fails to a non-zero position.' indication is activated. This is to alert the user of a potential unsafe condition.

Friction/Dither Setting
Sets the position controller's friction and dither values. This parameter should be set to zero (no effect) while tuning the PID and then increased for optimum response. If unsure, a typical value would be 25. Allowed values: 0–100.

Proportional Gain
Sets the position controller PID's proportional gain. Increased gain corresponds to increased PID output (higher proportional = faster response). This setting can also be dynamically adjusted using the PID Tuning screen. Allowed values: 0–100%.

Integral Gain
Sets the position controller PID's integral gain. Increased gain corresponds to increased PID output (higher integral = faster response). This setting can also be dynamically adjusted using the PID Tuning screen. Allowed values: 0–100%.

Derivative Gain
Sets the position controller PID's derivative gain. Increased gain corresponds to increased PID output (higher derivative = faster response). This setting can also be dynamically adjusted using the PID Tuning screen. Allowed values: 0–100%.

Setup Tab Sheet

The Setup tab (figure 4-5) provides all the position demand settings for the application including PWM, analog and CAN setup parameters. Changing the Demand Input Source will modify the parameter settings available as well as the displayed indications within the Service Tool.

A description of each configuration parameter and its adjustment range is also available in the contents of the Service Tool Help.

Demand Input Source
The Position Demand Source can be set to one of the following:
Single	Selects a single, non-redundant position demand input.
Redundant	Selects a redundant (primary/backup) position demand input.

Primary Position Demand Input
The Primary Position Demand source can be set to one of the following:
PWM	Selects a PWM position demand input.
Analog	Selects an analog (0–5 V) position demand input.
CAN	Selects a CAN position demand input.

Backup Position Demand Input- *(only displayed if configured for Redundant Demand Inputs)*
The Backup Position Demand source can be set to one of the following:
PWM	Selects a PWM position demand input.
Analog	Selects an analog (0–5 V) position demand input.
CAN	Selects a CAN position demand input.

Note: The Primary and Backup Position Demand input cannot be set to the same source.

Maximum Demand Difference - *(only displayed if configured for Redundant Demand Inputs)*
Sets the max difference between primary and backup demands.
Allowed values: 0.0 to 100%
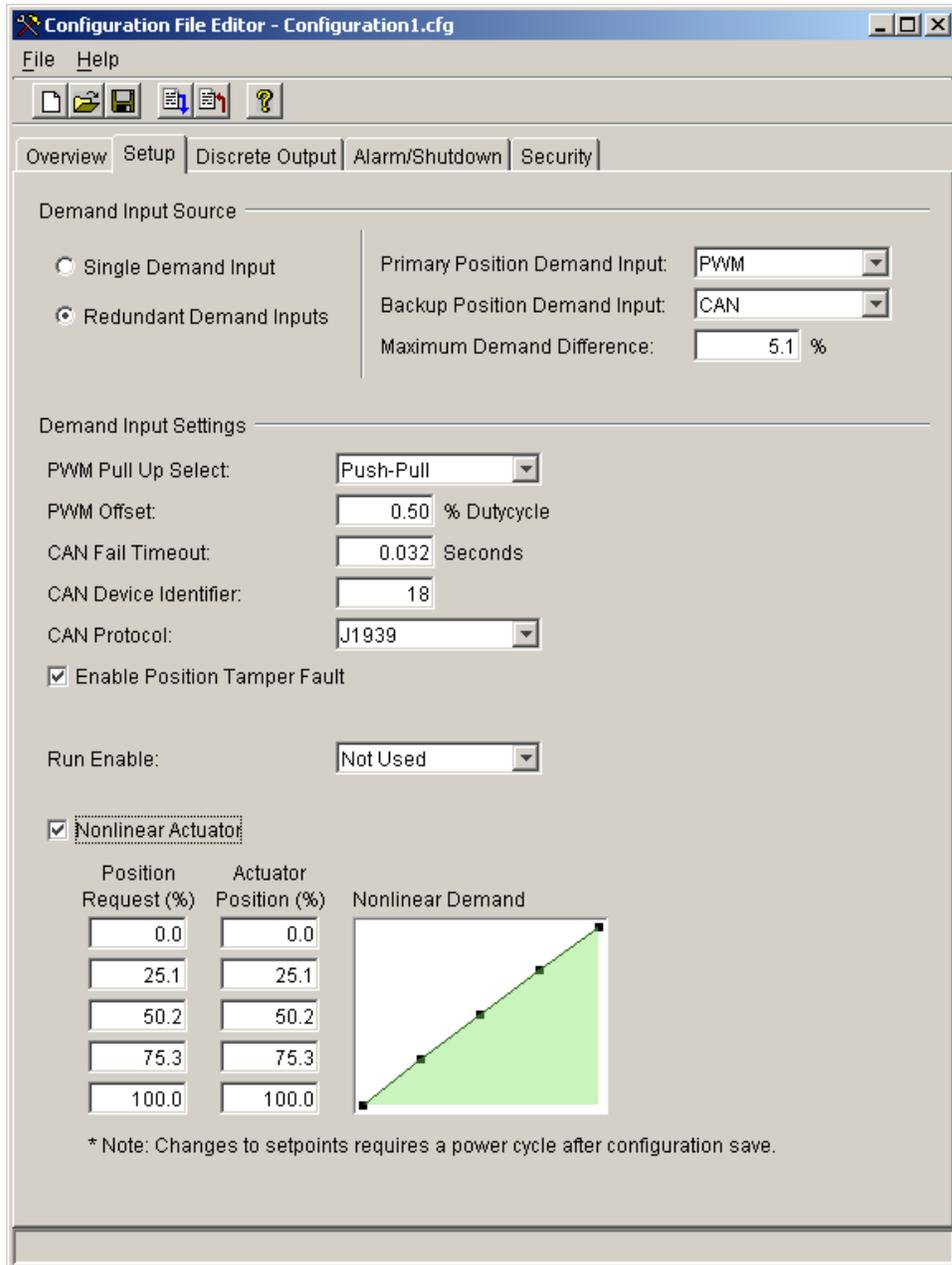
Figure 4-5. Configuration Editor—Setup tab

PWM Settings - *(only displayed if PWM is selected as a Demand Input)*
> Two additional configuration parameters appear when the position demand
> is set to PWM (see Figure 4-6).

PWM Pull Up Select
> Selects the appropriate PWM source. This configures the L-Series input
> internally to provide the proper pull-up logic. For details on selection of this
> parameter, refer to Chapter 3. Allowed values: Push-Pull, High Side Drive,
> or Low Side Drive.

PWM Offset
> Sets the PWM Duty cycle offset. This setting is provided to compensate for
> duty cycle variations in PWM input frequencies, voltages, and types.
> Allowed values: –5.01 to +5.01%

CAN Settings

CAN Fail Timeout - *(only displayed if CAN is selected as a Demand Input)*
> Sets the maximum allowed delay between CAN receive / inputs (Rx), in
> seconds, before a CAN Fault is annunciated. Allowed values: 0–10 seconds

CAN Protocol Select
> Selects the desired CAN messaging format. For details refer to the CAN
> section in chapter 2. Allowed values: J1939 or CANopen.

CAN Device Identifier *(only displayed for CANopen)*
> Sets the CAN Device ID (COB-ID). Allowed values: 1–127

CAN ID Discrete Input *(only displayed for J1939 with firmware 5418-6084)*
> Determines if the CAN ID selector is used. When used, allows two to four
> different device identifiers, determined by the discrete input state on device
> power-up. Allowed values: Not Used or Aux 2.

CAN ID LOW Discrete Input *(only displayed for J1939 with firmware 5418-6638)*
> Determines if the CAN ID selector is used. When used, allows two to four
> different device identifiers, determined by the discrete input state on device
> power-up. Allowed values: Not Used or Aux 2.

CAN ID HIGH Discrete Input *(only displayed for J1939 with firmware 5418-6638)*
> Determines if the CAN ID selector is used. When used, allows two to four
> different device identifiers, determined by the discrete input state on device
> power-up. Allowed values: Not Used, Aux 1 or Aux5.

CAN Device Identifier *(only displayed for J1939)*
> Sets the device source address. Allowed values: 18–21

CAN Device Identifier 2 *(only displayed for J1939 when using CAN ID LOW
discrete input)*
> Sets the device source address when the CAN ID discrete inputs select unit
> 2. Allowed values: 18–21

CAN Device Identifier 3 *(only displayed for J1939 when using CAN ID HIGH
discrete input)*
> Sets the device source address when the CAN ID discrete inputs select unit
> 3. Allowed values: 18–21

CAN Device Identifier 4 *(only displayed for J1939 when using both CAN ID HIGH and LOW discrete inputs)*
> Sets the device source address when the CAN ID discrete inputs select unit 4. Allowed values: 18–21

CAN Data Rate *(only displayed for J1939)*
> Selects the data rate for J1939 messaging. Allowed values: 250 or 500 kbps.

Enable Position Tamper Fault - *(only displayed if CAN is selected as the Backup Position Demand Input)*
> When selected, activates the Position Tamper Fault logic which disables the Primary Demand if it doesn't track the CAN demand.

Heartbeat Producer Time - *(only displayed for CANopen)*
> Sets the time increment for sending CANopen NMT heartbeat messages, in seconds. Allowed values: 0–10 seconds

Run Enable Select
> Determines the functionality of Run Enable.
> Allowed values: Not Used or Aux 1.

Non-linear Actuator
> Selects either a Linear position command, when unchecked, or a Nonlinear 5-point curve command. Linear/Nonlinear refers to the relationship between the position requested and the position commanded to the position PID. When this box is checked, additional parameters appear to set up the 5-point demand curve.

IMPORTANT   **If the non-linear curve is changed, control power must be cycled.**

Position Request (%)
> There are five breakpoint values that correspond to the position requested by the analog or PWM input signal. These values set up the curve inputs. Allowed values: 0–100%.
>
> These values must maintain a monotonic increase in their values, in order from lowest to highest. Also, after the configuration is loaded into the control, power must be cycled on the control before the settings take effect.

Actuator Position (%)
> There are five breakpoint values that correspond to the modified actuator position command. These values set up the curve outputs. Allowed values: 0–100%.

Discrete Output Tab Sheet

The Discrete Output (Figure 4-6) screen contains the discrete output configuration settings. If the discrete output is not used, these settings can be skipped.

Relay Output Configuration
The relay output can be configured to one of the following:

Normally On	Sets the relay driver to a normally on mode that turns off for any of the faults selected. This is the preferred, failsafe output configuration.
Normally Off	Sets the relay driver to a normally off mode that turns on for any of the faults selected.

> ⚠️ **WARNING**   **Woodward recommends that the Relay Output be configured for the failsafe 'Normally On' mode, to ensure maximum fault protection and annunciation. Failure to follow these guidelines could, under exceptional circumstances, lead to personal injury and/or property damage.**

Relay Output Fault Selections
The list of faults displayed can be individually selected to activate the relay output. Any of the selected faults will either turn the output off if configured for Normally On or turn the output on if configured for Normally Off.

> ⚠️ **WARNING**   **Woodward recommends that all faults be configured to activate the discrete output, this ensures maximum fault annunciation.**
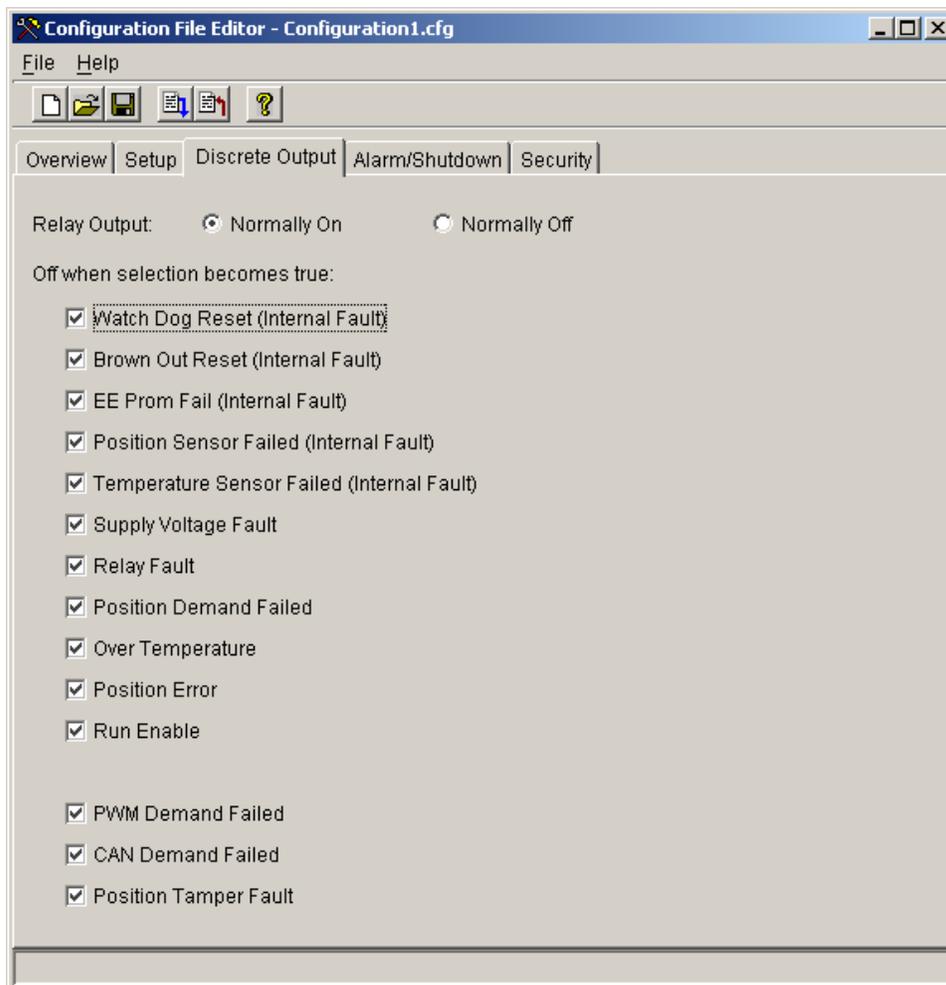
Figure 4-6. Configuration Editor—Discrete Output Tab

Alarm/Shutdown Tab Sheet

The Alarm/Shutdown (figure 4-7) screen contains the alarm and shutdown configuration settings.

Shutdown/Alarm Fault Selections
The list of faults displayed can be individually selected to either perform a Shutdown or just Alarm (no action).

> ⚠️ **WARNING**   **Woodward recommends that all faults be configured as shutdowns, which ensures maximum fault protection. Failure to follow these guidelines could, under exceptional circumstances, lead to personal injury and/or property damage.**

Enable Fault Latching
This setting determines whether the faults are latching or non-latching. When set to latching, a reset command is required to clear the fault.

Enable CAN Fault Latching – *(only displayed on CAN units if Enable Fault Latching is false)*
This setting determines whether the CAN fault is latching or non-latching. This option is provided to latch-in the CAN fault even though all other faults are set to non-latching.

Position Error Maximum (%)
Maximum deviation between the actual position and the position command. If the Error is exceeded for longer than the Position Error Delay, then the Position Error fault is annunciated. Allowed values: 0–100%.

Position Error Delay (sec)
Delay for position error annunciation. Allowed values: 0–10 seconds.

CAN Tracking Error Maximum (%) – *(only displayed if Position Tamper Fault is used)*
Maximum deviation between the primary position demand and the CAN position demand. If the Error is exceeded for longer than the CAN Tracking Error Delay, then the Position Tamper Fault is annunciated.
Allowed values: 0–100% but must be greater than the Max Demand Difference setting.

CAN Tracking Error Delay (sec)
Delay for Position Tamper Fault. Allowed values: 0–10 seconds.
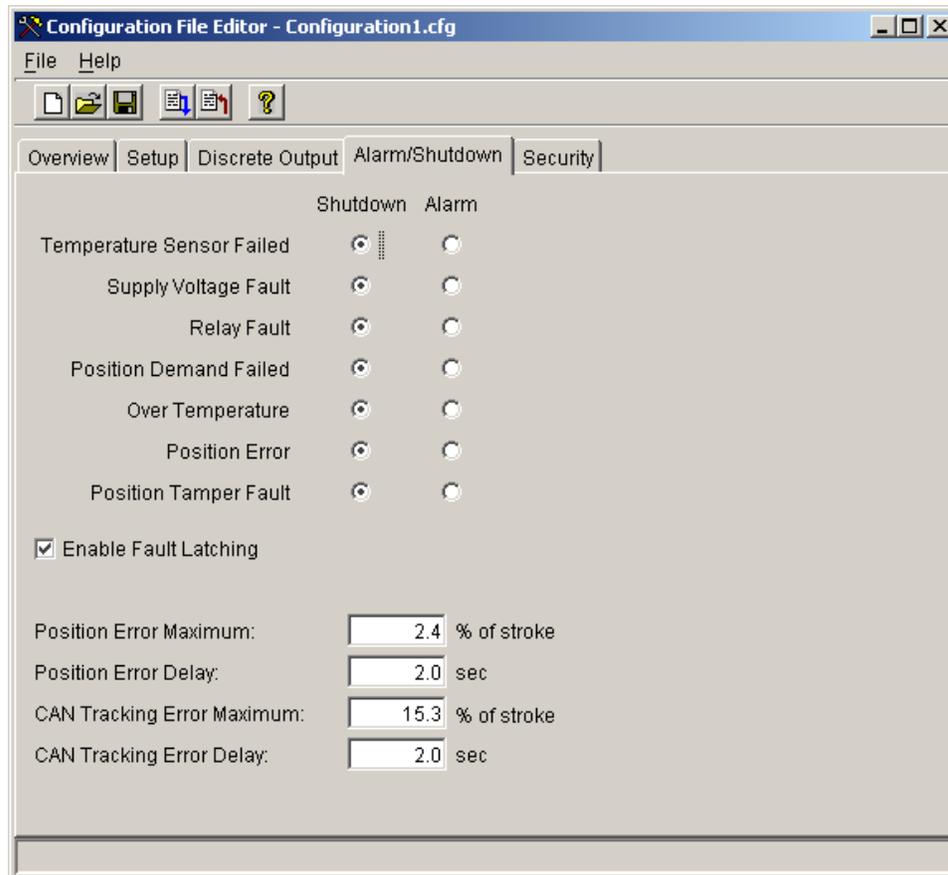
Figure 4-7. Configuration Editor—Alarm/Shutdown Tab

Security Tab Sheet

The security (figure 4-8) screen contains the security configuration settings.
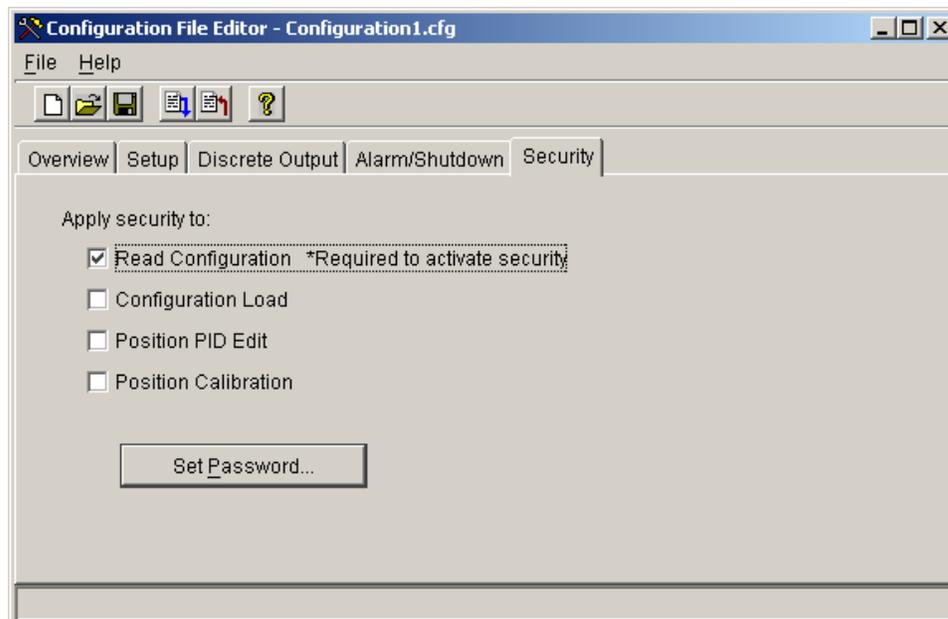
Figure 4-8. Configuration Editor— Security Tab

Security Configurations

All checked features will have the security password enforced prior to allowing the function. Unchecked features will not be prompted with a password.

Read Configuration

When checked, requires a password before the configuration can be read from the L-Series control (protects Open From Control execution).

This is the minimum level of protection and is required in order to use any other security option.

Configuration Load

When checked, requires a password before a configuration can be loaded into the L-Series control (protects Load to Control execution).

Position Calibration

When checked, requires a password before the position calibration mode can be entered (protects Manual and Automatic Position Calibration menu options).

Position PID Edit

When checked, requires a password before allowing tuning to the position PID (protects Edit Position PID menu option).

Figure 4-9. Security Tab Set Password Pop-up

Loading the Configuration (Save)

Select the File/'Load to Control' option from the menu or Blue Arrow icon on the Configuration Editor to load the changes into the control. The L-Series process must be zero prior to allowing a 'Load' command. This feature can be optionally password protected.
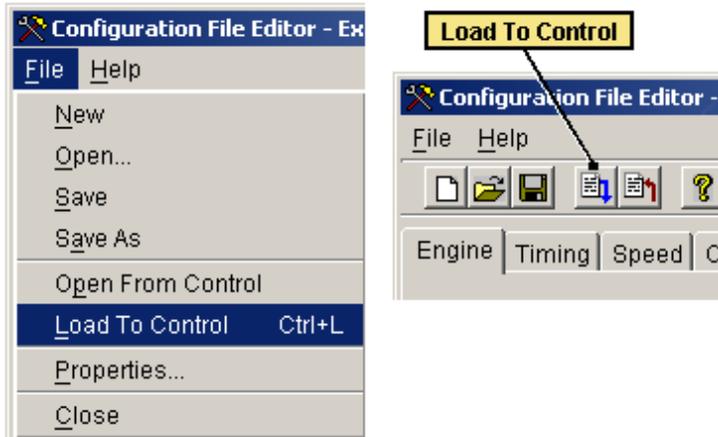
Figure 4-10. Security Tab Set Password Pop-up

Monitoring the Driver

The Service Tool has five different tab sheets to monitor driver parameters. The tab sheet screens include:

- Overview (Figure 4-11)
- Alarms (Figure 4-12)
- Shutdowns (Figure 4-13)
- Internal Shutdowns (Figure 4-14)
- Identification (Figures 4-15)

Each screen displays the position setpoint and actual position values.

Position Setpoint
Displayed value of the position demand, in percent.

Actual Position
Displayed value of the actual position, in percent.

Status Bar Indications
At the bottom of the Service Tool window is a status bar. The status bar has two sections. The bottom left section displays communication status and bottom right section displays alarm & shutdown status.

Communication Status
This section of the status bar shows the status of communication between the service tool and the L-Series Driver. For more information, see Establishing Communication.

- **Connected**—The Service Tool is connected to and communicating with the driver.
- **Not Connected**—The Service Tool is not connected to the driver.
- **Connecting**—The Service Tool is attempting to connect to the driver. This message is displayed when Connect is selected from the Communications menu or when attempting to re-establish communication to the driver. If the connection is lost it will continuously attempt to re-connect.

Alarm Status
Indicates that one or more alarms on the Alarms screen are active.

Shutdown Status
Indicates that one or more shutdowns on the Shutdowns or Internal Shutdowns screen are active.

Overview Parameters Screen

To monitor the overview parameters, go to the Overview page (Figure 4-11) on the main window.
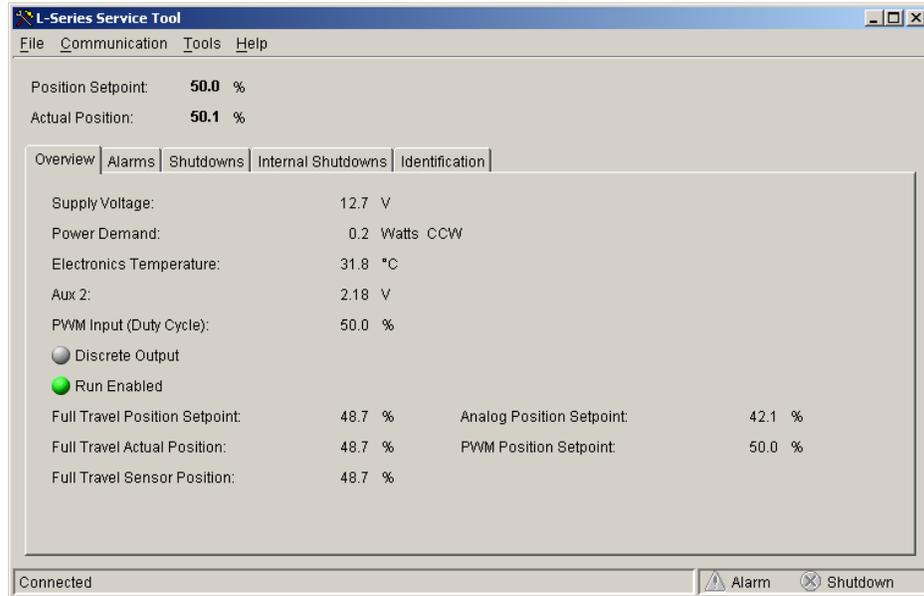
Figure 4-11. Service Tool—Overview Tab

Supply Voltage
Displayed value of the input power, in volts, as read by the processor.

Power Demand
Displayed value of the power demanded, in watts, as read by the processor. This is an indication of the work output.

Electronics Temperature
Displayed value of the electronics temperature sensor, in degrees Celsius, as read by the processor. The temperature sensor is physically located between the electronics module and the LAT motor.

PWM Input (Duty Cycle)
Displayed value of the PWM input, in percent duty cycle. This indication is displayed only when the position demand is set to 'PWM'.

AUX2 Input
Displayed value of the analog 0–5 V input, in volts. This indication is displayed only when the position demand is set to '0.5 V'.

Discrete Output
On/Off status of the discrete output command. The indicator is illuminated when the channel is commanded to ON and grayed-out when the command signal is OFF.

Run Enabled
Open (off) / Closed (on) indication of the Run Enable discrete input.

Full Travel Position Setpoint
Indication of the position setpoint in terms of total overall unit travel. Useful if a less than full-travel user-calibrated range is used.

Full Travel Actual Position
Indication of the actual position in terms of total overall unit travel. Useful if a less than full-travel user-calibrated range is used.

Full Travel Sensor Position
Indication of the position in terms of total overall unit travel before linearization. This value will match the TPS output.

Shutdown and Alarm Indications

The Shutdown and Alarm screens display the status is both active and logged fault conditions. The logged indications provide a history of events even after the unit has been power-cycle of run again.

  Indicates a logged alarm condition.

  Indicates an active alarm condition.

  Indicates a logged shutdown condition.

  Indicates an active shutdown condition.

An active fault is one that is currently active or latched in the control. The latching/non-latching faults configuration setting factors into this indication. If the fault is latching, then an active fault could either be one that is still present or one that occurred but has not been reset. Latched faults can be cleared by cycling power on the L-Series control or by selecting the 'Reset Alarms and Shutdowns' button on any of the Alarm or Shutdown screens.

A logged fault is one that occurred but is no longer currently active or latched in the control. Logged faults are permanently cleared by selecting the 'Reset Logged Alarms and Shutdowns' button on any of the Alarm or Shutdown screens.

Alarms Screen

To monitor the alarm conditions, go to the Alarms page on the main window. The values displayed on this screen dynamically change with the fault configuration. Refer to chapter 2 for a complete listing and details of all the faults.
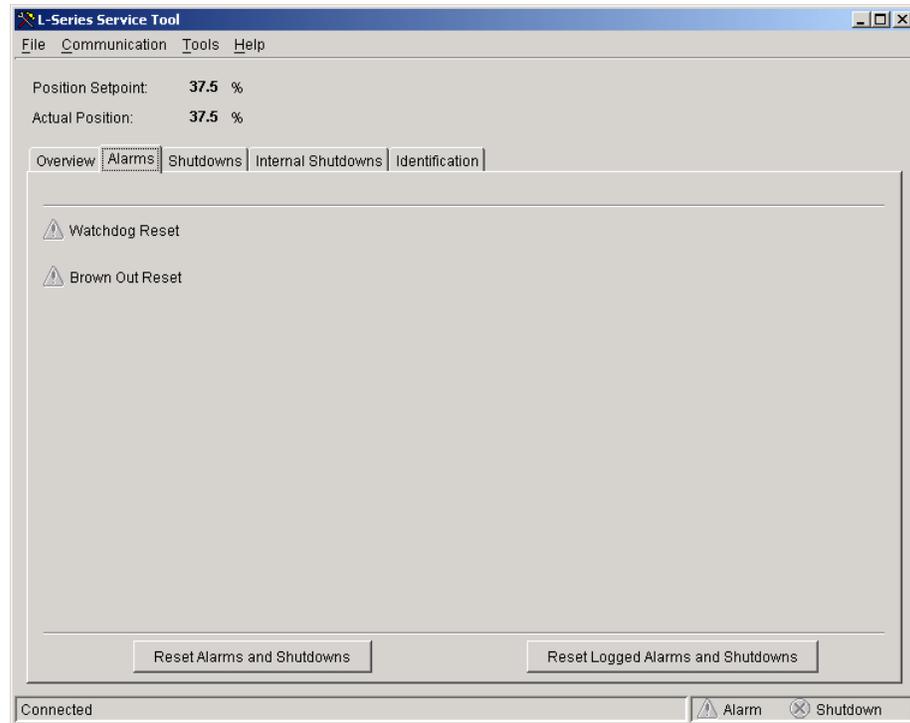
Figure 4-12. Service Tool – Alarms Tab

Shutdowns and Internal Shutdowns Screens

To monitor the shutdown conditions, go to the Shutdowns and the Internal Shutdowns pages on the main window. The values displayed on the Shutdowns screen dynamically change with the fault configuration. Refer to chapter 2 for a complete listing and details of all the faults.
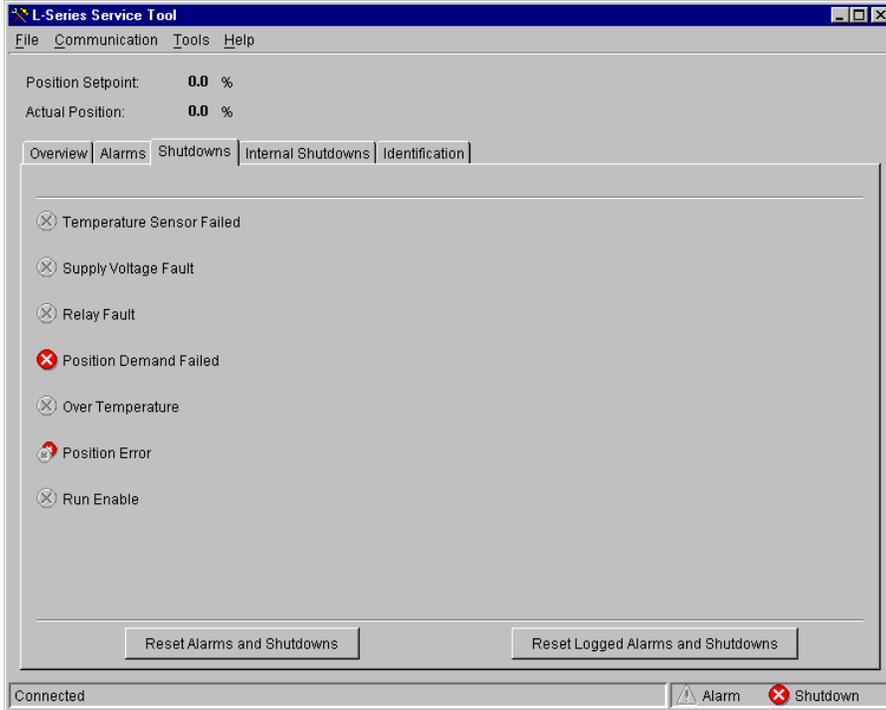
Figure 4-13. Service Tool – Shutdowns Tab
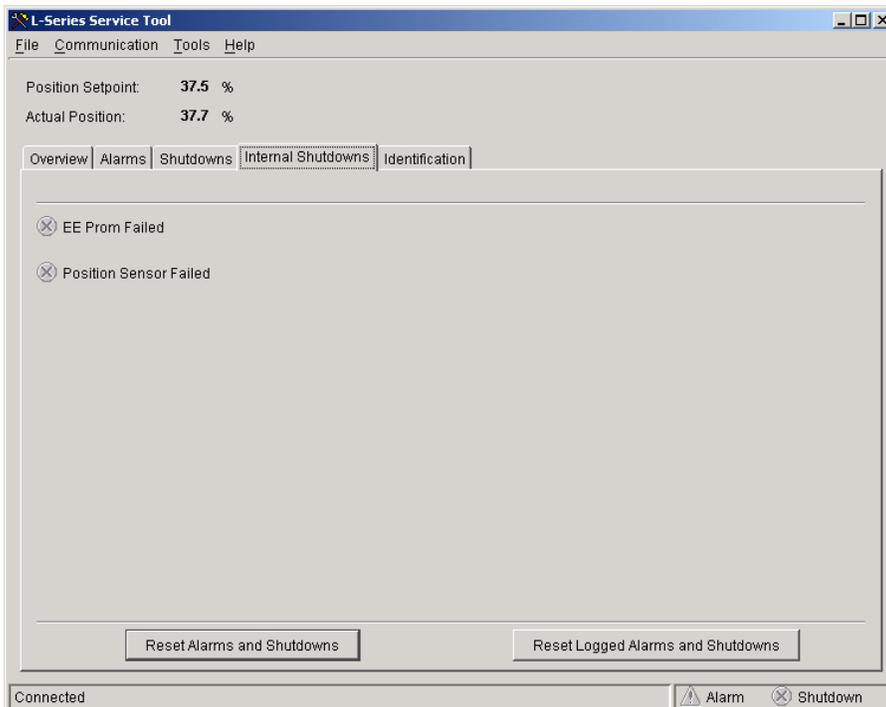
Figure 4-14. Service Tool – Internal Shutdowns Tab

Identification Screen

To monitor the L-Series product identification, go to the Identification (Figure 4-15) page on the main window.*
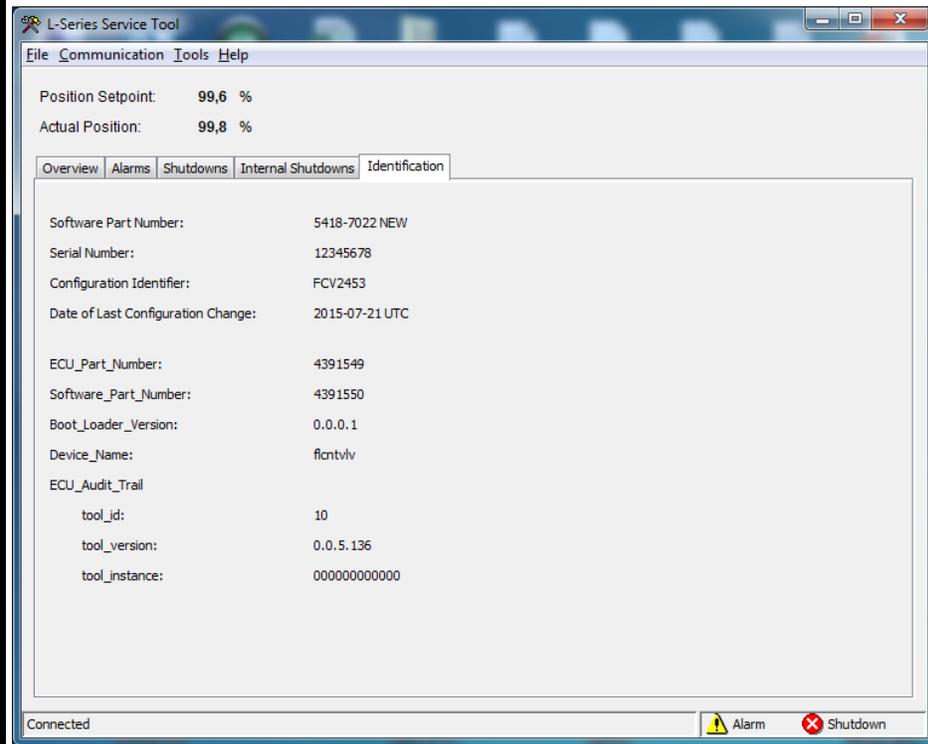
Figure 4-15. Service Tool—Identification Tab

* ECU_Part_Number, Software_Part_Number, Boot_Loader_Version, Device_Name and ECU_Audit_Trail are available in 5418-7022 only.

Tuning the PID

The Service Tool can be used to tune the PID or to just trend/monitor the PID output. To get to the PID Tuning screen, select the Edit Position PID from the Tools menu selection.
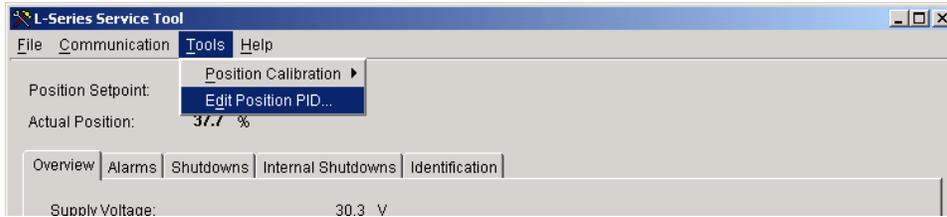
The L-Series controller can be put into a manual control mode from this screen by selecting the "Enable Manual Position Tuning' checkbox (Figure 4-16). Once in manual mode, the position setpoint box is highlighted and the value displayed is actively positioning the output. Use this command to create step changes for the PID and monitor the response using the displayed trend.

Pressing the Properties button pops open the Properties Window (Figure 4-17). From this window the user can adjust the trending window properties including the update rate and display range.
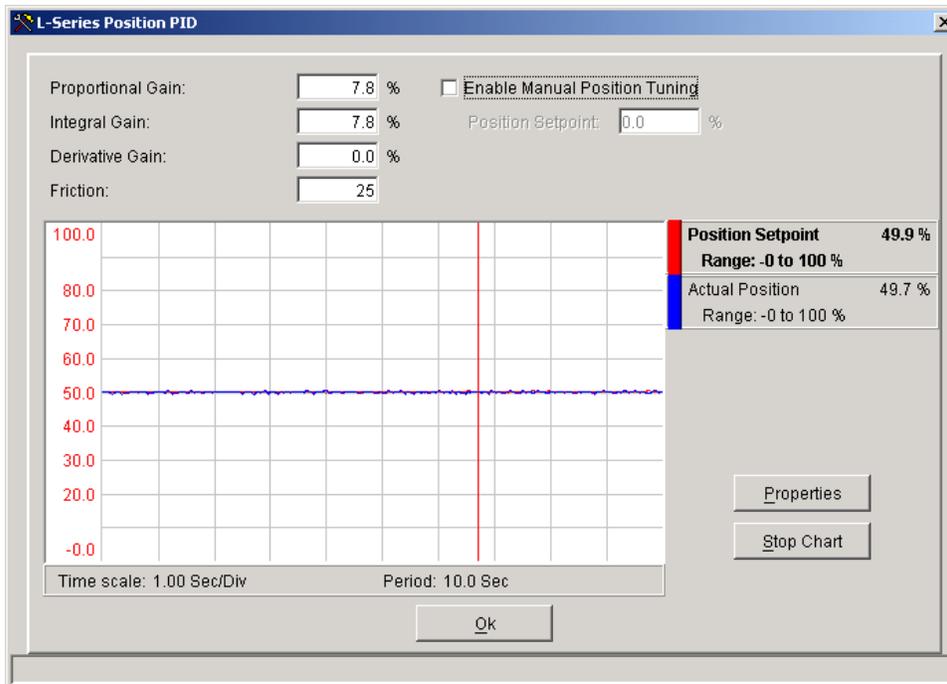
Figure 4-16. Service Tool—PID Tuning Window
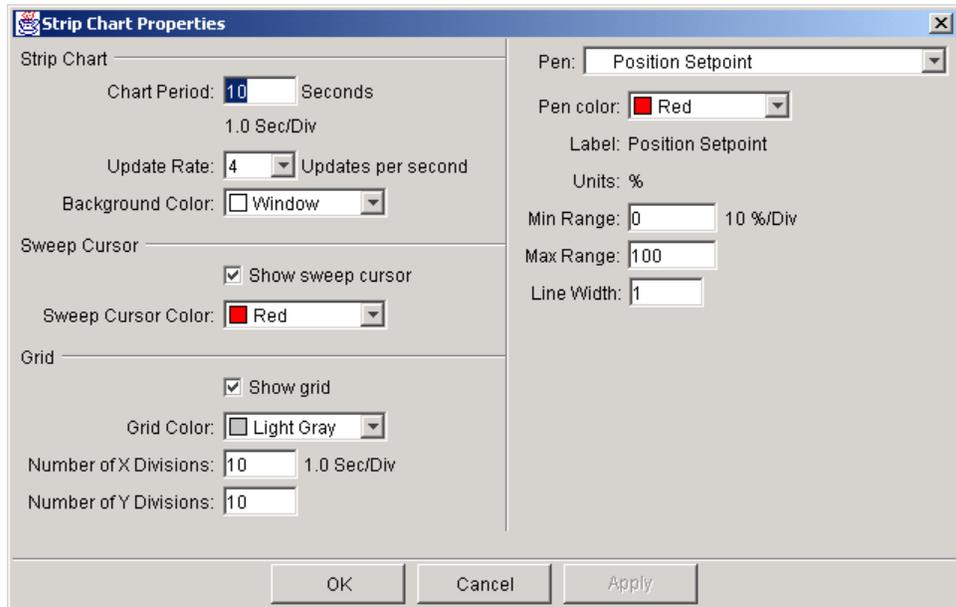
Figure 4-17. Service Tool—PID Tuning Properties Window

Position Calibration and Verification

Position calibration is available to map the position command input to the actual rotational travel of the unit. It is only used when the full travel of the actuator is constrained or limited such that 0 to 60 degrees of travel is not used. For example, an application-specific position calibration could map 0–100% position command to 10–40 degrees actual rotation.

There are two methods available to perform a position calibration: Automatic or Manual. If the application has hard stops that correspond to the actual min/max travel, then either Auto or Manual methods can be used—although auto is easier. If hard stops are not available, then the auto method will give invalid results and the manual method must be followed.

The Service Tool can be used to calibrate the control to end user stops (physical or soft) or to verify the position calibration. To get to the Position Calibration screens select the desired function from Position Calibration under the Tools menu selection.

IMPORTANT	**Position Calibration is only used when the full travel of the actuator is constrained or limited such that 0 to 60 degrees of travel is not used.**
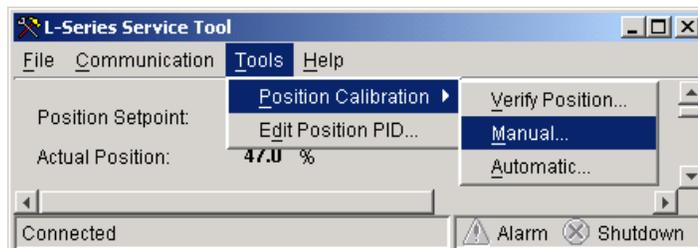
Calibration Sequence Overview

The following outlines the basic steps required to execute the position calibration.

Automatic Mode
1. Select Automatic Position Calibration Mode.
2. Select CW or CCW Direction.
3. L-Series automatically rotates in both CW and CCW directions until the stops are detected. The values are then captured and stored.
4. When completed, cycle the power on the L-Series.
5. Woodward recommends that a Position Verification be performed to confirm the calibration is correct. See Position Verification below.

Manual
1. Determine to rotational travel limits. This can be done by positioning the unit to the minimum and maximum positions and recording the position settings.
2. Select Manual Position Calibration Mode.
3. Select Direction.
4. Enter the pre-determined rotational travel limits values.
5. When completed, cycle the power on the L-Series.
6. Woodward recommends that a Position Verification be performed to confirm the calibration is correct. See Position Verification below.

Position Verification

When the Verify Position screen is entered, the control is put into position control and the position is set to the position the control was at when the screen was entered. The screen displays the "User" Requested Position, Actual Position, Minimum Position, and Maximum Position (see Figure 4-18). These User Positions are calculated from the user-calibrated stops.

The Full Travel Actual Position is the full stroke factory position without user stops after software linearization. The Full Travel Sensor Position is the full stroke factory position without user stops before software linearization. The Full Travel Sensor Position will match the TPS Output Signal.

The Verify Position screen can be used to check the calibration or to get the minimum and maximum position values for the manual calibration. If the Enable Requested Position Tuning box is checked the valve can be positioned anywhere from 0 to 100% of the user minimum and maximum stops by entering a value into the Requested Position. If the Enable Requested Position Tuning box is unchecked the valve will go limp and can be physical positioned by hand.

IMPORTANT	**If the full factory position calibration range is not being used (the Manual or Automatic Calibration has been performed) and the minimum position direction is changed, the calibration must be run again for the Verify Position mode to work correctly.**
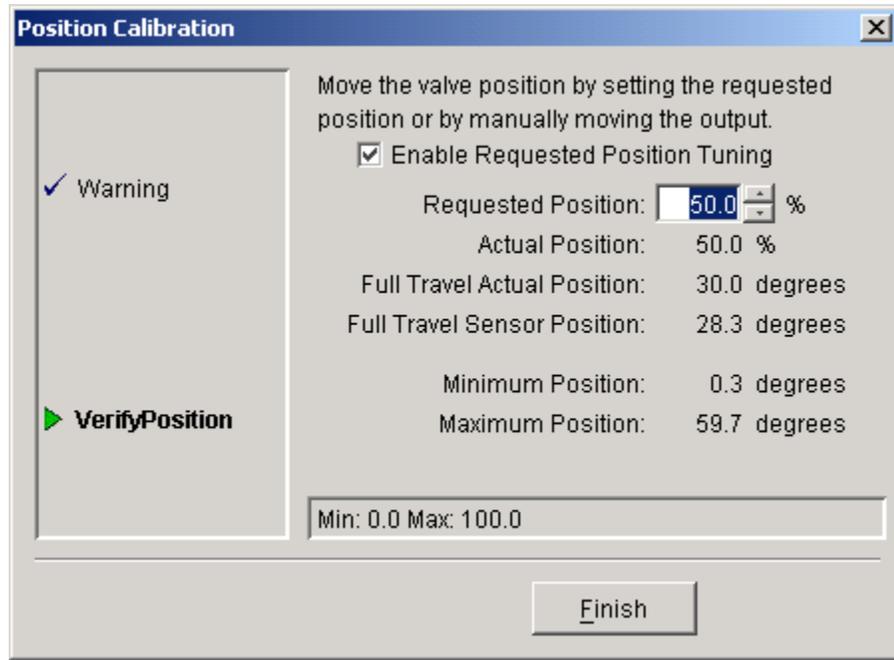
Figure 4-18. Service Tool—Verify Position Calibration

Manual

The manual calibration mode is used to set the minimum position and fail direction and to calibrate the valve to user soft stops (inside of any physical stops). The first screen to appear when entering the manual mode is used to set the minimum position and fail direction. This setting must be correct before manually calibrating the valve.
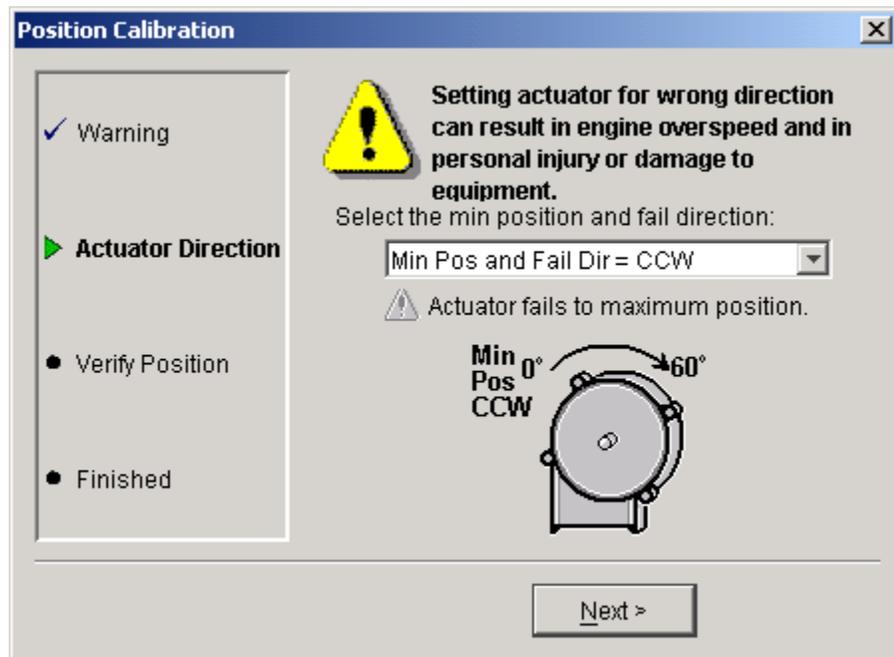
Figure 4-19. Service Tool—Manual Position Calibration

The next screen is used to set the minimum and maximum positions for the user soft stops. To find the minimum and maximum soft stops use the verify position mode described above to position the valve and use the Full Travel Actual Position reading for minimum and maximum position values.

IMPORTANT	After leaving this mode, power must be cycled for the new settings to take effect.
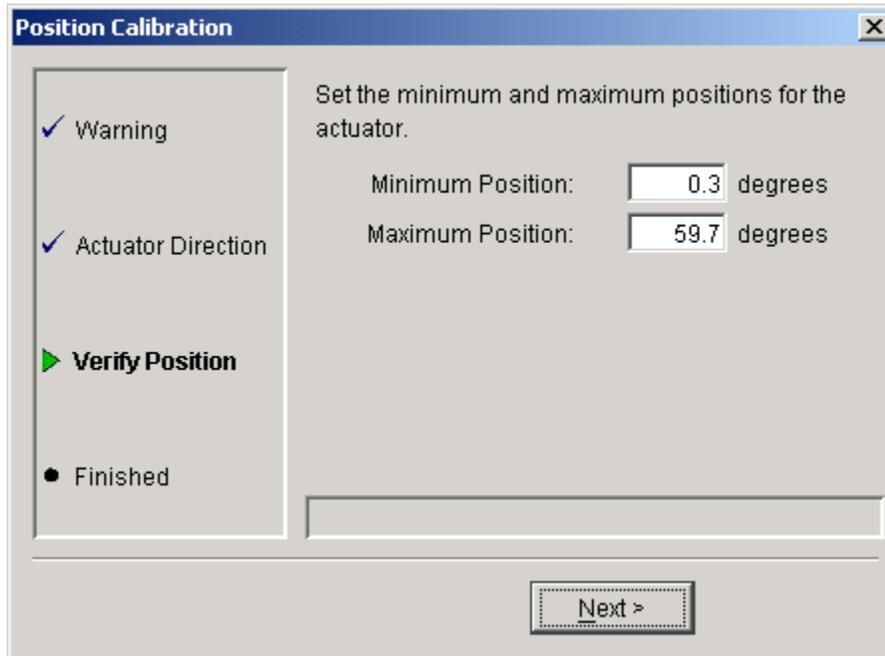
Figure 4-20. Service Tool—Manual Position Calibration Settings

Automatic

The automatic calibration mode is used to set the minimum position and fail direction and to calibrate the valve to user physical stops (mechanical hard stops). Like the manual mode, the first screen to appear is used to set the minimum position and fail direction. This setting must be correct before automatic calibration is performed.

After setting minimum position and fail direction the screen below will appear. The control is now moving first to the CCW stop and then to the CW stop to get the physical minimum and maximum positions.

IMPORTANT **After leaving this mode, power must be cycled for the new settings to take effect.**
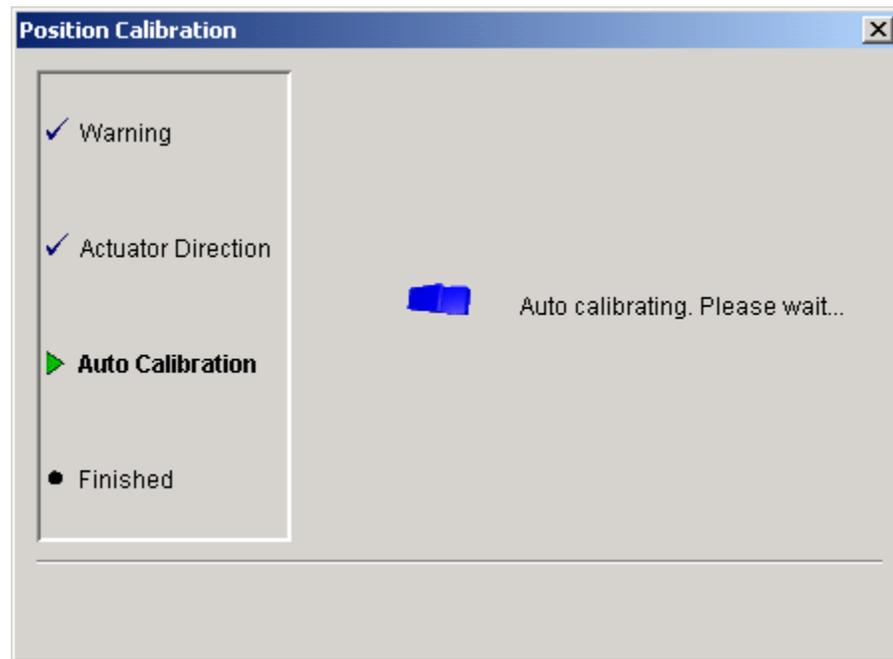
Figure 4-21. Service Tool – Auto Position Calibration

Chapter 5.
Troubleshooting

Introduction

This chapter presents several broad categories of application failures typically experienced in the field, possible causes, and some tests used to verify the causes. Because the exact failure experienced in the field is the product of the mechanical/electrical failure combined with the configuration file resident in the control, it is left as the OEM's responsibility to create a more detailed troubleshooting chart for the end user. Ideally, this end-user troubleshooting chart will contain information about mechanical, electrical, engine, and load failures in addition to the possible governor failures. For more detailed information about governor system failure modes and effects, contact Woodward for a copy of the system DFMEA.

The troubleshooting scenarios listed below assume that the end user has a digital multi-meter at his disposal for testing voltages and checking continuity, and assume that the application has been engineered and tested thoroughly.

General System Troubleshooting Guide

The following is a general troubleshooting guide for areas to check which may present potential difficulties. By making these checks appropriate to your engine/turbine before contacting Woodward for technical assistance, your system problems can be more quickly and accurately assessed.

- Valves
- Is the wiring correct?
- Is the direction of the stroke correct?
- Is the direction of the failsafe shutdown correct?
- Does the valve move through its proper stroke smoothly?
- Does the valve travel its full stroke?
- Can mid-stroke be obtained and held?
- Does the valve fully seat (close)?
- Does the valve fully open?

Engine/Generator Troubleshooting

Problem	Possible Cause	Suggested Test/Correction
Engine does not start	Stuck throttle/frozen shaft	Move throttle by hand. Assess smoothness, friction, and return spring force.
	Power not applied to control	Disconnect starter motor solenoid. Disconnect harness from governor. Activate application. Test for +12/24 V between +12/24 V pin and ground pin.
	Run Enable not closed	Verify status of input. Measure input. Verify input and configuration using Service Tool.
	No configuration or incorrect configuration in controller.	Using Service Tool, read configuration from controller and evaluate parameters for correction.
	Fault detected in controller.	Using Service Tool, read faults from controller. Verify/correct any shutdown conditions.
	Unsuccessful reflashing*	Do a power cycle and reflash L-Series again. L-Series will use communication settings from last reflashing event. If L-Series will fail to read non-volatile memory correctly it will use default communication settings: CAN baud rate 250k, Device Address 0x15, ECU_Part_Number 4385563 and Device_Name 'flcntvlv'.
Engine unstable	Improperly tuned dynamics.	Using Service Tool, tune the position dynamics.
	Intermittent position command input signal.	Using Service Tool, verify fault indications.
	Device sending position command is sending oscillating signal.	Measure input signal. Verify signal using Service Tool.
Poor frequency control	Improperly tuned dynamics.	Using Service Tool, tune the position dynamics.
	Friction/dither improperly set.	Using Service Tool, adjust the Friction/Dither setting.
Unable to develop full power	Non-indexed linkage slipped on shaft.	Manually verify full travel of throttle plate.
	Fault detected in controller.	Using Service Tool, view status of fault codes. Take appropriate action for active faults.

Engine/Generator Troubleshooting (cont'd.)

Problem	Possible Cause	Suggested Test/Correction
Not controlling at desired position setpoint	PWM input signal inaccuracy.	Measure input duty cycle and convert to percentage. Verify controller signal using Service Tool. If different, adjust the PWM Offset value in the Configuration Editor.
	Wiring fault or ground loop.	Check the wiring. Look for loose connections and disconnected or misconnected cables and connections. Remove all wiring except the position command and power input and verify operation/functionality.
	Analog input signal inaccuracy.	Measure the analog command voltage arriving at pin 10 to verify that it is at the expected value in the range of 0.5 to 4.5 V. Use the service tool to verify that AUX2 is being read correctly.
	Output shaft is bound or sticking.	Manually verify full shaft movement. Use the "verify position" function of the service tool (Chapter 4).
Discrete output not working	Wiring fault.	Check the wiring leading to pin 9 for open connections or misconnections. Verify that pin 9 is not connected directly to input power or ground.
	Configuration.	Using the Service Tool, verify that the faults and shutdowns are selected properly and that the output is configured for expected operation (either normally "on" or normally "off").
Service Tool not communicating–'Not Connected' status indicated	Wiring fault.	Check AUX3 and AUX4 connections. Verify harness setup and connections (see chapter 4) Check that Service Tool is running. Verify the port setting is correct.
	CAN is enabled.	Must be 'connecting' during power-up on CAN units.
Service Tool not communicating–'Error message displayed on PC when trying to connect	Old version of Service Tool or file corruption or bad install.	Re-install Service Tool, get the latest version from the Woodward web site (www.woodward.com)
Service Tool will not accept password	Cap Lock is on.	Password is case-sensitive, make sure you enter the password correctly using upper and lower case. If password is lost contact the OEM for retrieval.

* Available in 5418-7022 only

Troubleshooting Diagnostic Flags

Error Flag	Description	Possible Source	Possible Action
Supply Voltage Failure	The power supply voltage is higher than the diagnostic limits. The Power supply voltage is lower than the diagnostic limits.	Bad or damaged battery. Defective battery charging system. Incorrect setting of power supply voltage level. Power supply wiring to long or to thin. Control will flag low voltage during higher power uses.	Replace battery. Fix battery charging system. Set correct voltage levels on power supply. Make sure wiring is of the correct thickness and length according to manual.
Temperature Sense Failed	This error is set if the temperature inside the control is higher or lower than allowed by the specifications.	Control has been placed in an environment that is too hot or too cold. The internal temperature sensor is defective. This can be determined by checking the temperature of the unit and comparing this to the service tool value of the electronics temperature.	Lower temperature by adding cooling, heat shielding, moving the unit, etc. Increase temperature by adding heat. Return unit to Woodward for repair.
Position Error	If the demanded position and the actual position are outside the configured limits.	Incorrect position control dynamics or friction setting. Binding or excessive friction in the actuator linkage, or stops are set inside the desired range of travel.	Check/tune position dynamics using the Service Tool. Perform a position calibration. Check all mechanical linkages and stops.
Position Sensor Failure	If the internal position sensor is outside the diagnostic limits.	Internal failure of position sensor.	Return unit to Woodward.
Internal Shutdown	All internal shutdowns will set this flag.	The Control is defective.	Return unit to Woodward.
EEPROM Failure	The software can't write to the EEPROM. The software can't read from the EEPROM.	The Control is defective.	Return unit to Woodward.
Brown Out Reset	The brown out detection flag indicates power to the Control has sagged to a point of non-operation and is now restored.	Power source voltage drop. Loss of power or intermittent power supply wiring. Power supply wiring to long or too thin. L-Series will reset during transient power uses.	Possible power problem. Check wiring for bad or loss connection. Make sure wiring is of the correct thickness and length according to manual.
Watchdog Reset	If the watchdog has reset the Control, this flag will set.	After software update, the software watchdog will reset the Control. The software is disrupted by EMI or an internal component failure.	This is a normal situation. Reset the error code and reset the stored errors. This is an abnormal situation. Return the unit to Woodward.

Troubleshooting Diagnostic Flags (cont'd.)

Error Flag	Description	Possible Source	Possible Action
Overtemperature	High internal temperature.	Detection of high of temperature.	Check ambient temperature around Control. Verify temperature reading using service tool. If the temperatures seem normal, could indicate a problem with the temperature sensor.
Relay Fail Short	Control detected a fault in the discrete out wiring.	Incorrect or intermittent wiring problem.	Check wiring for bad or lost connection.
Run Enable Shutdown	Control detected that the Run Enable discrete in is not active.	Incorrect or intermittent wiring problem. Incorrect configuration.	Check wiring for bad or lost connection. Verify configuration. Check Run Enable setting.
Position Demand Failed	Control detected all position demands failed.	Incorrect or intermittent wiring problem. Incorrect configuration.	Check wiring for bad or lost connection. Verify configuration. Check Run Enable setting.
Analog Demand Failed	Control detected analog (0–5 V) position demand failed.	Incorrect or intermittent wiring problem. Incorrect configuration.	Check wiring for bad or lost connection. Following Analog Input troubleshooting listed below. Verify configuration.
PWM Demand Failed	Control detected PWM position demand failed.	Incorrect or intermittent wiring problem. Incorrect configuration.	Check wiring for bad or lost connection. Following PWM Input troubleshooting listed below. Verify configuration.
CAN Demand Failed	Indicates CAN communication fault or bus arbitration failure (J1939 address claim) or that CAN messages are received at a rate slower than the configured minimum update rate (CAN Fail Timeout).	Incorrect or intermittent wiring problem. Incorrect configuration. Device not sending updates fast enough or regularly (bursts).	Check wiring for bad or lost connection. Follow the CAN troubleshooting listed below. Verify CAN configuration settings. Verify ECM messages and update rates. Verify configuration of L-Series min update rate.
Position Tamper Fault	Control determined the primary demand is not tracking the CAN position demand.	Incorrect or intermittent wiring problem. Incorrect configuration.	Check wiring for bad or lost connection. Verify configuration. Check CAN Tracking settings.

Electrical Troubleshooting Guide

Analog Input

If the Analog Input is not functioning properly, verify the following:
- Measure the input voltage. It should be in the range of 0.5–4.5 V.
- Check the values seen by the L-Series driver using the Service Tool and verify that it matches the input signal.
- Verify that there are no or minimal ac components to the Analog Input signal. AC components can be caused by improper shielding.
- Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 V, look for loose connections and disconnected / misconnected cables/connections.
- Check the software configuration to ensure that the input is configured properly as the Demand Source.

PWM Input

If the PWM input is not functioning properly, verify the following:
- Measure the input voltage, frequency, and duty cycle.
- Check the values seen by the L-Series driver using the Service Tool and verify that is matches the input signal.
- Check the wiring. Look for loose connections and disconnected / misconnected cables/connections.
- Check the software configuration to ensure that the input is configured properly as the demand source.

CAN Input

If the CAN connection is not functioning properly, verify the following:
- Check the values seen by the L-Series driver, if any, using the Service Tool and verify that is matches the sent signal and/or received signal.
- Check the wiring. Look for loose connections and disconnected / misconnected cables/connections. Verify 120 Ohm resistor at ends of transmission lines.
- Check the software configuration to ensure that the signal is configured properly (Device ID, fail timeout, protocol, etc).

Run Enable Discrete Input

If the run enable discrete input is not functioning properly, verify the following:
- Measure the input voltage on the terminal block. It should be in the range of 10–28 Vdc.
- Check the status of the input from the Overview screen of the Service Tool.
- Check the wiring, looking for loose connections or misconnected cables.
- Verify the input is properly configured.

Alarm or Shutdown Conditions

If the L-Series control has any alarm or shutdown conditions, refer to Chapter 2 for details on the exact cause of the condition. The Service Tool must be used to determine the cause of any shutdown or alarm condition. Refer also to the 'Troubleshooting Diagnostics Flags' section above.

Discrete Output

If the discrete output is not functioning properly, verify the following:

* Measure the output voltage on the terminal block. It should be in the range of 10–28 Vdc when the output is off/false. The voltage will be in this range only if all shutdowns are false. This can be verified through the Service Tool.
* Check the wiring, looking for loose connections or disconnected / misconnected cables.
* Verify the configuration of the output.

Service Tool

If the service tool is not functioning properly, review the installation information in Chapter 4. Verify the following:

* Check the wiring, looking for loose connections or disconnected / misconnected cables.
* Check that Service Tool is running. Verify the Port setting is correct.
* Follow on-screen error messages. Re-install software as needed. The latest version of software is available for download from the Woodward web site (www.woodward.com).
* Service Tool will not communicate if reflashing has been unsuccessful (this is available only in firmware version 5418-7022). See 'Unsuccessful reflash' section for more details.

Unsuccessful Reflash

The ability to reflash is only provided in firmware version 5418-7022 using J1939 PGN 55808. On an unsuccessful reflash the device will not function and will remain in boot mode. The output shaft will be limp (no drive current). To recover do a power cycle and repeat reflashing sequence. Communication settings (CAN baud rate, Device Address, Identification) will remain inherited from previously installed firmware. Nevertheless in rare occasion when L-Series was unable to read EEPROM, communication settings and identity may be defaulted:

* CAN baud rate set to 250kbps,
* Device Address set to 0x15.
* Serial Number set to 12345678

When device is in a boot mode, following NAME is used in J1939 Address Claim:

L-Series NAME fields:
  Arbitrary Address Capable: 0 / Disabled
  Industry Group Field: 0 / Global
  Vehicle System Instance: 0 / First Instance
  Vehicle System Field: 0 / Non-specific System
  Function Field: 15 / Fuel System
  Function Instance Field: 0 / First
  ECU Instance Field: 0 / Device 1
  Manufacturer Code Field: 153 / Woodward Governor Industrial Controls
  Identity Number Field: Unique

Also please note that Device Address is based on configuration, so if that changes in reflashed firmware, Device Address may be changed as well.

Chapter 6.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:
1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.

- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.
- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in "like-new" condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE	**To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.**

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems	Products Used In Engine Systems	Products Used In Industrial Turbomachinery Systems
Facility---------------Phone Number	**Facility---------------Phone Number**	**Facility---------------Phone Number**
Brazil--------------+55 (19) 3708 4800	Brazil--------------+55 (19) 3708 4800	Brazil--------------+55 (19) 3708 4800
China ----------- +86 (512) 6762 6727	China ----------- +86 (512) 6762 6727	China ----------- +86 (512) 6762 6727
Germany:	Germany-------+49 (711) 78954-510	India-------------- +91 (129) 4097100
Kempen----+49 (0) 21 52 14 51	India-------------- +91 (129) 4097100	Japan-------------- +81 (43) 213-2191
Stuttgart--+49 (711) 78954-510	Japan-------------- +81 (43) 213-2191	Korea-------------- +82 (51) 636-7080
India-------------- +91 (129) 4097100	Korea-------------- +82 (51) 636-7080	The Netherlands - +31 (23) 5661111
Japan-------------- +81 (43) 213-2191	The Netherlands - +31 (23) 5661111	Poland-------------- +48 12 295 13 00
Korea-------------- +82 (51) 636-7080	United States ---- +1 (970) 482-5811	United States ---- +1 (970) 482-5811
Poland-------------- +48 12 295 13 00		
United States ---- +1 (970) 482-5811		

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name	
Site Location	
Phone Number	
Fax Number	

Prime Mover Information

Manufacturer	
Engine Model Number	
Number of Cylinders	
Type of Fuel (gas, gaseous, diesel, dual-fuel. etc.)	
Power Output Rating	
Application (power generation, marine, etc.)	

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

Control/Governor #2

Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

Control/Governor #3

Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

Symptoms

Description	

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix A.
L-Series Configuration Summary

APPLICATION _____

ACTUATOR SERIAL NUMBER _____
For details on individual settings, refer to Chapter 4.

Configuration Settings – Position Controller

Overview

Min Position Direction	CCW _____ CW _____
Shutdown Position (%)	= _____
Proportional Gain (%)	= _____
Integral Gain (%)	= _____
Derivative Gain (%)	= _____
Friction / Dither Setting	= _____

Setup

Single or Redundant/Backup Selection	Single _____ Redundant _____
Primary Position Demand Selection	PWM _____ Analog _____ CAN _____
Backup Position Demand Selection	PWM _____ Analog _____ CAN _____
Maximum Demand Difference (%)	= _____

PWM Input

PWM Drive Select	Push-Pull _____ High Side _____ Low Side _____
PWM Offset (%)	= _____

CAN

CAN Fail Timeout (sec)	= _____
Protocol	J1939 _____ CANopen _____
CAN ID LOW Discrete Input	Not Used _____ Aux 2 _____
CAN ID HIGH Discrete Input	Not Used _____ Aux 1 _____ Aux 5 _____
Device Identifier	= _____
Device Identifier 2	= _____
Device Identifier 3	= _____
Device Identifier 4	= _____
Data Rate	250 K _____ 500 K _____
Heartbeat Producer Time (sec)	= _____
Enable Position Tamper Fault?	Yes _____ No _____
Run Enable	Not Used _____ Aux 1 _____
Use Non-linear Actuator Curve?	Yes _____ No _____

Non-Linear Actuator Settings

Position Request (pt 0) (%)	= _____
Position Request (pt 1) (%)	= _____
Position Request (pt 2) (%)	= _____
Position Request (pt 3) (%)	= _____
Position Request (pt 4) (%)	= _____
Actuator Position (pt 0) (%)	= _____
Actuator Position (pt 1) (%)	= _____
Actuator Position (pt 2) (%)	= _____
Actuator Position (pt 3) (%)	= _____
Actuator Position (pt 4) (%)	= _____

Discrete Out

Discrete Out Normally On?	Yes _____ No _____
Indicates Watchdog Reset?	Yes _____ No _____
Indicates Brownout Reset?	Yes _____ No _____
Indicates EE Prom Failure?	Yes _____ No _____
Indicates Position Sensor Failure?	Yes _____ No _____
Indicates Temperature Sensor Failure?	Yes _____ No _____
Indicates Supply Voltage Fault?	Yes _____ No _____
Indicates Relay Fault?	Yes _____ No _____
Indicates Position Demand Failure?	Yes _____ No _____
Indicates Overtemperature?	Yes _____ No _____
Indicates Position Error?	Yes _____ No _____
Indicates Run Enable Shutdown?	Yes _____ No _____
Indicates Analog Demand Failed?	Yes _____ No _____
Indicates PWM Demand Failed?	Yes _____ No _____
Indicates CAN Demand Failed?	Yes _____ No _____
Indicates Position Tamper Fault?	Yes _____ No _____
Indicates CAN Stop Command?	Yes _____ No _____

Faults (Shutdown/Alarms)

Temp Sensor Failure Action	Shutdown _____ Alarm _____
Supply Voltage Fault Action	Shutdown _____ Alarm _____
Relay Fault Action	Shutdown _____ Alarm _____
Position Demand Failure Action	Shutdown _____ Alarm _____
Overtemperature Action	Shutdown _____ Alarm _____
Position Error Action	Shutdown _____ Alarm _____
Position Tamper Fault	Shutdown _____ Alarm _____

Faults are Latched?	Yes _____ No _____
CAN Fault is Latched?	Yes _____ No _____

Position Error Max (%)	= _____
Position Error Delay (sec)	= _____
CAN Tracking Error Max (%)	= _____
CAN Tracking Error Delay (sec)	= _____

Security

Apply security to Configuration Reading?	Yes _____ No _____
Apply security to Configuration Loading?	Yes _____ No _____
Apply security to Position PID Edit?	Yes _____ No _____
Apply security to Position Calibration?	Yes _____ No _____
Password	= _____

Appendix B.
L-Series Control Specifications

Specifications

Power Supply	12/24 V systems (10–32 Vdc) reverse polarity protection, 2.5 A max
Power Consumption	32 W maximum
Torque	Nominal: 0.34 N·m (0.25 lb-ft) at 25 °C
	Maximum Transient (at 105 °C): 0.20 N·m (0.15 lb-ft)
	Minimum Continuous (at 105 °C): 0.14 N·m (0.10 lb-ft)
Mass/Weight	425 g (15 oz)
Power-Up to Operation Time	<250 ms (< 1 s CAN versions)

Performance

Positioning Accuracy	±2% at 25 °C
	±4% (analog), ±3.6% (PWM), ±3% (CAN)–over temp range
Slew Time 10%–90%	33 ms
Overshoot	1%
Settling Time	10 ms
–6 db Roll-off at ±0.5% Input	32 Hz
–3 db Roll-off at ±2% Input	8 Hz

Environment

Ambient Operating Temperature	–40 to +105 °C (–40 to +221 °F)
Storage Temperature	–40 to +125 °C (–40 to +257 °F)
EMI/RFI	EN61000-6-2 : Immunity for Industrial Environments
	EN61000-6-4 : Emissions for Industrial Environments
	SAE J1113-21: Radiated Immunity (100 V/m)
	SAE J1113-11: Conducted Transient Immunity – Pulse 5b
	Suppressed Load Dump (45 V)
Humidity	US MIL-STD 810E, Method 507.3, Procedure III
Salt Spray	US MIL-STD 810E, Method 509.3, Procedure I
Shock	MS1-40G 11 ms sawtooth
Random Vibration	Random: 0.3 G²/Hz, 10–2000 Hz (22.1 Grms) 3 h/axis
	Sine: 5 G 2.5 mm peak-to-peak, 5–2000 Hz, 3 h/axis, 90 min dwells, 1 octave/min
Drop	SAE J1211, Paragraph 4.8.3 (modified)
Thermal Shock	SAE J1455, Paragraph 4.1.3.2
Ingress Protection	IP56 per EN60529

Analog Command Input

Parameter	Value
Input Type	0–5 V, Single-Ended Input
Input Scaling	0.5 V = 0% and 4.5 V = 100% position
Max Input (Full Scale)	5 V ± 1%
Isolation	None
Transient Protection	According to EMC norm
Input Impedance	499 kΩ
Anti-Aliasing Filter	1 anti-aliasing pole at 0.001 ms (159 kHz)
Resolution	10 bits
Accuracy	±1.3% of full scale over the temperature range of –40 to +125 °C, including drift
I/O Latency	8.2 ms
Calibration Method	2-point linear software calibration
Out of Range Signal	< 0.2 V or > 4.8 V
Overvoltage Protection	Input protected against 32 Vdc steady state

PWM Command Input

Parameter	Value
Input Magnitude	5–32 V p-p
Frequency Range	300–1500 Hz
Duty Cycle Scaling	10% = fully closed and 90% = fully open
Isolation	None
Input Impedance Push-Pull Mode	44 kΩ–113 kΩ
Input Impedance Open Collector Mode, High Side or Low Side.	15 kΩ
Resolution	16 bits at 300 Hz, 14 bits at 1.5 kHz
Accuracy	±1% of full scale (duty cycle), over the temperature range of –40 to +125 °C, including drift
I/O Latency	8.2 ms
Calibration	Duty cycle offset adjustment is available in Service Tool. This will tailor the input to the signal source
Out of Range Frequency	None
Out of Range Duty Cycle	< 3% or > 97%

Discrete Input

Parameter	Value
Input Current	0.5 mA @ 5 Vdc
Input Type	Ground referenced discrete input
Delay Time for Shutdown	< 200 ms for system to recognize shutdown
Delay Time for Reset Detection	< 1 s for valves to move to minimum position
Max Voltage from + Connection	32 V (power input voltage)
Isolation	None, Intended for use with external relay or other dry contact
Input Thresholds	> 3.1 Vdc = "ON" < 0.8 Vdc = "OFF"
Input Current	0.5 mA @ 5 Vdc

Discrete Output

Parameter	Value
Output Type	Low-side output driver
Max Contact Voltage (Open)	32 V
Max Current	0.5 A
Max Contact Voltage at 0.5 A (Closed)	1.5 V
Max Delay Time for Opening Contact	8.2 ms
Default at Power Up	Configurable in software
Error Condition	Configurable in software
OK Condition	Configurable in software
Driving Inductive Loads	Yes, internally protected low-side switch
Protection	Utilizes circuitry that will open the contact when output contacts are short-circuited. Self-resetting when fault is removed

TPS Output

Parameter	Value
Output Type	0–5 V, single-ended
Output Scaling	0.75 V = full CCW position and 4.25 V = full CW position
Isolation	None
3 db Circuit Bandwidth	350 Hz
Transient Protection	According to EMC norm
Output Impedance	2.8 kΩ (±1%)
Accuracy	±10% of full scale, @ 25 °C
Temperature Drift	±0.4% over the full temperature range
I/O Latency	n/a – direct from position sensor
Calibration Method	Sensor-in-place factory calibration. 2-point linear
Out of Range Signal	< 0.25 V or > 4.75 V
Overvoltage Protection	Output protected against 32 Vdc, steady-state; if >28 V is applied to pin 2, a position-related error will be annunciated

RS-232 Serial Communication Service Port

Parameter	Value
Isolation	None
Baud Rate	Fixed 19.2 Kbaud
Electrical Interface	Outputs are TTL level. Requires external transceiver for conversion to RS-232 levels for proper communication !!
Pinout	Tx = pin 4, Rx = pin 6, Gnd = pin 3
Maximum Cable Length	10 m (33 ft), not meant for permanent connection (for service only)
Cable Type	Straight-through (no crossover)

CAN Communications (optional)

Parameter	Value
Type	2-wire CAN, version 2.0B software selectable CANopen or J1939
J1939	Complies with SAE J1939 but uses proprietary group extensions; 29-bit
CANopen	CANopen node (ref CiA DS301 Version 4.02)
Device Identifier	Service Tool software setting
Isolation	None
Baud Rate	Fixed 250 kbps (CANopen) 250 or 500 kbps (J1939)
Pinout	Lo = pin 6 (AUX4), Hi = pin 4 (AUX3) (shared with RS-232 communications)
Line Limitations	40 m (130 ft) If an isolator is used: Trunk Length: 250 m (820 ft) Maximum Drop: 6 m (20 ft) Cumulative Drop: 78 m (256 ft)
Fault Detection	Service Tool setting

Electronics Temperature Sensor

Parameter	Value
Accuracy	±2 °C at 25 °C ambient ±3 °C over full range (–40 to +125 °C)
I/O Latency	8.2 ms

Software Execution Rates

Software Routine	Nominal Software Execution Rate
Position Control Algorithms	1.6 ms
Position Demand Algorithms	8.2 ms
Analog Input Logic	8.2 ms
PWM Input Logic	8.2 ms
Serial Port	background task
CAN communications	8.2 ms
Run Enable Discrete Input	8.2 ms
Discrete Output	8.2 ms
Diagnostics	8.2 ms

Reliability and Quality Goals

The L-Series control system has a reliability target of 17 500 hours MTBF. It also has a quality goal of less than 25 PPM when measuring out-of-the-box defects. This quality goal is a target based on continuous improvement.
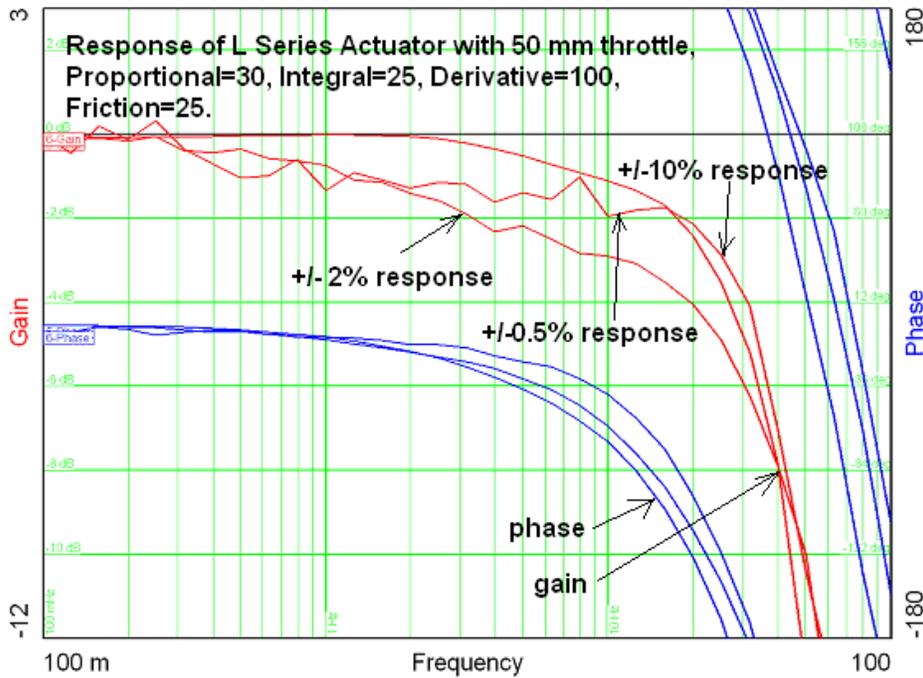

Figure C-1. Bode Plot of L-Series Response

Revision History

Changes in Revision C—
- Added information for new part number 5418-7022
- Updated Declarations

Changes in Revision B—
- Improvements to clarity and wording

Changes in Revision A—
- Added information for new part number 5418-6638

Declarations

EU DECLARATION OF CONFORMITY

EU DoC No.:	00240-04-EU-02-07
Manufacturer's Name:	WOODWARD INC.
Manufacturer's Contact Address:	3800 Wilson Avenue Loveland, CO 80538 USA
Model Name(s)/Number(s):	L-Series Actuator
The object of the declaration described above is in conformity with the following relevant Union harmonization legislation:	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (EMC)
Units marked and conforming to ATEX conform to Directive:	Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres
Markings on units conforming to ATEX:	⟨Ex⟩ II 3 G Ex nA II T3 Gc X IP56
Applicable Standards:	EN61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments EN61000-6-4, 2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments EN60079-0:2012/A11:2013 Explosive atmospheres-Part 0: Equipment-General requirements EN60079-15:2010 Explosive atmospheres-Part 15: Equipment protection by type "n

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We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

Signature

Christopher Perkins
Full Name
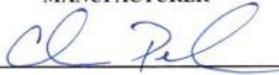
Engineering Manager
Position

Woodward, Fort Collins, CO, USA
Place

June 7, 2016
Date

5-09-1183 Rev 26   00240-04-EU-02-07

DECLARATION OF INCORPORATION
Of Partly Completed Machinery
2006/42/EC

File Name: 00240-04-EU-02-03

Manufacturer's Name: WOODWARD INC

Manufacturer's Address: 1000 E. Drake Rd.   3800 N. Wilson Ave.
Fort Collins, CO, USA, 80525   Loveland, CO, USA 80538

Model Names: L-Series Actuator

This product complies, where applicable, with the following Essential Requirements of Annex I: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

The relevant technical documentation is compiled in accordance with part B of Annex VII. Woodward shall transmit relevant information if required by a reasoned request by the national authorities. The method of transmittal shall be agreed upon by the applicable parties.

The person authorized to compile the technical documentation:

Name: Dominik Kania, Managing Director
Address: Woodward Poland Sp. z o.o., ul. Skarbowa 32, 32-005 Niepolomice, Poland

This product must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive, where appropriate.

The undersigned hereby declares, on behalf of Woodward, Inc., of Loveland and Fort Collins, Colorado that the above referenced product is in conformity with Directive 2006/42/EC as partly completed machinery:

MANUFACTURER

_____
Signature

Christopher Perkins
_____
Full Name

Engineering Manager
_____
Position

Woodward, Inc, Fort Collins, CO, USA
_____
Place

June 7, 2016
_____
Date

5-09-1182 (REV. 16)   00240-04-EU-02-03

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26635C.

WOODWARD

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Email and Website—www.woodward.com

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as well as authorized distributors and other authorized service and sales facilities throughout the world.**

Complete address / phone / fax / email information for all locations is available on our website.