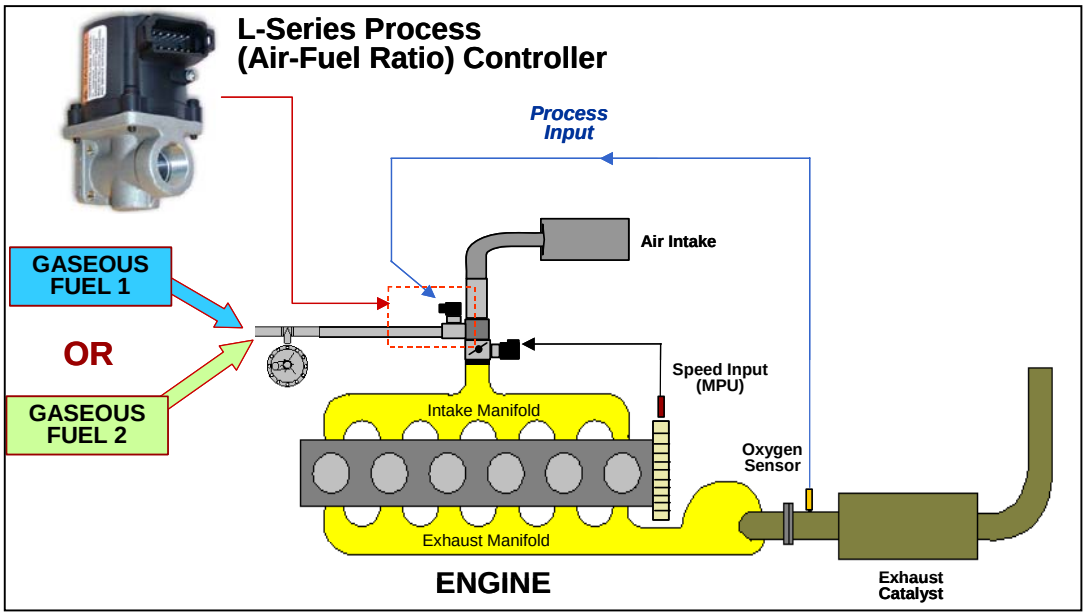
WOODWARD

Application Note



L-Series Air-Fuel Ratio Controller Configuration Instructions for Bi-Fuel Applications

Application Note 36719

WARNING—DANGER OF DEATH OR PERSONAL INJURY

WARNING—FOLLOW INSTRUCTIONS

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.

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WARNING—OVERSPEED PROTECTION

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—PROPER USE

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY

CAUTION—BATTERY CHARGING

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.

CAUTION—ELECTROSTATIC DISCHARGE

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.**

IMPORTANT DEFINITIONS

- **A WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
- **A CAUTION indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment or property.**
- **A NOTE provides other helpful information that does not fall under the warning or caution categories.**

Revisions—Text changes are indicated by a black line alongside the text.

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Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. 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.

3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. 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.

CAUTION
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*.

Chapter 1.
General Information

Scope and Purpose

The purpose of this Application Note is to provide instructions on setting up the configuration of the L-Series Process Controller for bi-fuel applications. It is intended to supplement the L-Series Process Controller Installation, Programming and Troubleshooting Manual 26251, Chapter 6, Configuration.

Bi-Fuel engine applications mean that an engine is capable or running on either one of two available fuel types. For instance, one of the most common bi-fuel applications is to run spark-ignited engines on either on natural gas or LP vapor. Dual-Fuel means that the engine is capable of running simultaneously on two distinct fuels.

Assumptions:

1. Customer has read the entire L-Series Process Control Manual 26251.
2. Customer has understood and complied with all of the warnings highlighted in Manual 26251.
3. Customer has selected and sized the correct process controller unit for their engine application.
4. Customer has downloaded the Service Tool Software from the Woodward website into a laptop or desktop computer that meets the compatibility requirements highlighted on Manual 26251 under the section *Service Tool Software*.
5. Customer has obtained a communication kit and has made the correct harness connections.
6. Customer has properly selected and sized the fuel system components for their engine application including shutdown mechanisms.
7. Customer understands that they are strongly encouraged and expected to thoroughly develop and test specific L-Series Air-Fuel Ratio control schemes for their bi-fuel applications under normal and extreme operating conditions.

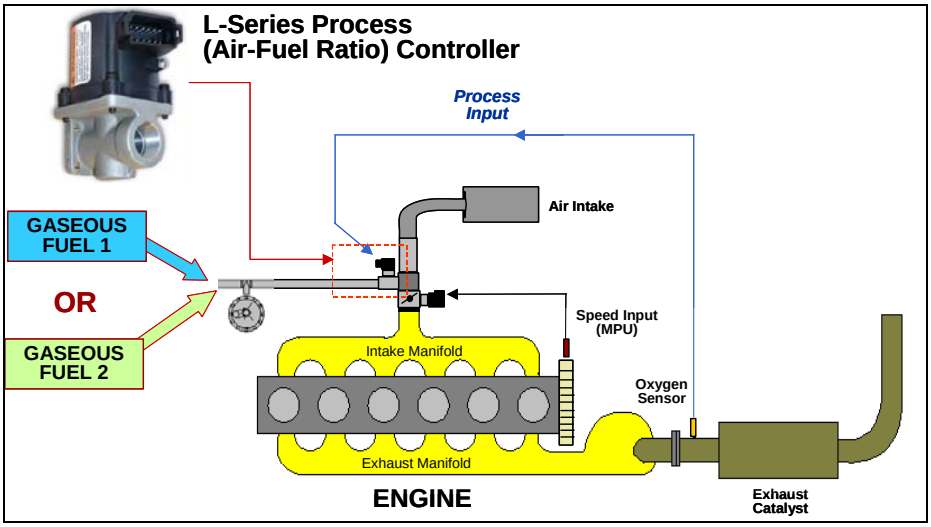

Figure 1. L-Series Air-Fuel Ratio Bi-Fuel Application Schematic

Configuration Procedure

Woodward's L-Series Process Controller requires wiring harness configuration prior to making any changes in the software. For bi-fuel engine applications, the customer must first determine how the fuel select command will be sent to the controller.

Figure 2 below shows a typical L-Series Process Controller application wiring. There are five inputs on the air-fuel ratio controller capable of both analog and discrete functions (Aux1 to Aux5); however, only four discrete inputs (Aux2 to Aux5) are available for sensors and switches since Aux1 is used exclusively for the oxygen sensor signal (process) input.

For illustration purposes in this Application Note, the Fuel Select switch will be assigned as a discrete input on Aux2 (pin 10) and will be configured to be Active Closed. Aux3 will be used for a bias input and Aux4 will be used as an Open-Loop select switch.

The configuration procedure is illustrated using the most recent L-Series Process Controller firmware (5418-2834 NEW). For illustration purposes, the configuration file in this manual was developed assuming a new configuration off-line.

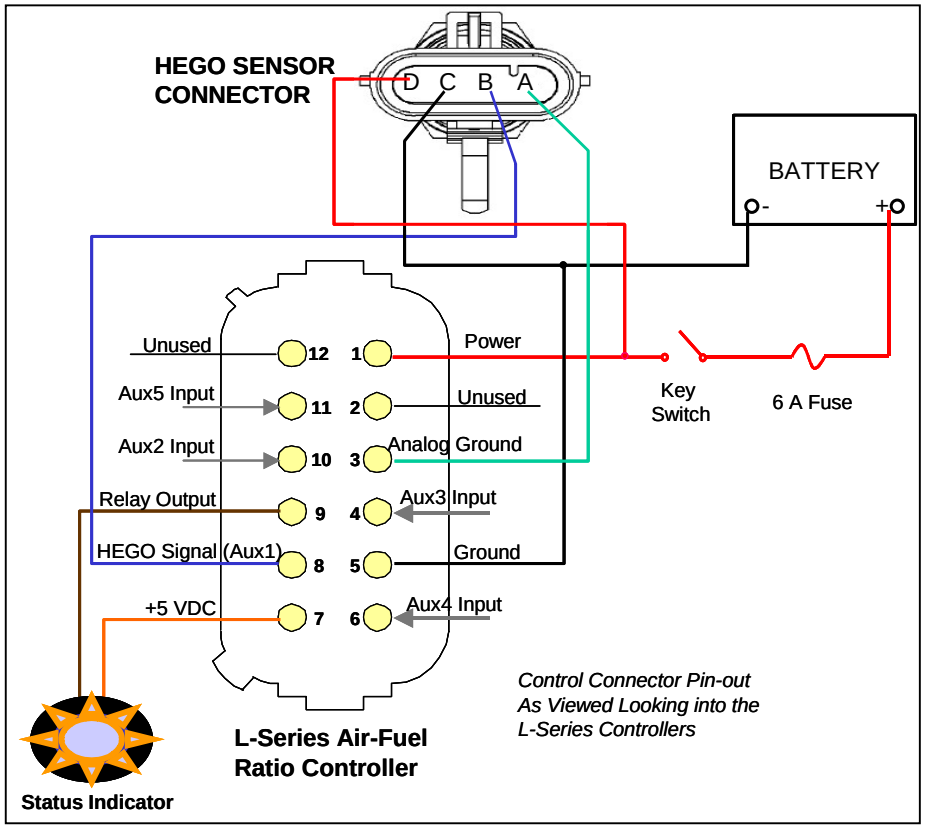

Figure 2. L-Series Air-Fuel Ratio Controller Inputs and Outputs Schematic

Configuring the Air-Fuel Ratio Controller

The following L-Series Service Tool screen snapshots show the sequence of steps that will help customers configure the L-Series Air-Fuel Ratio controller for bi-fuel operations.

Once communication is established with the L-Series controller, go to File and select Open Control Configuration from the pull down menu. This action opens the default configuration file that resides in the L-Series Process Controller.

Figure 3 below shows the available options from the File menu, and the Open Control Configuration preferred option is highlighted.

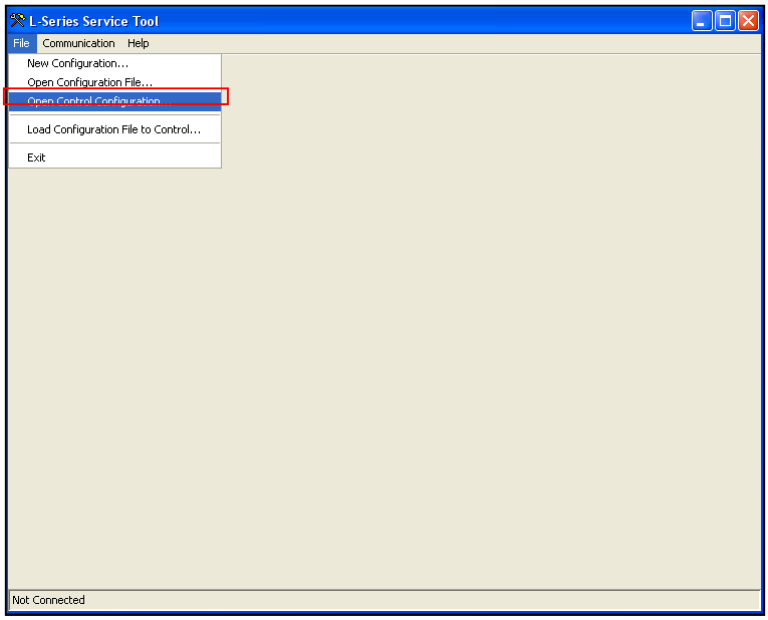

Figure 3. Screen for Opening the Controller Configuration

Next, the default configuration file loaded in the controller will open (Configuration1.cfg). The customer can now re-name this file. The configuration file naming rules highlighted in the Installation Manual must be followed.

The configuration file has five separate tabs (Overview, Process Control, Bias, Discrete Output, Alarm/Shutdown and Security). The Customer must configure all of these screens.

Overview Tab:
In this tab, the customer selects the Control Mode. For the bi-fuel application, customer should use the Air-Fuel Ratio Control. Also, the customers select the "Use Dual Targets" to enable the Two Targets, which will then enable the controller to have two different fuels Target 1 is fuel type 1 and Target 2 is fuel type two (Fuel Select Switch).

Figure 4 below shows the typical setting for a single-fuel application. For most applications (single or bi-fuel), the Position Controller Dynamics do not require additional tuning.

The customer must also configure the minimum position direction (CW or CCW) and position limits (minimum and maximum) for the controller for each fuel.

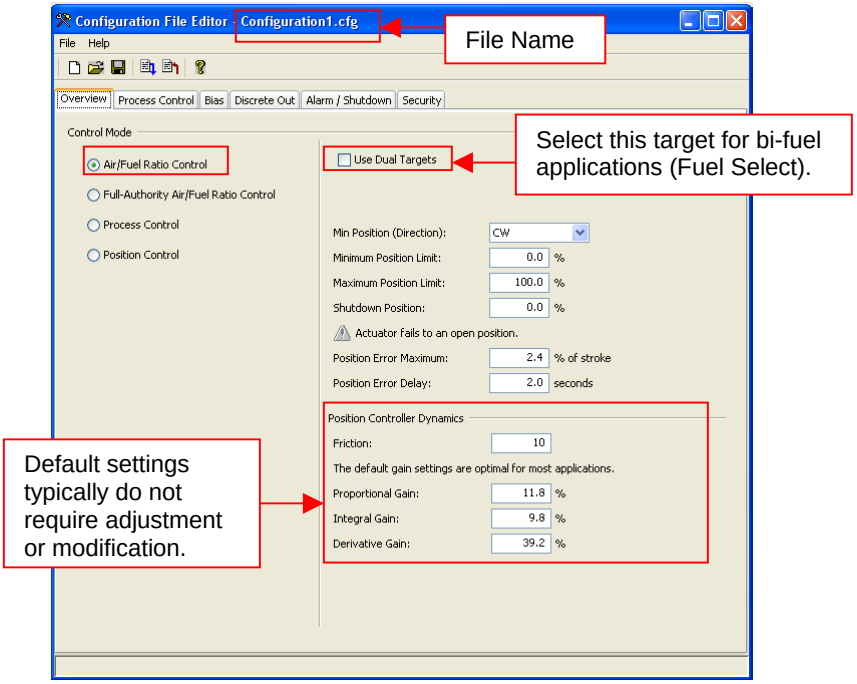

Figure 4. Overview Screen Showing Typical Single-Fuel Settings

Figure 5 below shows how to configure the Fuel Select switch. There are four options for setting the discrete inputs (Active Open, Active Closed, Always On, and Always Off). For illustration purposes, the Aux2 discrete input will be configured to Active when Closed.

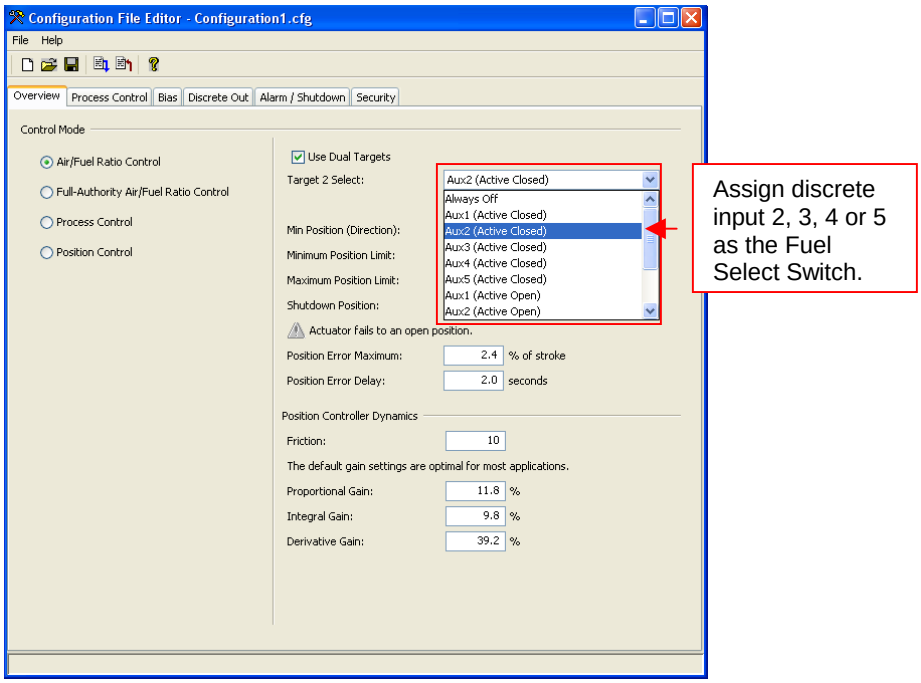

Figure 5. Overview Screen:
Selecting the Auxiliary (Aux) Input for Fuel Select

Figure 6 below shows the overview screen of the configuration file completed for bi-fuel applications. Now, the customer is ready to open the Process Control tab.

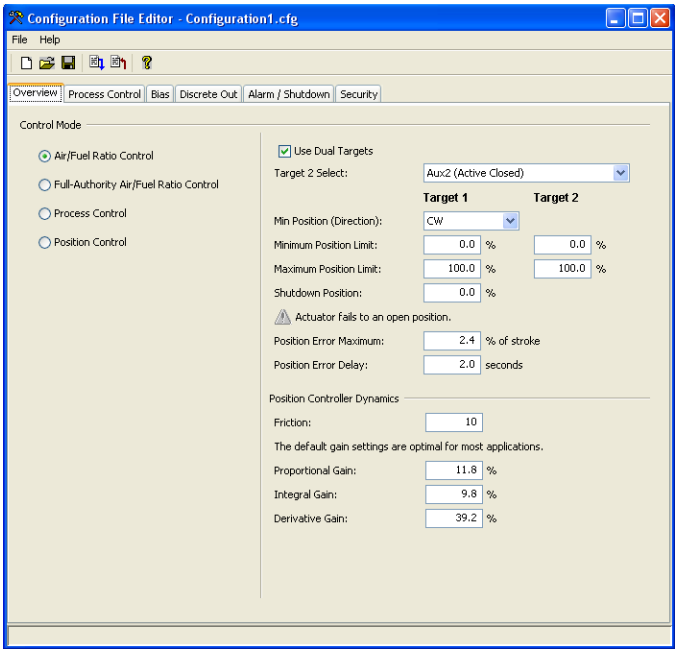

Figure 6. Overview Screen: Dual Target (Fuel Select) Configured

Process Control Tab - Input:

In the Process Control tab, define the process input type, its setpoints, dynamics as well as open loop settings for both fuels and oxygen settings for catalyst perturbation (dither).

In bi-fuel gaseous applications, the Process Input is typically a heated exhaust gas oxygen (HEGO) sensor. These sensors have a range of 0 to 1.25 Volts. The Aux1 input in the controller was designed to accept the HEGO input. So, the Customer must select the Input Range, Input Fault Limits and Scaling units. The typical scaling for the HEGO input is mV (millivolts).

Figure 7 shows the default Process Control, Input configuration.

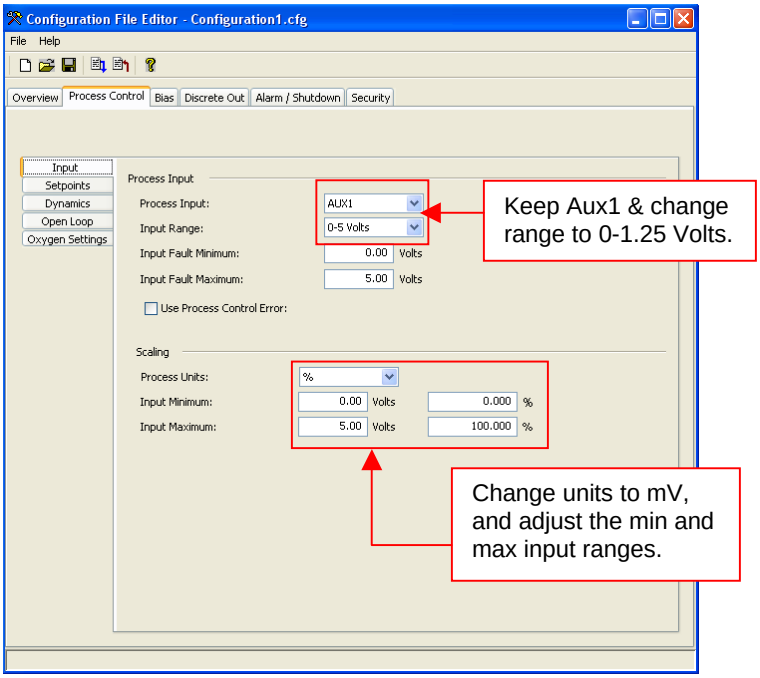

Figure 7. Default Process Control Input Tab Settings

In addition, the Input tab contains the checkbox for Use Process Control Error. This feature can be programmed to monitor the Process Input (HEGO signal) as a general diagnostics of operation. This feature can be adjusted to either an alarm or a shutdown. It is enabled only when the unit is in Closed-Loop mode.

Figure 8 is an example of a completed Process Control – Input screen. It shows the settings for a HEGO sensor and a user-defined time of 55 seconds for Process control error time. This means that an alarm or shutdown fault will be sent if the HEGO sensor has not changed sign (from – to + or vice versa) for the past 55 seconds.

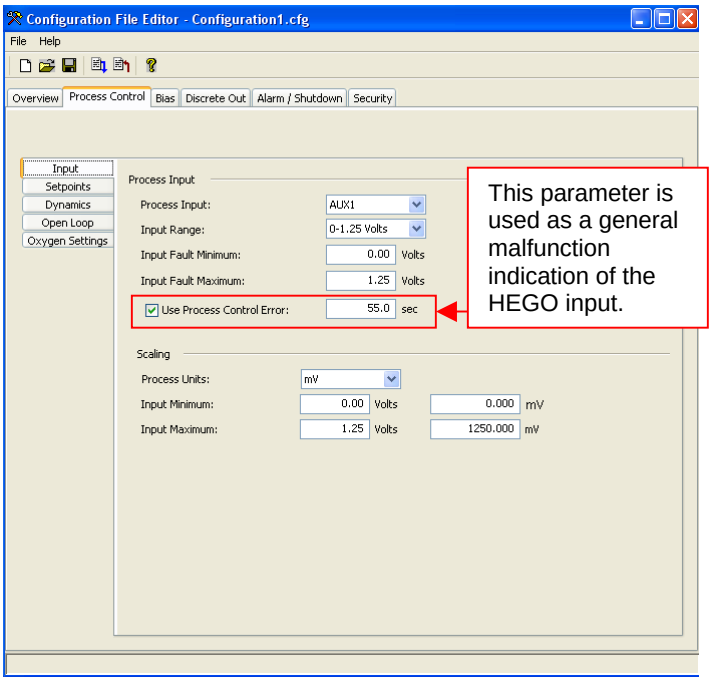

Figure 8. Sample Process Control Input Screen

Process Control Tab – Setpoints:

The target setpoints for both fuels are programmed in this tab. Determine the optimal target values and target rates through testing. It should be noted that unlike gasoline, which has a target setpoint of approximately 450 mV, gaseous fuels like natural gas and LP vapor require different setpoints in order to account for the measurable changes in oxygen in methane and propane. Therefore, the process setpoints are typically higher than 450 mV and should be determined through engine tuning under all operating conditions. The typical ranges are 700 mV for natural gas and 650 mV for propane.

Raise and Lower Setpoints can also be configured from the Setpoints Tab. However, for this application note, this feature will not be used. Refer to the L-Series Process Controller Manual 26251 for details on programming the Raise and Lower Setpoints.

Figure 9 shows the Process Control Setpoints Tab.

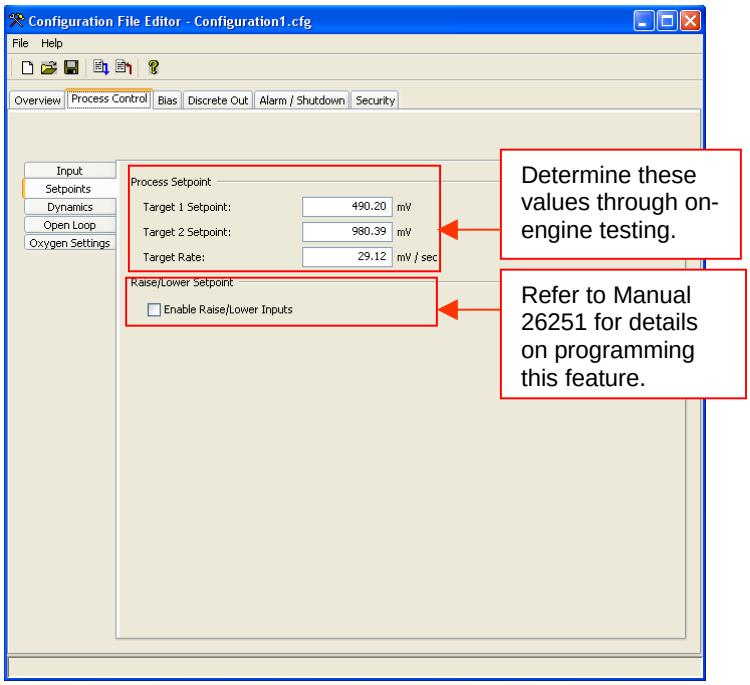

Figure 9. Process Control Setpoints Tab

Process Control – Dynamics Tab:

The process control dynamics tab provides process controller dynamics settings. The dynamic settings can also be adjusted on-line, real time, from the Edit Process Dynamics screen in the L-Series Service Tool Main Screen.

For bi-fuel applications, the Use Dual Dynamics should be selected. The auxiliary input selected for the dual dynamics should be the same input as the “Fuel Select” input chosen on the Overview screen. In these sample screens, the Aux2 discrete input was used. So, the same input switch that selects one of two fuels will also correspond to different dynamic settings.

Refer to the L-Series Process Controller Manual 26251 section on Dynamics in order to properly adjust these settings.

Figure 10 shows the Process Control – Dynamics tab of the configuration file. The Use Dual Dynamics tab is selected and matches the Aux2 input as the “Fuel Select” discrete input in the Overview Screen.

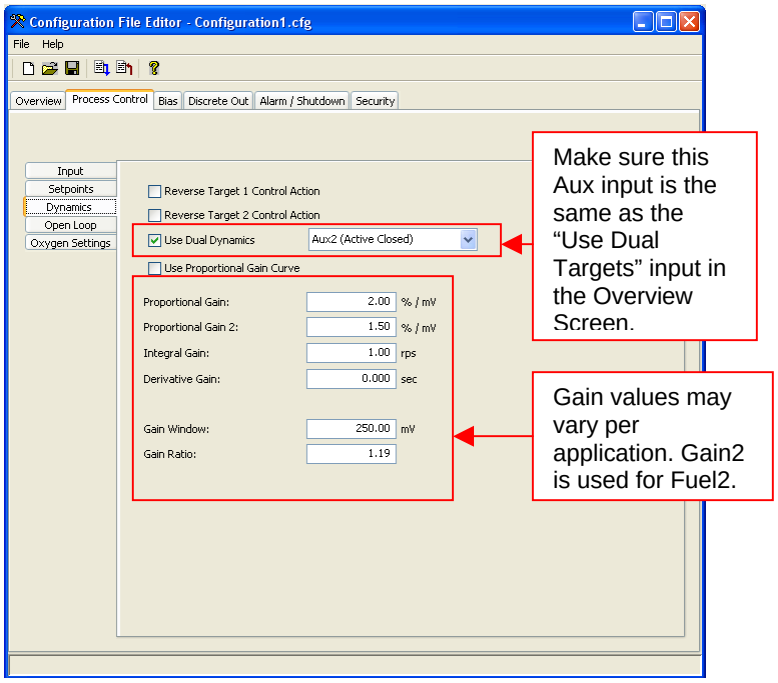

Figure 10. Process Control Dynamics Tab Set For Bi-Fuel Applications

Tune the dynamic settings for both fuels using the L-Series Service Tool. In some instances, the particular bi-fuel application might require additional tuning rather than a single set of gains. The Use Proportional Gain Curve selects between a single gain value versus a five-point gain curve.

Figure 11 shows how the configuration file can be configured to use a 5-point curve for each of the two fuels.

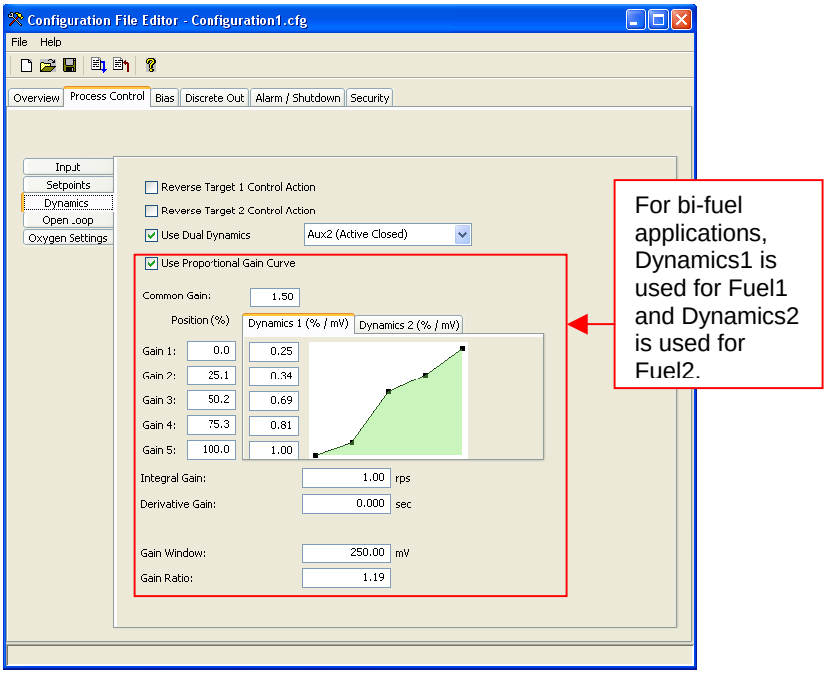

Figure 11. Process Control Dynamics using Proportional Gain Curves

Process Control - Open Loop Tab:

For bi-fuel applications, select a discrete input to manually force the unit into open-loop mode, if desired. In the example below, the Aux4 input was selected to make the controller go into open-loop mode.

In this tab, select the default open-loop position under Position Settings for each fuel. The L-Series Air-Fuel Ratio controller will go to the selected Target position when the HEGO sensor is warming up and when a fault has been logged that forces the system to go into open-loop mode.

Figure 12 shows an example configuration of a bi-fuel application. In this screenshot, the Target 1Position is equivalent to the desired open-loop position when the Fuel 1 is selected, and Target 2 Position is equivalent to the desired open-loop position for Fuel 2. It is shown in percentage open and it also shows a target rate or how fast the unit will change position from closed-loop to open-loop.

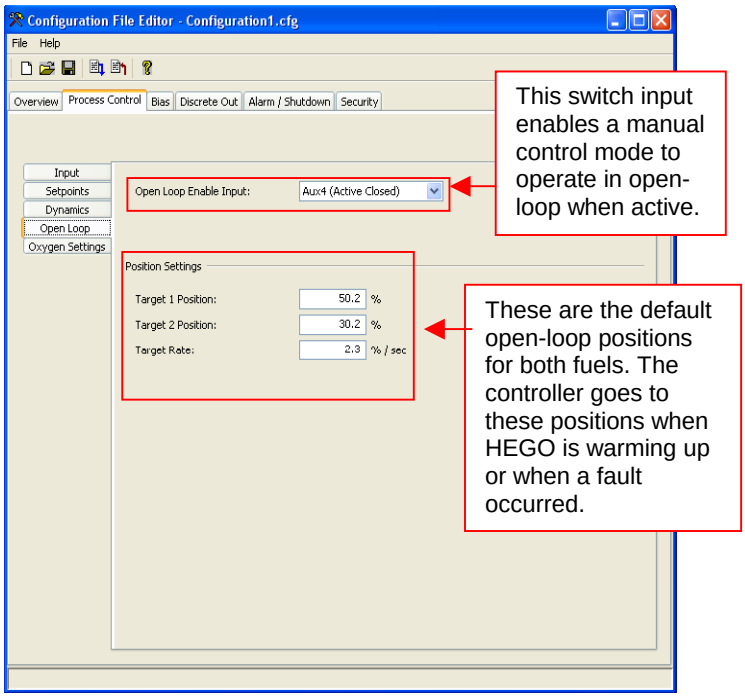

Figure 12. Process Control – Open Loop Tab Sample Configuration

Process Control – Oxygen Settings Tab:

The process control oxygen settings tab provides the closed-loop threshold and setpoint perturbation settings. The closed-loop threshold is the voltage below which the HEGO sensor is considered warm and ready for control, so the unit switches to closed-loop. The closed-loop delay is a timer that indicates the delay before which the HEGO sensor is considered warm and ready to control. Then, the setpoint delta min and max values are the amounts added to the process setpoints in order to provide catalysts perturbation. The perturbation helps extend the life and improve efficiency of the catalyst. Last, the setpoint hysteresis is the process input amount that must be sensed in order to change direction of process setpoint. In other words, this parameter controls the frequency of the perturbation.

For bi-fuel applications an independent post-catalyst analyzer should be used to measure the effectiveness of the perturbation function.

Figure 13 below shows a sample screenshot of the Process Control Oxygen Settings tab.

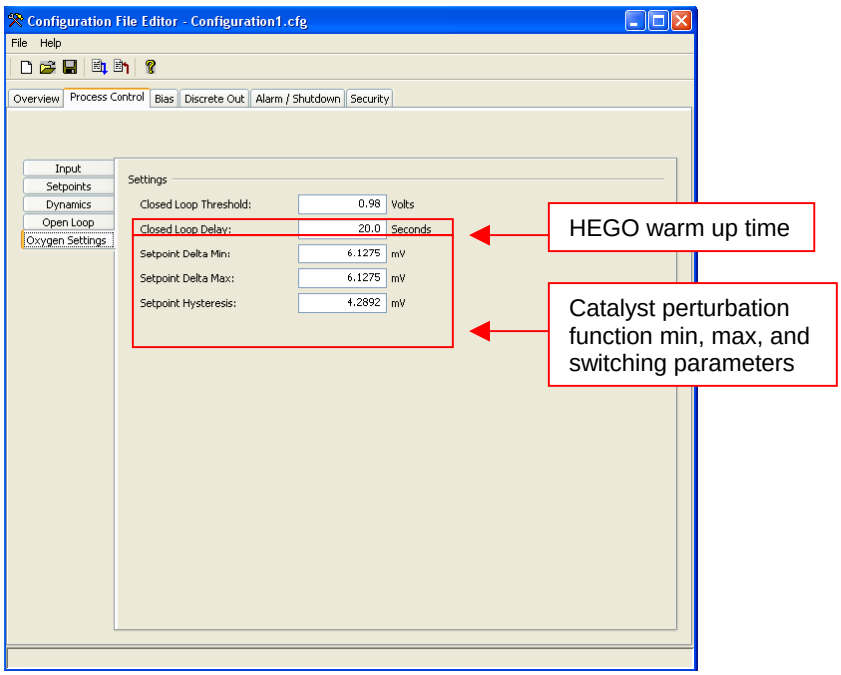

Figure 13. Process Control Tab – Oxygen Settings Sample Screen

The schematic in **Figure 14** helps further explain perturbation parameters.

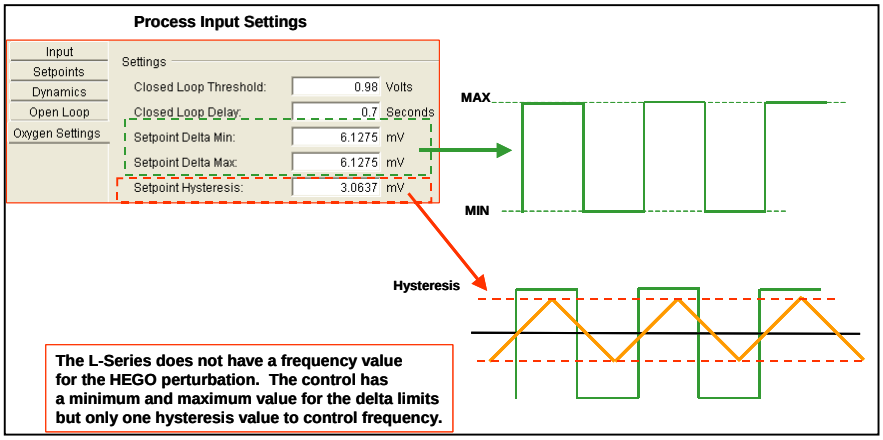

Figure 14. Process Input Setting Explanation of Perturbation Feature

Bias Tab:

The Bias Tab allows configuration of the bias settings for the process input. For gaseous-fueled industrial engine applications, the most common bias input is a manifold absolute pressure (MAP) sensor signal. **Figure 15** shows the default setting for the Bias tab in the configuration file. Select Enable Bias input in order to activate this feature. For bi-fuel applications, the bias feature will help optimize exhaust emissions based on the indication of load (i.e. MAP sensor).

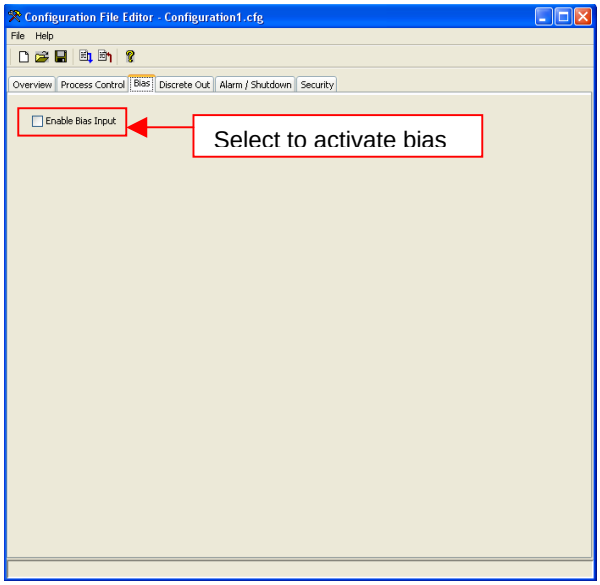

Figure 15. Default Bias Tab in Configuration File

Figure 16 shows a configured Bias Tab.

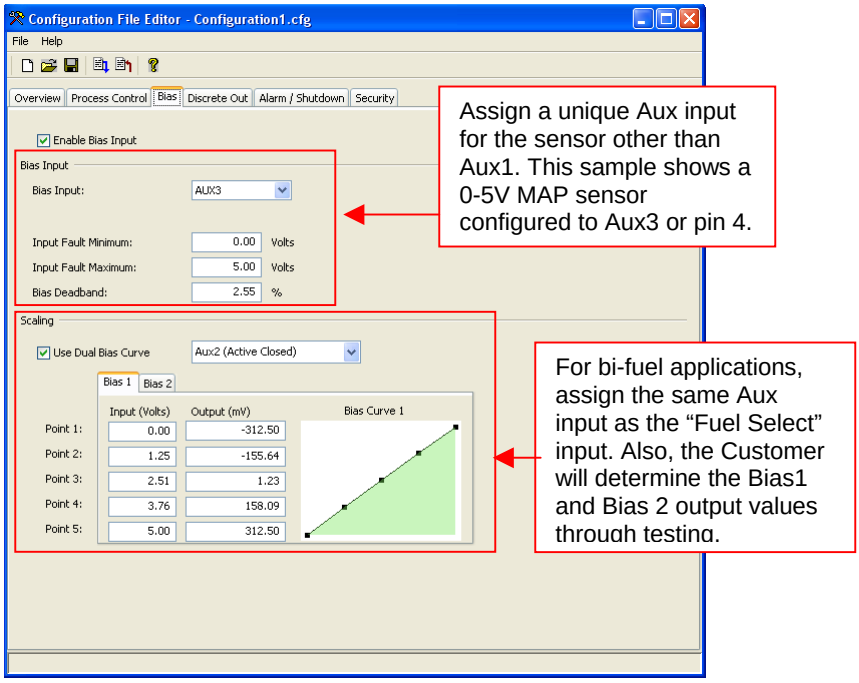

Figure 16. Bias Control Tab Configured for Bi-Fuel Applications

Discrete Output Tab:

Refer to the L-Series Process Controller Manual 26251 in order to properly set up the Discrete Output Tab parameters.

The list of faults displayed can be individually selected to activate the relay output. Figure **17** shows the default Discrete Output screenshot.

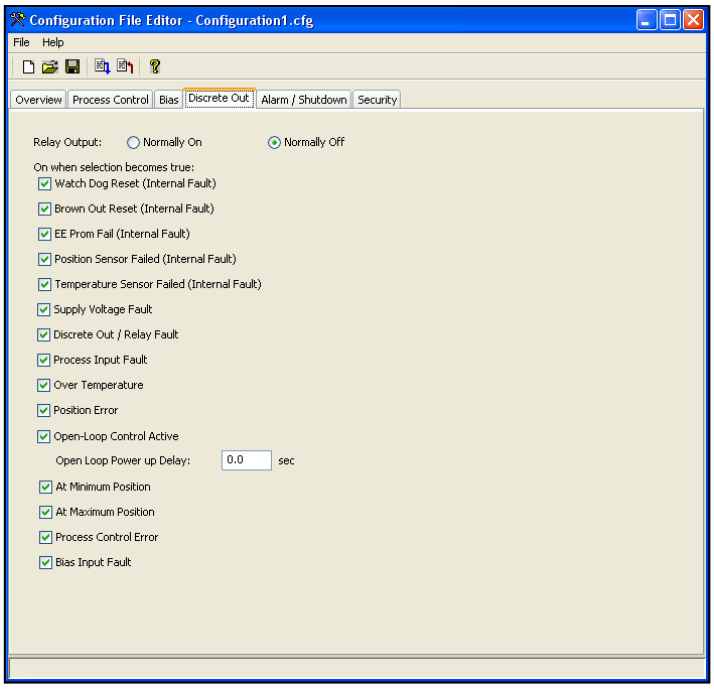

Figure 17. Discrete Output Sample Screen

Alarm/Shutdown Tab:

Figure 18 shows the Alarm and Shutdown tab.

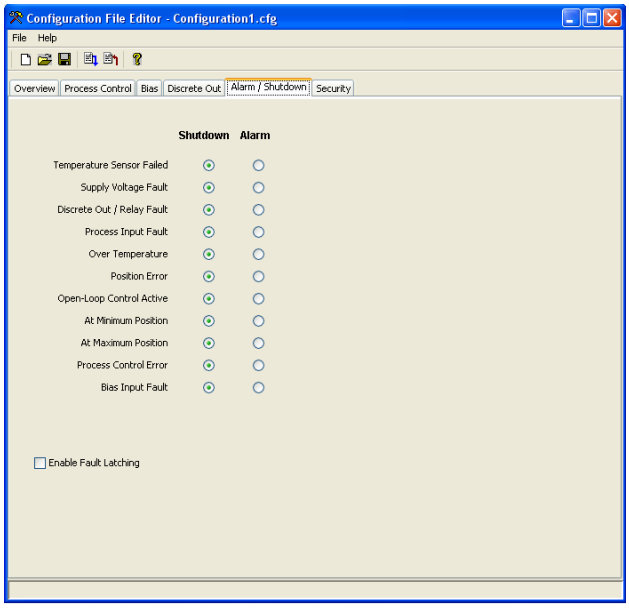

Figure 18. Alarm/Shutdown Sample Screen

Security Tab:

Refer to the L-Series Process Controller Manual 26251 in order to properly set up the security tab parameters, if desired.

Figure 19 shows the default Security screen.

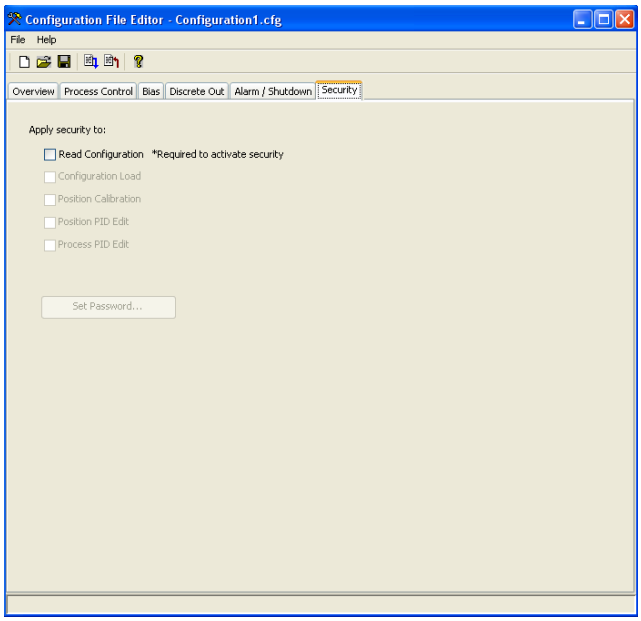

Figure 19. Configuration File Default Security Tab Settings

Downloading Configuration File

The Configuration File is now completed. Download the file into an L-Series Process Controller. Use the examples below to properly tune the control under all operating conditions. Once complete, save a copy of the control configuration fiel to your computer.

L-Series Service Tool

The following two screenshots are included in this Application Note in order to help customers begin the calibration process.

Figure 20 shows the default L-Series Service Tool screen. This screen will be the main dashboard for the calibration of the L-Series Air-Fuel Ratio controller. It shows:

Process Setpoints vs. Process Input in graphical and numerical format

Position Setpoint vs. Actual Position in graphical and numerical format

Control Mode (Open-Loop versus Closed-loop)

Alarms and Shutdowns

Connection Status (Connected or not Connected).

From this screen in the service tool, the Tools menu can be accessed. The Tools menu contains the Process Dynamics Editor, which is also a very useful tool during the tuning/calibration of bi-fuel engine applications. This tool allows on-line, real time calibration information in a chart form as well as perturbation limits configuration. **Figure 21** shows a sample of the Process Dynamics Editor screen.

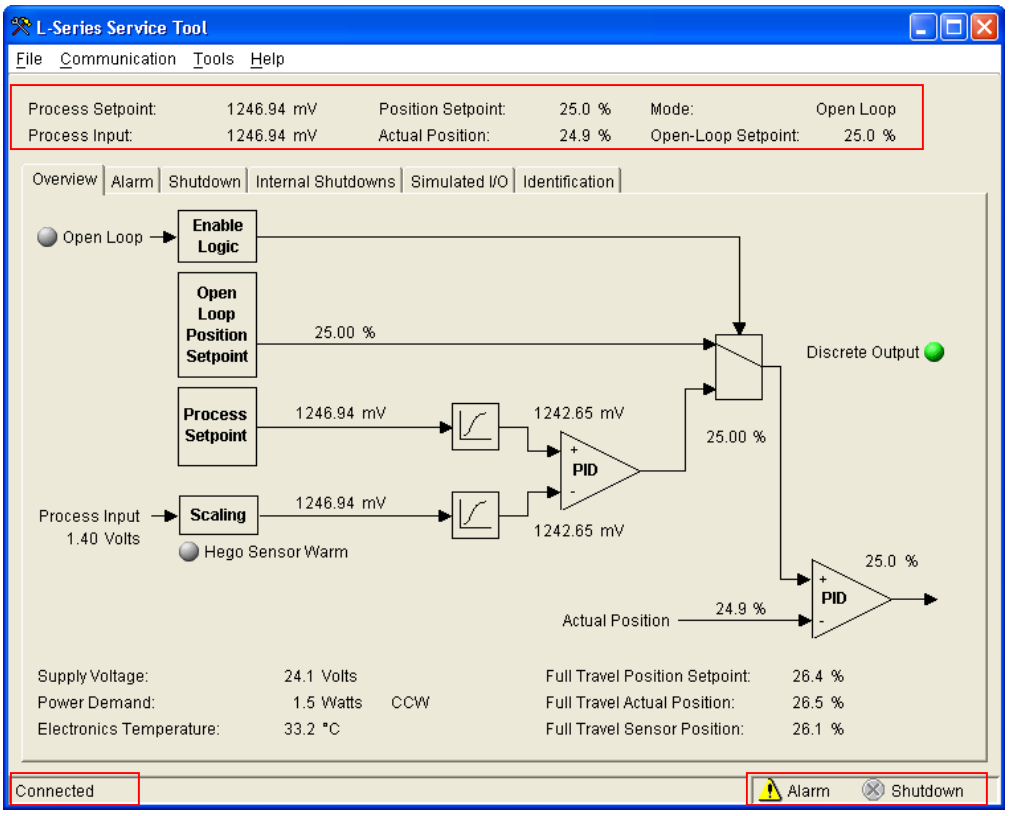

Figure 20. L-Series Service Tool Overview Screen

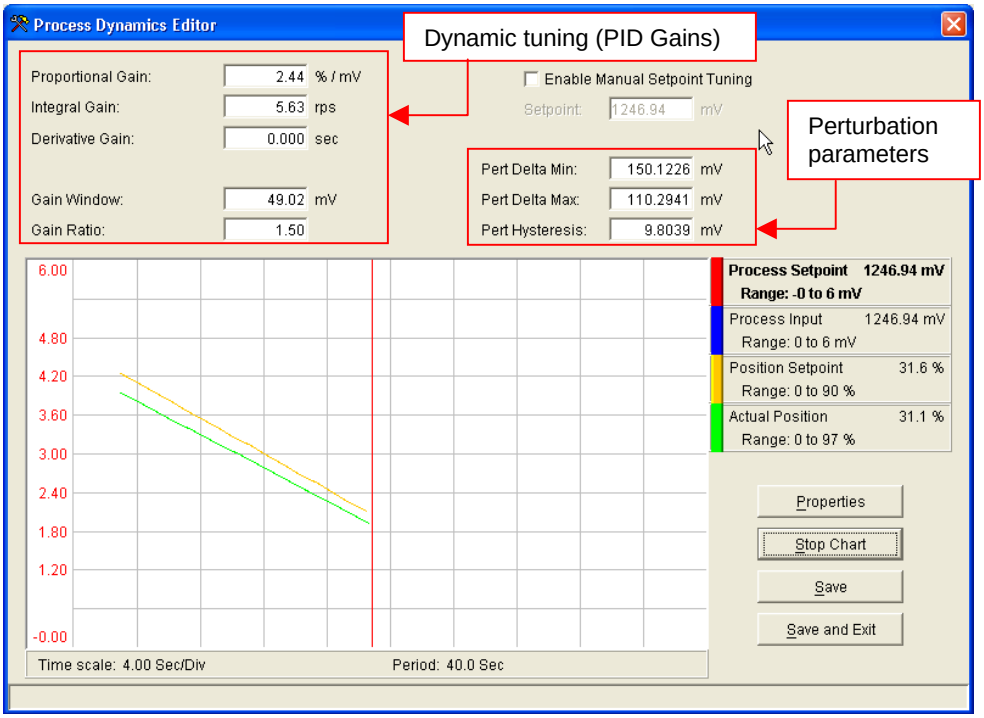

Figure 21. L-Series Service Tool - Process Dynamics Editor

Chapter 2.
Service Options

Product Service Options

The following factory options are available for servicing Woodward equipment, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is purchased from Woodward or the service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In most cases, your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

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 is also a flat rate structured program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call 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 Woodward facility as explained below (see “Returning Equipment for Repair” later in this chapter).

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned to Woodward within 60 days, Woodward will issue a credit for the core charge. [The core charge is the average difference between the flat rate replacement/exchange charge and the current list price of a new unit.]

Return Shipment Authorization Label. To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could be delayed and cause additional charges to be applied.

Flat Rate Repair

Flat Rate Repair is available for the majority of standard 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. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

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 and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). 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 to Woodward for repair, please contact Woodward in advance to obtain a Return Authorization Number. When shipping the item(s), attach a tag with the following information:

- 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.

CAUTION

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*.

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.

Return Authorization Number

When returning equipment to Woodward, please telephone and ask for the Customer Service Department [1 (800) 523-2831 in North America or +1 (970) 482-5811]. They will help expedite the processing of your order through our distributors or local service facility. To expedite the repair process, contact Woodward in advance to obtain a Return Authorization Number, and arrange for issue of a purchase order for the item(s) to be repaired. No work can be started until a purchase order is received.

NOTE

We highly recommend that you make arrangement in advance for return shipments. Contact a Woodward customer service representative at 1 (800) 523-2831 in North America or +1 (970) 482-5811 for instructions and for a Return Authorization Number.

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.

How to Contact Woodward

In North America use the following address when shipping or corresponding:

Woodward Governor Company
PO Box 1519
1000 East Drake Rd
Fort Collins CO 80522-1519, USA

Telephone—+1 (970) 482-5811 (24 hours a day)
Toll-free Phone (in North America)—1 (800) 523-2831
Fax—+1 (970) 498-3058

For assistance outside North America, call one of the following international Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Facility	Phone Number
Brazil	+55 (19) 3708 4800
India	+91 (129) 4097100
Japan	+81 (476) 93-4661
The Netherlands	+31 (23) 5661111

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's website (**www.woodward.com**) for the name of your nearest Woodward distributor or service facility.

Engineering Services

Woodward Industrial Controls Engineering Services offers the following after-sales support for Woodward products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Contact information:

Telephone—+1 (970) 482-5811
Toll-free Phone (in North America)—1 (800) 523-2831
Email—icinfo@woodward.com
Website—**www.woodward.com**

Technical Support is available through our many worldwide locations or our authorized distributors, depending upon the product. This service can assist you with technical questions or problem solving during normal business hours. Emergency assistance is also available during non-business hours by phoning our toll-free number and stating the urgency of your problem. For technical support, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Product Training is available at many of our worldwide locations (standard classes). We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability. For information concerning training, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Product Training***.

Field Service engineering on-site support is available, depending on the product and location, from one of our many worldwide locations or from one of our authorized 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 field service engineering assistance, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

General

Your Name _____
Site Location _____
Phone Number _____
Fax Number _____

Prime Mover Information

Engine/Turbine Model Number _____
Manufacturer _____
Number of Cylinders (if applicable) _____
Type of Fuel (gas, gaseous, steam, etc) _____
Rating _____
Application _____

Control/Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter _____
Control Description or Governor Type _____
Serial Number _____

Woodward Part Number and Revision Letter _____
Control Description or Governor Type _____
Serial Number _____

Woodward Part Number and Revision Letter _____
Control Description or Governor Type _____
Serial Number _____

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.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please include the manual number from the front cover of this publication.

WOODWARD

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Email and Website—www.woodward.com

Woodward has company-owned plants, subsidiaries, and branches, 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.

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