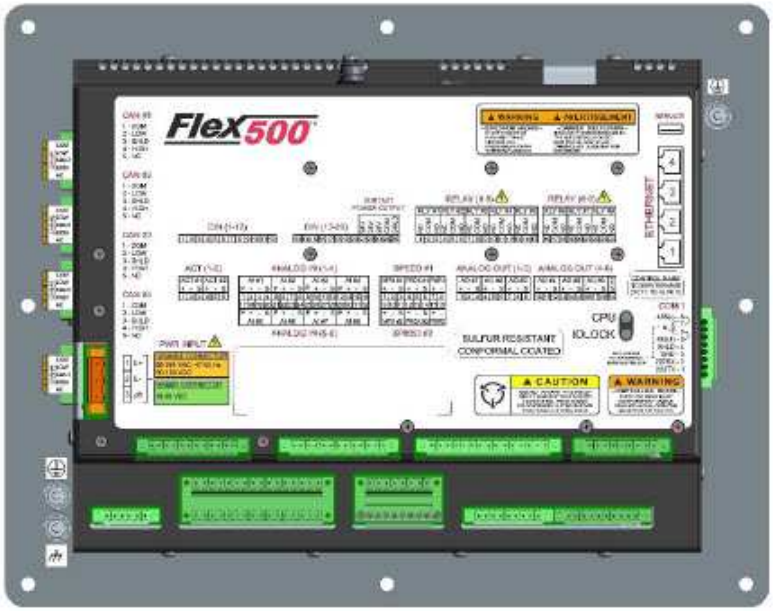
WOODWARD

Product Manual 35049
(Revision A, 5/2018)
Original Instructions



Liquid DLE FMS

Installation and Operation Manual

General Precautions

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.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

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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.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Revisions— A bold, black line alongside the text identifies changes in this publication since the last revision.

Manual 35049

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Important Definitions

This is the safety alert symbol 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.

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.

IMPORTANT

External wiring connections for reverse-acting controls are identical to those for direct-acting controls.

Safety Symbols


Direct Current


Alternating Current


Both Alternating and Direct Current


Caution, risk of electrical shock


Caution, refer to accompanying documents


Protective conductor terminal


Frame or chassis terminal

Chapter 1.
General Information

Introduction

The Woodward liquid DLE fuel metering system (FMS) described in this specification is designed for use with General Electric (GE) LM2500 and LM6000 engines. This system collects the liquid fuel flow demands from the Core Engine Control System over redundant CANopen communication links and controls the fuel metering valves and bypass pressure control valve with GE qualified metering algorithms from Woodward.

The FMS system controller is based on the Flex500 controls platform from Woodward. The Flex500 is a programmable control platform that utilizes a 32-bit microprocessor running a powerful Real Time Operating System (RTOS). This operating system is specifically designed to control the proper timing of all application code so that dynamic performance of the final control system is absolutely guaranteed. Each piece of the application code is “scheduled” under a rate group structure that ensures execution of the code at a predetermined time.

The FMS is also available with the Intelligent Gateway controls platform. Contact Woodward for additional details or support using the Intelligent Gateway.

Fuel Metering System (FMS) Elements

Table 1-1. Required Woodward System Components

Component	Ref. Item Number	Qty.	Extended Description
Liquid DLE FMS	8301-1633	1	Flex500: Liquid DLE FMS
DVP	8200-188 or similar	4	DVP, 125Vdc, IP30, Connectorized
LQ25T	9908-236 or similar	3	LQ25T, Dual Resolver, Connectorized
LQ25BP	9908-222 or similar	1	LQ25BP, Dual Resolver, Connectorized
Cable – Motor Pwr	5450-1819.xx	4	Motor Power Cable
Cable – Res 1	5450-1095.xx	4	Resolver 1 Feedback Cable
Cable – Res 2/ID	5450-1809.xx	4	Resolver 2 Feedback & ID Module Cable

Cable lengths are manufactured in 5-foot increments. Typical lengths are 70-feet and 130-feet. The .xx in the item numbers above are placeholders for the length identification.

Chapter 2.
Fuel System Components

Introduction

This section highlights the system elements outside the Woodward scope of supply that must be procured and managed by the turbine packager or end user. This section only briefly describes these system elements to give better context and is not intended as a detailed specification of components. Use only for reference. Follow GE IDM requirements and all applicable specifications.

Liquid Fuel System P&ID

The following liquid fuel system P&ID is for reference purposes only.

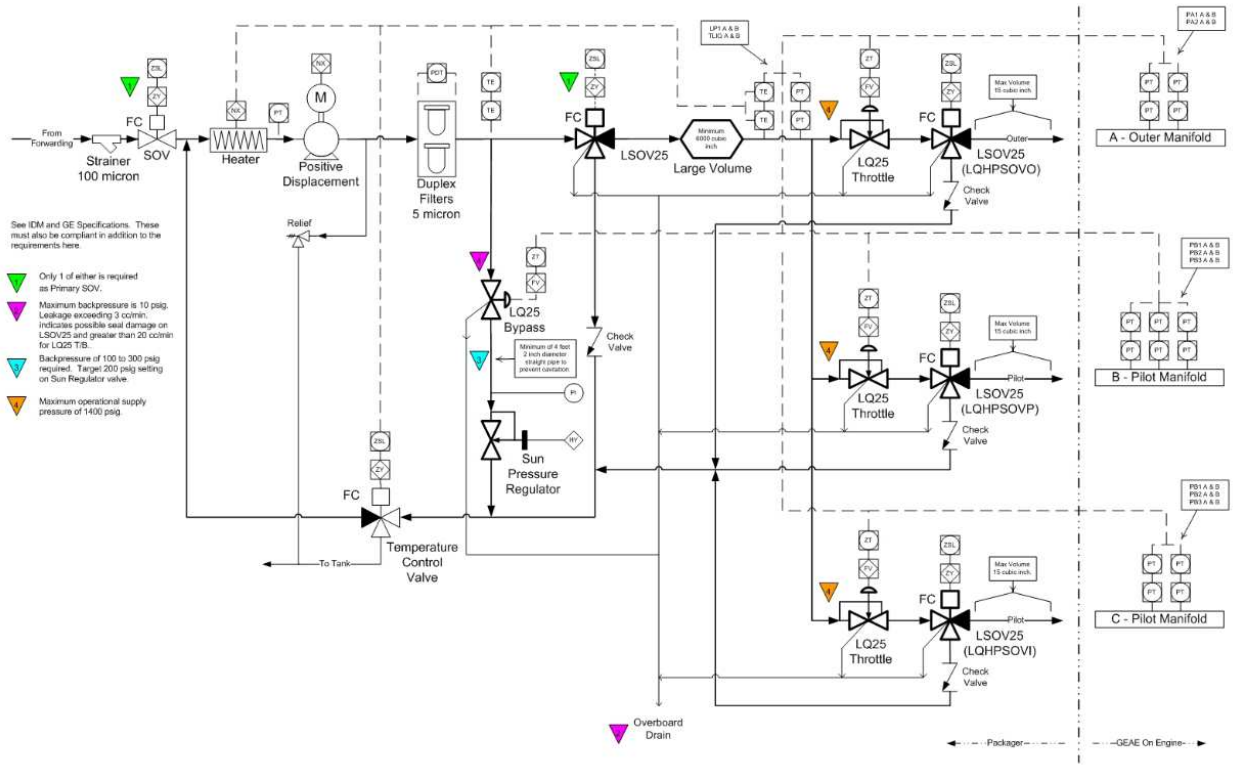

Figure 2-1. Liquid Fuel System P&ID

Positive Displacement Pump

The liquid DLE fuel system requires a positive displacement fuel pump that is capable of supplying fuel to the metering system in accordance with the engine requirements. For LM6000 applications, the fuel pump size is approximately 36,000pph of fuel flow at 1400psi with fuel specific gravity of 0.84. The LFMS is configurable to support pump flow output from 20,000 to 45,000 pph.

Heater

Fuel heating is required to insure minimum fuel temperature of 100°F for starting and up to core idle. Follow GE IDM requirements for fuel heating.

Fuel Filtration

Duplex filters downstream of the positive displacement fuel pump should be β=200 (ε = 99.5%) minimum at 5μ or less.

Liquid Fuel Shutoff

Use a dual redundant shutoff configuration for the liquid DLE fuel system. Woodward 3-way LSOV25 shutoff valves used for fuel shutoff downstream of the LQ25T metering valves. Packager can choose either 2-way or 3-way shutoff valve for redundancy as required.

Fuel Temperature (TLQ)

Obtain liquid fuel temperature from a dual element RTD installed in the header upstream of the LQ25T metering valves. Sensor and processing accuracy to be < ±2.0°F

Fuel Pressure (LP1)

The Liquid DLE Fuel Metering System interfaces to redundant liquid fuel pressure sensors located in the manifold upstream of the LQ25T metering valves. These are analog pressure sensors that interface to the FMS via 4-20mA. Typically, the packager will use the same pressure sensors for LP1A and LP1B as the engine manifold pressure sensors. Sensor and processing accuracy to be < 0.1% of full scale including non-linearity, hysteresis, repeatability, combined (span, zero), and over temperature range. Sensors must be fast response < 100msec). The LFMS Controller is designed for LP1 sensors in units of PSIA with hi scaling of 1000 to 2500psia.

Large Volume

A 3000 cubic inch (49L) volume between the LQ25 Bypass Valve and the engines fuel metering valves is required to ensure accurate system pressure control and subsequent fuel control. It is recommended that this volume is in the form of a large flow through section of oversized piping, for example, a 5 foot section of 8inch piping with connections on either end for flow through. This upstream volume attenuates pump noise before it reaches the engine, but does not affect metered flow bandwidth on the throttling regulator metering valves.

Liquid Fuel Valve Driver (DVP)

The Digital Valve Positioner (DVP) is a digital electronic position driver used to control actuation systems on reciprocating engines and turbines. The DVP controls valves and actuators with either limited angle torque (LAT) or brushless DC (BLDC) motor types. The driver provides position output based on resolver feedback located on the valve or actuator. The DVP uses the latest in Woodward control architecture and a robust controller to provide high-speed precise valve control.

The DVP uses plug-and-play installations on many valve types. Woodward has integrated smart technology into the new generation of valves and actuators called an ID (identification) module. Upon connection to a valve or actuator equipped with an ID module, the DVP will automatically read critical valve-specific information to set up the driver. After this auto-detection and customer interface configuration, the DVP is ready for use.

Refer to DVP Manual 26329 for installation and operation specifics

Liquid Fuel Valves

The Liquid DLE Fuel Metering System incorporates two different Woodward liquid fuel valves, the LQ25T (throttling) and LQ25BP (bypass). The Liquid DLE FMS supports only the latest LQ25T/BP valves using ID-modules. The ID-module is a memory device built into the valve.

Refer to manual 26476 for installation and operation of the LQ25T/BP valves.

LQ25BP Back Pressure Regulator

A pressure regulator is used downstream of the LQ25BP to prevent cavitation. Reference Woodward item number 1306-629.

Chapter 3.
Flex500 Controller

Flex500

The FMS system utilizes the Flex500 hardware control platform from Woodward.

At the heart of the Intelligent Gateway Control is a 32-bit microprocessor that runs a powerful Real Time Operating System (RTOS). This operating system controls the proper timing of all application code ensuring dynamic performance of the final control system. Each piece of the application code is "scheduled" under a Rate Group structure that ensures execution of the code at a predetermined time.

Documentation

- Flex500 Manual 26838
- Vx Works RTOS Manual 26336
- Flex500 Outline and Wiring Diagram 9989-3260

General Precautions

Read the entire Flex500 manual and all other pertinent publications prior to 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.

Flex500 Hardware

The Liquid DLE FMS utilizes a specific configuration of Flex500 hardware:

Flex500 Bulkhead (Marine/ATEX Compliance, 18-36Vdc) 8200-1352

FMS Configuration Mode Selection

The Liquid DLE FMS is configurable for two different valve networking architectures:

- Mode Select 1 (Default) – Redundant CANopen to all 4 metering valve drivers
- Mode Select 2 – Split CANopen with analog backup (CAN3 to LMVs, CAN4 to Bypass VLV)

Table 3-1. Mode Selection Table

	Mode 1 Selection		Mode 2 Selection	
Valve	**Primary Control**	**Backup Control**	**Primary Control**	**Backup Control**
LMV Outer	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
LMV Pilot	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
LMV Inner	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
Bypass VLV	CAN Network 3	CAN Network 4	CAN Network 4	Analog I/O & Discrete I/O

The FMS must be put into local Configuration mode in order to change the FMS Valve Network Configuration Mode. Local Configuration mode will put the unit into IOLOCK. See Service Tool section for details about this configuration option.

This mode selection is available in Flex500 FMS firmware 5418-7569 revision B and newer.

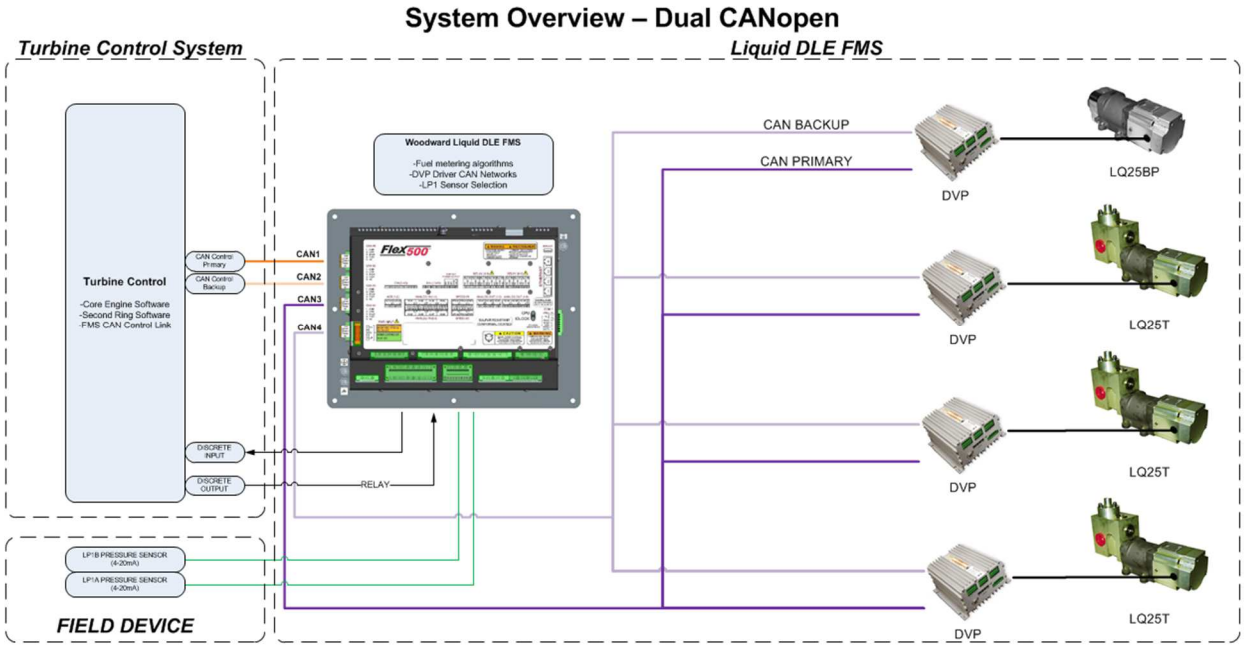

Figure 3-1. LFMS System Overview Dual CANopen (Mode Config=1)

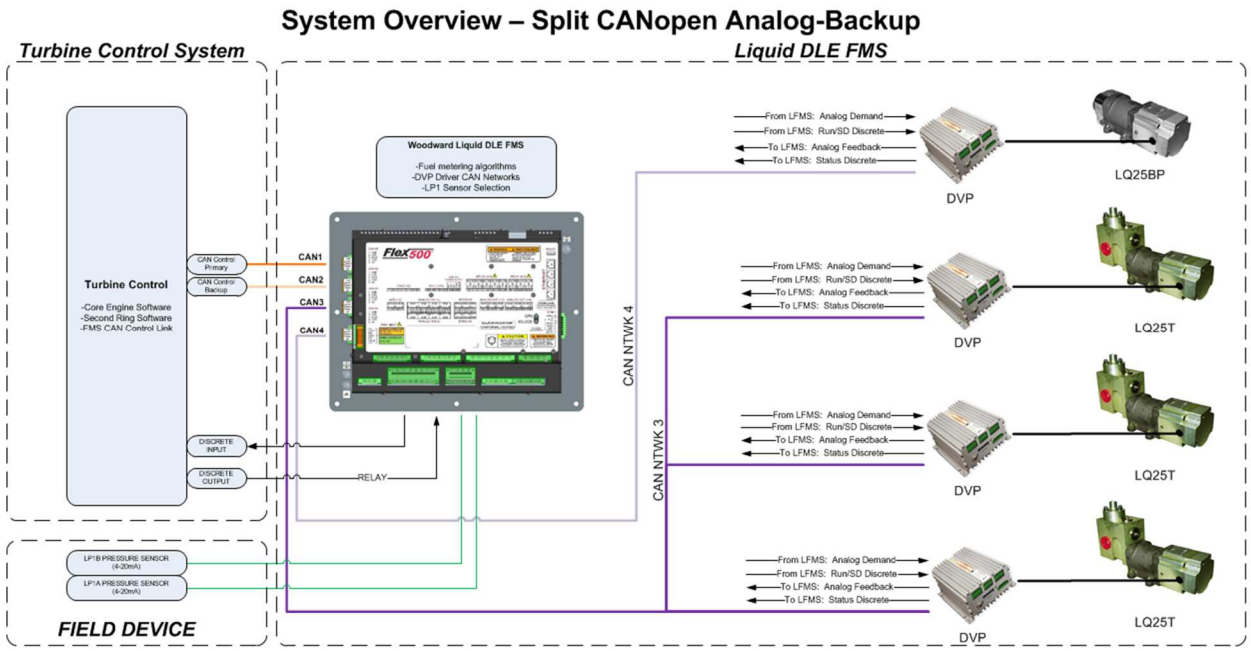

Figure 3-2. LFMS System Overview Split CANopen (Mode Config=2)

Hardwired Analog Inputs

Two analog inputs (4-20mA) are reserved for the liquid system pressure (LP1) necessary to run the bypass pressure control loop. The signals are connected as described in the table below. Additionally, metering valve analog feedback inputs are provided for FMS Configuration Mode 2.

Table 3-2. Analog Input Signal Connections

Sensor	Flex500 Control	Default Scaling	Channel Config	FMS Config Mode
LP1A	Analog Input #1	*0-2300 psia	Loop Power Mode	Always Active
LP1B	Analog Input #2	*0-2300 psia	Loop Power Mode	Always Active
LMVO_FDBK	Analog Input #3	0-100 %	Self Power Mode	Active in Mode 2 Only
LMVP_FDBK	Analog Input #4	0-100 %	Self Power Mode	Active in Mode 2 Only
LMVI_FDBK	Analog Input #5	0-100 %	Self Power Mode	Active in Mode 2 Only
BYPV_FDBK	Analog Input #6	0-100 %	Self Power Mode	Active in Mode 2 Only

*LP1A & LP1B scaling can be configured using the Service Tool. The Flex500 controller must be put into local Configuration mode in order to update scaling values. Local Configuration mode will put the unit into IOLOCK.

*The Flex500 analog inputs may be configured for loop or self-powered mode.

Hardwired Analog Outputs

Four analog outputs (4-20mA) are reserved for the metering and bypass control valves backup demand signals for FMS Configuration Mode 2.

Table 3-3. Analog Output Signal Connections

Sensor	Flex500 Control	Scaling	Channel Config	FMS Config Mode
LMVO_DMD	Analog Output #1	0-100 %	4-20mA	Active in Mode 2 Only
LMVP_DMD	Analog Output #2	0-100 %	4-20mA	Active in Mode 2 Only
LMVI_DMD	Analog Output #3	0-100 %	4-20mA	Active in Mode 2 Only
BYPV_DMD	Analog Output #4	0-100 %	4-20mA	Active in Mode 2 Only

Hardwired Discrete Signals

Discrete Input #1 is reserved for Run/SD command from the Core Engine Controller and Relay Output #1 provides FMS status feedback. Discrete Inputs #2-5 are reserved for valve status when Configuration Mode 2 is enabled. Relay Outputs #2-5 are reserved for valve command when Configuration Mode 2 is enabled.

Table 3-4. Hardwired Discrete Input/Output Signals

Flex500 Discrete Inputs

Signal	Flex500 Control	Boolean State	FMS Config Mode
FMS Run/SD Command	Discrete Input #1	T: Running F: Trip Command	Always Active
LMVO Status	Discrete Input #2	T: No Valve Fault F: Valve Trip	Active in Mode 2 Only
LMVP Status	Discrete Input #3	T: No Valve Fault F: Valve Trip	Active in Mode 2 Only
LMVI Status	Discrete Input #4	T: No Valve Fault F: Valve Trip	Active in Mode 2 Only
BYPV Status	Discrete Input #5	T: No Valve Fault F: Valve Trip	Active in Mode 2 Only

Flex500 Relay Outputs

Signal	Flex500 Control	Boolean State	FMS Config Mode
FMS Shutdown Status Fault	Relay Output #1	T: No Shutdowns F: FMS Shutdown	Always Active
LMVO Run/SD Command	Relay Output #2	T: Valve Run Cmd F: Valve Trip Cmd	Active in Mode 2 Only
LMVP Run/SD Command	Relay Output #3	T: Valve Run Cmd F: Valve Trip Cmd	Active in Mode 2 Only
LMVI Run/SD Command	Relay Output #4	T: Valve Run Cmd F: Valve Trip Cmd	Active in Mode 2 Only
BYPV Run/SD Command	Relay Output #5	T: Valve Run Cmd F: Valve Trip Cmd	Active in Mode 2 Only

Relays are recommended between the two systems to isolate the discrete signals.

Turbine Control CANopen Interface

The control interface for the Liquid DLE controller is redundant CANopen

Table 3-5. Turbine Control Interface and Control

Control Interface	Flex500 Control
Primary Control	CAN Network #1
Backup Control	CAN Network #2

The control interface between the Core Engine Control system and fuel metering controller is considered a closed network and additional devices are not to be used on these networks.

Table 3-6. CANopen Control Network Distance/Speed Limitations:

Network Speed	Max Trunk Length (Thick Cable)	Max Trunk Length (Thin Cable)	Max Drop Length	Max Cumulative Drop Length
1 Mbps	30m	30m	1m	10m
500 kbps	100m	100m	6m	40m
250 kbps	250m	100m	6m	80m

The default CAN Control Interface speed is 500kbps.

Valve Control CANopen Interface

The Liquid DLE FMS is configurable for two different valve networking & redundancy architectures:

Mode Select 1 (Default) – Redundant CANopen to all 4 metering valve drivers
Mode Select 2 – Split CANopen with analog backup (CAN3 to LMVs, CAN4 to Bypass VLV)

Table 3-7. Valve Interface and Control

	Mode 1 Selection		Mode 2 Selection	
Valve	**Primary Control**	**Backup Control**	**Primary Control**	**Backup Control**
LMV Outer	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
LMV Pilot	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
LMV Inner	CAN Network 3	CAN Network 4	CAN Network 3	Analog I/O & Discrete I/O
Bypass VLV	CAN Network 3	CAN Network 4	CAN Network 4	Analog I/O & Discrete I/O

The metering valve logic and valve CANopen interface is controlled at a 5msec data rate. As the liquid DLE system requires four valves on the same CANopen network, the network is limited to a maximum distance of 250m from the DVP's to the Liquid DLE FMS Controller.

Table 3-8. Liquid DLE FMS Controller Cable Specifications

Network Speed	**Max Trunk Length (Thick Cable)**	**Max Trunk Length (Thin Cable)**	**Max Drop Length**	**Max Cumulative Drop Length**
*500 kbps	100m	100m	6m	40m
250 kbps	250m	100m	6m	80m

*Default Valve CANopen network speed is 500kbps.

Flex500 Bulkhead Layout and Dimensions

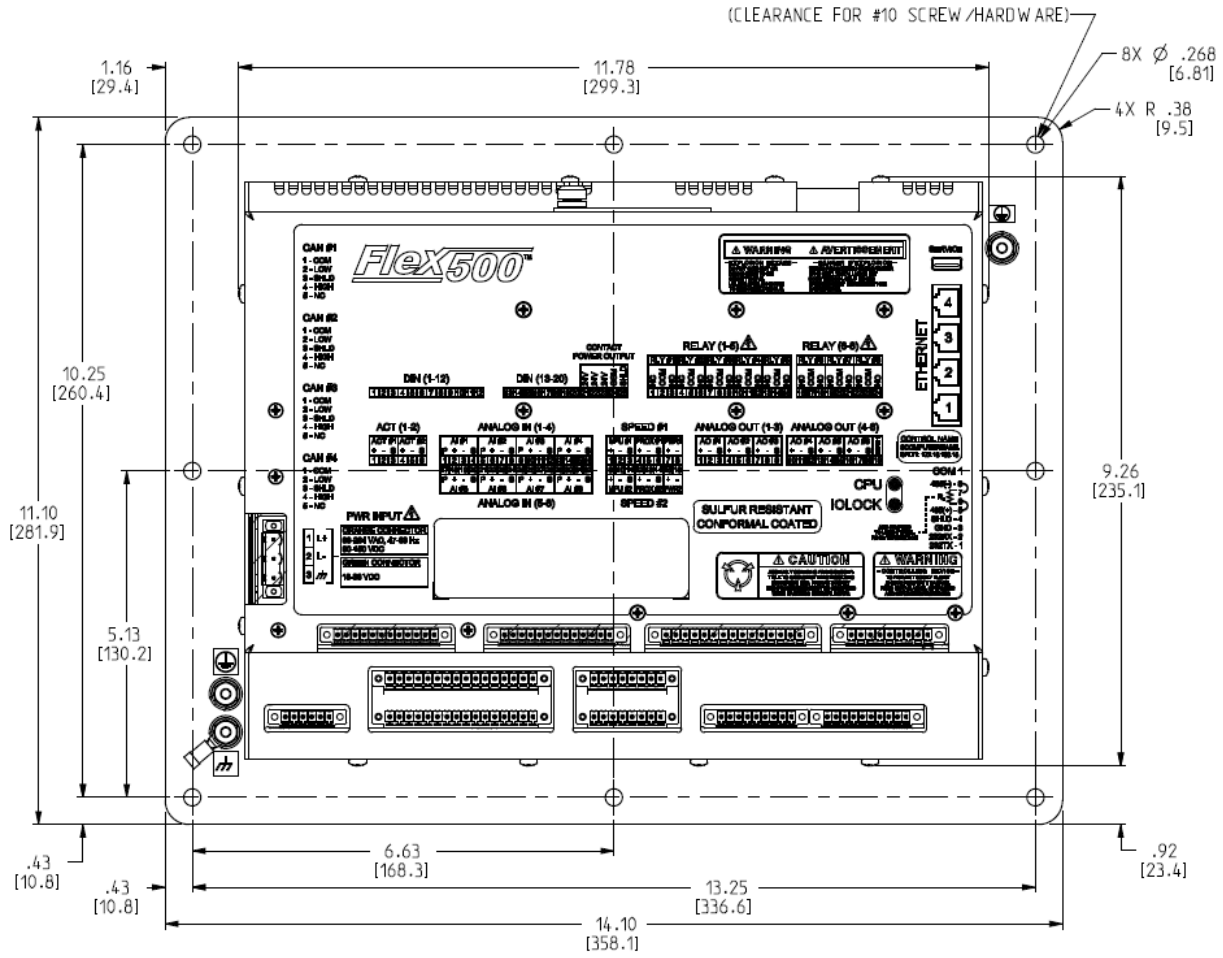

Figure 3-3a. Flex500 Bulkhead Dimensions

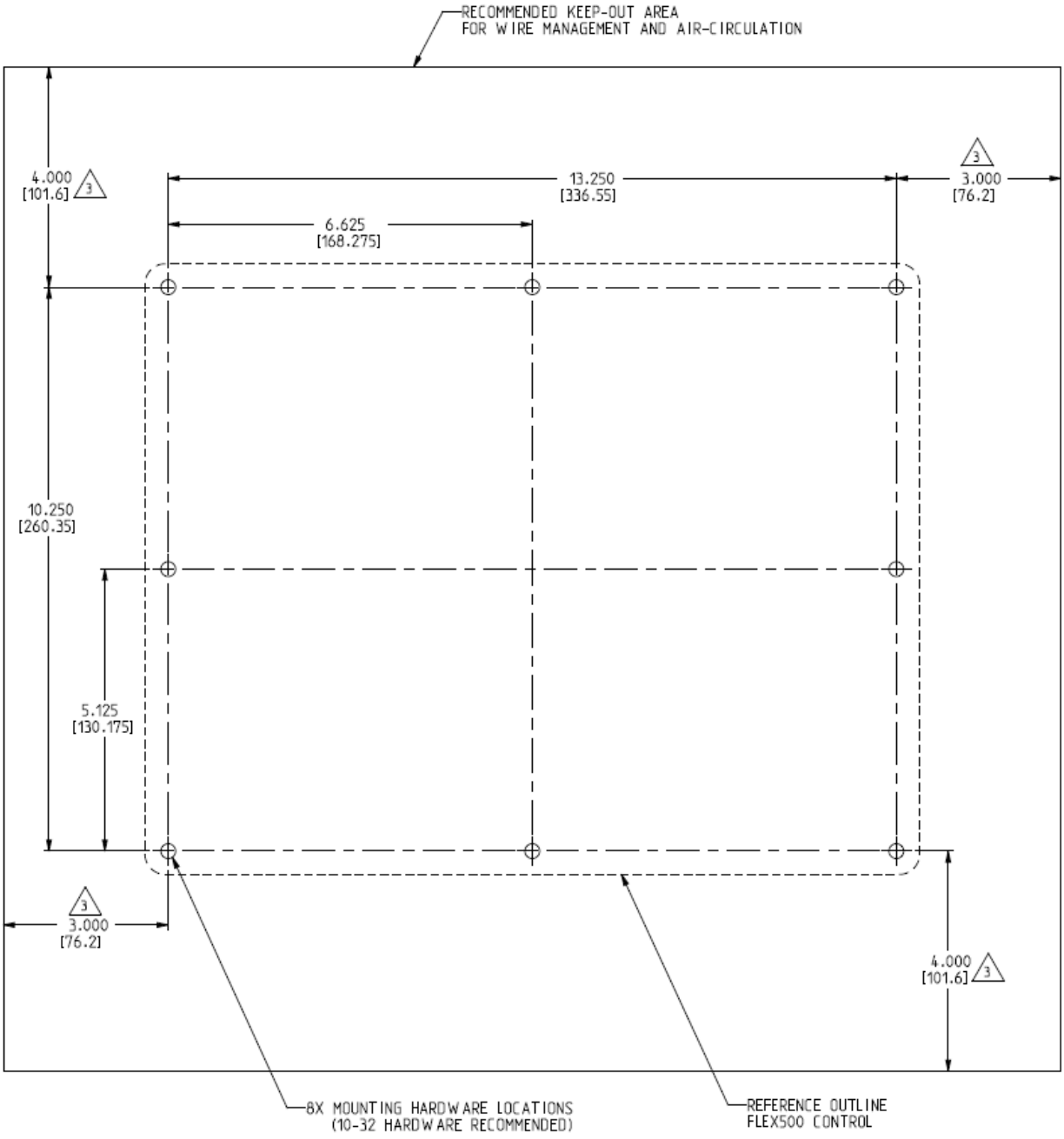

Figure 3-3b. Flex500 Bulkhead Panel Mounting Reference

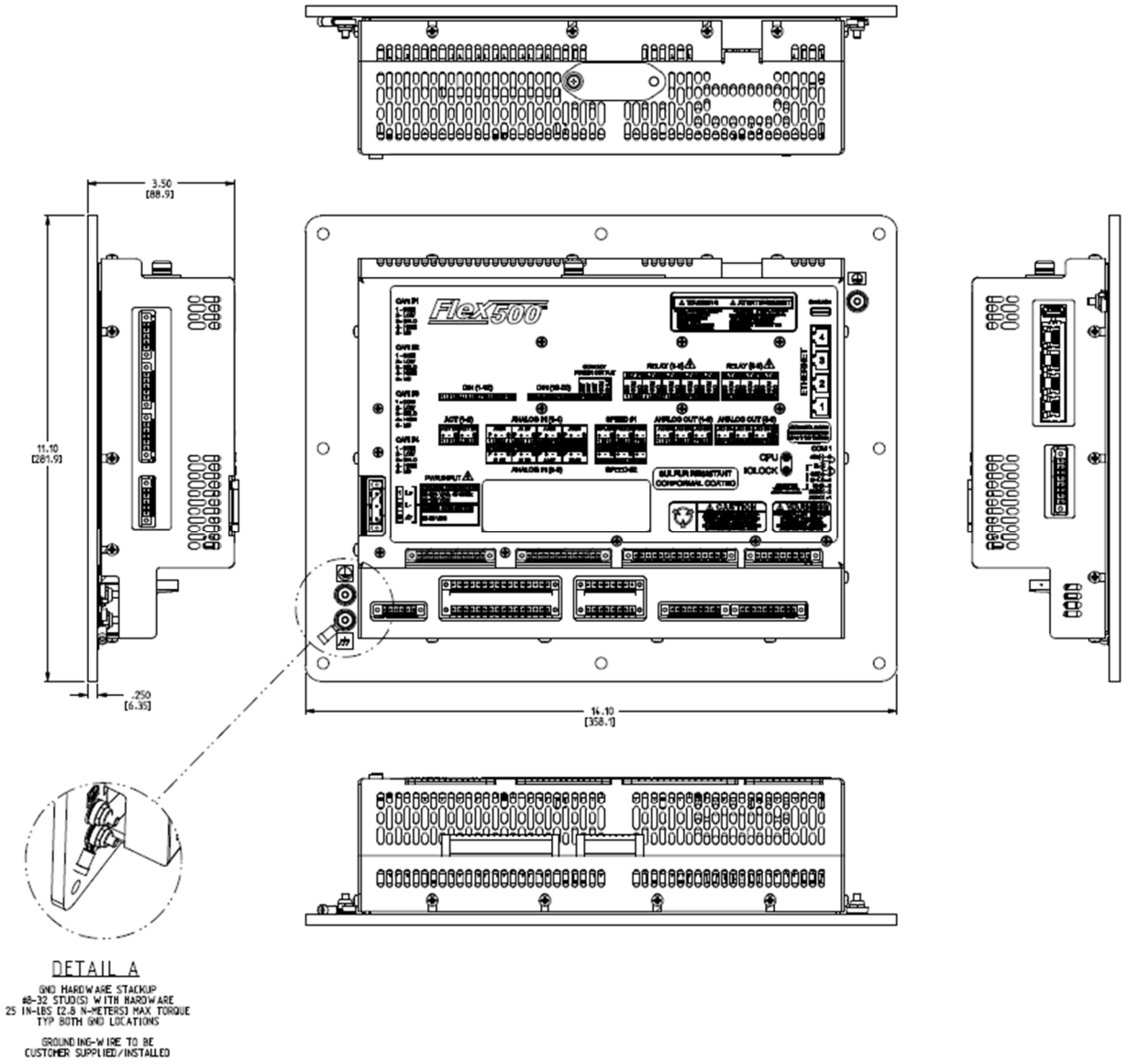

Figure 3-3c. Flex500 Bulkhead Envelope Dimensions and Grounding details

Chapter 4.
Valve/Driver Configuration

Metering Valves

The design of the liquid DLE metering controller operates Woodward qualified valves with DVP (Digital Valve Positioner).

- QTY 1: LQ25BP Liquid Bypass Pressure Control Valve*
- QTY 3: LQ25T Liquid Metering Control Valves*

*Only the id-module versions of these valves are supported with the Liquid DLE FMS

Valve Driver Network Limitations

The metering valve logic and valve CANopen interface is controlled at a 5ms data rate. As the liquid DLE system requires four valves on the same CANopen network, the network is limited to a maximum distance of 250m from DVPs to Liquid DLE FMS Controller.

Table 4-1. Network Speed with Cable Specifications

Network Speed	Max Trunk Length (Thick Cable)	Max Trunk Length (Thin Cable)	Max Drop Length	Max Cumulative Drop Length
500 kbps	100m	100m	6m	40m
250 kbps	250m	100m	6m	80m

Note: The default Valve CANopen Network speed is 500kbps.

Valve Driver Networking

The controller is specifically designed to operate the Woodward DVP valve positioner. The interface to the metering valve drivers is dependent on the network mode selection.

- Mode Select 1 (Default): Redundant CANopen
- Mode Select 2: Split Simplex CANopen with Analog Backup

Table 4-2. Valve Interface and Control

Valve	Mode 1 Selection		Mode 2 Selection	
	Primary Control	Backup Control	Primary Control	Backup Control
LMV Outer	CAN Network 3	CAN Network 4	CAN Network 3	*Analog I/O & Discrete I/O
LMV Pilot	CAN Network 3	CAN Network 4	CAN Network 3	*Analog I/O & Discrete I/O
LMV Inner	CAN Network 3	CAN Network 4	CAN Network 3	*Analog I/O & Discrete I/O
Bypass VLV	CAN Network 3	CAN Network 4	CAN Network 4	*Analog I/O & Discrete I/O

DVP Configuration

The DVP driver configurations for Mode Selection 1 and 2 are detailed in the following tables:

Table 4-3. Mode Selection 1 – DVP Configuration

	LMVO	LMVP	LMVI	Bypass Valve
Setpoint Source Configuration				
Demand Input	CANopen Digital Input			
CAN HW ID Mode	Disabled			
CANopen Redundancy Manager	CANopen Dual			
Baud Rate	250K or 500K Depending on Network			
Timeout	40msec			
Extended PDO	Enabled			
Port 1 Node ID	16	17	18	19
Port 2 Node ID	16	17	18	19
Demand Position Difference Alarm Limit	1.00%			
Demand Position Difference Alarm Delay	50msec			
Demand Position Difference Shutdown Limit	2.00%			
Demand Position Difference Shutdown Delay	50msec			
Setpoint Source Modifications				
Demand Filter Mode Selection	Input Filter Off			
Current Diagnostics				
Current Diagnostic Mode	Off			
Process Fault and Status Flag Configuration				
Position Error Motor Alarm	Alarm (yellow)			
Position Error Motor Shutdown	Shutdown (red)			
Position Error Valve Shaft Alarm	Alarm (yellow)			
Position Error Valve Shaft Shutdown	Shutdown (red)			
Dual Resolver Difference Alarm	Alarm (yellow)			
Dual Resolver Difference Shutdown	Shutdown (red)			
All other process faults should remain as defaulted by the service tool				
Discrete Input Configuration				
Discrete Input Action Mode	Turned Off			
Analog Output Configuration				
Analog Output Mode Selection	Turned Off			
Discrete Output 1 & 2 Configuration				
Discrete Output 1 Configuration Mode	Turned Off			
Discrete Output 2 Configuration Mode	Turned Off			
Linearization Configuration				
Position Linearization Table	Curve Disabled			
User Force Limiter Configuration				
User Force Limiter Enable	Disabled			

Table 4-4. Mode Selection 2 – DVP Configuration

	LMVO	LMVP	LMVI	Bypass Valve
Setpoint Source Configuration				
Demand Input	CANopen Digital Input			
CAN HW ID Mode	CAN HW ID Disabled			
CANopen Redundancy Manager	CANopen Single with Analog Backup			
Baud Rate	250K or 500K Depending on Network			
Timeout	40msec			
Extended PDO	Enabled			
Port 1 Node ID	16	17	18	19
Demand Position Difference Alarm Limit	1.00%			
Demand Position Difference Alarm Delay	50msec			
Demand Position Difference Shutdown Limit	2.00%			
Demand Position Difference Shutdown Delay	50msec			
Analog Input Mode Selection	4 to 20mA			
4-20mA Input Scaling, Max Input Value	20.0mA			
4-20mA Input Scaling, Min Input Value	4.0mA			
4-20mA Input Scaling, Position at Max Input	100.0%			
4-20mA Input Scaling, Position at Min Input	0.0%			
4-20mA Diagnostic Range, High Limit Value	22.0mA			
4-20mA Diagnostic Range, Low Limit Value	2.0mA			
Setpoint Source Modifications				
Demand Filter Mode Selection	Input Filter Off			
Current Diagnostics				
Current Diagnostic Mode	Off			
Process Fault and Status Flag Configuration				
Position Error Motor Alarm	Alarm (yellow)			
Position Error Motor Shutdown	Shutdown (red)			
Position Error Valve Shaft Alarm	Alarm (yellow)			
Position Error Valve Shaft Shutdown	Shutdown (red)			
Dual Resolver Difference Alarm	Alarm (yellow)			
Dual Resolver Difference Shutdown	Shutdown (red)			
All other process faults should remain as defaulted by the service tool				
Discrete Input Configuration				
Discrete Input Action Mode	Shutdown Reset/Reset			
Discrete Input 1 Configuration	Unchecked (Active Open)			
Analog Output Configuration				
Analog Output Mode Selection	Actual Position			
Analog Output Position Scaling, Max Position	100.0%			
Analog Output Position Scaling, Min Position	0.0%			
Analog Output Position Scaling, Max Current	20.0mA			
Analog Output Position Scaling, Min Current	4.0mA			
Discrete Output 1 & 2 Configuration				
Discrete Output 1 Configuration Mode	In-Active when Diagnostic is Detected			
Combined Fault Flags (Alarm, SD Position, SD System)	Unchecked (these faults will not open)			
Combined Fault Flag Shutdown Internal	Checked (SD Internal will open contact)			
Discrete Output 2 Configuration Mode	Turned Off			
Linearization Configuration				
Position Linearization Table	Curve Disabled			
User Force Limiter Configuration				
User Force Limiter Enable	Disabled			

Chapter 5.
Liquid DLE Controller Operation

Manual Control Modes

The liquid DLE controller logic consists of the qualified fuel metering logic, signal inputs, communications interfaces, and metering valve driver interfaces.

The controller collects the fuel flow demand signals from the Core Engine Controller and positions the fuel metering valves/drivers based on the qualified fuel metering logic. By design, the controller does not include any sequencing logic. All sequencing logic must be performed in the packagers specified control system.

Valve Stroking

Manual Valve Stroking mode is used to force the control valves using manual position demands:

- BPSCALVAL – Bypass Valve Manual Position Demand
- LMVOCALVAL – Outer Valve Manual Position Demand
- LMVPCALVAL – Pilot Valve Manual Position Demand
- LMVICALVAL – Inner Valve Manual Position Demand

NOTICE	To enter Remote Valve Stroking the following permissive conditions must be met:
Manual Valve Stroking	**Turbine Control Signal CALENBL = TRUE** **Turbine Control Signal FUELON = FALSE**

CANopen Force Mode

Use Force Mode to force the CANopen write values from the FMS across the CAN interface.

NOTICE	To enter CANopen force mode the following permissive conditions must be met:
Force Mode Permissives	**Flex500 in Configuration Mode (IOLOCK)** **Service Tool Force Mode Request = TRUE** **Turbine Control Signal FUELON = FALSE**

After enabling this mode, the Service Tool can be used to force the individual CANopen interface variables.

This mode will lock out the manual valve-stroking feature and will drive the valves to safe position.

- LMVBP – Bypass Valve to 100%
- LMVO – Outer Valve to 0%
- LMVP – Pilot Valve to 0%
- LMVI – Inner Valve to 0%

⚠WARNING	Force mode shall only be used for development test purposes. This mode will allow users to force CANopen PDO messages from the FMS to the Turbine Control System.
Force Mode	

Chapter 6.
Service Tool

Installation & Connection

The Liquid DLE FMS Service Tool for the Flex500 version resides on the controller itself as a .wgui file. RemoteView PC install tool is necessary to access the .wgui file and visualize the control. The RemoteView tool will communicate with the Flex500-FMS via an Ethernet connection.

RemoteView Install Item Number: 9927-2344

Service Tool connection may be made through any of the FMS Ethernet Ports. The default IP addresses of the Flex500 are shown below.

IMPORTANT

This module has been factory configured with fixed Ethernet IP addresses of:

- **Ethernet #1 = 172.16.100.15, Subnet Mask = 255.255.0.0**
- **Ethernet #2 = 192.168.128.20, Subnet Mask = 255.255.255.0**
- **Ethernet #3 = 192.168.129.20, Subnet Mask = 255.255.255.0**
- **Ethernet #4 = 192.168.130.20, Subnet Mask = 255.255.255.0**

RemoteView Application

Double-click on the FMS Controller, and then double-click on the application “5418-7617” to launch the RemoteView tool and GUI.

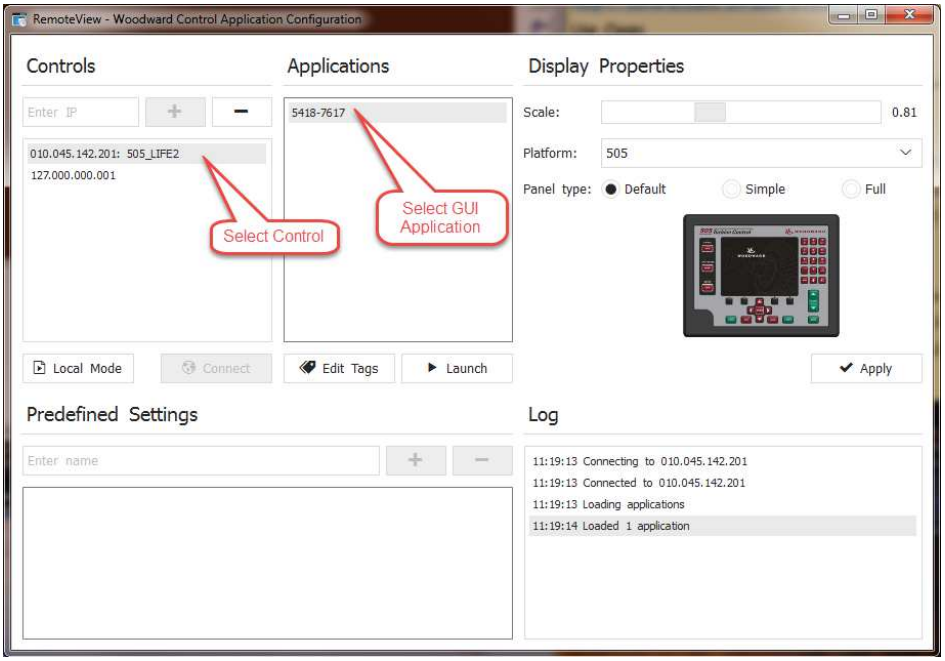

Figure 6-1. RemoteView Tool and GUI

System Overview

The LFMS HOME screen provides easy to navigate menu-based selections. The available screens and their functions are detailed below.

Figure 6-2. Home Screen

Table 6-1. Flex500 Service Tool Menu Overview

Main Menu Selection	Sub Menu Navigation	Function
Overview	N/A	Provides overview of FMS operation
Trend	N/A	Trending of Pressure Controller
Analog Inputs	Summary Analog Input	View Channel Information, Calibration Properties
Contact Inputs	Summary Contact Input	View Channel Information
Relay Outputs	Summary Relay Output	View Relay Status
Analog Outputs	Summary Analog Output	View Channel Information
FMS Configuration	3 Configuration Pages	FMS Control CAN NTWK Config Valve Control CAN NTWK Config Pump Flow and LP1 Gain Config LP1 Pressure Sensor Scaling
Valve Configuration	4 Configuration Pages (LMVO, LMVP, LMVI, Bypass)	Valve Node ID & View Information
CAN Message Forcing	Multiple pages for Forcing Mode	Developer use only
Mode	Login, Save, Calibration, Config	User Login and Mode Selection

LFMS Operational Overview Screen

The Overview screen is used to monitor to the operation of the LFMS in operation. This screen is useful as it shows the demanded manifold flow rates from the Turbine Control System, and the metering valve position outputs.

Figure 6-3. Overview Screen

Configuration Procedures

Program Architecture

The LFMS is easy to configure with the intuitive user interface and menu-driven software. The operating procedures are divided into two sections: the Configuration Mode, and the Run Modes (Operation and Calibration). The Configure Mode is used to configure the LFMS for the specific application and valve network/redundancy architecture.

Display Modes and User Levels

The LFMS operates in several modes and access user levels, each of which has a different purpose. The modes are OPERATION, CALIBRATION, and CONFIGURATION. In order to enter and exit a particular mode, the user must be logged in with an appropriate user level. These user levels are MONITOR, OPERATOR, SERVICE and CONFIGURE. In addition to granting authority to enter and exit modes, user levels also determine what parameters the user is authorized to adjust.

Table 6-2. Display Modes and User Levels

		Mode		
		Operation	Calibration	Configuration
User Level	Monitor	X		
	Operator	X		
	Service	X	X	
	Configure	X	X	X

Mode Descriptions

The OPERATION mode is the only mode that can be used to run the LFMS. This is the default mode. Exiting CALIBRATION or CONFIGURATION mode will return to OPERATION mode. User levels: Monitor, Operator, Service or Configure

The CALIBRATION mode is used to force signal outputs in order to calibrate signals and field devices. In this mode, the actuator, analog, and relay outputs can be manually controlled. To enter this mode the LFMS must read FUELON=FALSE from the Turbine Control System (RxPDO4, Byte 3, Bit 2). If FUELON goes TRUE while in CALIBRATION mode, the LFMS will exit CALIBRATION mode.

The CONFIGURE mode is used to setup the valve network & redundancy architecture for a specific application prior to operation of the unit. To enter this mode the LFMS must read FUELON=FALSE from the Turbine Control System (RxPDO4, Byte 3, Bit 2). When the unit enters CONFIGURE mode the control is placed in IOLOCK which will disable all Output I/O channels. In order to exit CONFIGURATION mode, the LFMS must read “FUELON=FALSE”.

User Level Descriptions

The Monitor & Operator user levels allows for control of the LFMS.

Login: Operator
Password: wg1111

The Service user level allows the same commands as the Operator user level plus the ability to calibrate channels and manually force outputs.

Login: Service
Password: wg1112

The Configure user level allows the same commands as the Service user level plus the ability to change the FMS Configurations (Valve Network, Liquid Pump Flow Rate, Gains, and Channel Scaling).

Login: Configure
Password: wg1113

Changing FMS Mode Selection

Selecting the Mode button from the operator service tool screen will bring up the User Login and Mode Selection page. An example case is provided below illustrating how a user would login at a Configure level and change the valve networking architecture.

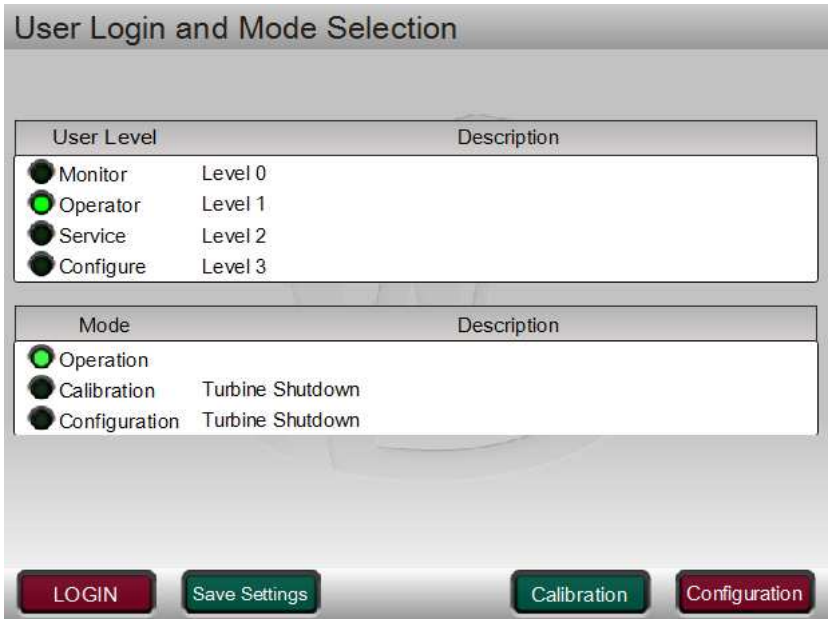

Figure 6-4. User Login and Mode Selection

Change to User Level - Configure

1. Select “MODE” button
2. Select “LOGIN” button
3. Select “Configure” user level, this will automatically fill in the User Level
4. Enter the “Configure” level password, “wg1113”
5. Select the “Login” button to complete the user login process

Change to Configuration Mode

1. Select “Configuration” button
2. Select “OK” when prompted to put the unit into IOLOCK
3. Navigate to the FMS Configuration Screen (Page 1) from the home menu
4. Change the Valve CAN Network from Mode 1 to Mode 2
5. Mode read-back should now show “Split CANopen Analog Backup”
6. Select “MODE” button
7. Select “Exit Configuration”, which will save the settings and reset

Analog Input Channel Calibration

The analog input channel scaling and calibration can be accessed by navigating through the Analog Input menu to the AI_0x channel screen. With the FMS in Calibration Mode, the user can now select the Calibrate button to access the 4-20mA Gain & Offset.

Figure 6-5. Analog Input Channel Configuration

IMPORTANT **LP1 Pressure Sensor Inputs must be scaled 4-20mA to PSIA (pounds per square inch absolute)**

IMPORTANT **Metering Valve Analog Feedback Inputs must be scaled 4-20mA to 0-100%**

FMS Configuration (Page 1)

This screen allows the operator to configure the FMS CANopen Control network settings and Valve CANopen Control network settings. Additionally the user may select the valve control network architecture mode, when in IOLOCK.

Figure 6-6. FMS Configuration Page 1

CAN Hard Reset

The CAN HARD RESET buttons are used during setup and troubleshooting. Theses resets will re-initialize the CAN networks and should only be performed with the unit offline. The hard reset functionality is only available when Z_LFUELON = FALSE.

The FMS CAN Network hard reset command will not typically be used as the NMT master will perform the network reset.

The Valve CAN Network hard reset is used after a change to the Baud Rate or Network Timeout to force the Valve Network NMT master (FMS) to use the updated values.

FMS Configuration (Page 2)

This screen allows the operator to view the manual valve stroke demands from the Turbine Control System. Additionally the user may also configure the Liquid Fuel Pump Flow Rate (pph) and the pressure controller proportional and integral gain values when the FMS is in Configure Mode.

Figure 6-7. FMS Configuration Page 2

FMS Configuration (Page 3)

This screen provides LP1A and LP1B pressure reading and scaling information. In order to adjust the sensor scaling the FMS must be in Configure Mode.

Figure 6-8. FMS Configuration Page 3

Valve Configuration Screens

A valve configuration screen is provided for each of the four valves used for the Liquid DLE Fuel Metering System. From this screen, the user can configure the CANopen Node Id (when in Configure Mode), and monitor the specific valve/driver information.

Figure 6-9. Valve Configuration Screens

Alarm, Shutdown & Historical Viewer

The current Alarm or Shutdown view is available through the navigation buttons on the left control pane. Additionally a historical event log is available through the “Event History” button.

Figure 6-10. Event History Screen

Control CAN Force Mode

The CAN force mode screens are provided to check the CANopen interface from the FMS to the Core Engine Control.

NOTICE	To enter CANopen force mode the following permissive conditions must be met:
Force Mode Permissives	**Flex500 in Configuration Mode (IOLOCK)** **Service Tool Force Mode Request = TRUE** **Turbine Control Signal FUELON = FALSE**

Once the CAN Force Mode is enabled the analog values or Booleans may be tuned and verified in the Core Engine Control. Two Service Tool pages are provided to tune all the variables. The first page covers TXPDO1 – TXPDO6. The second page covers TXPDO7 and TXPDO8.

Figure 6-11. CANopen Forcing Pages

Chapter 7.
AppManager Configuration

The Woodward Control Application Manager (AppManager) manages applications, security, datalogs, and other functions.

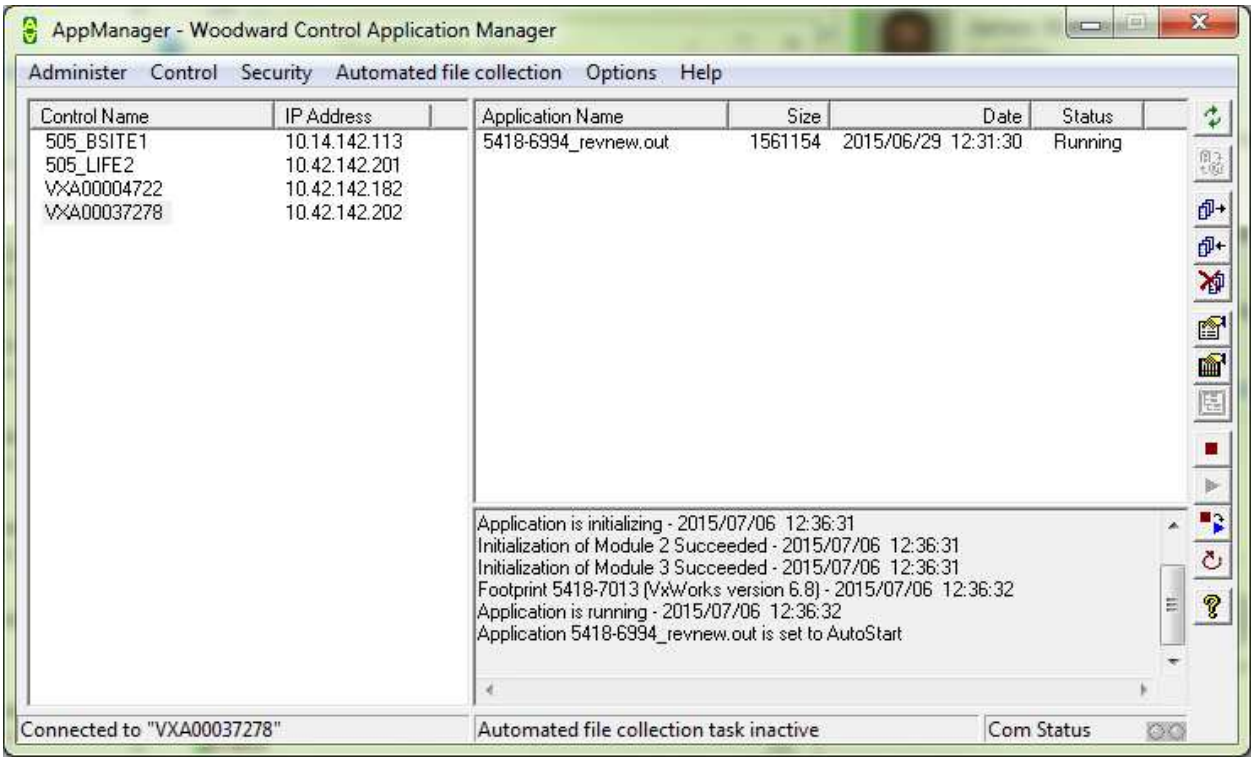

Figure 7-1. Woodward Control Application Manager (AppManager) Screen

Application Management

The Liquid DLE FMS is delivered from Woodward with the application software pre-installed and set to “AutoStart” when the control boots.

Change IP Address

Reference manual 26336 – “Woodward VxWorks RTOS”.

Datalogging

The Liquid DLE FMS comes preconfigured for datalogging critical parameters. The default operation is to generate a shutdown log file. This log file is a total of 120seconds in duration capturing 100seconds before the shutdown and 20seconds after. The FMS supports continuous datalogging.

Reference manual 26336 – “Woodward VxWorks RTOS” for details on configuring datalogging.

Chapter 8.
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:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which 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 Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

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

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

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

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.

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 within 60 days, a credit for the core charge will be issued.

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 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 authorization 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 offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- 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. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. 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.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or 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 us via telephone, email us, or use our website: **www.woodward.com**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

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

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

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 _____

Turbine Model Number _____

Type of Fuel (gas, steam, 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.

Revision History

Revision A—

- Added new content to the Positive Displacement Pump section of Chapter 2.
- FMS Configuration Mode Selection added to Chapter 3
- Hardwired Analog Inputs section created from a sub-heading with significant content changes. and Hardwired Output section added to Chapter 3
- Content added to Table 3-2 and redesignated from Table 3-1.
- New Table 3-1 added with FMS Configurations Mode Selection
- Numerous Table and Figure caption changes in Chapter 3 due to new content additions
- Significant changes in Valve Driver Networking section of Chapter 4
- DVP Configuration section of Chapter 4 has significant changes including addition of Table s 4-3 and 4-4
- Heading change from Description of Operation to Manual Control Modes and Operational Mode section deleted in Chapter 5
- Most of the screen shots have been changed in Chapter 6
- Much of Chapter 6 has new content or content which has been reconfigured.

Released

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 35049.

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