WOODWARD

Product Manual 26440
(Revision D, 1/2013)
Original Instructions

505LST Digital Control System

9907-169/-170/-171

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

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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.

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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.

Regulatory Compliance

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

EMC Directive: Declared to 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

ATEX – Potentially Explosive Atmospheres Directive: Declared to 94/9/EEC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.
EEx nA II T3 X

C-Tick (ACA/RSM): Declared to Australian Radiocommunications Act of 1992 and the New Zealand Radiocommunications Act of 1989.

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

UL: UL Listed for Class I, Division 2, Groups A, B, C, & D
T3A at 60 °C Ambient (NEMA 4X or similar enclosure provided)
T3B at 65 °C Ambient (NEMA 4X or similar enclosure omitted)
For use in Canada and the United States per UL File E156028

IMPORTANT **This equipment is considered indicator equipment and is not to be used as metrology equipment. All measurements need to be verified using calibrated equipment.**

Special Conditions for Safe Use
Field wiring must be stranded copper wire rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

Peripheral equipment must be suitable for the location in which it is used.

A fixed wiring installation is required.

Grounding is required by the input PE Terminal.

A switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach for the operator and is clearly marked as the disconnecting device for the equipment.

⚠WARNING **Ensure that power has been disconnected prior to opening the control or replacing the input power fuse.**

⚠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 2.

⚠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, Division 2.

⚠WARNING

Do not use any test points on the power supply or control boards unless the area is known to be non-hazardous.

⚠AVERTISSEMENT

Ne pas utiliser les bornes d'essai du block d'alimentation ou des cartes de commande à moins de se trouver dans un emplacement non dangereux.

Chapter 1.
General Information

Introduction

This manual describes the Woodward 505LST Digital Control System. It provides installation instructions, configuration instructions, and operating instructions.

The 505LST microprocessor-based control is designed to control various types of large reheat steam turbines. The 505LST is field configurable which allows a single design to be used in several different control applications. The 505LST is capable of controlling four modulating valves (six with the use of the Woodward SPC). The 505LST has three main I/O configuration settings, identified as Turbine Types (see Turbine Types below). The control configures the I/O around the type of valving that is on the turbine.

Part Numbers

9907-169	90–150 Vdc, 88–132 Vac
9907-170	18–32 Vdc
9907-171	220 Vac

505 controllers now utilize a special polyacrylate conformal coating material to coat and protect their internal circuit boards from corrosive environments. This new polyacrylate material replaces the previous silicon conformal coating and provides an improved barrier between board components and sulfur-based gases. 505 controls that have this coating will have a label on the side stating “SULFUR RESISTANT CONFORMAL COATED”. All 505 controllers shipped from Woodward with the revision letters listed below, or subsequent letters, were shipped with the new polyacrylate conformal coating material:

Table 1-1. 505s with Polyacrylate Coated Boards

Part Number	Revision	Label on 505
9907-169	E	9907-169E
9907-170	E	9907-170E
9907-171	E	9907-171E

505LST Operating Modes

The 505LST control has two basic modes of operation: Program Mode and Run Mode. Program Mode is used to select the options needed to configure the control to your specific turbine application. Once the control has been configured, the Program Mode is typically never again used, unless turbine options or operation changes. Once configured, the Run Mode is used to operate the turbine from start-up through shutdown.

In addition to the basic modes of operation, the 505LST control has Service, OPSYS_Faults, and Debugging modes. Service Mode is used to make control adjustments while the system is in operation. OPSYS_Faults Mode is used to view system faults and alarms that have occurred. DEBUG mode is used to troubleshoot system code during development and is not intended for general use. It is only for use by properly trained Woodward personnel or when expressly authorized by Woodward.

505LST Inputs and Outputs

The 505LST uses the following inputs:

- Two MPU (magnetic pickup) speed-sensing inputs.
- Six designated analog inputs: Speed/VPC Demand input, valve position inputs, and Main (Throttle) Steam pressure. The Speed/VPC Demand input has isolation circuitry and is typically connected to the DCS. The other inputs, if connected to a DCS or non-isolated device, should use a signal isolator.
- Sixteen contact inputs: shutdown, valve position indication, emergency shutdown, reset.
- Dedicated function keys on the front panel of the control.

Control Outputs

The 505LST provides the following control outputs:

- Four actuator outputs.
- Four designated 4–20 mA outputs to drive meters or signals to DCS.
- Eight designated Form-C relay contact outputs.

Control Interfaces

Two Modbus® * ports, to be used as control interfaces. The protocol can be either ASCII or RTU and the communications can be RS-232, RS-422, or RS-485. One computer (PC) port can be used for program and settings uploading and downloading.

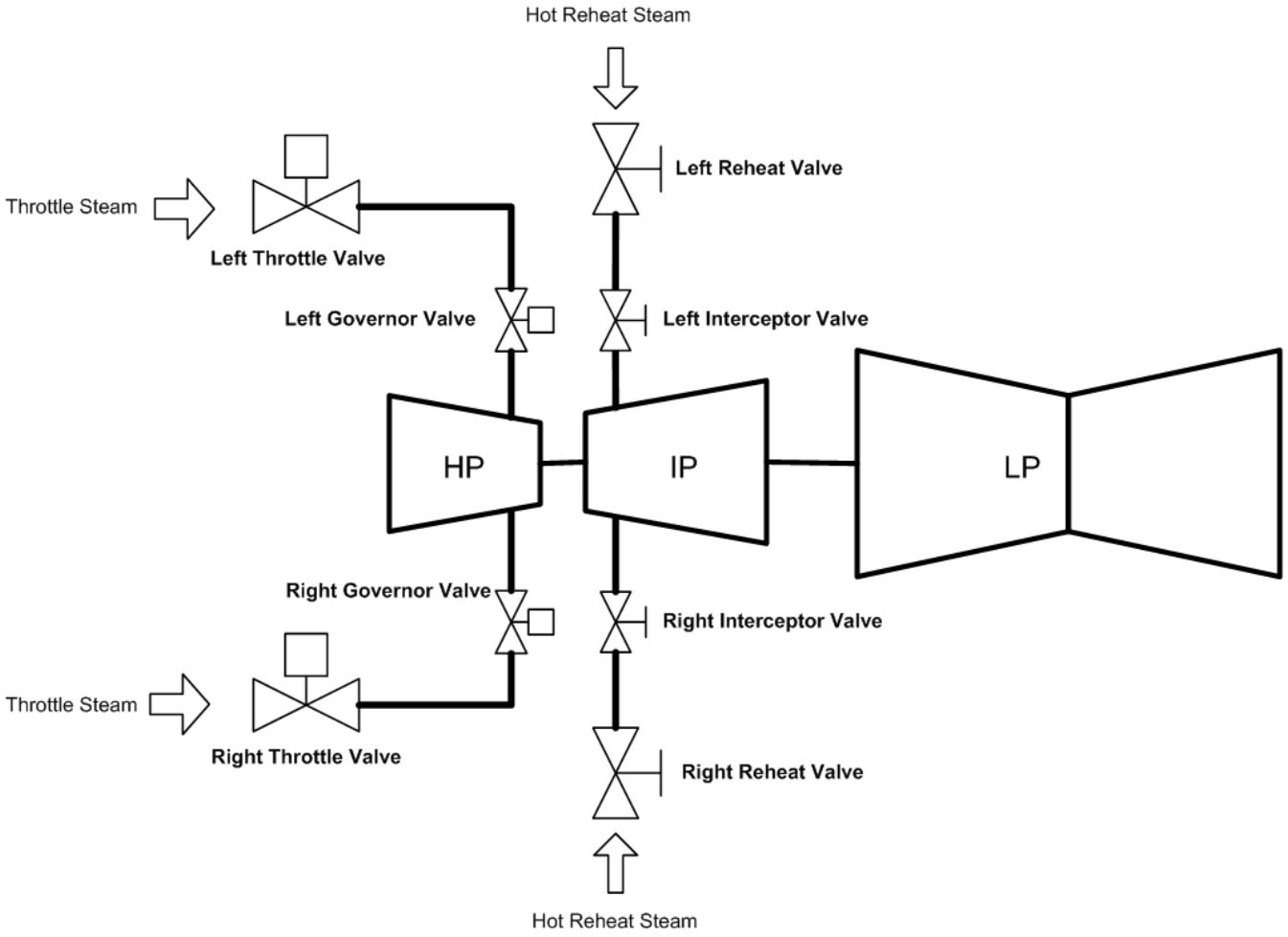
*—Modbus is a trademark of Schneider Automation Inc.

Turbine Types

The descriptions below are the different turbine types that are supported by the 505LST. Choosing the correct turbine type is the first step of the configuration process.

Turbine Type 1

The first configurable control configuration is set up for left and right throttle valves and governor valve applications. This configuration rolls the turbine on the throttle valves, and then transfers to the governor valves when the operator initiates the transfer. This configuration also includes left and right interceptor and reheat valve control. The throttle and governor valves are modulating valves controlled by the 505LST. The interceptor and reheat valves are controlled with contact outputs. Refer to Figures 1-1, 1-2, and 1-3.



Modulated 4–20 mA valve controlled by the 505LST

Non-modulated valve tested and tripped via contact out from 505LST

Figure 1-1. Turbine Type 1 Schematic

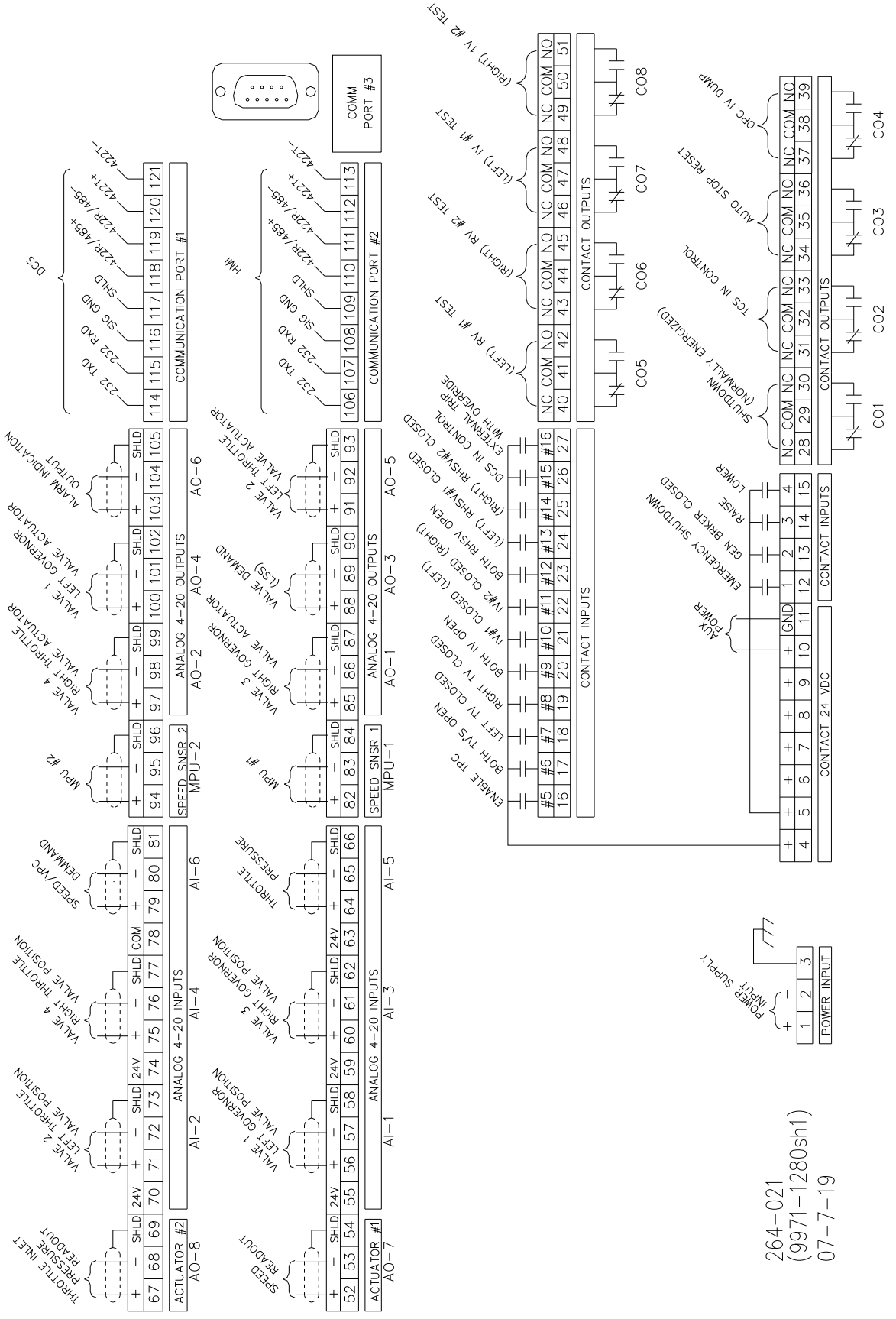


Figure 1-2. Turbine Type 1 Wiring Diagram

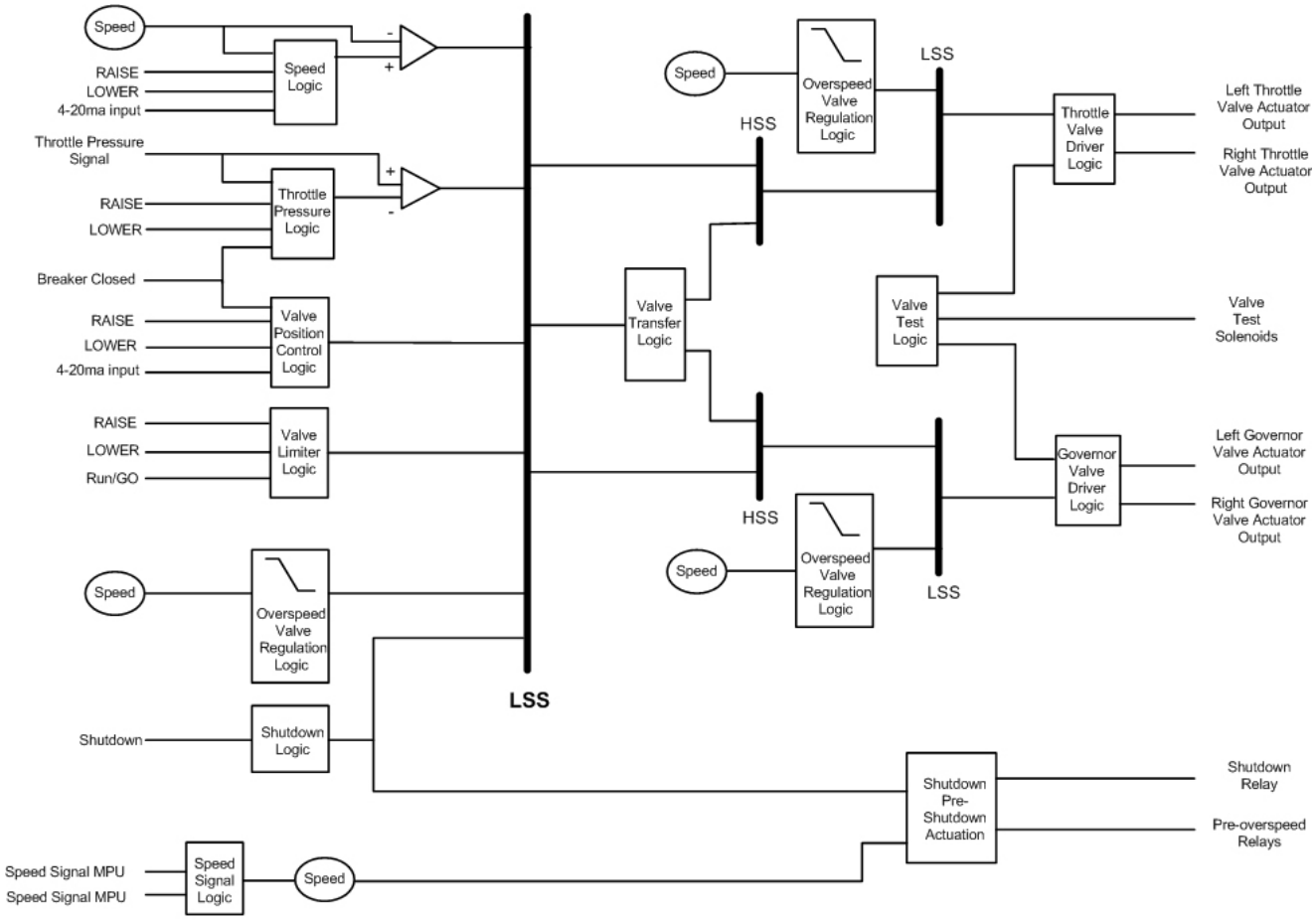
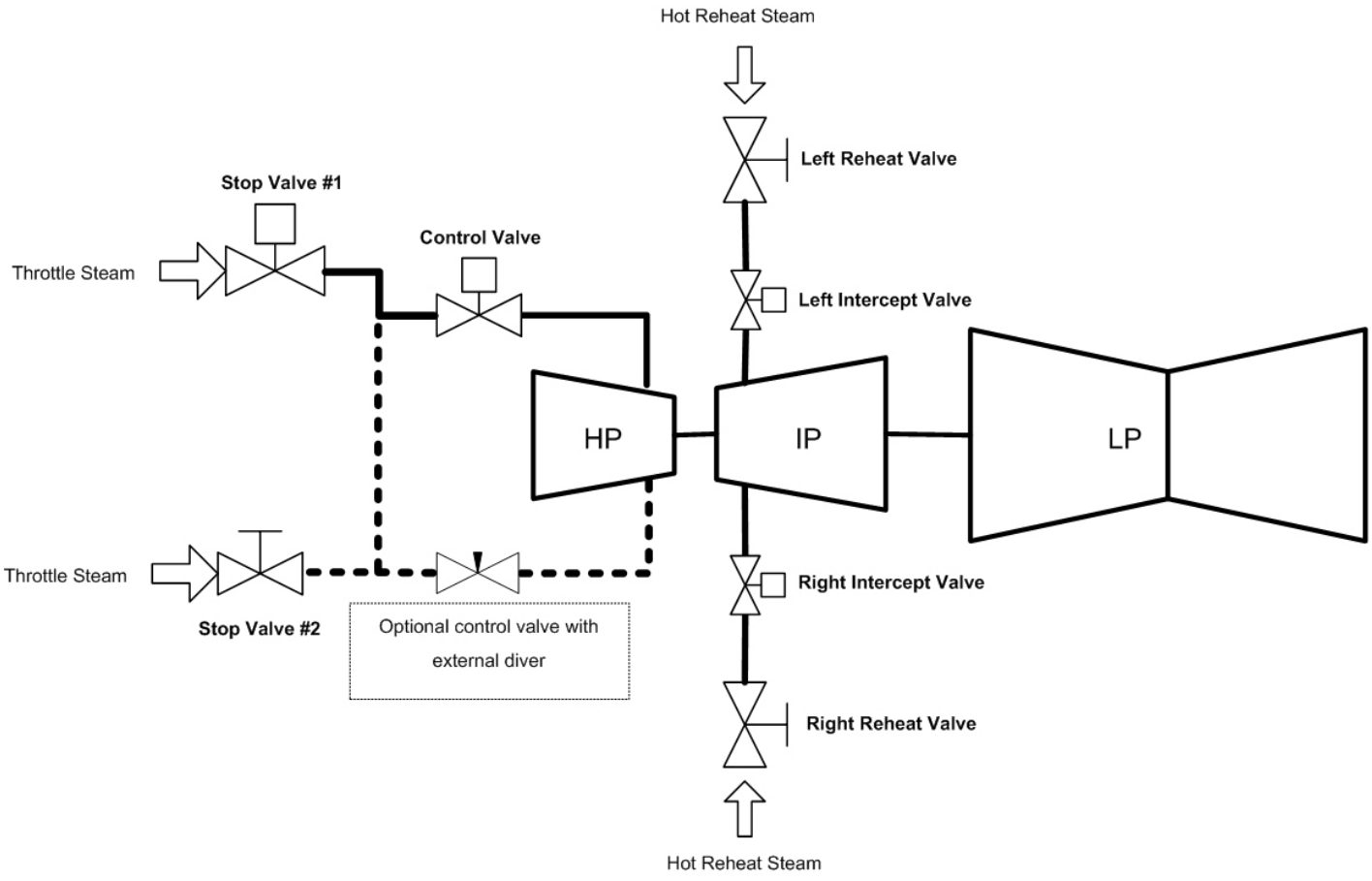


Figure 1-3. Turbine Type 1 Block Diagram

Turbine Type 2

The control's turbine type 2 configuration is set up for single stop and single actuated control valves. This configuration rolls the turbine on the stop valve, and then transfers to the control valve when the operator initiates the transfer. This configuration also controls 2 intercept valves using two analog outputs, and two reheat stop valves with contact outputs (testing outputs). This configuration may also have an additional non-modulated stop valve. Additional modulating valves can be added externally to the 505LST, by adding a Woodward SPC (Servo Position Controller) to the 505LST output and staggering the current to the SPC. Refer to Figures 1-4, 1-5, and 1-6.



Modulated valve

Solenoid-controlled valve

Modulated valve via external driver

Figure 1-4. Turbine Type 2 Schematic

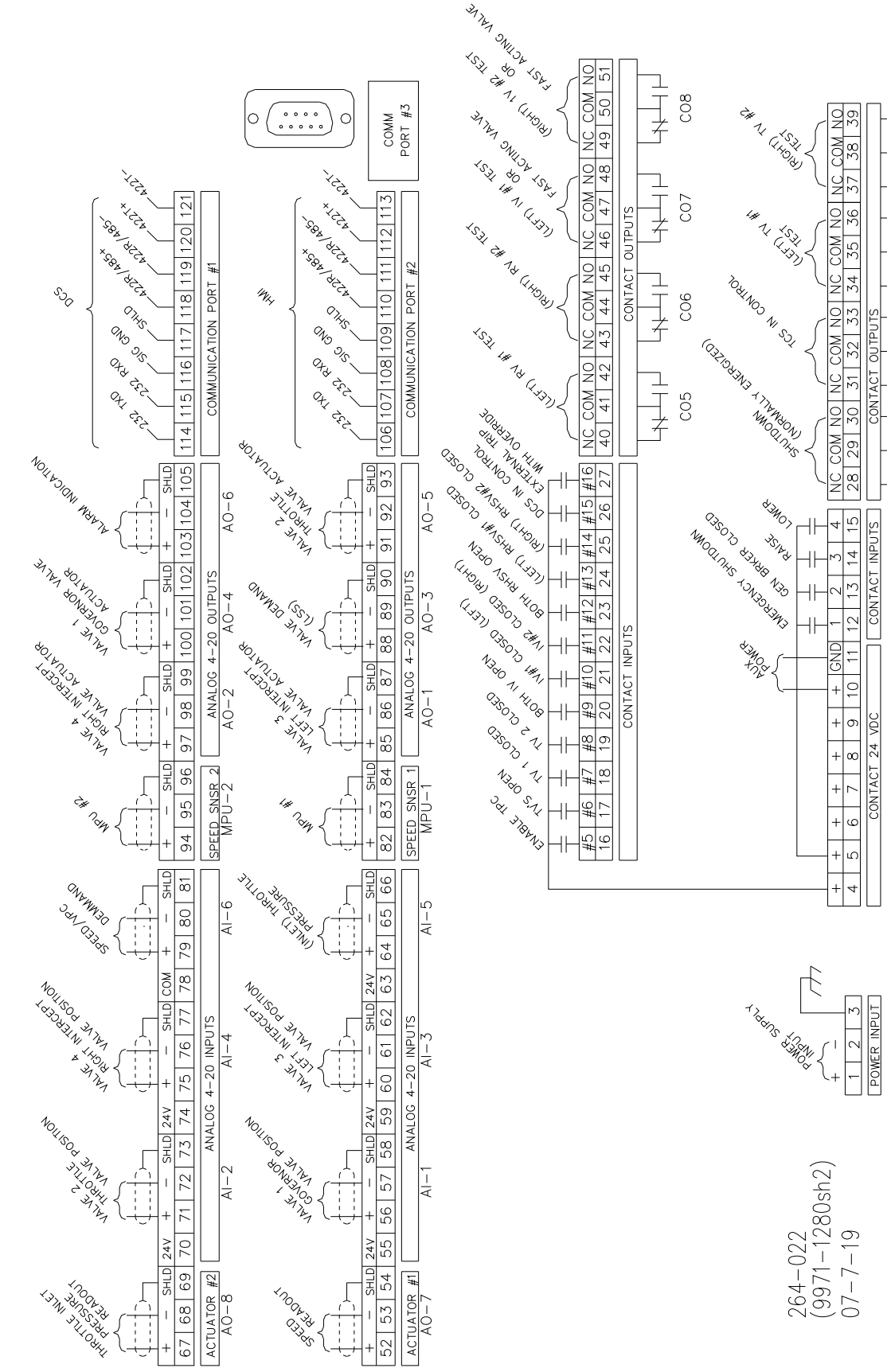


Figure 1-5. Turbine Type 2 Wiring Diagram

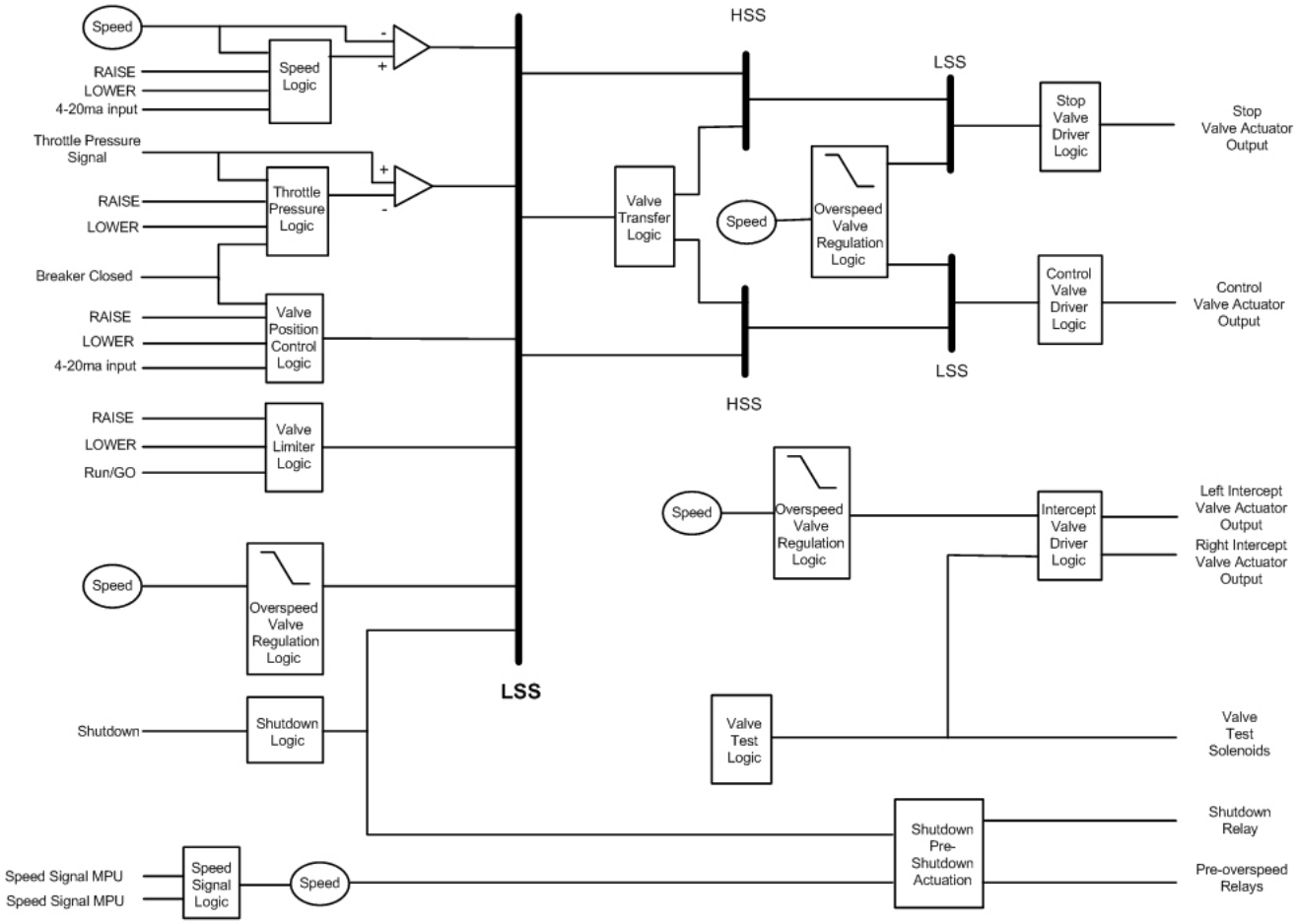
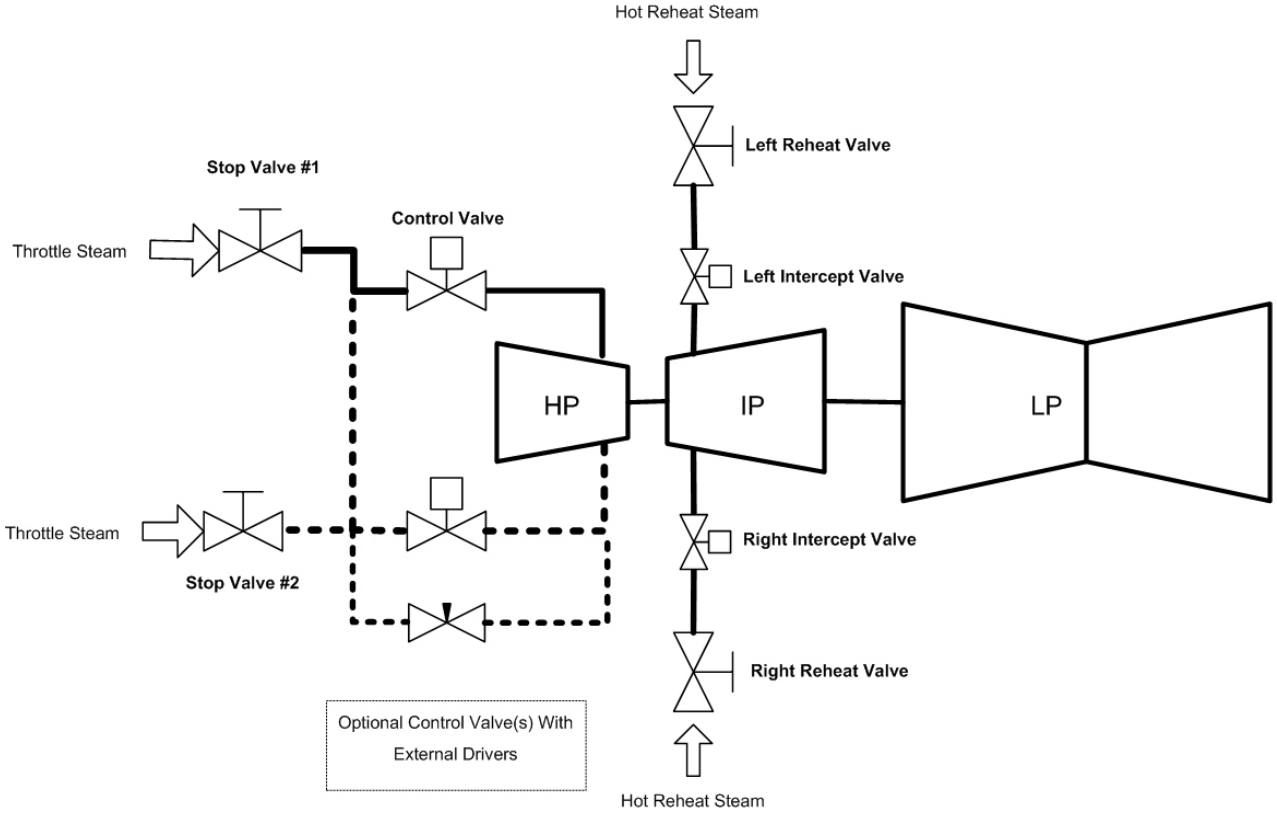


Figure 1-6. Turbine Type 2 Block Diagram

Turbine Type 3

The control's turbine type 3 configuration is set up for two control valve applications. This configuration also controls two modulating intercept valves, and two solenoid-controlled reheat stop valves. This configuration assumes that no modulating stop valves are used, and has contact outputs and inputs for testing up to two stop valves. Refer to Figures 1-7, 1-8, and 1-9.




Modulated valve


Solenoid-controlled valve


Modulated valve via external driver

Figure 1-7. Turbine Type 3 Schematic

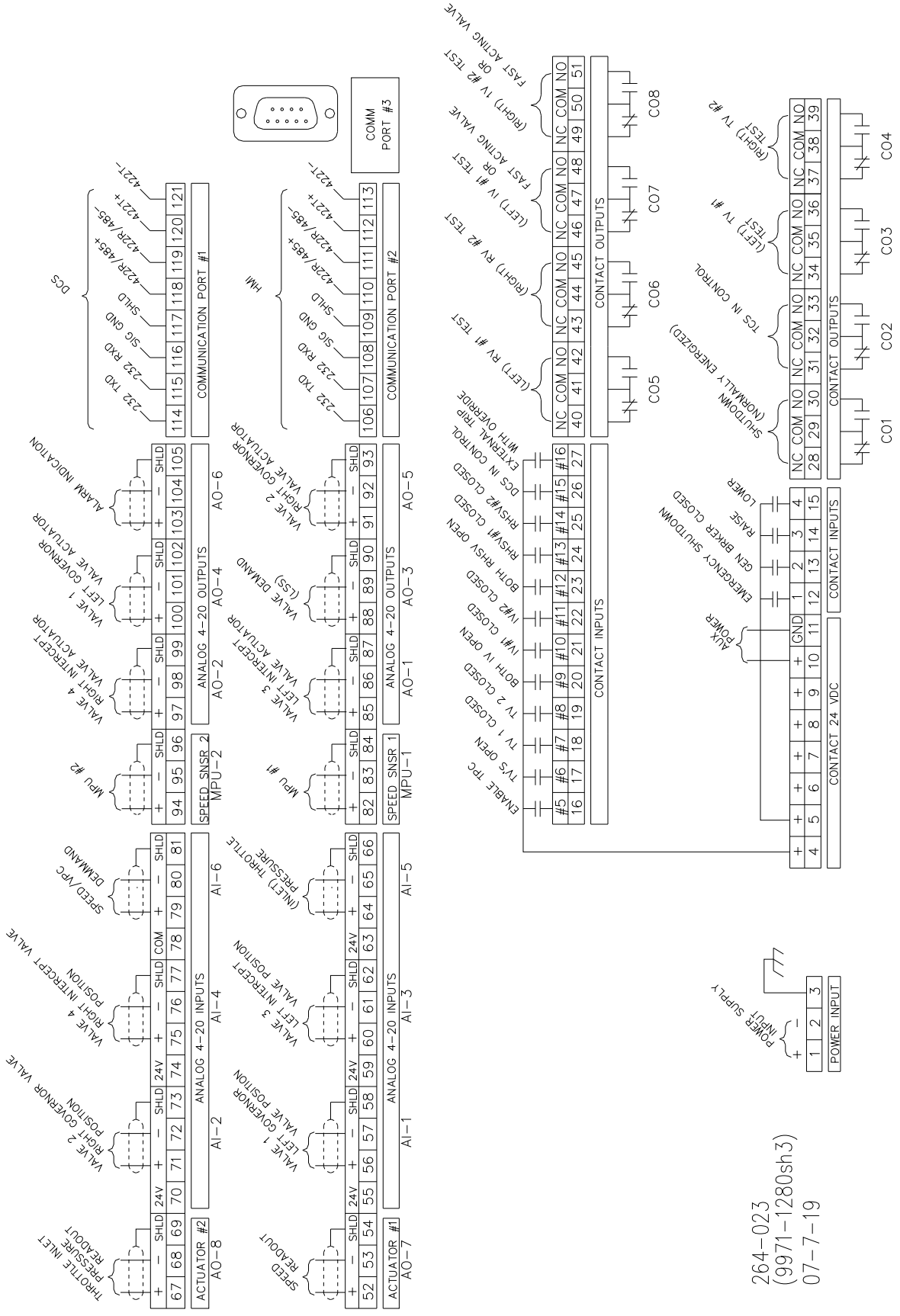


Figure 1-8. Turbine Type 3 Wiring Diagram

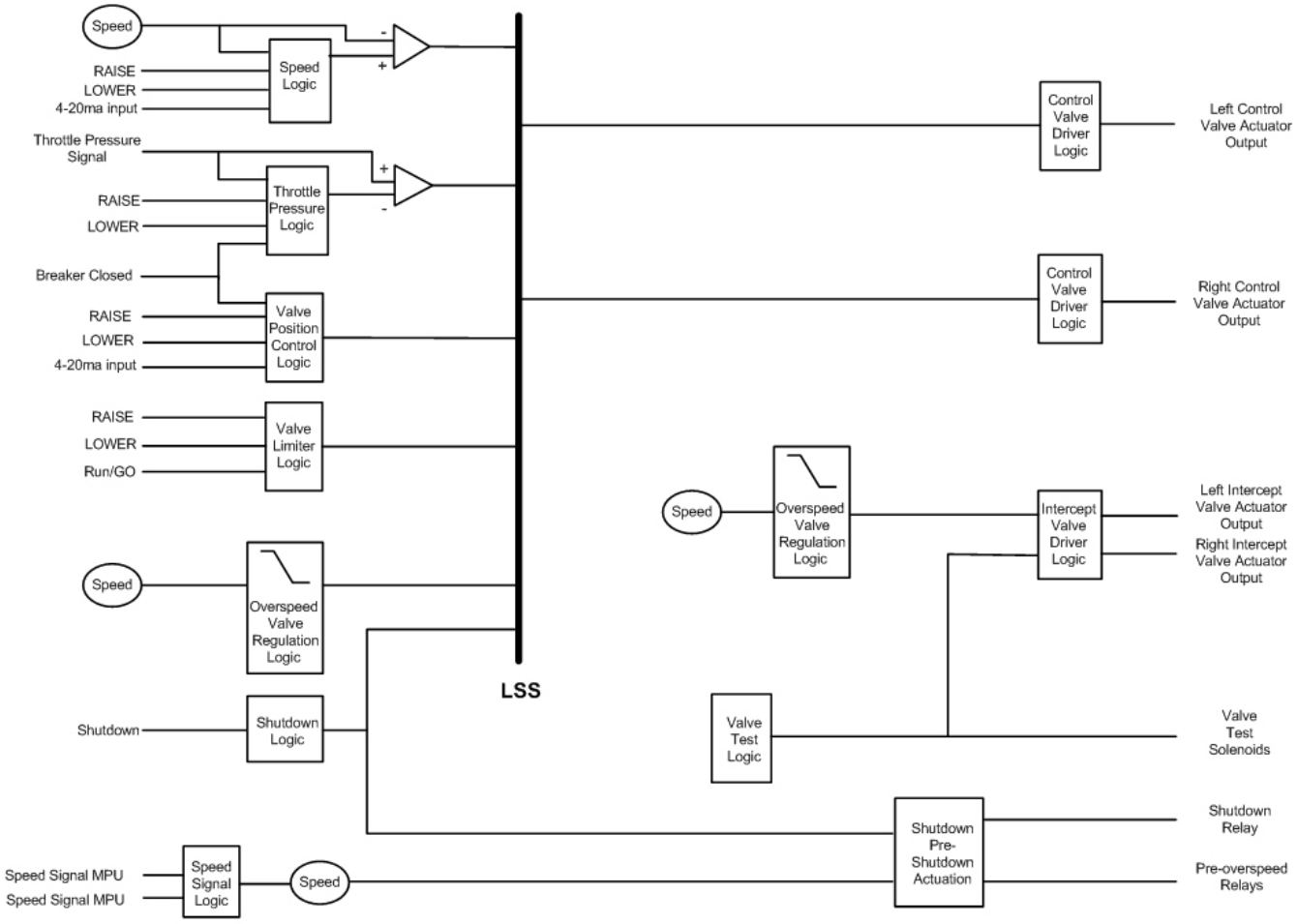


Figure 1-9. Turbine Type 3 Block Diagram

Actuator Outputs

The actuator outputs from the 505LST are 4–20 mA based signals, and are proportional-type outputs. To control integrating servo valves such as Moog and Abex, the Woodward SPC (Servo Position Controller) could be used in conjunction with the 505LST to close the position loop of the servo valve. Multiple control valves could also be set up by using the SPC and staggering the current from the 505LST.

Chapter 2.
Installation Procedures

General Installation and Operation

This Equipment is suitable for use in Class I, Division 2 , Groups A, B, C, and D (Class I, Zone 2, Group IIC) or non-hazardous locations.

This equipment is suitable for use in European Zone 2, Group II environments per compliance with EN60079-15, Electrical apparatus for explosive atmospheres – Type of protection 'n'.

These listings are limited only to those units bearing the certification identification.

Field wiring must be rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

Peripheral equipment must be suitable for the location in which it is used.

Wiring must be in accordance with Class I, Division 2 (Zone 2) wiring methods and in accordance with the authority having jurisdiction.

⚠WARNING

EXPLOSION HAZARD—Substitution of components may impair suitability for Class I, Division 2.

Do not disconnect while circuit is live unless the area is known to be non-hazardous.

⚠AVERTISSEMENT

RISQUE D'EXPLOSION—La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.

Ne pas débrancher tant que le circuit est sous tension, a moins qu'il ne s'agisse d'un emplacement non dangereux.

⚠WARNING

Do not use any test points on the power supply or control boards unless the area is known to be non-hazardous.

⚠AVERTISSEMENT

Ne pas utiliser les bornes d'essai du block d'alimentation ou des cartes de commande à moins de se trouver dans un emplacement non dangereux.

Introduction

This chapter provides instructions on how to mount and connect the 505LST into a system. Hardware dimensions, ratings, and jumper configurations are given to allow a customer to mount, wire, and configure the 505LST package to a specific application.

Electrical ratings, wiring requirements, and options are provided to allow a customer to fully install the 505LST in a new or existing application.

Mechanical Data and Hardware Installation

If so labeled on the enclosure, the 505LST is UL/cUL listed for use in hazardous locations in UL file E156028. This Equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D (Class I, Zone 2, Group IIC) or non-hazardous locations only.

This equipment is suitable for use in European Zone 2, Group II environments per compliance with EN60079-15, Electrical apparatus for explosive atmospheres – Type of protection ‘n’.

These listings are limited only to those units bearing the certification identification.

Field wiring must be rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

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

Peripheral equipment must be suitable for the location in which it is used.

Enclosures

Figure 3-1 shows 505LST control layout and mounting pattern. The 505LST digital control is housed in a flush mount enclosure. This enclosure is designed for installation within a control room panel or cabinet, and by itself, cannot be bulkhead-mounted. The 505LST package, once properly installed within a NEMA-4X panel or cabinet, meets NEMA-4X ratings. A gasket is attached to the rear side of the package’s bezel to properly seal the 505LST’s face-plate to a panel. All field wiring connects to the 505LST through removable terminal blocks located on the 505LST’s back side.

The 505LST’s internal components are industrial grade. These components include the Central Processing Unit (CPU), its memory, the switching power supply, all relays, all Input/Output circuitry, and all circuitry for the front panel display, touch keypad, and the serial communications.

An optional NEMA-4X enclosure is available to allow the 505LST to be bulkhead mounted (see Figure 3-2). The 505LST digital control mounts on the front door of the enclosure. This allows for easy service access through the enclosure’s front door. This bulkhead mounted enclosure has two removable gland plates attached to the bottom. A user may cut appropriately sized conduit openings (up to 1.5”) as required, in the removable gland plates for wiring access. For EMI reasons, it is recommend that all low-current wires (terminals 52 through 121) are separated from all high-current wires (terminals 1 through 51).

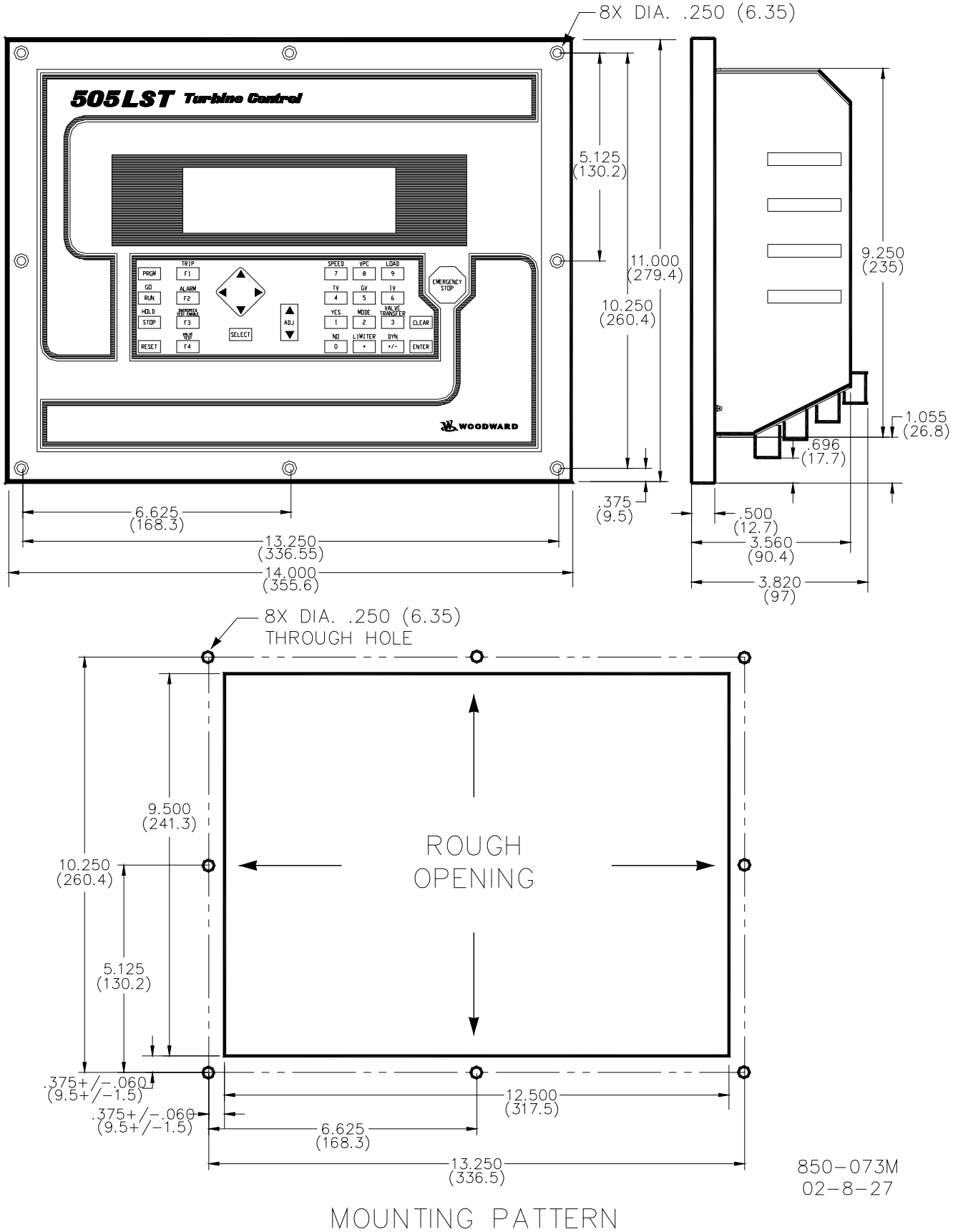


Figure 3-1. 505LST Dimensions

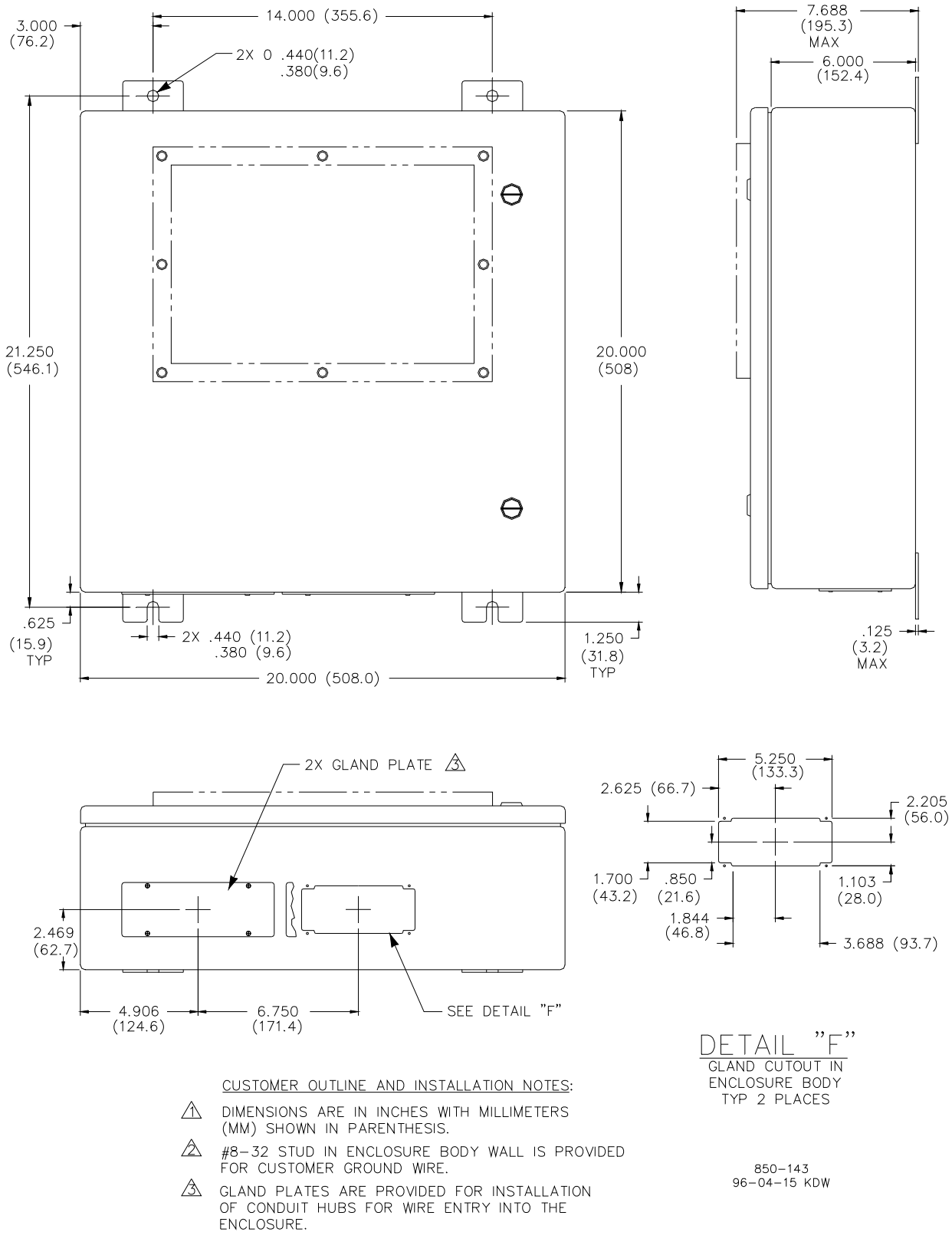


Figure 3-2. 505LST Bulkhead-Mounted Enclosure

Mounting

The standard 505LST package must be mounted to allow sufficient room for wiring access. Eight front panel screws permit secure mounting. The standard 505LST weighs approximately 4.1 kg (9 lb), and has an operating range of –25 °C to 65 °C ambient air temperature.

The optional enclosure allows the control to be bulkhead mounted. See Figure 3-2 for mounting dimensions. This enclosure weighs approximately 10 kg (22 lb), and allows an operating range of -20°C to 60°C ambient air temperature.

505LST Hardware Jumpers

To allow the 505LST the flexibility of interfacing with different types of speed probes, transducers, and communication cables, user changeable jumpers are used. These jumpers are accessed by removing the 505LST's back cover. They are located on the I/O module. Refer to Table 3-1 for jumper options and Figure 3-4 for jumper locations. Each set of jumpers is used to select between two or three interface options for one circuit (see Figure 3-3). Of the three position jumper options provided, only one interface option at a time can be selected. Power should be removed before the jumpers are accessed, and proper ESD precautions should be taken before any contact is made with any part of the circuit board.

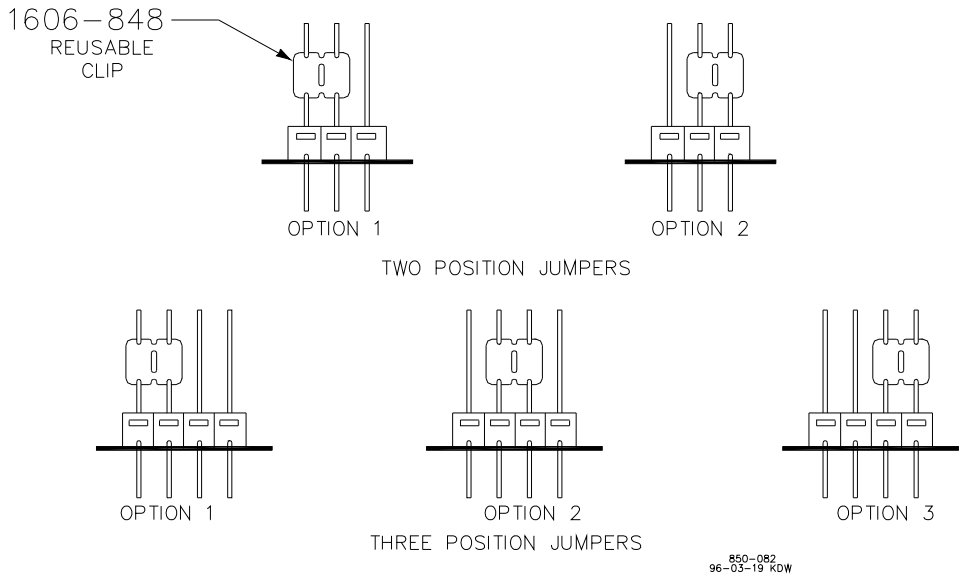


Figure 3-3. Jumper Options

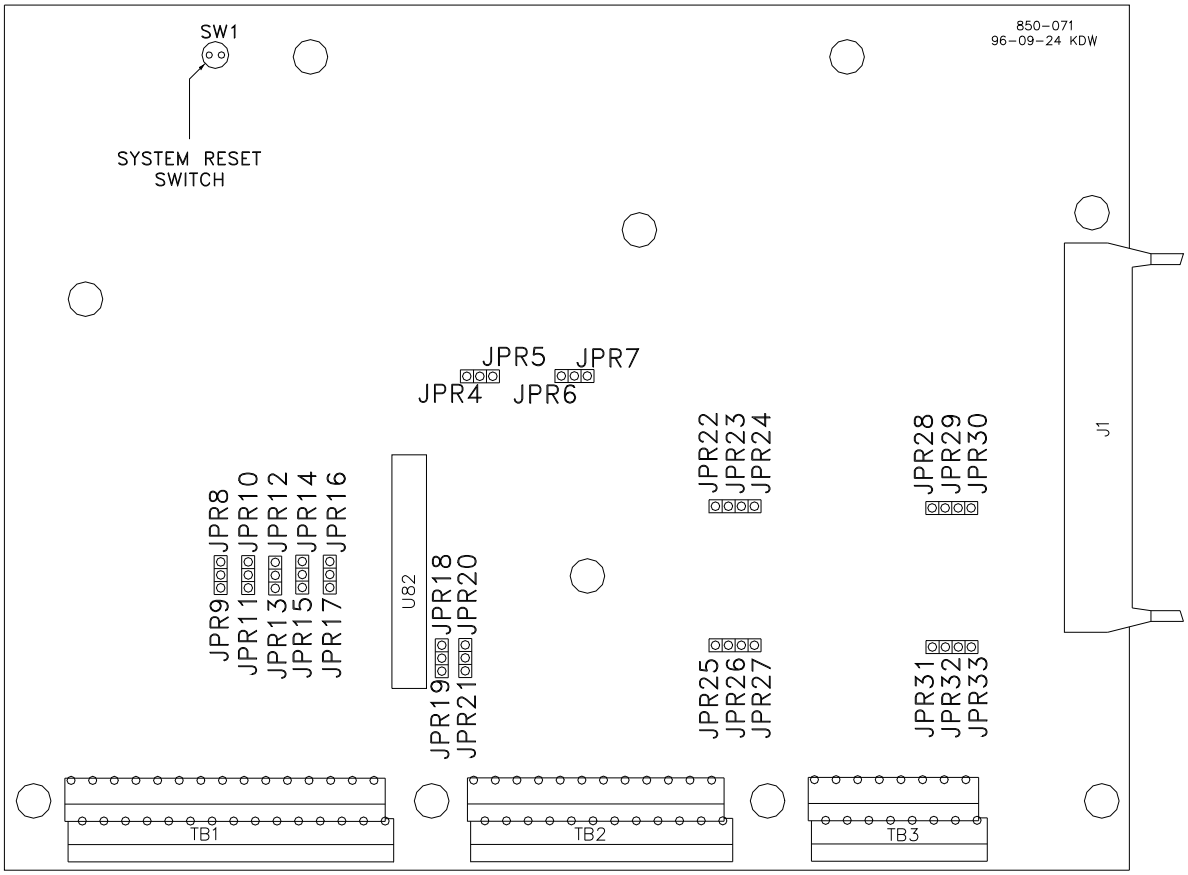


Figure 3-4. Jumper Locations

Table 3-1. Jumper Options Chart

FUNCTION	JUMPERS
SPEED SENSOR #1 MPU	JPR7, JPR21 *
SPEED SENSOR #1 PROX. PROBE	JPR6, JPR20
SPEED SENSOR #2 MPU	JPR5, JPR19 *
SPEED SENSOR #2 PROX. PROBE	JPR4, JPR18
ANALOG INPUT #1 - LOOP POWERED-(2 - WIRE)	JPR8
ANALOG INPUT #1 - SELF-POWERED	JPR9 *
ANALOG INPUT #2 - LOOP POWERED-(2 - WIRE)	JPR10
ANALOG INPUT #2 - SELF-POWERED	JPR11 *
ANALOG INPUT #3 - LOOP POWERED-(2 - WIRE)	JPR12
ANALOG INPUT #3 - SELF-POWERED	JPR13 *
ANALOG INPUT #4 - LOOP POWERED-(2 - WIRE)	JPR14
ANALOG INPUT #4 - SELF-POWERED	JPR15 *
ANALOG INPUT #5 - LOOP POWERED-(2 - WIRE)	JPR16
ANALOG INPUT #5 - SELF-POWERED	JPR17 *
ANALOG INPUT #6 – Isolated No jumper settings (Ref Page 24)	
COM PORT #1 NO TERMINATIONS	JPR23, JPR26 *
COM PORT #1 RS485/RS422 RECEIVE TERMINATION	JPR22, JPR25
COM PORT #1 RS422 TRANSMIT TERMINATION	JPR24, JPR27
COM PORT #2 NO TERMINATIONS	JPR29, JPR32 *
COM PORT #2 RS485/RS422 RECEIVE TERMINATION	JPR28, JPR31
COM PORT #2 RS422 TRANSMIT TERMINATION	JPR30, JPR33

* = DEFAULT

Electrical Connections

All inputs and outputs to the 505LST are made through terminal blocks on the bottom of the 505LST package. For EMI reasons, it is recommend that all low-current wires (terminals 52 through 121) are kept separate from all high-current wires (terminals 1 through 51). Refer to Figure 3-7 for a representative 505LST I/O interface schematic.

The terminal blocks are screwless CageClamp type blocks. The spring clamp can be operated by using a standard 3 mm or 1/8 in flat-bladed screwdriver or a snap-on thumb lever (see Figure 3-5). Two snap-on thumb levers are provided with the 505LST unit. The 505LST terminal blocks accept wires from 0.08-2.5 mm² (27-12 AWG) wire. Two 0.8 mm² (18 AWG) or three 0.5 mm² (20 AWG) wires can be easily installed in each terminal.

The 505LST control's terminal blocks are designed to be removed by hand. After 505LST input power is disconnected, the terminal blocks can be removed one at a time by lifting them off using your finger tips. When removing a terminal block, never pull on the wires connected to the terminal block.

Wires for the fixed mounted power terminals should be stripped 5-6 mm (0.22 in) long. Wire for the pluggable I/O terminals should be stripped 8-9 mm (0.33 in) long.

When a bulkhead enclosure is required, all electrical connections must be made through the gland plates provided on the bottom of the bulkhead mount enclosure to the terminal blocks inside (see Figure 3-2).

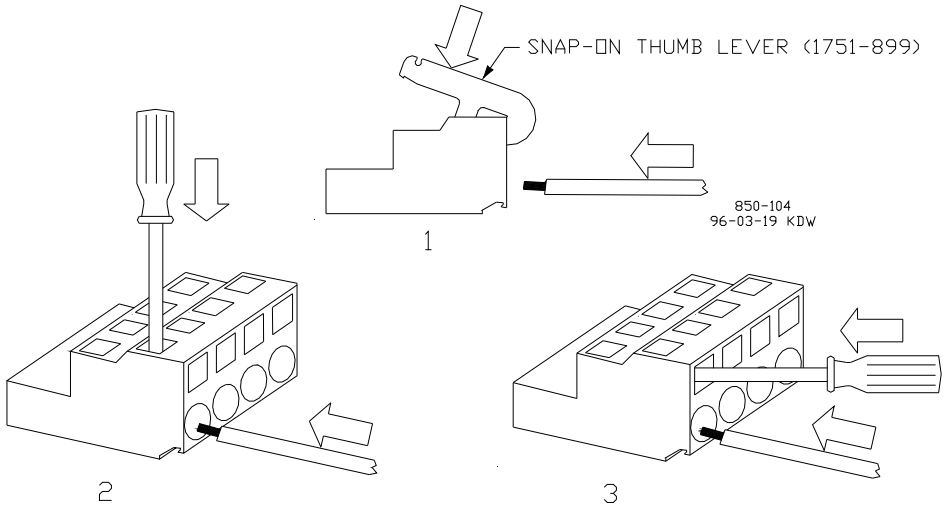


Figure 3-5. CageClamp Terminal Blocks

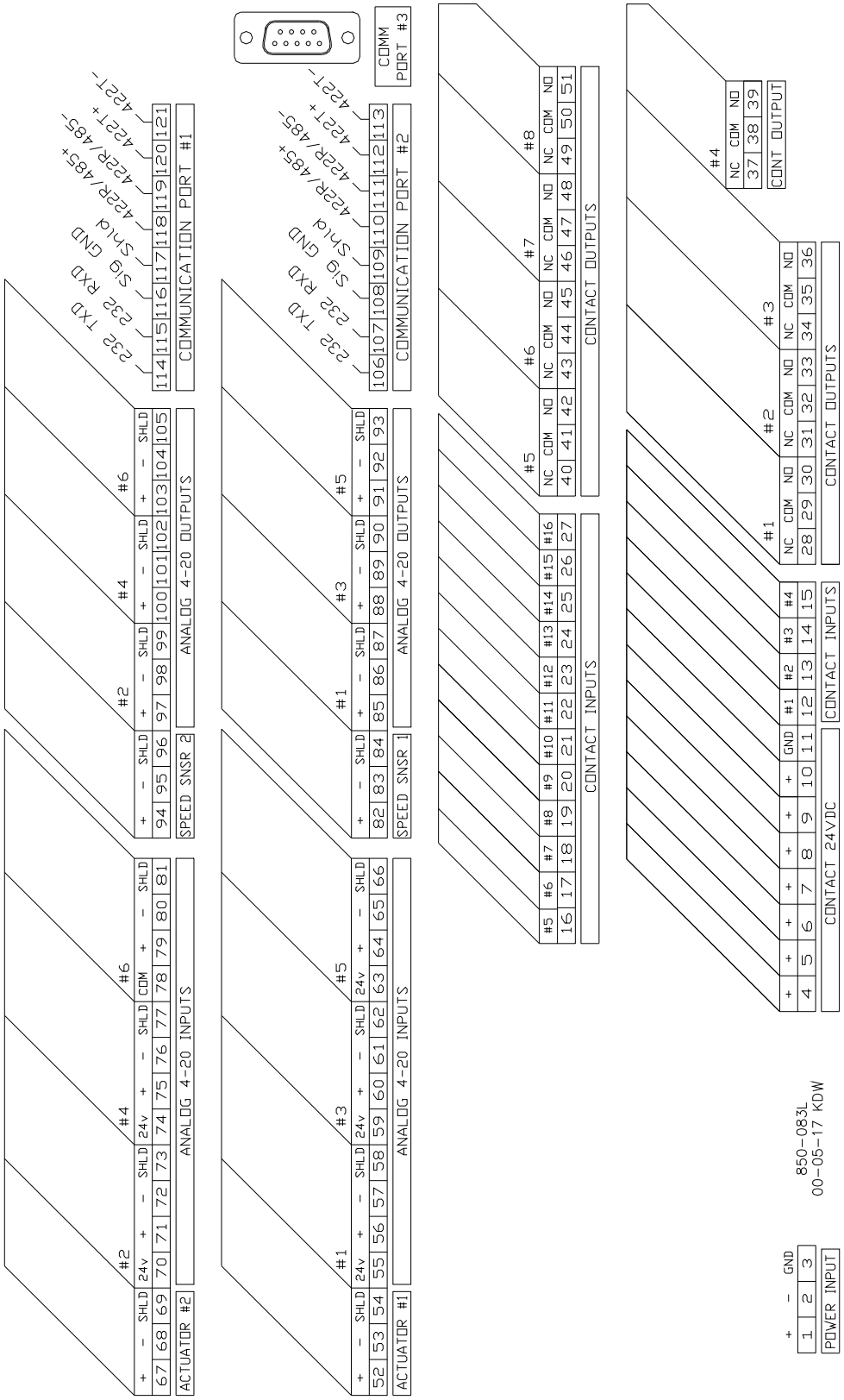


Figure 3-6. Control Wiring Diagram

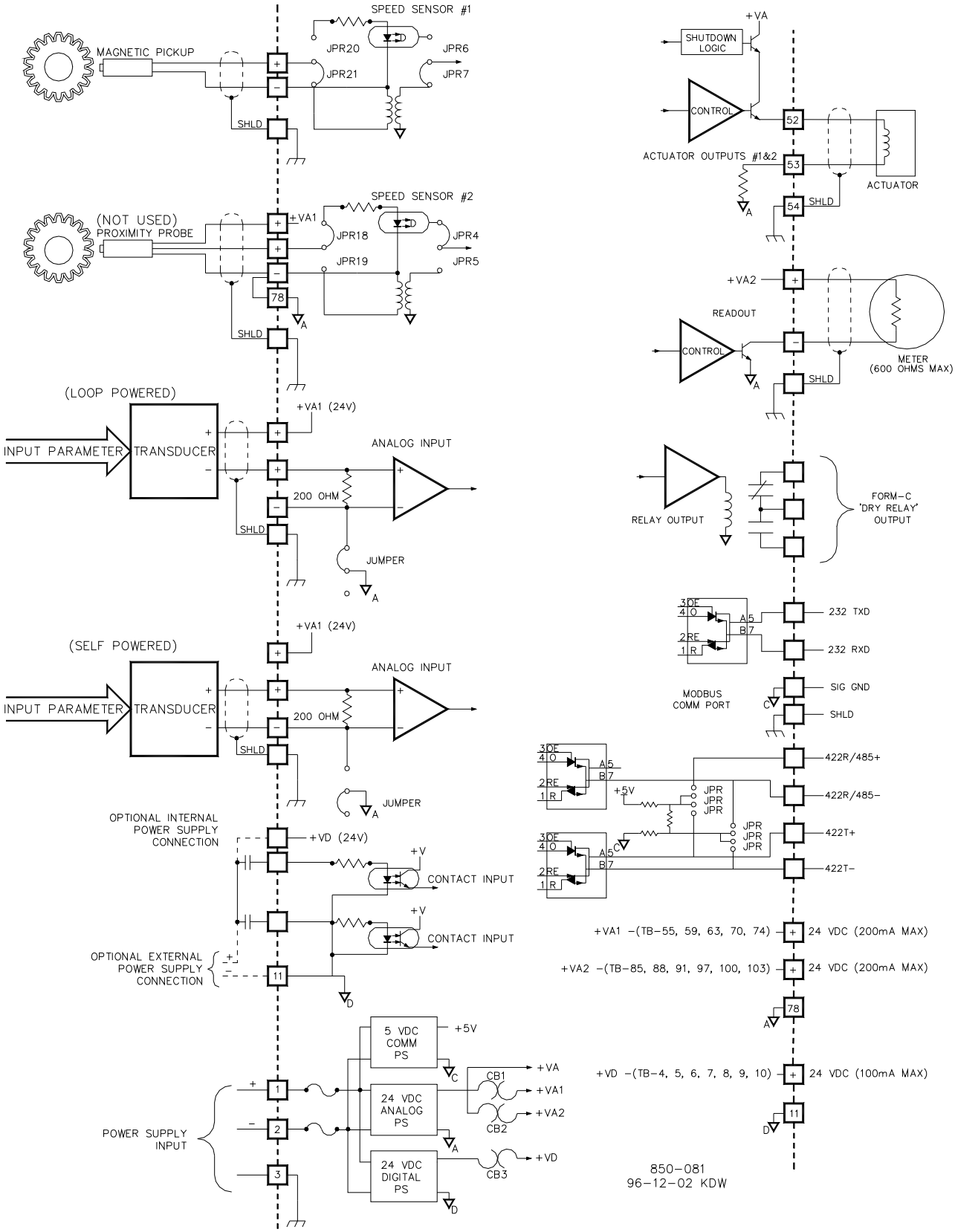


Figure 3-7. Representative 505LST I/O Schematic

Power Supplies

The 505LST is available with three different input power source selections. The part number of the 505LST depends on the rating of the input power source it can accept. The ratings of the required input power source on each unit can be identified by the back panel sticker or control part number. The sticker shows the correct source power ratings for each unit by a punched hole next to the rating.

The 505LST's input power supply terminal blocks accept wires from 0.08 to 2.5 mm^2 (27 to 12 AWG). Internal fuses, in series with each input power path, are used to protect the 505LST's input circuitry. All fuses are rated as slow-blow type fuses. These fuses are located on its power supply module (bottom module) and are accessed by removing the 505LST's back cover. Refer to Figure 3-8 for fuse locations. The ratings for the 505LST's power requirement and internal fuse sizes are:

Power Supply	Fuse and power rating
18-32 Vdc	6.25 A internal fuse, 77 VA maximum draw
88-132 Vac @ 47-63 Hz or 90-150 Vdc	2.5 A internal fuse, 143 VA maximum draw

Each 505LST requires a power source capable of a certain output voltage and current. In most cases this power rating is stated in Volt-Amps (VA). The maximum VA of a source can be calculated by taking the rated output voltage times the maximum output current at that voltage. This value should be greater than or equal to the 505LST's VA requirement.

505LST power supply holdup times are determined by the 505LST power supply and input power used. The times listed below are based on worst-case conditions (i.e. 88 Vac with a possible range of 88-132 Vac when power is lost). These holdup times should be used when the 505LST is powered by an Uninterruptible Power Source (UPS) to evaluate if the UPS's switchover time is quick enough avoid a system trip. A UPS's switch-over time must be less than the specified holdup times below:

Power Supply	Hold-up time
18-32 Vdc	14 milliseconds
88-132 Vac @ 47-63 Hz or 90-150 Vdc	30 milliseconds

A 24 V power supply is available within the 505LST to power external transducers or devices. This supply has two breaker-protected output channels. One power supply channel (VA1) is capable of providing 24 Vdc ±10%, @ 200 mA maximum output current to power 505LST current inputs and auxiliary devices. Power connections can be made through terminals 55, 59, 63, 70, and 74 with terminal 78 as the common. Refer to Figure 3-7.

⚠WARNING

The total current draw through terminals 55, 59, 63, 70, and 74 cannot exceed 200 mA or the 505LST's internal power supply breaker (CB1) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.

The second power supply channel is capable of providing 24 Vdc ±10%, @ 200 mA maximum output current, to power 505LST current outputs and auxiliary devices. Power connections can be made through terminals 85, 88, 91, 97, 100, and 103 with terminal 78 as the common. Refer to Figure 3-7.

WARNING

The total current draw through terminals 85, 88, 91, 97, 100 and 103 cannot exceed 200 mA or the 505LST's internal power output breaker (CB2) will open resulting in a possible CPU reset and trip condition. If this occurs, all load must be removed from the specified terminals to allow the breaker to reset.

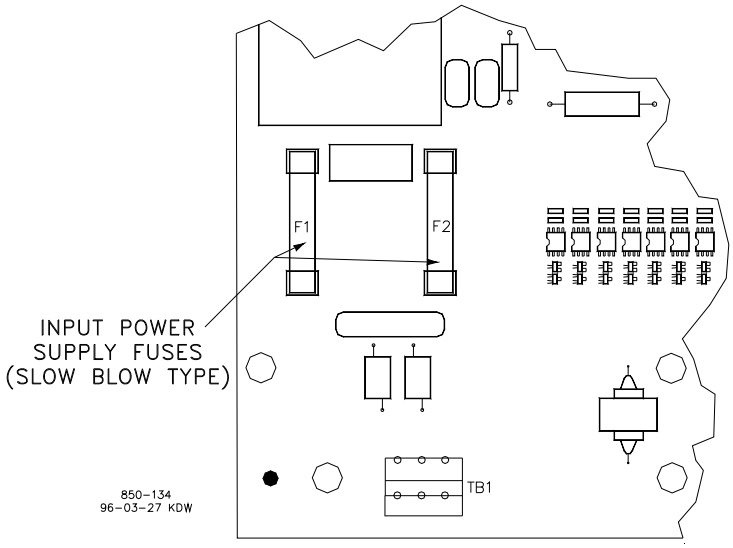


Figure 3-8. Fuse location

Shields and Grounding

Individual shield termination is provided at the terminal block for each of the speed sensor inputs, actuator outputs, analog inputs, analog outputs, and communications ports. All of these inputs should be wired using shielded, twisted-pair wiring. The shields should be connected to earth ground at the control terminal block following industry-standard practices. The exposed wire length, beyond the shield, should be limited to one inch. Refer to Figure 3-9.

Relay outputs, contact inputs, and power supply wiring do not normally require shielding, but can be shielded if desired.

For EMI reasons, it is recommend that all low-current wires (terminals 52 through 121) are separated from all high-current wires (terminals 1 through 51). Input Power ground terminal #3 should also be wired to external ground. Refer to Figure 3-7.

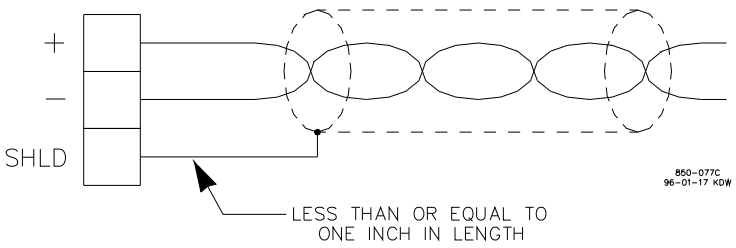


Figure 3-9. Shielded Wire Connections

Speed Sensor Inputs

To sense speed, the control accepts signals from one or two passive Magnetic Pickup Units (MPUs) mounted adjacent to a gear which is connected or coupled to the turbine's rotor.

A passive MPU provides a frequency output signal corresponding to turbine speed by sensing the movement of a gear's teeth past the MPUs pole piece. The closer the MPUs pole piece is to a gear's teeth and the faster the gear turns the higher a passive MPUs output amplitude will be. The 505LST must sense an MPU voltage of between 1 and 25 Vrms for proper operation.

With proper MPU, gear size and MPU-to-gear clearance, speed measurement should be capable down to 100 Hz. Standard MPU clearance is recommended to be 0.25 to 1.02 mm (0.010 to 0.040 in) from tooth face to pole piece. For information on selecting the correct MPU or gear size please refer to Woodward manual 82510. See Figure 3-7 for the wiring schematic.

It is not recommended that gears mounted on an auxiliary shaft coupled to the turbine rotor be used to sense turbine speed. Auxiliary shafts tend to turn slower than the turbine rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes it is also not recommend that the speed-sensing device senses speed from a gear coupled to the generator side of a system's rotor coupling.

Both speed sensing inputs use the same programmed gear ratio and number of teeth to calculate speed, thus the speed probes used should sense speed from the same gear.

The 505LST can be programmed to sense only one speed input signal. However, it is recommended that the 505LST is programmed to sense two speed inputs, and that two speed probes are used with all applications to increase system reliability.

IMPORTANT

The speed signal that the 505LST can accept must be within the following limits:

(T x M x R) / 60 must be < 15000 Hz

T = Gear Teeth
M = Overspeed Test Limit Setting
R = Gear Ratio

If the signal is not within these limits, the 505LST will respond with a speed sensor frequency error during the program checking procedure.

Contact Inputs

In general, contacts must change state for a minimum of 15 milliseconds for the control to sense and register a change in state. All contact inputs accept dry contacts. Contact wetting voltage is available through terminals 4, 5, 6, 7, 8, 9, and 10. If desired, an external 18-26 Vdc power source can be used for the circuit wetting voltage. In this case terminal 11 (contact input common) must be connected to the external power source's common to establish a common reference point. Each contact input draws 2.5 mA when closed and requires at least 1 mA and 14 V to recognize a closure command. See Figures 3-6 and 3-7 for wiring information, and Volume #2 for input specifications.

⚠WARNING

The total current draw through terminals 4, 5, 6, 7, 8, 9, and 10 cannot exceed 100 mA or the 505LST's internal power output breaker (CB5) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.

The raise and lower speed setpoint contact inputs can be used to remotely raise and lower the parameter in control.

The Generator Breaker contact must be wired so it is closed when the generator breaker is closed.

Analog Inputs

All analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. Jumpers are available to match the analog input circuit to the transducer being interfaced with, or the power supply common may be jumpered on the terminal block. Verification of jumper location is recommended before system startup or operation. See Table 3-1 for jumper options and Figure 3-4 for jumper locations. All six analog inputs have an input impedance of 200 Ω.

Because inputs 1 to 5 are not fully isolated, care must be taken in their application and maintenance to avoid "ground-loop"-type problems. If interfacing to a non-isolated device with one of these inputs, the use of a loop isolator is recommended to break any return current paths (these can result in erroneous readings).

Analog input six is a fully isolated input and is designed to be used with a non-isolated source such as a Distributed Control System (DCS). This input does not use or have jumpers for hardware configuration options. Refer to Figure 3-7, Self Powered Input, for correct wiring configuration.

Analog Outputs

Applications using a 505LST current output must use the assigned analog value. The analog output connections for the 505LST are shown in Figure 3-7. All 505LST analog outputs can drive a maximum of 600 Ω including wiring.

Actuator Outputs

Two actuator outputs are available and programmable to interface with 4–20 mA based actuators (refer to Table 3-2).

Each actuator output can be individually configured to interface with Woodward or non-Woodward actuators. Actuator drive current is selected in Program Mode. Maximum impedance for each 4 to 20 mA actuator output driver is 360 Ω (actuator impedance + wire resistance).

Each actuator driver senses the drive current to allow over-current and under-current shutdowns.

Table 3-2. Actuator Driver Limits

Driver Limits	4–20 mA Range
Over current	26 mA
Under current	0.6 mA
Max Output Current Range	2–24 mA
Max Output Impedance	360 Ω
Min Stop Adjust Range	2-20 mA
Max Stop Adjust Range	10–24 mA

To ensure proper control to actuator resolution do not calibrate the span of the actuator demand to less than a range of 12 mA (4–20 mA output). If necessary, the actuator to valve linkage may need to be adjusted to ensure proper 505LST to valve resolution.

Relay Outputs

There are eight relay outputs available from the 505LST. All relay contacts are Form C type contacts and are rated at:

- 5 A @ 28 Vdc, resistive load
- 0.5 A @ 115 Vac, resistive load

IMPORTANT

Before installation verify that the 505LST's relay contacts meet the power requirements of the circuit with which it is being interfaced. Interposing relays are required, in cases where the interfaced circuit demands relay contacts with a higher power rating. If interposing relays are required, it is recommended that interposing relays with surge (inductive kick-back) protection be used. Improper connection could cause serious equipment damage.

Serial Communications

There are three serial communications ports on the 505LST. The DCS and HMI ports are for Modbus communications and can be configured for RS-232, RS-422, or RS-485 communications. Figures 3-10, 3-11, and 3-12, show the communications port connections for ports #1 and #2. The DCS and HMI ports are accessed though terminal blocks located on the 505LST's back side. RS-422 and RS-485 communication lines can function up to a length of 1220 m (4000 ft). Refer to Chapter 8 Communications for a list of all the commands and parameters available through ports 1 and 2. Port 3, utilizing a 9-pin Sub-D connector, is dedicated for uploading and downloading unit configuration values.

Program Mode can not be accessed through the communication ports. Program configuration must be done from the keypad on the front of the control.

Modbus Wiring

The 505LST control can communicate with two devices via RS-232, RS-422 or RS-485 using an ASCII or RTU Modbus transmission protocol. The communications port is brought out to terminal blocks for wiring. Each communications mode is wired to different terminals. The following sections identify the terminal landings required for each mode.

RS-232 Wiring

A RS-232 link is limited to a distance of 15.25 m (50 ft). The 505LST control uses terminal blocks 114-117 and 106-109 for RS-232 connections. Figure 3-10 shows typical RS-232 communications connection. The transmit data (TXD), receive data (RXD), and signal ground (SIG GND) must be properly connected as shown. In addition the shield (SHLD) should be connected in at least one location.

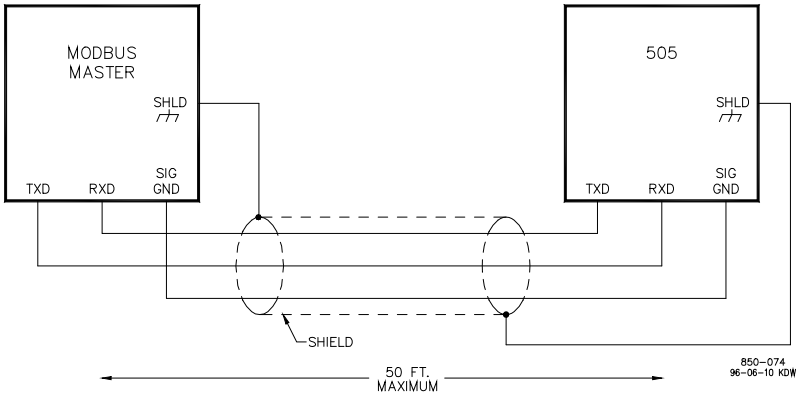


Figure 3-10. Typical RS-232 Communications

RS-422 Wiring

An advantage of RS-422 communications is that it uses a differential voltage and can accommodate much longer transmission distances (up to 1220 m [4000 ft]). The 505LST control use terminal blocks 108-113 and 116-121 for RS-422 connections. Figure 3-11 shows a typical RS-422 communications connection. The transmit data pairs (422T+ and 422T–), receive data pairs (422R+ and 422R-), and signal ground (SIG GND) must be properly connected as shown in Figure 3-11. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505LST control has termination resistors built-in. See the jumper option chart (Table 3-1) to connect the termination resistor.

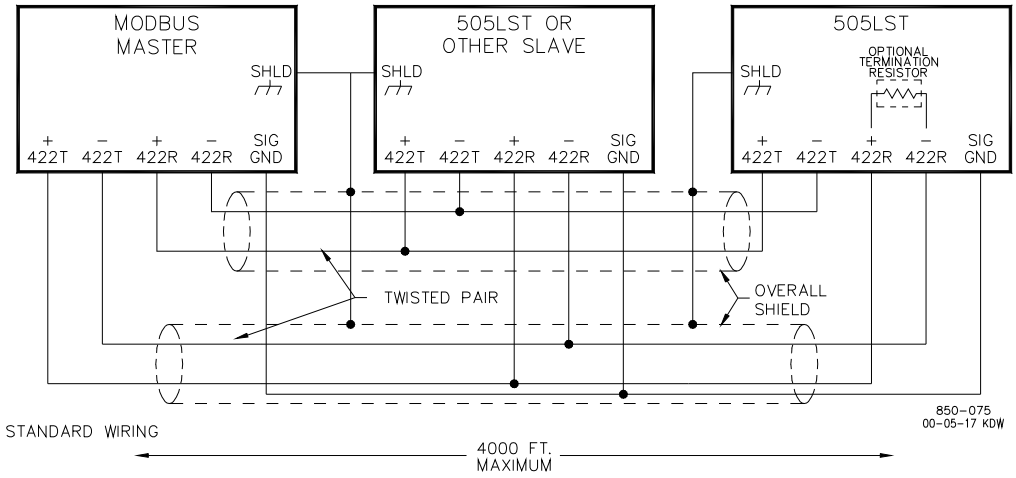


Figure 3-11. Typical RS-422 Communications

RS-485 Wiring

RS-485 communications can also accommodate transmission distances of up to a distance of 1220 m (4000 ft). The 505LST control utilizes terminal blocks 108-111 and 116-119 for RS-485 connections. Figure 3-12 shows a typical RS-485 communications connection. The data lines (422R+/485+ and 422R–/485–) and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505LST control has termination resistors built-in. See the jumper option chart (Table 3-1) to connect the termination resistor.

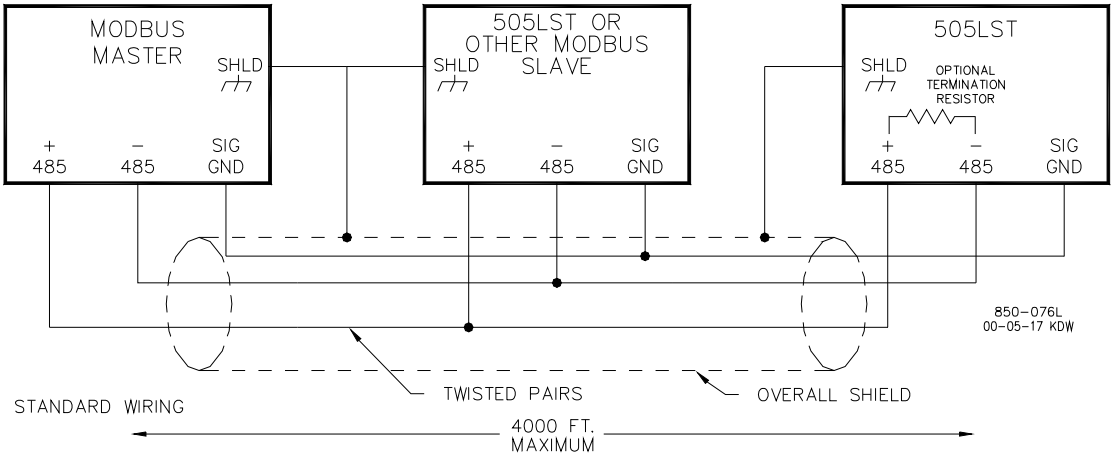


Figure 3-12. Typical RS-485 Communications

Communications Grounding and Shielding

All three 505LST communications ports are fully isolated from earth ground. The RS-422 and RS-485 specifications state that a ground wire is needed if there is no other ground path between units. the preferred method to do this for isolated ports is to include a separate wire in the ground cable that connects the circuit grounds together. Connect the shield to earth ground in at least one location, see Figure 3-13.

Non-isolated nodes may not have a signal ground available. If signal ground is not available, use the alternate wiring scheme shown in Figure 3-14. The alternate way is to connect all circuit grounds of isolated nodes to the shield, and then connect the shield to earth ground at a non-isolated node.

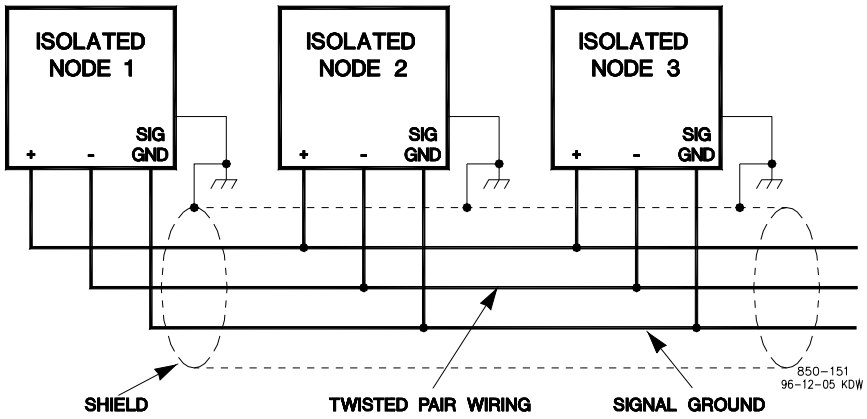


Figure 3-13. Preferred Multipoint Wiring with a Separate Signal Ground Wire

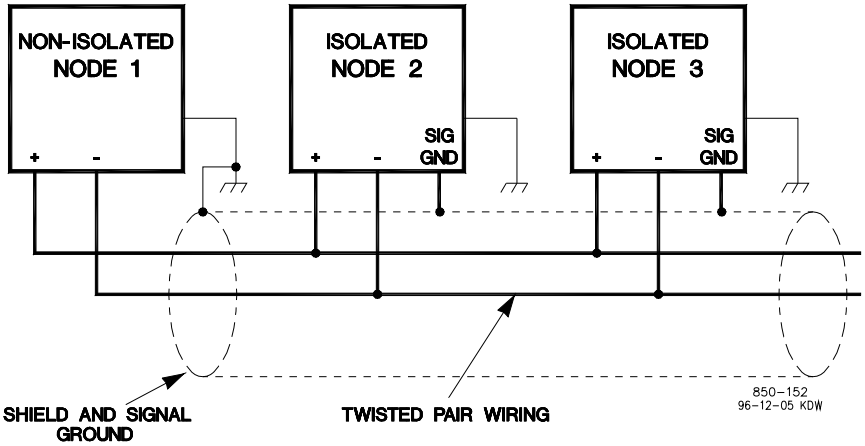


Figure 3-14. Alternate Multipoint Wiring without a Separate Signal Ground Wire

Chapter 3.
Configuration Procedures

Program Architecture

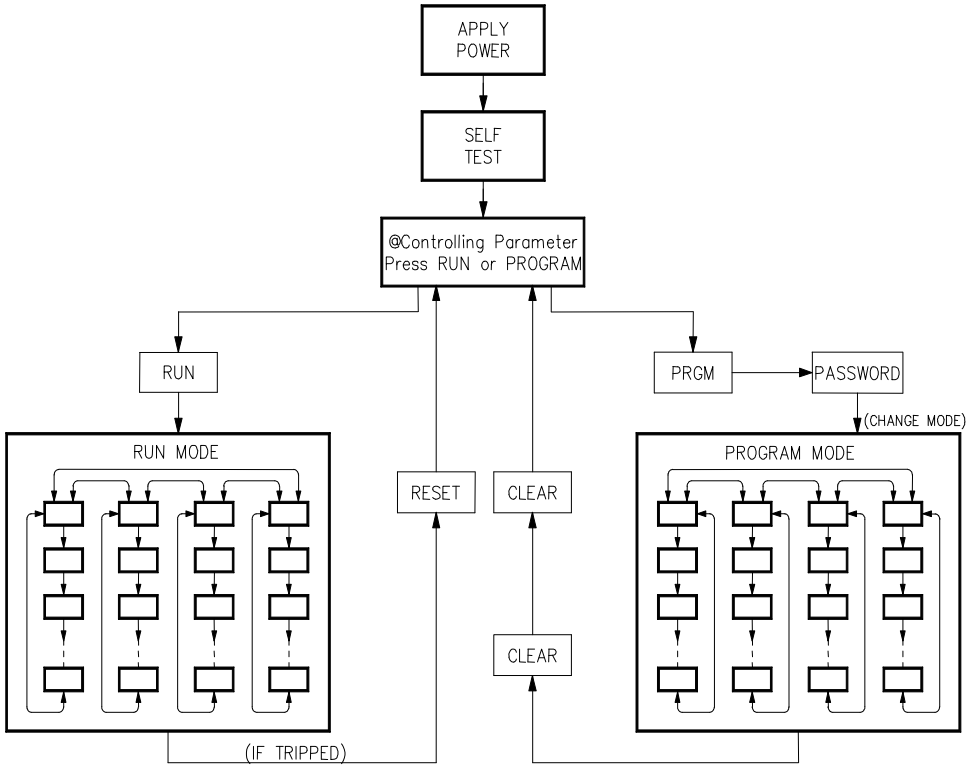


Figure 4-1. Basic Program Architecture

The 505LST is easy to program, due mainly to its menu-driven software. Basic program architecture is illustrated in Figure 4-1. When the control is powered up, and after the brief CPU self test has been completed, the control displays WOODWARD GOVERNOR CO. The operating procedures are divided into two sections: the Program Mode and the Run Mode (refer to Chapter 4 505LST Operation for Run Mode information). Program Mode is used to configure the 505LST for the specific application and set all operating parameters. Run Mode is the normal turbine operation mode and is used to view operating parameters and operate the turbine.

The touch keypad has several dual-function keys. Pushing any dual-function key in the Program Mode enters the appropriate numeric or yes/no value printed on the key. Pushing the key in the Run Mode enters the operating parameter printed on the key, unless the “ENTER” key has been pressed to enter a specific numeric setpoint value.

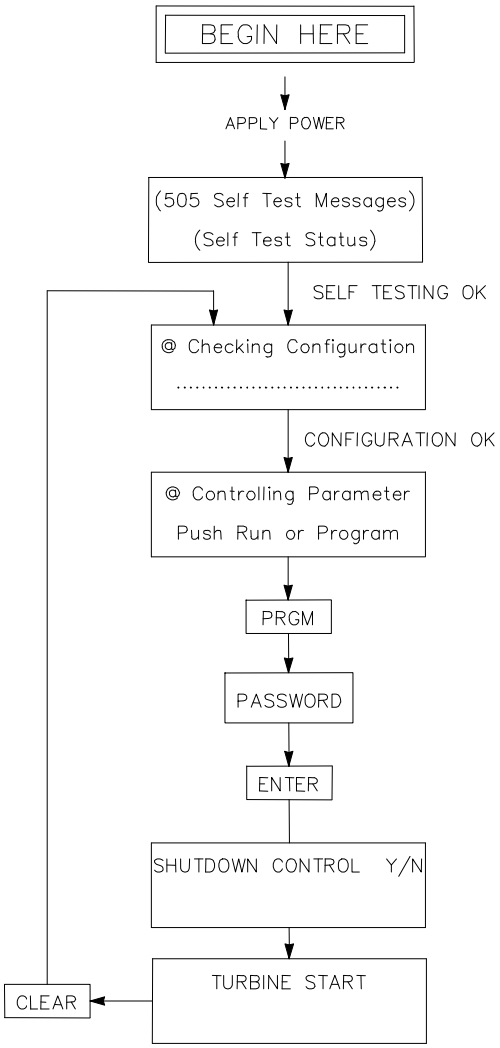


Figure 4-2. Initial 505LST Program Mode Entry

Programming the 505LST

Although the 505LST has been preprogrammed to run with default values, it should be configured with application-specific values for your turbine. The 505LST Program Mode can be accessed once the configuration check is complete and the turbine is not running. By pressing the PRGM key and entering the password then pressing ENTER on the 505LST keypad the SHUTDOWN CONTROL Y/N prompt will appear. If YES is pressed the 505LST issues a shutdown and Program Mode is accessed. If NO is pressed the 505LST reverts to the Select Mode screen and Program Mode will not have been accessed.

All configuration values and saved service mode changes are stored in the non-volatile memory (EEPROMs) of the 505LST control. If power is removed from the 505LST all saved values return when power is restored. No batteries or back up power supply are required.

NOTICE

The field-configured portion of the program is reset to the default values after factory repair. To prevent damage to your equipment, you must reconfigure the Program Mode before the unit is put back into service.

Using Program Menus

Once Program Mode has been entered with the password (refer to the Appendix), the specific application information must be entered into the 505LST. The arrow keys (SCROLL LEFT, SCROLL RIGHT) allow you to move right or left across the tops of the Program mode columns. The SCROLL UP and SCROLL DOWN keys allow you to move up or down the columns.

The control displays default or previously entered values of each program step. If a displayed value is satisfactory, press the SCROLL UP, SCROLL DOWN, or ENTER keys to continue. If a new value is required, enter it, then press ENTER. The ENTER key must be pressed to enter any new value. When the ENTER key is pressed, the control automatically advances to the next step.

To return to the header of a program block, press the CLEAR key. To completely exit out of Program Mode, press the CLEAR key from the top of the header. This will save the programmed values.

All control program questions are displayed on the top line of the display; all entries made are displayed on the lower line of the display. At the beginning of each column the control displays the header, and pushing scroll down accesses the column.

Exiting the Program Mode

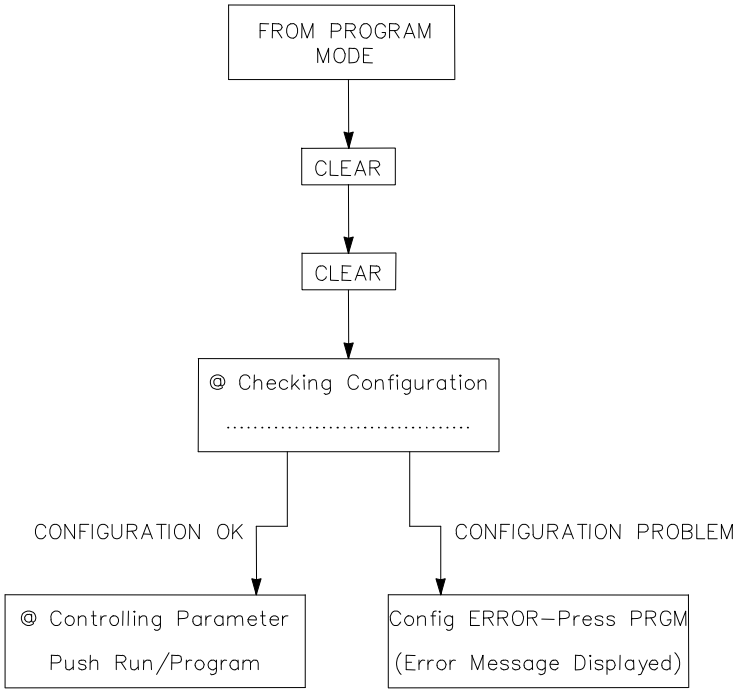


Figure 4-3. Exiting the Program Mode

Once the programming steps have been completed, Program Mode can be exited (refer to Figure 4-3). To exit Program Mode press the “CLEAR’ key twice. This initiates the 505LST to save the configuration.

NOTICE

Press the CLEAR key twice to permanently save any settings into the 505LST. If variables are tuned or changed but not stored in EEPROM by pressing the CLEAR key twice, those changes will be lost if power is removed from the control or if the control receives a CPU reset.

Program Blocks

The list below shows the configuration headers that are in this program. To program the control, simply step through the blocks as described above and configure the control features for the desired application.

Configuration Blocks	To configure
Turbine Type Header	Valving type, and I/O associated with valves
Turbine Start Header	Start mode, idle/rated, and auto start sequence settings
Speed Configure Header	MPU information, speed setpoints, and overspeed trip setpoint
Driver Configuration Header	Driver outputs, limit switches and valve tests
Control Function Configuration HeaderControl functions (Throttle pressure)	
Feedback Inputs Configuration HeaderAnalog input options and ranges	
Critical Speeds Configuration HeaderCritical speed ranges options	

Valve Limit Ramp Rates
Configuration Header Valve limit rates
VPC Ramp Rates Configuration
HeaderValve limit rates
XFR Ramp Rates Configuration
HeaderValve limit rates
Readouts Configuration Header Analog output ranges
Port Configuration Header Modbus communication options
Alarm Trip Screens Block Automatic alarm and trip screen

Each of the program blocks are described in detail below. After a column has been configured and the display is back at the top of the column, use the left or right arrow keys to select the next column to configure or check.

All control program questions are displayed on the top line of the display; all entries made are displayed on the lower line of the display. At the beginning of each column the control displays the header, pushing scroll down accesses the column.

The program blocks contain information detailing each question and/or 505LST program configuration option. Each question/option shows the default (dflt) value and the adjustable range of that parameter (shown in parentheses). In addition, any additional constraints on the configuration are shown in italics following the description.

Program Headers

Turbine Type Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the header.

SELECT I/O TYPE dflt = 1 (1,2,3)
Enter the appropriate I/O type from 1 to 3. The number chosen will reflect the turbine type that will be controlled. The control will automatically configure the valve outputs and I/O. Enter the number followed by ENTER. The program then steps back to TURBINE TYPE HEADER.

Refer to Chapter 1 to understand and select the appropriate turbine type functionality for your application.

Turbine Start Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the header.

USE SEMI AUTO? dflt = NO (Yes/No)
Enter YES followed by ENTER if this function is desired. If NO is selected followed by ENTER, the program steps to the next block. If this function is programmed, then a HMI or DCS is used to bring the turbine up to rated speed. The operator enters a target and selects GO to start ramping the speed reference to the desired target. If YES is selected the program steps back to TURBINE START HEADER.

USE AUTO START? dflt = YES (Yes/No)
Enter YES followed by ENTER if this function is desired. If NO is selected followed by ENTER, the program steps back to the TURBINE START HEADER. If this function is programmed and GO/RUN is selected, the 505LST automatically accelerates the speed setpoint to a programmable idle speed and holds for a programmable rated speed setpoint. The start sequence can be continued or stopped through the keypad, Modbus, or an external switch. If YES is selected the program steps to the next block.

LOW IDLE SETPT (RPM) dflt = 1000 (250, 3600)
Enter the Low Idle Speed Setting followed by the ENTER key. This is the hold speed when using the automatic start sequence. The speed setpoint remains at this setting until the RUN/GO button is pressed. When the ENTER key is pressed the program steps back to TURBINE START HEADER.

Speed Configure Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the header.

TEETH SEEN BY MPU dflt = 60.0 (1, 300)
Enter the number of teeth on the gear that the speed probe is mounted on followed by the ENTER key. The program then steps to the next block.

MPU GEAR RATIO dflt = 1.0 (0.05, 100)
Enter the speed sensor gear ratio followed by the ENTER key. This value is the ratio of the speed sensor gear to the turbine shaft. This gear ratio is the result of dividing the speed of the speed sensor gear by the speed of the turbine shaft. The program then steps to the next block.

USE SPEED INPUT #2? dflt = YES (Yes/No)
Select YES followed by ENTER if both speed inputs are to be used. The program then steps to the next block.

VP MPU OVRD DISBLE dflt = 19.0 (0.0, 100)
Set the maximum governor valve demand signal where speed should be sensed followed by the ENTER key. This is the governor demand signal percentage that if speed is not sensed (above 150 rpm) a no speed sensed trip will occur. The program then steps to the next block.

MAX SPEED STPT (RPM) dflt = 4032 (3610, 4500)
Set the maximum control speed followed by the ENTER key. This is the normal governor operation upper limit. For turbine/generator applications, this value must be at least equal to [Rated Speed + (Droop % x Rated Speed)]. Make sure to set this speed above the mechanical overspeed point, to ensure proper testing of the overspeed. The program then steps to the next block.

RATED SPEED (RPM) dflt = 3600 (1800, 3600)
Enter the Rated Speed Setting followed by the ENTER key. If using the automatic start sequence, this is the final speed setting. Once this speed setpoint is reached, the start sequence is complete. The program then steps to the next block.

SPEED DROOP (%) dflt = 5.0 (0.0, 10)
Enter the droop percentage followed by the ENTER key. Used to set frequency regulation, typically set between 4-6% and not more than 10%. The program then steps to the next block.

OVERSPEED SETPOINT (RPM) dflt = 3888 (2000, 4500)
Set the 505LST's overspeed trip level (in rpm) followed by the ENTER key. This is the governor overspeed trip setpoint only and is not to be used as ultimate overspeed protection. The program then steps to the next block.

BACKUP OVERSPD SETPT (RPM) dflt = 4000 (2000, 4500)
Set the 505LST's backup overspeed trip level (in rpm) followed by the ENTER key. This is the governor backup overspeed trip setpoint only and is only available when doing a mechanical overspeed trip test. It is not to be used as ultimate overspeed protection. The program then steps to the next block.

SPEED GV CLAMP TO 100 (RPM) dflt = 3636 (3600, 3800)
Set the 505LST's GV clamp at 100% (in rpm) followed by the ENTER key. This is the speed that the 505LST starts to close the control valves to help prevent an overspeed trip. 3636 means that the valves start to close at 101%. This assumes a rated speed of 3600. The program then steps to the next block.

SPEED GV CLAMP AT 0 (RPM) dflt = 3780 (3600, 3800)
Set the 505LST's GV clamp at 0% (in rpm) followed by the ENTER key. This is the speed that the 505LST will have driven the control valves completely closed to help prevent an overspeed trip. 3780 means that the valves will be closed at 105%. This assumes a rated speed of 3600. The program then steps to the next block.

SPEED IV CLAMP AT 100 (RPM) dflt = 3636 (3600, 3800)
Set the 505LST's IV clamp at 100% (in rpm) followed by the ENTER key. This is the speed that the 505LST will start to close the control valves to help prevent an overspeed trip. This value is not used on turbine type 1, only on turbines with modulating intercept valves. 3636 means that the valves will start to close at 101%. This assumes a rated speed of 3600. The program then steps to the next block.

SPEED IV CLAMP AT 0 (RPM) dflt = 3690 (3600, 3800)
Set the 505LST's IV clamp at 0% (in rpm) followed by the ENTER key. This is the speed that the 505LST will have driven the control valves completely closed to help prevent an overspeed trip. This value is only used on turbines with modulating intercept valves, and is not used on turbine type 1. 3690 is the speed at which the valves close. The program then steps to the next block.

SLOW SPEED RATE (RPM/MIN) dflt = 100 (0, 500)
Enter the slow speed rate in rpm per minute followed by the ENTER key. This the rate of speed change when slow is selected. Slow rate is always automatically selected after the turbine trips. The program then steps to the next block.

MEDIUM SPEED RATE (RPM/MIN) dflt = 200 (0, 500)
Enter the medium speed rate in rpm per minute followed by the ENTER key. This is the rate of speed change when medium is selected. The program then steps to the next block.

FAST SPEED RATE (RPM/MIN) dflt = 400 (0, 500)
Enter the fast speed rate in rpm per minute followed by the ENTER key. This is the rate of speed change when fast is selected. The program then steps to the next block.

CRITICAL SPEED RATE (RPM/MIN) dflt = 500 (0, 1000)
Enter the critical speed rate in rpm per minute followed by the ENTER key. This is the rate of speed change anytime the speed reference is in a configured critical speed range. This speed rate is not used if no critical speeds have been configured. The program then steps to the next block.

SPEED P GAIN dflt = 5.000 (0.0, 50)
Enter the Speed PID proportional gain percentage followed by ENTER. This value is used to set speed control response when the Generator or Utility Tie breaker contacts are open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.500 (refer to Chapter 7 PID Tuning). The program then steps to the next block.

SPEED I GAIN dflt = 0.500 (0.0, 50)
Enter the Speed PID integral gain percentage followed by ENTER. This value is used to set speed control response when the Generator or Utility Tie breaker contacts are open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is .200. Refer to Chapter 7. The program then steps back to the SPEED CONFIGURATION HEADER.

Driver Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

2 GOVERNOR VALVES? dflt = YES (yes/no)
Enter yes followed by ENTER if turbine has two modulating Governor (control) valves. If YES is selected, the control is configured to drive 2 outputs for the Governor valves. The program then steps to the next block.

2 THROTTLE VALVES? dflt = YES (yes/no)
Enter yes followed by ENTER if turbine has two modulating Throttle (stop) valves. If YES is selected the control is configured to drive 2 outputs for the throttle valves. The program then steps to the next block.

USE L TV LIMIT SWITCHES? dflt = YES (yes/no)
Enter YES followed by ENTER if limit switches are to be used for valve testing. If YES is selected the control is configured to use discrete inputs to determine if the left throttle valve is opened or closed. If NO is selected testing may still be accomplished if there is an analog input configured for this valve position. The program then steps to the next block.

USE R TV LIMIT SWITCHES? dflt = YES (yes/no)
Enter YES followed by ENTER if limit switches are to be used for valves testing. If YES is selected the control is configured to use discrete inputs to determine if the right throttle valve is opened or closed. If NO is selected testing may still be accomplished if there is an analog input configured for this valve position. The program then steps to the next block.

USE IVRV LIMIT SWITCHES? dflt = YES (yes/no)
Enter yes followed by ENTER if limit switches are to be used for valve testing. If YES is selected the control is configured to use discrete inputs to determine if the intercept and reheat valves are opened or closed. If NO is selected testing may still be accomplished if there is an analog input configured for these valve positions. The program then steps to the next block.

ENABLE TV TESTS? dflt = YES (yes/no)
Enter YES followed by ENTER to enable valve testing in the control. If YES is selected the operator will be able to perform the throttle valve tests. If NO is selected all throttle valve testing is disabled. If external valve testing is to be performed NO should be selected here. If YES is selected and turbine type 1 is selected, the control performs a combined Governor and Throttle valve test. If 1 Governor valve is selected in configuration, during valve testing only the selected T+T valve will be stroked. The program then steps to the next block.

ENABLE TV LIMITER? dflt = NO (yes/no)
Enter YES followed by ENTER to enable the Throttle Valve Limiter. If YES is selected the operator will be able to use the throttle valve limiter. If NO is selected the throttle valve limiter is disabled. The program then steps to the next block.

ENABLE IV RHV TESTS? dflt = YES (yes/no)
Enter YES followed by ENTER if limit switches are to be used for valve testing. If YES is selected the control is configured to use discrete inputs to determine if the right throttle valve is opened or closed. If NO is selected testing may still be accomplished if there is an analog input configured for this valve position. If YES is selected and turbine type 2 or 3 is selected, the control will perform a combined Intercept and Reheat valve test. The program then steps to the next block.

GV POS AS IVRV TEST PERM? dflt = NO (yes/no)
Enter YES followed by ENTER if Governor Valve position is to be a permissive for the intercept/reheat valve testing. If YES is selected the control uses a configured MIN and MAX governor valve position as a permissive to begin intercept and reheat valve testing. If NO is selected testing may still be accomplished, and governor valve position will not affect testing. If YES is selected the control prompts for a MIN and MAX position for valve testing. If NO is selected the control will skip past the position configuration.

MIN GV POS IVRV TEST dflt = 0 (0,100)
Enter the minimum governor valve position to be used as a permissive to test intercept/reheat test (followed by ENTER). If the governor valve goes below this value the control will not allow the intercept/reheat valves to be tested. The actual value position used is demand to the governor valves. The program then steps to the next block.

MAX GV POS IVRV TEST dflt = 100 (0,100)
Enter the maximum governor valve position to be used as a permissive to test intercept/reheat test (followed by ENTER). If the governor valve goes above this value the control will not allow the intercept/reheat valves to be tested. The actual value position used is demand to the governor valves. The program then steps to the next block.

GV POS AS TV TEST PERM? dflt = NO (yes/no)
Enter YES followed by ENTER if Governor Valve position is to be a permissive for the throttle valve testing. If YES is selected the control uses a configured MIN and MAX governor valve position as a permissive to begin throttle valve testing. If NO is selected testing may still be accomplished, and governor valve position will not affect testing. If YES is selected the control prompts for a MIN and MAX position for valve testing. If NO is selected the control skips position configuration.

MIN GV POS FOR TV TEST? dflt = 0 (0,100)
Enter the minimum governor valve position to be used as a permissive for the throttle test (followed by ENTER). If the governor valve goes below this value the control will not allow the throttle valves to be tested. The actual value position used is demand to the governor valves. The program then steps to the next block.

MAX GV POS FOR TV TEST? dflt = 100 (0,100)
Enter the maximum governor valve position to be used as a permissive fro the throttle test (followed by ENTER). If the governor valve goes above this value the control will not allow the throttle valves to be tested. The actual value position used is demand to the governor valves. The program then steps to the next block.

TV 1 TEST BY SOLENOID? dflt = NO (yes/no)
Enter YES followed by ENTER if throttle valve 1 is to be tested with a contact output (solenoid). If YES is selected the control uses a configured discrete output to test the valve. To use the solenoid output turbine type must be 2 or 3. The output is energized to test the valve, and stays energized as long as the test button is being pushed. If NO is selected testing may still be accomplished, but the valve will be modulated though the test. Selecting NO also assumes that there will be a combined governor/throttle valve test. The program then steps to the next block.

TV 2 TEST BY SOLENOID? dflt = NO (yes/no)
Enter YES followed by ENTER if throttle valve 2 is to be tested with a contact output (solenoid). If YES is selected the control uses a configured discrete output to test the valve. To use the solenoid output turbine type must be 2 or 3. The output is energized to test the valve, and stays energized as long as the test button is being pushed. If NO is selected testing may still be accomplished, but the valve will be modulated though the test. Selecting NO also assumes that there will be a combined governor/throttle valve test. The program then steps to the next block.

LEFT IVRV TEST 1 OUTPUT? dflt = NO (yes/no)
Enter YES followed by ENTER if 1 contact output is to be used to test the left intercept/reheat valves. If YES is selected the control uses a configured discrete output to test the valves. To use the solenoid output the turbine type must be 1. The output is energized to test the valves, and stays energized as long as the test button is being pushed. This output should be selected if the external combined test is to be used with this control. The program then steps to the next block.

RICHT IVRV TEST 1 OUTPUT? dflt = NO (yes/no)
Enter YES followed by ENTER if 1 contact output is to be used to test the right reheat/reheat valves. If YES is selected the control uses a configured discrete output to test the valves. To use the solenoid output turbine type must be 1. The output is energized to test the valves, and stays energized as long as the test button is being pushed. This output should be selected if the external combined test is to be used with this control. The program then steps back to the DRIVER CONFIGURATION HEADER.

Control Function Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

USE THROTTLE PRESSURE CONTROL? dflt = YES (yes/no)
Enter YES followed by ENTER if throttle pressure control is to be used. If YES is selected the control configures an analog input to be used for throttle pressure. If NO is selected throttle pressure control and throttle pressure limiter will not be available. The contact input for runback will also not be functional. The program then steps to the next block.

THROTTLE PRESSURE 4ma VALUE? dflt = 0 (-20000,20000)
Enter the 4 mA (minimum) value for the throttle pressure signal, followed by ENTER. The program then steps to the next block.

THROTTLE PRESSURE 20ma VALUE? dflt = 2000 (-20000,20000)
Enter the 20 mA (maximum) value for the throttle pressure signal, followed by ENTER. The program then steps to the next block.

THROTTLE P GAIN dflt = 5.000 (.01,5.0)
Enter the proportional gain value for the throttle pressure control, followed by ENTER. A recommended starting value is 0.100. See Chapter 7 for more details. The program then steps to the next block.

THROTTLE I GAIN dflt = 0.500 (.01,5.0)
Enter the integral gain value for the throttle pressure control, followed by ENTER. A recommended starting value is 0.150. See Chapter 7 fro more details. The program then steps to the next block.

TPC ENABLE PRESS dflt = 1500 (500,3500.0)
Enter the throttle pressure enable point for the automatic throttle pressure control, followed by ENTER. The value that is entered is the point that the throttle pressure must go above to enable the automatic throttle pressure control. The throttle pressure control does not come into control until the pressure drops below the TPC min pressure setpoint. The program then steps to the next block.

TPC MIN PRESS dflt = 1300 (500,3500.0)
Enter the throttle pressure minimum point for the automatic throttle pressure control, followed by ENTER. The value that is entered is the point that the throttle pressure must drop below to activate the automatic throttle pressure control. The throttle pressure control comes into control when the throttle pressure drops below this value (if the TPC IN/OUT is IN). The program then steps to the next block.

USE 4–20ma FOR SPD REF? dflt = NO (NO,YES)
Enter YES, followed by ENTER if 4–20 mA is to be used for speed reference. If YES is selected the control will configure the 4–20 mA for speed reference, and the next 2 blocks will configure the range. If YES is selected the value will be used in the coordinated control mode. If YES is selected the program steps to the SPEED DEMAND 4 mA block. The 4–20 mA input can be set up for both speed and valve position set-points. If NO is selected the program steps to the USE 4–20 mA FOR VPC block.

SPEED DEMAND 4ma VALUE dflt = 0 (0,3600)
Enter speed demand value (RPM) at 4 mA, followed by ENTER. The value entered will be the bottom end of the 4–20 mA speed reference. The program then steps to the next block.

SPEED DEMAND 20ma VALUE dflt = 4000 (2000,5000)
Enter speed demand value (RPM) at 20 mA, followed by ENTER. The value entered will be the top end of the 4–20 mA speed reference. This value must be larger than the 4 mA speed reference value. The maximum controlling speed will not greater than MAX SPEED SETPOINT set in the SPEED CONFIGURE section, regardless of the setting of this 20 mA value. The program then steps to the next block.

COORDINATED CONTROL OFFLINE dflt = NO (NO,YES)
Enter 'Yes' followed by 'Enter' if the unit will be operated in coordinated control offline.

USE 4–20ma FOR VPC? dflt = NO (NO,YES)
Enter YES, followed by ENTER if 4–20 mA is to be used for valve position control. If YES is selected the control configures the 4–20 mA for valve position control, and the next 2 blocks configure the range. If YES is selected the value is used in the coordinated control mode. If YES is selected the program steps to the VALVE DEMAND 4 mA block. If NO is selected the program steps to the DCS USED FOR SEMI? block.

VALVE DEMAND 4ma VALUE dflt = 0 (0,100)
Enter valve position demand value(%) at 4 mA, followed by ENTER. The value entered is the bottom end of the 4–20 mA valve demand reference. The program then steps to the next block.

VALVE DEMAND 20ma VALUE dflt = 100 (0,100)
Enter valve position value (%) at 20 mA, followed by ENTER. The value entered is the top end of the 4–20 mA valve demand reference. This value must be larger than the 4 mA valve demand reference value. The program then steps to the next block.

DCS USED FOR SEMI? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the DCS Modbus values will be used for semi auto. If YES is selected the control uses the DCS Modbus port for the speed and valve demand when in semi-auto start. If NO is selected the control uses the demands from the HMI Modbus port. The program then steps to the next block.

COORDINATED CONTROL ONLINE dflt NO = (NO,YES)
Enter 'Yes' followed by Enter to enable that the unit be operated in Coordinated control from the DCS.

USE PREWARM? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the prewarm function is to be utilized. If YES is selected the control allows the operator to stroke the valves in the SERVICE prewarm section. If NO is selected the control allows the operator to access the prewarm service section. The program then steps to the next block.

CONTACT LIMITER HI VALUE dflt = 101 (0,101)
Enter contact limiter HI value, followed by ENTER. The value entered will not allow the valve position reference to go above that value. This limiter is in effect only for contact input and front panel adjustments; coordinated 4–20 mA and Modbus reference values are not limited by this limiter. This value is also available in the SERVICE menu. The program then steps to the next block.

CONTACT LIMITER LOW VALUE? dflt = 0 (0,101)
Enter contact limiter LOW value, followed by ENTER. The value entered will not allow the valve position reference to go below that value. This limiter is in effect only for contact input and front panel adjustments; coordinated 4–20 mA and Modbus reference values are not limited by this limiter. This value is also available in the SERVICE menu . The program steps back to the CONTROL FUNCTION CONFIGURATION HEADER.

Feedback Inputs Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

USE VALVE 1 FEEDBACK? dflt = YES (NO,YES)
Enter YES, followed by ENTER if valve 1 feedback is to be used. To determine the type of valve refer to the turbine type and control wiring in the Turbine Types section in Chapter 1). If YES is selected the control uses the feedback for alarming and valve testing. If YES is selected the program steps to VLV 1 FEEDBACK 4 mA VALUE BLOCK. If NO is selected the program steps to USE VALVE 2 FEEDBACK? Block.

VLV 1 FEEDBACK 4ma VALUE dflt = 0 (-20000,20000)
Enter valve 1 position at 4 mA, followed by ENTER. The program then steps to the next block.

VLV 1 FEEDBACK 20ma VALUE dflt = 100 (-20000,20000)
Enter valve 1 position at 20 mA, followed by ENTER. This value must be larger than the 4 mA valve 1 position value. The program then steps to the next block.

USE VALVE 2 FEEDBACK? dflt = YES (NO,YES)
Enter YES, followed by ENTER if valve 2 feedback is to be used. To determine the type of valve refer to the turbine type and control wiring in the Turbine Types section in Chapter 1. If YES is selected the control uses the feedback for alarming and valve testing. If YES is selected the program steps to VLV 2 FEEDBACK 4 mA VALUE BLOCK. If NO is selected the program steps to USE VALVE 3 FEEDBACK? Block.

VLV 2 FEEDBACK 4ma VALUE dflt = 0 (-20000,20000)
Enter valve 2 position at 4 mA, followed by ENTER. The program then steps to the next block.

VLV 2 FEEDBACK 20ma VALUE dflt = 100 (-20000,20000)
Enter valve 2 position at 20 mA, followed by ENTER. This value must be larger than the 4 mA valve 2 position value. The program then steps to the next block.

USE VALVE 3 FEEDBACK? dflt = YES (NO,YES)
Enter YES, followed by ENTER if valve 3 feedback is to be used. To determine the type of valve refer to the turbine type and control wiring in the Turbine Types section in Chapter 1. If YES is selected the control uses the feedback for alarming and valve testing. If YES is selected the program steps to VLV 3 FEEDBACK 4 mA VALUE BLOCK. If NO is selected the program steps to USE VALVE 4 FEEDBACK? Block.

VLV 3 FEEDBACK 4ma VALUE dflt = 0 (-20000,20000)
Enter valve 3 position at 4 mA, followed by ENTER. The program then steps to the next block.

VLV 3 FEEDBACK 20ma VALUE dflt = 100 (-20000,20000)
Enter valve 3 position at 20 mA, followed by ENTER. This value must be larger than the 4 mA valve 3 position value. The program then steps to the next block.

USE VALVE 4 FEEDBACK? dflt = YES (NO,YES)
Enter YES, followed by ENTER if valve 4 feedback is to be used. To determine the type of valve refer to the turbine type and control wiring in the Turbine Types section in Chapter 1. If YES is selected the control uses the feedback for alarming and valve testing. If YES is selected the program steps to VLV 4 FEEDBACK 4 mA VALUE BLOCK. If NO is selected the program steps to FEEDBACK INPUT CONFIGURATION HEADER.

VLV 4 FEEDBACK 4ma VALUE dflt = 0 (-20000,20000)
Enter valve 4 position at 4 mA, followed by ENTER. The program then steps to the next block.

VLV 4 FEEDBACK 20ma VALUE dflt = 100 (-20000,20000)
Enter valve 4 position at 20 mA, followed by ENTER. This value must be larger than the 4 mA valve 4 position value. The program then steps to the FEEDBACK INPUT CONFIGURATION HEADER.

Critical Speeds Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

USE CRITICAL SPEEDS? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed avoidance is to be used. If YES is selected the control will not allow stopping inside a critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 1 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 1 LOW SETPOINT dflt = 850 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 1 HIGH SETPOINT dflt = 1000.0 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

USE CRITICAL SPEED #2? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed band #2 is to be used. If YES is selected the control will not allow stopping inside this critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 2 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 2 LOW SETPOINT dflt = 1370 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 2 HIGH SETPOINT dflt = 1460 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

USE CRITICAL SPEED #3? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed band #3 is to be used. If YES is selected the control will not allow stopping inside this critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 3 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 3 LOW SETPOINT dflt = 1800 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 3 HIGH SETPOINT dflt = 2050 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

USE CRITICAL SPEED #4? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed band #4 is to be used. If YES is selected the control will not allow stopping inside this critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 4 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 4 LOW SETPOINT dflt = 2130 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 4 HIGH SETPOINT dflt = 2430 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

USE CRITICAL SPEED #5? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed band #5 is to be used. If YES is selected the control will not allow stopping inside this critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 5 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 5 LOW SETPOINT dflt = 2500 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 5 HIGH SETPOINT dflt = 2650 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

USE CRITICAL SPEED #6? dflt = NO (NO,YES)
Enter YES, followed by ENTER if the critical speed band #6 is to be used. If YES is selected the control will not allow stopping inside this critical speed band, and the critical speed rate is used while in that speed band. If YES is selected the program steps to CRIT 6 LOW SETPOINT block. If NO is selected the program steps to the CRITICAL SPEEDS CONFIGURATION HEADER.

CRIT 6 LOW SETPOINT dflt = 2800 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the low end of this critical speed band. The program then steps to the next block.

CRIT 6 HIGH SETPOINT dflt = 3160 (500,3500)
Enter critical speed, followed by ENTER. This value is also available in the SERVICE menu. This is the high end of this critical speed band. The program then steps to the next block.

Valve Limit Ramp Rates Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

START RAMP RATE (%/MIN) dflt = 5(0,10)
Enter the start ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve limiter moves the valve reference when starting the turbine. The program then steps to the next block.

MEDIUM RAMP RATE (%/MIN) dflt = 100 (0,100)
Enter the medium ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve limiter moves when the valve limiter is used and the medium rate is selected. The program then steps to the next block.

FAST RAMP RATE (%/MIN) dflt = 200 (0,500)
Enter the fast ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve limiter moves when the valve limiter is used and the fast rate is selected. The program then steps to the VALVE LIMIT RAMP RATES CONFIGURATION HEADER.

VPC Ramp Rates Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

SLOW RAMP RATE (%/MIN) dflt = 2(0,100)
Enter the slow ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve position controller (VPC) moves the valve position reference when VPC is in control, and the slow rate is selected. The program then steps to the next block.

MEDIUM RAMP RATE (%/MIN) dflt = 3 (0,500)
Enter the medium ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve position controller (VPC) moves the valve position reference when VPC is in control, and the medium rate is selected. The program then steps to the next block.

FAST RAMP RATE (%/MIN) dflt = 10 (0,1000)
Enter the fast ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve limiter moves when the valve limiter is used and the fast rate is selected. The program then steps to the VALVE LIMIT RAMP RATES CONFIGURATION HEADER.

XFR Ramp Rates Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

SLOW RAMP RATE (%/MIN) dflt = 100(0,100)
Enter the slow ramp rate, followed by ENTER. This is the rate that the valve transfer ramp moves the valve position during a valve transfer when the slow rate is selected. The program then steps to the next block.

MEDIUM RAMP RATE (%/MIN) dflt = 200 (0,400)
Enter the medium ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve transfer ramp moves the valve position during a valve transfer when the medium rate is selected. The program then steps to the next block.

FAST RAMP RATE (%/MIN) dflt = 400 (0,600)
Enter the fast ramp rate, followed by ENTER. This value is also available in the SERVICE menu. This is the rate that the valve transfer ramp moves the valve position during a valve transfer when the fast rate is selected. The program then steps to the XFER RAMP RATES CONFIGURATION HEADER.

Readouts Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

VLV DMND 4ma OUT VALUE dflt = 0 (-20000,20000)
Enter the 4 mA out value, followed by ENTER. This value is to set up the analog output to represent valve demand. If 0 is selected the output will be at 4 mA when valve demand is at 0. The program then steps to the next block.

VLV DMND 20ma OUT VALUE dflt = 100 (-20000,20000)
Enter the 20 mA out value, followed by ENTER. This value is to set up the analog output to represent valve demand. If 100 is selected the output will be at 20 mA when valve demand is at 100. This value must be greater than the 4 mA value. The program then steps to the next block.

THROTTLE PRS 4ma OUT VALUE dflt = 0 (-20000,20000)
Enter the 4 mA out value, followed by ENTER. This value is to set up the analog output to represent actual throttle pressure. If 0 is selected the output will be at 4 mA when throttle pressure is at 0. The program then steps to the next block.

THROTT PRS 20ma OUT VALUE dflt = 2000 (-20000,20000)
Enter the 20 mA out value, followed by ENTER. This value is to set up the analog output to represent actual throttle pressure. If 2000 is selected the output will be at 20 mA when throttle pressure is at 2000. This value must be greater than the 4 mA value. The program then steps to the next block.

SPEED 4ma OUT VALUE dflt = 0 (-20000,20000)
Enter the 4 mA out value, followed by ENTER. This value is to set up the analog output to represent actual turbine speed. If 0 is selected the output will be at 4 mA when turbine speed is at 0. The program then steps to the next block.

SPEED 20ma OUT VALUE dflt = 4000 (-20000,20000)
Enter the 20 mA out value, followed by ENTER. This value is to set up the analog output to represent actual turbine speed. If 4000 is selected the output will be at 20 mA when turbine speed is at 4000. This value must be greater than the 4 mA value. The program then steps to the READOUT CONFIGURATION HEADER.

Port Configuration Header

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure. Once inside this configuration category the clear button can be pressed to step back to the HEADER.

USE DCS PORT? dflt = NO (Yes/No)
Set to YES followed by ENTER to use the DCS Port. Set to NO followed by ENTER to skip to ‘Use HMI Port’. If the displayed value is already correct, select ENTER.

BAUD RATE dflt = 9 (1, 11)
Enter the integer corresponding to the communications baud rate followed by the ENTER key. If the displayed value is already correct, select ENTER.

1 = 110	2 = 300	3 = 600	4 = 1200
5 = 1800	6 = 2400	7 = 4800	8 = 9600
9 = 19200	10 = 38400	11 = 57600	

STOP BITS dflt = 1 (1, 3)
Enter the integer corresponding to the stop bits required followed by the ENTER key. If the displayed value is already correct, select ENTER. Enter a ‘1’ for 1 stop bit, a ‘2’ for 1.5 stop bits or a ‘3’ for 2 stop bits.

PARITY dflt = 1 (1, 3)
Enter the integer corresponding to the parity required followed by the ENTER key. If the displayed value is already correct, select ENTER. Enter a ‘1’ for none, a ‘2’ for odd parity or a ‘3’ for even parity.

DRIVER dflt = 1 (1, 3)
Enter the integer corresponding to the serial communications mode required followed by the ENTER key. Enter a ‘1’ for RS-232, a ‘2’ for RS-422 or a ‘3’ for RS-485 communications. If the displayed value is already correct, select ENTER.

ASCII OR RTU dflt = 2 (1, 2)
Enter the integer corresponding to the Modbus protocol mode required, followed by the ENTER key. Enter a ‘1’ for ASCII, a ‘2’ for RTU. If the displayed value is already correct, select ENTER.

USE HMI PORT? dflt = NO (Yes/No)
Set to YES followed by ENTER to use the Modbus Port 2. If the displayed value is already correct, select ENTER. Modbus Port #2 is entered following the same rules as described for Modbus Port #1.

BAUD RATE dflt = 9 (1, 11)
Enter the integer corresponding to the communications baud rate followed by the ENTER key. If the displayed value is already correct, select ENTER.

1 = 110	2 = 300	3 = 600	4 = 1200
5 = 1800	6 = 2400	7 = 4800	8 = 9600
9 = 19200	10 = 38400	11 = 57600	

STOP BITS dflt = 1 (1, 3)
Enter the integer corresponding to the stop bits required followed by the ENTER key. If the displayed value is already correct, select ENTER. Enter a ‘1’ for 1 stop bit, a ‘2’ for 1.5 stop bits or a ‘3’ for 2 stop bits.

PARITY dflt = 1 (1, 3)
Enter the integer corresponding to the parity required followed by the ENTER key. If the displayed value is already correct, select ENTER. Enter a ‘1’ for none, a ‘2’ for odd parity or a ‘3’ for even parity.

DRIVER dflt = 1 (1, 3)
Enter the integer corresponding to the serial communications mode required followed by the ENTER key. Enter a ‘1’ for RS-232, a ‘2’ for RS-422 or a ‘3’ for RS-485 communications. If the displayed value is already correct, select ENTER.

ASCII OR RTU dflt = 2 (1, 2)
Enter the integer corresponding to the Modbus protocol mode required, followed by the ENTER key. Enter a ‘1’ for ASCII, a ‘2’ for RTU. If the displayed value is already correct, select ENTER.

Alarm Trip Screens Block

When this header appears in the display, scroll down to configure this block or scroll left or right to select another block to configure.

ENABLE ALARM SCREEN dflt = YES (Yes/No)
Set to YES followed by ENTER to enable alarm screen on front panel for any new alarm. If set to NO alarms will not automatically appear on screen.

ENABLE TRIP SCREEN dflt = YES (Yes/No)
Set to YES followed by ENTER to enable trip screen on front panel for any new trip. If set to NO trips will not automatically appear on screen.

RESET TRIP DELAY dflt = 100 (0,200)
Enter delay time in seconds, followed by ENTER. This delay time is the time that the shutdown contact input is overridden while resetting the turbine. If the shutdown contact input has not been reset in this time the unit trips.

BREAKER OPEN TRIP dflt = NO(No/Yes)
Set to YES followed by ENTER to enable the breaker open trip. If YES is selected once the generator breaker has been closed for 30 seconds this trip is armed, then if the breaker opens the unit trips.

Exiting Program Mode

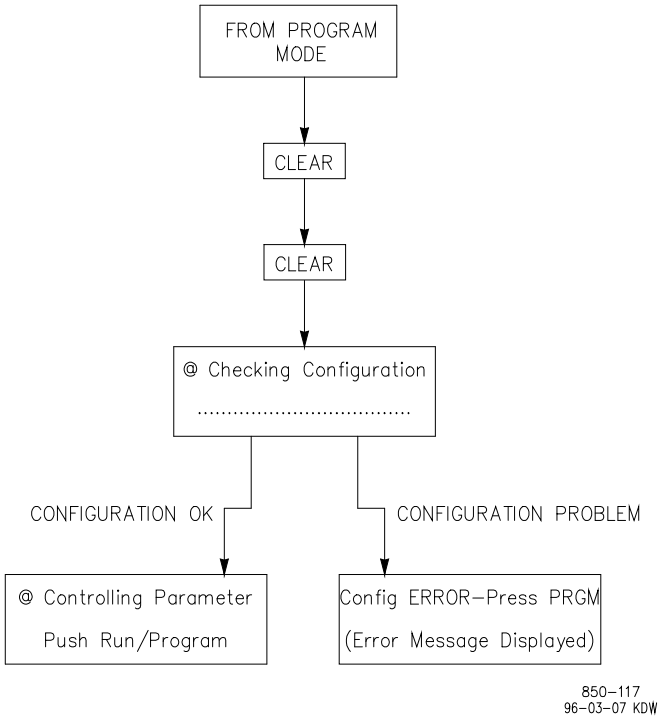


Figure 4-4. Exiting the Program Mode

Once the programming steps have been completed, the Program Mode can be exited (refer to Figure 4-4). To exit the Program mode the “CLEAR’ key is pressed twice. This saves the configuration in the 505LST.

Chapter 4.
505LST Operation

Run Mode Architecture

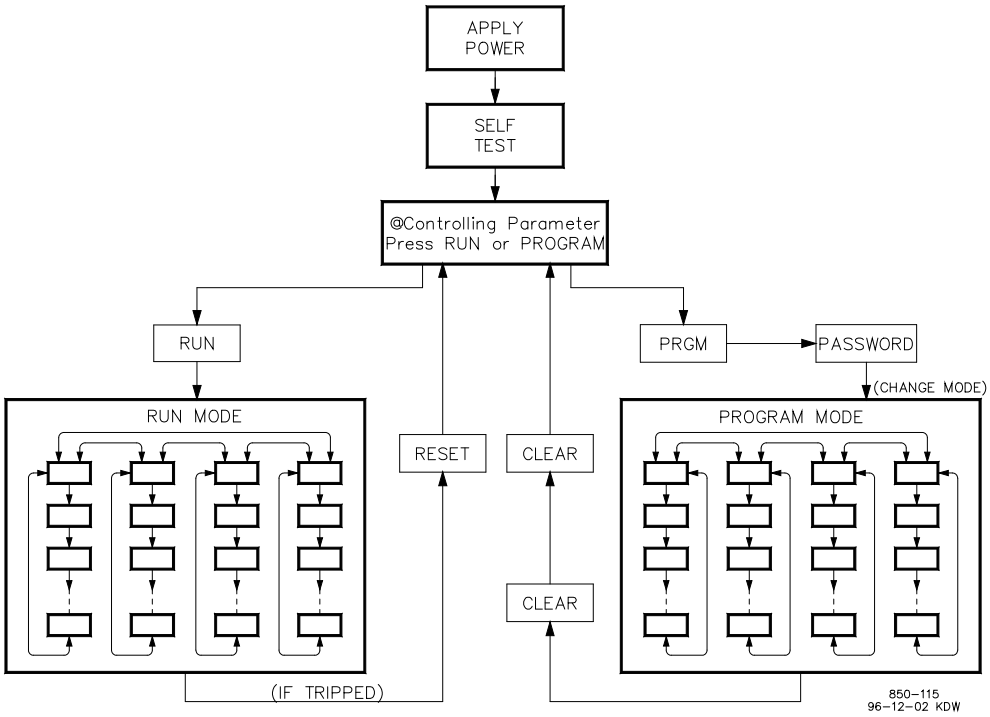


Figure 5-1. Basic Program Architecture

The 505LST is easy to program, due mainly to its menu-driven software. Basic program architecture is illustrated in Figure 5-1. When the control is powered up, and after the brief CPU self test has been completed, the control displays WOODWARD GOVERNOR CO. The operating procedures are divided into two sections: the Program Mode (refer to Chapter 3 Configuration Procedures for Program Mode information) and the Run Mode. Program Mode is used to configure the 505LST for the specific application and set all operating parameters. Run Mode is the normal turbine operation mode and is used to view operating parameters and operate the turbine. A Service Mode is also available to make additional on-line adjustments while the unit is running (refer to Chapter 5 Service Mode).

Keypad and Display

The 505LST's service panel consists of a keypad and LED display located on the front of the control. The LED display has two, 24 character lines that can be used to display operating parameters and troubleshooting parameters in plain English. Also, there are 30 keys available to provide complete control from the front of the 505LST. No additional control panels are required to operate the turbine, every turbine control function can be performed from the 505LST's front panel.

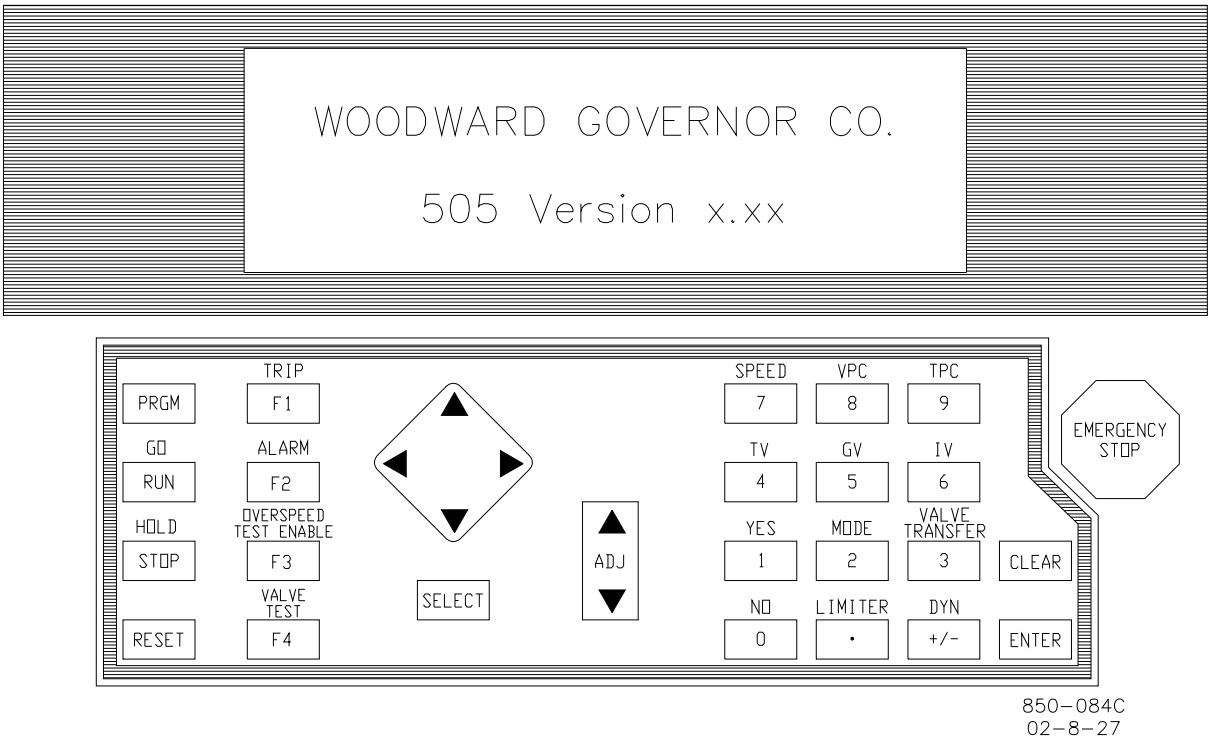


Figure 5-2. Example 505LST Keypad and Display

A description of the non-application specific key's function follows:

SCROLL
This is the large diamond-shaped button in the middle of the keypad with arrows at each of its four corners. The < > (scroll left, right) moves the display left or right through the function blocks of the Program or Run Modes. The ∧ ∨ (scroll up, down) moves the display up or down within a function block of the Program or Run Mode.

SELECT
The Select key is used to select control of the 505LST display's top or bottom line variable. The @ sign is used to indicate which line (variable) can be adjusted by the adjust keys. Only when there is a changeable variable on both lines (dynamics, valve calibration modes) does the "select key" and @ sign determine which line variable can be adjusted. When there is only one variable per screen the "select key" and @ sign's position are irrelevant.

ADJ (adjust)
In the Run Mode, "∧" moves any adjustable parameter up (larger) and "∨" moves any adjustable parameter down (smaller). Also used to toggle tunables *TRUE and *FALSE.

PRGM

PRGM (program)
This key selects the Program Mode. If selected, the screen prompts for the password. If you enter the proper password, you will then be asked if you want to 'SHUTDOWN CONTROL? Y/N'. If you enter YES the I/O will lockup. If you do this procedure while the turbine is running, the turbine will trip.

RUN

RUN
Initiates a turbine run or "go".

STOP

STOP
Initiates a turbine stop or "hold".

RESET

RESET
Resets/clears Run Mode alarms and shutdowns. Also used to latch the turbine when tripped.

NO
0

0/NO
Enters 0/NO or disable.

YES
1

1/YES
Enters 1/YES or enable.

EMERGENCY SHUTDOWN BUTTON
Large red octagonal button on the front of the enclosure. This is an Emergency Shutdown command for the control.

MODE
2

2/MODE
Enters 2 or displays the Control Mode and Operating Modes. Use the scroll down arrow to step down all Modes. If permissives allow, Modes can be changed from here. The following messages are available under this screen:

Mode	Messages
Control Mode	Speed VPC TPC
Operating Mode (top line) Select Auto (bottom line)	Manual Auto Coord SemiAuto (pressing "YES" key selects Auto)
Operating Mode (top line) Select Coord (bottom line)	Manual Auto Coord SemiAuto (pressing "YES" key selects Coord)
Operating Mode(top line) Select Manual (bottom line)	Manual Auto Coord SemiAuto (pressing "YES" key selects Manual)
Operating Mode (top line) Select SemiAuto (bottom line)	Manual Auto Coord SemiAuto (pressing "YES" key selects Semi Auto)

Mode	Messages
Local Only (top line)	NO YES
YES To Select (bottom line)	pressing “YES” key selects Local Only
Remote Only (top line)	NO YES
YES To Select (bottom line)	pressing “YES” key selects Remote Only
(scroll down, back to top of this sequence)	

3/VALVE TRANSFER

Enters 3 or displays the control commands and parameters for performing a valve transfer. From this screen the operator can perform a valve transfer and monitor all associated information on the valves. Use the scroll down arrow to step down all messages.

Command / Parameter	Messages
Xfer Status (top line)	In Prog Ready TV Ramp Up GV Ramp Down Done
YES for Auto (bottom line)	Manual Auto (pressing “YES” will select Auto and initiate valve transfer)
Xfer Status (top line)	In Prog Ready TV Ramp Up GV Ramp Down Done
(bottom line)	TV in Control GV in Control
TV Demand (top line)	0-100% (actual demand)
TV Ramp (bottom line) When on this screen ADJ “∧“ or ADJ“∨“ will manually move the Throttle Valve	0-100%(TV transfer ramp value)
GV Demand (top line)	0-100% (actual demand)
GV Ramp (bottom line) When on this screen ADJ“∧“ or ADJ“∨“ will manually move the Governor Valve	0-100% (GV transfer ramp value)
GV Rate (top line)	Slow Med Fast
YES to change (bottom line)	(pressing the “YES” key scrolls through rates)

4/TV (throttle valve)

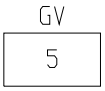
Enters 4 or displays the throttle valve information. From this screen the operator can press the scroll down button and find information on the throttle valves. This information includes demand, position, etc. Use the scroll down arrow to step down all messages.

TURBINE TYPE 1 TV DISPLAY

Command / Parameter	Messages
TV Lmtr Enbld	YES/NO
In Ctrl (bottom line)	Tripped Speed Protect Speed VPC TPC Valve Lim
TV Left Limiter	0–100%
TV Left Demand	0–100%
TV Right Limiter	0–100%
TV Right Demand	0–100%
Left TV Pos (top line)	% actual valve position
Right TV Pos (bottom line)	% actual valve position
(scroll down, back to top of this sequence)	

TURBINE TYPE 2 TV DISPLAY

Command / Parameter	Messages
TV Demand	0-100%(actual demand)
In Ctrl (bottom line)	Tripped Speed Protect Speed VPC TPC Valve Lim
TV Pos (top line)	% actual valve position
(scroll down, back to top of this sequence)	



5/GV (governor valve)
Enters 5 or displays the governor valve information. From this screen the operator can press the scroll down button and find information on the governor valves. This information includes demand, position, etc. Use the scroll down arrow to step down all messages.

TURBINE TYPE 1 AND 3 GV DISPLAY

Command / Parameter	Messages
GV Demand	0-100%(actual demand)
In Ctrl (bottom line)	Tripped Speed Protect Speed VPC TPC Valve Lim
Left GV Pos (top line)	% actual valve position
Right GV Pos (bottom line)	% actual valve position
(scroll down, back to top of this sequence)	

TURBINE TYPE 2 GV DISPLAY

Command / Parameter	Messages
GV Demand	0-100%(actual demand)
In Ctrl (bottom line)	Tripped Speed Protect Speed VPC TPC Valve Lim
GV Pos (top line)	% actual valve position
(scroll down, back to top of this sequence)	

6/IV (intercept valve)
Enters 6 or displays the intercept valve information. From this screen the operator can press the scroll down button and find information on the intercept valves. This information includes demand, position, etc. Use the scroll down arrow to step down all messages.

TURBINE TYPE 2 OR 3 IV DISPLAY

Command / Parameter	Messages
IV Demand	0-100%(actual demand)
In Ctrl (bottom line)	Tripped Speed Protect Speed VPC TPC Valve Lim
Left IV Pos (top line)	% actual valve position
Right IV Pos (bottom line)	% actual valve position
(scroll down, back to top of this sequence)	

7/SPEED

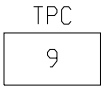
Enters 7 or displays the speed control information. From this screen the operator can press the scroll down button and find information on the speed parameters. This information includes: speed reference, ramp rates, actual speed etc. Use the scroll down arrow to step down all messages.

Command / Parameter	MESSAGES
Speed In Control (top line)	NO YES
Speed ADJ (bottom line). When on this screen ADJ"∧" or ADJ"∨" will manually move the Speed Reference if unit is in speed control.	XXX.XX RPM (Actual Speed)
Speed (top line)	XXX.XX RPM (Actual Speed)
Speed Ref (bottom line). When on this screen ADJ"∧" or ADJ"∨" will manually move the Speed Reference if unit is in speed control.	XXX.XX RPM (Actual Speed Reference)
Speed Rate (top line)	XXX (Actual speed rate selected RPM/Minute)
YES to select (bottom line)	XXX(Configured slow speed rate)
Speed Rate (top line)	XXX (Actual speed rate selected RPM/Minute)
YES to select (bottom line)	XXX(Configured medium speed rate)
Speed Rate (top line)	XXX (Actual speed rate selected RPM/Minute)
YES To Select (bottom line)	XXX(Configured fast speed rate)
(scroll down, back to top of this sequence)	

8/VPC (Valve Position Control)

Enters 8 or displays the Valve Position Control information. From this screen the operator can press the scroll down button and find information on the VPC parameters. This information includes: VPC setpoint, ramp rate, selection of ramp rates, indication if this mode is in control, etc. Use the scroll down arrow to step down all messages.

Command / Parameter	MESSAGES
VPC In Control (top line)	NO YES
VPC Stpt ADJ (bottom line). When on this screen ADJ"∧" or ADJ"∨" will manually move the Valve Position Reference if unit is in VPC control.	XXX.XX % (Actual Valve Position Reference)
Control Mode (top line)	Speed VPC TPC
YES to select VPC. VPC can only be selected when the Turbine is online	XXX.XX RPM (Actual Speed Reference)
VPC Rate (top line)	XXX (Actual Valve Position Control rate selected %/Minute)
YES to select (bottom line)	XXX(Configured slow VPC rate)
VPC Rate (top line)	XXX (Actual Valve Position Control rate selected %/Minute)
YES to select (bottom line)	XXX (Configured medium VPC rate)
VPC Rate (top line)	XXX (Actual Valve Position Control rate selected %/Minute)
YES To Select (bottom line)	XXX(Configured fast VPC rate)
(scroll down, back to top of this sequence)	



9/TPC (throttle pressure control)
Enters 9 or displays the Load control functions. If Load Control is not used but the 505LST is programmed to monitor the MWs, the actual MWs will be displayed. Use the scroll down arrow to step down all messages.

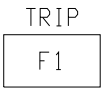
Command / Parameter	MESSAGES
TPC In Control (top line)	NO YES
TPC Stpt ADJ (bottom line) When on this screen ADJ"∧" or ADJ"∨" will manually move the Throttle Pressure Reference if unit is in TPC control	XXX.XX (Actual Throttle Pressure Reference)
Control Mode (top line)	Speed VPC TPC
YES to select TPC (bottom line). TPC can only be selected when the Turbine is online	(pressing "YES" key selects TPC)
Throttle Prs (top line)	XXX.XX (Actual Throttle Pressure)
TPC Setpoint (bottom line)	XXX.XX (Actual Throttle Pressure Reference)
TPC Auto Arm (top line)	Off On
YES to toggle (bottom line)	
TPC Enable High (top line) (this is the value that the TPC will arm when throttle pressure goes above this point)	
XXX (Actual Throttle Pressure Control rate selected psi/SEC)	*1500.00 (this is the configurable value; use ADJ button to change)
TPC Action Low (top line)	(this is the value that the TPC will automatically enable when throttle pressure goes below this point)
Use ADJ	*1300.00 (this is the configurable value; use ADJ button to change)
TPC Slow Rate (top line)	NO YES
Use ADJ (bottom line)	XXX (Actual Throttle Pressure slow rate psi/SEC)
TPC Fast Rate (top line)	NO YES
Use ADJ (bottom line)	XXX (Actual Throttle Pressure fast rate psi/SEC)
(scroll down, back to top of this sequence)	

CLEAR
Clears Program Mode and Run Mode entries and takes control out of it's present mode.

ENTER
Enters new values in the Program Mode, and allows the "direct entry" of specific setpoint values in the Run Mode.

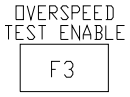
DYNAMICS (+/–)
Accesses the dynamic settings of the parameter controlling the actuator position. This key also changes the sign of a value being entered.

(DECIMAL KEY)/LIMITER
Enters decimal point in number being entered from front panel or brings up the Valve Limiter function



TRIP (F1)
Displays the reason for any trip condition (last/newest trip) when the key's LED indicator is illuminated. Press the Scroll down arrow (diamond key) to display additional trips.

ALARM (F2)
Displays the reason for any alarm condition (last/newest alarm) when the key's LED indicator is illuminated. Press the Scroll down arrow (diamond key) to display additional trips



OVERSPEED TEST ENABLE (F3)
Permits the speed reference to be raised beyond the maximum controlling speed setpoint to test either the electrical or mechanical overspeed trip.

VALVE TEST (F4)
Displays valves parameters and allows valve testing. Use the scroll down arrow to step down all messages.

TURBINE TYPE 1 VALVE TEST DISPLAY:

Command / Parameter	MESSAGES
Left TV,GV Test (top line) YES-Start, NO-Abort (bottom line)	NO YES
Left GV Pos (top line) Left GV Dmd (bottom line)	XX.XX% (Actual Position) XX.XX% (Actual Demand)
Left TV Pos (top line) Left TV Dmd (bottom line)	XX.XX% (Actual Position) XX.XX% (Actual Demand)
Right TV,GV Test (top line) YES-Start, NO-Abort (bottom line)	NO YES
Right GV Pos (top line) Right GV Dmd (bottom line)	XX.XX% (Actual Position) XX.XX% (Actual Demand)
Right TV Pos (top line) Right TV Dmd (bottom line)	XX.XX% (Actual Position) XX.XX% (Actual Demand)

Command / Parameter	MESSAGES
Left IV, RH (top line)	IV Travel IV Closed IV Open
YES/NO-Test (bottom line)	RH Travel RH Closed RH Open
Right IV, RH (top line)	IV Travel IV Closed IV Open
YES/NO-Test (bottom line)	RH Travel RH Closed RH Open
(scroll down, back to top of this sequence)	

TURBINE TYPE 2 or 3 VALVE TEST DISPLAY:

Command / Parameter	MESSAGES
TV 1 Test (top line)	NO YES
YES/NO-Test (bottom line)	TV1 Travel TV1 Closed TV1 Open
TV 2 Test (top line)	NO YES
YES/NO-Test (bottom line)	TV2 Travel TV2 Closed TV2 Open
Left IV, RH (top line)	IV Travel IV Closed IV Open
YES/NO-Test (bottom line)	RH Travel RH Closed RH Open
Right IV, RH (top line)	IV Travel IV Closed IV Open
YES/NO-Test (bottom line)	RH Travel RH Closed RH Open
(scroll down, back to top of this sequence)	

Watchdog Timer/CPU Fault Control

A watchdog timer and CPU fault circuit monitors the operation of the microprocessor and microprocessor memory. If the microprocessor fails to reset the timer within 15 milliseconds of the last reset, the CPU fault-control activates the reset output. This resets the CPU, de-energizes all relay outputs and turns off all mA outputs.

505LST Operation

The 505LST has two independent control channels: speed, and throttle (inlet) pressure. The outputs of these controllers are Low-Signal-Selected (LSS) with the valve limiter, VPC (valve position controller), and overspeed valve regulation. The output of the LSS directly sets the position of the valve that is in control. The valve that is in control depends on the turbine type (refer to the Turbine Types section in Chapter 1), and if the control has gone through a full-arc or partial-arc transfer. The speed PID and the valve position controllers have the option of utilizing an analog input signal to remotely position their setpoints.

Additional features of the 505LST include frequency control, valve testing, critical speed avoidance and an automatic start sequence. There are two serial communications ports for DCS and HMI communications, which can be used to monitor and control the turbine using Modbus protocol.

Turbine Start

The turbine is started with the same procedure no matter which mode is used to control speed. A ‘RUN/GO’ command starts ramping the start ramp (valve limiter) towards 100%. When the speed reaches the minimum control speed setpoint, the speed PID takes control and the valve limiter continues to 100%. The start ramp can be stopped by giving a raise or lower command. If the ramp is stopped, it has to be raised manually to 100%.

A ‘RUN/GO’ command may be issued from the 505LST keypad or through Modbus communications. If turbine speed is sensed when a ‘RUN/GO’ command is issued, the control instantly matches the speed setpoint to the sensed speed and continues towards the minimum controlling speed. If the sensed turbine speed is greater than the minimum controlling speed setting, the speed setpoint matches this sensed speed, the Speed PID starts control at this point, and the control waits for further action to be taken by the operator (unless auto start is configured). If the turbine speed is first sensed within a critical speed avoidance band when ‘RUN/GO’ is selected, the speed setpoint matches the actual speed and increases to the upper-end of the critical avoidance band where it waits for action to be taken by the operator.

Start Permissive

All shutdowns must be cleared before a ‘RUN/GO’ command can be issued.

Zero Speed Signal Override

The 505LST issues a shutdown if no speed signal is detected (i.e. magnetic pickup voltage less than 1 Vrms or speed is less than the 'Failed Speed Level'). To allow the control to start with speed not being sensed, this shutdown logic must be overridden. When starting, the failed signal logic for the passive MPUs is overridden. The override is removed once a speed greater than 150 rpm is sensed. If a speed signal greater than 200 rpm is not sensed by a passive probe, its failed logic latches and an alarm is given. The turbine trips if both passive probes fail. If 200 rpm is not sensed before the valve demand reaches 20%, the turbine trips because no speed is sensed.

Critical Speed Avoidance

In many turbines, it is desirable to avoid certain speeds or speed ranges (or pass through them as quickly as possible) due to excessive turbine vibration or other factors. During programming, six critical speed avoidance bands may be selected. Within a critical speed range, the 505LST moves the speed setpoint at the critical speed rate programmed and does not allow the speed setpoint to stop within the critical speed avoidance band. If the turbine is accelerating through a critical avoidance band and excessively high vibrations are experienced, selecting the speed setpoint lower command brings the unit back to the lower limit of the band.

Speed PID Operational Modes

Speed Setpoint

The Speed PIDs setpoint may be adjusted from the 505LST keypad, external contacts, Modbus commands, or through a 4–20 mA analog input.

Speed Control

The speed control receives a turbine speed signal from one or two magnetic pickups. The speed PID (Proportional, Integral, Derivative) control amplifier then compares this signal to the speed reference to generate an output signal to the actuator (through a low signal select bus). When the generator breaker is open, speed control is utilized to start and manually synchronize the turbine-generator or to perform overspeed tests. The speed control's reference is adjustable with raise or lower commands through the keypad on the front of the control, remote contact inputs or the Modbus communications port. In addition, an analog input can be programmed to remotely position the speed reference.

Manual Speed Control

The Raise and Lower inputs are configured to control the speed setpoint when offline. Raise and Lower commands are also configured in the Modbus to be used with the DCS or HMI ports. The reference can also be adjusted via the 505LST keypad by selecting the SPEED key, then ADJ "∧" or "∨". When the above-mentioned inputs are selected, the 505LST reverts to Manual Mode. Manual Mode is always available and would primarily be used when the operator wants to take immediate control of the speed.

Coordinated Speed Control

The 4–20 mA Speed/VPC input can be configured to control the speed setpoint. Typically, a process control external to the 505LST interfaces with this input to regulate the turbine's speed. The coordinated speed setpoint input directly affects the 505LST's speed setpoint. To enable the Coordinated Speed Control, Coordinated Control must be configured, Coordinated Control selected, by either the DCS, HMI or 505LST keypad, and the GO/RUN command active. When the remote setpoint is enabled, the speed reference moves at the rate selected. The remote speed function can be enabled and disabled as required from the front-panel keypad or the Modbus communication line. Each time the raise or lower contact inputs, or raise or lower Modbus commands, are selected the control reverts to hold.

Semi-Auto Speed Control

Semi-Auto Speed Control is only available if a DCS or HMI is used with the 505LST. In this mode, the operator sets the required speed via the DCS or HMI, then selects GO/RUN. At any time, the operator can stop the reference from moving by selecting HOLD/STOP. When the operator is ready to continue to the setpoint, they would select GO/RUN again. When the raise or lower contact inputs or raise or lower Modbus commands are selected the control holds/stops the reference, and it remains in semi-auto control. At this point the operator can select GO/RUN and continue, or manually increase or decrease the reference by giving the control a raise or lower command.

When the unit is started, the valve limiter starts ramping, at the programmed start ramp rate, from 0% to 100%. When speed is sensed and the speed control has control of the valves, the valve limiter will move valve ramp quickly out of the way.

Automatic Speed Control

The Automatic Speed Control option gives the operator the ability to start from a programmed idle speed, hold there until the GO/RUN function is reapplied, then go to a programmed rated speed setpoint. The selection of HOLD/STOP or GO/RUN can be made through the 505LST keypad or Modbus communications. At any time the raise or lower contact inputs or raise or lower Modbus commands are selected the control reverts to hold.

When the unit is started, the valve limiter starts ramping, at the programmed start ramp rate, from 0% to 100%. When speed is sensed and the speed control has control of the valves, the valve limiter will move valve ramp quickly out of the way.

Valve Limiter

The valve limiter limits the actuator output signal or valve position to aid in starting up and shutting down a turbine. The output of the valve limiter is low-signal-selected with the output of the speed control. The control or limiter channel asking for the lowest valve position will control valve position. Thus, the valve limiter limits the maximum valve position. The valve limiter can be adjusted through the keypad or Modbus commands.

The valve limiter can also be used to troubleshoot system dynamics problems. If it is believed that the 505LST is the source of system instability, the valve limiter can be positioned to manually take control of the valve position. Care should be taken when using the valve limiter in this fashion, so as to not allow the system to reach a dangerous operating point.

When the unit is started, the valve limiter starts ramping, at the programmed start ramp rate, from 0% to 100%. When speed is sensed and the speed control has control of the valves, the valve limiter will move valve ramp quickly out of the way.

The valve limiter is not intended to be used as a controller. When the valve limiter is lowered into control, the parameter and mode of control will not track the limiter. Therefore to return to the mode and parameter that was in control, the limiter needs to be raised. This allows the valve to start opening, increasing speed or load back to its original value before the limiter was lowered.

Throttle Pressure Control

Throttle Pressure Control (TPC) is a PID controller. Throttle pressure is the steam pressure at the inlet to the turbine valves. TPC is a limiting control that is low signal selected with Speed, VPC, and Valve Limiter. This control mode can be enabled from the front panel, Modbus, or from the contact input. The TPC automatic IN/OUT reference is set at configured minimum setpoint during normal operation. The TPC is enabled when the TPC IN/OUT is selected, the breaker is closed, and throttle pressure increases above the enable-configured setpoint. Then if the pressure drops below the minimum throttle pressure setting, the control goes into TPC. The control uses the minimum pressure setting as a setpoint for the controller. TPC is disabled if the pressure transducer fails or after a trip occurs.

TPC can also be used as a boiler pressure limit. This will move the valves in order to maintain steam pressure. This mode acts as a good runback mode as well, moving the load on the turbine and minimizing the upset on the boiler. Moving the load only the amount required to stabilize the boiler. When this occurs the TPC setpoint may be adjusted by raise and lower commands from the keypad, Modbus, or contact inputs. The ramp rate is set for 5 psi/sec, after three seconds of continuous raise or lower the rate is 10 psi/sec, and is adjustable in Service Mode under “TPC“.

Throttle Pressure Control requires a pressure transducer and an internal reference. The pressure transducer supplies a 4–20 mA signal to the control that needs to be configured. This signal is monitored for failure as it enters the control. If the input current drops below 2 mA or raises above 22 mA the signal is considered failed and the TPC is disabled.

Runback

A contact input is also programmed to select throttle pressure control. In the event of a boiler runback, rather than arbitrarily closing the governor valves, TPC will be enabled at the current pressure. The 505LST then attempts to maintain throttle pressure, assisting the boiler control. After a runback occurs, the 505LST remains in throttle pressure control until the operator selects another control mode.

Full-Arc Partial-Arc Transfer

Full-Arc Partial-Arc (FAPA) transfer is an automatic valve transfer from one set of valves to another. It is desirable to have the governor (control) valves wide open while first rolling the turbine, to allow the steam to have an equal warming effect across all of the steam chest and steam admission points. Keeping these open allows for even heating. Once the turbine is warm, transfer the control from the throttle (stop) valves to the governor (control) valves. This transfer can be done automatically from the front panel or Modbus, or manually from the front panel of the 505LST. For automatic transfer the valve linearization curves need to be set up for both the throttle and governor valves. These curves need to be linear with load and or steam flow to ensure a smooth transfer. The transfer can be performed online or offline depending on the turbine type. The transfer can also be performed manually by selecting valve transfer on the front panel of the 505LST then select lower for the governor valve. The governor (control) valve will only move while the adjust key is being depressed. Once the governor (control) valve is in control the operator should select throttle (stop) valve and raise it out of the steam flow. If the throttle (stop) valve does not move the governor (control) valves may need to be lowered more. If turbine type 3 is selected there will be no valve transfer, and when the control and or turbine is reset (latched) the governor (control) valves will stay closed, and be in control.

Valve Position Control

Valve Position Control (VPC) is the mode of control that the control is in most of the time that the unit is on-line. Once the generator breaker closes the control automatically selects VPC control, which automatically moves the valves to pick up the initial load. The initial load is based on throttle pressure at the time the breaker closed, where a higher pressure means less valve lift necessary to achieve the initial load. The control is defaulted to pickup a small amount of load. This value can be changed in the service menu under initial load curve (see the Initial Load Curve Header section in Chapter 5). The initial load value may be different if the unit closes online with a different valve, and may need to be adjusted. VPC has a 5% droop or valve regulation as a default. This value is configurable and can be adjusted in the speed configuration header. This regulation has a dead band from 3597 to 3603 rpm. When turbine speed is between these values the droop or regulation has no effect. Once the turbine speed goes outside this range and is online the regulation starts working. The valves will be completely closed when the speed reaches 5% above rated speed, and will be fully open when speed reaches 5% below rated speed.

Manual VPC Control

The raise and lower inputs are configured to control the VPC setpoint when online and in the VPC mode. Raise and lower commands are also configured in the Modbus used with the DCS or HMI ports. The reference can also be adjusted from the 505LST keypad by selecting the VPC key, then ADJ "∧" or "∨" .Any time the above mentioned inputs are selected, the 505LST reverts to the manual control mode. Manual mode is primarily used when the operator wants to take immediate control of the speed. Manual mode is always available.

Coordinated VPC Control

The 4–20 mA Speed/VPC input can be configured to control the VPC setpoint. Typically, a process control external to the 505LST interfaces with this input to regulate the turbine's valve position. The coordinated VPC setpoint input directly affects the 505LST's VPC setpoint. To enable coordinated speed control, Coordinated Control must be configured, Coordinated Control selected, by either the DCS, HMI or 505LST keypad, and the GO/RUN command initiated. When the remote demand (coordinated control) is enabled, the VPC reference will move at the rate selected. The coordinated VPC function can be enabled and disabled as required from the 505LST keypad or the communication line. If the raise or lower contact inputs or raise or lower Modbus commands are selected the control reverts to hold.

Semi-Auto VPC Control

Semi-Auto VPC is only available if a DCS or HMI is used with the 505LST. In this mode, the operator sets in the required valve position via the DCS or HMI, then selects GO/RUN. At any time, the operator can stop the reference from moving by selecting HOLD/STOP. When in this mode the control uses the rate that has been selected for VPC. When the operator is ready to continue to the setpoint, they would select GO/RUN again. If the raise or lower contact inputs or raise or lower Modbus commands are selected the control will hold/stop the reference, and remain in semi-auto control. At this point the operator can select GO/RUN and continue, or manually increase or decrease the reference by giving the control a raise or lower.

Valve Testing

Valve testing can be configured in several different ways, and can be very different for each configuration.

Turbine Type 1
GV/TV testing: If valve testing is configured, and the turbine type is type 1, the control performs a combined GV/TV test. It is recommended that the control be put into throttle pressure control. The 505LST then tries to maintain the throttle pressure to minimize swings during valve testing. The valves will probably not be totally linear, so the lower the load when you start testing the better. When the test is started the control modulates closed the governor valve, then modulates closed the throttle valve. When the throttle valve is closed the control opens the throttle valve, then the control takes the governor valve back open to the controlling point of the governor valve. For the valve test to function correctly the 505LST needs to have either contact inputs or a 4–20 mA input for valve positions.

IV/RV testing: If valve test is configured, and the turbine type is type 1, and IVRV test 1 output is **NOT** configured, the control will perform a combined IV/RV test. When the test is started the 505LST energizes a contact output that should be connected to the intercept valve test solenoid. The intercept valve closes, and the control then energizes a relay output that should be connected to the reheat stop valve. The reheat stop valve closes, and after it closes the contact output is de-energized and the reheat valve reopens. When the reheat valve is open the 505LST then de-energizes the intercept valve contact output, and the intercept valve opens, at this point the test is complete. For this test to function properly the 505LST needs to have contact inputs for valve position feedback. The test may be halted at any time by pressing the "NO" key.

IV/RV testing: If valve test is configured, and turbine type is 1, and IVRV test 1 output **IS** configured, the control only energizes one output for testing (IV test). The output stays energized as long as the start test button on the front panel of the 505LST is being pressed. This type of testing should be used if the user would like to maintain all of the existing test logic, but would like it triggered by the 505LST.

Turbine Types 2 and 3

TV testing: If valve test is configured, and the turbine type is type 2 or 3, the control will energize the TV test solenoid as long as the start test pushbutton is pressed. To get TV#2 test to energize 2 TV's must be configured.

IV/RV testing: If valve test is configured and the turbine type is type 2, the 505LST performs a combined IV/RV test. For turbine type 2 or 3 when the test is initiated the 505LST modulates the intercept valve closed until it reaches 10% open then the control energizes the fast acting valve. When the intercept valve is closed the control then energizes a contact output to close the reheat valve. When the reheat valve is closed the relay for the reheat valve de-energizes, allowing the reheat valve to open. When the reheat valve is fully open the 505LST modulates the intercept valve back to the open position. For the valve test to function correctly the 505LST needs to have either contact inputs or a 4–20 mA input for valve positions. The test may be halted at any time by pressing the "NO" key.

Emergency Shutdown

When an Emergency Shutdown condition occurs, the actuator output signal is stepped to 0 mA, the shutdown relay de-energizes, and the shutdown cause (first shutdown condition sensed) is displayed on the 505LST front panel. Pressing the scroll down key from this screen shows any additional shutdown conditions that were sensed. The 505LST's total throughput time is 20 milliseconds (worst case). All trip conditions are indicated through the 505LST's front panel, and through Modbus communications. The Emergency Shutdown contact input must be **OPEN** to trip the control, and **CLOSED** when the turbine is reset.

Overspeed Test Function

The 505LST's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505LST's internal overspeed trip logic and any external overspeed trip device's settings and logic. An Overspeed Test allows the control's speed setpoint to be increased above the normal operating range. This test can be performed from the 505LST keypad or through Modbus. An overspeed test is allowed only under the following conditions:

- The Speed PID must be in control
- The generator breaker must be open.

If the OSPD key is pressed and the above conditions are not met the 505LST OSPD key will not come on.

The operator raises the speed until the Electrical Overspeed setpoint is reached. At this time the OSPD key starts flashing. To trip on electrical overspeed remove the overspeed enable to trip the turbine. To continue ramping the speed up to check the mechanical trip continue to raise speed until the trip occurs. If the speed reaches maximum speed setpoint without tripping the turbine will trip and an alarm will be given for Mechanical Trip Failed.

GV Regulation

The governor valves are modulated at 5% regulation. This means that at 5% over rated speed, 3780 RPM, the governor valves are modulated closed. Governor valve regulation is accomplished by low selecting the governor valve demand with the regulation signal. The governor regulation signal is linear with speed, 100% at 3636 rpm and 0% at 3780 rpm. Thus, as speed increases past 3636 rpm, the governor regulation signal decreases from 100%. Once, the governor regulation signal is less than the current governor valve demand the governor valves begin to close.

OPC Trip

This output is used to dump pre-overspeed oil. Usually this is a valve that can re-open relatively quickly if necessary. The OPC relay output is energized if either of two conditions is present. One is when speed exceeds 3708 rpm. The second is if speed is increasing at an instantaneous rate greater than 200 rpm per second. The OPC relay output remains energized as long as either condition exists. OPC trip is only available on turbine type 1.

Reset Pulse
The reset pulse output is a relay output that pulses during a turbine reset. This output is only active when turbine type 1 is configured. The contact closes when the turbine reset button is pushed and stays closed for as long as the configured reset pulse is programmed. The contact opens as soon as the external trip contact is reset. This output is labeled Auto Stop Reset on the control wiring (refer to Figure 1-2).

Local/Remote
If local only control is selected only commands from the local 505LST front panel are used. If remote only is selected, only commands across the Modbus are used. If neither local or remote only is selected all commands will be accepted and executed. The emergency stop push button on the front panel of the 505LST is always active.

Alarms
When an alarm is active the alarm pushbutton lamp comes on. Pressing this button displays the active alarms, which can be scrolled though. Analog output #6 goes to 20 mA when there is an active alarm that has not been reset. The alarm button lamp stays on until the condition clears and a reset has been given*. All alarm messages are listed below:

- Comm Port 1 Failed
- Comm Port 2 Failed
- Left GV Feedback Failed
- Left TV Feedback Failed
- RightGV Feedback Failed
- RightTV Feedback Failed
- Throttle Press Sig Failed
- Speed/VPC Signal Failed
- Speed Sensor #1 Failed
- Speed Sensor #2 Failed
- Actuator 1 Fault
- Actuator 2 Fault
- Backup OSPD DEV Fail
- Left IVRV Test Failed
- Right IVRV Test Failed
- TV 1 Test Failed

- TV 2 Test Failed
- TPC Auto Enable
- TV 1 Not Closed
- Both TVs Not Open
- TV 2 Not Closed
- Left IV Not Closed
- Both IV's Not Open
- Left RHSV Not Closed
- Both RHSVs Not Open
- Valve 3 Not Closed
- Valve 1 Not Open
- Valve 3 Not Open
- Right IV Not Closed
- Right RHSV Not Closed
- Valve 1 Not Closed
- Prewarm Active

Trip

When a trip is active the trip pushbutton lamp comes on. Pressing this button displays the active trips, which can be scrolled though. They appear in the order that they occurred. All trip messages are listed below:

- Lost Speed Signals
- Overspeed Trip
- Emergency PB Trip
- Emergency Trip Input
- No Speed Sensed
- Power Up Shutdown
- Modbus DCS Trip
- Modbus HMI Trip
- Generator Breaker Open
- External Emergency Trip
- T.V. Position Error Trip

Chapter 5.
Service Mode

Overview

The Service Mode allows the user to make adjustments and monitor the control without entering Configure Mode. The main advantage of Service Mode is that adjustments may be made while the unit is running. From the main screen (which displays “WOODWARD GOVERNOR CO”), use the scroll down control to enter the service password area, then follow the instructions on the screen. Enter the password (refer to the Appendix) then press enter to access Service Mode.

Use the scroll left and right controls to move through the service headers. Use the scroll up and down controls to move up and down through the entries in that service header.

Exiting the Service Mode

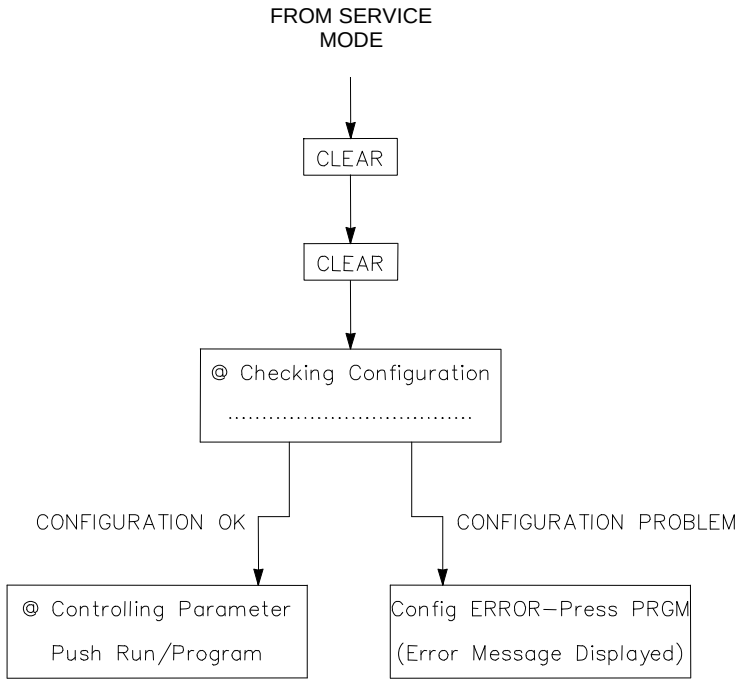


Figure 6-1. Exiting the Service Mode

Once the servicing steps have been completed, Service Mode can be exited (refer to Figure 6-1). To exit Service Mode press the “CLEAR’ key twice. This initiates the 505LST to save the settings.

NOTICE

Press the CLEAR key twice to permanently save any settings into the 505LST. If variables are tuned or changed but not stored in EEPROM by pressing the CLEAR key twice, those changes will be lost if power is removed from the control or if the control receives a CPU reset.

Contact Inputs Service Header

This service header allows the user to monitor the state of the contact inputs. The inputs are numbered, and can be cross-referenced to the control wiring (see Figure 1-2, 1-5, or 1-8). When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Contact in 1 Scrolls down through all contact outputs 1-17, including:	NO YES
Contact 17 in This is the Emergency Stop Keypad button	NO YES
(scroll down, back to Contact Inputs Service Header)	

Contact Outputs Service Header

This service header allows the user to monitor the state of the contact outputs. The outputs are numbered, and can be cross referenced to the control wiring (see Figure 1-2, 1-5, or 1-8). When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Contact out 1 Scrolls down through all contact outputs 1-13.	NO YES
Contact out 9 This is the F4 Keypad Indication	NO YES
Contact out 10 This is the Emergency Stop Keypad Indication	NO YES
Contact out 11 This is the F3 Keypad Indication	NO YES
Contact out 12 This is the F2 Keypad Indication	NO YES
Contact out 13 This is the F1 Keypad Indication	NO YES
(scroll down, back to Contact Outputs Service Header)	

Analog Inputs Service Header

This service header allows the user to monitor the state of the analog inputs. The inputs are numbered, and can be cross-referenced to the control wiring (see Figure 1-2, 1-5, or 1-8). When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. All values are scaled in mA, so the inputs will read 4–20 mA.

Command / Parameter	Messages
Analog input 1	XXX (actual mA)
(scroll down through all analog inputs 1-6)	
(scroll down, back to Analog Inputs Service Header)	

Analog Outputs Service Header

This service header allows the user to monitor the state of the analog outputs. The inputs are numbered, and can be cross referenced to the control wiring (see Figure 1-2, 1-5, or 1-8). When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. All values are scaled in milliamps, so the inputs will read 4–20 milliamps.

Command / Parameter	Messages
Analog output 1	XXX (actual mA)
(scroll down through all analog outputs 1-6)	
Analog output 7 (ACT 1 output)	XXX (actual mA)
Analog output 8 (ACT 2 output)	XXX (actual mA)
(scroll down, back to Analog Outputs Service Header)	

Left Control VLV Curve Header

This service header allows the user to tune the linearity curve for the left governor (control) valve. It is important that this curve is linear with steam flow and/or load. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. The “X” points will be demand in, and the “Y” points will be the position out. So demand in (X) could be looked at as steam flow, and (Y) could be looked at as the valve position required to get that steam flow.

Command / Parameter	Messages
Point X-1	0.000 DFLT (-5.0,110.0)
Point Y-1	-2.0 DFLT (-5.0,110.0)
Point X-2	10.000 DFLT (-5.0,110.0)
Point Y-2	10.000 DFLT (-5.0,110.0)
Point X-3	20.000 DFLT (-5.0,110.0)
Point Y-3	20.000 DFLT (-5.0,110.0)
Point X-4	30.000 DFLT (-5.0,110.0)
Point Y-4	30.000 DFLT (-5.0,110.0)
Point X-5	40.000 DFLT (-5.0,110.0)
Point Y-5	40.000 DFLT (-5.0,110.0)
Point X-6	50.000 DFLT (-5.0,110.0)
Point Y-6	50.000 DFLT (-5.0,110.0)
Point X-7	60.000 DFLT (-5.0,110.0)
Point Y-7	60.000 DFLT (-5.0,110.0)
Point X-8	70.000 DFLT (-5.0,110.0)
Point Y-8	70.000 DFLT (-5.0,110.0)
Point X-9	80.000 DFLT (-5.0,110.0)
Point Y-9	80.000 DFLT (-5.0,110.0)
Point X-10	90.000 DFLT (-5.0,110.0)
Point Y-10	90.000 DFLT (-5.0,110.0)
Point X-11	100.000 DFLT (-5.0,110.0)
Point Y-11	100.000 DFLT (-5.0,110.0)
(scroll down, back to Control VLV Curve Left Header)	

Right Control VLV Curve Header

This service header allows the user to tune the linearity curve for the right governor (control) valve. It is important that this curve be linear with steam flow and or load. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. The “X” points will be demand in, and the “Y” points will be the position out. So demand in (X) could be looked at as steam flow, and (Y) could be looked at as the valve position required to get that steam flow.

Command / Parameter	Messages
Point X-1	0.000 DFLT (-5.0,110.0)
Point Y-1	-2.0 DFLT (-5.0,110.0)
Point X-2	10.000 DFLT (-5.0,110.0)
Point Y-2	10.000 DFLT (-5.0,110.0)
Point X-3	20.000 DFLT (-5.0,110.0)
Point Y-3	20.000 DFLT (-5.0,110.0)
Point X-4	30.000 DFLT (-5.0,110.0)
Point Y-4	30.000 DFLT (-5.0,110.0)
Point X-5	40.000 DFLT (-5.0,110.0)
Point Y-5	40.000 DFLT (-5.0,110.0)
Point X-6	50.000 DFLT (-5.0,110.0)
Point Y-6	50.000 DFLT (-5.0,110.0)
Point X-7	60.000 DFLT (-5.0,110.0)
Point Y-7	60.000 DFLT (-5.0,110.0)
Point X-8	70.000 DFLT (-5.0,110.0)
Point Y-8	70.000 DFLT (-5.0,110.0)
Point X-9	80.000 DFLT (-5.0,110.0)
Point Y-9	80.000 DFLT (-5.0,110.0)
Point X-10	90.000 DFLT (-5.0,110.0)
Point Y-10	90.000 DFLT (-5.0,110.0)
Point X-11	100.000 DFLT (-5.0,110.0)
Point Y-11	100.000 DFLT (-5.0,110.0)
(scroll down, back to Control VLV Curve Right Header)	

Left Throttle Valve Curve Header

This service header allows the user to tune the linearity curve for the throttle (stop) valve. It is important that this curve be linear with steam flow and or load. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. The “X” points will be demand in, and the “Y” points will be the position out. So demand in (X) could be looked at as steam flow, and (Y) could be looked at as the valve position required to get that steam flow.

Command / Parameter	Messages
Point X-1	0.000 DFLT (-5.0,110.0)
Point Y-1	-5.00 DFLT (-5.0,110.0)
Point X-2	0.250 DFLT (-5.0,110.0)
Point Y-2	0.100 DFLT (-5.0,110.0)
Point X-3	0.500 DFLT (-5.0,110.0)
Point Y-3	0.250 DFLT (-5.0,110.0)
Point X-4	20.000 DFLT (-5.0,110.0)
Point Y-4	17.000 DFLT (-5.0,110.0)
Point X-5	30.000 DFLT (-5.0,110.0)
Point Y-5	30.000 DFLT (-5.0,110.0)
Point X-6	35.000 DFLT (-5.0,110.0)
Point Y-6	40.000 DFLT (-5.0,110.0)
Point X-7	50.000 DFLT (-5.0,110.0)
Point Y-7	50.000 DFLT (-5.0,110.0)
Point X-8	70.000 DFLT (-5.0,110.0)
Point Y-8	70.000 DFLT (-5.0,110.0)
Point X-9	80.000 DFLT (-5.0,110.0)
Point Y-9	80.000 DFLT (-5.0,110.0)
Point X-10	90.000 DFLT (-5.0,110.0)
Point Y-10	90.000 DFLT (-5.0,110.0)
Point X-11	100.000 DFLT (-5.0,110.0)
Point Y-11	101.000 DFLT (-5.0,110.0)
TV bypass limit This sets the maximum demand of the TV bypass valve (bypass 100% open at this demand)	20.000 DFLT (0.0,100.0)
(scroll down, back to Throttle Valve Curve Header)	

Right Throttle Valve Curve Header

This service header allows the user to tune the linearity curve for the throttle (stop) valve. It is important that this curve be linear with steam flow and or load. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. The “X” points will be demand in, and the “Y” points will be the position out. So demand in (X) could be looked at as steam flow, and (Y) could be looked at as the valve position required to get that steam flow.

Command / Parameter	Messages
Point X-1	0.000 DFLT (-5.0,110.0)
Point Y-1	-5.00 DFLT (-5.0,110.0)
Point X-2	0.250 DFLT (-5.0,110.0)
Point Y-2	0.100 DFLT (-5.0,110.0)
Point X-3	0.500 DFLT (-5.0,110.0)
Point Y-3	0.250 DFLT (-5.0,110.0)
Point X-4	20.000 DFLT (-5.0,110.0)
Point Y-4	17.000 DFLT (-5.0,110.0)
Point X-5	30.000 DFLT (-5.0,110.0)
Point Y-5	30.000 DFLT (-5.0,110.0)
Point X-6	35.000 DFLT (-5.0,110.0)
Point Y-6	40.000 DFLT (-5.0,110.0)
Point X-7	50.000 DFLT (-5.0,110.0)
Point Y-7	50.000 DFLT (-5.0,110.0)
Point X-8	70.000 DFLT (-5.0,110.0)
Point Y-8	70.000 DFLT (-5.0,110.0)
Point X-9	80.000 DFLT (-5.0,110.0)
Point Y-9	80.000 DFLT (-5.0,110.0)
Point X-10	90.000 DFLT (-5.0,110.0)
Point Y-10	90.000 DFLT (-5.0,110.0)
Point X-11	100.000 DFLT (-5.0,110.0)
Point Y-11	101.000 DFLT (-5.0,110.0)
(scroll down, back to Throttle Valve Curve Header)	

Initial Load Curve Header

This service header allows the user to tune the initial load curve. The initial load curve sets up a relationship between throttle pressure and amount of valve lift required to get initial load, this relationship allows the unit to come online with the same amount of load every time. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor. The “X” points will be throttle pressure in, and the “Y” points will be the position out. This curve with the defaults should be in the 1-3% load pickup.

Command / Parameter	Messages
Point X-1	500.0 DFLT (400.0,4000.0)
Point Y-1	7.5 DFLT (0.0,100.0)
Point X-2	700.0 DFLT (400.0,4000.0)
Point Y-2	4.5 DFLT (0.0,100.0)
Point X-3	875.0 DFLT (400.0,4000.0)
Point Y-3	2.5 DFLT (0.0,100.0)
Point X-4	1000.0 DFLT (400.0,4000.0)
Point Y-4	2.0 DFLT (0.0,100.0)
Point X-5	1167.0 DFLT (400.0,4000.0)
Point Y-5	2.0 DFLT (0.0,100.0)
(scroll down, back to Initial Load Curve Header)	

Valve Limit Rates Header

This service header allows the user to tune the valve limit rates. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Start Rate	5.000 DFLT (0,10)
Medium Rate	100.00 DFLT (0,100)
Fast Rate	200.00 DFLT (0,500)
(scroll down, back to Valve Limits Rate Header)	

Speed Parameters Header

This service header allows the user to tune and monitor the speed parameters. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Actual Speed	XXXX
MPU #1	XXXX (speed MPU 1 is reading)
MPU #2	XXXX (speed MPU 2 is reading)
Speed Reference	XXXX
Speed PID	XXXX
Hi Spd Capture	XXXX (highest speed since last trip)
Trip Speed	XXXX (speed of turbine at trip)
Slow Rate	100.0 DFLT (0.0,500.0)
Medium Rate	200.0 DFLT (0.0,500.0)
Fast Rate	400.0 DFLT (0.0,500.0)
Critical Rate	500.0 DFLT (0.0,1000.0)
Overspeed Setpt	3888.0 DFLT (2000.0,4500.0)
Backup OS Setpt	4000.0 DFLT (2000.0,4500.0)
Spd CV to 100%	3636.0 DFLT (3600.0,3800.0)
Spd CV to 0%	3780.0 DFLT (3600.0,3800.0)
Spd IV to 100%	3636.0 DFLT (3600.0,3800.0)
Spd IV to 0%	36900.0 DFLT (3600.0,3800.0)
LSS Ovrd MPU	19.0 DFLT (0.0,100.0)
(scroll down back to Speed Parameters Header)	

VPC Parameters Header

This service header allows the user to tune and monitor the Valve Position(VPC) parameters. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
VPC Reference	XXXX
VPC Target	XXXX
DCS Demand	XXXX
VPC Demand	XXXX
Slow Rate	2.00 DFLT (0.0,100)
Medium Rate	3.00 DFLT (0.0,500)
Fast Rate	10.00 DFLT (0.0,1000)
(scroll down back to VPC Parameters Header)	

TPC Parameters Header

This service header allows the user to tune and monitor the Throttle Pressure (TPC) parameters. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
TPC Reference	XXXX
TPC Actual Press	XXXX
TPC enable Setpt	1500.0 DFLT (500.0,3500.0)
TPC Min Control	1300.0 DFLT (500.0,3500.0)
(scroll down back to TPC Parameters Header)	

Prewarm Functions Header

This header will appear if prewarm is enabled in the configuration. The service header allows the user to tune and monitor the prewarm functions. An alarm message will appear when this function is enabled while in Run mode. The user then has the option of tripping the Stop valves. This will de-energize the Shutdown relay on CO1. By using the “ADJ” button, the user can slowly increase the output to the governor valves. This function will trip if the turbine speed goes above 100 rpm. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Enable Prewarm	NO DFLT (NO,YES)
Trip Stop Valve	NO DFLT (NO,YES)
CV Ramp	0.0 DFLT (0.0,100.0)
(scroll down back to Prewarm Functions Header)	

Speed Criticals Header

This service header allows the user to tune and monitor the Critical speeds. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Crit 1 Lo	850.0 DFLT (500.0,3500.0)
Crit 1 Hi	1000.0 DFLT (500.0,3500.0)
Crit 2 Lo	1370.0 DFLT (500.0,3500.0)
Crit 2 Hi	1460.0 DFLT (500.0,3500.0)
Crit 3 Lo	1800.0 DFLT (500.0,3500.0)
Crit 3 Hi	2050.0 DFLT (500.0,3500.0)
Crit 4 Lo	2130.0 DFLT (500.0,3500.0)
Crit 4 Hi	2430.0 DFLT (500.0,3500.0)
Crit 5 Lo	2500.0 DFLT (500.0,3500.0)
Crit 5 Hi	2650.0 DFLT (500.0,3500.0)
Crit 6 Lo	2800.0 DFLT (500.0,3500.0)
Crit 6 Hi	3160.0 DFLT (500.0,3500.0)
(Scroll down back to Speed Criticals Header)	

Alarm Trip Screen Header

This service header allows the user to tune and monitor the alarm and trip screens. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Enable Alarm Scrn#	YES DFLT (YES,NO)
Enable Trip Scrn	YES DFLT (YES,NO)
Reset Trip Delay	100.0 (0.0,200.0)
Breaker Opn Trip	NO DFLT(YES,NO)
(scroll down back to Alarm Trip Screen Header)	

Analog In Adjustments Header

This service header allows the user to tune and monitor the analog inputs. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
(VLV 1 LVDT Offset	0.00 (-20.0,20.0)
VLV 1 LVDT Gain	1.00 (0.0,2.0)
VLV 2 LVDT Offset	0.00 (-20.0,20.0)
VLV 2 LVDT Gain	1.00 (0.0,2.0)
VLV 3 LVDT Offset	0.00 (-20.0,20.0)
VLV 3 LVDT Gain	1.00 (0.0,2.0)
VLV 4 LVDT Offset	0.00 (-20.0,20.0)
VLV 4 LVDT Gain	1.00 (0.0,2.0)
T Press Offset	0.00 (-20.0,20.0)
T Press Gain	1.00 (0.0,2.0)
SPD/VPC Offset	0.00 (-20.0,20.0)
SPD/VPC Gain	1.00 (0.0,2.0)
(Scroll down back to Analog In Header)	

Analog Out Adjustments Header

This service header allows the user to tune and monitor the analog outputs. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
Speed Offset (this block adjusts Valve 3 not speed)	0.00 (-20.0,20.0)
Speed Gain (this block adjusts Valve 3 not speed)	1.00 (0.0,2.0)
Vlv Dmnd Offset (this block adjusts Valve 4 not Vlv Dmnd)	0.00 (-20.0,20.0)
Vlv Dmnd Gain (this block adjusts Valve 4 not Vlv Dmnd)	1.00 (0.0,2.0)
MW Offset (this block will adjust Vlv Dmnd not MW)	0.00 (-20.0,20.0)
MW Gain (this block adjusts Vlv Dmnd not MW)	1.00 (0.0,2.0)
Inlet Offset	0.00 (-20.0,20.0)
Inlet Gain	1.00 (0.0,2.0)
CV Offset (this block adjusts Speed Readout not CV)	0.00 (-20.0,20.0)
CV Gain (this block adjusts Speed Readout not CV)	1.00 (0.0,2.0)
IV Offset (this block adjusts Alarm not IV)	0.00 (-20.0,20.0)
IV Gain (this block adjusts Alarm not IV)	1.00 (0.0,2.0)
(scroll down back to Analog Out Header)	

DCS Port Config Header

This service header allows the user to tune and monitor the analog outputs. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
DCS Baud Rate	9 DFLT (1, 11) 1 = 110 2 = 300 3 = 600 4 = 1200 5 = 1800 6 = 2400 7 = 4800 8 = 9600 9 = 19200 10 = 38400 11 = 57600
DCS Stop Bits	1 DFLT (1, 3) ‘1’ for 1 stop bit, ‘2’ for 1.5 stop bits, or ‘3’ for 2 stop bits
DCS Parity	1 DFLT (1, 3) ‘1’ for none, ‘2’ for odd parity, or ‘3’ for even parity.
DCS Driver	1 DFLT (1, 3) ‘1’ for RS-232, ‘2’ for RS-422, or ‘3’ for RS-485
ASCII OR RTU	2 DFLT (1, 2) ‘1’ for ASCII, or ‘2’ for RTU
(scroll down back to DCS Port Config Header)	

HMI Port Config Header

This service header allows the user to tune and monitor the analog outputs. When this header appears in the display, scroll down to access this block or scroll left or right to select another block to monitor.

Command / Parameter	Messages
HMI Baud Rate	9 DFLT (1, 11) 1 = 110 2 = 300 3 = 600 4 = 1200 5 = 1800 6 = 2400 7 = 4800 8 = 9600 9 = 19200 10 = 38400 11 = 57600
HMI Stop Bits	1 DFLT (1, 3) ‘1’ for 1 stop bit, ‘2’ for 1.5 stop bits, or ‘3’ for 2 stop bits
HMI Parity	1 DFLT (1, 3) ‘1’ for none, ‘2’ for odd parity, or ‘3’ for even parity.
HMI Driver	1 DFLT (1, 3) ‘1’ for RS-232, ‘2’ for RS-422, or ‘3’ for RS-485
ASCII OR RTU	2 DFLT (1, 2) ‘1’ for ASCII, or ‘2’ for RTU
(scroll down back to HMI Port Config Header)	

Chapter 6.
OPSYS_FAULTS Mode

Introduction

The OPSYS_FAULTS mode displays all operating system faults or alarms that have occurred since the last Faults Reset operation. It also permits resetting (clearing) the alarm list.

The OPSYS_FAULTS mode headers are:

- Faults Detected - Displays faults detected since the last power down.
- Alarms Detected - Displays alarms detected since the last time the alarm list was cleared.
- Clear Alarms Detected - Clears the alarm list.

The information in the OPSYS_FAULTS mode is arranged as shown in Figure 7-1.

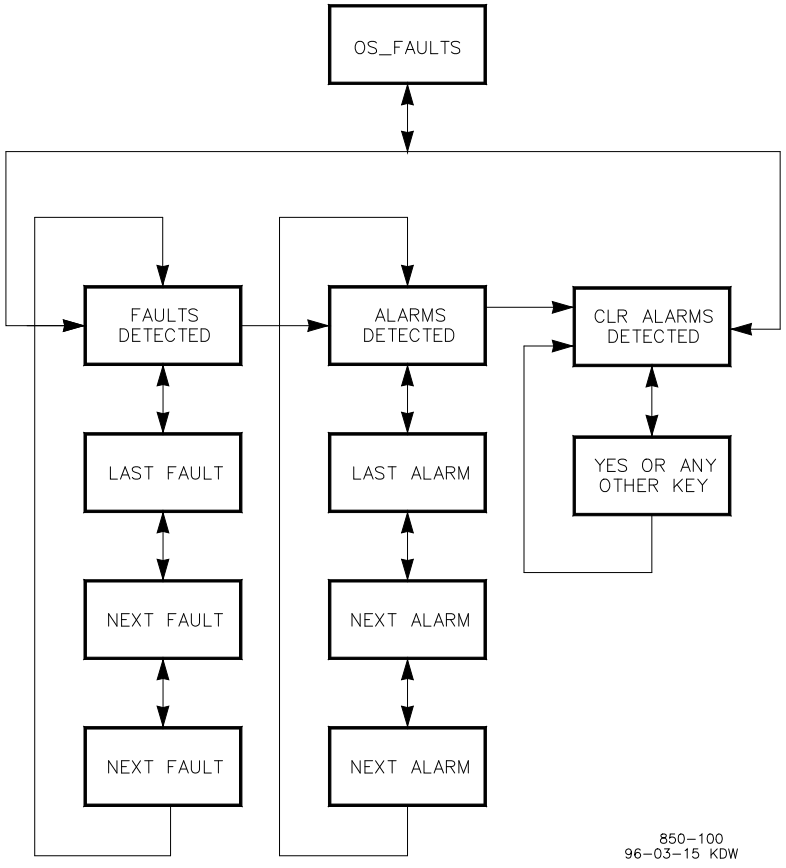
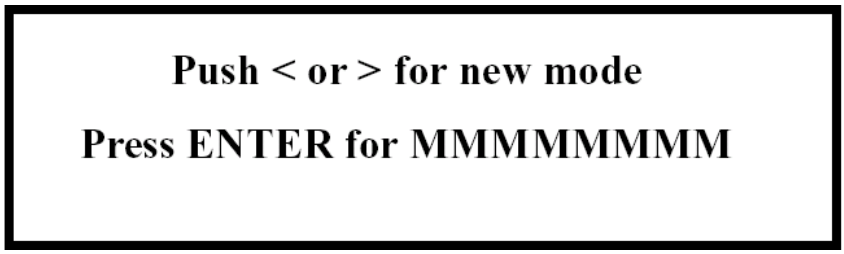


Figure 7-1. OPSYS_Faults Display Sequence

Enter OPSYS_Faults mode

The following message is displayed when the system is at the select mode level.



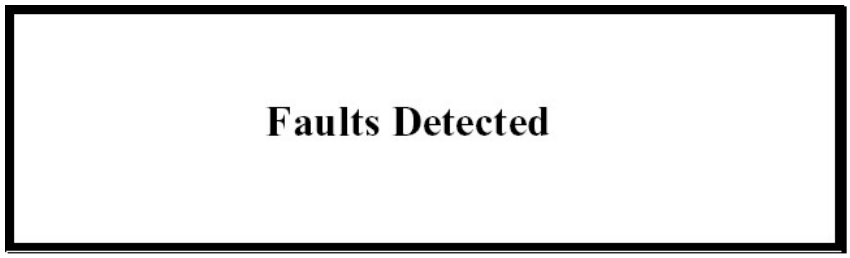
(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OPSYS_FAULTS or SYS_INFO)

Press the scroll left (<) or scroll right (>) key until the message indicates the OPSYS_FAULTS mode.
Press the ENTER key. The following message is displayed.

IMPORTANT **For password information see the Appendix. If the password information is not in this manual, see the supervisor or equipment engineer.**

Enter the password on the numeric keys and press the ENTER key. The header shown below is displayed.

Use the scroll left (<) or scroll right (>) key to select the desired OPSYS_FAULTS mode header. The header shown below is displayed.

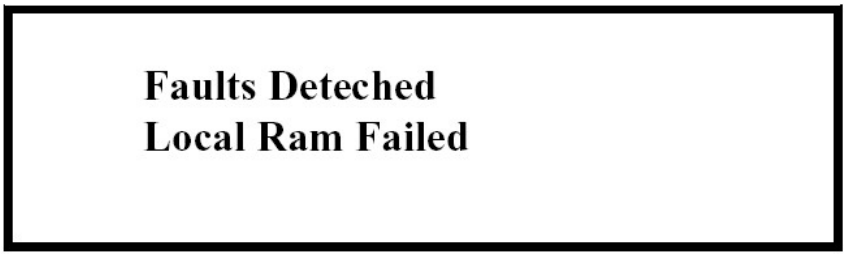


or

or

Faults Detected Header

While the Faults Detected header is displaying, use the scroll down or scroll up to display the faults detected under it. A message describing the most recent fault detected will display under the header message, as shown below.



Press scroll down to see the next fault detected. Each time scroll down or scroll up is pressed, another fault detected under this header is displayed. An example is shown below.

If no faults have been detected, the following message displays for one second.

After one second, only the header message will display.

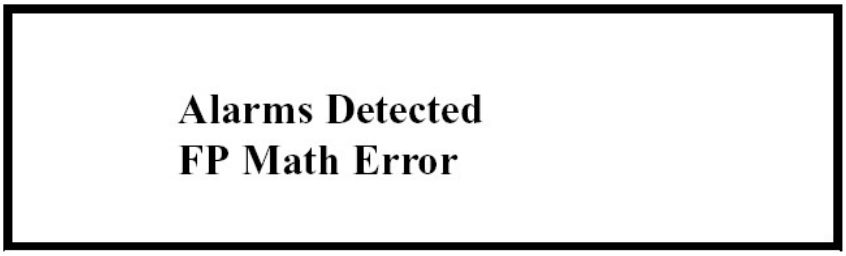
From a displaying fault message, to go back to the Faults Detected header press the CLEAR key.
To go from the Faults Detected header to the Top Level/Root display, press the CLEAR key again.

IMPORTANT

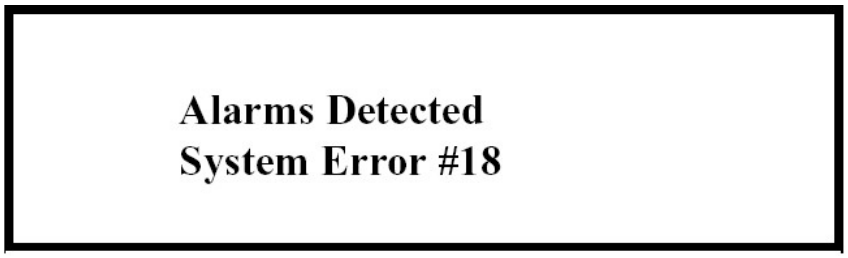
If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

Alarms Detected Header

While the Alarms Detected header is displaying, use scroll down to display the alarms detected under it. A message describing the most recent alarm detected is displayed under the header message, as shown below.



Press scroll down to see the next alarm detected. Each time scroll down or scroll up is pressed, another detected alarm is displayed. An example is shown below.



If no alarms have been detected, the following message is displayed for one second.

After one second, only the header message is displayed.

From a displaying alarm message, to go back to the Alarms Detected header press the CLEAR key.
To go from the Alarms Detected header to the Top Level/Root display, press the CLEAR key.

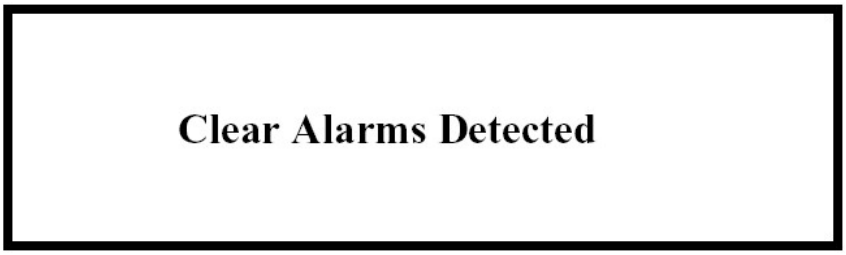
IMPORTANT **If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.**

Clear Alarms Detected Header

To clear the alarm list, while the Clear Alarms Detected header is displaying, press the scroll down key. The following message is displayed.

To clear the alarm list, press Y (for Yes). The alarm list is cleared and the following message is displayed for one second.

If any other key is pressed, the display returns to the header level and only the following message is displayed.



To go from the Clear Alarms Detected header to the Top Level/Root display, press the CLEAR key.

IMPORTANT **If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.**

SYS_INFO Mode

The SYS_INFO mode displays information about the system. It also permits changing passwords for the different modes and loading a configuration file from a personal computer.

The SYS_INFO mode headers are:

- System Information — Displays software version and information about the application program.
- Change Password — Allows user to change all the system passwords for the various modes.
- Download Configuration — Allows the user to download a configuration file from a personal computer.

The information in the SYS_INFO mode is arranged as shown in Figure 7-2.

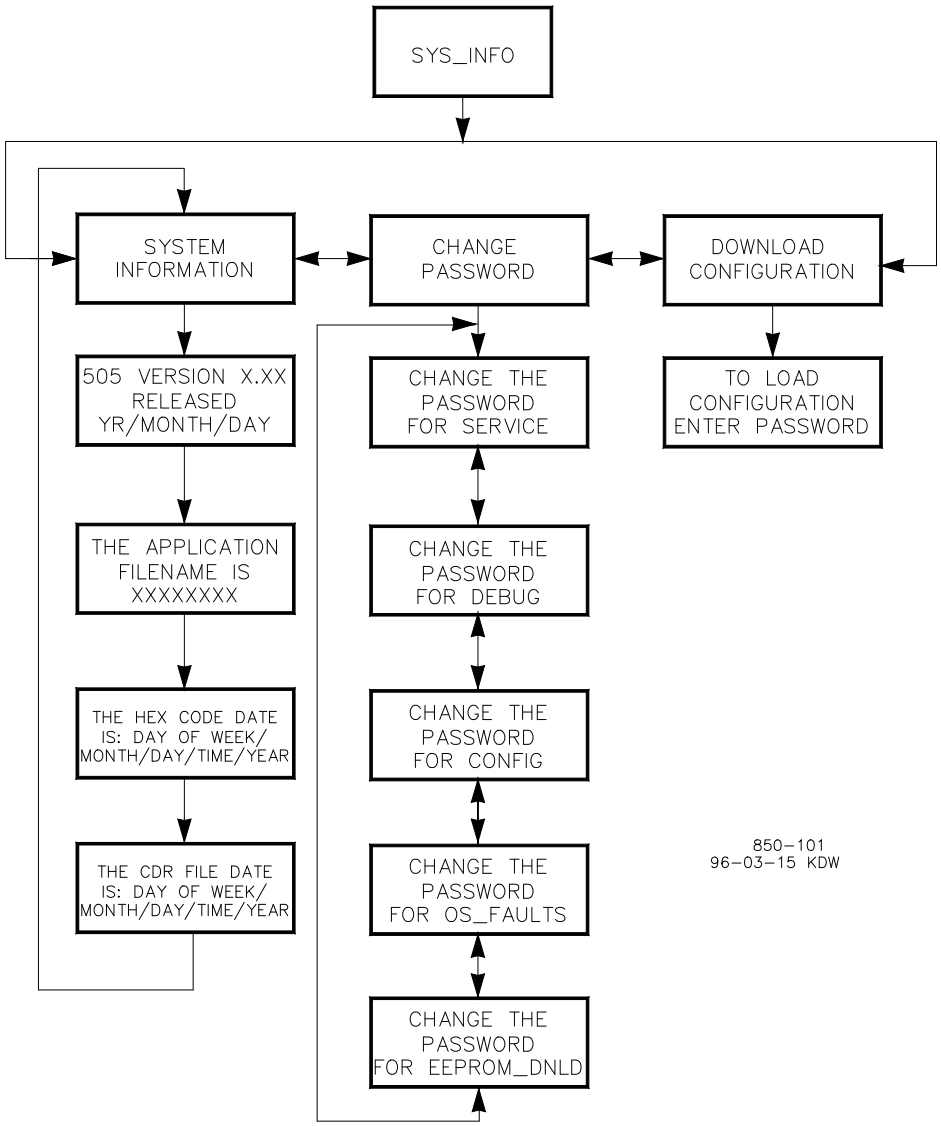


Figure 7-2. SYS_INFO Mode Information Arrangement

To enter the SYS_INFO mode

The following message is displayed when the system is at the select mode level.

Push < or > for new mode
Press ENTER for MMMMMMMM

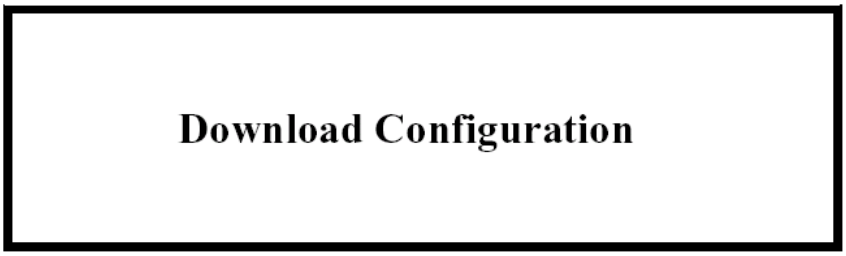
(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OPSYS_FAULTS or SYS_INFO.)

Press scroll left or scroll right until the message indicates the SYS_INFO mode. Press the ENTER key. The header shown below is displayed.

Use the scroll left (<) or scroll right (>) key to select the desired SYS_INFO mode header. The header shown below is displayed.

or

or

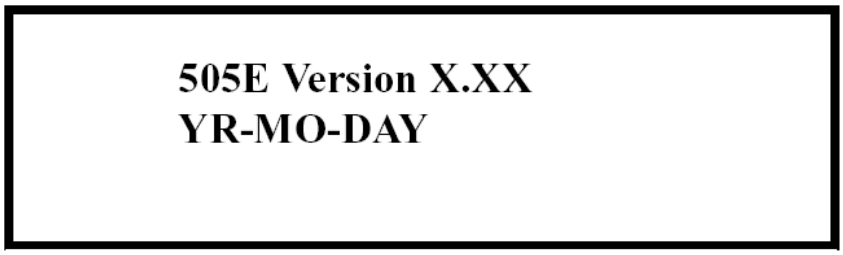


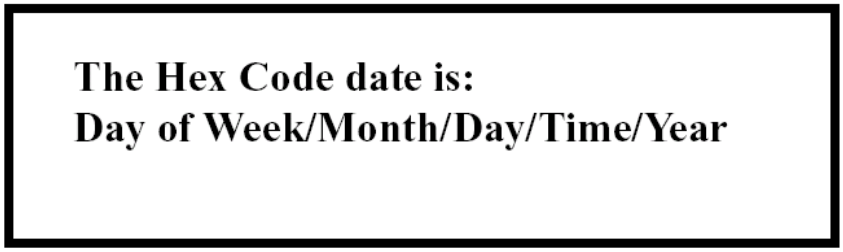
System Information Header

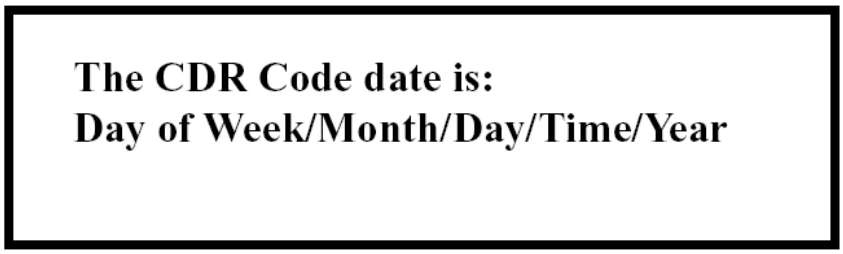
While the System Information header is displaying, use the scroll down key to display the system information under it. A message is displayed as shown below.

This is information about the version being used.

Continue to Press scroll down to see more system information. The messages as shown below are displayed.







From a system information message, to go back to the System Information header press the CLEAR key.

To go from the System Information header to the Top Level/Root display, press the CLEAR key.

IMPORTANT

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

Change Password Header

NOTICE

If any password is changed and that new password is forgotten or lost, the user will be locked out of that mode or function forever. It is suggested that changed passwords be documented and kept in a secure place so that authorized personnel have access to them.

While the Change Password header is displaying, use the scroll down or scroll up keys to enter the Change Password blocks. The following message is displayed.

Push ENTER to change the Password for MMMMMMMM

(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OPSYS_FAULTS, or EEPROM_DNLD.)

Press scroll left or scroll right to see the next passworded mode or function. Push ENTER when the desired mode or function is displayed. Carefully follow the instructions displayed on the screen.
From a change password message, to go back to the Change Password header, press the CLEAR key.
To go from the Change Password header to the Top Level/Root display, press the CLEAR key again.

IMPORTANT

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

Download Configuration Header

IMPORTANT **The Download function is to be used only by Woodward certified technicians.**

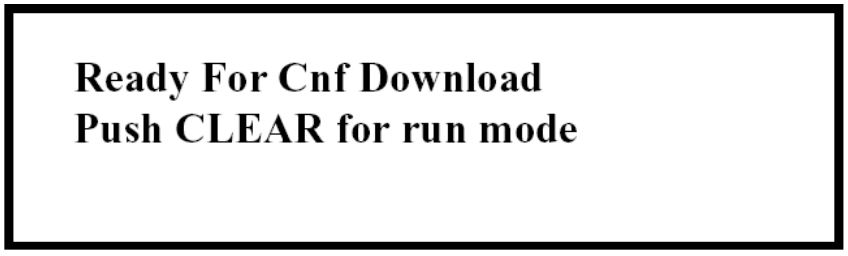
While the Download Configuration header is displaying, use the scroll down key to enter this function. A message will display as shown below.

For password information, see the Appendix. If the password information is not in this manual, see the supervisor or equipment engineer.

Enter the password on the numeric keys, then press the ENTER key. The system displays the following message.

NOTICE **Entry into the SYS_INFO mode while the turbine is running will cause an automatic shutdown of the turbine with resulting process stoppage. The control will prompt "SHUTDOWN CONTROL? Y/N". Entering YES will shut down the turbine. All mA outputs will go to zero and all relays will de-energize. Entering NO will abort the shutdown.**

If the NO key is pressed the system returns to the Download Configuration header. If the YES key is pressed, the system displays the following message.



Push CLEAR to abort the configuration download, else download the configuration. Then push the CLEAR key to begin running the control with the new configuration parameters.

Chapter 7.
PID Tuning

Speed and Throttle Pressure Dynamics Adjustments Overview

The speed and throttle pressure control utilize PID controllers. The response of each control loop can be adjusted for optimum response, however it is important to understand what a PID controller is and the effect each controller adjustment has on the controller response. Proportional gain, integral gain (stability), and DR (speed derivative ratio) are the adjustable and interacting parameters used to match the response of the control loop with the response of the system. They correspond to the P (proportional), I (integral), and D (derivative) terms, and are displayed by the 505LST as follows:

P = Proportional gain (%)
I = Integral gain (%)
D = Derivative (determined by DR and I)

Proportional Control

Proportional response is directly proportional to a process change.

Analogy: Setting hand throttle to keep constant speed on straight and level.

Proportional control (using the same analogy) results in a certain speed as long as the car is not subjected to any load change such as a hill. If a throttle is set to any particular setting, the speed of the car remains constant as long as the car remains straight and level. If the car goes up a hill, it will slow down. Of course, going down a hill the car would gain speed.

Integral Control

Integral compensates for process and setpoint load changes.

Analogy: Cruise control maintains constant speed regardless of hills.

Integral, sometimes called reset, provides additional action to the original proportional response as long as the process variable remains away from the setpoint. Integral is a function of the magnitude and duration of the deviation. In this analogy the reset response would keep the car speed constant regardless of the terrain.

Derivative

Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).

Analogy: Accelerating into high speed lane with merging traffic.

Derivative, sometimes called “preact” or “rate”, is very difficult to draw an accurate analogy to, because the action takes place only when the process changes and is directly related to the speed at which the process changes. Merging into high speed traffic of a freeway from an “on” ramp is no easy task and requires accelerated correction (temporary overcorrection) in both increasing and decreasing directions. The application of brakes to fall behind the car in the first continuous lane or passing gear to get ahead of the car in the first continuous lane is derivative action.

Proportional Response

The amount of controller change is directly related to the process change and the Proportional gain setting on the controller; Controller output change is Proportional to the process change. If there is no process change, there is no change in output from the controller (or valve change) regardless of the deviation. This results in an undesired offset between the original desired Setpoint and the resulting drop in the Control Point.

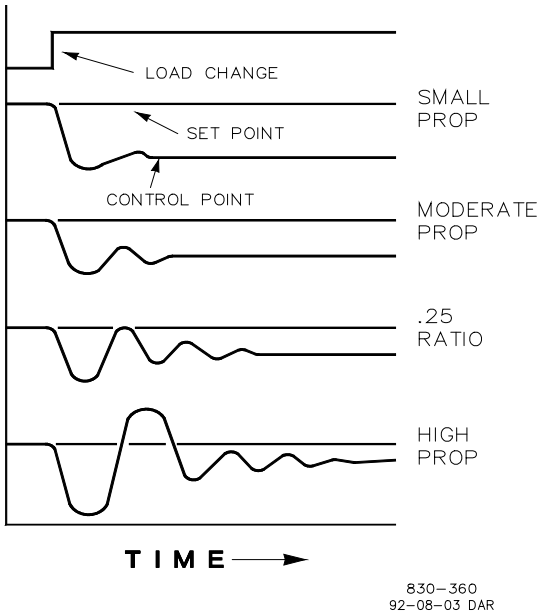


Figure 8-1. Proportional Gain Setting Effects

Proportional Gain (Effect of Settings)

Figure 8-1 shows the effect of Proportional gain settings on control. Starting at the top of the graph a load change is introduced. With a small Proportional gain (meaning a large process change is required to produce full valve travel), stability is good but offset is very high. With a moderate gain setting (higher number setting) stability is still good - offset is still fairly high. With a high setting, offset is considerably smaller but the stability is poor. The 0.25 ratio effects a minimum area whereby the offset is reduced to a minimum while stability is in a decaying manner at 0.25% ratio. The decay ratio used (0.25%) means that if the second cycle is 1/4 of the first cycle, then each succeeding cycle will be 1/4 of the preceding cycle until the cycle is not visible.

Since Proportional gain is adjusted to produce (only) the proper stability of a process, do not continue increasing its effect to correct offset conditions. The amount of stability and offset is directly related to the setting of the Proportional setting. Stability is of course also affected by the stability of the process. In essence, the amount of output from the controller due to the Proportional setting is From The Error. If There Is No Error, Then There Is No Proportional Effect.

Integral Response

Integral Gain as stated in the Woodward controls is repeats per minute (or Reset Rate). Therefore, a high amount of Integral gain (high number) would result in a large amount of Reset action. Conversely, a low Integral gain (low number) would result in a slower reset action.

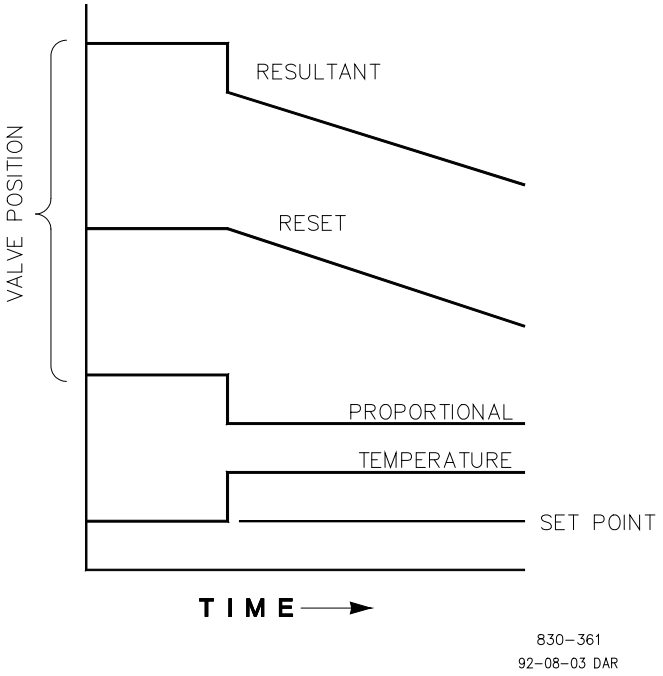


Figure 8-2. Open Loop Proportional and Integral Response

Integral response is provided to eliminate the offset that resulted from straight Proportional control. The figure above shows how the controller action is Proportional to the measurement change, but as we saw earlier, this results in offset. The Integral (or Reset) action is a function of both time and magnitude of the deviation. As long as an offset condition (due to load changes) exists, Integral action is taking place.

The amount of Integral action is a function of four things:

- The magnitude of the deviation
- The duration of the deviation
- The Proportional gain setting
- The Integral setting

In Figure 8-2, the Integral response is shown increasing due to the offset condition existing between the temperature and the setpoint. The resultant action is the top curve showing the step Proportional response that ends as soon as the measurement stops changing. Then the Integral (or reset) action is added to the Proportional action in an amount equal to the Integral of the deviation. In other words, Reset action continues (in either or both directions) as long as there is a difference (deviation) between the setpoint and the process measurement.

In this case, the deviation will never be eliminated (or even reduced) because the system is in Open Loop.

Proportional + Integral (Closed Loop)

Figure 8-3 shows the closed loop effects of integral action. The bottom curve displays the load change. The next curve up shows the setpoint and the measured variable, temperature. With the load change the temperature droops or deviates from the setpoint.

The next highest curve is the Proportional action and follows the measured variable proportionately. The Integral curve adds to the Proportional curve resulting in a different valve position, thereby returning the process to the Setpoint.

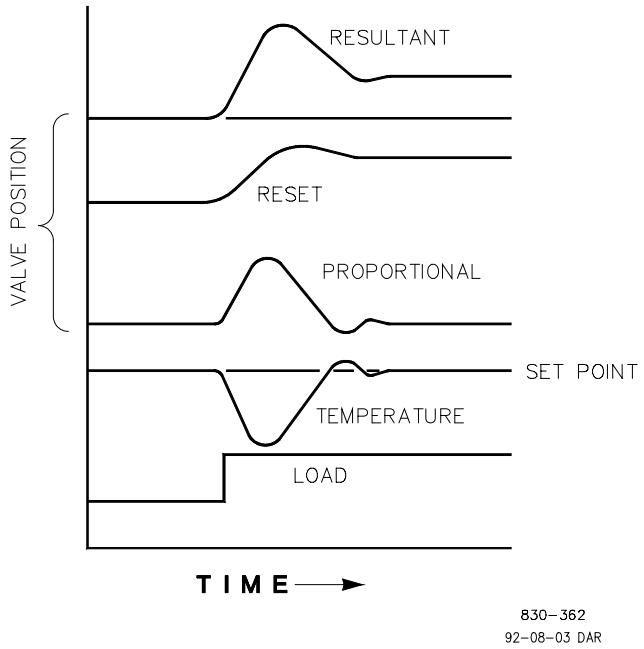


Figure 8-3. Closed Loop Proportional and Integral Response

In Closed Loop, however (as opposed to Open Loop), as the measurement decays toward the Setpoint the Proportional action is taking place Proportionally to the measurement change, and the Integral action is decaying proportionately to the magnitude and duration of the deviation until the measurement reaches the setpoint at which time the Integral action is zero.

Integral (Effects of Settings)

Figure 8-4 shows the effect of fast or slow Integral action. For a given load change an offset results with Proportional response only. Since recovery time (for a given load change) is important, the Integral setting should remove the offset in minimum time without adding additional cycling. If two cycles are added, then too much Integral Gain has been added. Of course, Proportional only must first establish the 1/4 decay ratio. If increased cycling occurs, the Integral must be turned off or the controller switched to “manual” if allowed to go too far. Ideally, the process should not continue to cycle after the setpoint is reached as in the second curve from the bottom.

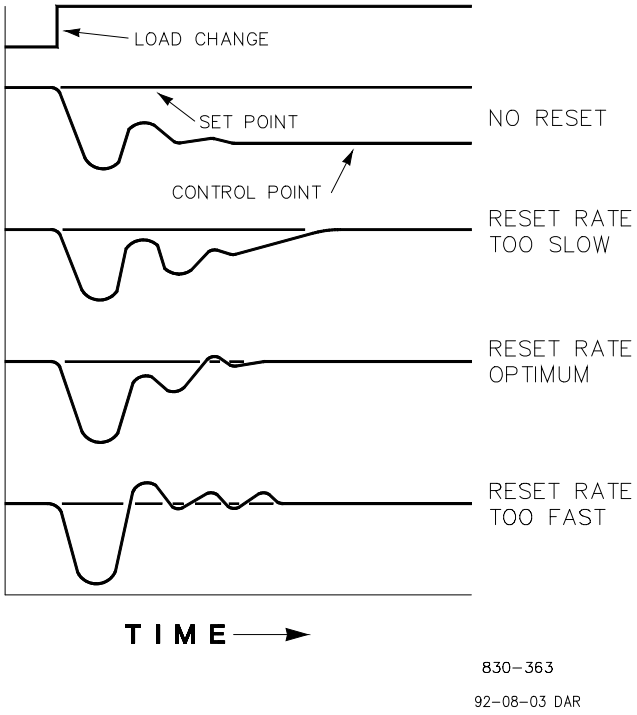


Figure 8-4. Integral Gain (Reset) Setting Responses

Derivative Response

In a process control loop the Derivative action is directly related to how fast the process changes (rate of change). If the process change is slow then the Derivative action is proportional to that rate of change. Derivative acts by advancing the Proportional action. Derivative acts at the start of the process change, when the process changes its rate and when the process stops its change.

Derivative action takes place at only three times:

- When the process starts to change
- When the rate of change takes place in the process
- When the process stops changing

The net result of Derivative action is to oppose any process change and combined with Proportional action to reduce stabilization time in returning the process to the setpoint after an upset. Derivative will not remove offset.

Woodward Derivative is split into two working domains, Input dominant and Feedback dominant. The allowed values for DR range from 0.01 to 100. The most common derivative is Feedback dominant, it is automatically selected with an Derivative Ratio (DR) from 1 to 100. The Input dominant domain is selected with DR values between 0.01 to 1.

Feedback dominant applies the derivative action to the integrator feedback term of the PID equation and is more stable than input dominant derivative. This will not take corrective action as early and it will be less noise sensitive. When tuning the derivative, the DR will be established in the 1 to 100 range because it is easier to tune and more forgiving of excessive values. Most PIDs will employ feedback dominant derivative.

Input dominant derivative applies the DR term before the integrator term of the PID equation. When the DR is less than 1, the derivative is input dominant and reacts very quickly to process upsets. This function is very adapted for PIDs that control the load parameter, such as load shaft turbine speed. Since the input dominant derivative is so sensitive, it should be reserved only for applications without high frequency noise.

Except for input dominant and feedback dominant features, the reciprocal of one domain will appear identical in the other domain. As an example, consider an DR of 5.0, the reciprocal being 1/5. That means that an DR of 5.0 will appear the same as DR of 0.200. The difference in response between these values of 5.0 and 0.2 is in the dominance feature.

If in doubt about the type of derivative to use, then set up for feedback dominant, 1 < DR < 100.

Proportional + Derivative (Closed Loop)

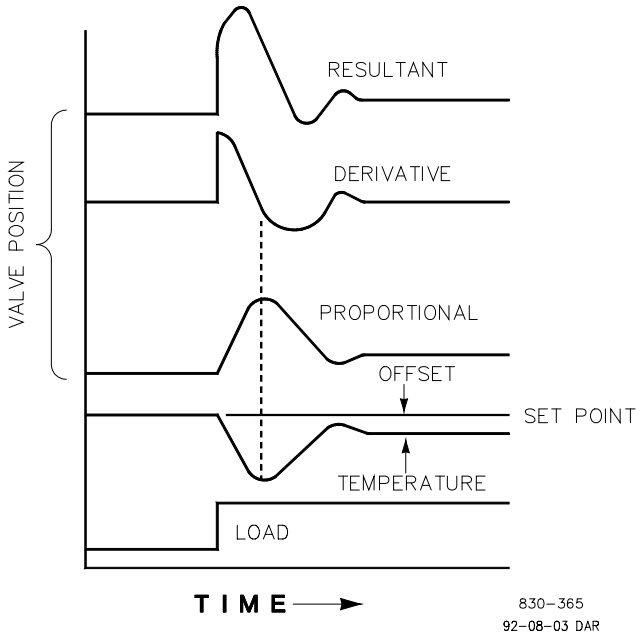


Figure 8-5. Closed Loop Proportional and Derivative Action

Figure 8-5 shows how Derivative acts to oppose a change in process in either direction. The dashed line shows the Derivative action going through zero to oppose the process deviation traveling toward zero. Notice offset still exists between the desired setpoint and the drooped control point that resulted from the load change. The top curve is the resultant controller output, Proportional plus Derivative.

If an upset (momentary) had occurred rather than a load change, there would be no offset.

Derivative (Effects Of Settings)

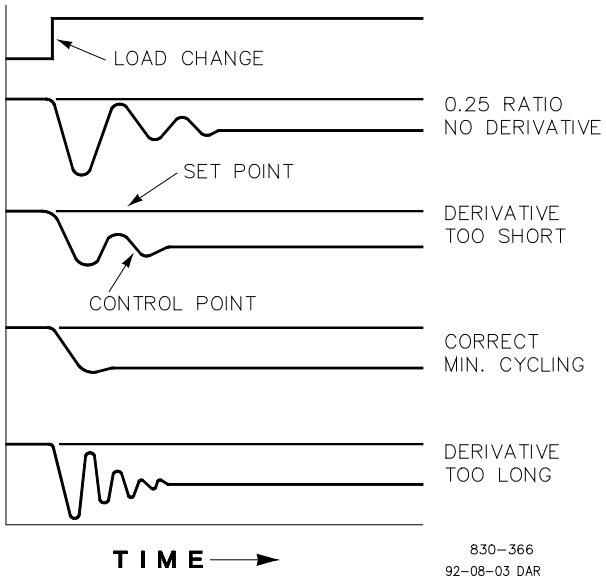


Figure 8-6. Derivative Setting Effects

Figure 8-6 shows the effect of different Derivative settings. The curves are relative since it depends on what type of control is desired in order to properly adjust Derivative time. For example, if minimum cycling is desired (as is shown here) then Derivative is added to the 1/4 decay cycle provided by Proportional until more than one cycle is removed and of course the 1/4 decay is destroyed. However, in most cases it is desirable to retain the 1/4 decay cycle, in which case Derivative is added to the point of removing only one cycle from the 1/4 decay ratio then the gain is increased until the 1/4 decay ratio is restored.

In all the above curves, you will note offset exists since offset can only be eliminated by the addition of Integral (or Reset).

Proportional + Integral + Derivative (Closed Loop)

Figure 8-7 shows the relationship of valve position to the interaction of the PID modes of control whenever a load change takes place in closed loop. As the temperature drops due to the load change, the proportional action moves the control valve proportionately to the measurement (temperature) change. The integral gain/reset adds to the proportional action as a result of the magnitude and time (duration) of the deviation. And the derivative temporarily over-corrects based on the speed at which the measurement moves in any direction. The resultant curve (at the top) shows a similar over-correction (in this case), but in addition the valve will stay at the new position required to keep the measurement at the setpoint.

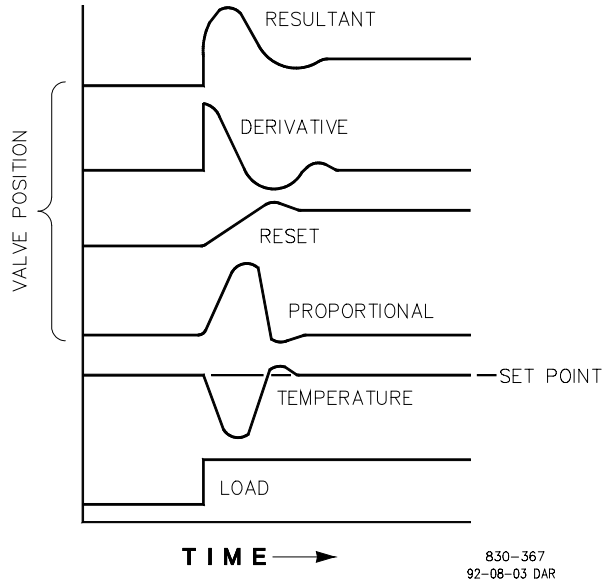


Figure 8-7. Closed Loop Proportional, Integral and Derivative Action

In summary, Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).

Do not use if high frequency noise is normally in the measured variable or the main lag is dead time. After Proportional is set to 1/4 decay ratio and Derivative is adjusted to remove one cycle as well as decreasing the 1/4 decay ratio, then the Proportional gain can be increased to restore the 1/4 decay ratio.

Adding Derivative

The value of the Derivative Ratio (DR) term can range from 0.01 to 100. In order to simplify adjustment of the dynamics of the 505LST, adjusting the integral gain value sets both the I and D terms of the PID controller. The DR term establishes the degree of effect the integral gain value has on the “D” term, and changes the configuration of a controller from input rate sensitive (input dominant) to feedback rate sensitive (feedback dominant) and vice versa.

Another possible use of the DR adjustment is to reconfigure the controller from a PID to a PI controller. This is done by adjusting the DR term to its upper or lower limits, depending on whether an input or feedback dominant controller is desired.

- A DR setting of 1 to 100 selects feedback dominant mode.
- A DR setting of .01 to 1 selects input dominant mode.
- A DR setting of .01 or 100 selects a PI only controller, input and feedback dominant respectively.

The change from one of these configurations to the other may have no effect during normal operation, however, it can cause great differences in response when the governor is coming into control. (i.e. at startup, during a full load change, or during transfer of control from another channel).

An input dominant controller is more sensitive to the change-of-rate of its input (i.e. Speed, Cascade in or Auxiliary in), and can therefore prevent overshoot of the setpoint better than a feedback dominant controller. Although this response is desirable during a startup or full load rejections, it can cause excessive control motions in some systems where a smooth transition response is desired.

A controller configured as feedback dominant is more sensitive to the change-of-rate of its feedback (LSS). A feedback dominant controller has the ability to limit the rate of change of the LSS bus when a controller is near its setpoint but is not yet in control. This limiting of the LSS bus allows a feedback dominant controller to make smoother control transitions than an input dominant controller.

General Guidelines Field Tuning

The quality of regulation obtained from an automatic control system depends upon the adjustments that are made to the various controller modes. Best results are obtained when the adjustment (tuning) is done systematically. Prior training and experience in controller tuning are desirable for effective application of this procedure.

This procedure will lead to controller settings which will provide:

- Process control without sustained cycling.
- Process recovery in a minimum time

Controller settings derived for given operating conditions are valid over a narrow range of load change. The settings made for one operating set of conditions may result in excessive cycling or highly damped response at some other operating condition. This procedure should be applied under the most difficult operating conditions to assure conservative settings over the normal operating range.

It is good practice to keep the average of the setpoint changes near the normal setpoint of the process to avoid excessive departure from normal operating level.

After each setpoint change, allow sufficient time to observe the effect of the last adjustment. It is recommended to wait until approximately 90% of the change is completed.

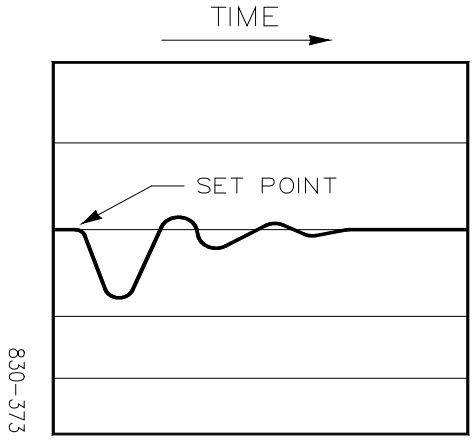


Figure 8-8. Typical Response to Load Change

Tuning Example

If the system is unstable, make sure the governor is the cause. This can be checked by closing the valve limiter until it has control of the actuator output. If the governor is causing the oscillation, time the oscillation cycle time. General rules are:

- If the system's oscillation cycle time is less than 1 second reduce the Proportional gain term
- If the system's oscillation cycle time is greater than 1 second reduce the Integral gain term (Proportional gain may also need to be increased).

On an initial startup with the 505LST, all PID dynamic gain terms will require adjustment to match the respective PIDs response to that of its control loop. There are multiple dynamic tuning methods available that can be used with the 505LST's PIDs to assist in determining the gain terms that provide optimum control loop response times.

The following method can be used to achieve PID gain values that are close to optimum:

1. Increase Derivative Ratio (DR) to 100 (Service Mode adjustment)
2. Reduce integral gain to 0.01 (Run Mode adjustment)
3. Increase proportional gain until system just starts to oscillate (Run Mode). The optimum gain for this step is when the system just starts to oscillate and maintains a self-sustaining oscillation that does not increase or decrease in magnitude.
4. Record the control gain (Kc) and oscillation period (T) in seconds.
5. Set the dynamics as follows:

For PI control : G = P(I/s + 1)
Set: Proportional gain = 0.45*Kc
Integral gain = 1.2/T
Derivative ratio = 100

For PID control : G = P(I/s + 1 + Ds)
Set: Proportional gain = 0.60*Kc
Integral gain = 2/T
Derivative Ratio = 8/(T*Integral Gain) for feedback dominant
= (T*Integral Gain)/8 for input dominant

This method of tuning will get the gain settings close, and they can be fine-tuned from this point.

Chapter 8. Communications

Modbus Communication

The 505LST control can communicate with plant Distributed Control Systems (DCS) and/or operator control panels through two Modbus communication ports. These ports support RS-232, RS-422 and RS-485 communications using ASCII or RTU MODBUS transmission protocols. Modbus utilizes a master/slave protocol. This protocol determines how a communication network's master and slave devices establish and break contact, how a sender is identified, how messages are exchanged, and how errors are detected.

Monitor Only

The two Modbus communication ports, as defaulted from the factory, are not programmed. Although these ports are not programmed they continue to update all information to all registers.

If a device is required to monitor all the 505LST's controlling parameters, modes, etc., without affecting control, the master device must not send signals over the Boolean write or analog write locations.

Monitor and Control

Once a Modbus port is configured within the 505LST's Program Mode, the 505LST will accept RUN mode commands from an external network master device (DCS, etc.). This allows a Modbus compatible device to monitor and perform all 505LST RUN mode parameters and commands except for the Overspeed Test enable, On-Line/Off-Line Dynamics select, and Override Failed Speed Signal commands.

Both Modbus ports are independent of each other, and can be used simultaneously. To use a 505LST Modbus port to monitor and operate the 505LST through, program the port's 'Use Modbus Port' setting to 'YES'.

Modbus Protocol

The 505LST control supports two Modbus transmission modes. A mode defines the individual units of information within a message, and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in Table 9-1 below.

Table 9-1. ASCII versus RTU Modbus

CHARACTERISTIC	ASCII	RTU
Coding System	Hexadecimal (uses ASCII printable binary characters: 0-9, A-F)	8-bit binary
Start Bits	1	1
Data Bits per Character	7	8
Parity	Even, odd or none	Even, odd or none
Stop Bits	1, 1.5, or 2	1, 1.5, or 2
Baud Rate	110, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, or 57600	110,300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, or 57600
Error Checking	LRC (Longitudinal Redundancy Check)	CRC (Cyclical Redundancy Check)

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 9-1).

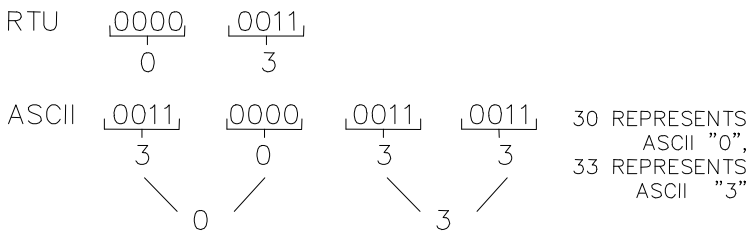


Figure 9-1. ASCII / RTU Representation of 3

The Modbus protocol allows one master and up to 247 slaves on a common network. Each slave is assigned a fixed, unique device address in the range of 1 to 247. With the Modbus protocol, only the network master can initiate a transaction. A transaction consists of a request from the master to a slave unit and the slave's response. The protocol and Modbus device number are set in Program Mode and can be adjusted in Service Mode, if required.

The 505LST control is programmed to function as a slave unit only. As a slave unit, the 505LST will only respond to a transaction request by a master device. The 505LST can directly communicate with a DCS or other Modbus supporting device on a single communications link, or through a multi-dropped network. If multi-dropping is used, up to 246 devices (505LSTs or other customer devices) can be connected to one Master device on a single network. The control address is programmed under the 505LST's communications block and can be changed in the service mode, if needed.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information. See Figure 9-2.

	BEGINNING OF FRAME	SLAVE ADDRESS	FUNCTION CODE	DATA	ERROR CHECK CODE	END OF FRAME
ASCII	:	2 CHARS 8 BITS	2 CHARS 8 BITS	4 BITS DATA PER CHAR	2 CHAR 8 BITS	CR LF
RTU	3–CHAR DEAD TIME	1 CHAR 8 BITS	1 CHAR 8 BITS	8 BITS DATA PER CHAR	2 CHAR 16 BITS	3 CHAR DEAD TIME

Figure 9-2. Modbus Frame Definition

The Modbus function code tells the addressed slaves what function to perform. Table 9-2 lists the function codes supported by this control.

Table 9-2. Modbus Function Codes

CODE	DEFINITION	REFERENCE ADDRESS
01	Read Digital Outputs *(Raise/Lower and Enable/Disable Commands)*	0XXXX
02	Read Digital Inputs *(Status Indications / Alarms and Trips)*	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs *(Speed, Setpt, etc.)*	3XXXX
05	Write Single Discrete Output *(Raise/Lower and Enable/Disable Commands)*	0XXXX
06	Write Single Register *(Enter Setpt Directly)*	4XXXX
08	Loopback Diagnostic Test *(Subfunction 0 only)*	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the control issues an alarm message. The error codes are defined in Table 9-4 below. The exception error status and respective error codes can be viewed in Service mode.

If the control has not received a message for the configured time-out period, the control generates an alarm with an error message, but no message is sent to the master. This time-out is defaulted to 2 seconds and only applies to units using both monitor and control (adjustable in Service Mode).

Table 9-3. Modbus Slave Exception Error Codes

ERROR CODE	ERROR MESSAGE	CODE SENT TO MASTER	DESCRIPTION
0	No Error	0	No Error.
1	Bad Modbus function	1	The specified function is not supported for this control.
2	Bad Modbus data address	2	The Modbus value addressed is not valid for this control.
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid.
9	Bad Modbus checksum	None	Message checksum did not match.
10	Bad Modbus message	None	Message could not be decoded.
N/A	Lost Modbus link	None	No messages received for the configured time-out period.

Port Adjustments

Before the 505LST can communicate with the master device, the communication parameters must be verified. These values are set in Program Mode and can be adjusted, if required, in Service Mode.

Table 9-4. Modbus Communication Port Adjustments

PARAMETER	ADJUSTMENT RANGE
Baud Rate	110 to 57600
Parity	NONE, ODD or EVEN
Stop Bits	1 to 2
Driver	RS-232, RS-422, or RS-485

Modbus Addressing

The Modbus communication ports in the 505LST control are programmed for unique Modbus addresses. A complete listing of these addresses for your application is located in this manual. The Modbus address listing consists of Boolean Writes, Boolean Reads, Analog Reads, and Analog Writes. The Boolean reads and writes are also referred to as input and holding coils. The analog reads and writes are also referred to as input registers and holding registers.

All values that can be addressed by Modbus are considered to be discrete and numeric. The discrete values are a 1 bit binary, on or off value and the numerics are 16 bit values. Discrete values are sometimes referred to as coils or digitals and numerics are referred to as registers or analogs. All read/write registers are interpreted by the 505LST as signed 16 bit integer values. Since Modbus can only handle integers, values that require a decimal point in the Modbus Master Device are multiplied by a scaling constant before being sent by 505LST.

The maximum number of discretes and registers that can be transmitted in one packet is dependent on each implementation of Modbus. Table 9-5 defines these limits.

Table 9-5. Maximum Modbus Discrete and Analog Values

MODE OF TRANSMISSION	MAX DISCRETES	MAX REGISTERS
ASCII	944	59
RTU	1188	118

Boolean Writes (Holding Coils)

Holding coils are logical signals that are both readable from and writable to the 505LST control. An example of a Boolean write value would be raise or lower commands. A logical true denoted by the value 1 will cause the command listed in the description to be executed. For example, if a 1 is written to address 0:0010 and this corresponded to a speed raise command, the manual speed setpoint increases until a 0 is written to address 0:0010. The 505LST control supports function codes 1, 5, and 15. These correspond to reading selected holding coils, writing to a single holding coil, and writing to multiple holding coils, respectively.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writable to, the 505LST control. An example of an Boolean read value would be a turbine trip status indication. The input coil will have the value 1 if the statement in the description column is true and a 0 if false. The `1:' term in the address identifies an input coil. The 505LST control supports Modbus function code 2, which involves reading selected input coils.

Analog Reads (Input Registers)

Input registers are analog values that are readable from, but not writable to, the 505LST control. An example of an analog read value would be turbine speed. The values of the input registers are stored internal to the control as floating point numbers representing engineering units (i.e. kPa or rpm). The values that are transmitted are integer values ranging from -32767 to +32767. Since Modbus can only handle integers, values that have a decimal point are multiplied by a constant before being sent by Modbus. For example, these input registers may be listed as the Modbus value `x100' or `x10' under the description heading to denote the value is multiplied by a scaling constant. This allows transmission of decimal parts of a unit if this is necessary for better resolution.

Refer to Chapter 5 Service Mode for defaulted communication constants and ranges. The 505LST control supports Modbus function code 4, which involves reading selected input registers.

Analog Writes (Holding Registers)

Holding registers are analog values that are writable to the 505LST control. These values can also be read by a device performing error checking. An example of an analog write value would be a direct speed setpoint value as opposed to raise and lower commands. The value of the holding registers are also stored in the control as numbers representing engineering units (i.e. psi or rpm). The 505LST control supports Modbus function codes 3, 6, and 16. These correspond to reading selected holding registers, writing to a single holding register, and writing to multiple holding registers, respectively.

Modbus Scale Factors
Modbus has two limitations:

- Only integers can be sent
- The value is limited between -32767 and 32767.

These limitations can be overcome by scaling the value before it is sent across the Modbus. The default scale factor for the analog values is 1. The scale factor can be changed in Service Mode to between 1 and 100. The following input and setpoint values that are sent across the Modbus have independent scale factors: Casc (3:0030), Aux (3:0037), FSP (3:0041), kW (3:0045), and Sync/Load Share (3:0043). These scaled parameters and their scale factor are available through the Modbus. Values that require a decimal point must be multiplied by the scale factor (10 or 100) prior to being sent across the Modbus. The value sent must then be divided by the scale factor in the Master.

The Scale Factor adjusts all associated analog reads and writes accordingly. For example, the Cascade Scale Factor adjusts the cascade input and setpoint analog read values as well as the Entered Setpt analog write value.

For example, if the Cascade setpoint of 60.15 needs to be sent across the Modbus and have two decimal places, the Cascade Scale Factor would be set to 100 in the Service Mode. This changes the value so that the decimal places can be sent across the Modbus communications link (60.15 * 100 = 6015). After the value is sent across the Modbus, it must be rescaled in the Master to the original value (6015 / 100 = 60.15). A Directly Entered Cascade Setpoint (4:0002) of 61.5 would be sent across the link as 6150 and the 505LST automatically divides the value by the Casc Scale Factor and uses the value of 61.5 as the setpoint.

Modbus Percentage

Some of the analog read addresses have percentages sent across. The formula used in the percentage calculation is (actual / max) * 100. The percentage is multiplied by 100 before being sent across the Modbus to provide up to 2 decimal places, if desired.

For More Modbus Information

Detailed information on the Modbus protocol is presented in “Reference Guide PI-MBUS-300” published by AEC Corp./Modicon Inc., formerly Gould Inc. To implement your own source code, you must register with Modicon. Registration includes purchasing document PI-MBUS-303 and signing a non-disclosure agreement. You can register to use Modbus at your nearest Modicon field office.

Addr	Description
0:0001	ALARM RESET
0:0002	TURBINE RESET
0:0003	TRIP
0:0004	TV #1 TEST
0:0005	TV #2 TEST
0:0006	IV/RHSV #1 TEST
0:0007	IV/RHSV #2 TEST
0:0008	TEST ABORT
0:0009	VALVE LIMIT RAISE
0:0010	VALVE LIMIT LOWER
0:0011	SEMI-AUTO SELECT (ON-LINE)
0:0012	AUTO SELECT (OFF-LINE LIKE 505)
0:0013	MANUAL SELECT
0:0014	CHEST PREWARM
0:0015	COORDINATE CONTROL (ON-LINE & OFF-LINE
0:0016	TPC IN/OUT SELECT
0:0017	TP CONTROL SELECT
0:0018	VP CONTROL SELECT
0:0019	VALVE TRANSFER ENABLE
0:0020	RAISE SELECT
0:0021	LOWER SELECT
0:0022	GO/RUN COMMAND
0:0023	STOP/HOLD COMMAND
0:0024	SLOW RATE SELECT
0:0025	MEDIUM RATE SELECT
0:0026	FAST RATE SELECT
0:0027	spare
0:0028	OVERSPEED TEST ENABLE/DISABLE
0:0029	VALVE STROKE LOWER
0:0030	VALVE STROKE RAISE
0:0031	spare
0:0032	GV STROKE
0:0033	IVL STROKE
0:0034	TV STROKE
0:0035	IVR STROKE
0:0036	

Boolean Reads (RPTbr)

Addr	Description
1:0001	ALL MPU'S FAILED TRIP
1:0002	ELECTRICAL OVERSPEED TRIP
1:0003	EMERGENCY TRIP (LOCAL PANEL)
1:0004	EMERGENCY TRIP (TRIP STRING)
1:0005	NO SPEED DETECTED TRIP
1:0006	POWER UP TRIP
1:0007	DCS MODBUS TRIP
1:0008	HMI MODBUS TRIP
1:0009	BREAKER OPEN TRIP
1:0010	GO
1:0011	COMM PORT 1 FAULT ALARM
1:0012	COMM PORT 2 FAULT ALARM
1:0013	AI-01 SIGNAL FAILED
1:0014	AI-02 SIGNAL FAILED
1:0015	AI-03 SIGNAL FAILED
1:0016	AI-04 SIGNAL FAILED
1:0017	AI-05 SIGNAL FAILED (TPC Signal)
1:0018	AI-06 SIGNAL FAILED (SPD/VPC DMND)
1:0019	MPU #1 SIGNAL FAILED
1:0020	MPU #2 SIGNAL FAILED
1:0021	ACTUATOR #1 DRIVER FAULT
1:0022	ACTUATOR #2 DRIVER FAULT
1:0023	BACKUP OVERSPEED DEVICE FAILED
1:0024	IV/RHSV #1 TEST FAILED
1:0025	IV/RHSV #2 TEST FAILED
1:0026	THROTTLE VALVE #1 TEST FAILED
1:0027	THROTTLE VALVE #2 TEST FAILED
1:0028	IN AUTOMATIC TPC ALARM
1:0029	TV #1 NOT CLOSED ALARM
1:0030	TV'S NOT OPEN ALARM
1:0031	TV #2 NOT CLOSED ALARM
1:0032	PREWARM ACTIVE
1:0033	LEFT IV NOT CLOSED ALARM
1:0034	BOTH IV NOT OPEN ALARM
1:0035	LEFT RHSV NOT CLOSED ALARM
1:0036	BOTH RHSV NOT OPEN ALARM
1:0037	VLV 3 NOT CLOSED ALARM
1:0038	VLV 1 NOT OPEN ALARM
1:0039	VLV 3 NOT OPEN
1:0040	RIGHT IV NOT CLOSED ALARM
1:0041	RIGHT RV NOT CLOSED ALARM
1:0042	VLV 1 NOT CLOSED ALARM
1:0043	DI-01 STATUS (EMERGENCY SHUTDOWN)
1:0044	DI-02 STATUS (GENERATOR BREAKER CLOSED
1:0045	DI-03 STATUS (RAISE)
1:0046	DI-04 STATUS (LOWER)
1:0047	DI-05 STATUS ENABLE TPC
1:0048	DI-06 STATUS (BOTH TV'S OPEN)
1:0049	DI-07 STATUS (TV #1 CLOSED)
1:0050	DI-08 STATUS (TV #2 CLOSED)
1:0051	DI-09 STATUS (BOTH IV OPEN)
1:0052	DI-10 STATUS (IV #1 CLOSED)
1:0053	DI-11 STATUS (IV #2 CLOSED)
1:0054	DI-12 STATUS (BOTH RHSV OPEN)
1:0055	DI-13 STATUS (RHSV #1 CLOSED)
1:0056	DI-14 STATUS (RHSV #2 CLOSED)
1:0057	DI-15 STATUS (DCS IN CONTROL)
1:0058	DI-16 STATUS (GO)

Addr	Description
1:0059	DI-17 STATUS (E-STOP ON FRONT PANEL)
1:0060	DO-01 STATUS (SHUTDOWN)
1:0061	DO-02 STATUS (TCS IN CONTROL)
1:0062	DO-03 STATUS
1:0063	DO-04 STATUS
1:0064	DO-05 STATUS (REHEAT STOP #1 TEST)
1:0065	DO-06 STATUS (REHEAT STOP #2 TEST)
1:0066	DO-07 STATUS
1:0067	DO-08 STATUS
1:0068	DO-09 STATUS F4 INDICATION
1:0069	DO-10 STATUS (EMERGENCY STOP KEYPAD IN
1:0070	DO-11 STATUS F3 INDICATION
1:0071	DO-12 (ALARM KEYPAD INDICATION)
1:0072	DO-13 F1 (INDICATION)
1:0073	OVERSPEED PROTECTION IN CONTROL
1:0074	SPEED IN CONTROL
1:0075	VALVE POSITION CONTROL
1:0076	THROTTLE PRESSURE IN CONTROL
1:0077	VALVE LIMITER IN CONTROL
1:0078	AUTO SELECTED
1:0079	COORDINATED CONTROL SELECTED
1:0080	MANUAL SELECTED
1:0081	SLOW RATE SELECTED
1:0082	MEDIUM RATE SELECTED
1:0083	FAST RATE SELECTED
1:0084	IN CRITICAL SPEED RANGE
1:0085	IV/RHSV #1 IN TEST
1:0086	IV/RHSV #2 IN TEST
1:0087	STOP VALVE #1 IN TEST
1:0088	STOP VALVE #2 IN TEST
1:0089	OVERSPEED TEST ENABLED
1:0090	ABOVE NORMAL ELECTRICAL OVERSPEED
1:0091	TURBINE IS TRIPPED
1:0092	SPEED OK TO SYNCHRONIZE
1:0093	TPC ENABLED (IN/OUT)
1:0094	CONTROL VALVE STROKE ACTIVE
1:0095	INTERCEPT VALVE STROKE ACTIVE
1:0096	USE SEMI-AUTO OFFLINE SELECTED
1:0097	IN VALVE TRANSFER
1:0098	GO
1:0099	CONTACT INPUT LIMITED
1:0100	ANALOG INPUT 1 USED
1:0101	ANALOG INPUT 2 USED
1:0102	ANALOG INPUT 3 USED
1:0103	ANALOG INPUT 4 USED
1:0104	ANALOG INPUT 5 USED
1:0105	ANALOG INPUT 6 USED
1:0106	SECOND MPU USED
1:0107	SV 1 LIMIT SWITCHES USED
1:0108	SV 2 LIMIT SWITCHES USED
1:0109	RHSV LIMIT SWITCHES USED
1:0110	ENABLE SV TEST SELECTED
1:0111	ENABLE IV RHSV TEST SELECTED
1:0112	USE INLET PRESS CONTROL SELECTED
1:0113	USE MW CONTROL SELECTED
1:0114	USE AUTO START SEQ SELECTED
1:0115	USE 4–20mA FOR SPEED REF SELECTED
1:0116	USE 4–20mA FOR VPC SELECTED
1:0117	UNIT HAS 2 THROTTLE VALVES
1:0118	PREWARM ACTIVE

Addr	Description
1:0119	SEMI-AUTO OFFLINE SELECTED
1:0120	TV LIMITER ENABLED
1:0121	SPARE
1:0122	SPARE
1:0123	SPARE
1:0124	SPARE
1:0125	SPARE
1:0126	SPARE
1:0127	SPARE
1:0128	SPARE
1:0129	SPARE
1:0130	SPARE
1:0131	ALL MPU'S FAILED TRIP
1:0132	ELECTRICAL OVERSPEED TRIP
1:0133	EMERGENCY TRIP (LOCAL PANEL)
1:0134	EXTERNAL TRIP (WITH OVERRIDE)
1:0135	NO SPEED DETECTED TRIP
1:0136	POWER UP TRIP
1:0137	DCS MODBUS TRIP
1:0138	HMI MODBUS TRIP
1:0139	BREAKER OPEN TRIP
1:0140	EXTERNAL EMERGENCY TRIP
1:0141	TV POSITION ERROR TRIP
1:0142	SPARE
1:0143	SPARE
1:0144	SPARE

Analog Reads (RPTar)

Addr	Description
3:0001	AI-01 CURRENT
3:0002	AI-02 CURRENT
3:0003	AI-03 CURRENT
3:0004	AI-04 CURRENT
3:0005	AI-05 CURRENT
3:0006	AI-06 CURRENT (SPEED/VPC DEMAND)
3:0007	AI-01 ACTUAL VALUE
3:0008	AI-02 ACTUAL VALUE
3:0009	AI-03 ACTUAL VALUE
3:0010	AI-04 ACTUAL VALUE
3:0011	AI-05 ACTUAL VALUE
3:0012	AI-06 ACTUAL VALUE (SPEED/VPC DEMAND)
3:0013	AO-01 VALUE
3:0014	AO-03 VALUE
3:0016	AO-04 VALUE
3:0017	AO-05 VALUE
3:0018	AO-06 VALUE
3:0019	AO-01 4–20 X 10
3:0020	AO-02 4–20 X 10
3:0021	AO-03 4–20 X 10
3:0022	AO-04 4–20 X 10
3:0023	AO-05 4–20 X 10
3:0024	AO-06 4–20 X 10
3:0025	MPU 1 SPEED
3:0026	MPU 2 SPEED
3:0027	ACTUAL SPEED
3:0028	SPEED PID
3:0029	SPEED REFERENCE
3:0030	ACTUATOR 1 CURRENT

Addr	Description
3:0031	SPARE
3:0032	ACTUATOR 2 CURRENT
3:0033	IV 1 DEMAND
3:0034	IV 2 DEMAND
3:0035	CONTACT INPUT LMT HI VALUE
3:0036	THROTTLE PRESSURE SETPOINT
3:0037	THROTTLE PRESSURE PID
3:0038	SEMI-AUTO SPEED TARGET
3:0039	VALVE LIMIT VALUE
3:0040	TV DEMAND VALVE TRANSFER
3:0041	GV DEMAND VALVE TRANSFER
3:0042	LSS DEMAND
3:0044	VPC SETPOINT
3:0045	VPC DEMAND
3:0046	NORMAL OVERSPEED SETPOINT
3:0047	ABSOLUTE OVERSPEED SETPOINT
3:0048	HIGH SPEED CAPTURE
3:0049	SPEED AT TRIP
3:0050	SPEED RATE VALUE
3:0051	VPC RATE VALUE
3:0052	SPEED REF ANALOG IN 6
3:0053	VALVE LIMITER RATE VALUE
3:0054	FIRST OUT TRIP NUMBER
3:0055	GV1 DEMAND
3:0056	GV2 DEMAND
3:0057	TV1 DEMAND
3:0058	TV2 DEMAND

Analog Writes (RPTaw)

Addr	Description
4:0001	DCS MW VALUE
4:0002	DCS INLET PRESSURE VALUE
4:0003	VALVE POSITION SETPOINT
4:0004	LO INPUT CONTACT LIMITER
4:0005	SPEED SETPOINT

Last Turbine Trip Cause

The cause of the last turbine trip (address 3:0054) is an integer that represents the following cause:

Value	Description
1.	All Speed Probes Failed
2.	Overspeed Trip
3.	Emergency Shutdown Button (front panel pushbutton)
4.	External Trip Input
5.	High Demand No Speed Trip
6.	Power up Shutdown
7.	Comm Link #1 Trip
8.	Comm Link #2 Trip
9.	Generator Breaker Opened
10.	External Emg Trip w/Override
11.	T.V. Position Error Trip

Chapter 9.
Service Options

Product Service 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 and 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 **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.

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

www.woodward.com/directory

Woodward Factory Servicing 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**.

How to Contact Woodward

For assistance, call one of the following 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.

Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Turbine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
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

You can also locate your nearest Woodward distributor or service facility on our website at:

www.woodward.com/directory

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:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
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	

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. Passwords

Introduction

The 505LST Digital Control requires a password to be entered before access can be given to Service, Configure, Debug, or OPSYS_Faults modes. These passwords are intended to help prevent unauthorized or untrained personnel from accessing these modes and possibly making changes that could cause damage to the turbine or associated processes. If only certain people are to know these passwords, remove this page and keep it in a separate place, away from the manual.

Service Mode Password

The password for your control is: 1 1 1 1

When the display reads “ENTER PASSWORD TO SELECT SERVICE”, press the buttons on the 505LST keypad in this sequence to gain access to the SERVICE mode.

Configure Mode Password

The password for your control is: 1 1 1 3

When the display reads “ENTER PASSWORD TO SELECT CONFIGURE”, press the buttons on the 505LST keypad in this sequence to gain access to the CONFIGURE mode.

Debug Mode Password

The password for your control is 1 1 1 2

When the display reads “ENTER PASSWORD TO SELECT DEBUG”, press the buttons on the 505LST keypad in this sequence to gain access to the DEBUG Mode.

OPSYS_Faults Mode Password

The password for your control is 1 1 1 4

When the display reads “ENTER PASSWORD TO SELECT OPSYS_FAULTS”, press the buttons on the 505LST keypad in this sequence to gain access to the OPSYS_FAULTS mode.

505LST Control Specifications

Woodward Part Numbers:	9907-169, 90–150 Vdc, 88–132 Vac 9907-170, 18–32 Vdc 9907-171, 220 Vac
Power Supply Rating	18–40 Vdc (24 or 32 Vdc nominal) 88–132 Vac 50/60 Hz (120 Vac nominal) 90–150 Vdc (125 Vdc nominal)
Power Consumption	8 W nominal
Steady State Speed Band	MPU: 60–15 000 Hz (8–2100 rpm) Proximity switch: 7.5–1000 Hz (8–2100 rpm)
Remote Speed Setting Input	4–20 mA
Tachometer Output	4–20 mA
Ambient Operating Temperature	–40 to +65 °C (–40 to +149 °F)
Storage Temperature	–55 to +105 °C (–67 to +221 °F)
EMI/RFI Specification	US MIL-STD 461C (Parts 5 & 9)
Ingress Protection	The front panel is rated for IP56 when installed in an appropriate enclosure.
Pollution Resistance	
Particulates:	IEC 664-1 Pollution Degree 2 (Normally only nonconductive pollution occurs. Temporary conductivity caused by condensation is to be expected.)
Gaseous Pollutants:	The polyacrylate conformal coating withstands NO2, CO2, SO2, and H2S gases per IEC 60068-2-60:1995 Part 2.60 Methods 1 and 4 (Flowing Mixed Gas Corrosion Test). It will withstand levels typical of telecommunications and computer installations as defined by Battelle Labs Class III (between IEC 60721-3-3 classification 3C1 and 3C2, light industrial to urban industrial, heavy traffic).

Revision History

Changes in Revision D—

- Updated Regulatory Compliance information (page vi)

Changes in Revision C—

- Added information about wiring and disconnecting power

Declarations

DECLARATION OF CONFORMITY
According to EN 45014

Manufacturer's Name:	WOODWARD GOVERNOR COMPANY (WGC) Industrial Controls Group
Manufacturer's Address:	1000 E. Drake Rd. Fort Collins, CO, USA, 80525
Model Name(s)/Number(s):	505 Control: 18-32 Vdc (9907-164 and similar) 505E Control: 18-32 Vdc (9907-167 and similar) 505H Control: 18-32 Vdc (9907-117 and similar)
Conformance to Directive(s):	89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility. 94/9/EC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres
Applicable Standards:	EN61000-6-2, 1999: EMC Generic Standards - Immunity for Industrial Environments EN50081-2, August 1993: EMC Generic Emissions Standard, Part 2: Industrial Environment EN50082-2, March 1995: EMC Generic Immunity Standard, Part 2: Industrial Environment EN 60079-15, 2003: Electrical apparatus for potentially explosive atmospheres - Type of protection 'n'

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

MANUFACTURER

Jennifer R Williams
Signature

Jennifer Williams
Full Name

Engineering Manager
Position

WGC, Fort Collins, CO, USA
Place

7-9-04
Date

5-09-1183 Rev 8, 2-May-2003 00XXX-04-EU-02-XX

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26440D.

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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.