



## **2301D-ST Digital Electronic Load Sharing & Speed Control for Small Steam Turbines**

**8273-128—Normal Mounting Location  
8273-1001—Hazardous Mounting Location**

**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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# Warnings and Notices

## Important Definitions



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

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

### **WARNING**

#### Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

### **WARNING**

#### Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- Eye Protection
- Hearing Protection
- Hard Hat
- Gloves
- Safety Boots
- Respirator

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

### **WARNING**

#### Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

### **WARNING**

#### Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

**NOTICE****Battery Charging  
Device**

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

## Electrostatic Discharge Awareness

**NOTICE****Electrostatic  
Precautions**

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.
- Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.

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

Follow these precautions when working with or near the control.

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

## Regulatory Compliance

### European Compliance for CE Mark

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.

**Low Voltage Directive:** Declared to the 73/23/EEC COUNCIL DIRECTIVE of 19 February 1973 on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits.

### North American Compliance

These listings are limited only to those units bearing the appropriate CSA identification and marking.

**CSA:** CSA Certified for Class I, Division 2, Groups A, B, C, D, T4 Hazardous Locations and ordinary locations at 70 °C ambient. For use in Canada and the United States.  
Certificate 1150575

**NOTE**—Wiring must be in accordance with applicable electric codes with the authority having jurisdiction.

Connector J1 must not be used in hazardous locations.

The control must be installed in a suitable enclosure. The final combination must be approved by the local authority having jurisdiction.

Connect the ground terminal to earth ground.

### **WARNING**

**EXPLOSION HAZARD**—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous.

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

### **AVERTISSEMENT**

**RISQUE D'EXPLOSION**—Ne pas enlever les couvercles, ni raccorder / débrancher les prises électriques, sans vous en assurez auparavant que le système a bien été mis hors tension; ou que vous vous situez bien dans une zone non explosive.

La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.

# Chapter 1.

## General Information

### Description

The 2301D-ST is a digital control with integral application software program designed for single-valve steam turbines. Like Woodward's 2301A line of controls, this control is housed in a sheet metal chassis and consists of a single printed circuit board. To facilitate unit retrofits, the 2301D-ST's I/O terminals are located in the same general location as Woodward's 2301A line of controls. This control is designed to perform the speed and load control functions of a small steam turbine package. The 2301D-ST's application software is field configurable, allowing it to be configured and modified to meet site-specific requirements.

With more I/O than its predecessor (the 2301A LSSC), the 2301D-ST also has serial communications, allowing it to easily interface with a Human Machine Interface (HMI), PLC or plant DCS. The 2301D-ST is configured and serviced (dynamic adjustments made) via a laptop computer connected to the control's RS232 communications port. These configuration and dynamic settings are set, changed, tuned and saved via a laptop computer and Woodward's user-friendly Watch Window software program. This program allows users to set and adjust all application-based parameters, plus upload and download configurations to and from the control. The 2301D-ST includes the following basic turbine control functions:

- Speed control
- Valve Limiter
- Over speed trip
- Shutdown logic
- Alarm Logic
- Platform Diagnostics

The following functions can be configured, depending on application requirements:

- Manual, Semi-Automatic or Automatic Start Sequencing
- Remote Speed Control
- Isochronous Load sharing with soft load / unload transfer
- Droop Load Control
- Actuator Feedback Droop Control
- Synchronizer Bias Signal Input
- Power sensor Input (CTs, PTs)
- Process Control
- Servlink (DDE) / Modbus® \* Communications
- Self Powered Actuator Option

\* Modbus is a trademark of Schneider Automation Inc.

The 2301D-ST Hardware includes:

- 1 Load Sensor
- 3 PT Inputs, 3 CT Inputs
- 1 Actuator Driver
- 1 MPU Speed Sensor
- 1 Configurable Analog Output
- 2 Configurable Analog Inputs
- 8 Discrete (Switch) Inputs
- 4 Discrete (Relay Driver) Outputs

## Applications

The 2301D-ST is a field-configurable control designed to perform the basic speed and load control functions for single-valve steam turbines. It can be configured to allow a user to match the control's functionality to the application. Configuration and service (dynamic adjustments made) is done via a laptop computer, connected to the control's RS-232 communications port and utilizing Woodward's Watch Window program which is a Windows-based PC software program. These configuration and dynamic settings can be set, changed, tuned and saved using this same program. See Chapter 3 for instructions on configuring the control for your specific application.

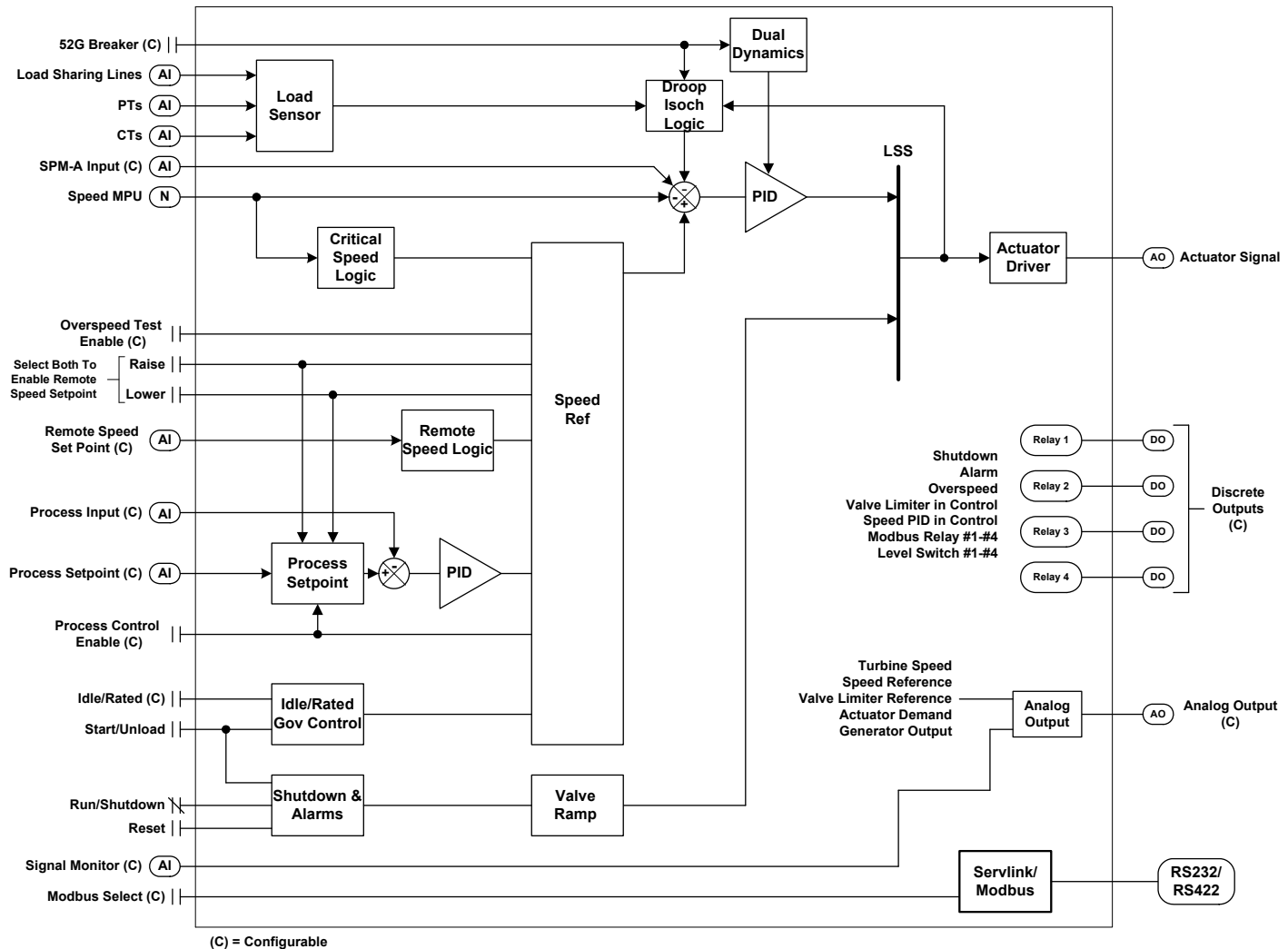


Figure 1-1. Functional Control Overview

## References

The following publications contain additional product or installation information on Load Sharing and Speed Controls and related components. They can be obtained from the Woodward website ([www.woodward.com/publications](http://www.woodward.com/publications)) or ordered from any Woodward office.

Manual	Title
25070	<i>Electronic Control Installation Guide</i>
25195	<i>Governing Fundamentals</i>
82384	<i>SPM-A Synchronizer</i>
82510	<i>Magnetic Pickups and Proximity Switches for Electronic Governors</i>
82715	<i>Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules</i>

Product Spec	Title
03297	<i>2301D-ST Digital Load Sharing and Speed Control</i>
82383	<i>SPM-A Synchronizer</i>
82516	<i>EG3P/6P/10P Actuator</i>
82575	<i>EGB1P/2P Governor/Actuator</i>
03202	<i>Woodward Watch Window Standard</i>

## Chapter 2. Installation

### Introduction

This chapter contains general installation instructions for the 2301D-ST control. Power requirements, environmental precautions and location considerations are included to determine the best location for the control. Additional information includes unpacking instructions, electrical connections and an installation check-out procedure.

### Unpacking

Before handling the control, read the “Electrostatic Discharge Awareness” information on page v. Be careful when unpacking the electronic control. Check the control for signs of damage such as bent or dented panels, scratches and loose or broken parts. If any damage is found, immediately notify the shipper.

### Mounting Considerations

***This product is intended for installation in a “closed electrical operating area” or in an enclosed industrial control cabinet.*** Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling
- Space for servicing and repair
- Protection from direct exposure to water or to a condensation-prone environment
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- Avoidance of vibration
- Selection of a location that will provide an operating temperature range of –40 to +70 °C (–40 to +158 °F)
- The control must NOT be mounted on the turbine.

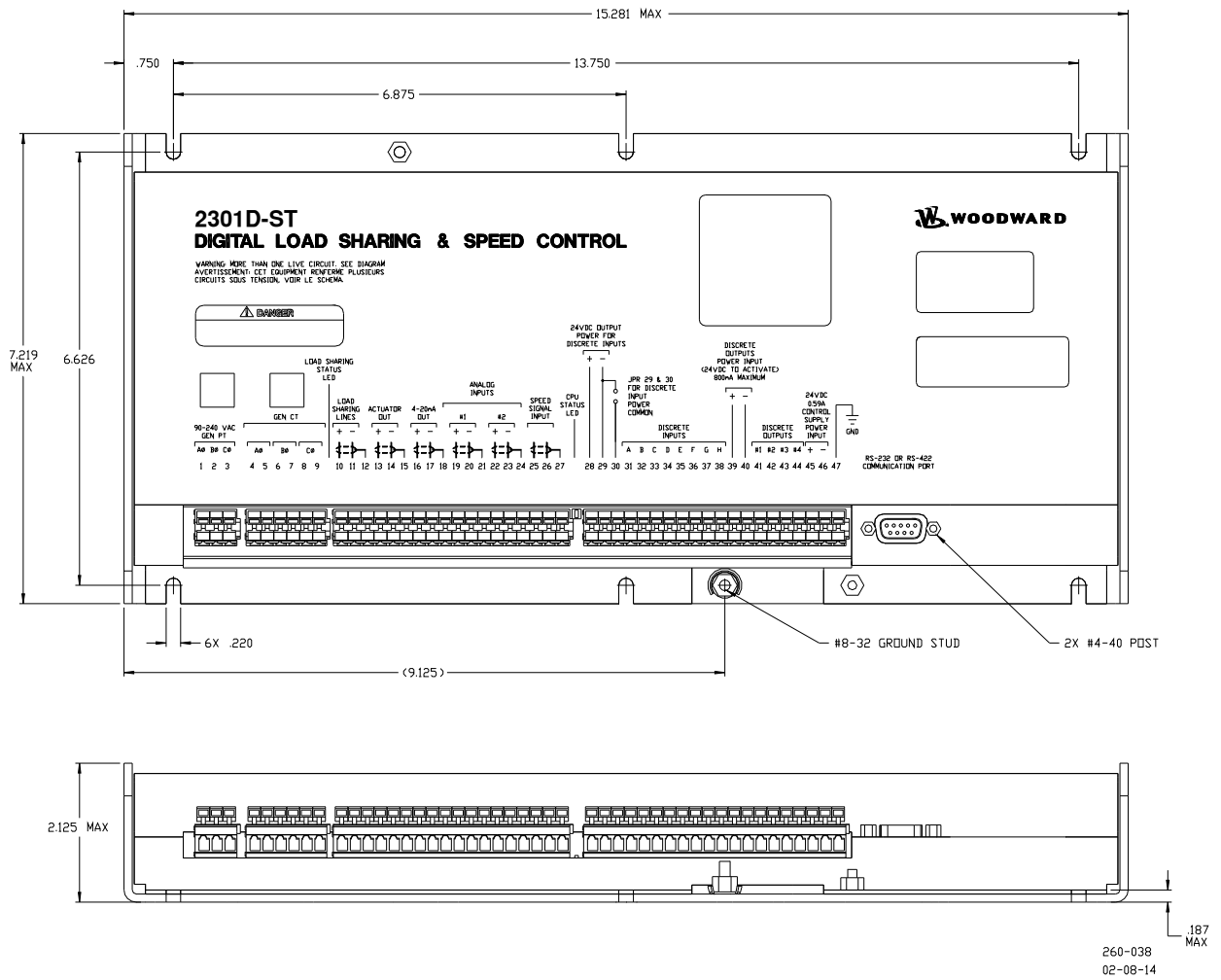
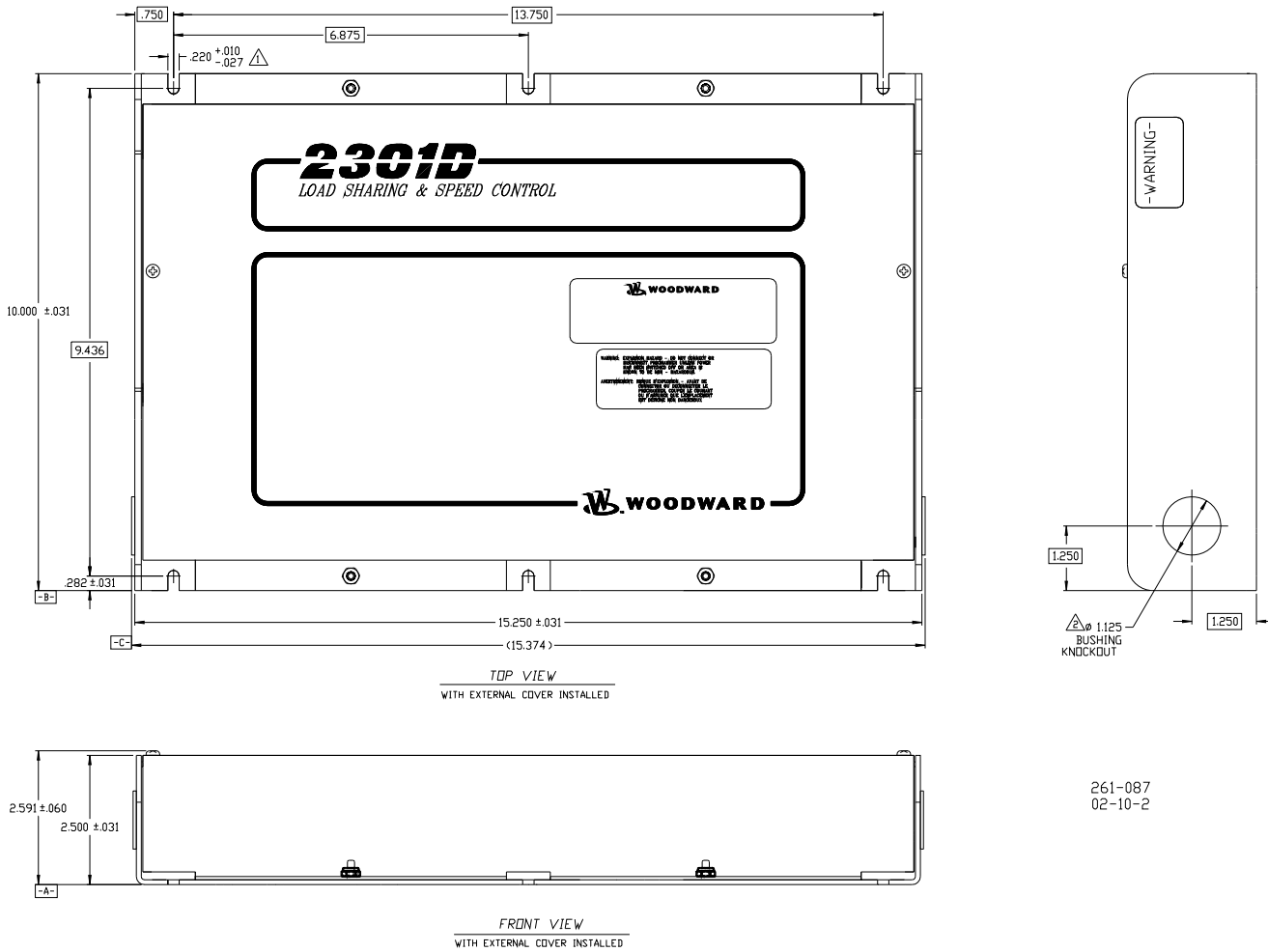


Figure 2-1. 2301D-ST Outline Drawing (8273-128)



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Figure 2-2. 2301D-ST Outline Drawing (8273-1001)  
(Hazardous Locations, external cover installed)

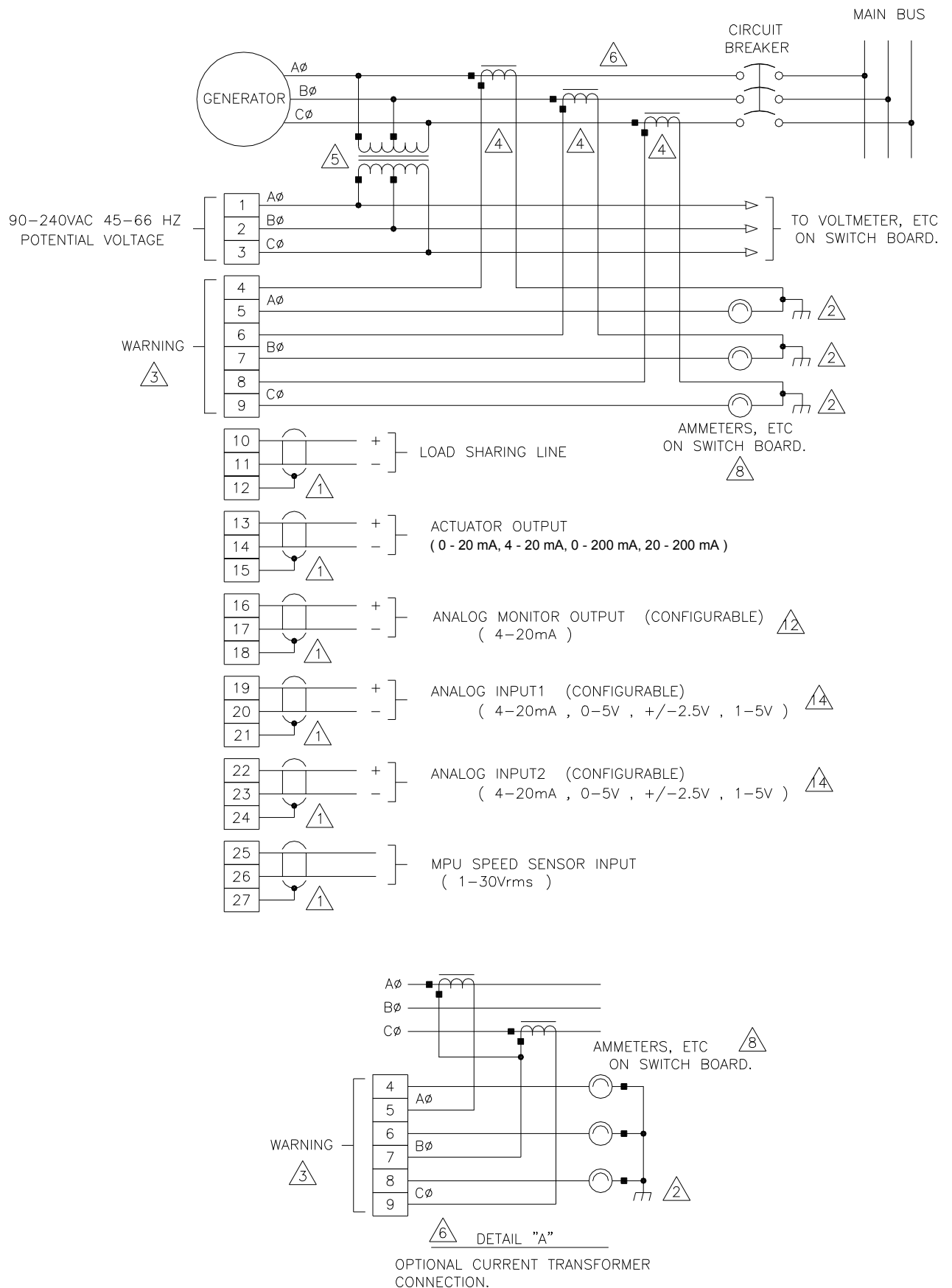
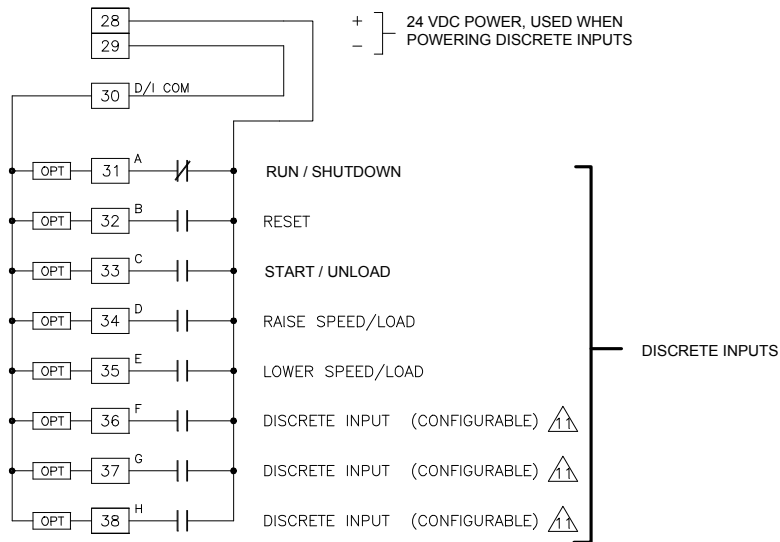
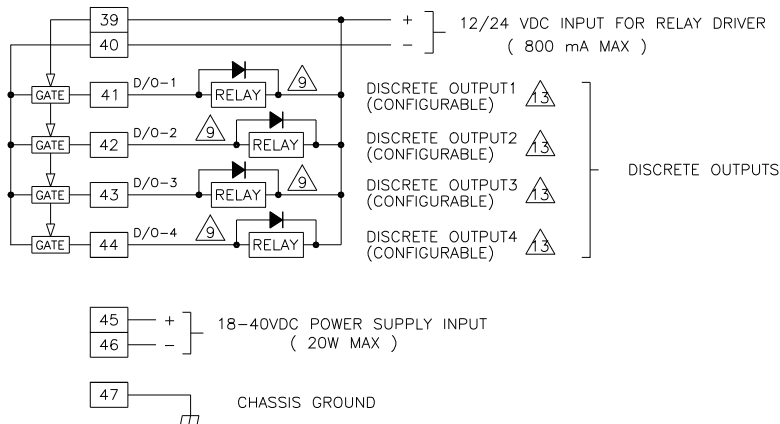
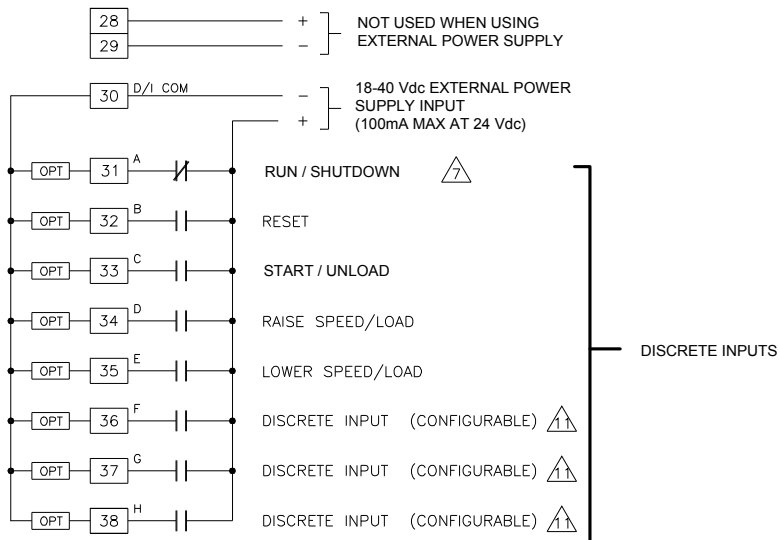


Figure 2-3a. 2301D-ST Plant Wiring Diagram (sheet 1)

## DISCRETE INPUTS WITH INTERNAL POWER SUPPLY



## DISCRETE INPUTS WITH EXTERNAL POWER SUPPLY



RS-232 OR RS-422  
COMMUNICATION PORT  
PIN ASSIGNMENT  
(FOR SERVELINK/MODBUS)

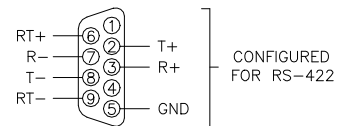
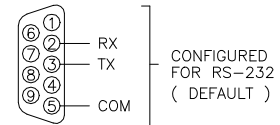


Figure 2-3b. 2301D-ST Plant Wiring Diagram (sheet 2)

## NOTES:

- ① SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.
- ② POINT OF GROUNDING IF REQUIRED BY WIRING CODE.
- ③ INTERNAL CURRENT TRANSFORMER BURDEN MUST BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMER AT ALL TIMES, TO PREVENT LETHAL HIGH VOLTAGES.
- ④ POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT. CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1 VA PER PHASE.
- ⑤ WITH A BALANCED THREE PHASE LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AT THE CONTROL AS FOLLOWS:  
 PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4 TO 5.  
 PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6 TO 7.  
 PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8 TO 9.
- ⑥ FOR OPTIONAL CURRENT TRANSFORMER CONNECTION, SEE DETAIL "A".
- ⑦ **WARNING ! DO NOT USE FOR EMERGENCY SHUTDOWN, THE PRIME MOVER SHOULD BE EQUIPPED WITH A SEPARATE OVER SPEED, OVER TEMPERATURE, OR OVER PRESSURE SHUTDOWN DEVICE (S) TO PROTECT AGAINST RUN AWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.**  
  
 DISCRETE INPUTS WITH CABLE LENGTHS GREATER THEN 30 METERS THAT ARE USED FOR CRITICAL FUNCTIONS, SUCH AS SHUTDOWN, SHOULD NOT BE FLOATED IN EITHER AN ON OR OFF STATE. THESE INPUTS SHOULD BE SWITCHED TO EITHER 24 VDC OR GROUND.
- ⑧ IF METERS ARE NOT USED, JUMPERS MUST BE INSTALLED IN PLACE OF METERS SHOWN.
- ⑨ INDICATES RELAY COIL OR LAMP, 200 mA MAXIMUM PER CHANNEL.
- ⑩ JUMPER TERMINAL 29 TO 30 IF USING INTERNAL POWER FOR DISCRETE INPUTS. TERMINAL 28 AND 29 SHOULD NOT BE USED , IF EXTERNAL POWER IS USED.
- ⑪ THESE CONTACT INPUTS ARE CONFIGURABLE .
- ⑫ THIS ANALOG OUTPUT IS CONFIGURABLE.
- ⑬ THESE CONTACT OUTPUTS ARE CONFIGURABLE.
- ⑭ THESE ANALOG INPUTS ARE CONFIGURABLE.

Figure 2-3c. 2301D-ST Plant Wiring Diagram (notes)

## Electrical Connections



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

**NOTICE**

**Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system. Make all required electrical connections based on the wiring diagrams.**

All inputs and outputs are made through screwless spring-actuated terminal blocks. For EMI reasons, it is recommend that all low-current wires be separated from all high-current wire.

The spring clamp can be actuated using a standard 2.5 mm or 3/32 inch flat bladed screwdriver. The terminal blocks accept wires from 0.08–4 mm<sup>2</sup> (27–12 AWG). Two 0.8 mm<sup>2</sup> (18 AWG) or three 0.5 mm<sup>2</sup> (20 AWG) wires can be easily installed in each terminal. Wires for the fixed mounted power terminals should be stripped 5–6 mm (0.22 inch) long.

**IMPORTANT**

It is recommended that stranded wire be used for connections to the terminal block. Do not tin (solder) the wires that terminate at the terminal blocks. The spring-loaded terminal blocks are designed to flatten stranded wire and if those strands are tinned together, the connection loses surface area and is degraded.

## Shields and Grounding

An individual shield termination is provided at the terminal block for each of the signals requiring shielding. All of these inputs should be wired using shielded, twisted-pair wiring. The exposed wire length beyond the shield should be limited to one 25 mm (1 inch). Relay outputs, contact inputs and power supply wiring do not normally require shielding, but can be shielded if desired.

The 2301D-ST is designed for shield termination to earth ground at the control. If intervening terminal blocks are used in routing a signal, the shield should be continued through the terminal block. If shield grounding is desired at the terminal block, it should be ac coupled to earth. All other shield terminations except at the control should be ac coupled to earth through a capacitor. A 1000 pF, 500 V capacitor is sufficient. The intent is to provide a low impedance path to earth for the shield at frequencies of 150 kHz and up. Multiple direct connections of a shield to earth risk high levels of current to flow within the shield (exception, see note below on cabinet installations).

Shields can be grounded at both ends (2301D-ST and load) if the cable length is sufficiently short (within a cabinet) to prevent ground loop current in the shield.

**IMPORTANT**

**Cabinet Installations:** If the 2301D-ST is installed in a cabinet, shielded I/O can be terminated directly to the cabinet (earth ground) at the entry to the cabinet, as well as at the control.

For EMC reasons, it is recommend that all low-current wires be separated from all high-current wires. Input Power ground terminal should also be wired to earth ground.

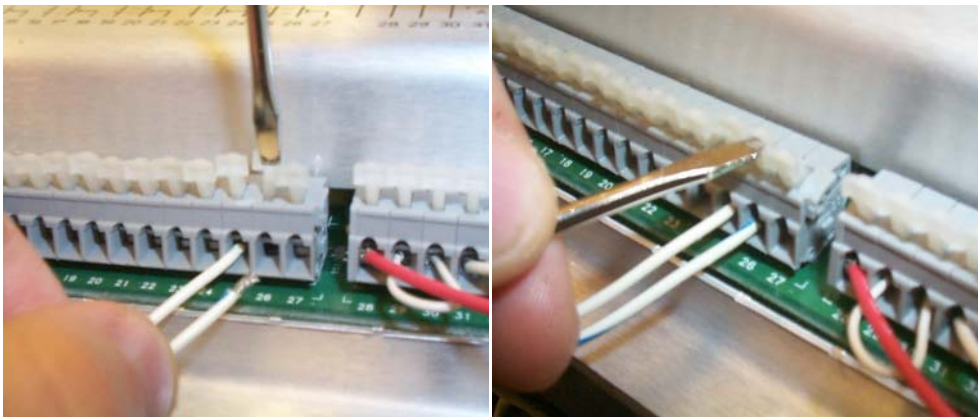


Figure 2-4. Installation of Wiring into Terminal

## Power Supply Connections

The 2301D-ST requires a voltage source of 18 to 40 Vdc, with a current capacity of at least 900 mA for operating power. If a battery is used for operating power, an alternator or other battery charging device is necessary to maintain a stable supply voltage.

Connect 18–40 Vdc input power to terminals 45(+) and 46(–).

### **IMPORTANT**

The 18–40 Vdc input power must be supplied from a power supply/battery charger certified to IEC standard with SELV (Safety Extra Low Voltage) classified output. The installer should properly size wiring and fusing for the input power and PT/CT circuits.

## Potential Transformer Connections

The control's potential transformer inputs accept line-to-line voltages of 90 to 240 Vac. Refer to plant wiring diagram Figure 2-3. Connect the potential transformer secondary leads to the following terminals:

- Phase A to Terminal 1
- Phase B to Terminal 2
- Phase C to Terminal 3

## Current Transformer Connections

The control's current transformer inputs accept a current range of 0 to 7.2 A. Refer to plant wiring diagram Figure 2-3. Connect the current transformer leads to the following terminals:

- Phase A to Terminals 4 & 5
- Phase B to Terminals 6 & 7
- Phase C to Terminals 8 & 9

## Load Sharing Lines Connections

The Load Sharing Lines provide an analog communication path between compatible controls. The 2301D-ST provides an internal relay for connecting the Load Sharing Signal to the internal circuitry at the appropriate times. When the internal relay is closed, a green LED will illuminate between terminals 9 and 10. Because the load-sharing-line relay is contained in the control, no relay is required between the control and the load-sharing-line bus. Use shielded cable and connect the load-sharing lines directly to terminals 10(+) and 11(–). Connect the shield to terminal 12. When all controls in the system are 2301D-STs, the shields may be connected continuously between controls. When load sharing with different controls, do not connect the shields at the point where connections are made to the load-sharing-line bus. The optional 52G (Generator Breaker) contact is used in conjunction with the control's load sharing lines. When isochronous control is selected via the 52G (Generator Breaker) input contact, the unit's load sharing lines are enabled.

## Discrete Input Connections

In general, discrete inputs 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 28 and 29. If desired, an external 18-40 Vdc power source can be used for the circuit wetting voltage. In this case terminal 30 (contact input common) must be connected to the external power source's negative common to establish a common reference point. Each contact input pulls 3 mA when closed and requires at least 14 Vdc to recognize a closure command. See Figure 2-3 for wiring information and 2301D-ST Control Specification for input specifications.

A positive voltage on any discrete input terminal is sensed by the control as a closed contact or "TRUE" state. With no voltage applied to a discrete input terminal the control senses an open contact or "False" state.

For power loading reasons, it is recommended that the control's internal 24 Vdc not be used to power other external equipment.

### IMPORTANT

Discrete inputs with cable lengths greater than 30 meters that are used for critical functions, such as emergency stop, should not be floated in either an on or off state. These inputs should be switched to +24 Vdc or ground.

## External Shutdown Contact (Terminal 31)

Terminal 31 functions as the control's External Shutdown contact input. Before the unit can be started, this External Shutdown input command must be cleared. This input can be configured for open-to-shutdown or close-to-shutdown functionality. The control will initiate an emergency shutdown any time a shutdown command is given and will immediately step its actuator drive current to zero and, if so configured, change the state of its shutdown output. This input is typically tied into the system's trip string to enable it to react to any system trip command.

## Reset Contact (Terminal 32)

Terminal 32 functions as the control's Reset contact input. The external Reset contact is used to reset any latched alarms and/or shutdown conditions, if the condition has been cleared. If the alarm or shutdown condition has not been cleared the Reset command will not affect its status. To issue a reset, the contact must be pulsed to close. No action is taken if contact is either left closed or open after pulse.

### IMPORTANT

If the RUN and Start contact inputs are closed (activated), and the Reset contact input is pulsed closed to open, the turbine may start!

## Start/Unload Contact (Terminal 33)

Terminal 33 functions as the control's External Start/Unload contact input. When an external start command is given (a closed contact state) and all shutdown conditions have been cleared, the control will cycle through its configured start routine. If all shutdown conditions have not been cleared the unit will not begin to cycle through its start routine.

The turbine can also be re-started as the turbine is coasting down in speed.

There are two ways to start the turbine in this manner:

1. The first method:
  - a. While the turbine is coasting down in speed, the Run / Stop contact must be closed to the Run position and the Start contact must be in the Start position.
  - b. The Reset contact can then be toggled, to clear any shutdowns.
  - c. The speed reference will start increasing, and the valve ramp will also start increasing at the specified ramp rates.
  - d. When the speed reference matches the actual turbine speed, the speed PID will take control, and continue to ramp the speed up to the Rated Speed.
2. The second method:
  - a. While the turbine is coasting down in speed, the Run / Stop contact must be closed to the Run position.
  - b. The Reset contact can then be toggled, to clear any shutdowns.
  - c. The Start / Unload contact, should be toggled to Unload and back to Start.
  - d. The speed reference will instantly jump to the actual speed of the turbine, and start ramping up to the Rated speed.
  - e. The valve ramp will also start opening at the Valve Ramp rate.
  - f. When the speed reference matches the actual turbine speed, the speed PID will take control, and continue to ramp the speed up to the Rated Speed.
  - g. The second method is the faster of the two methods, as the speed reference does not start from zero.

This contact input also functions as an external unload command input, when the control is in the isochronous load-sharing mode and this contact input is opened.

### **Raise Speed/Load Contact (Terminal 34)**

Terminal 34 functions as a raise speed contact input when the unit's generator breaker contact is open, and a raise load contact when the unit is in the droop mode. When the control is in the isochronous load-sharing mode, this contact will increase the speed reference.

If both a Lower Speed contact and a Raise Speed contact are closed, the remote analog setpoint (4–20 mA) mode is enabled, and the control's internal speed/load setpoint will follow the respective analog input signal.

### **Lower Speed/Load Contact (Terminal 35)**

Terminal 35 functions as a lower speed contact input when the unit's generator breaker contact is open, and a lower load contact when the unit is in the droop mode. When the control is in the isochronous load-sharing mode, this contact will lower the speed reference.

If both a Lower Speed contact and a Raise Speed contact are closed, the remote analog setpoint (4–20 mA) mode is enabled, and the control's internal speed/load setpoint will follow the respective analog input signal.

## Contact Inputs (Terminal 36–38)

The 2301D-ST has three other discrete input channels that are available for use. These contacts are configurable and can be programmed to perform one of the following functions:

- **IDLE - RATED SPEED**  
When the state of this contact is open the speed reference moves toward the programmed IDLE speed setpoint at it's own configured rate set in service menus. When the state of this contact is closed the speed reference moves toward the programmed RATED speed setpoint at it's own configured rate set in service menus.
- **52G BREAKER**  
The state of this input should directly reflect the state of the unit's generator breaker. This input is used to activate the correct control mode. When this contact input is open, the droop is enabled. When this contact input is closed the unit will be in the isochronous mode.

Typically when used as the isoch/droop select contact, this contact is wired to directly reflect the state of the system's utility tie breaker, with a switch or relay wired in series with the tie breaker aux contact to allow users to manually select the load mode the control operates in when paralleled to the utility. The control is always set to droop mode by opening the 52G BREAKER input.

- **OVERSPEED TEST ENABLE**  
When overspeed testing is performed, this contact is used. An overspeed test is allowed only under the condition that the remote speed setpoint function must be disabled and the turbine speed is within speed range. An overspeed test will allow the control's speed setpoint to be increased above the normal maximum limit. When this contact is closed, the control detects overspeed and issues a trip. After overspeed testing ends, the contact should be opened.
- **SECOND DYNAMICS**  
If this option is enabled, the On-Line dynamic variables are available. With the contact open, Off-Line dynamic variables are active, and with the contact closed, then the On-Line dynamic variables are active.
- **MODBUS / SERVLINK SELECT**  
This contact functions as the control's Modbus communications enable contact input for the control's 9-Pin Sub-D communication port. When this contact is open or is not used, the control's communications port communicates using a Servlink\DDDE protocol. This is used to communicate with Woodward's Watch window program for unit configuration and/or service.

When this contact is closed, the control's 9-Pin Sub-D communications port communicates using a Modbus RTU protocol and the control functions as a Modbus Slave device. The 2301D-ST can be fully operated and all control values monitored via Modbus communications. Alternatively Modbus communications can be used to interface with a PLC or plant DCS.

### NOTICE

**Do not use Modbus communications to perform configuration, I/O test, or calibration.**

- **PROCESS CONTROL ENABLE**  
This contact is used to enable the process control logic when closed. In order for process control to work correctly an external 4–20 mA signal needs to be setup on one of the analog inputs to provide feedback for the process PID.

## Actuator Output

Connect the unit's actuator wires to the control's actuator driver output on terminals 13(+), 14(–), and 15(shield). This output's current range is software configurable and can be programmed to output a drive current of 0–200 mA, 20–200 mA, 4–20 mA, or 0–20 mA. Do not connect the shield wire to the actuator or any other point. Verify that the output's shield wire has continuity its entire distance to the actuator and is insulated from all other conducting surfaces.

## Analog Inputs (#1, #2)

Connect input wiring to terminals 19(+), 20(–), and 21(shield) to use Analog Input #1 and connect input wiring to terminals 22(+), 23(–), and 24(shield) to use Analog Input #2. These Analog Inputs are software configurable to function as one of the following options:

- Remote Speed Setpoint
- Monitor Signal
- Synchronizer Bias Signal Input (–2.5 to +2.5 Vdc signal)
- Process Setpoint
- Process Signal

The type of the analog input signals can also be chosen from one of the following options:

- 4–20 (mA)
- 0–5 (V)
- $\pm 2.5$  (V)
- 1–5 (V)

### **IMPORTANT**

**Synchronizer Bias Signal Input is determined as  $\pm 2.5$  V that is automatically set up by software.**

## MPU Speed Sensor Input

To sense turbine speed, the control accepts a signal from a passive magnetic pickup unit (MPU) mounted off a gear connected or coupled to the turbine's rotor. Connect the MPU speed sensor to terminals 25, 26, and 27(shield). This input is limited to a frequency range of 100–24 950 Hz, (90–20 000 rpm) and a voltage range of 1.7–35 Vac (it needs the voltage above 2.7 Vac in case of a signal above 13 000 Hz). Verify that the input's shield wire has continuity its entire distance to the input sensor and is insulated from all other conducting surfaces.

With proper MPU, gear size and MPU-to-gear clearance, speed measurement should be capable down to 100 Hz. Check the speed sensor for visible damage. Standard MPU clearance is recommended to be between 0.25 and 1.0 mm (0.010 and 0.040 inch) at the closest point. Make sure the gear has less than 0.5 mm (0.020 inch) diametric run out. See manual 82510, *Magnetic Pickups and Proximity Switches for Electronic Governors*.

## Relay Driver Outputs (Terminals 41–44)

The 2301D-ST has four discrete output driver channels. Terminals 41, 42, 43, and 44 are configurable and can be programmed to perform one of the following functions:

- SHUTDOWN
- ALARM
- ELECTRICAL OVERSPEED TRIP TEST
- VALVE LIMITER IN CONTROL
- SPEED PID IN CONTROL
- VALVE LIMITER IN CONTROL
- MODBUS CONTROLLED RELAY #1
- MODBUS CONTROLLED RELAY #2
- MODBUS CONTROLLED RELAY #3
- MODBUS CONTROLLED RELAY #4
- LEVEL SWITCH

### IMPORTANT

For fail-safe operation, the Shutdown relay should be energized during normal system operation, and will de-energize when a shutdown occurs.

Any of the four relays can be programmed to function as a level switch. When programmed as a level switch the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level). The following is a list of the level switches:

- TURBINE SPEED
- TURBINE SPEED REFERENCE
- VALVE LIMITER REFERENCE
- ACTUATOR DEMAND
- GENERATOR OUTPUT
- SIGNAL MONITOR

These discrete outputs are low-side drivers with a maximum output current of 160 mA. The discrete output drivers are isolated from the control's internal power supply, but not from each other and are powered by an external +12 Vdc or +24 Vdc source connected at terminals 39(+) and 40(–). Refer to Figure 2-3 for plant wiring information.

### Relay Driver Clarifications

1. SHUTDOWN  
Each relay driver can be programmed to indicate a Shutdown Condition (energizes for a shutdown condition) or a Trip Relay (de-energizes for a shutdown/trip).
2. ALARM  
Each relay driver can be programmed to indicate a general Alarm Condition (energizes for an alarm condition) or an Alarm Relay (de-energizes for an alarm).
3. ELECTRICAL OVERSPEED TEST  
Each relay driver can be programmed to indicate that the electrical turbine overspeed was sensed.
4. VALVE LIMITER IN CONTROL  
Each relay driver can be programmed to indicate the valve limiter controls the actuator/ valve.

5. **SPEED PID IN CONTROL**  
Each relay driver can be programmed to indicate the speed PID controls the actuator/valve.
6. **MODBUS CONTROLLED RELAY #1**  
Each relay driver can be programmed to indicate the Modbus controlled relay #1 according to the following function.
7. **MODBUS CONTROLLED RELAY #2**  
Each relay driver can be programmed to indicate the Modbus controlled relay #2 according to the following function.
8. **MODBUS CONTROLLED RELAY #3**  
Each relay driver can be programmed to indicate the Modbus controlled relay #3 according to the following function.
9. **MODBUS CONTROLLED RELAY #4**  
Each relay driver can be programmed to indicate the Modbus controlled relay #4 according to the following function.
10. **LEVEL SWITCH**  
Each relay driver can be programmed to function as a level switch. If the level switch feature is selected, its ON level and OFF level must also be configured.

#### **Level Switch Options**

1. TURBINE SPEED
2. TURBINE SPEED REFERENCE
3. VALVE LIMITER REFERENCE
4. ACTUATOR DEMAND
5. GENERATOR OUTPUT
6. MONITOR SIGNAL

#### **Analog Output**

Connect readout wiring to terminals 16(+), 17(–), and 18(shield) to use the control's 4–20 mA Analog Output. This Analog output is software configurable to function as one of the following readout options:

- TURBINE SPEED
- TURBINE SPEED REFERENCE
- VALVE LIMITER SETPOINT
- ACTUATOR DEMAND
- GENERATOR OUTPUT
- SIGNAL MONITOR

Verify that the output's shielded wire has continuity its entire distance to the output device and is insulated from all other conducting surfaces. This current driver based output is designed to drive into impedances of up to 250  $\Omega$ . This output is not isolated from the other control inputs and outputs, thus an isolation device may be required with this output if the device being interfaced to is not isolated.

This analog output's 4–20 mA current drive signal is directly proportional to the programmed function signal that it is configured to represent. Refer to Chapter 3 for output configuration instructions. Its clarifications are the same as Level Switches.

## Communication Port

The control's serial communications port is used to configure and service the unit, as well as communicate to a Human Machine Interface (HMI) or plant distributed control system (DCS). This port's protocol is switchable via the control's "Modbus communications enable" contact input. When this contact input is open or has no connection to it, the control's communications port communicates using an RS-232 driver and a Servlink/DDE protocol. The Servlink/DDE protocol is used to communicate with Woodward's Watch Window program for unit configuration and or service. Refer to Chapter 3 for configuration and setup instructions.

When the control's "Modbus Communications Enable" contact input is closed, the control's communications port then communicates using a Modbus RTU or ASCII protocol, functioning as a Modbus Slave device, via RS-232 or RS-422 drivers, depending on the configuration. The 2301D-ST can be fully operated and all control values monitored via Modbus communications. Alternatively Modbus communications can be used to interface with a PLC or plant DCS. Refer to Figure 2-3 for plant wiring information.

### IMPORTANT

The communication port must be connected with an approved jacketed serial communication cable. The connector must be secured to the 2301D-ST to prevent contact with other circuits.

## RS-232

See Figure 2-5 for cable connection.

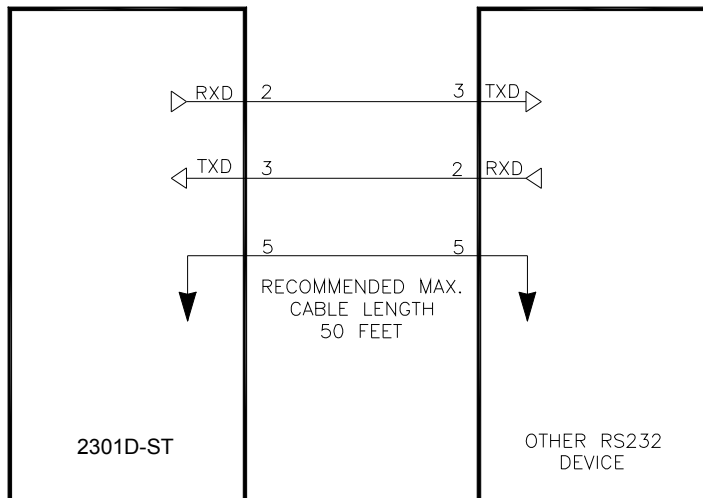


Figure 2-5. RS232 Pin assignments for Serial Communication Cable

## RS-422

See Figure 2-6 for termination and cable connection example.

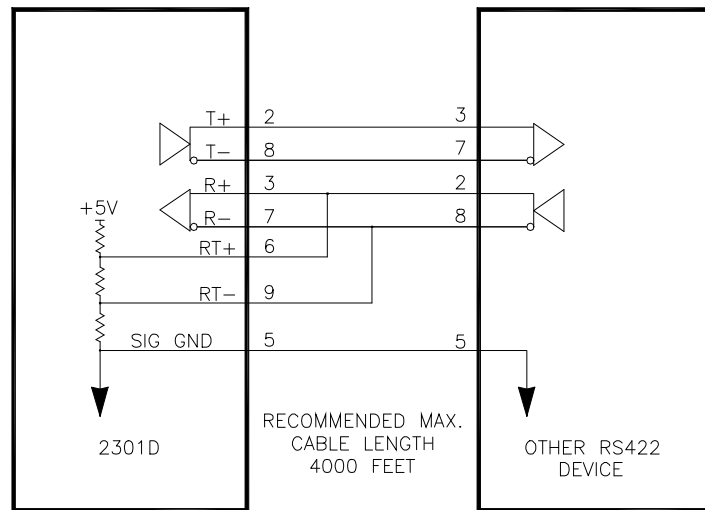


Figure 2-6. Typical RS422 Communications Connections

## Termination

For RS-422, termination should be located at the receiver when one or more transmitters are connected to a single receiver. When a single transmitter is connected to one or more receiver, termination should be at the receiver farthest from the transmitter. Figure 2-7 is an example.

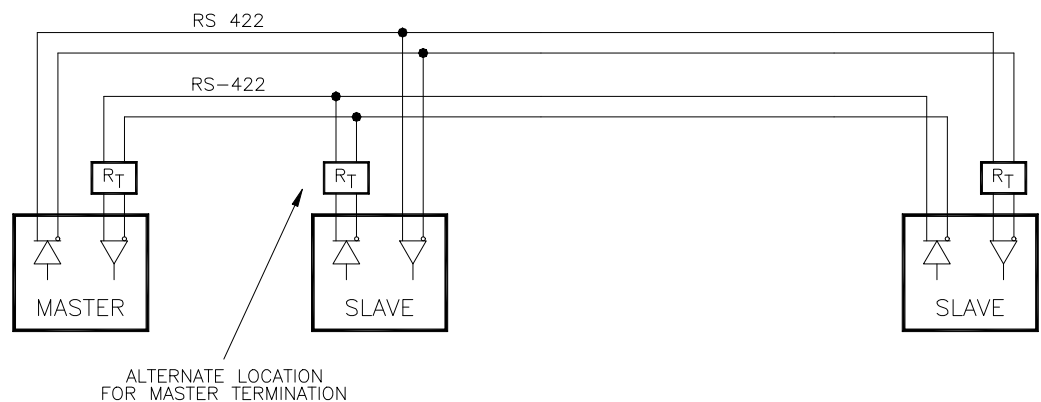


Figure 2-7. RS-422 Terminator Locations

## Grounding and Shielding

The RS-422 specifications state that a ground wire is needed if there is no other ground path between units. The preferred method to do this is to include a separate wire in the cable that connects the circuit grounds together. Connect the shield to earth ground at one point only. The alternate way is to connect all circuit grounds to the shield, and then connect the shield to earth ground at one point only. If the latter method is used, and there are non-isolated nodes on the party line, connect the shield to ground at a non-isolated node, not at an isolated node. Figures 2-8 and 2-9 illustrate these cabling approaches.

**IMPORTANT**

Non-isolated nodes may not have a signal ground available. If signal ground is not available, use the alternate wiring scheme in Figure 2-9 with the signal ground connection removed on those nodes only.

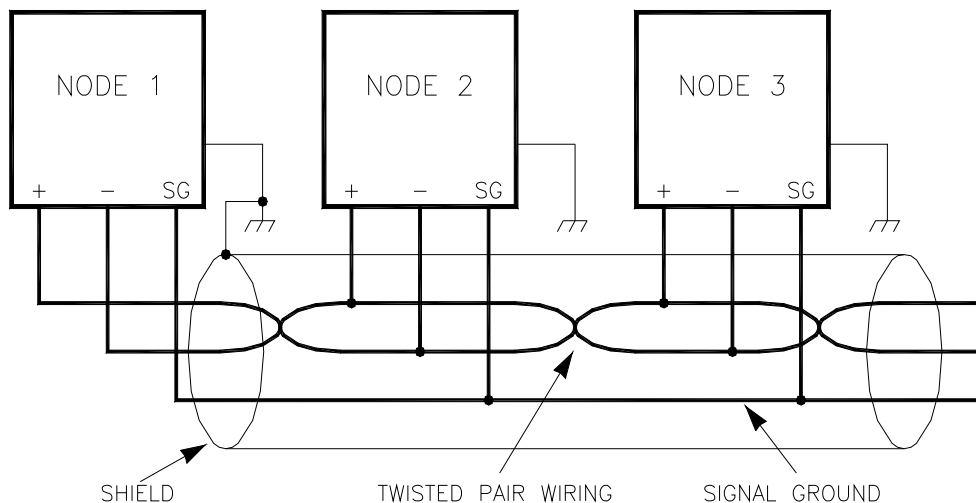


Figure 2-8. Preferred Multipoint Wiring Using Shielded Twisted-pair Cable with a Separate Signal Ground Wire

**IMPORTANT**

The SG (signal ground) connection is not required if signal ground is unavailable.

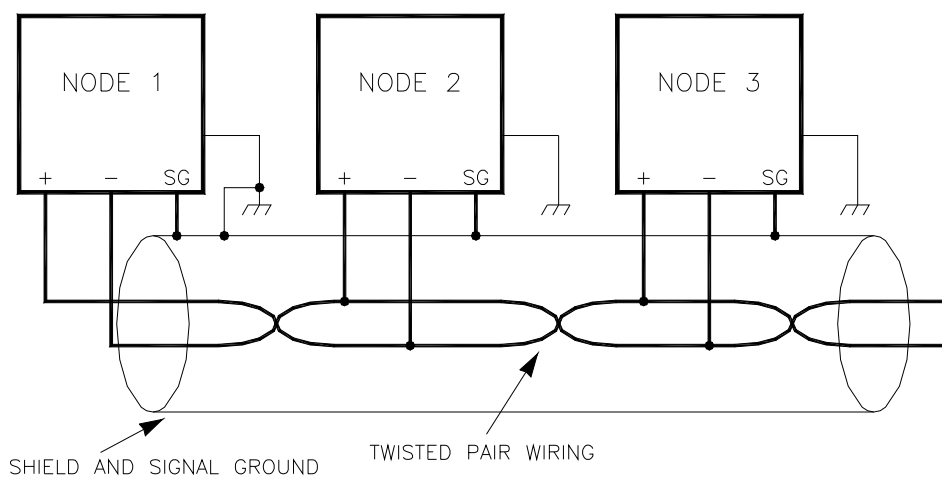


Figure 2-9. Alternate Multipoint Wiring Using Shielded Twisted-pair Cable without a Separate Signal Ground Wire

## Installation Check-out Procedure

Once the 2301D-ST is installed, perform the following checkout procedure before beginning the start-up adjustments in Chapter 4.

### Visual Inspection

1. Check the linkage between the actuator and the valve on the steam turbine for looseness or binding. Refer to the appropriate actuator manual and to manual 25070, *Electronic Control Installation Guide*, for additional information on linkage.



**The actuator lever should be near but not at the minimum position when the steam rack is at the minimum position. If the actuator lever gets to its minimum position before completely shutting off steam, the control may not be able to shut down the prime mover, causing damage to equipment or injury or death.**

2. Check for correct wiring in accordance with the plant wiring diagram, Figure 2-3.
3. Check for broken terminals and loose terminal screws.
4. Check the speed sensor for visible damage.
5. Check the clearance of the magnetic pickup between the gear and the sensor and adjust if necessary.

## Chapter 3.

# Service and Configuration Procedures

### Introduction

This chapter contains information on control configurations, setting adjustments and the use of Woodward's Watch Window software tool. Because of the variety of installations, system and component tolerances, the 2301D-ST must be tuned and configured for each system to obtain optimum performance. Refer to Chapter 4 for start-up settings, adjustments and instructions.



#### **WARNING**

**An improperly calibrated control could cause an overspeed or other damage to the prime mover. To prevent possible serious injury from an overspeeding prime mover, read this entire procedure before starting the prime mover.**

### Watch Window Program

Watch Window is the primary troubleshooting tool for Woodward controls that support the Servlink protocol. Watch Window runs on a PC connected to the control system through a serial communications port. The PC may be permanently connected to the control or only as needed. The communications server, Servlink I/O Server, is included in the same CD-ROM with the Watch Window software.

An "inspector" provides a window for real-time monitoring and editing of all control Configuration and Service Menu parameters and values. Custom "inspectors" can easily be created and saved. Each window can display up to 28 lines of monitoring and tuning parameters without scrolling. The number with scrolling is unlimited. Two windows can be open simultaneously to display up to 56 parameters without scrolling. Tunable values can be adjusted at the inspector window. Watch Window communicates with the control through an RS-232 cable connection to the comm. port configured as a point-to-point only Servlink Server.

Watch Window is a typical Windows application that provides a powerful and intuitive interface. The menu structures are familiar to Windows users. Variable navigation is provided through the Explorer window similar to the Explorer in Windows.

Watch Window performs these primary functions:

- **Monitoring and Tuning of Control Variables**—Watch Window presents variables in a tabular format. The user chooses the variables to view. Multiple pages of variables can be created, each with useful parameters for various troubleshooting or tuning procedures. The user can toggle between pages depending on the task being performed.
- **Control Configuration and Set Point Management**—Watch Window can upload or download all tunable variables from the control system. This feature allows a user (e.g., fleet owner, distributor, packager) to upload (and save) all tunable parameters from one control and download the same settings to other controls for similar turbine configurations.



Watch Window version 1.05 and higher, allows for automatic generation of inspector sheets. Click on the Q icon (Quick Inspector) on the tool bar. A sheet will automatically be created from each Service and Configure Header programmed into the control. Multiple inspectors can be created to allow for viewing more than one sheet at a time.



To enter the I/O Lock mode and enable a configure value to be entered, click on the I/O Lock icon on the Tool Bar. Because the values set in Configure are critical to turbine operation, it is not safe to operate the prime mover while these parameters are being configured. In the Configure mode the control outputs will be set to their off state and the microprocessor will stop executing the application code. The control will have to be reset to continue operation.



The Reset icon allows the microprocessor to store the configure parameters, to return the outputs to their active state and to resume executing the application software.



When the tuning or setting of parameters is complete, the values must be saved in the control's non-volatile memory. Go to the Tool Bar and click the PROM icon for Save Values. The values will be saved in non-volatile memory and will be unaffected by loss of power to the control.



If an application configuration has been previously saved to a \*.CFG file, the saved set of parameters can be loaded into the 2301D-ST as a group by selecting the Load Application Settings icon.



To save the configuration to a file in the external computer for backup or download later into another 2301D-ST, select the Save Application Settings icon. All the tunable values presently set in the control will be saved to a file and can be loaded into this 2301D-ST to reprogram it to the saved values or into another 2301D-ST at a later time.

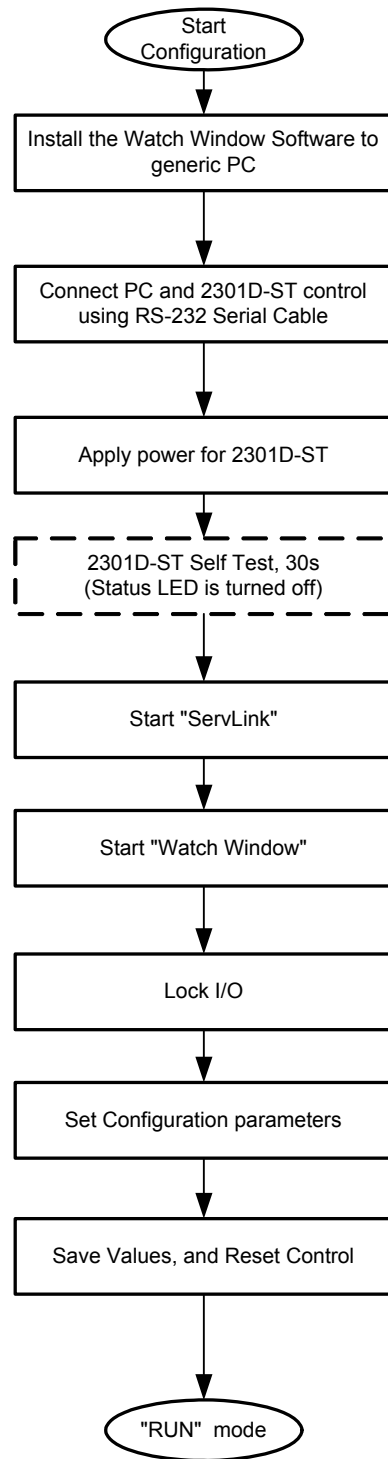


Figure 3-1. Basic Configuration Procedures

## Install Watch Window Software

Woodward's Watch Window Standard configuration and service tool may be downloaded at no cost from the Woodward website ([www.woodward.com](http://www.woodward.com)). As an alternative a Watch Window CD Install Kit may be purchased from the nearest Woodward distributor. Once downloaded, select the kit's Setup.exe program on the computer on which you wish to install the Watch Window software program. Please refer the product specification 03202 for detailed installation procedures.

## Connect PC to 2301D-ST

The connection of a computer is only required for calibration and setup of the 2301D-ST on a prime mover as shown in Figure 3-2 below. The computer and Watch Window software program are not required or necessary for normal operation of the control. The cable is a 9-pin female to 9-pin male, null modem (crossover) cable.

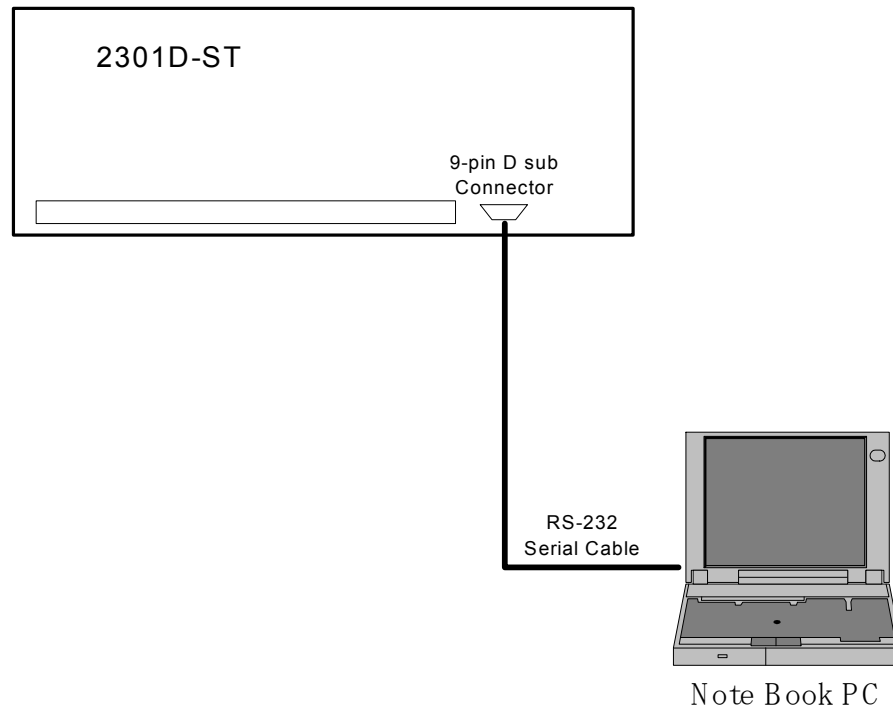


Figure 3-2. Connection between PC and 2301D-ST

## Apply Power to the 2301D-ST

At power-up, the 2301D-ST runs through its boot-up routine and performs a set of initial diagnostics to verify CPU, memory and bus health. This boot-up routine takes approximately 30 seconds to execute. During this time, the control's red status LED (located between terminals 27 and 28) should be on. When boot-up is complete, the application program code begins running, the control outputs will be enabled and system control will begin - the control's red status LED will be turned off and should remain off as long as the control is running.

### Initial 2301D-ST Communications:

Before communications can begin between the Watch Window program and a control, a network definition file must be created. Once this network definition file is created and saved, it never has to be recreated.

To create a network definition file:

1. Open the Watch Window program's associated Servlink server by Clicking on Start > Programs > Woodward > Servlink Server.exe
2. Select the communications port the control is connected to
3. Select "Point-to-Point" communications
4. Select the a Baud Rate of 38400
5. Select the OK button

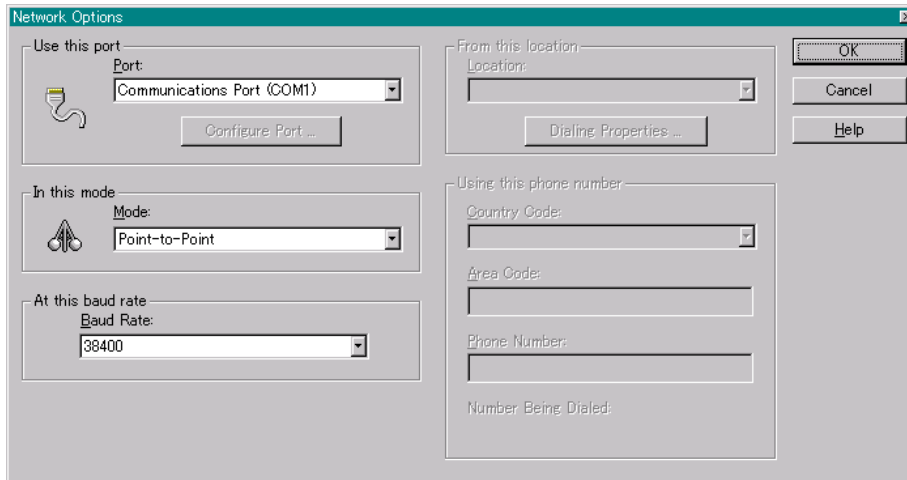


Figure 3-3. Setup Servlink Communication

At this point the Servlink Server program will establish control communications, begin reading all control setting registers and create a lookup table for these registers to expedite future control communications. Upon reading register location information from the control the following Windows pop-up box will appear. (This step can take several minutes to complete.)

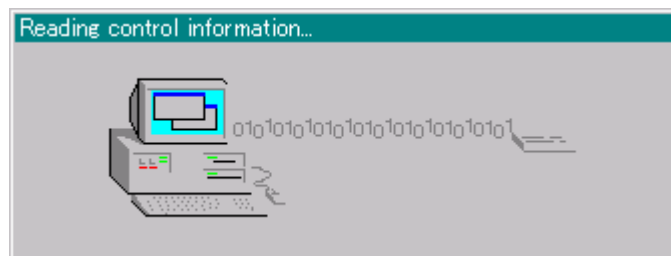



Figure 3-4. Reading Control Information

Once all control program registers have been read, the text "Df1t Control ID" will appear within the Servlink program window and the network definition file can be saved for future retrieval by the Watch Window program. If the network definition file is not saved it will have to be re-created before computer-to-control communications can be established again.

## Start Watch Window Software

At this point, start the Watch Window software program by clicking on Start > Programs > Woodward > Watch Window Standard.exe.

The Watch Window Menu bar, Explorer and Inspector will appear as shown in Figure 3-5. Click on the  icon (Quick Inspector) on the tool bar. Multiple sheets will automatically be created from each Service and Configure Header programmed into the control. Refer to Figure 3-6. Optionally, other inspectors can be created to allow viewing of more than one sheet at a time.

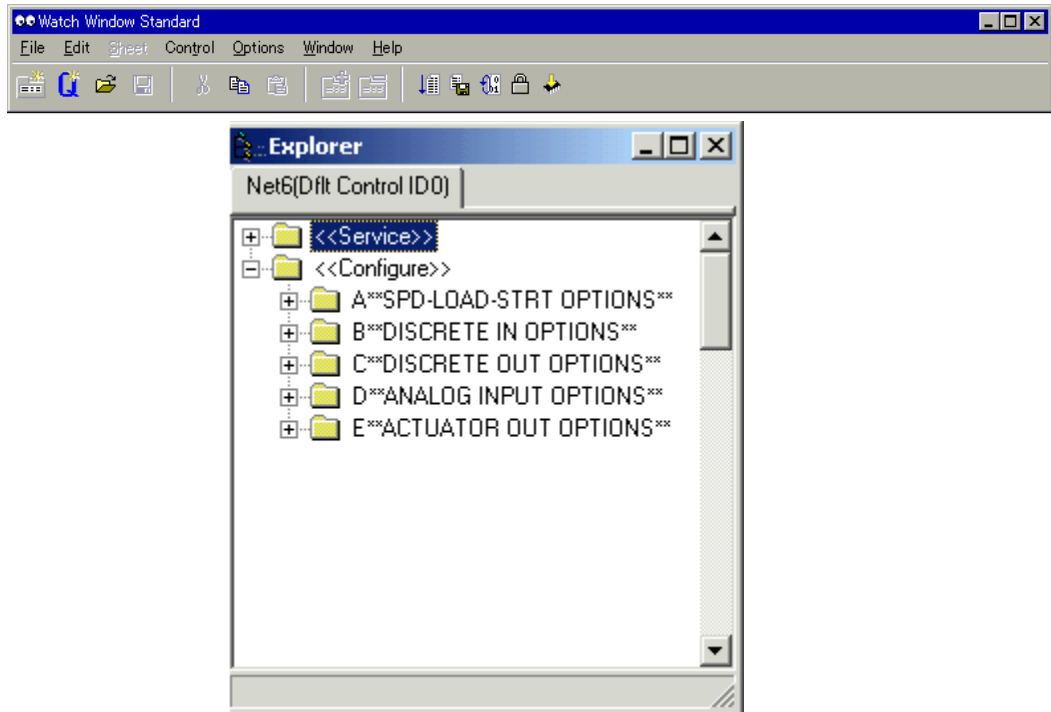




Figure 3-5. Watch Window Menu and Explore (Configure)

## Configure Menu Descriptions

The 2301D-ST has “5” Configure menus and “21” Service menus to simplify and protect control settings and their adjustments. All menus appear as pages, are arranged alphabetically and can be located by using the inspector’s arrow buttons located above the pages to scroll to the desired menu.

The program’s Configure menu items are protected when the control is in operation and cannot be changed. Before configuration values can be changed the control must be in its I/O Lock mode. Service menus are not protected and can be modified at any time.

To enter the I/O Lock mode and enable configure changes, click on the  I/O Lock icon on the Tool Bar. Because the values set in Configure are critical to turbine operation, it is not safe to operate the prime mover while these parameters are being configured. In the I/O Lock mode the control outputs will be set to their off state and the microprocessor will stop executing the application code.

Once the configuration changes have been completed click on the  Reset icon to allow the control to store the configured parameters, return the outputs to their active state and resume executing the application software.

### CONFIGURE: A\*\*SPD, LOAD, STRT OPTIONS\*\*

Inspector2					
Service: U**APPLICATION INFO**					
Configure: A**SPD-LOAD-STRT OPTIONS**					
Configure: B**DISCRETE IN OPTIONS**					
Configure: C**DISCRETE OUT OPTIONS**					
Configure: D**AI					
Control	C	Block	Field	Value	Description
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	01 RATED SETPOINT (RPM)	3600.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	02 ENTER RATED/MAX LOAD(KW)	1000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	03 GEN FREQ IS 50HZ?	False	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	04 MPU MIN SPD LEVEL (RPM)	250.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	05 NUMBER OF GEAR TEETH	60	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	06 MAX OVRSPD TEST LMT(RPM)	4140.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	07 USE SELF POWERED ACT?	False	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	08 MPU OVERRIDE %	20.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	09 SELF PWRD TIME DLY (SEC)	60.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	10 GEAR RATIO	1.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	11 USE CRITICAL BAND?	False	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	12 CRIT SHTDN TIME DLY(SEC)	300.000	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	13 USE MANUAL START ?	False	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	14 USE SEMI-AUTO START ?	False	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	15 USE AUTOMATIC START ?	True	
Net2(Dflt Contr		CONFIGURE: A**SPD-LOAD-STRT OPTIONS**	16 START MODE =	AUTOMATIC START MODE	

Min = 0.000 : Max = 32000.000

Figure 3-6. Configure: A\*\*SPD, LOAD, STRT OPTIONS\*\* Menu

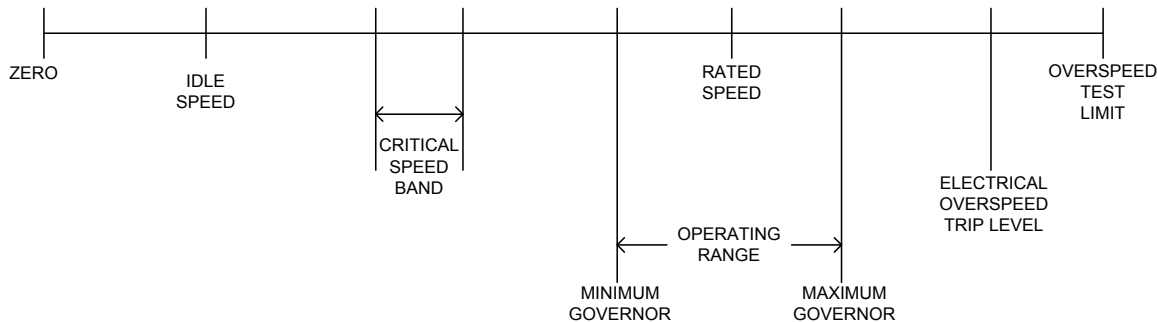


Figure 3-7. Speed Relationships

#### 01 RATED SETPOINT (RPM) dflt=3600.0 (0.0, 300000)

Set to the rated synchronous rpm of the turbine / generator. This value is used to set the 2301D speed sensor hardware to software conversion.

#### 02 ENTER RATED/MAX LOAD (KW) dflt=1000 (10, 30000)

This value sets the rated/maximum load of the generator.

#### 03 GEN FREQ IS 50HZ? dflt= FALSE(FALSE, TRUE)

This value sets the frequency of the generator. False equals 60 Hz., True equals 50 Hz. This value is used for display purposes only.

**04 MPU MIN SPD LEVEL (RPM)**

dflt= 250.0 (0.0, 2000)

Enter the minimum detectable speed level for the control. Below this level the MPU would be detected as failed and a trip will be issued. The MPU input signal must be at least 1.0 Vrms at the minimum speed level programmed.

**05 NUMBER OF TEETH**

dflt=60 (16, 500)

Enter the number of teeth or holes of the gear that the magnetic pickup unit (MPU) is mounted to. This value is used to determine the hertz-to-rpm relationship.

**IMPORTANT**

The maximum input frequency that can be measured by the speed sensing circuit is 25,000 Hz. Therefore to allow for transient conditions, the Number of Teeth times Rated RPM divided by 60 should be less than 19,000.

**WARNING**

The number of gear teeth is used by the control to convert pulses from the speed-sensing device to turbine rpm. To prevent possible serious injury from an over speeding turbine, make sure the control is properly programmed to convert the gear-tooth count into turbine rpm. Improper conversion could cause turbine overspeed.

**06 MAX OVERSPD TEST LMT (RPM)**

dflt=4140.0 (0.0, 32000)

Enter the maximum overspeed trip speed setting. This is the overspeed trip setpoint used to test the mechanical overspeed shutdown device.

(Must be greater than or equal to the ELEC OVERSPEED TRIP SETPOINT).

Note: This menu item was moved here from Service Menu I\*\*Overspeed Test\*\* in revision "G" software or later.

**07 USE SELF POWERED ACTUATOR?**

dflt=FALSE(FALSE, TRUE)

Set to true if the actuator gets its hydraulic power from the turbine. If this value is set TRUE, the shutdown discrete output will still operate, but as the turbine slows down and reaches the MPU Override %, the actuator will ramp open. If the MPU fails and a trip occurs, the SELF PWRED DELAY TIME (SEC) will be used to ramp the valve open. If the turbine speed is decreased from an upstream valve such as the Trip and Throttle Valve or a Control Valve, as the speed reaches the MPU Override % the magnetic pickup failed signal will be overridden. The Actuator will ramp open.

**WARNING**

Using the SELF POWERED ACTUATOR option will disable the internal shutdowns and on the event of a shutdown will cause the actuator to ramp open. To prevent possible serious injury from an overspeeding turbine, make sure the trip and throttle valve or control valve will properly shut off steam to the turbine. Improper set-up could cause turbine overspeed.

**08 MPU OVERRIDE %**

dflt=20.0 (0.1, 100.0)

Enter the percent of actual speed that the magnetic pickup failed signal will be overridden, so that the turbine can be controlled by an upstream valve. This option is used only with the USE SELF POWERED ACTUATOR feature.

**09 SELF PWRD TIME DLY (SEC)**

dflt=60.0 (5.0, 30000.0)

Enter the delay time in seconds that will open the actuator upon loss of the magnetic pickup. This option is used only with the USE SELF POWERED ACTUATOR feature.

**10 GEAR RATIO**

dflt=1.0 (0.1, 10)

Enter the result of the (MPU gear speed) / (turbine shaft speed) speed ratio. This value is used to determine the internal hertz-to-rpm relationship and is calculated by dividing the speed of the MPU gear by the speed of the turbine shaft.

**WARNING**

Using the wrong the gear teeth setting or the Speed Ratio Setting could cause an overspeed condition, resulting in damage to equipment, personal injury or death.

**11 USE CRITICAL BAND?**

dflt=FALSE (FALSE, TRUE)

Set to TRUE to use the critical speed avoidance logic. When the speed setpoint is within the band, the speed setpoint cannot be stopped. This band is used to protect the turbine and driven device from speeds that have inherently high vibration.

**12 CRIT SHDN TIME DLY (SEC)**

dflt=300 (0.0, 1200)

When the speed is in the critical band for longer than the delay time a trip is initiated. The tunable 09 Use Critical Band must be set to TRUE to activate this.

**13 USE MANUAL START?**

dflt=FALSE (FALSE, TRUE)

Set to TRUE to enable manual start mode of operation. Using this feature will cause the actuator output to ramp fully open. This allows the operator to manually control speed of the turbine until governor speed is reached. Only select one of the three start modes.

**14 USE SEMI-AUTO START?**

dflt=FALSE (FALSE, TRUE)

Set to TRUE to enable the semi-automatic mode of operation. Using this feature will allow the operator to control the valve ramp using the discrete input raise and lower switches. Only select one of the three start modes.

**15 USE AUTOMATIC START?**

dflt=TRUE (FALSE, TRUE)

Set to TRUE to enable the automatic mode of operation. Using this feature will allow the operator to automatically start the turbine. Only select one of the three start modes.

**16 START MODE** = Displays the current start mode of operation selected.

**CONFIGURE: B\*\*DISCRETE IN OPTIONS\*\***

Inspector2				
Configure: A**SPD-LOAD-STRT OPTIONS** Configure: B**DISCRETE IN OPTIONS** Configure: C**DISCRETE OUT OPTIONS** Configure: D**ANALOG INPUT OPTIONS** Configure: E**ACTUATOR OUT1**				
Control	Block	Field	Value	Description
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	01 CONFIGURATION ERROR ?	False	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	02 SEL DI F FUNCTION (1-7)	1	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	03 DISPLAY DI F FUNCTION	DI#6 Not Used	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	04 SEL DI G FUNCTION (1-7)	1	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	05 DISPLAY DI G FUNCTION	DI#7 Not Used	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	06 SEL DI H FUNCTION (1-7)	1	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	07 DISPLAY DI H FUNCTION	DI#8 Not Used	
2301D-ST rev k.NET	CONFIGURE: B**DISCRETE IN OPTIONS**	08 ENABLE R/L WHEN LS?	False	

Figure 3-8. Configure: B\*\*DISCRETE IN OPTIONS\*\* Menu

**01 CONFIGURATION ERROR?**

dflt=FALSE (FALSE, TRUE)

This value will show TRUE if you have selected two discrete inputs to perform the same function. This value should never be true in normal operation.

**02 SEL DI F FUNCTION (1-7)**

dflt=1 (1, 7)

Select one of the following parameters for Discrete Input F at terminal 36.

- 1=NOT USED
- 2=IDLE / RATED
- 3=GEN BRKR 52G (ISOCH/DROOP)
- 4=OVERSPEED TEST ENABLE
- 5=MODBUS ENABLE
- 6=ENABLE PROCESS CONTROL
- 7=SECOND DYNAMICS

**03 DISPLAY DI F FUNCTION** displays the current Discrete Input F selected function.

**04 SEL DI G FUNCTION (1-7)**

dflt=1 (1, 7)

Select one of the following parameters for Discrete Input F at terminal 37.

- 1=NOT USED
- 2=IDLE / RATED
- 3=GEN BRKR 52G (ISOCH/DROOP)
- 4=OVERSPEED TEST ENABLE
- 5=MODBUS ENABLE
- 6=ENABLE PROCESS CONTROL
- 7=SECOND DYNAMICS

**05 DISPLAY DI G FUNCTION** displays the current Discrete Input G selected function.

**06 SEL DI H FUNCTION (1-7)**

dflt=1 (1, 7)

Select one of the following parameters for Discrete Input F at terminal 38.

- 1=NOT USED
- 2=IDLE / RATED
- 3=GEN BRKR 52G (ISOCH/DROOP)
- 4=OVERSPEED TEST ENABLE
- 5=MODBUS ENABLE
- 6=ENABLE PROCESS CONTROL
- 7=SECOND DYNAMICS

**07 DISPLAY DI H FUNCTION** displays the current Discrete Input H selected function.

**IMPORTANT**

Each configurable discrete input option may be configured only once.

**08 ENABLE R/L WHEN LS**

dflt=FALSE (FALSE, TRUE)

Set to TRUE to use the Raise Speed/Load and Lower Speed/Load discrete inputs while in isochronous load sharing. Typically this is not used as the control will balance the loads automatically.

**CONFIGURE: C\*\*DISCRETE OUT OPTIONS\*\***

Control	Category	Block	Field	Value	D
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	01 IS TRIP RELAY NC?	False	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	02 IS ALARM RELAY NC?	True	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	03 RELAY 1 ENERGIZES (1-11)	2	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	04 RELAY 1 SELECTED	Shutdown	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	05 RELAY 2 ENERGIZES (1-11)	3	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	06 RELAY 2 SELECTED	Alarm	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	07 RELAY 3 ENERGIZES (1-11)	4	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	08 RELAY 3 SELECTED	Elec. Overspeed Trip Test	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	09 RELAY 4 ENERGIZES (1-11)	6	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	10 RELAY 4 SELECTED	Speed PID in Control	
Net6(Dflt Control ID0)		CONFIGURE: D**DISCRETE OUT OPTIONS**	11 RESET CLEARS TRIPS?	False	

Min = 0 : Max = 1

Figure 3-9. Configure: C\*\*DISCRETE OUT OPTIONS\*\* Menu

The 2301D-ST has four discrete output driver channels. Terminals 41, 42, 43 and 44 are configurable and can be programmed to perform one of several functions (listed below).

Any of the four relay drivers can also be programmed to function as a level switch. When programmed as a level switch the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level). Level Switch set up is in Menu “Q”.

**01 IS TRIP RELAY NC?** dflt=TRUE (FALSE, TRUE)

This option sets the logic of the Shutdown Relay. Set to TRUE if the Shutdown Relay output is normally closed. Set to FALSE if the Shutdown Relay output is normally open.

**02 IS ALARM RELAY NC?** dflt=TRUE (FALSE, TRUE)

This option sets the logic of the Alarm Relay. Set to TRUE if the Alarm Relay output is normally closed. Set to FALSE if the Alarm Relay output is normally open.

**03 RELAY 1 ENERGIZES (1-11)** dflt=1 (1, 11)

Select one of the following parameters for discrete output at terminals 41.

- 1=NOT USED
- 2=SHUTDOWN
- 3=ALARM
- 4=ELEC. OVERSPEED TRIP TEST
- 5=VALVE LIMITER IN CONTROL
- 6=SPEED PID IN CONTROL
- 7=MODBUS CONTROLLED RELAY #1
- 8=MODBUS CONTROLLED RELAY #2
- 9=MODBUS CONTROLLED RELAY #3
- 10=MODBUS CONTROLLED RELAY #4
- 11=LEVEL SWITCH

**04 RELAY 1 SELECTED** displays the relay function for terminal 41.

**05 RELAY 2 ENERGIZES (1-11)**

dflt=1 (1, 11)

Select one of the following parameters for discrete output at terminals 42.

- 1=NOT USED
- 2=SHUTDOWN
- 3=ALARM
- 4=ELEC. OVERSPEED TRIP TEST
- 5=VALVE LIMITER IN CONTROL
- 6=SPEED PID IN CONTROL
- 7=MODBUS CONTROLLED RELAY #1
- 8=MODBUS CONTROLLED RELAY #2
- 9=MODBUS CONTROLLED RELAY #3
- 10=MODBUS CONTROLLED RELAY #4
- 11=LEVEL SWITCH

**06 RELAY 2 SELECTED** displays the relay function for terminal 42.

**07 RELAY 3 ENERGIZES (1-11)**

dflt=1 (1, 11)

Select one of the following parameters for discrete output at terminals 43.

- 1=NOT USED
- 2=SHUTDOWN
- 3=ALARM
- 4=ELEC. OVERSPEED TRIP TEST
- 5=VALVE LIMITER IN CONTROL
- 6=SPEED PID IN CONTROL
- 7=MODBUS CONTROLLED RELAY #1
- 8=MODBUS CONTROLLED RELAY #2
- 9=MODBUS CONTROLLED RELAY #3
- 10=MODBUS CONTROLLED RELAY #4
- 11=LEVEL SWITCH

**08 RELAY 3 SELECTED** displays the relay function for terminal 43.

**09 RELAY 4 ENERGIZES (1-11)**

dflt=1 (1, 11)

Select one of the following parameters for discrete output at terminals 44.

- 1=NOT USED
- 2=SHUTDOWN
- 3=ALARM
- 4=ELEC. OVERSPEED TRIP TEST
- 5=VALVE LIMITER IN CONTROL
- 6=SPEED PID IN CONTROL
- 7=MODBUS CONTROLLED RELAY #1
- 8=MODBUS CONTROLLED RELAY #2
- 9=MODBUS CONTROLLED RELAY #3
- 10=MODBUS CONTROLLED RELAY #4
- 11=LEVEL SWITCH

**10 RELAY 4 SELECTED** displays the relay function for terminal 44.

**11 RESET CLEARS TRIPS?**

dflt=TRUE (FALSE, TRUE)

If set TRUE the Shutdown Relay will be reset when a Reset input is given. If set FALSE all shutdown conditions including the external Shutdown input must be cleared before a Reset input will reset the Shutdown Relay.

**CONFIGURE: D\*\*ANALOG INPUT OPTIONS\*\***

Control	Category	Block	Field	Value	Description
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 01 CONFIGURATION ERROR ?		False	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 02 SEL AI #1 FUNCTION (1-6)		1	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 03 DISPLAY AI #1 FUNCTION		Input #1 Not Used	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 04 SEL AI #1 TYPE (1-4)		1	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 05 DISPLAY AI #1 TYPE		4 - 20 (mA)	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 06 USE INPUT #1 FAIL TRIP		False	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 07 SEL AI #2 FUNCTION (1-6)		1	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 08 DISPLAY AI #2 FUNCTION		Input #2 Not Used	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 09 SEL AI #2 TYPE (1-4)		1	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 10 DISPLAY AI #2 TYPE		4 - 20 (mA)	
Net16(Dflt Cont)		CONFIGURE: E**ANALOG INPUT OPTION 11 USE INPUT #2 FAIL TRIP		False	

Figure 3-10. Configure: D\*\*ANALOG INPUT OPTIONS\*\* Menu

**01 CONFIGURATION ERROR?** dflt=FALSE (FALSE, TRUE)  
 Displays a TRUE if any of the two analog inputs are set the same. Not Used and Monitor Signal Input can be set the same. Displays a FALSE if the analog input configuration is correct.

**02 SEL AI #1 FUNCTION (1-6)** dflt=1 (1, 6)  
 Select one of the following parameters for Analog Input #1 at terminal 19-21.  
 1=NOT USED  
 2=REMOTE SPEED SETPOINT  
 3=MONITOR SIGNAL INPUT  
 4=SYNCHRONIZER BIAS SIGNAL  
 5=REMOTE PROCESS SETPOINT  
 6=PROCESS SIGNAL

**03 DISPLAY AI #1 FUNCTION**  
 Displays the function selected for Analog Input #1.

**04 SEL AI #1 TYPE (1-4)** dflt=1 (1, 4)  
 This value is used to set the Analog Input #1 type.  
 1 = 4–20 (mA)  
 2 = 0–5 (V)  
 3 =  $\pm 2.5$  (V)  
 4 = 1–5 (V)

**05 DISPLAY AI #1 TYPE**  
 Displays configured Analog Input #1 type.

**06 USE INPUT #1 FAIL TRIP** dflt=FALSE (FALSE, TRUE)  
 Set to TRUE to use the trip function that Analog Input #1 has failed.

<b>Input Set For:</b>	<b>Low Trip Point:</b>	<b>High Trip Point:</b>
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
$\pm 2.5$ Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

**07 SEL AI #2 FUNCTION (1-6)**

dflt=1 (1, 6)

Select one of the following parameters for Analog Input #2 at terminal 22-23.

- 1=NOT USED
- 2=REMOTE SPEED SETPOINT
- 3=MONITOR SIGNAL INPUT
- 4=SYNCHRONIZER BIAS SIGNAL
- 5=REMOTE PROCESS SETPOINT
- 6=PROCESS SIGNAL

**08 DISPLAY AI #2 FUNCTION**

Displays the function selected for Analog Input #2.

**09 SEL AI #2 TYPE (1-4)**

dflt=1 (1, 4)

This value is used to set the Analog Input #2 type.

- 1 = 4–20 (mA)
- 2 = 0–5 (V)
- 3 =  $\pm 2.5$  (V)
- 4 = 1–5 (V)

**10 DISPLAY AI #2 TYPE**

Displays configured Analog Input #2 type.

**11 USE INPUT #2 FAIL TRIP**

dflt=FALSE (FALSE, TRUE)

Set to TRUE to use the trip function that Analog Input #2 has failed.

Input Set For:	Low Trip Point:	High Trip Point:
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
$\pm 2.5$ Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

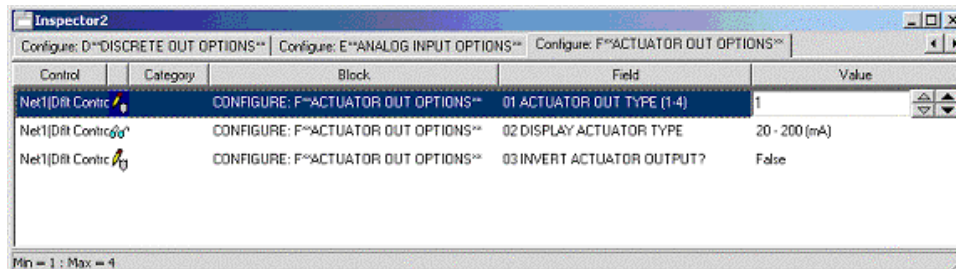
**CONFIGURE: E\*\*ACTUATOR OUT OPTIONS\*\***

Figure 3-11. Configure: E\*\*ACTUATOR OUT OPTIONS\*\* Menu

**01 ACTUATOR OUT TYPE (1-4)**

dflt=1 (1, 4)

This value is used to set the actuator output type.

- 1 = 20–200 (mA)
- 2 = 0–200 (mA)
- 3 = 4–20 (mA)
- 4 = 0–20 (mA)


**02 DISPLAY ACTUATOR TYPE** displays the configured actuator output type.


**03 INVERT DRIVER OUTPUT?**

dflt=FALSE (FALSE, TRUE)

Set to TRUE for reverse acting actuators and FALSE for forward acting actuators. Forward acting actuators require increase current to increase speed/load. Reverse acting actuators require decrease current to increase speed/load (reverse acting actuators should always incorporate a mechanical ballhead backup governor).

## Save and Reset 2301D-ST Control.

When the tuning or setting of parameters is complete, the values must be saved in the control's non-volatile memory. Go to the Tool Bar and click the  PROM icon for Save Values. The values will be saved in non-volatile memory and will be unaffected by loss of power to the control.

Once the all configuration changes have been completed, click on the Watch Window program's  Reset icon to allow the control to store the configured parameters, return the outputs to their active state and resume executing the application software.

## Service Menu Descriptions

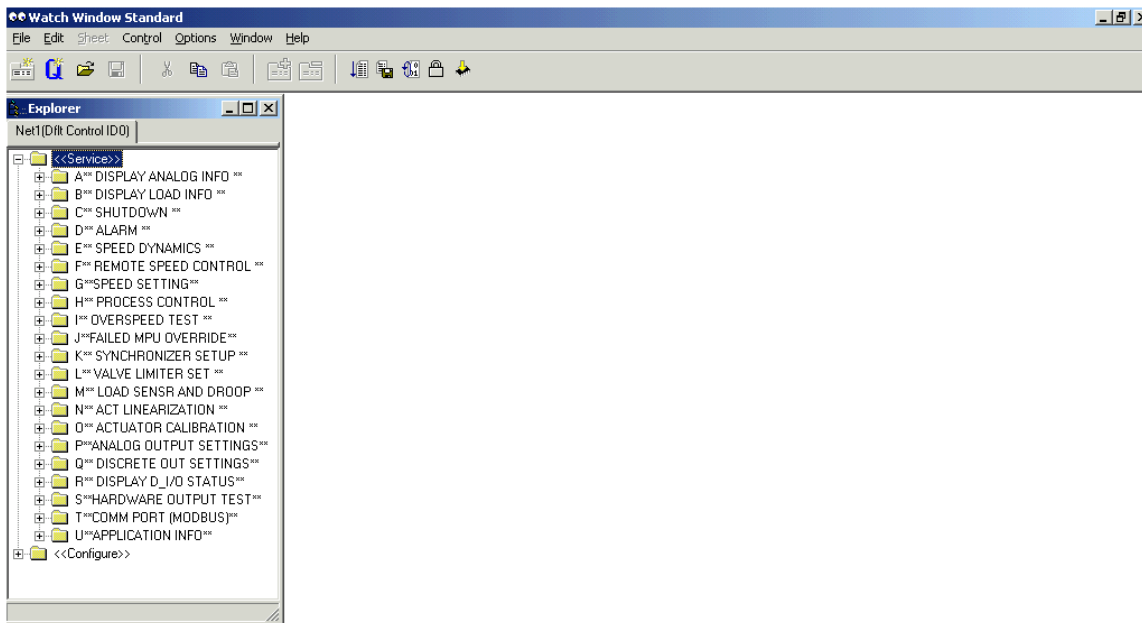


Figure 3-12. Watch Window Menu and Explorer (Service)

**A\*\* DISPLAY ANALOG INFO \*\***

Control	C	Block	Field	Value
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	01 SPEED CONTROL STATUS =	AT RATED SPEED
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	02 TURBINE SPEED (RPM) =	5949.29
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	03 GENERATOR FREQUENCY (HZ)	59.99
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	04 SPEED REFERENCE (RPM) =	5950
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	05 ACTUATOR SIGNAL (%) =	22.29
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	06 ACTUATOR CURRENT (MA) =	59.65
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	07 VALVE LIMITER (%) =	100.00
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	08 SPEED PID (%) =	22.29
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	09 CRITICAL SPEED BAND? =	False
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	10 SPEED REF BIAS (RPM) =	5949.54
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	11 ANALOG INPUT #1 =	0.01
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	12 ANALOG INPUT #2 =	0.01
2301d-st.NET(C66^)		SERVICE: A** DISPLAY ANALOG INFO **	13 START MODE SELECTED	AUTOMATIC START MODE

Figure 3-13. Service: A\*\* DISPLAY ANALOG INFO \*\* Menu

This is a display group for general monitoring of the turbine.

**01 SPEED CONTROL STATUS** displays the status of the speed control. Will display one of the following:

SHUTDOWN  
 READY FOR RESET  
 READY TO START  
 VALVE LIMITER  
 SPEED PID RAMP  
 AT IDLE SPEED  
 AT MIN GOVERNOR SPEED  
 AT RATED SPEED  
 AT MAX GOVERNOR SPEED  
 IN CRITICAL RAMP

**02 TURBINE SPEED (RPM)** displays actual turbine speed in rpm.

**03 GENERATOR FREQUENCY (HZ)** displays the calculated generator frequency in hertz. This will typically be a value from the following table:

Generator Poles	60 Hz Generator	50 Hz Generator
2	3600 rpm	3000 rpm
4	1800 rpm	1500 rpm
6	1200 rpm	1000 rpm
8	900 rpm	750 rpm

If a rated speed other than the values listed here is entered, the calculated generator frequency shown may not be correct.

**04 SPEED REFERENCE (RPM)** displays turbine speed setpoint in rpm.

**05 ACTUATOR SIGNAL (%)** displays actuator demand percentage (0-100%).

**06 ACTUATOR CURRENT (mA)** displays the current output to the actuator in milliamps.

**07 VALVE LIMITER (%)** displays the valve limiter demand percentage (0-100%).

**08 SPEED PID (%)** displays the speed PID output percentage (0-100%).

**09 CRITICAL SPEED BAND?** displays a TRUE or a FALSE denoting that the speed reference is in the critical band.

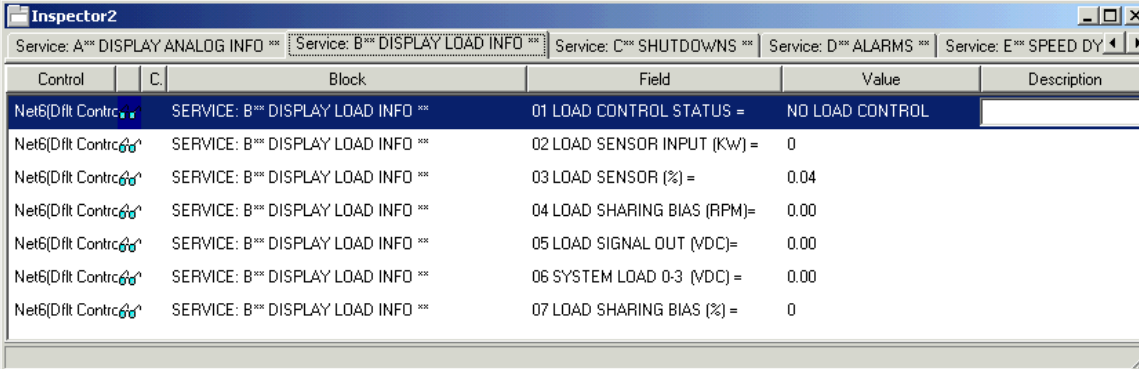
**10 SPEED REF BIAS (RPM)** displays the total speed bias into the summing junction.

**11 ANALOG INPUT #1** displays analog input #1 value.

**12 ANALOG INPUT #2** displays analog input #2 value.

**13 START MODE SELECTED** displays the START MODE selected. Will display one of the following:  
 NO CONTROL MODE SELECTED  
 MANUAL CONTROL MODE SELECTED  
 SEMI-AUTOMATIC CONTROL MODE  
 AUTOMATIC CONTROL MODE SELECTED  
 IN-CORRECT MODE SET-UP

## B\*\* DISPLAY LOAD INFO \*\*



Control	C.	Block	Field	Value	Description
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	01 LOAD CONTROL STATUS =	NO LOAD CONTROL	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	02 LOAD SENSOR INPUT (Kw) =	0	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	03 LOAD SENSOR (%) =	0.04	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	04 LOAD SHARING BIAS (RPM)=	0.00	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	05 LOAD SIGNAL OUT (VDC)=	0.00	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	06 SYSTEM LOAD 0-3 (VDC) =	0.00	
Net6(Dflt Contr...		SERVICE: B** DISPLAY LOAD INFO **	07 LOAD SHARING BIAS (%) =	0	

Figure 3-14. Service: B\*\* DISPLAY LOAD INFO \*\* Menu

This menu is used for general monitoring of the generator information.

**01 LOAD CONTROL STATUS** displays generator load control mode. Will display one of the following:  
 NO LOAD CONTROL  
 KW DROOP  
 SPEED DROOP  
 ISOCHRONOUS  
 LOADING  
 UNLOADING

**02 LOAD SENSOR INPUT (KW)** displays generator load in kilowatt. This value is calculated as the current (I) multiplied by the phase angle between the voltage (V) and the current (I), (cos theta).

**03 LOAD SENSOR PERCENTAGE** displays the generator load in percentage (0-100%).

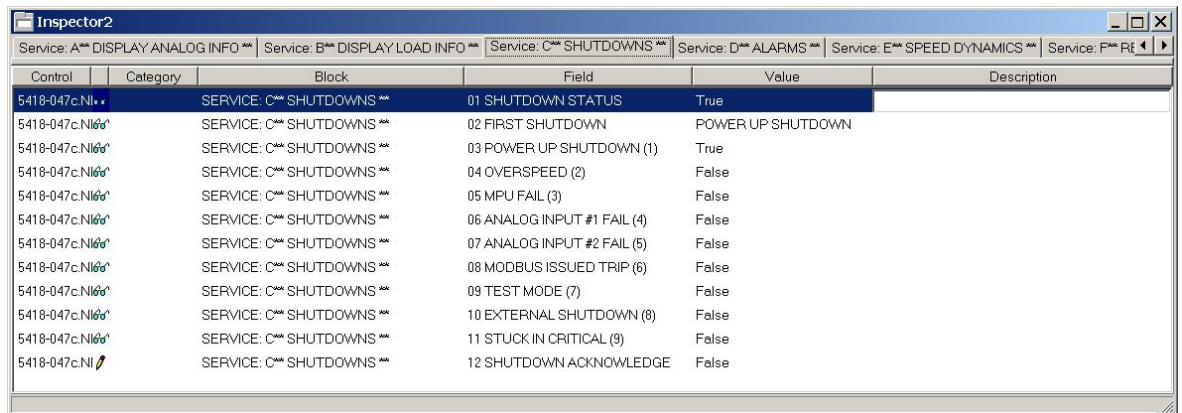
**04 LOAD SHARING BIAS (RPM)** displays the speed bias, in rpm, from the load sharing input.

**05 LOAD SIGNAL OUT (Vdc)** indicates the generator KW in units of load Gain voltage. The value will vary from 0.0 to 6.0 Vdc as the generator load varies from 0 to rated KW.

**06 SYSTEM LOAD 0-3 (Vdc)** displays the system load on the load sharing line as a function of the load sharing lines. 0 equals zero percent load, 3 equals 100 percent load.

**07 LOAD SHARING BIAS** displays the speed bias percentage (0-100%).

## C\*\* SHUTDOWNS \*\*



Control	Category	Block	Field	Value	Description
5418-047c.NI*	SERVICE: C** SHUTDOWNS **	01 SHUTDOWN STATUS		True	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	02 FIRST SHUTDOWN		POWER UP SHUTDOWN	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	03 POWER UP SHUTDOWN (1)		True	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	04 OVERSPEED (2)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	05 MPU FAIL (3)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	06 ANALOG INPUT #1 FAIL (4)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	07 ANALOG INPUT #2 FAIL (5)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	08 MODBUS ISSUED TRIP (6)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	09 TEST MODE (7)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	10 EXTERNAL SHUTDOWN (8)		False	
5418-047c.NI6*	SERVICE: C** SHUTDOWNS **	11 STUCK IN CRITICAL (9)		False	
5418-047c.NI	SERVICE: C** SHUTDOWNS **	12 SHUTDOWN ACKNOWLEDGE		False	

Figure 3-15. Service: C\*\* SHUTDOWN \*\* Menu

This menu displays the status of the shutdown modes.

**01 SHUTDOWN STATUS** displays the shutdown condition. If the control has shutdowns, it displays TRUE. If no shutdowns exist, it displays FALSE.

**02 FIRST SHUTDOWN** displays the cause of the first shutdown. If the control has a shutdown condition, this menu item indicates the first shutdown:

POWER UP SHUTDOWN

OVERSPEED

MPU FAIL

ANALOG INPUT #1 FAIL (if configured as such)

ANALOG INPUT #2 FAIL (if configured as such)

MODBUS ISSUED TRIP

TEST MODE

EXTERNAL SHUTDOWN

**03 POWER UP SHUTDOWN (1)** displays the status of power up shutdown. Shutdown is detected when the power supply to the 2301D-ST is turned off.

**04 OVERSPEED (2)** displays the status of overspeed trip. Shutdown is detected when the turbine reaches an overspeed.

**05 MPU FAIL (3)** displays the status of MPU fail. Shutdown is detected if the MPU fails.

**06 ANALOG INPUT #1 FAIL (4)** displays the status of Analog Input #1 (if configured). A failed input is detected when the analog #1 exceeds the following ranges:

Input Set For:	Low Trip Point	High Trip Point
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
±2.5 Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

**07 ANALOG INPUT #2 FAIL (5)** displays the status of Analog Input #2 (if configured). A failed input is detected when the analog #2 exceeds the following ranges:

Input Set For:	<Low Trip Point	>High Trip Point
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
±2.5 Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

**08 MODBUS ISSUED TRIP (6)** displays the status of the Modbus Issued Trip (if configured). A trip is detected when an input from the Modbus controller has issued a trip command.

**09 TEST MODE (7)** displays the status of Test Mode input. A trip is detected when the Actuator Calibration or the Enable Hardware Test is enabled.

**10 EXTERNAL SHUTDOWN (8)** displays the status of SHUTDOWN / RUN DISCRETE input. A shutdown is detected when the discrete input on terminal 31 is FALSE.

**11 STUCK IN CRITICAL (9)** displays the status of a shutdown caused by a stuck in critical band failure.

**12 SHUTDOWN ACKNOWLEDGE** dflt=FALSE (FALSE, TRUE)  
When set to TRUE will reset the SHUTDOWN RELAY discrete output. (See also description of RESET CLEARS TRIPS in the configure menu C\*\*DISCRETE OUT OPTIONS\*\*.

## D\*\* ALARMS \*\*

Control	Category	Block	Field	Value	Des...
st.NET(Dflt Con...	SERVICE: D** ALARMS **	01 ALARM STATUS		False	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	02 FIRST ALARM		NO ALARMS	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	03 ANALOG INPUT #1 FAIL (1)		False	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	04 ANALOG INPUT #2 FAIL (2)		False	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	05 LOAD SENSOR FAIL (3)		False	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	06 LOAD SHARE LINE FAIL (4)		False	
st.NET(Dflt Con...	SERVICE: D** ALARMS **	07 ALARM ACKNOWLEDGE		False	

Figure 3-16. Service: D\*\* ALARM \*\* Menu

This menu displays the status of the alarm modes.

**01 ALARM STATUS** gives the existing alarm conditions. If control has alarms, it displays TRUE. If no alarms exist, it displays FALSE.

**02 FIRST ALARM** displays the cause of the first alarm. If the control has an alarm condition, this menu item indicates the first alarm:

NO ALARMS

ANALOG INPUT #1 FAIL

ANALOG INPUT #2 FAIL

LOAD SENSOR FAIL

LOAD SHARING LINE FAIL

**03 ANALOG INPUT #1 FAIL (1)** displays the status of Analog Input #1 (if configured). A failed input is detected when the analog #1 exceeds the following ranges:

Input Set For:	Low Trip Point	High Trip Point
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
±2.5 Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

**04 ANALOG INPUT #2 FAIL (2)** displays the status of Analog Input #2 (if configured). A failed input is detected when the analog #2 exceeds the following ranges:

Input Set For:	Low Trip Point	High Trip Point
4–20 mA	2.0 mA	22.0 mA
0–5 Vdc	–0.63 Vdc	5.63 Vdc
±2.5 Vdc	–3.13 Vdc	+3.13 Vdc
1–5 Vdc	0.5 Vdc	5.5 Vdc

**05 LOAD SENSOR FAIL (3)** displays the status of load sensor inputs (if configured). A failed input is detected when the CT input goes less than –150 mA.

**06 LOAD SHARE LINE FAIL (4)** displays the status of load sharing input. A failed input is detected when the input goes less than –0.05 VDC.

**07 ALARM ACKNOWLEDGE** dflt=FALSE (FALSE, TRUE)

By setting this input to TRUE momentarily, the ALARM discrete output will be reset to a normal state.

**E\*\* SPEED DYNAMICS \*\***

Control	Block	Field	Value	Description
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	01 OFF LINE PROP GAIN	5.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	02 OFF LINE INT GAIN	1.800	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	03 OFF LINE DERIV RATIO	20.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	04 OFF LINE WINDOW WIDTH	60.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	05 OFF LINE GAIN RATIO	1.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	06 USE ON LINE DYNAMICS?	False	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	07 ON LINE PROP GAIN	5.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	08 ON LINE INT GAIN	1.800	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	09 ON LINE DERIV RATIO	20.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	10 ON LINE WINDOW WIDTH	60.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	11 ON LINE GAIN RATIO	1.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	12 USING ON LINE DYNAMICS?	False	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	13 USE LOAD REJECTION?	False	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	14 LD REJ SPD CHG (RPM/SEC)	50.000	
Net2(Dflt Contrc)	SERVICE: E** SPEED DYNAMICS **	15 LD REJ PERCENT SPEED (%)	102.000	

Min = 0.010 : Max = 100.000

Figure 3-17. Service: E\*\* SPEED DYNAMICS \*\* Menu

This menu gives the operator the ability to tune the dynamic adjustments. Dynamic adjustments are settings that affect the stability and transient performance of the turbine. There are two sets of dynamics provided. The 52G GENERATOR BREAKER contact input selects the Dynamics being used for control.

If the “Select Modbus Speed PID” is set to TRUE from Modbus, Dynamics switching from Modbus will take priority over the operation of the dynamics switching. By setting the “Select Speed PID Dynamic Settings #1” to TRUE momentarily from Modbus, OFF LINE Dynamic Settings are used in the control. Otherwise, by setting the “Select Speed PID Dynamic Settings #2” to TRUE momentarily from Modbus, ON LINE Dynamic Settings are used in the control.

**01 OFF LINE PROP GAIN** dflt=5.0 (0.01, 100.0)  
Determines how fast the control responds to an error in turbine speed from the speed-reference setting. The Proportional Gain is used to provide stable control of the turbine in an unloaded condition.

**02 OFF LINE INT GAIN** dflt=1.8 (0.01, 50.0)  
Compensates for the lag time of the turbine. It adjusts the time required for the control to return the speed to zero error after a disturbance. The Integral Gain is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance in an unloaded condition.

**03 OFF LINE DERIV RATIO** dflt=20.0 (0.01, 100.0)  
Compensates for the actuator system time constant. Increasing the value makes the actuator transient performance increase in an unloaded condition.

**04 OFF LINE WINDOW WIDTH 1 (RPM)**

dflt=60.0 (1.00, 200.0)

The magnitude (in rpm) of speed error at which the control automatically switches to fast response. The control uses the absolute value of speed error to make this switch. The absolute value is the difference between the speed reference and the speed. A Window Width too narrow will result in cycling that always factors in the Gain Ratio (see Figure 3-18). Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**05 OFF LINE GAIN RATIO**

dflt=1.0 (1.00, 10.0)

The ratio of the Gain setting at steady state to the Gain setting during transient conditions. The Gain Ratio operates in conjunction with the Window Width and Gain adjustments by multiplying the Gain set point by the Gain Ratio when the speed error is greater than the Window Width. This makes the control dynamics fast enough to minimize engine-speed overshoot on start-up and to reduce the magnitude of speed error when loads are changing. This allows a lower gain at steady state for better stability and reduced steady-state actuator linkage movement (see Figure 3-18). Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

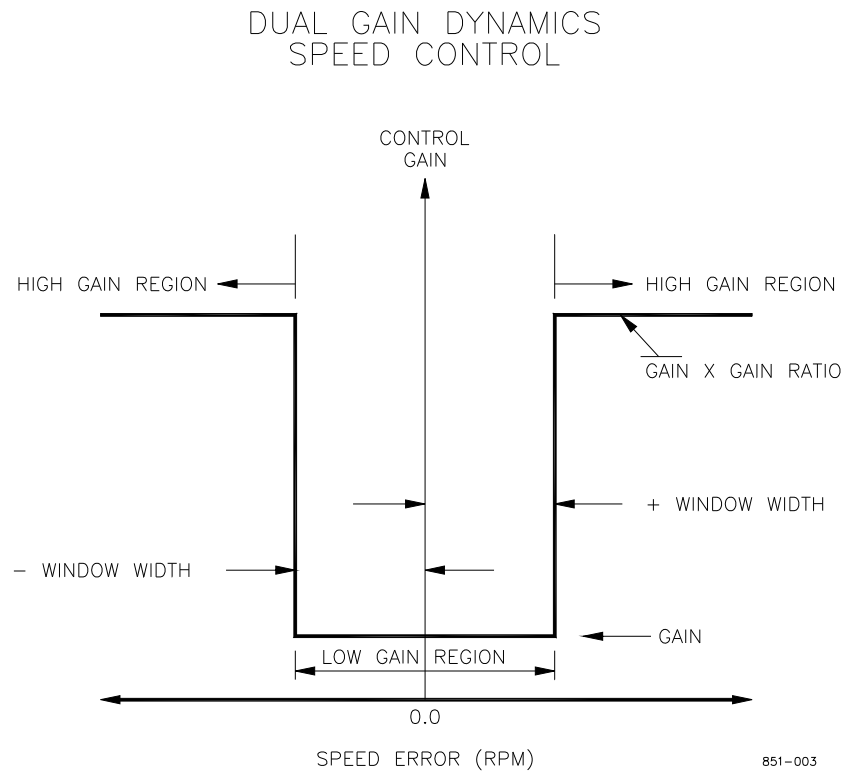


Figure 3-18. Control Gain as a Function of Speed Error

**06 USE ON LINE DYNAMICS?**

dflt=FALSE (FALSE, TRUE)

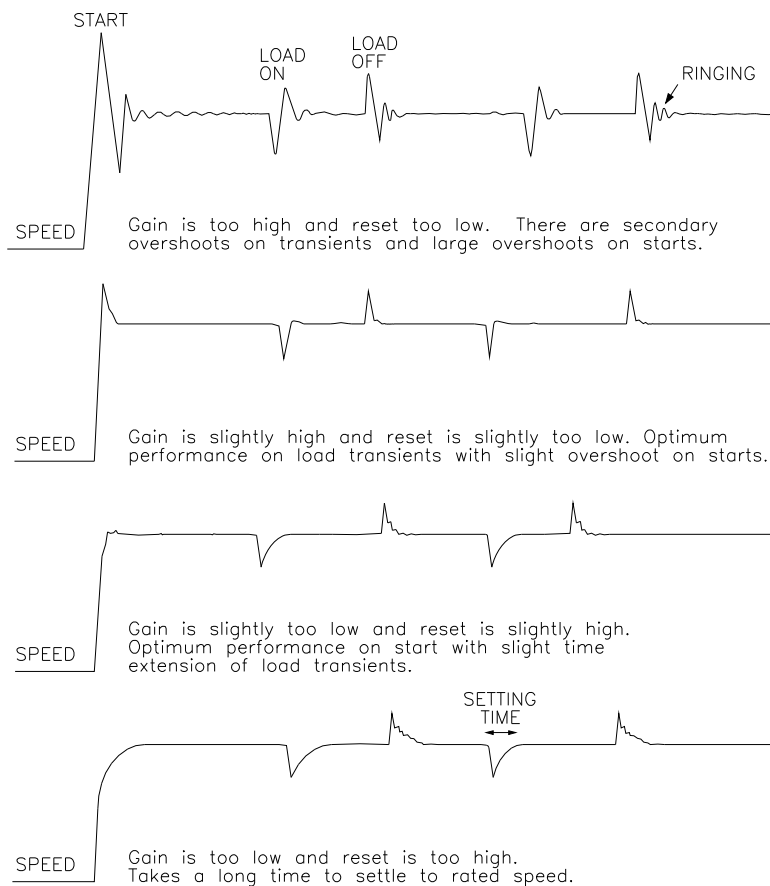
Set to TRUE when selecting the ON LINE dynamics feature when the 52G GENERATOR BREAKER contact input is closed.

**07 ON LINE PROP GAIN**

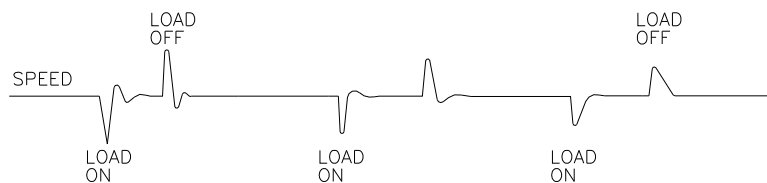
dflt=5.0 (0.01, 100.0)

Determines how fast the control responds to an error in turbine speed from the speed-reference setting. The Proportional Gain is used to provide stable control of the turbine in a loaded condition.

## RESULTS – GAIN AND RESET ADJUSTMENTS



## IDEAL LOAD STEP RESPONSE



## RESULTS – COMPENSATION ADJUSTMENT

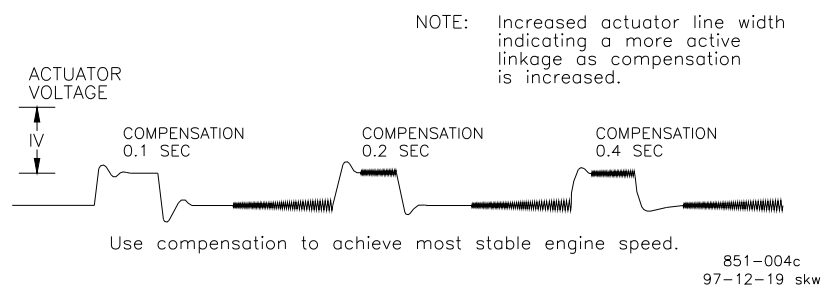


Figure 3-19. Typical Transient Response Curves

**08 ON LINE INT GAIN**

dflt=1.8 (0.01, 50.0)

Compensates for the lag time of the turbine. It adjusts the time required for the control to return the speed to zero error after a disturbance. The Integral Gain is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance in a loaded condition.

**09 ON LINE DERIV RATIO**

dflt=20.0 (0.01, 100.0)

Compensates for the actuator system time constant. Increasing the value makes the actuator transient performance increase in a loaded condition.

**10 ON LINE WINDOW WIDTH 1 (RPM)**

dflt=60.0 (1.00, 200.0)

The magnitude (in rpm) of speed error at which the control automatically switches to fast response. The control uses the absolute value of speed error to make this switch. The absolute value is the difference between the speed reference and the speed. A Window Width too narrow will result in cycling that always factors in the Gain Ratio (see Figure 3-18). Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**11 ON LINE GAIN RATIO**

dflt=1.0 (1.00, 10.0)

The ratio of the Gain setting at steady state to the Gain setting during transient conditions. The Gain Ratio operates in conjunction with the Window Width and Gain adjustments by multiplying the Gain set point by the Gain Ratio when the speed error is greater than the Window Width. This makes the control dynamics fast enough to minimize engine-speed overshoot on start-up and to reduce the magnitude of speed error when loads are changing. This allows a lower gain at steady state for better stability and reduced steady-state actuator linkage movement (see Figure 3-18). Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**12 USING ON LINE DYNAMICS?**

Displays TRUE when ON LINE Dynamic Settings are being used in the control.  
Displays FALSE when the OFF LINE dynamics are being used in the control.

**13 USE LOAD REJECTION?**

dflt=FALSE (FALSE, TRUE)

Load Rejection is used when the possibility of large load transients could trip the turbine out on overspeed. For example, when a generator breaker opens, while load is on the turbine. This logic, when set to True, will sample the fuel demand setting at the time the breaker is closed, will limit the Maximum PID output to this value, and will pulse the Integral Gain value of the PID, if the speed changes faster than the values listed: LD REJ SPD CHG, and LD REJ PERCENT SPEED). Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**14 LD REJ SPD CHG (RPM/SEC)**

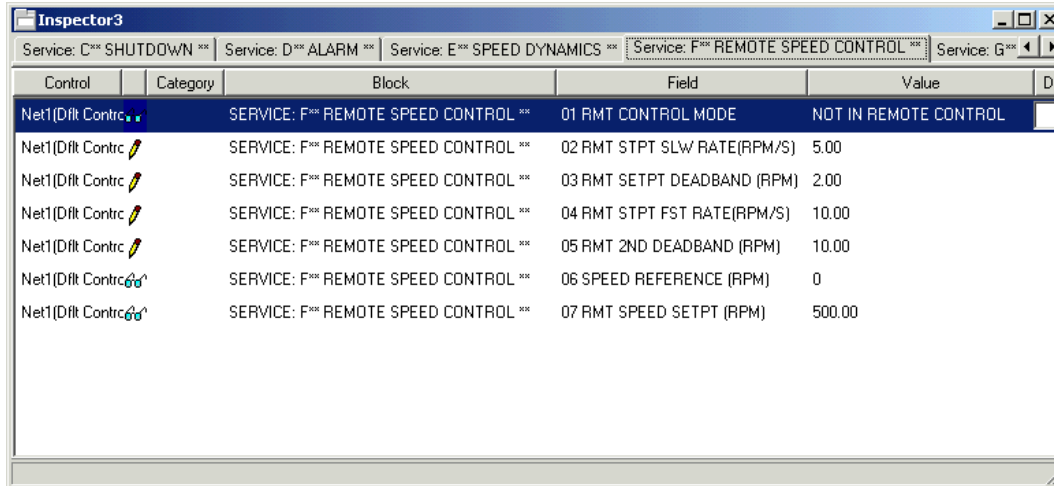
dflt=50.0 (50.0, 250.0)

This value when exceeded, and the USE LOAD REJECTION? Value is true, and the LD REJ PERCENT SPEED (%) is exceeded, will enable the load rejection logic. Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**15 LD REJ PERCENT SPEED (%)**

dflt=102.0 (10000, 105.0)

This value when exceeded, and the USE LOAD REJECTION? Value is true, and the LD REJ SPD CHG (RPM/SEC) is exceeded, will enable the load rejection logic. Note: This menu item was added in revision "G" version of software. It will not show up in previous versions.

**F\*\* REMOTE SPEED CONTROL \*\***


Control	Category	Block	Field	Value	D.
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	01 RMT CONTROL MODE	NOT IN REMOTE CONTROL	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	02 RMT STPT SLW RATE(RPM/S)	5.00	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	03 RMT SETPT DEADBAND (RPM)	2.00	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	04 RMT STPT FST RATE(RPM/S)	10.00	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	05 RMT 2ND DEADBAND (RPM)	10.00	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	06 SPEED REFERENCE (RPM)	0	
Net1(Dflt Contrc...		SERVICE: F** REMOTE SPEED CONTROL **	07 RMT SPEED SETPT (RPM)	500.00	

Figure 3-20. Service: F\*\* REMOTE SPEED CONTROL\*\* Menu

THIS MENU IS USED FOR THE REMOTE SPEED CONTROL LOGIC. The operation of two kinds of remote speed setting is possible for the control. One is the control by the analog input. Another is the control from Modbus. These two cannot be performed simultaneously. Priority is given to an analog input over Modbus input.

**01 REMOTE CONTROL MODE** displays the status of remote control speed operation. Will display one of the following:

NOT IN REMOTE CONTROL  
MODBUS REMOTE  
ANALOG INPUT REMOTE

**02 RMT/PROC SLW RATE (RPM/S)** dflt=5.0 (0.0, 1000.0)

Enter the speed remote / process control rate (rpm/second). This is the rate of speed change for remote or process operation if using an analog input or a Modbus Entered Speed Setpoint to set the Speed/Load Setpoint.

**03 RMT SETPT DEADBAND (RPM)** dflt=2.0 (0.0, 100.0)

Enter the dead band of remote speed setpoint operation. When the difference between the control's speed setpoint and the remote speed setpoint is equal to or less than the dead band window size, the control will not take any action.

**04 RMT STPT FST RATE (RPM/S)** dflt=10.0 (0.0, 1000.0)

Enter the speed setpoint remote control rate (rpm/second). This is the rate of speed change for remote operation if using an analog input or a Modbus Entered Speed Setpoint to set the Speed/Load Setpoint.

**05 RMT 2ND DEADBAND (RPM)** dflt=10.0 (0.0, 100.0)

Enter the second dead band for the remote speed setpoint operation. When the difference between the control's speed setpoint and the remote speed setpoint is equal to or greater than the dead band window size, the control will change at the RMT STPT FST RATE.

**06 SPEED REFERENCE (RPM)** displays the speed setpoint in rpm.

**07 REMOTE SPEED SETPT (RPM)** displays the remote speed setpoint in rpm.

**G\*\* SPEED SETTING \*\***

Inspector2					
Service: D** ALARMS **		Service: E** SPEED DYNAMICS **		Service: F** REMOTE SPEED CONTROL **	
		Service: G** SPEED SETTING **		Service: H** PROCE **	
Control	C.	Block	Field	Value	Description
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	01 IDLE SPD SETPOINT (RPM)	1000.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	02 IDLE TO RATED (RPM/SEC)	25.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	03 RATED TO IDLE (RPM/SEC)	25.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	04 MIN GOV SETPOINT (RPM)	3550.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	05 MAX GOV SETPOINT (RPM)	3843.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	06 LOWER SLOW RATE (RPM/S)	10.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	07 LOWER FAST RATE (RPM/S)	25.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	08 RAISE SLOW RATE (RPM/S)	10.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	09 RAISE FAST RATE (RPM/S)	25.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	10 R / L TIME DELAY (SEC)	5.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	11 CRITICAL LOW POINT (RPM)	2500.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	12 CRITICAL HI POINT (RPM)	3000.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	13 CRITICAL RATE (RPM/SEC)	100.00	
Net6(Dflt Contrc		SERVICE: G**SPEED SETTING**	14 USE SET POINT SET-BACK?	False	

Min = 0.00 : Max = 32000.00

Figure 3-21. Service: G\*\* SPEED SETTING \*\* Menu

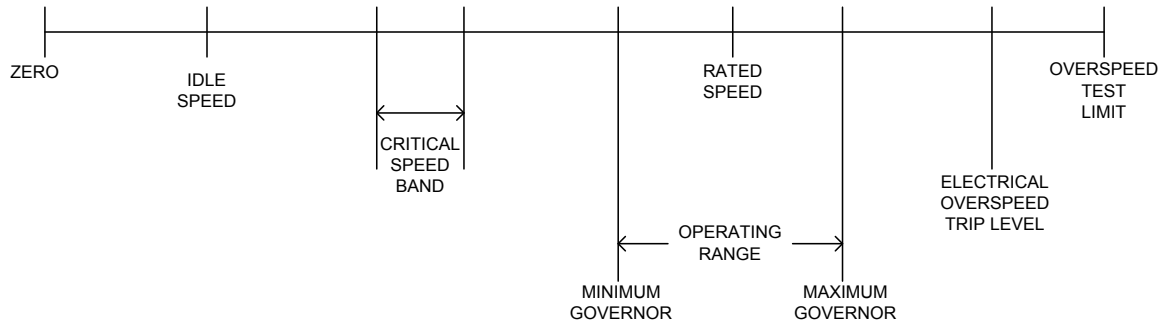


Figure 3-22. Speed Relationships

This menu is used for setting up the speed set points of the turbine.

**01 IDLE SPD SETPOINT (RPM)** dflt=1000 (0.0, 32000)

Enter the idle speed setting. This is the speed setting when using the optional IDLE / RATED discrete input.

**02 IDLE TO RATED (RPM/SEC)** dflt=25.0 (0.0, 32000)

Enter the idle to rated rate (rpm/second). This is the rate at which the speed setpoint moves to the Rated speed setpoint when using the optional Idle / Rated discrete input.

**03 RATED TO IDLE (RPM/SEC)** dflt=25.0 (0.0, 32000)

Enter the rated to idle rate (rpm/second). This is the rate the speed setpoint moves to the Idle speed setpoint when using the optional Idle / Rated discrete input.

**04 MIN GOV SETPOINT (RPM)**

dflt=3550.0 (0.0, 32000)

Enter the minimum governor speed setting. This is the normal operation lower limit. (Must be greater than or equal to the IDLE SPEED SETPOINT and less than or equal to the RATED SPEED SETPOINT).

**05 MAX GOV SETPOINT (RPM)**

dflt=3843.0 (0.0, 20000)

Enter the maximum speed setting. This is the normal operation upper limit. (Must be greater than or equal to the RATED SPEED SETPOINT and less than or equal to the ELECTRICAL OVERSPEED TRIP SETPOINT).

**06 LOWER SLOW RATE (RPM/S)**

dflt=25.0 (0.0, 1000)

Enter the lower speed slow rate (rpm/second). This is the rate the speed setpoint moves when using the LOWER SPEED / LOAD discrete input until the Raise / Lower Time Delay has expired. At this time the Lower Fast Rate takes over.

**07 LOWER FAST RATE (RPM/S)**

dflt=25.0 (0.0, 1000)

Enter the lower speed rate (rpm/second). This is the rate the speed setpoint moves when using the LOWER SPEED / LOAD discrete input after the Raise / Lower Time Delay has expired.

**08 RAISE SLOW RATE (RPM/S)**

dflt=25.0 (0.0, 1000)

Enter the raise speed rate (rpm/second). This is the rate the speed setpoint moves when using the RAISE SPEED / LOAD discrete input until the Raise / Lower Time Delay has expired. At this time the Lower Fast Rate takes over.

**09 RAISE FAST RATE (RPM/S)**

dflt=25.0 (0.0, 1000)

Enter the raise speed rate (rpm/second). This is the rate the speed setpoint moves when using the RAISE SPEED / LOAD discrete input.

**10 R/L TIME DELAY (SEC)**

dflt=5.0 (0.5, 30.0)

Enter the time in seconds that the Raise or Lower Slow Rates has control of the speed setpoint. After this time has expired, the Raise or Lower Fast Rate has control of the speed setpoint.

**11 CRITICAL LOW POINT (RPM)**

dflt=2500.0 (0.0, 32000)

Enter the lower limit of the critical speed avoidance band.  
(Must be less than the CRITICAL HI POINT and greater than IDLE SPEED SETPOINT)

**12 CRITICAL HI POINT (RPM)**

dflt=3000.0 (0.0, 32000)

Enter the upper limit of the critical speed avoidance band.  
(Must be greater than the CRITICAL LOW POINT must be less than the MIN GOV SETPOINT).

**13 CRITICAL RATE (RPM/SEC)**

dflt=100.0 (0.0, 32000)

Enter the rate that the speed setpoint will move through the critical speed avoidance range (in rpm/second).

**14 USE SET POINT SET-BACK?**

dflt=FALSE (FALSE, TRUE)

Set this value to TRUE to use the SET POINT SET-BACK feature. This feature will instantly reset the speed setpoint to the actual running speed of the turbine when the RAISE SPEED / LOAD or LOWER SPEED / LOAD discrete inputs are switched. During a ramp, this input can be used to stop the ramp from changing the speed set point. Set this value to FALSE to disable this feature.

(This feature must be left FALSE when using this control for generator applications)!

**H\*\* PROCESS CONTROL \*\***

Control	C...	Block	Field	Value	Description
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	01 PROCESS CONTROL ENABLED	False	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	02 USE PROCESS CONTROL ?	True	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	03 INVERT PROCESS ?	False	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	04 MIN PROC SETPT (UNITS)	30.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	05 MAX PROC SETPT (UNITS)	80.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	06 PROC SETPT RT(UNITS /SEC)	5.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	07 USE SETPOINT TRACKING?	True	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	08 SETPT INIT VALUE (UNITS)	50.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	09 SPD SETPT LOW LMT (RPM)	3500.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	10 SPD SETPT HIGH LMT (RPM)	3700.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	11 PROCESS PID PROP GAIN	4.68	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	12 PROCESS PID INTEG GAIN	7.72	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	13 PROCESS DERIVATIVE RATIO	0.38	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	14 PROCESS CNTRL DEADBAND	0.01	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	15 USE REMOTE PROC SETTING?	False	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	16 REMOTE PROC MAX RATE	5.00	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	17 ANALOG INPUT #1(MA)	4.02	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	18 ANALOG INPUT #2 (MA)	6.93	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	19 PROCESS SETPOINT (UNITS)	7.83	
Net3(Dflt Contrc		SERVICE: H** PROCESS CONTROL **	20 PROCESS ACTUAL (UNITS)	7.83	

Figure 3-23. Service: H\*\* PROCESS CONTROL \*\* Menu

THIS MENU IS USED FOR THE PROCESS CONTROL OF THE TURBINE.

**01 PROCESS CONTROL ENABLED**

Displays the state of the process control. TRUE means the Process Control is enabled, FALSE means it is disabled.

**02 USE PROCESS CONTROL?**

dflt=FALSE(FALSE, TRUE)

The Process control can be configured to control any system process, related to or affected by turbine speed or load. Typically this controller is configured and used as a turbine inlet or exhaust pressure controller. When this value is set TRUE, the Process PID can move the speed setpoint at a variable rate up to the REMOTE PROC MAX RATE setting. If the USE PROCESS CONTROL is FALSE the inputs will have no effect on the control.

**03 INVERT PROCESS?**

dflt= FALSE(FALSE, TRUE)

Select TRUE if the process control will be reverse acting. If FALSE is selected, the control will be forward acting. Typically this will be set to FALSE, the only time the input would be inverted is if the valve needs to open when the input exceeds the setpoint. An example where the invert would be TRUE is for turbine inlet pressure control.

**04 MIN PROC SETPT (UNITS)**

dflt=0.0 (-20000.0, 20000.0)

This value is the minimum setpoint value that the process setpoint can be decreased/lowered to (lower limit of process setpoint). This value should set to the same value as the INPUT#X MIN VALUE (UNITS) under the Configure menu D\*\*ANALOG INPUT OPTIONS\*\*.

**05 MAX PROC SETPT (UNITS)** dflt=0.0 (-20000.0, 20000.0)

This value is the maximum setpoint value that the process setpoint can be increased/raised to (upper limit of process setpoint). This value should set to the same value as the INPUT#X MAX VALUE (UNITS) under the Configure menu D\*\*ANALOG INPUT OPTIONS\*\*.

(Must be greater than the 'Min Proc Setpt' Setting)

**06 PROC SETPT RT (UNITS/SEC)** dflt=5.00 (0.01, 1000.00)

This value is the rate (in units per second) at which process setpoint moves when adjusted.

**07 USE SETPOINT TRACKING?** dflt= FALSE(FALSE, TRUE)

If TRUE, the process setpoint tracks the process input to provide bumpless transfer to process control when it is enabled. If FALSE, the process setpoint remains at the last position except on power-up.

**08 SETPT INIT VALUE (UNITS)** dflt=0.0 (-20000.0, 20000.0)

When not using the Setpoint Tracking function, this is the value that the process setpoint initializes to upon power-up.

(Must be less than or equal to the 'Max Process Setpt' Setting)

**09 SPD SETPT LOW LMT (RPM)** dflt=0.0 (0.0, 20000.0)

Set the minimum speed setpoint that the process controller can lower the speed setpoint to. To protect the unit, this value should be at or above rated speed if the unit is a generator. (Must be greater than or equal to the 'Minimum Governor Speed Setpt' Setting)

**10 SPD SETPT HIGH LMT (RPM)** dflt=0.0 (0.0, 20000.0)

Set the maximum speed setpoint that process controller can raise the speed setpoint to.

(Must be less than or equal to the 'Maximum Governor Speed Setpt' Setting)

**11 PROCESS PID PROP GAIN** dflt=1.0 (0.0, 100)

Enter the process PID proportional gain value. This value is used to set process control response.

**12 PROCESS PID INTEG GAIN** dflt=0.3 (0.001, 50.0)

Enter the process PID integral gain value. This value is used to set process control response.

**13 PROCESS DERIVATIVE RATIO** dflt=100.0 (0.01, 100.0)

Enter the process PID derivative ratio value. This value is used to set process control response.

**14 PROCESS CNTRL DEADBAND** dflt=0.01 (0.01, 5.0)

Enter the process control deadband value. This value is used to set the deadband the process control will respond to.

**15 USE REMOTE PROC SETTING?** dflt= FALSE(FALSE, TRUE)

Set to TRUE to allow the Process setpoint to be adjusted from an analog input. (Must program a 'Remote Process Setpoint' analog input)

**16 REMOTE PROC MAX RATE** dflt=5.0 (0.01, 1000.0)

Enter the maximum rate at which the remote input will move the process setpoint.

**17 ANALOG INPUT #1**

Displays the input of analog input #1.

**18 ANALOG INPUT #2**

Displays the input of analog input #2.

**19 PROCESS SETPOINT (UNITS)**

Displays the process setpoint in engineering units.

**20 PROCESS ACTUAL (UNITS)**

Displays the process control variable in engineering units.

**I\*\* OVERSPEED TEST \*\***

Control	Category	Block	Field	Value	D..
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	01 OVERSPEED TEST STATUS	Overspeed Trip Test Active	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	02 OVERSPEED TEST ENABLE	True	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	03 ELEC OVRSPD TRIP SETPT	4032.00	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	04 MAX OVRSPD TEST LMT(RPM)	4140.00	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	05 ELECT OVERSPD TRIP TEST	True	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	06 TURBINE SPEED (RPM)	4035.92	
Net10(Dflt Cont)		SERVICE: I** OVERSPEED TEST **	07 SPEED REF (RPM)	4036	

Min = 0 : Max = 1

Figure 3-24. Service: I\*\* OVERSPEED TEST \*\* Menu

**01 OVERSPEED TEST STATUS** displays the state of the overspeed test function.

**02 OVERSPEED TEST ENABLE** dflt=FALSE (FALSE, TRUE)

Set the overspeed test discrete input TRUE when this optional test is performed. An overspeed test is allowed only under the condition that the remote speed setpoint function is disabled and the 52G generator breaker is open. An overspeed test will allow the control's speed setpoint to be increased above the normal maximum limit. When the actual speed reaches the ELEC OVRSPD TRIP SETPT, the ELECT OVERSPD TRIP TEST will switch from FALSE to TRUE. When this input is FALSE, the control will detect an over speed and will issue a trip. After overspeed testing ends, manually lower the turbine speed below the ELEC OVRSPD TRIP SETPT or else the turbine will trip. When testing is done, return the input to FALSE.

**03 ELEC OVRSPD TRIP SETPT** dflt=4032.0 (0.0, 32000)

Enter the electrical overspeed trip speed setting in rpm. This is the controls electrical overspeed trip setpoint only and should not be used as the ultimate overspeed protection.

(Must be greater than or equal to the MAX GOVERNOR SETPOINT and less than the MAXIMUM OVERSPEED SETPOINT).

**04 ELEC OVERSPD TRIP TEST** displays the status of the electrical overspeed trip set point latch. When testing the overspeed function, this value will go true when the actual speed reaches the ELEC OVRSPD TRIP SETPT.

**05 TURBINE SPEED (RPM)** displays actual turbine speed in rpm.

**06 SPEED REF (RPM)** displays turbine speed setpoint in rpm.

### J\*\* FAILED MPU OVERRIDE \*\*

Control	Category	Block	Field	Value	D.
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	01 AUTO-OVRD OFF SPEED	450.00	
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	02 AUTO-OVRD ON SPEED	650.00	
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	03 AUTO-OVRD ON DELAY (SEC)	5.00	
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	04 USE MPU OVRD TIMER?	False	
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	05 USE ROLLDOWN OVRD?	False	
Net1(Dflt Contr		SERVICE: J**FAILED MPU OVERRIDE**	06 MAX STARTING TIME =	60.00	

Min = 0.00 : Max = 2000.00

Figure 3-25. Service: J\*\* FAILED MPU OVERRIDE\*\* Menu

THIS MENU IS USED FOR SETTING THE MPU OVERRIDE LOGIC.

#### 01 AUTO-OVRD OFF SPEED dflt=450.0 (0.0, 2000.0)

This is the setpoint at which the auto MPU override goes off. Once the MPU speed is greater than this value, the MPU override will go off. If the speed drops below the MPU MIN SPD LEVEL (RPM) (see Configure Menu – A\*\*SPEED AND STRT OPTIONS\*\*) after the override goes off, the turbine will trip on loss of speed.

#### 02 AUTO-OVRD ON SPEED dflt=650.0 (0.0, 2000.0)

This is the setpoint where the rolldown override will start if Use Rolldown Override is set to TRUE. When the speed drops below this low-speed setting for the delay time, the override is turned on.

#### 03 AUTO-OVRD ON DELAY (SEC) dflt=5.00 (0.0, 100.0)

This is the delay time before the MPU override goes TRUE. It is used with the Rolldown Override option - the delay time associated with turning on the override. If the speed drops below the Minimum Speed Level setting before the time expires, the unit will trip on loss of MPU signal and reset the speed set-point to minimum.

#### 04 USE MPU OVRD TIMER? dflt=FALSE (FALSE, TRUE)

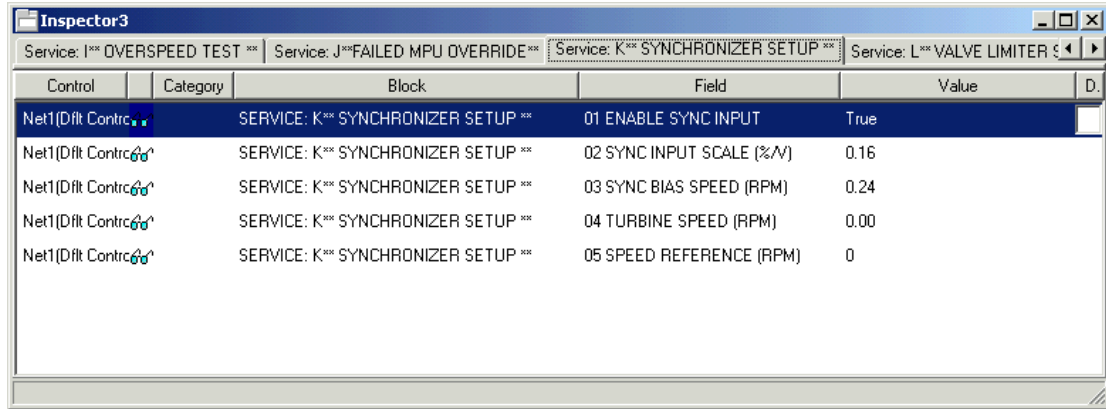
If the override timer is to be used, this should be set to TRUE. This option will limit the amount of time allowed to get to minimum speed (set in Configure mode).

#### 05 USE ROLLDOWN OVERRIDE? dflt=FALSE (FALSE, TRUE)

Set this to TRUE to enable the rolldown MPU override. This option turns on the Failed MPU Override if the speed is being slowly reduced by closing the Trip-and-Throttle valve or stop valve — this override is turned on after the speed drops below the AUTO-OVRD ON SPEED setting for the AUTO-OVRD ON DELAY time.

#### 06 MAX STARTING TIME dflt=60.0 (0.0, 3000.0)

Maximum time required to start; if this time expires the MPU will no longer be overridden. If the turbine has not reached the MPU MIN SPD LEVEL before this time expires, the turbine will trip on loss of speed

**K\*\* SYNCHRONIZER SETUP \*\***


Control	Category	Block	Field	Value	D.
Net1(Dfkt Contrc		SERVICE: K** SYNCHRONIZER SETUP **	01 ENABLE SYNC INPUT	True	
Net1(Dfkt Contrc		SERVICE: K** SYNCHRONIZER SETUP **	02 SYNC INPUT SCALE (%/V)	0.16	
Net1(Dfkt Contrc		SERVICE: K** SYNCHRONIZER SETUP **	03 SYNC BIAS SPEED (RPM)	0.24	
Net1(Dfkt Contrc		SERVICE: K** SYNCHRONIZER SETUP **	04 TURBINE SPEED (RPM)	0.00	
Net1(Dfkt Contrc		SERVICE: K** SYNCHRONIZER SETUP **	05 SPEED REFERENCE (RPM)	0	

Figure 3-26. Service: K\*\* SYNCHRONIZER SETUP\*\* Menu

THIS MENU IS USED TO SETUP THE SYNCHRONIZER LOGIC.

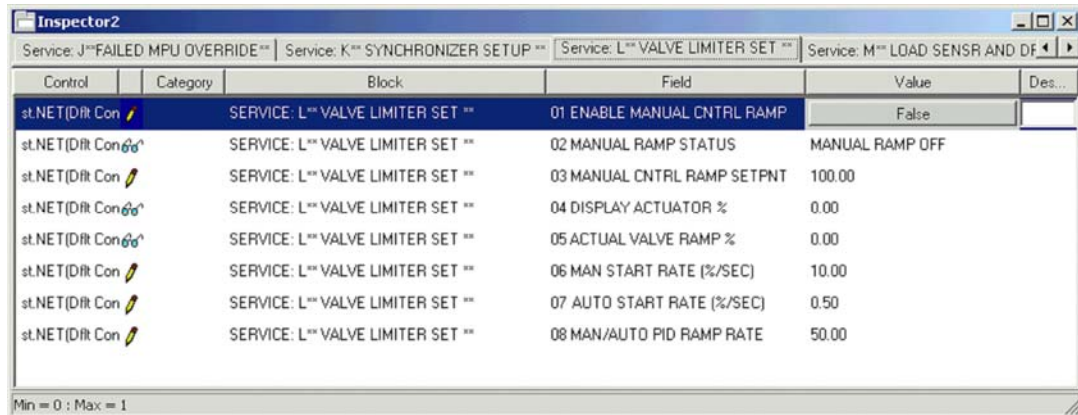
**01 ENBL SYNC INPUT** displays whether the sync input is being used. If it is TRUE, the SYNC INPUT can be used.

**02 SYNC INPUT SCALE (%/V)** dflt=0.7 (0.1, 5.0)  
Should be set to the Analog Input sync input scale.

**03 SYNC BIAS SPD (RPM)** displays the value of sync bias speed.

**04 TURBINE SPEED (RPM)** displays actual turbine rpm.

**05 SPD REF (RPM)** displays turbine speed setpoint rpm.

**L\* VALVE LIMITER SET \*\***


Control	Category	Block	Field	Value	Des...
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	01 ENABLE MANUAL CNTRL RAMP	False	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	02 MANUAL RAMP STATUS	MANUAL RAMP OFF	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	03 MANUAL CNTRL RAMP SETPNT	100.00	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	04 DISPLAY ACTUATOR %	0.00	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	05 ACTUAL VALVE RAMP %	0.00	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	06 MAN START RATE (%/SEC)	10.00	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	07 AUTO START RATE (%/SEC)	0.50	
st.NET(Dfkt Con		SERVICE: L** VALVE LIMITER SET **	08 MAN/AUTO PID RAMP RATE	50.00	

Min = 0 : Max = 1

Figure 3-27. Service: L\* VALVE LIMITER SET \*\* Menu

THIS MENU IS USED TO SET UP THE VALVE LIMITER CONTROL.

**01 ENABLE MANUAL CNTRL RAMP**

dflt=FALSE (FALSE,TRUE)

Set this value to TRUE to manually control the valve ramp. MANUAL CNTRL RAMP SETPNT is used manually lower the ramp. This value is low signal selected (LSS) with the turbine speed control. If manually lowered below the speed control PID value, the valve ramp will take control.

**02 MANUAL RAMP STATUS** displays the status of the MANUAL CONTROL RAMP.

**03 MANUAL CNTRL RAMP SETPNT**

dflt=100.0 (0.0, 100.0)

Set this value to manually control the valve ramp. This value is low signal selected (LSS) with the turbine speed control.



If manually lowered below the speed control PID value, the valve ramp will take control. This could cause serious consequences, overspeed, or shutdown.

**04 DISPLAY ACTUATOR %** displays the actual actuator output percentage.

**05 ACTUAL VALVE RAMP %** displays the actual valve ramp output percentage.

**06 MAN START RATE (%/SEC)**

dflt=10.0 (0.0, 100.0)

If configured for MANUAL START, this value sets the valve ramp start rate in percent per second.

**07 AUTO START RATE (%/SEC)**

dflt=0.5 (0.0, 100.0)

If configured for a SEMI-AUTOMATIC START, this value sets the valve ramp start rate in percent per second.

**08 MAN/AUTO PID RAMP RATE**

dflt=50.0 (1.0, 100.0)

If configured for a MANUAL START OR AUTOMATIC START MODE, this value sets the PID ramp that sets the PID controller out of the way. This value is set in percent per second.

**M\*\* LOAD SENSOR AND DROOP \*\***

Control	Cat...	Block	Field	Value	Description
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	01 USE LOAD SENSOR?	False	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	02 USE KW DROOP?	False	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	03 USE ACT POS DROOP?	False	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	04 DROOP PERCENTAGE (%)	5.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	05 ACT % @ NO LD (POS DRP)	20.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	06 ACT % @ FULL LD(POS DRP)	80.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	07 ENTER RATED LOAD (KW)	1000	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	08 LOAD GAIN VOLTAGE	6.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	09 KW CALIBRATION ZERO	0.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	10 KW CALIBRATION GAIN	10.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	11 LOAD TIME (KW/SEC)	20.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	12 ENABLE FAST LOAD RATE	False	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	13 FAST LOAD TIME (KW/SEC)	60.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	14 FAST RAMP LOAD (%)	80.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	15 LOAD SHARE GAIN	0.20	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	16 UNLOAD TIME (KW/SEC)	20.00	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	17 GEN OUTPUT (KW)	0	
Net2(DfIt Contrc		SERVICE: M** LOAD SENSR AND DROOP **	18 LOAD SIGNAL OUT (VDC)	0.00	

Min = 0 : Max = 1

Figure 3-28. Service: M\*\* LOAD SENSOR AND DROOP \*\* Menu

THIS MENU IS USED TO SET UP THE GENERATOR LOAD CONTROL PARAMETERS.

**01 USE LOAD SENSOR?** dfIt=FALSE (FALSE, TRUE)  
Set to TRUE to use the built in generator load sensor for generator applications or FALSE when using control for pump, blower, or compressor applications.

**02 USE ACT POS DROOP?** dfIt=FALSE (FALSE, TRUE)  
Set to TRUE to use internal LSS demand/actuator position to calculate a droop percentage. When this setting is TRUE, actuator position feedback is used as the controlling parameter for stability when the unit is on-line. Droop percentage is set up in Service Menu "M" below. Actuator position levels in Service Menu "M", below, must be set properly when this value is set to TRUE. If these values are not set properly, the droop percentage will be off. When this setting is FALSE, Actuator Position Droop will not be used. **Note: Do not set this value to True if applying the Potential Transformer and Current Transformer inputs to calculate the true KW load value.**

**03 DROOP PERCENTAGE (%)** dfIt=5.0 (0.00, 12.0)  
This value is the percentage of rated speed the speed reference will droop when the generator load is increased to maximum load. This value is used for KW Droop and Actuator Position Droop.

**04 ACT % @ NO LD (POS DRP)** dfIt=20.0 (0.0, 100.0)  
This value is the percentage of actuator output used to calibrate the actuator position droop feedback at no load. If actuator position feedback droop is used, this value must match the actuator output position at no load.

**06 ACT % @ FULL LD (POS DRP)**

dflt=80.0 (0.0, 100.0)

This value is the percentage of actuator output used to calibrate the actuator position droop feedback at full load. If actuator position feedback droop is used, this value must match the actuator output position at full load.

**07 ENTER RATED LOAD (KW)**

dflt = 1000 (10, 30000)

This value should be set to the generator full load (100%) in kW.

**08 LOAD GAIN VOLTAGE**

dflt=6.00 (0.1, 9.0)

Enter the load gain desired at 100% load. The software will use the Rated KW value above and this Load Gain voltage value to scale the analog output to the load sharing circuitry to perform load sharing with other controls in the system. A value of 6.0 is usually sufficient to allow load sharing with other units utilizing 0–3 Vdc analog load sharing lines. This value must be common with all other controls connected to the common Load Sharing Signal lines.

**09 KW CALIBRATION ZERO**

dflt=0.00 (-20.00, 20.00)

Adjust until the KW reading is zero when the generator output is zero.

**10 KW CALIBRATION GAIN**

dflt=10.0 (5.0, 40.0)

Adjust until the KW reading for the load sensor output matches the external instrumentation readings.

**11 LOAD TIME (KW/SEC)**

dflt=20.0 (1.0, 600.0)

Set this value for loading rate. This sets the rate at which the Load Ramp will increase for soft loading.

**12 ENABLE FAST LOAD RATE**

dflt=FALSE (FALSE, TRUE)

Set to TRUE if the function to activate a faster loading ramp rate than the LOAD TIME entered above when the system load level is high.

**13 FAST LOAD TIME (KW/SEC)**

dflt=60.0 (1.0, 600.0)

Enter the loading rate at which the load will increase when the system load is above the percentage entered for the FAST RAMP LOAD (%).

**14 FAST RAMP LOAD (%)**

dflt=80.0 (1.0, 600.0)

When the system load, as measured through the load sharing lines, is determined to be above this percentage the soft load ramp rate will switch to a faster rate to allow this oncoming unit to pick up its share of the load faster.

**15 UNLOAD TIME (KW/SEC)**

dflt=20.0 (1.0, 600.0)

Set this value for loading rate. This sets the rate at which the Load Ramp will increase for soft loading.

**16 LOAD SHARE GAIN**

dflt=0.20 (0.01, 10.0)

Set this value for stable load control while in isochronous load sharing on an isolated bus.

**17 GEN OUTPUT (KW)** is the output of the generator sensed load and should match external instrumentation

**18 LOAD SIGNAL OUT (VDC)** converts the generator kW into the load Gain voltage value.

**N\*\* ACT LINEARIZATION \*\***

Control	Category	Block	Field	Value	D.
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	01 X-1 VALUE	0.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	02 Y-1 VALUE	0.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	03 X-2 VALUE	10.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	04 Y-2 VALUE	10.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	05 X-3 VALUE	20.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	06 Y-3 VALUE	20.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	07 X-4 VALUE	30.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	08 Y-4 VALUE	30.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	09 X-5 VALUE	40.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	10 Y-5 VALUE	40.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	11 X-6 VALUE	50.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	12 Y-6 VALUE	50.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	13 X-7 VALUE	60.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	14 Y-7 VALUE	60.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	15 X-8 VALUE	70.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	16 Y-8 VALUE	70.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	17 X-9 VALUE	80.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	18 Y-9 VALUE	80.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	19 X-10 VALUE	90.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	20 Y-10 VALUE	90.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	21 X-11 VALUE	100.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	22 Y-11 VALUE	100.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	ACTUATOR DEMAND (%)	0.00	
Net1(Dflt Contrc		SERVICE: N** ACT LINEARIZATION **	ACTUATOR OUT (MA)	0.00	

Min = -10.00 : Max = 110.00

Figure 3-29. Service: N\*\* ACT LINEARIZATION \*\* Menu

THIS MENU IS USED TO LINEARIZE THE ACTUATOR / VALVE.

**01 X-1 VALUE** dflt=0.0 (-10.0,110.0)  
 Input point #1 of actuator linearization curve, in percentage.  
 (Must be less than the 'X-2 Value')

**02 Y-1 VALUE** dflt=0.0 (-10.0,110.0)  
 Output point #1 of actuator linearization curve, in percentage.

**03 X-2 VALUE** dflt=10.0 (-10.0,110.0)  
 Input point #2 of actuator linearization curve, in percentage.  
 (Must be less than the 'X-3 Value')

**04 Y-2 VALUE** dflt=10.0 (-10.0,110.0)  
 Output point #2 of actuator linearization curve, in percentage.

**05 X-3 VALUE** dflt=20.0 (-10.0,110.0)  
 Input point #3 of actuator linearization curve, in percentage.  
 (Must be less than the 'X-4 Value')

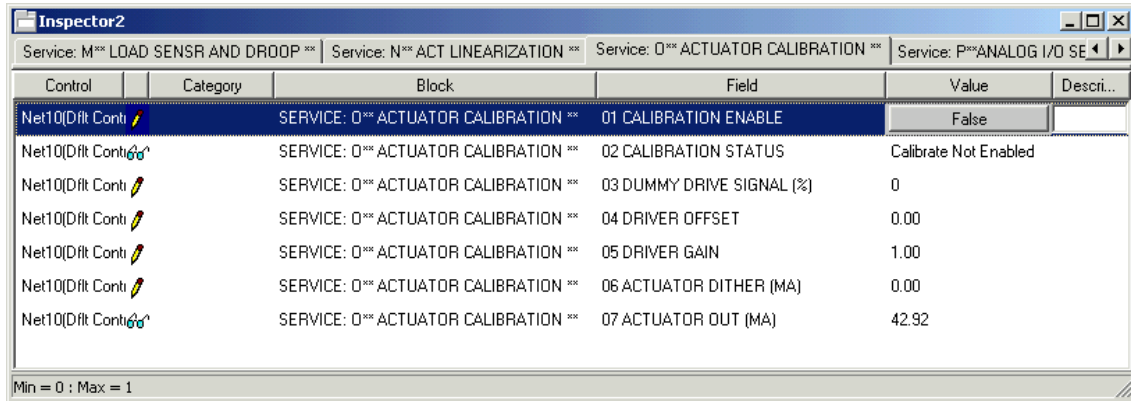
**06 Y-3 VALUE** dflt=20.0 (-10.0,110.0)  
 Output point #3 of actuator linearization curve, in percentage.

- 07 X-4 VALUE** dflt=30.0 (-10.0,110.0)  
Input point #4 of actuator linearization curve, in percentage.  
(Must be less than the 'X-5 Value')
- 08 Y-4 VALUE** dflt=30.0 (-10.0,110.0)  
Output point #4 of actuator linearization curve, in percentage.
- 09 X-5 VALUE** dflt=40.0 (-10.0,110.0)  
Input point #5 of actuator linearization curve, in percentage.  
(Must be less than the 'X-6 Value')
- 10 Y-5 VALUE** dflt=40.0 (-10.0,110.0)  
Output point #5 of actuator linearization curve, in percentage.
- 11 X-6 VALUE** dflt=50.0 (-10.0,110.0)  
Input point #6 of actuator linearization curve, in percentage.  
(Must be less than the 'X-7 Value')
- 12 Y-6 VALUE** dflt=50.0 (-10.0,110.0)  
Output point #6 of actuator linearization curve, in percentage.
- 13 X-7 VALUE** dflt=60.0 (-10.0,110.0)  
Input point #7 of actuator linearization curve, in percentage.  
(Must be less than the 'X-8 Value')
- 14 Y-7 VALUE** dflt=60.0 (-10.0,110.0)  
Output point #7 of actuator linearization curve, in percentage.
- 15 X-8 VALUE** dflt=70.0 (-10.0,110.0)  
Input point #8 of actuator linearization curve, in percentage.  
(Must be less than the 'X-9 Value')
- 16 Y-8 VALUE** dflt=70.0 (-10.0,110.0)  
Output point #8 of actuator linearization curve, in percentage.
- 17 X-9 VALUE** dflt=80.0 (-10.0,110.0)  
Input point #9 of actuator linearization curve, in percentage.  
(Must be less than the 'X-10 Value')
- 18 Y-9 VALUE** dflt=80.0 (-10.0,110.0)  
Output point #9 of actuator linearization curve, in percentage.
- 19 X-10 VALUE** dflt=90.0 (-10.0,110.0)  
Input point #10 of actuator linearization curve, in percentage.  
(Must be less than the 'X-11 Value')
- 20 Y-10 VALUE** dflt=90.0 (-10.0,110.0)  
Output point #10 of actuator linearization curve, in percentage.
- 21 X-11 VALUE** dflt=100.0 (-10.0,110.0)  
Input point #11 of actuator linearization curve, in percentage.
- 22 Y-11 VALUE** dflt=100.0 (-10.0,110.0)  
Output point #11 of actuator linearization curve, in percentage.

**23 ACTUATOR DEMAND (%)** displays the actuator demand before the linearization curve, in percentage.

**24 ACTUATOR OUT (MA)** displays the actuator demand after the linearization curve, in milliamps.

## O\*\* ACTUATOR CALIBRATION \*\*



Control	Category	Block	Field	Value	Descri...
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	01 CALIBRATION ENABLE	False	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	02 CALIBRATION STATUS	Calibrate Not Enabled	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	03 DUMMY DRIVE SIGNAL (%)	0	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	04 DRIVER OFFSET	0.00	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	05 DRIVER GAIN	1.00	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	06 ACTUATOR DITHER (MA)	0.00	
Net10(Dflt Cont)		SERVICE: O** ACTUATOR CALIBRATION **	07 ACTUATOR OUT (MA)	42.92	

Min = 0 : Max = 1

Figure 3-30. Service: O\*\* ACTUATOR CALIBRATION \*\* Menu

Before initial operation or after a turbine overhaul where any actuator or valve travel may have been affected, the below Valve Calibration procedure will allow the 2301D-ST to be calibrated to the valve.

**01 CALIBRATION ENABLE** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to calibrate the actuator or valve. Will not be enabled unless Shutdown is active, and speed is zero. If calibration is completed, it should be set to FALSE.

**02 CALIBRATION STATUS**  
Displays the status of the CALIBRATION ENABLE input.

**03 DUMMY DRIVE SIGNAL (%)** dflt=0 (0,100)  
Set the valve's output percentage between 0-100%. This allows both the actuator and valve to be tested for binding, play, resolution, linearity, and repeatability.

**04 DRIVER OFFSET** dflt=0.0 (-100.0,100.0)  
Adjust the valve's output current for a minimum stop.

**05 DRIVER GAIN** dflt=1.0 (0.0,10.0)  
Adjust the valve's output current for a maximum stop.

**06 ACTUATOR DITHER (MA)** dflt=0.0 (0.0, 10.0)  
Enter the dither, in milliamps. Enter 0.0 if no dither is required. Woodward TM-type actuators typically require dither.

**07 ACTUATOR OUT (MA)** displays the actuator output, in milliamps.

**P\*\* ANALOG I/O SETTINGS \*\***

Control	Category	Block	Field	Value	Description
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	01 DISPLAY AI #1 FUNCTION	Input #1 Not Used	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	02 INPUT#1 MIN VALUE (UNIT)	0.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	03 INPUT#1 MAX VALUE (UNIT)	100.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	04 ANALOG IN #1 UNITS	0.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	05 DISPLAY AI #2 FUNCTION	Input #2 Not Used	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	06 INPUT#2 MIN VALUE (UNIT)	0.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	07 INPUT#2 MAX VALUE (UNIT)	100.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	08 ANALOG IN #2 UNITS	0.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	09 ANALOG OUTPUT SEL (1-7)	1	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	10 ANALOG OUTPUT SELECTED	Not Used	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	11 ANOUT MIN VALUE (UNITS)	0.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	12 ANOUT MAX VALUE (UNITS)	100.0000	
Net16(DfIt Contr		SERVICE: P**ANALOG I/O SETTINGS**	13 ANALOG OUT (MA)	4.0000	

Figure 3-31. Service: P\*\* ANALOG I/O SETTINGS \*\* Menu

This section calibrates the analog inputs and selects the parameter to be sent to the analog output driver and the desired scaling of the output.

**01 DISPLAY AI #1 FUNCTION** displays the programmed function of analog input #1.

**02 INPUT #1 MIN VALUE (UNIT)** dflt=0.0 (-32000.0, 32000.0)  
Set the value (in engineering units) that corresponds to the minimum range on Analog Input #1.

**03 INPUT #1 MAX VALUE (UNIT)** dflt=100.0 (-32000.0, 32000.0)  
Set the value (in engineering units) that corresponds to the maximum range on Analog Input #1.

**NOTICE**

**When setting the Min and Max Values for Analog Input #1 or #2, the following equation must be followed:**  

$$[(\text{Max Value}) - (\text{Min Value}) * 16] < 32000$$

**04 ANALOG IN #1 UNITS** displays the conversion of the analog input to engineering units.

**05 DISPLAY AI #2 FUNCTION** displays the programmed function of analog input #2.

**06 INPUT #2 MIN VALUE (UNIT)** dflt=0.0 (-32000.0, 32000.0)  
Set the value (in engineering units) that corresponds to the minimum range on Analog Input #2.

**07 INPUT #1 MAX VALUE (UNIT)**

dflt=100.0 (-32000.0, 32000.0)

Set the value (in engineering units) that corresponds to the maximum range on Analog Input #2.

**NOTICE**

When setting the Min and Max Values for Analog Input #1 or #2, the following equation must be followed:

$$[(\text{Max Value}) - (\text{Min Value}) * 16] < 32000$$

**08 ANALOG IN #2 UNITS** displays the conversion of the analog input to engineering units.

**09 ANALOG OUTPUT SEL (1-7)**

dflt=1 (1, 7)

Select one of the following parameters for 4–20 mA output at terminals 16,17 and 18.

1=NOT USED

2=TURBINE SPEED

3=TURBINE SPEED REFERENCE

4=VALVE LIMITER SETPOINT

5=ACTUATOR DEMAND

6=GENERATOR OUTPUT

7=MONITOR SIGNAL

**10 ANALOG OUTPUT SELECTED** displays the item name of analog output.

**11 ANOUT MINIMUM VALUE (UNIT)**

dflt=0.0 (-32000.0, 32000.0)

Adjust for the value of the displayed parameter in engineering units when the analog output is at 4 mA.

**12 ANOUT MAXIMUM VALUE (UNIT)**

dflt=100.0 (-32000.0, 32000.0)

Adjust for the value of the displayed parameter in engineering units when the analog output is 20 mA.

**13 ANALOG OUT (MA)** displays the analog output, in milliamps.

**Q\*\* DISCRETE OUT SETTINGS \*\***

Control	Category	Block	Field	Value	D.
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	01 RELAY 1 SELECTED AS	Shutdown	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	02 RELAY 1 LEVEL SW (1-7)	1	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	03 RELAY#1 LEVEL SELECT FOR	NOT USED	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	04 RELAY 1 ON LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	05 RELAY 1 OFF LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	06 RELAY 2 SELECTED AS	Alarm	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	07 RELAY 2 LEVEL SW (1-7)	1	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	08 RELAY#2 LEVEL SELECT FOR	NOT USED	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	09 RELAY 2 ON LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	10 RELAY 2 OFF LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	11 RELAY 3 SELECTED AS	Elec. Overspeed Trip Test	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	12 RELAY 3 LEVEL SW (1-10)	1	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	13 RELAY#3 LEVEL SELECT FOR	NOT USED	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	14 RELAY 3 ON LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	15 RELAY 3 OFF LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	16 RELAY 4 SELECTED AS	Speed PID in Control	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	17 RELAY 4 LEVEL SW (1-10)	1	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	18 RELAY#4 LEVEL SELECT FOR	NOT USED	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	19 RELAY 4 ON LEVEL =	0.00	
Net1(Dflt Contrc)		SERVICE: Q** DISCRETE OUT SETTINGS**	20 RELAY 4 OFF LEVEL =	0.00	

Figure 3-32. Service: Q\*\* DISCRETE OUT SETTINGS \*\* Menu

The 2301D-ST has four discrete output driver channels. Terminals 41, 42, 43 and 44 are configurable and can be programmed to perform one of the following functions.

And any of the four relay drivers can also be programmed to function as a level switch. When programmed as a level switch the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level).

**01 RELAY 1 SELECTED AS** displays the function selected for terminal 41. This relay is selected in the configure menu - C\*\*DISCRETE OUT OPTIONS\*\*

**02 RELAY 1 LEVEL SW (1-7)** dflt=1 (1, 7)

Select one of the following parameters for discrete output at terminals 41 when it was selected as a level switch.

- 1=NOT USED
- 2=TURBINE SPEED
- 3=TURBINE SPEED REFERENCE
- 4=VALVE LIMITER SETPOINT
- 5=ACTUATOR DEMAND
- 6=GENERATOR OUTPUT
- 7=MONITOR SIGNAL

**03 RELAY 1 LEVEL SELECT FOR** displays the level function selected for terminal 41.

**04 RELAY 1 ON LEVEL** dflt=0.0 (-32000.0, 32000.0)  
Enter the level switch ON setting in engineering units. There is an ON and an OFF setting for each level switch option. This allows the user to program the desired hysteresis for the function selected.

**05 RELAY 1 OFF LEVEL** dflt=0.0 (-32000.0, 32000.0)  
Enter the level switch OFF setting in engineering units.  
(Must be less than the 'Relay On Level')

**06 RELAY 2 SELECTED AS** displays the function selected for terminal 42. This relay is selected in the configure menu - C\*\*DISCRETE OUT OPTIONS\*\*

**07 RELAY 2 LEVEL SW (1-7)** dflt=1 (1, 7)  
Select one of the following parameters for discrete output at terminals 42 when it was selected as a level switch.  
1=NOT USED  
2=TURBINE SPEED  
3=TURBINE SPEED REFERENCE  
4=VALVE LIMITER SETPOINT  
5=ACTUATOR DEMAND  
6=GENERATOR OUTPUT  
7=MONITOR SIGNAL

**08 RELAY 2 LEVEL SELECT FOR** displays the level function selected for terminal 42.

**09 RELAY 2 ON LEVEL** dflt=0.0 (-32000.0, 32000.0)  
Enter the level switch ON setting in engineering units. There is an ON and an OFF setting for each level switch option. This allows the user to program the desired hysteresis for the function selected.

**10 RELAY 2 OFF LEVEL** dflt=0.0 (-32000.0, 32000.0)  
Enter the level switch OFF setting in engineering units.  
(Must be less than the 'Relay On Level').

**11 RELAY 3 SELECTED AS** displays the function selected for terminal 43. This relay is selected in the configure menu - C\*\*DISCRETE OUT OPTIONS\*\*

**12 RELAY 3 LEVEL SW (1-7)** dflt=1 (1, 7)  
Select one of the following parameters for discrete output at terminals 43 when it was selected as a level switch.  
1=NOT USED  
2=TURBINE SPEED  
3=TURBINE SPEED REFERENCE  
4=VALVE LIMITER SETPOINT  
5=ACTUATOR DEMAND  
6=GENERATOR OUTPUT  
7=MONITOR SIGNAL

**13 RELAY 3 LEVEL SELECT FOR** displays the level function selected for terminal 43.

**14 RELAY 3 ON LEVEL** dflt=0.0 (-32000.0, 32000.0)  
Enter the level switch ON setting in engineering units. There is an ON and an OFF setting for each level switch option. This allows the user to program the desired hysteresis for the function selected.

**15 RELAY 3 OFF LEVEL**

dflt=0.0 (-32000.0, 32000.0)

Enter the level switch OFF setting in engineering units.  
(Must be less than the 'Relay On Level')

**16 RELAY 4 SELECTED AS** displays the function selected for terminal 44. This relay is selected in the configure menu - C\*\*DISCRETE OUT OPTIONS\*\*

**17 RELAY 4 LEVEL SW (1-7)**

dflt=1 (1, 7)

Select one of the following parameters for discrete output at terminals 44 when it was selected as a level switch.

1=NOT USED

2=TURBINE SPEED

3=TURBINE SPEED REFERENCE

4=VALVE LIMITER SETPOINT

5=ACTUATOR DEMAND

6=GENERATOR OUTPUT

7=MONITOR SIGNAL

**18 RELAY 4 LEVEL SELECT FOR** displays the level function selected for terminal 44.

**19 RELAY 4 ON LEVEL**

dflt=0.0 (-32000.0, 32000.0)

Enter the level switch ON setting in engineering units. There is an ON and an OFF setting for each level switch option. This allows the user to program the desired hysteresis for the function selected.

**20 RELAY 4 OFF LEVEL**

dflt=0.0 (-32000.0, 32000.0)

Enter the level switch OFF setting in engineering units.  
(Must be less than the 'Relay On Level').



**WARNING** The Discrete outputs can be changed for other functions when the turbine is running. Therefore, do not change the Configured Shutdown Relay when the turbine is running.

**R\*\* DISPLAY D\_I/O STATUS \*\***

Control	Category	Block	Field	Value	Des...
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	01 DI EXTERNAL SHUTDOWN	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	02 DI RESET	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	03 DI START/UNLOAD	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	04 DI RAISE SPEED	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	05 DI LOWER SPEED	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	06 DISCRETE INPUT F	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	07 DISCRETE INPUT G	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	08 DISCRETE INPUT H	Open	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	09 DISCRETE OUTPUT #1	De-energized	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	10 DISCRETE OUTPUT #2	Energized	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	11 DISCRETE OUTPUT #3	De-energized	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	12 DISCRETE OUTPUT #4	Energized	
st.NET(Dflt Con...		SERVICE: R** DISPLAY D_I/O STATUS**	13 INTERNAL L/S RELAY K1	De-energized	

Figure 3-33. Service: R\*\* DISPLAY D\_I/O STATUS \*\* Menu

This section has no adjustments to set, it is used only for display status of discrete inputs and the status of the discrete outputs.

**01 DI EXTERNAL SHUTDOWN** indicates status of discrete input A.

**02 DI RESET** indicates status of discrete input B.

**03 DI START / UNLOAD** indicates status of discrete input C.

**04 DI RAISE SPEED** indicates status of discrete input D.

**05 DI LOWER SPEED** indicates status of discrete input E.

**06 DISCRETE INPUT F** indicates status of discrete input F.

**07 DISCRETE INPUT G** indicates status of discrete input G.

**08 DISCRETE INPUT H** indicates status of discrete input H.

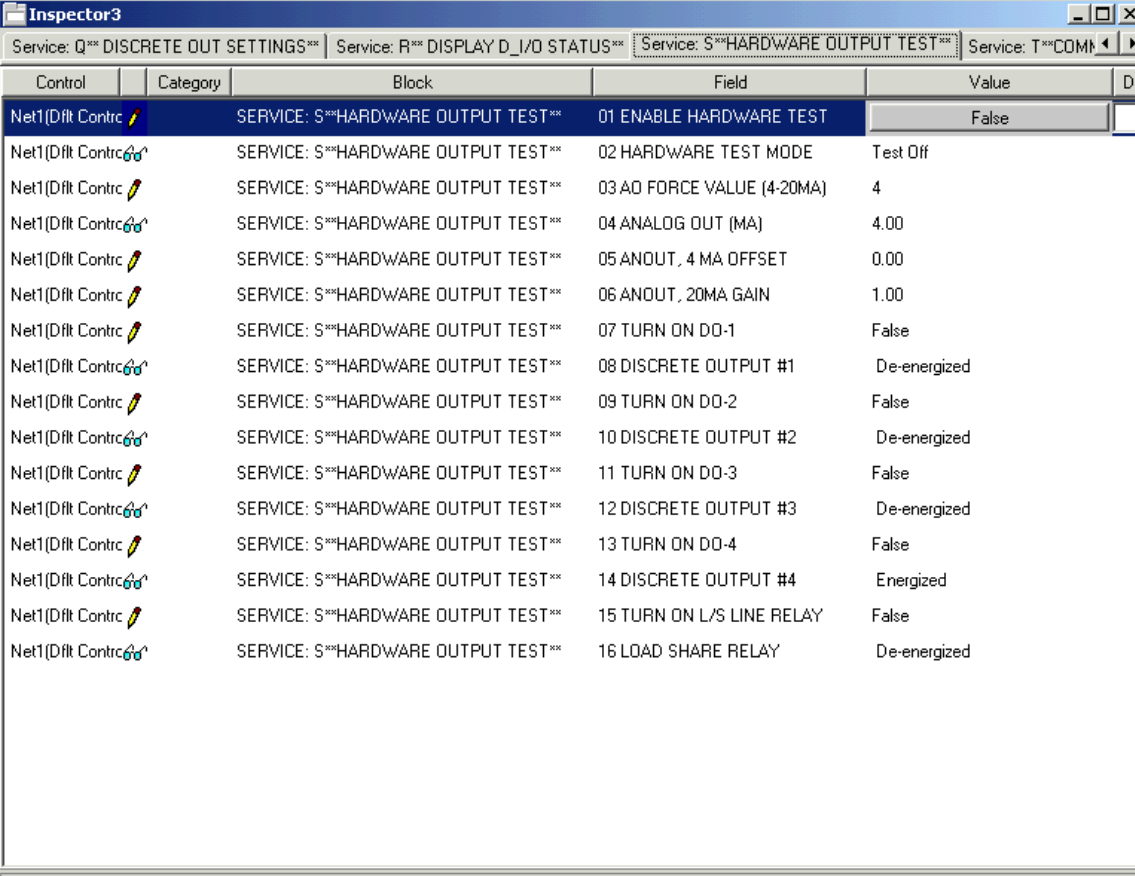
**09 DISCRETE OUTPUT #1** indicates status of discrete output #1.

**10 DISCRETE OUTPUT #2** indicates status of discrete output #2.

**11 DISCRETE OUTPUT #3** indicates status of discrete output #3.

**12 DISCRETE OUTPUT #4** indicates status of discrete output #4.

**13 INTERNAL L/S RELAY K1** indicates status of discrete output driving the internal load-sharing relay.

**S\*\* HARDWARE OUTPUT TEST \*\***


Control	Category	Block	Field	Value	D.
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	01 ENABLE HARDWARE TEST	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	02 HARDWARE TEST MODE	Test Off	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	03 AO FORCE VALUE (4-20MA)	4	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	04 ANALOG OUT (MA)	4.00	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	05 ANOUT, 4 MA OFFSET	0.00	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	06 ANOUT, 20MA GAIN	1.00	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	07 TURN ON DO-1	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	08 DISCRETE OUTPUT #1	De-energized	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	09 TURN ON DO-2	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	10 DISCRETE OUTPUT #2	De-energized	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	11 TURN ON DO-3	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	12 DISCRETE OUTPUT #3	De-energized	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	13 TURN ON DO-4	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	14 DISCRETE OUTPUT #4	Energized	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	15 TURN ON L/S LINE RELAY	False	
Net1(Dflt Contrc		SERVICE: S**HARDWARE OUTPUT TEST**	16 LOAD SHARE RELAY	De-energized	

Min = 0 : Max = 1

Figure 3-34. Service: S\*\* HARDWARE OUTPUT TEST \*\* Menu

This section allows the operator to test the analog output and the relay driver outputs by artificially forcing the signals. This test can only be performed in the shutdown state.

**01 ENABLE HARDWARE TEST** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to test the hardware output. When test is finished, it should set to FALSE.

**02 HARDWARE TEST MODE** displays the status of the HARDWARE TEST mode.

**03 AO FORCE VALUE (4–20 MA)** dflt=4 (4, 20)  
Set this value to the desired value, to test the analog output on terminals 16, 17.

**04 ANALOG OUT (mA)** displays the actual current output in milliamps.

**05 ANOUT, 4 MA OFFSET** dflt=0.0 (-100.0,100.0)  
Adjusts the analog output current to a specified offset.

**06 ANOUT, 20 MA GAIN** dflt=1.0 (0.0,10.0)  
Adjusts the analog output current to a specified gain or level.

**07 TURN ON DO-1** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to turn ON the relay driver output #1. If test is finished, it should set to FALSE.

**08 DISCRETE OUTPUT #1** displays the state of discrete output #1.

**09 TURN ON DO-2** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to turn ON the relay driver output #2. If test is finished, it should set to FALSE.

**10 DISCRETE OUTPUT #2** displays the state of discrete output #2.

**11 TURN ON DO-3** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to turn ON the relay driver output #3. If test is finished, it should set to FALSE.

**12 DISCRETE OUTPUT #3** displays the state of discrete output #3.

**13 TURN ON DO-4** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to turn ON the relay driver output #4. If test is finished, it should set to FALSE.

**14 DISCRETE OUTPUT #4** displays the state of discrete output #4.

**15 TURN ON LS LINE RELAY** dflt=FALSE (FALSE, TRUE)  
Set to TRUE to turn ON the internal load-sharing relay, observe the green LED between terminal 9 and 10. If test is finished, it should set to FALSE.

**16 LOAD SHARE RELAY** displays the state of the load sharing relay.

#### T\*\* COMM PORT (MODBUS) \*\*

Control	Category	Block	Field	Value	Description
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	01 PORT FAIL	False	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	02 LINK ERROR	True	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	03 ERROR PERCENT	0.00	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	04 ERROR NUMBER	0	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	05 BAUD RATE	10	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	06 BAUD RATE IS SET FOR	38400	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	07 DATA BITS	2	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	08 DATA BITS ARE SET FOR	8	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	09 STOP BITS	1	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	10 STOP BITS ARE SET FOR	1	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	11 PARITY	1	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	12 PARITY IS SET FOR	OFF	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	13 DRIVER	1	
5418-047c.NI60		SERVICE: T**COMM PORT (MODBUS)**	14 DRIVER IS SET FOR	RS 232	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	15 TIME OUT (SEC)	4.00	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	16 NETWORK ADDRESS	1	
5418-047c.NI		SERVICE: T**COMM PORT (MODBUS)**	17 ENABLE MODBUS CONTROL	False	

Figure 3-35. Service: T\*\* COMM PORT (MODBUS) \*\* Menu

The menu is used to setup the serial port for Modbus use.

**01 PORT FAIL** indicates a hardware fault of RS-232/RS-422 communication port.

**02 LINK ERROR** indicates Link Error sets TRUE when the slave fails to answer a data request in specified number of time-out seconds.

### 03 ERROR PERCENT

Error Percent outputs reflects communication quality as a percentage by dividing the number of exception errors detected by the total number of communication transactions. This essentially gives the number of message/packet errors detected.

### 04 ERROR NUMBER

Error Number outputs the code number of the communication/exception error that occurred.

CODE	NAME	MEANING
00	NO ERROR	Error free
The following are returned to the master.		
01	ILLEGAL FUNCTION	Message function received is not an allowable action for addressed slave. (Unsupported or illegal function code).
02	ILLEGAL DATA ADDRESS	Address referenced in data field is not an allowable address for the addressed slave location. (Master requested data, which is not configured from slave).
03	ILLEGAL DATA VALUE	Amount of data requested from slave was too large for slave to return in a single response. Woodward maximum is 118 registers.
The following are displayed only.		
09	CHECKSUM ERROR	Error in the checksum. Can indicate link quality and/or noise problems.
10	GARBLED MESSAGE	Data received by the slave, but it is too short to be a valid Modbus message/command.

Table 3-1. Communication Error Code

### 05 BAUD RATE

dflt=10 (1, 10)

Set the Baud rate, which defines the transfer rate for port communications.

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

### 06 BAUD RATE IS SET FOR

Shows the selected Baud rate.

### 07 DATA BITS

dflt=1 (1, 2)

Set the Data bits input defines the protocol for the number of data bits in the data packets.

1=7
2=8

### 08 DATA BITS ARE SET FOR

Shows the selected data bits.

### 09 STOP BITS

dflt=1 (1, 3)

Set the Stop bits, which defines the number of stop bits for the communications protocol. Stop bits specify the time that elapses between transmitted characters.

1=1 stop bit
2=2 stop bits
3=1.5 stop bits

**10 STOP BITS ARE SET FOR**

Shows the selected stop bits setting.

**11 PARITY**

dflt=1 (1, 3)

Set the Parity input defines protocol for the parity. If you selected 8 data bits select '1' for none.

1=OFF (none)

2=ODD

3=EVEN

**12 PARITY IS SET FOR**

Shows the parity setting.

**13 DRIVER**

dflt=1 (1, 2)

Set the Driver input defines the type of driver output for this port.

1=RS232

2=RS422

**14 DRIVER IS SET FOR**

Shows the selected driver.

**15 TIME OUT (SEC)**

dflt=4.0 (0.0, 100.0)

Set the Time-out Number of Seconds input defines the Modbus link dead time allowed before a link error occurs.

**16 NETWORK ADDRESS**

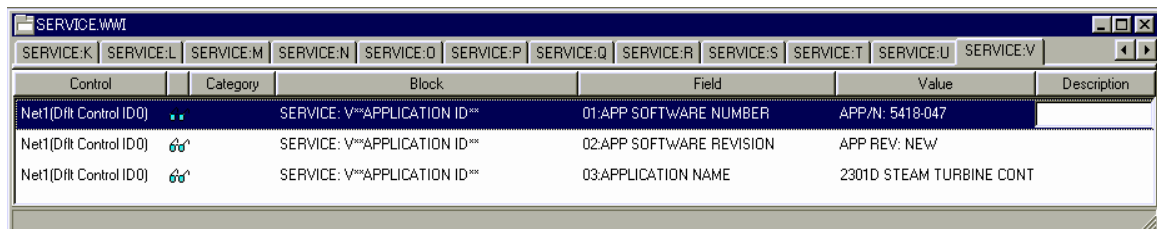
dflt=1 (1, 247)

Set the Network Address input defines the slave block address on the Modbus network. The network address may depend on master device allowable addresses.

**17 ENABLE MODBUS CONTROL**

dflt=FALSE (FALSE, TRUE)

When set TRUE you are able to control using Modbus.

**U\*\* APPLICATION INFO \*\***


Control	Category	Block	Field	Value	Description
Net1(Dflt Control ID0)	..	SERVICE: V**APPLICATION ID**	01:APP SOFTWARE NUMBER	APP/N: 5418-047	
Net1(Dflt Control ID0)	64	SERVICE: V**APPLICATION ID**	02:APP SOFTWARE REVISION	APP REV: NEW	
Net1(Dflt Control ID0)	64	SERVICE: V**APPLICATION ID**	03:APPLICATION NAME	2301D STEAM TURBINE CONT	

Figure 3-36. Service: U\*\* APPLICATION INFO \*\* Menu

This section shows the application software information.

**01 APP Software Number** indicates the software part number.

**02 APP Software Revision** indicates the status of the application software revision.

**03 Application Name** indicates the application name.

## Chapter 4.

# Description of Operation

This chapter provides an overview of the features and operation of the 2301D-ST Load Sharing and Speed Control.

The 2301D-ST Load Sharing and Speed Control uses a 32 bit microprocessor for all control functions. All control adjustments are made with an external computer that communicates with the control via a serial port. The external computer can be disconnected from the control during normal operation, to provide security against tampering.

When power is applied, the 2301D-ST performs internal memory tests to 'boot-up' the processor. This takes approximately 30 seconds to complete. The CPU Status LED between terminals 27 and 28 remains on during this boot-up. The control will remain in I/O lock and will not provide control to the prime mover until the boot-up is complete. For systems requiring fast start functions, it is necessary to continuously power the 2301D-ST.



**DO NOT attempt to start the prime mover while the CPU Status LED is ON.**



**DO NOT apply power to the control at this time. Applying power before a control is completely connected may damage the control.**

The 2301D-ST's normal operating architecture is divided into two sections: The Service Mode and the Configuration Mode. The Configuration Mode is used to configure the 2301D-ST for the specific application and to set all operating parameters (see Chapter 5). The Service Mode is the normal turbine operation mode and is used to view operating parameters and run the turbine.

The 2301D-ST is controllable from the Discrete Inputs or Modbus commands. The following processes are explained by using the Discrete Inputs. These Discrete Inputs currently used here exist in the commands (Boolean Writes) of Modbus. They can be operated similarly through the Modbus communication.

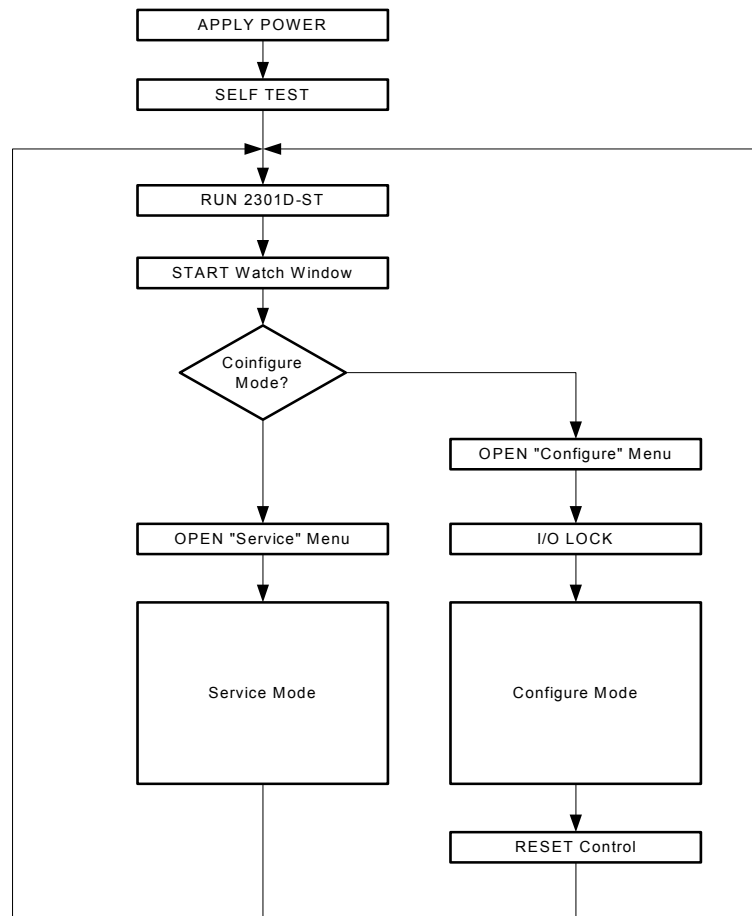


Figure 4-1. Basic Operational Architecture

### AUTOMATIC START-UP PROCEDURE

- |   |  |
|---|--|
| <p>1. Initial – all discrete inputs are off. Shutdown input is in the shutdown state.</p> | <p>Initial Settings:<br/>           Speed reference is set to 0%.<br/>           Valve limiter is 0%.<br/>           Actuator Output (Terminal 13-14) will be at 0 mA.<br/>           Shutdown Relay (Terminal 41) will be Shutdown condition.<br/>           The turbine should be stopped, the speed signal (Terminal 25-26) is minimum.<br/>           Analog Input 1 and 2, Load sharing line and PT's, CT's are normal range based on their configurations.</p> |
| <p>2. Shutdown / Run discrete input.</p>  | <p>Discrete Input- A (Terminal 31) should be set to the RUN (Closed) position to start and run the turbine, and Shutdown (Open) to shutdown the actuator output. Set the Modbus Controlled Shutdown from the Modbus controller to True to run the turbine, and to False to shutdown the, if used.</p>  |
| <p>3. Reset all alarms and shutdown latches.</p>  | <p>Discrete Input- B (Terminal 32) should be toggled to reset all alarms and shutdown latches. This will affect the initial speed setpoint only after all trip conditions are cleared. The actuator or valve does not open by the reset input.</p>   |

## 4. Start / Unload.

The Discrete Input Start / Unload should be toggled to start the turbine. If this input is being used as a Load / Unload contact, do not toggle this input to start the turbine. By closing this contact, will start the turbine and if this a generator application will also soft load the generator from an isolated bus.

The start mode of operations determines what the actuator will do when a start condition is given. The open of valve limiter may be aborted at any time by issuing valve limiter raise or lower commands, or an emergency shutdown.

## Automatic Start.

The Valve Ramp Limiter will ramp up to its maximum limit after the Start Command is issued. The speed reference increases to the rated speed by the programmed sequence. Once the turbine speed reaches the speed reference, the valve ramp limiter goes out of the way (100%), and the speed is controlled by the PID. The speed will continue to ramp to rated speed.

Figure 4-2 is an example of an automatic start sequence.

1. Close the Run / Shutdown discrete input, toggle the Reset discrete input, and close the Start / Unload contact.
2. The speed reference ramps up by the programmed rate.
3. As the turbine speed increases, the PID controller will take over control, and the valve ramp jumps to 100%, which is out of the way.
4. The speed PID controller then ramps the speed reference at a controlled rate to the rated speed setpoint. At any time, momentarily closing the Speed Raise or Speed Lower discrete input will stop the turbine from ramping. This allows the operator to heat soak the turbine at various speeds. To continue the ramp, manually close the Speed Raise Contact.
5. If for some reason the turbine shuts down, due to a 2301D-ST shutdown, and the Run and Start contact inputs are closed, a toggle on the Reset contact will initiate the start sequence.

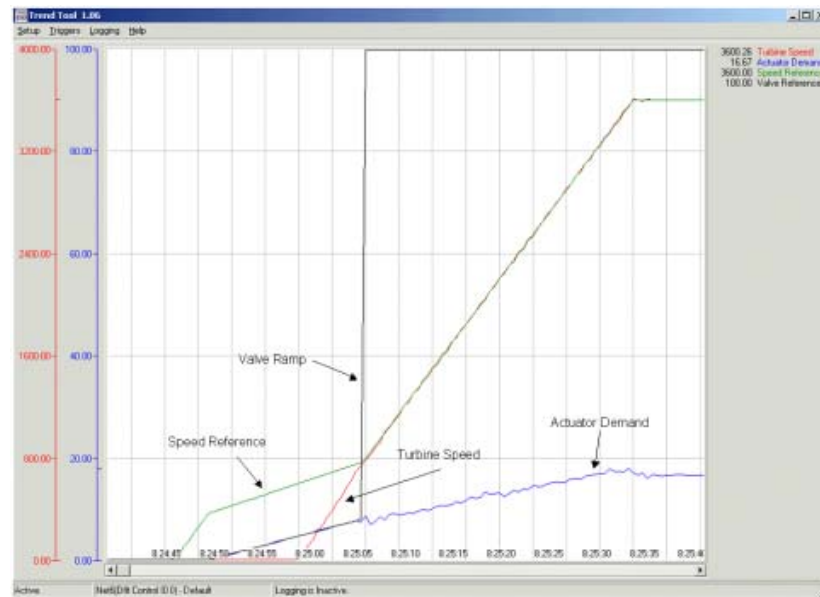


Figure 4-2. Automatic Start-up

## Semi-automatic Start.

The Speed Reference will increase up to the rated speed reference after the Start Command is issued. The valve reference and actuator demand are controlled by the raise / lower contact inputs.

Figure 4-3 is an example of a semiautomatic start sequence.

1. Close the Run / Shutdown discrete input, toggle the Reset discrete input, and close the Start / Unload contact.
2. The speed reference ramps up to by the programmed rate to the rated speed reference.
3. By closing the raise speed contact, the valve ramp reference will start increasing, thus increasing the turbine speed. The operator has control over where the valve ramp reference is set at by using the raise speed and lower speed discrete inputs. This allows the operator to heat soak the turbine at different speed levels.
4. Continuing to raise the valve ramp reference will cause the speed to increase until the speed matches the speed reference. The PID controller will then take over control. The valve ramp reference will quickly ramp out of the way (100%).
5. The operator can allow control the speed of the turbine with the raise and lower speed discrete inputs.

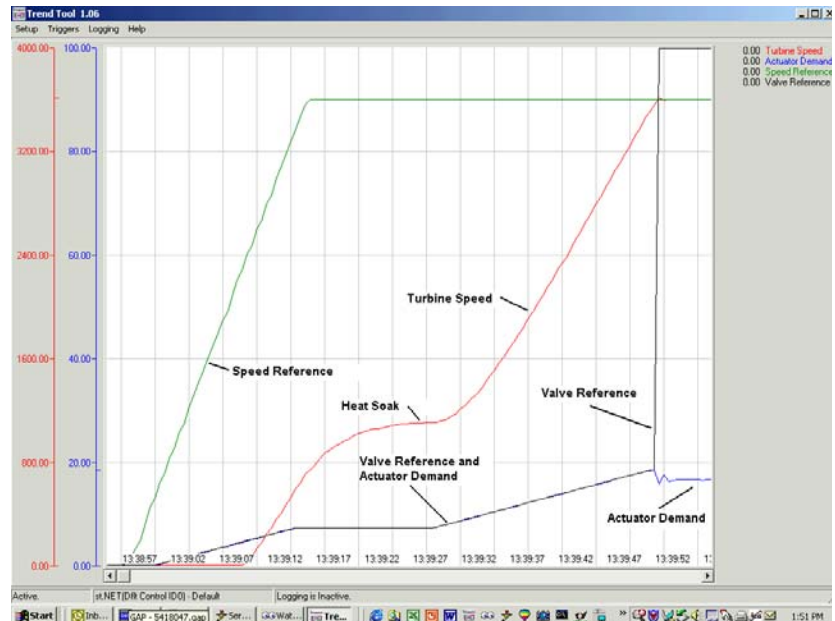


Figure 4-3 Semi-automatic Start-up

## Manual Start

The Speed Reference will increase up to the rated speed reference after the Start Command is issued. The speed of the turbine is controlled by the trip and throttle valve or control valve until turbine speed reaches speed reference.

Figure 4-4 is an example of a manual start sequence.

1. Close the Run / Shutdown discrete input, toggle the Reset discrete input, and close the Start / Unload contact.
2. The speed reference, the valve ramp reference, and the actuator demand ramp up by the programmed rate to the rated speed reference.
3. By opening the trip and throttle valve or control valve the turbine speed will increase. The operator has control over where the speed of the turbine is at by using the trip and throttle valve. This gives the operator a chance to heat soak the turbine at different speed levels.
4. Continuing to open the trip and throttle valve will cause the speed to increase until the speed matches the speed reference. The PID controller will then take over control.
5. The operator can then control the speed of the turbine with the raise and lower speed discrete inputs.

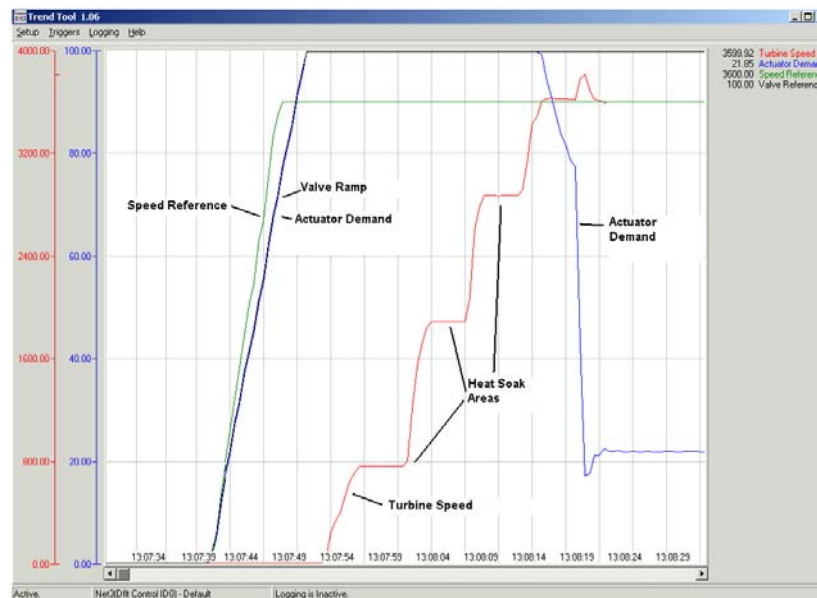


Figure 4-4 Manual Start-up

5. **Rolling Turbine Restart** In Automatic Start mode, the turbine may be re-started, even though the turbine is still rolling. If a re-start is needed, the only requirement is that the Run contact is closed, the Reset contact is toggled off to on and the Start contact is toggled off to on. When the Start contact is set to the Start position, the speed reference will immediately jump to the actual speed of the turbine. The governor valve will start opening. The speed of the turbine will start increasing back to Rated Speed. The speed reference will not jump higher than the Rated Speed value. If the Start contact is not toggled, and the Reset contact is the only input that is toggled, the turbine will go through a normal start sequence with the speed reference slowly ramping up, and the governor valve opening on the valve limiter.

6. Raise - Lower Speed / Load      The speed PID's reference may be adjusted from the external contacts or Modbus commands.
- The speed reference moves in the range of minimum governor speed to maximum governor speed.
- If the application is power generation and the generator is in Droop against a utility bus, Raise / Lower contacts will raise and lower the load setting.
- If Process Control is selected, the Raise / Lower contacts will raise and lower the process setpoint.
7. Remote Speed Control      Closing both the Raise and Lower speed discrete inputs will put the control into Remote Speed control. The speed setpoint can be positioned remotely through an analog signal by the configured Remote Speed Input or through a Modbus directly entered value. This allows the Speed setpoint to be set remotely by a process control or distributed plant control system.
- Remote Speed example:
1. Not in overspeed test mode, Raise Speed discrete input is closed, Lower Speed discrete input is closed, Run discrete input is closed.
  2. If remote is selected, and the turbine is started, the speed reference will ramp at the Remote Setpoint Fast Rate.
  3. If remote is not selected, the speed reference will ramp at the Idle to Rated Rate.
  4. If the turbine is running, and Remote Control is selected, the speed reference will ramp to the Remote Speed Setpoint. Found in F\*\*Remote Speed Control.
  5. As the analog input, remote speed input is changed, the speed reference will ramp up or down at the Remote Setpoint Slow Rate unless the difference between the setpoint and the actual speed is greater than the Remote 2nd Deadband. At this point the ramp will change to the Remote Setpoint Fast Rate until the deadband is met.
  6. If the analog input USE INPUT #X FAIL TRIP is set TRUE and if the input goes less than 2 mA or greater than 22 mA, the control will shut down.
8. Over Speed Test Function      The 2301D-ST's Over Speed test Function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical over speed protection logic and circuitry. The Over Speed Test will allow the control's speed setpoint to be increased above the normal maximum limit. This test can be performed from the Service Mode of Watch Window software, through external commands or via the Modbus commands.
- Overspeed Test
1. Close the Overspeed Test Enable discrete input (if configured) or the Overspeed Test Enable in the service menu I\*\*Overspeed Test\*\*.
  2. The Overspeed Test Status menu item in service menu I\*\*Overspeed Test\*\* should switch from Overspeed Trip Test In-active to Overspeed Trip Test Active.
  3. The Speed Raise contact can now be closed, to allow the speed setpoint to be set above rated speed range.
  4. When the turbine speed reaches the Electrical Overspeed Trip Setpoint, the Electrical Overspeed Trip Test discrete output will activate (if Configured). This indicates that the Electrical Overspeed Trip Setpoint was reached. No Shutdowns will occur.
  5. Continuing to close the Speed Raise contact will increase the turbine speed up to the MAX OVRSPD TEST LIMIT. At this point, the mechanical overspeed trip should have occurred. If not the MAX OVRSPD TEST LIMIT will have to be raised.



**WARNING** To prevent possible serious injury from an overspeeding turbine, make sure the turbine is equipped with another shutdown device(s) that operate totally independently of the control to protect against runaway or damage to the turbine.

9. SPM-A Synchronizer To use a synchronizer to synchronize a generator, one analog input #1 or #2 must be configured as Synchronizer Bias Signal Input.  
  
The synchronizer input is used to match the prime movers speed and generator phase with bus that it is being paralleled to. Analog input #1 at terminals 19,20,and 21 (or Analog input #2 at terminals 22,23,and 24) can be used as the synchronizer input. The sensitivity of the synchronizer can be adjusted.
10. KW Droop / Actuator Position Droop Operation KW Droop or Actuator Position Droop mode.  
  
The 2301D-ST should be connected to the generator through the internal load sensor using the PT's and CT's. When using the optional 52G BREAKER discrete input is open, Droop will be the control mode. In the Droop mode, the load sensor provides feedback to the speed control to decrease the speed reference based on load. Raise or Lower discrete inputs can be used to control the amount of load on the generator, when tied to the utility bus. The controls power sensor output can be monitored via serial communication or through the control's analog readout. If required, any of the control's four relay outputs can be configured as power level switches to drive auxiliary devices or indicators.
11. Isochronous Load Control Operation ISOCHRONOUS mode  
  
The operator can control the speed reference with the Raise or Lower discrete inputs. In this mode, the 2301D-ST will operate in isochronous operation or in isochronous load sharing operation.  
  
The 2301D-ST includes an analog load sharing network input, which is compatible with Woodward's 2301A line of controls. The control's soft load / unload transfer function can also be configured to rate limit unit loading and unloading.
12. Critical Speed 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, one critical speed avoidance band may be selected. This band may be any speed range that is less than the minimum governor speed setting. Within a critical speed range, the 2301D-ST 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 will bring the unit back to the lower limit of the band. Refer to Figure for an example of the critical speed avoidance.

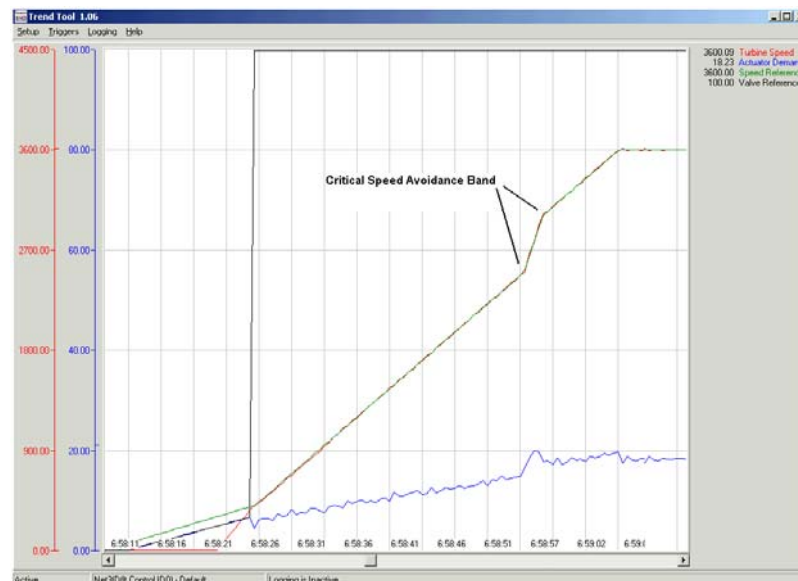


Figure 4-5. Critical Speed Avoidance Band

## 13. Process Control

## Process Control

The process control can be configured to control any system process, related to or affected by turbine speed or load. Typically this controller is used as a turbine inlet or exhaust pressure controller. The process control is a PID controller that compares a 4–20 mA process signal with the process setpoint. The PID controller sets the speed controller setpoint until the process signal and the setpoint match. The process setpoint is adjustable with raise or lower contact inputs, or the communication links. Also, the setpoint can be directly set by entering the new setpoint through Modbus communications. In addition, a remote process setpoint analog input can be programmed to remotely position the cascade setpoint.

## Process Control Example:

1. Let's take for example that we want to control the turbine exhaust pressure with a transducer range of 0–100 psi (0–690 kPa).
2. The generator is tied to the utility bus in droop, so as the process changes, the load will change.
3. Here are the variables that need to be set:
  - a) Under the Service menu P\*\*ANALOG I/O SETTINGS\*\*:
    - 02 INPUT #1 MIN VALUE (UNITS) = 0 psi (0 kPa)
    - 03 INPUT #1 MAX VALUE (UNITS) = 100 psi (690 kPa)
  - b) Under the Service menu H\*\*PROCESS CONTROL\*\*:
    - 05 MIN PROC SETPNT (UNITS) = 0 psi (0 kPa)
    - 06 MAX PROC SETPNT (UNITS) = 100 psi (690 kPa)
    - 08 SETPT INIT VALUE (UNITS) = 60 psi (414 kPa)
    - 09 SPEED SETPT LOW LIMIT = 3610 rpm
    - 10 SPEED SETPT HIGH LIMIT = 3780 rpm
  - c) Under the Service menu F\*\*REMOTE SPEED CONTROL \*\*:
    - 02 RMT/PROC CNTRL SLOW RATE (RPM/S) = 5
  - d) Under the Configure menu D\*\*ANALOG INPUT OPTIONS\*\*:
    - 02 SEL AI#1 FUNCTION (1-7) = 7 (Process Signal)
    - 03 SEL AI#1 TYPE (1-4) = 1 (4–20 mA)
    - 08 USE INPUT #1 FAIL TRIP = Optional
  - e) Under the Configure menu C\*\*DISCRETE INPUT OPTIONS\*\*:
    - 02 SEL DI F FUNCTION (1-6) = 6 (Process Enable)
4. This is just a partial list of the variables needed to run the turbine, the variable listed here pertain just to the Process Control.
5. With the turbine running at synchronous speed and the breaker closed to the utility bus in droop mode, enable the process control. The load will change to control the exhaust pressure at 60 psi (414 kPa).
6. Adjust the ramp rates, deadband, and PID Dynamic adjustments for the proper operation and stability of the turbine and process.

## 14. Power System Management Concepts

This section provides a summary review of droop, isochronous, droop/isochronous, and isochronous load sharing operating concepts. These concepts provide an understanding for power management.

## Paralleling

There are two basic methods used for paralleling: droop, where speed decreases with load increase and isochronous, where speed remains constant with load increase. The paralleling system shown in Figure 4-6 consists of a load matching circuit and kW sensor circuitry.

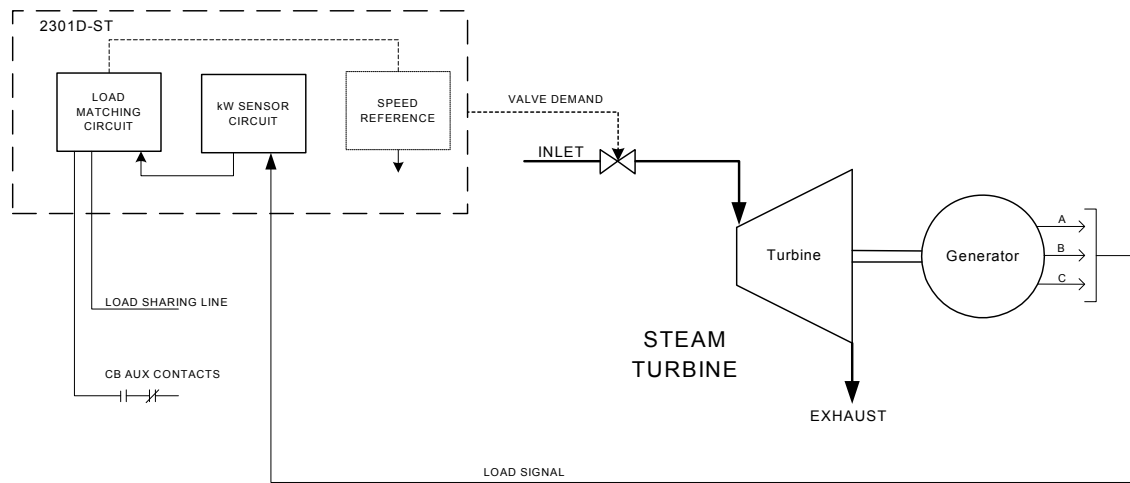


Figure 4-6. Paralleling System

An auxiliary contact on the generator breaker connected to the discrete input is used to select speed and load control operation. When the input to the 52G BREAKER contact is open, the control is in droop speed control. When the 52G BREAKER contact is closed, the control is in isochronous load control or droop control.

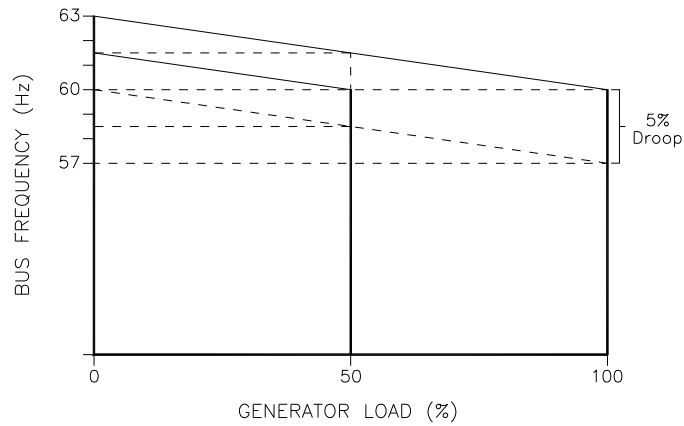
The Load sensor computes the load carried by each phase of the generator. The current load on each phase is multiplied by the cosine of the phase difference between the current and the voltage and the three phases are added to determine the total load.

The output of the load amplifier is adjusted by the load gain set point. By setting the load gain voltage on each unit to the same level at full load, proportional load sharing is achieved. Regardless of differences in generator set capacities in the system, each generator set is loaded to the same percentage of its capacity. A final adjustment of the individual load gain adjustment will compensate for minor differences in the generator sets.

Droop mode allows operation of a generator on an infinite bus or in parallel with other turbine generator units using hydro mechanical governors. In droop, speed changes as the load on the generator changes. An increase in load results in a decrease in speed. The amount of speed change or droop is expressed in percent (of rated speed) and is set by the load droop set point.

#### Droop Mode

Droop is a decrease in speed or frequency, proportional to load. That is, as the load increases, the speed or frequency decreases, as illustrated in Figure 4-7. This reduction in speed is accomplished with negative feedback. The feedback increases as the system is loaded.



With Droop, the Speed Decreases With Load

027-024  
96-02-01

Figure 4-7. Droop Mode

Droop is the speed reduction, expressed in percentage that occurs when the generator is fully loaded. With a given droop setting, a generator set will always produce the same power output at a particular speed or frequency. Droop is sometimes called the percent speed regulation. If all generator sets in a droop system have the same droop setting, they will each share load proportionally. The amount of load will depend on their speed settings. If the system load changes, the system frequency will also change. A change in speed setting will then be required to offset the change in feedback and return the system to its original speed or frequency. In order for each generator set in the system to maintain the same proportion of the shared load, each generator will require the same change in speed setting.

#### Isochronous Mode

A generator set operating in the isochronous mode will operate at the same set frequency regardless of the load it is supplying, up to the full load capability of the generator set (see Figure 4-8). This mode can be used on one generator set running by itself in an isolated system.

The isochronous mode can also be used on a generator set connected in parallel with other generator sets. If two generator sets operating in the isochronous mode without load sharing controls are tied together to the same load, one of the units will try to carry the entire load and the other will shed all of its load. In order to share load with other units, some additional means must be used to keep each generator set from either trying to take all the load or from motoring.

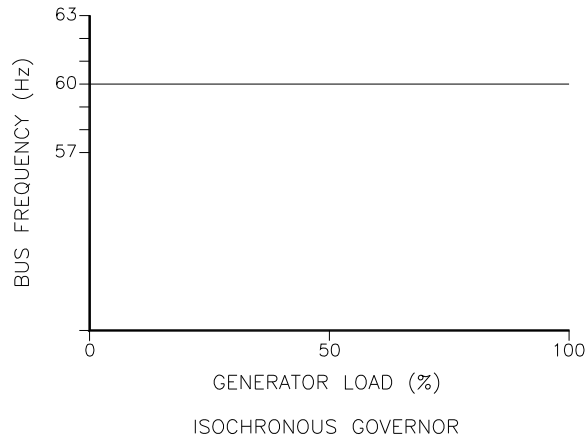
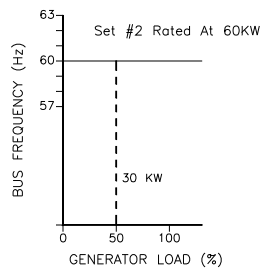
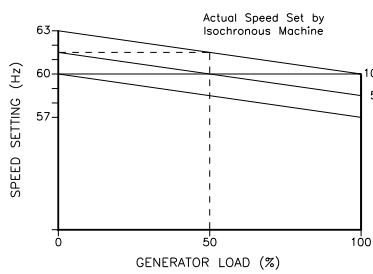
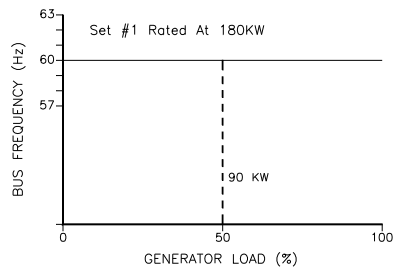
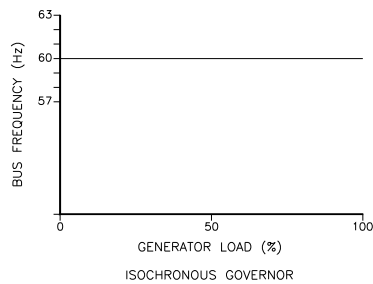
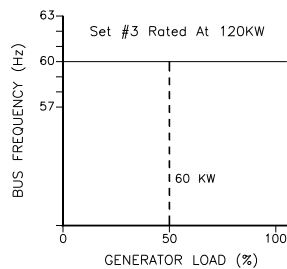


Figure 4-8. Isochronous Mode



DROOP GOVERNOR  
Isochronous Maintains Frequency and Load Swings  
Droop Units Maintain a Set Load

027-  
96-0



When Properly Set Up, Each Engine-Generator Set  
Supplies Its Proportional Share of the Load

027-027  
96-02-01

Figure 4-9. Droop/Isochronous Load Sharing

Figure 4-10. Isochronous Load Sharing

**Droop/Isochronous  
Load Sharing on an  
Isolated Bus**

Droop/isochronous load sharing combines the first two modes. All generator sets in the system, except one, are operated in the droop mode. The one unit not in droop is operated in the isochronous mode. It is known as the swing machine. In this mode, the droop machines will run at the frequency of the isochronous unit. The droop and speed settings of each droop unit are adjusted so that each generates a fixed amount of power (see Figure 4-9). The output power of the swing machine will change to follow changes in the load demand. Maximum load for this type of system is limited to the combined output of the swing machine and the total set power of the droop machines. The minimum system load cannot be allowed to decrease below the output set for the droop machines. If it does, the system frequency will change and the swing machine can be motored. The machine with the highest output capacity should be operated as the swing machine, so that the system will accept the largest load changes within its capacity.

**Isochronous Load  
Sharing on an Isolated  
Bus**

Isochronous load sharing operates all generator sets in a system in the isochronous mode. Load sharing is accomplished by adding a load sensor to each electric isochronous control system. The load sensors are interconnected by the load sharing lines. Any imbalance in load between units will cause a change to the regulating circuit in each control system. While each unit continues to run at isochronous speed, these changes force each machine to supply a proportional share of power to meet the total load demand on the system (see Figure 4-10).

## Chapter 5.

# Pre-Start and Start-up Procedures

### Introduction

This chapter provides an overview of the start-up procedures and operation of the 2301D-ST Load Sharing and Speed Control.



#### **WARNING**

Read this entire procedure before starting the prime mover.

### Start-up Adjustments

1. Complete the Installation Procedure in Chapter 2 and the Service and Configuration Procedures in Chapter 3.

#### **NOTICE**

Be sure the Start Mode is set correctly for your application.

Be sure the Rated Speed and Number of Teeth are set correctly for your application as described earlier in this chapter.

2. Apply input power to the control.
3. Check the speed-reading.

When using a signal generator to verify the proper configuration setting: set the signal generator for the frequency of the speed sensor at rated speed and connect it to terminals 25 and 26. (The rated speed frequency in Hz equals the rated turbine speed in rpm times the number of teeth on the speed sensing gear divided by 60.)

Open the Service Menu A\*\* DISPLAY ANALOG INFO \*\*: 02 TURBINE SPEED (RPM), the value should be a same number as RATED Speed (rpm). If the Monitor value is different, need to check the configuration parameters, Number of Gear teeth, etc.

4. Check the speed sensor.

Minimum voltage required from the speed sensor to operate the electronic control is 1.0 Vrms, measured at the lowest controlling speed. The Loss of Speed shutdown is not recognized until the turbine speed exceeds the override setpoint.



#### **WARNING**

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.

## Actuator Calibration

The actuator output from the control can be stroked (or calibrated) from the Service Menu O\*\* ACTUATOR CALIBRATION \*\*. Set TRUE the CALIBRATION ENABLE to calibrate the actuator or valve. Adjust 0% position related to the OFFSET, and 100% position related to the GAIN by moving the DUMMY SIGNAL.

When the valve position (%) is equal to 0%, the actuator should be below minimum. This is important. The actuator must have sufficient under-travel at the minimum stop to ensure that the actuator can fully close the steam valve completely. When the valve position (%) is 100%, the actuator should be at maximum to ensure full load can be attained. This process of going between minimum and maximum will have to be repeated several times before the initial start to ensure the actuator and linkages are properly set up.



**STEAM TO THE TURBINE MUST BE SHUT OFF BY OTHER MEANS DURING THIS PROCESS. Overspeeding the turbine will cause damage to the turbine and can cause personnel injury or death to personnel.**

## Check Discrete Inputs/Outputs

Open the Service Menu R\*\* DISPLAY D\_I/O STATUS \*\* window, operation of programmed input switches or relay outputs will be checked. Even if the control plans to use Modbus communication, while performing configuration or I/O test or calibration, don't turn ON the assigned Modbus switch.

## Check Analog Inputs

When using a signal generator to verify the proper configuration setting: set the signal generator for the value of analog input, and connect it to each terminal. Open the Service Menu A\*\* DISPLAY ANALOG INFO \*\*: 10, 11 if the readings are correct as the signals are applied.

## Dynamic Adjustment

The object of the PROPORTIONAL GAIN and INTEGRAL GAIN adjustment is to obtain the optimum, or desired, stable prime mover speed response. Connect a dc analog voltmeter to terminals 13(+) and 14(–) to monitor the actuator voltage.

Increasing the setting of the PROPORTIONAL GAIN to provide faster transient response (decreases the magnitude of the speed change from a sudden change in load). To achieve optimum response, slowly increase the PROPORTIONAL GAIN until the voltage on the voltmeter becomes slightly unstable, then slowly lower the PROPORTIONAL GAIN as necessary to stabilize the meter reading. Step load the generator, bump the actuator terminal shaft, to make sure that the prime mover returns to the proper speed with little overshoot or undershoot of the speed setting. To reduce overshoot, decrease the INTEGRAL GAIN. When the INTEGRAL GAIN is in the lower part of its adjustment (0 to 10 ), by decreasing the INTEGRAL GAIN, you may need to decrease the P\_GAIN to maintain stable operation. If the prime mover is slow in returning to the proper speed, increase the INTEGRAL GAIN.

## Speed Sensor Check

Measure the voltage across terminals 25 and 26 to be sure there is a minimum of 1.0 Vrms at low limit speed and a maximum of 25 Vrms at rated speed. If the voltage exceeds 25 Vrms, increase the gap of the speed sensor and be sure that there is still a minimum of 1.0 Vrms at low limit speed.

## Current Transformer (CT) Phasing Check

### IMPORTANT

This control contains internal current transformers. Due to their low impedance, shorting their inputs is not effective. The current input must be removed from the control and shorted externally.

### WARNING

**HIGH VOLTAGE**—Never disconnect any wire attached to load sensor terminals 4 through 9 when the prime mover is running unless temporary 0.5  $\Omega$ , 20 W resistors are installed as shown in Figure 5-1 and all load is removed. The current transformers can develop dangerously high voltages when open circuited while the prime mover is running.

1. Go to the B\*\* DISPLAY LOAD INFO \*\* service menu and observe 02 LD SENSOR INPUT (KW) and 05 LOAD SIGNAL OUT (VDC) to measure the load sensor output. The displayed values are not yet calibrated to read Kilowatts, but are used here for indication.
2. Start the prime mover. With the generator operating in the isochronous mode and not in parallel, load the generator to as near full load as possible.
3. Use a clamp-on ammeter and measure the per phase current of the Current transformer output. Check that current in each of the three CT's is equal. In a balanced three phase system the Load Signal Out reading will be approximately:  
  

$$\text{Load Signal Out} = \text{kW Input Calibration Gain} \times 0.1 \times \text{AMPs (rms reading of one phase)}$$

The kW Input Calibration Gain setting is in Service Menu M\*\*LOAD SENS AND DROOP\*\*.

A clamp-on ammeter is recommended to eliminate the need to open CT wiring to insert an ammeter in series with the CT output.
4. If the Load Signal Out Reading is within 10% of the above calculation, the PT/CT phasing is correct. If the phasing is incorrect, proceed to the Phase Correction Procedure. If the phasing appears correct, skip the Phase Correction Procedure and go to the Load Calibration Adjustment procedure.

### IMPORTANT

If after completing the LOAD SENSOR CALIBRATION and DROOP adjustments, the control loading is extremely sensitive to changes in the power factor when operating in parallel, complete the phase correction procedure.

The most accurate calibration is made at full load. However, if it is not possible to run the generator set at full load, run it at less than full load and reduce the voltage reading given in this calibration procedure proportionally. For example: run a 200 kW generator set at 100 kW and divide all voltages given in this calibration procedure by 2. If you reduce the load in this manner, be sure to reduce it by the same amount throughout the calibration procedure.

## Phase Correction Procedure

### **IMPORTANT**

**This procedure requires a minimum power factor of (.9). If a .9 power factor cannot be obtained, tracing through the wiring is the only means of correcting the current transformer phasing.**

The highest positive reading of kW or Load Signal Out will be obtained when the CT's are correctly matched to the load sensor terminals in both phase and polarity. The following procedure will assure the correct connection of the current transformers. It is required only if the phasing check indicates incorrect phasing, or loading stability is extremely sensitive to the power factor.

Make trial connections of the first CT to all three load sensor inputs, polarized both ways (a total of six connections). Record the Load Signal Out reading for each connection. Connect the first CT to the terminals that produce the highest positive reading and with the polarity that produces the highest positive voltage. The displayed Load Gain reading is limited to about 0.2, therefore a negative reading indicates a phasing or polarity error.

Try the second CT on each of the remaining two CT input terminals, in each polarity and record the Load Signal Out reading. Connect the second CT to the terminals that produce (and with the polarity that produces) the highest positive reading.

Try the last CT on the remaining input terminals, polarized both ways and record the voltage. Connect the last CT in the polarity that produces the highest Load Signal Out reading.

The Phase Correction Procedure requires that the prime mover be shut down many times to disconnect the current transformers. For convenience, a temporary method of connecting the current transformers shown in Figure 5-1 is recommended. Connecting a 0.5  $\Omega$ , 20 W burden resistor across each current transformer allows the current transformers to be disconnected from the terminal strip with the prime mover running, after removing all load.

### **WARNING**

**HIGH VOLTAGE—The current transformers can develop dangerously high voltages. Do not disconnect a current transformer while the prime mover is running unless temporary 0.5  $\Omega$ , 20 W resistors are installed as shown in Figure 5-1 and all load is removed.**

If the temporary burden resistors described above are not used, the prime mover **MUST** be shut down in addition to removing the load in the following procedure.

Monitor the load sensor output in this procedure by connecting an external computer and entering the Watch Window sheet for B\*\* DISPLAY LOAD INFO \*\* sheet and observe 02 LOAD SENSOR INPUT (KW) Load Sensor calibration and monitoring. Since the kW calibration cannot be completed until the phasing is correct, the value shown is for reference only. The Load Sensor of the 2301D-ST will only read a small negative value.

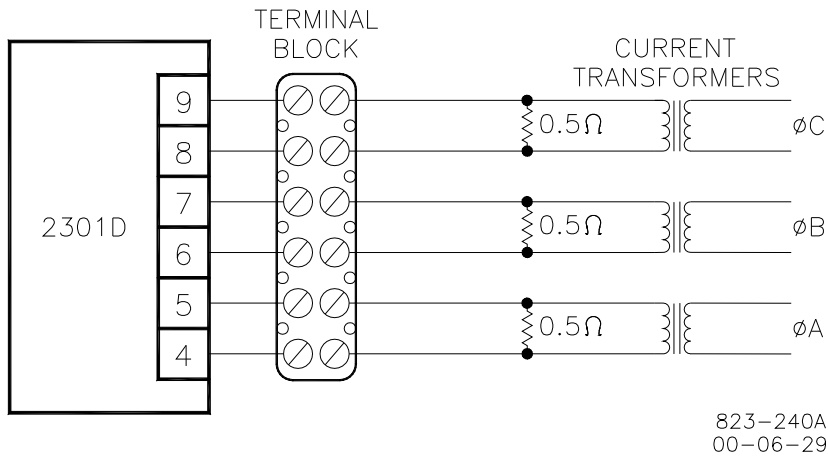


Figure 5-1. Temporary Wiring for Transformer Phase Correction

1. Shut down the prime mover.

**WARNING**

**HIGH VOLTAGE—**The current transformers can develop dangerously high voltages. Do not disconnect a current transformer while the prime mover is running unless temporary 0.5  $\Omega$ , 20 W resistors are installed as shown in Figure 5-1 and all load is removed.

2. Label each CT wire with the phase and polarity that you think it should be. Even though this identification may prove to be incorrect, this step is necessary so that the individual wires can be identified during the description of the procedure.
3. Disconnect the phase B CT wires from terminals 6 and 7. Connect these two wires together using a small screw and nut and tape the connection.
4. Disconnect the phase C CT wires from terminals 8 and 9. Connect and tape these two wires together as in Step 3.
5. Connect the two wires from the phase A CT to the phase A input terminals 4 and 5.
6. Start the prime mover, apply full load and monitor the load sensor output. Start a list and record this value.
7. Unload the system and reverse the phase A CT wires on terminals 4 and 5.\*
8. Apply full load, monitor the load sensor and record this value.
9. Unload the system, remove phase A CT wires from terminals 4 and 5 and connect them to phase B input terminals 6 and 7.\*
10. Apply full load, monitor the load sensor and record this value.
11. Unload the system and reverse the phase A CT wires on terminals 6 and 7.\*
12. Apply full load, monitor the load signal and record this value.
13. Unload the system, remove phase A CT wires from terminals 6 and 7 and connect them to phase C input terminals 8 and 9.\*
14. Apply full load, monitor the load sensor and record this value.
15. Unload the system and reverse the phase A CT wires on terminals 8 and 9.\*
16. Apply full load, measure the load signal and record this reading.
17. Unload the system and compare the six readings taken.\*
18. Remove the phase A CT wires from terminal 8 and 9 and connect the phase A wires to the pair of terminals that produced the highest positive load value and in the polarity that produced the highest positive load value.
19. Remove tape and disconnect the phase B CT wires. Connect the phase B CT wires to one pair of the two remaining pairs of CT input terminals on the load sensor.
20. Apply full load and measure the load signal. Start a new list and record this reading.

21. Unload the system and reverse the phase B CT wires on the same terminals.\*
22. Apply full load, measure the load signal and record this reading.
23. Unload the system, remove phase B CT wires and connect them to the other pair of terminals.\*
24. Apply full load, measure the load signal and record this reading.
25. Unload the system and reverse phase B CT wires on the same terminals.\*
26. Apply full load and measure the load signal. Record this reading and compare the four readings on the list.
27. Unload the system. Remove the phase B CT wires and connect them to the pair of CT input terminals that produced the highest positive load signal reading and with the polarity that produced the highest positive load signal reading.\*
28. Remove tape and disconnect the phase C CT wires. Connect these two wires to the remaining pair of CT input terminals.
29. Apply full load, measure the load signal and record this reading.
30. Unload the system and reverse the phase C CT wires on the same terminals.\*
31. Apply full load, measure the load signal and record this reading.
32. Unload and shut down the system. Compare the two readings.\*
33. Connect the phase C CT wires to the same pair of CT input terminals, but in the polarity that produced the highest positive load signal reading.
34. Re-label each wire with the phase designation of the terminal that it is now connected to.
35. Remove the burden resistors and terminal block.

## Load Calibration Adjustment

For this procedure, the generator must be running isochronously and not paralleled.

Start the prime mover and apply full load. With the Watch Window at the B\*\* DISPLAY LOAD INFO \*\* sheet and observe 02 LOAD SENSOR INPUT (KW). If this reading does not match external instrumentation, adjust calibration gain and offset under the Service Menu M\*\*LOAD SENSR AND DROOP\*\* until Watch Window value matches metering. The values should match at all intermediate points.

### NOTICE

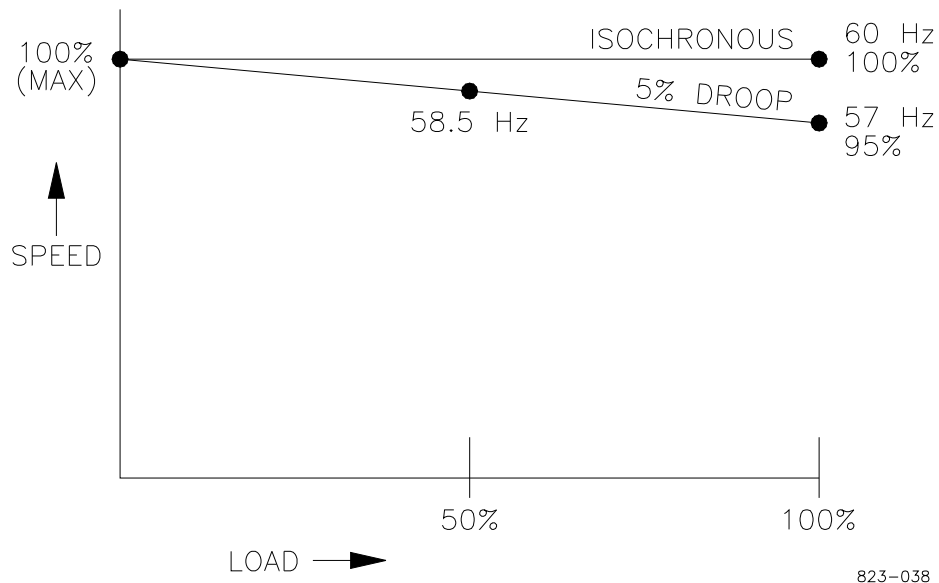
**\*—If values at full load (or a lower reading proportional to a load less than 100%) cannot be obtained and the phasing has been checked and is correct, the current transformers are probably the wrong size. The current-transformer output must be from 3 to 7 A (5 A nominal) at full load.**

When in parallel operation in isochronous mode or on an isolated bus, generator speeds must be the same. If they are not equal, load sharing will not remain proportional as the load varies. Any difference in loads between the units can be corrected by adjusting the Load Gain. Increasing the LOAD GAIN will cause that generator to carry less load. If stability problems occur when in parallel operation at a particular load signal reading, reduce the reading by reducing the LOAD GAIN and reduce the load signal reading setting of all other generators in the system to the same reading. When the load signal readings of all generators in a system are reduced, the load sharing gain will be reduced and this may result in some loss of load sharing sensitivity.

It may be necessary to reduce the load signal reading of each unit in the system to as low as 3 volts in cases of extremely poor system dynamics. If your system requires a load signal reading as low as 3 volts, consult Woodward for suggestions for possible remedies.

## Droop Adjustment

Because of the calculation available in the control, the droop percentage entered will result in the correct speed change if the KW sensor is properly calibrated. The droop percent is automatically corrected for load gain voltage values. The speed trim range can be configured to stop the speed reference at 100% load, or if a remote reference source is used its range can be set to give no load to full load limits.



823-038

Figure 5-2. Droop Adjustment

## Chapter 6. Troubleshooting

### Introduction

The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

#### **NOTICE**

**Incorrect voltage can damage the control. When replacing a control, check the power supply, battery, etc., for the correct voltage.**

### Troubleshooting Procedure

This chapter is a general guide for isolating system problems. The guide assumes that the system wiring, soldering connections, switch and relay contacts and input and output connections are correct and function properly. Make the checks in sequence. Various system checks assume that the prior checks have been done correctly.

#### **WARNING**

**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.**

### Control Start-up

When the control is powered on, the CPU begins execution of a section of the software program known as the boot code. This code performs hardware diagnostics and checks that a valid application program has been installed. During this period all control outputs will remain disabled. The boot code takes approximately 30 seconds to execute. During this period the red status LED should be on. When execution of the boot code has completed, control will be transferred to the application program. When the application program begins, the control outputs will be enabled and system control will begin. At that point the red status LED will be turned off and should remain off as long as the control is running.

If the control fails its self-test diagnostics during boot, fails its on-line self-tests while running the application program, or fails in any other way that it can detect, then the CPU will blink the red status LED to indicate the failure.

#### **NOTICE**

**To prevent damage to the prime mover, the prime mover must be shut down for all system checks.**

## Control Test and Calibration

### General

Conduct the following checks on the 2301D-ST. Then verify the functioning of set points and adjustments.

1. Connect a computer to the communication port. Start the SERVLINK / WATCH WINDOW software in accordance with the instructions in Chapter 3. Verify that correct voltage and polarity are input to the control.
2. Verify the controller ID on the 2301D-ST Standard PC Interface by clicking "Control" then "Properties". The Application ID message "5418-047" with the revision level (new, A, etc) should appear.
3. Select the Configure and Service Menu. Verify that all set points are as recorded during installation. Repeat for the other menus. If any differences are found, change the set point(s) to the correct value. Click the "SAVE VALUES" icon on the tool bar. Remove power from the control for at least 10 seconds. Verify correct values were retained during power down. Failure indicates the control has failed and should be replaced.

### Discrete Inputs

Run the following test to verify the function of the discrete inputs. **DO NOT PERFORM THIS TEST WITH THE TURBINE RUNNING!**


Repeat this step for all discrete inputs. Close the appropriate input. The status in the Service Menu R\*\* DISPLAY D\_I/O STATUS\*\* should switch from OPEN to CLOSED. If the value does not change when the contact is closed, the control has failed and should be replaced.

### Discrete Outputs

Verify operation of the Discrete Outputs, by referring to the Service Menu S\*\*HARDWARE OUTPUT TEST\*\* sheet.

With the turbine shut down, enable the manual relay driver test. Open another inspector sheet, select Service R\*\*DISPLAY D\_I/O STATUS\*\* and monitor the discrete outputs. From the relay test procedure, each discrete output may be activated and its operation verified. If the output is activated, the voltage measured between terminal 39 and the appropriate output terminal (41–44) should equal input voltage at terminal 39 and 40. Testing can be monitored visually by observation of the green LED near terminal 9 and 10, or by listening for an audible 'click'. The manual relay test must be disabled (status "FALSE") or the control will hold the actuator current to minimum.

Symptom	Cause	Solution
<p>Prime mover will not start. Actuator not moving to start steam position.</p> <p><b>IMPORTANT</b></p> <p>If the actuator moves to start position, a problem with the prime mover steam supply is indicated.</p>	Supply voltage polarity reversed (dc only), or no supply voltage.	<p>On power up the CPU status LED should come on for 30 seconds.</p> <p>Check for proper voltage from terminals 45(+) to 46(–). Reverse leads if polarity is incorrect.</p>
	<p>Actuator not responding to input signal from control.</p> <p><b>IMPORTANT</b></p> <p>The hydraulic actuator must have oil pressure and gear rotation to operate (respond).</p>	<p>If there is a voltage output at control terminals 13(+) and 14(–), but the actuator does not move, the wiring to the actuator should be checked for opens or shorts. With the EG3P actuator, remember that terminals C and D of the mating plug should be jumpered.</p> <p>Make resistance checks at the actuator. Coil resistance on Woodward actuators is approximately 35 Ω. (Read with leads at terminals 13 and 14 disconnected.)</p>
	Shutdown cause.	Check Shutdown status in the Service Menu C** SHUTDOWN** #01. If the status is TRUE, check all Shutdown causes; release each cause one by one. (See Chapter 3)
	Actuator or linkage.	Check actuator or linkage for proper installation and operation. Problems may be oil supply, direction of rotation, insufficient drainage, linkage, worn actuator components, or improper adjustment.
	No actuator voltage at terminals 13 and 14.	<p>Check for shorted or grounded actuator leads by removing wires to terminals 13 and 14. Stop prime mover. Check for 18 to 24 V at terminals 13 and 14.</p> <p>Check that A**DISPLAY ANALOG INFO** Menu is reading the turbine speed during spinning. If no speed-reading, check the MPU.</p>

Symptom	Cause	Solution
Prime mover will not start. Actuator not moving to start steam position (continued).	Speed sensor signal not clearing failed speed signal circuit.	<p>Check for at least 1 Vrms at terminals 25 and 26 and at least 5% of the minimum rated speed frequency range. Check wiring for proper connection. Check shields for proper installation. Check the A**DISPLAY ANALOG INFO** Menu for Turbine Speed reading.</p> <p>Speed sensor not spaced properly—check for at least 1.0 Vac at terminals 25 and 26 during cranking. If less than 1.0 Vac, magnetic pickup may be spaced too far from gear. Make sure there are no metal chips on end of pickup.</p> <p>If no voltage is present, magnetic pickup may be open-circuited or shorted. Make resistance check with the leads disconnected from control. Should be about 100 to 300 <math>\Omega</math>.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;">  <b>WARNING</b> </div> <p><b>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.</b></p>
	Faulty 2301D-ST control.	Replace.
Prime mover will not start.		Check for Actuator Demand % after Start command is issued.
Prime mover overspeeds only on starts.	Ramp adjustment.	Increase RAMP TIME. This decreases acceleration rate.
	Wrong SPEED settings.	Check that SPEED settings are entered as described in Chapter 3. Verify the Actuator Demand % drops to minimum (0%) when turbine speed is greater than speed reference.
	Dynamics adjustment.	Dynamics may be adjusted for sluggish operation, causing overspeed on start. Adjust GAIN for fastest stable response. RESET may be adjusted too low. Increase RESET setting.
Prime mover overspeeds after operating at rated speed for some time.	Prime mover.	Check for proper operation of prime mover steam system. If actuator moves toward minimum steam during overspeed, problem is in steam system.
	Magnetic pickup and 2301D-ST control.	Check the magnetic pickup output voltage at speeds above idle—at least 1.0 Vrms. If magnetic pickup should fail and the override failed speed signal circuit is disabled, the 2301D-ST will call for maximum steam.

Symptom	Cause	Solution
Prime mover overspeeds after operating at rated speed for some time (continued).	2301D-ST control.	Control the prime mover manually at rated speed. If the Turbine Speed reading in the Display Menu does not match external indicators, the control is not configured properly. When the turbine speed value is greater than the speed reference value, the output voltage should be zero. If speed range is correct for the application, replace the control.
Prime mover will not stabilize at rated no load speed. The instability may occur at no load or it may vary with load. Control may be erratic.	2301D-ST control.	Adjust PROP GAIN, INTEGRAL GAIN and DERIVATIVE RATIO as described in "Adjust for Stable Operation" and "Dynamic Adjustment" in Chapter 3.
	Speed reference controls.	Check display menu. The speed reference value should be constant. If speed reference is erratic, check remote input (if used), intermittent raise/lower contact inputs. The speed bias sum at no load should be constant.
	Improper linkage adjustment.	Make sure that actuator moves approximately 2/3 of its travel from no load to full load. Be sure linkage is linear on turbine, diesel and steam-injected prime movers. Be sure linkage is non-linear on carbureted prime movers. Refer to actuator manual for proper installation.
	Necessary external wires not properly shielded.  Electrical noise, caused by wiring carrying an ac voltage, stray magnetic fields from transformers, etc., can be picked up by improperly shielded wire. Noise will cause instability if picked up by lines associated with the amplifier summing point such as external speed trim, paralleling lines, droop contact, magnetic pickup lines and synchronizer input.	<p>The following tests will isolate noise and interference.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p><b>NOTICE</b></p> <p><b>Do not perform these tests in other than single-unit operating configuration.</b></p> </div> <p>Verify that the switchgear frame, governor chassis and prime mover have a common ground connection. Temporarily remove the battery charger cables from the control battery system.</p> <p>If the prime mover operation is significantly improved by these modifications, replace the wiring one at a time to locate the source of the trouble.</p> <p>External wiring may require additional shielding or rerouting from high-current lines or components.</p> <p>If the problem cannot be resolved by these checks, it will be necessary to remove the 2301D-ST from the switchgear. Temporarily mount it next to the prime mover and connect only a battery, magnetic pickup and actuator to the control (use a separate battery placed next to the prime mover).</p>

Symptom	Cause	Solution
Prime mover will not stabilize at rated no load speed. The instability may occur at no load or it may vary with load. Control may be erratic (continued).	Necessary external wires not properly shielded (continued).	If stability occurs when the control is mounted next to the prime mover, return the control to the switchgear. Run new magnetic pickup, actuator, and battery power lines. Shield all wires to the control. Route all wires through conduit or an outer shield. Tie the outer shield to system ground at end opposite of the control.
	Prime mover may not be receiving steam as called for by the actuator voltage.	Check actuator linkage to steam controlling mechanism for any lost motion, binding, or excessive loading. Verify a steady steam pressure of proper value.  Check actuator per appropriate actuator manual.
	Prime mover not operating properly.	Prime mover may be causing speed variations. Control turbine manually to determine if instability is in prime mover or governor control. Verify proper adjustment of steam control linkage.
	Input voltage low.	Check supply voltage. It should be at least 18 Vdc.
Prime mover does not share load with other units.	Prime mover not receiving steam as called for by the governor.	If voltage to actuator is maximum, visually determine if actuator shaft is at maximum position. If it is not, an actuator problem is indicated, or the linkage or steam system is restricted.
	Unequal speed settings.	Be sure that speed settings of all units at no load are identical.
	Unequal load gain voltages.	With the prime mover operating in single unit configuration, LOAD GAIN must be set at 6.0 Vdc. See LOAD GAIN ADJUSTMENT in Chapter 3.
	Improper load sensing phasing.	Perform phasing procedure in Chapter 3.
	Circulating currents between generators.	Refer to appropriate voltage regulator manual.
Prime mover does not maintain constant speed (isochronous).	Actuator.	If actuator has a ballhead backup, verify that its hydraulic governor section, speed setting, and speed droop adjustments are properly set (see the applicable governor manual).
	Prime mover.	If the droop occurs near the full-load point only, it is possible the prime mover is not producing the horsepower called for by the steam control, or is being overloaded. Either is indicated if the steam control is at maximum position.

## Chapter 7. Communications

### Modbus Communication

The 2301D-ST control can communicate with plant distributed control systems or CRT based operator control panels through one Modbus communication port. The communication port support RS-232 and RS-422 communications using 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 Modbus communication port, as defaulted from the factory, is not programmed. Although this port is not programmed it continue to update all information to all registers. This allows the 2301D-ST to be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, and to the 2301D-ST's defaulted protocol settings (parity, stop bits, etc.), this device can be used to monitor all the 2301D-ST's controlling parameters, modes, etc. without effecting control. To use a 2301D-ST port it must be configured properly.

### Monitor And Control

Once a Modbus port is activated by the Modbus selector command, the 2301D-ST will accept an external network master device. This allows a Modbus compatible device to monitor and perform all 2301D-ST mode parameters and commands to use a 2301D-ST port it must be configured properly.

### Modbus Communication Mode

The 2301D-ST 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 RTU (Remote Terminal Unit). These modes are defined in the following table.

Characteristic	RTU
Coding System	8-bit binary
Start Bits	1
Data Bits per Character	8
Parity	none
Stop Bits	1
Baud Rate	110,300, 600, 1200, 1800, 2400, 4800, 9600, 19200, or 38400
Error Checking	CRC (Cyclical Redundancy Check)

Table 7-1. RTU Modbus

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream.

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 the Program Mode and can be adjusted in the Service Mode, if required.

The 2301D-ST control is programmed to function as a slave unit only. As a slave unit, the 2301D-ST will only respond to a transaction request by a master device. The 2301D-ST 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 (2301D-STs or other customer devices) can be connected to one Master device on a single network. The control address is programmed under the 2301D-ST's communications block

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 Table 7-2).

	Beginning of Frame	SLAVE Address	Function Code	DATA	Error Check Code	End of Frame
RTU	3-Char Dead Time	1 Char 8 bits	1 Char 8 bits	8 bits Data per Char	1 Char 8 bits	3-Char Dead Time

Table 7-2. Modbus Frame Definition

The Modbus function code tells the addressed slaves what function to perform. The following table lists the function codes supported by this control.

## Modbus Function Codes

Code	Definition	Reference Address
01	Read Digital Outputs ( <i>Raise/Lower and Enable/Disable Commands</i> )	0XXXX
02	Read Digital Inputs ( <i>Status Indications / Alarms and Trips</i> )	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs ( <i>Speed, Setpt, etc.</i> )	3XXXX
05	Write Single Discrete Output ( <i>Raise/Lower and Enable/Disable Commands</i> )	0XXXX
08	Loopback Diagnostic Test ( <i>Subfunction 0 only</i> )	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

Table 7-3. Modbus Function Codes

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 the following table. The exception error status and respective error codes can be viewed in the Service mode under U\*\*COM PORT (MODBUS)\*\*.

If the control has not received a message for the configured time-out period, the control will alarm with an error message, but no message is sent to the master. This time-out is defaulted to 4 seconds and only applies to units using both monitor and control (adjustable in the Service Mode).

## Port Adjustments

Before the 2301D-ST will communicate with the master device, the communication parameters must be verified. These values are set from the Service Mode.

Parameter	Port Adjustment Range
Baud Rate	110 TO 38400
Data Bits	7 or 8
Stop Bits	1, 2 or 1.5
Parity	NONE, ODD or EVEN
Receive Mode	Line or Character
Flow	OFF, XON/XOFF or CTR-RTS
Auto Echo	OFF or ON
End Line	LF, CR or CRLF
Ignore	OFF or ON
Driver	RS232 or RS422

Table 7-4. Port Adjustments

## 2301D-ST Control Modbus Addresses

The Modbus communication ports in the 2301D-ST are programmed for unique Modbus addresses. A complete listing of these addresses for your application is located at the end of this section in the 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 2301D-ST 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 2301D-ST. See Appendix B for defaulted communication constants and ranges.

## Boolean Writes

Boolean Writes are logic signals that are writeable to the 2301D-ST 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.

If a start (address 0.0005) command is given it will be latched. To reset the latch remove the start command and give a command to unload (address 0.0006). This is applicable for the following commands:

- 0.0005 Start (latch)
- 0.0006 Unload
- 0.0009 Rated (latch)
- 0.0010 Idle
- 0.0017 Isoch (CB close 52G) (latch)
- 0.0018 Droop

## Boolean Reads

Boolean Reads are logic signals that are readable from, but not writeable to, the 2301D-ST. An example of a Boolean read value would be a turbine trip status indication. The logic true 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 logic true. The 2301D-ST supports Modbus function code 2, which involves reading selected logic signals.

## Analog Reads

Input registers are analog values that are readable from, but not writeable to, the 2301D-ST. Turbine speed is an example of an analog read value. The values of the input registers are stored internally to the control as floating point numbers representing engineering units (kPa or rpm). The values that are transmitted are integers 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 will allow transmission of decimal parts of a unit if this is necessary for better resolution.

See the 2301D-ST Service mode for defaulted communication constants and ranges. The 2301D-ST supports Modbus function code 4, which involves reading selected input registers.

## Analog Writes

Holding registers are analog values that are writeable to the 2301D-ST. These values can also be read by a device performing an error check. An example of an analog write value would be a direct speed setpoint as opposed to raise and lower commands. The values of the holding registers are also stored in the control as numbers representing engineering units (kPa or rpm). The 2301D-ST 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. The following tables give the address and description of all Boolean and analog reads and writes:

## Modbus Scale Factors

Modbus has two limitations:

- only integers can be sent across;
- 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 the Watch Window (INTFC.COM) between 1 and 1000. 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, 100 or 1000) prior to being sent across the Modbus. The value sent is then divided by the scale factor in the Master. The Scale Factor adjusts all associated analog reads accordingly. The Multiplier (scale factor) can be changed in the Watch Window.

## Shutdown Command through Modbus

Two different types of shutdown commands (emergency and controlled) can be issued through Modbus. The Emergency Shutdown command instantly takes the speed setpoint, valve limiter and actuator current to zero. The Controlled Shutdown function is used to stop the turbine in a controlled manner, as opposed to an Emergency Trip. When a STOP command (controlled shutdown) is issued the Speed Setpoint is ramped to zero at the optional rate. After the Speed Setpoint reaches zero, the valve limiter is instantly stepped to zero.

The Emergency Shutdown and Controlled Shutdown commands do not influence operation of Trip Relay.

By setting the Shutdown Acknowledge BW to TRUE (one) momentarily, the Trip Relay output can be forcedly returned to a normal state. But its trip condition is not canceled.

## Start Command through Modbus

The start-up of a turbine is possible by the command through Modbus. The Open/Close of Contact inputs (RUN/SHUTDOWN etc.) serve as the independent command in Modbus BW. These commands operate in a momentary input.

## 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. To find the office nearest you, contact Modicon Technical Support at 1-800-468-5342.

## Chapter 8.

# 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](http://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](http://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

<u>Facility</u>	<u>Phone Number</u>
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

<u>Facility</u>	<u>Phone Number</u>
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

<u>Facility</u>	<u>Phone Number</u>
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](http://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	_____
<b>Control/Governor #1</b>	
Woodward Part Number & Rev. Letter	_____
Control Description or Governor Type	_____
Serial Number	_____
<b>Control/Governor #2</b>	
Woodward Part Number & Rev. Letter	_____
Control Description or Governor Type	_____
Serial Number	_____
<b>Control/Governor #3</b>	
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 A.

### Service/Configuration Chart

CONFIGURE MENU	PROGRAMMED VALUE	DEFAULT VALUE	TUNABLE RANGE	
			MIN.	MAX.
A**SPD LOAD STRT OPTIONS**				
01 Rated Speed (RPM)		3600.0	0.0	32000.0
02 Enter Rated/Max Load (KW)		1000	10	30000
03 MPU Min Spd Level (RPM)		250.0	0.0	2000.0
04 Gen Frequency is 50 Hz?		FALSE	FALSE	TRUE
05 Number of Gear Teeth		60	16	500
06 Use Self Powered Act ?		FALSE	FALSE	TRUE
07 MPU Override %		20.0	1.0	100.0
08 Self Pwrd Time Dly (SEC)		60.0	5.0	30000.0
09 Gear Ratio		1.0	0.1	10.0
10 Use Critical Band?		FALSE	FALSE	TRUE
11 Crit Shdn Time Dly (SEC)		300	0.0	1200
12 Use Manual Start?		FALSE	FALSE	TRUE
13 Use Semi-Auto Start?		FALSE	FALSE	TRUE
14 Use Automatic Start?		TRUE	FALSE	TRUE
15 Start Mode =	Monitor			
B**DISCRETE IN OPTIONS**				
01 Configuration Error	Monitor			
02 Sel DI F Function (1-7)		1	1	7
03 Display DI F Function	Monitor			
04 Sel DI G Function (1-7)		1	1	7
05 Display DI G Function	Monitor			
06 Sel DI H Function (1-7)		1	1	7
07 Display DI H Function	Monitor			
08 Enable R/L When LS		FALSE	FALSE	TRUE
C**DISCRETE OUT OPTIONS**				
01 Is Trip Relay NC?		TRUE	FALSE	TRUE
02 Is Alarm Relay NC?		TRUE	FALSE	TRUE
03 Relay 1 Energizes (1-12)		2	1	12
04 Relay 1 Selected For	Monitor			
05 Relay 2 Energizes (1-12)		3	1	12
06 Relay 2 Selected For	Monitor			
07 Relay 3 Energizes (1-12)		4	1	12
08 Relay 3 Selected For	Monitor			
09 Relay 4 Energizes (1-12)		5	1	12
10 Relay 4 Selected	Monitor			
11 Reset Clears Trips?		FALSE	FALSE	TRUE

<b>D**ANALOG INPUT OPTIONS**</b>				
01 Configuration Error?	Monitor			
02 Sel AI #1 Function (1-6)		1	1	6
03 Display AI #1 Function	Monitor			
04 Sel AI #1 Type (1-4)		1	1	4
05 Display AI #1 Type	Monitor			
06 Use Input #1 Fail Trip		FALSE	FALSE	TRUE
07 Sel AI #2 Function (1-6)		1	1	6
08 Display AI #2 Function	Monitor			
09 Sel AI #2 Type (1-4)		1	1	4
10 Display AI #2 Type	Monitor			
11 Use Input #2 Fail Trip		FALSE	FALSE	TRUE
<b>E**ACTUATOR OUT OPTIONS**</b>				
01 Actuator Out Type (1-4)		1	1	4
02 Display Actuator Type		1	1	2
03 Invert Driver Output?		FALSE	FALSE	TRUE

SERVICE MENU	PROGRAMMED VALUE	DEFAULT VALUE	TUNABLE RANGE	
			MIN.	MAX.
A** DISPLAY ANALOG INFO **				
01 Speed Control Status =	Monitor			
02 Turbine Speed (RPM) =	Monitor			
03 Generator Frequency (HZ) =	Monitor			
04 Speed Reference (RPM) =	Monitor			
05 Actuator Signal (%) =	Monitor			
06 Actuator Current (mA) =	Monitor			
07 Valve Limiter (%) =	Monitor			
08 Speed PID (%) =	Monitor			
09 Critical Speed Band? =	Monitor			
10 Speed Ref Bias (RPM) =	Monitor			
11 Analog Input #1 (mA) =	Monitor			
12 Analog Input #2 (mA) =	Monitor			
13 Start Mode Selected =	Monitor			
B** DISPLAY LOAD INFO **				
01 Load Control Status =	Monitor			
02 Load Sensor Input (KW) =	Monitor			
03 Load Sensor (%) =	Monitor			
04 Load Sharing Bias (RPM)	Monitor			
05 Load Signal Out (Vdc) =	Monitor			
06 System Load 0-3(Vdc) =	Monitor			
07 Load Sharing Bias (%) =	Monitor			
C** SHUTDOWNS **				
01 Shutdown Status	Monitor			

02 First Shutdown	Monitor			
03 Power Up Shutdown (1)	Monitor			
04 Overspeed (2)	Monitor			
05 MPU Fail (3)	Monitor			
06 Analog Input#1 Fail (4)	Monitor			
07 Analog Input#2 Fail (5)	Monitor			
08 Modbus Issued Trip (6)	Monitor			
09 Test Mode (7)	Monitor			
10 External Shutdown (8)	Monitor			
11 Stuck in Critical (9)	Monitor			
12 Shutdown Acknowledge		FALSE	FALSE	TRUE
<b>D** ALARMS **</b>				
01 Alarm Status	Monitor	-	-	-
02 First Alarm	Monitor	-	-	-
03 Analog Input#1 Fail (1)	Monitor	-	-	-
04 Analog Input#2 Fail (2)	Monitor	-	-	-
05 Load Sensor Fail (3)	Monitor			
06 Load Share Line Fail (4)	Monitor			
07 Alarm Acknowledge		FALSE	FALSE	TRUE
<b>E** SPEED DYNAMICS **</b>				
01 Off Line Prop Gain		5.0	0.01	100.0
02 Off Line Int Gain		1.8	0.01	50.0
03 Off Line Deriv Ratio		5.0	0.01	100.0
04 Off Line Window Width		60.0	1.0	200.0
05 Off Line Gain Ratio		1.0	1.0	10.0
06 Use On Line Dynamics?		FALSE	FALSE	TRUE
07 On Line Prop Gain		20.0	0.01	100.0
08 On Line Int Gain		1.8	0.01	50.0
09 On Line Deriv Ratio		20.0	0.01	100.0
10 On Line Window Width		60.0	1.0	200.0
11 On Line Gain Ratio		1.0	1.0	10.0
12 Using On Line Dynamics?	Monitor			
13 Use Load Rejection?		False	True	False
14 Ld Rej Spd Chg (RPM/SEC)		50.0	50.0	250.0
15 Ld Rej Percent Speed (%)		102.0	100.0	105.0
<b>F** REMOTE SPEED CONTROL **</b>				
01 Remote Control Mode	Monitor			
02 Rmt/Proc Slw Rate (RPM/S)		5.0	0.0	1000.0
03 Rmt Stpt Deadband (RPM)		2.0	0.0	10.0
04 Rmt Stpt Fst Rate (RPM/S)		10.0	0.0	1000.0
05 Rmt 2nd Deadband (RPM)		10.0	0.0	100.0
06 Speed Reference (Rpm)	Monitor	-	-	-
07 Rmt Speed Setpt (Rpm)	Monitor	-	-	-

<b>G**SPEED SETTING**</b>				
01 Idle Spd Setpoint		1000.00	0.0	32000.00
02 Idle to Rated (RPM/SEC)		25.0	0.0	32000.0
03 Rated to Idle Rate (RPM/SEC)		25.0	0.0	32000.0
04 Min Gov Setpoint (RPM)		3550.00	0.0	32000.00
05 Max Gov Setpoint (RPM)		3843.00	0.0	32000.00
06 Lower Slow Rate (RPM/S)		10.00	0.00	1000.00
07 Lower Fast Rate (RPM/S)		25.00	0.00	1000.00
08 Raise Slow Rate (RPM/S)		10.00	0.00	1000.00
09 Raise Fast Rate (RPM/S)		25.00	0.00	1000.00
10 R / L Time Delay (Sec)		5.0	0.5	30.0
11 Critical Low Point (RPM)		2500.00	0.00	32000.00
12 Critical Hi Point (RPM)		3000.00	0.00	32000.00
13 Critical Rate (RPM/SEC)		100.00	0.00	32000.00
14 Use Set Point Set-Back?		FALSE	FALSE	TRUE
<b>H** PROCESS CONTROL **</b>				
01 Process Control Enabled	Monitor			
02 Use Process Control?		FALSE	FALSE	TRUE
03 Invert Process?		FALSE	FALSE	TRUE
04 Min Proc Setpt (Units)		0.00	-32000.00	32000.00
05 Max Proc Setpt (Units)		1000.00	-32000.00	32000.00
06 Proc Setpt Rt (Units / Sec)		5.00	0.01	1000.00
07 Use Setpoint Tracking?		FALSE	FALSE	TRUE
08 Setpt Init Value (Units)		5.00	-32000.00	32000.00
09 Spd Setpt Low Lmt (RPM)		0.00	-32000.00	32000.00
10 Spd Setpt High Lmt (RPM)		0.00	-32000.00	32000.00
11 Process PID Prop Gain		1.0	0.00	100.00
12 Process PID Integ Gain		0.3	0.001	50.0
13 Process Derivative Ratio		100.00	0.01	100.00
14 Process Cntrl Deadband		0.01	0.01	5.0
15 Use Remote Proc Setting?		FALSE	FALSE	TRUE
16 Remote Proc Max Rate		5.00	0.01	1000.00
17 Analog Input #1	Monitor			
18 Analog Input #2	Monitor			
19 Process Setpoint (Units)	Monitor			
20 Process Actual (Units)	Monitor			
<b>I** OVERSPEED TEST **</b>				
01 Overspeed Test Status	Monitor			
02 Overspeed Test Enable		FALSE	FALSE	TRUE
03 Elec Overspeed Trip Setpt		4032.00	0.00	32000.00
04 Max Ovrspd Test Lmt (RPM)		4140.00	0.00	32000.00
05 Elec Overspd Trip Test	Monitor			
06 Turbine Speed(Rpm)	Monitor			
07 Speed Ref(Rpm)	Monitor			

<b>J** FAILED MPU OVERRIDE **</b>				
01 Auto-Ovrd Off Speed		450.00	0.00	2000.00
02 Auto-Ovrd On Speed		650.00	0.00	2000.00
03 Auto-Ovrd On Delay (SEC)		5.00	0.00	100.00
04 Use MPU Ovrd Timer		FALSE	FALSE	TRUE
05 Use Rolldown Ovrd?		FALSE	FALSE	TRUE
06 Max Starting Time (SEC)		60.00	0.00	3000.00
<b>K** SYNCHRONIZER SETUP **</b>				
01 ENABLE SYNC INPUT	Monitor	-	-	-
02 SYNC INPUT SCALE(%/V)		0.7	0.1	5.0
03 SYNC BIAS SPD(rpm)	Monitor	-	-	-
04 TURBINE SPEED(rpm)	Monitor	-	-	-
05 SPEED REF(rpm)	Monitor	-	-	-
<b>L** VALVE LIMITER SET **</b>				
01 Enable Manual Cntrl Ramp		FALSE	FALSE	TRUE
02 Manual Ramp Status	Monitor			
03 Manual Cntrl Ramp Setpnt		100.00	0.00	100.00
04 Display Actuator %	Monitor			
05 Actual Valve Ramp %	Monitor			
06 Man Start Rate (%/SEC)		10.00	0.00	100.00
07 Auto Strt Rate (%/SEC)		0.5	0.0	100.0
08 Man/Auto PID Ramp Rate		50.00	1.00	1000.00
<b>M** LOAD SENSR AND DROOP **</b>				
01 Use Load Sensor?		FALSE	FALSE	TRUE
02 Use kW Droop?		FALSE	FALSE	TRUE
03 Use Act Pos Droop?		FALSE	FALSE	TRUE
04 Droop Percentage (%)		5.0	0.0	12.0
05 Act % @ No Ld (Pos Drp)		20.00	0.00	100.00
06 Act % @ Full Ld (Pos Drp)		80.00	0.00	100.00
07 Enter Rated Load (KW)		1000	10	30000
08 Load Gain Voltage		6.00	0.10	9.00
09 KW Calibration Zero		0.00	-20.00	20.00
10 KW Calibration Gain		10.00	5.00	40.00
11 Load Time (KW/SEC)		20.00	1.00	600.00
12 Enable Fast Load Rate		FALSE	FALSE	TRUE
13 Fast Load Time (KW/SEC)		60.00	1.00	600.00
14 Fast Ramp Load (%)		80.00	1.00	110.00
15 Unload Time (KW/SEC)		20.00	1.00	600.00
16 Load Sharing Gain		0.20	0.01	10.0
17 Gen Output (KW)	Monitor			
18 Load Signal Out (Vdc)	Monitor			

<b>N** ACT LINEARIZATION **</b>				
01 X-1 Value		0.0	-10.0	110.0
02 Y-1 Value		0.0	-10.0	110.0
03 X-2 Value		10.0	-10.0	110.0
04 Y-2 Value		10.0	-10.0	110.0
05 X-3 Value		20.0	-10.0	110.0
06 Y-3 Value		20.0	-10.0	110.0
07 X-4 Value		30.0	-10.0	110.0
08 Y-4 Value		30.0	-10.0	110.0
09 X-5 Value		40.0	-10.0	110.0
10 Y-5 Value		40.0	-10.0	110.0
11 X-6 Value		50.0	-10.0	110.0
12 Y-6 Value		50.0	-10.0	110.0
13 X-7 Value		60.0	-10.0	110.0
14 Y-7 Value		60.0	-10.0	110.0
15 X-8 Value		70.0	-10.0	110.0
16 Y-8 Value		70.0	-10.0	110.0
17 X-9 Value		80.0	-10.0	110.0
18 Y-9 Value		80.0	-10.0	110.0
19 X-10 Value		90.0	-10.0	110.0
20 Y-10 Value		90.0	-10.0	110.0
21 X-11 Value		100.0	-10.0	110.0
22 Y-11 Value		100.0	-10.0	110.0
23 Actuator Demand (%)	Monitor	-	-	-
24 Actuator Out (mA)	Monitor	-	-	-
<b>O** ACTUATOR CALIBRATION **</b>				
01 Calibration Enable		FALSE	FALSE	TRUE
02 Dummy Drive Signal (%)		0	0	100
03 Driver Offset		0.0	-100.0	100.0
04 Driver Gain		1.0	0.0	10.0
05 Actuator Dither (mA)		0.0	0.0	10.0
06 Actuator Out (mA)	Monitor			
<b>P**ANALOG I/O SETTINGS**</b>				
01 Display AI #1 Function	Monitor			
02 Input #1 Min Value (Unit)		0.00	-32000.0	32000.0
03 Input #1 Max Value (Unit)		100.00	-32000.0	32000.0
04 Analog In #1 Units	Monitor			
05 Display AI #2 Function	Monitor			
06 Input #2 Min Value (Unit)		0.00	-32000.0	32000.0
07 Input #2 Max Value (Unit)		100.00	-32000.0	32000.0
08 Analog In #2 Units	Monitor			
09 Analog Output Sel (1-7)	Monitor			
10 Analog Output Selected	Monitor			
11 Anout Min Val (Unit)		0.0	-32000.0	32000.0
12 Anout Max Val (Unit)		100.0	-32000.0	32000.0
13 Analog Out (mA)	Monitor			

<b>Q**DISCRETE OUT SETTINGS**</b>				
01 Relay 1 Selected As	Monitor			
02 Relay 1 Level Sw (1-7)		1	1	7
03 Relay#1 Level Select For	Monitor			
04 Relay 1 ON Level =		0.0	-32000.0	32000.0
05 Relay 1 OFF Level =		0.0	-32000.0	32000.0
06 Relay 2 Selected As	Monitor			
07 Relay 2 Level Sw (1-7)		1	1	7
08 Relay#2 Level Select For	Monitor			
09 Relay 2 ON Level =		0.0	-32000.0	32000.0
10 Relay 2 OFF Level =		0.0	-32000.0	32000.0
11 Relay 3 Selected As	Monitor			
12 Relay 3 Level Sw (1-7)		1	1	7
13 Relay#3 Level Select For	Monitor			
14 Relay 3 ON Level =		0.0	-32000.0	32000.0
15 Relay 3 OFF Level =		0.0	-32000.0	32000.0
16 Relay 4 Selected As	Monitor			
17 Relay 4 Level Sw (1-7)		1	1	7
18 Relay#4 Level Select For	Monitor			
19 Relay 4 ON Level =		0.0	-32000.0	32000.0
20 Relay 4 OFF Level =		0.0	-32000.0	32000.0
<b>R** DISPLAY D_I/O STATUS**</b>				
01 DI External Shutdown	Monitor			
02 DI Reset	Monitor			
03 DI Start / Unload	Monitor			
04 DI Raise Speed	Monitor			
05 DI Lower Speed	Monitor			
06 Discrete Input F	Monitor			
07 Discrete Input G	Monitor			
08 Discrete Input H	Monitor			
09 Discrete Output #1	Monitor			
10 Discrete Output #2	Monitor			
11 Discrete Output #3	Monitor			
12 Discrete Output #4	Monitor			
13 Internal L/S Relay K1	Monitor			
<b>S**HARDWARE OUTPUT TEST**</b>				
01 Enable Hardware Test		FALSE	FALSE	TRUE
02 Hardware Test Mode	Monitor			
03 AO Force Value (4–20 mA)		4	4	20
04 Analog Out (mA)	Monitor			
05 Anout, 4 mA Offset		0.0	-100.0	100.0
06 Anout, 20 mA Gain		1.0	0.0	10.0
07 Turn On Do-1		FALSE	FALSE	TRUE
08 Discrete Output #1	Monitor			

09 Turn On Do-2		FALSE	FALSE	TRUE
10 Discrete Output #2	Monitor			
11 Turn On Do-3		FALSE	FALSE	TRUE
12 Discrete Output #3	Monitor			
13 Turn On Do-4		FALSE	FALSE	TRUE
14 Discrete Output #4	Monitor			
15 Turn On L/S Line Relay		FALSE	FALSE	TRUE
16 Load Share Relay	Monitor			
<b>T**COM PORT (MODBUS)**</b>				
01 PORT FAIL	Monitor	-	-	-
02 LINK ERROR	Monitor	-	-	-
03 Error Percent	Monitor	-	-	-
04 Error Number	Monitor	-	-	-
05 BAUD RATE		10	1	10
06 BAUD RATE IS SET FOR	Monitor			
07 DATA BITS		1	1	2
08 DATA BITS ARE SET FOR	Monitor			
09 STOP BITS		1	1	3
10 STOP BITS ARE SET FOR	Monitor			
11 PARITY		1	1	3
12 PARITY IS SET FOR	Monitor			
13 DRIVER		1	1	2
14 DRIVER IS SET FOR	Monitor			
15 TIME OUT (sec)		4.0	0.0	100.0
16 Network Address		1	1	247
17 ENABLE MODBUS CONTROL		FALSE	FALSE	TRUE
<b>U**APPLICATION ID**</b>				
01 APP Software Number	Monitor	-	-	-
02 APP Software Revision	Monitor	-	-	-
03 Application Name	Monitor	-	-	-

## Appendix B.

# Modbus Communication List

This Modbus Communication List is applicable for software revision 5418-047C.

### Boolean Writes

Address	Description
0:0001	Modbus Controlled Shutdown
0:0002	Alarm Acknowledge
0:0003	Shutdown Acknowledge
0:0004	System Reset
0:0005	Start
0:0006	Unload
0:0007	Raise Speed / Load
0:0008	Lower Speed / Load
0:0009	Rated
0:0010	Idle
0:0011	Enable Process Control
0:0012	Disable Process Control
0:0013	Enable Speed PID dynamic settings
0:0014	Disable Speed PID dynamic settings
0:0015	Select Speed PID Dynamic Settings #1
0:0016	Select Speed PID Dynamic Settings #2
0:0017	Isoch (CB close 52G)
0:0018	Droop
0:0019	Enable Overspeed Trip
0:0020	Disable Overspeed Trip
0:0021	Energize Modbus Relay #1
0:0022	De-energize Modbus Relay #1
0:0023	Energize Modbus Relay #2
0:0024	De-energize Modbus Relay #2
0:0025	Energize Modbus Relay #3
0:0026	De-energize Modbus Relay #3
0:0027	Energize Modbus Relay #4
0:0028	De-energize Modbus Relay #4
0:0029	Enable Modbus Remote Control
0:0030	Disable Modbus Remote Control

### Boolean Reads

Address	Description
1:0001	Shutdown Status
1:0002	Alarm Status
1:0003	External Shutdown
1:0004	Overspeed Trip Alarm
1:0005	Modbus Issued Trip
1:0006	MPU Fail Trip
1:0007	Analog Input #1 Trip (if configured)
1:0008	Analog Input #2 Trip (if configured)
1:0009	Analog Input #1 Failed
1:0010	Analog Input #2 Failed
1:0011	Load Sensor Failed

1:0012	Load Share Line Failed
1:0013	Speed PID In-Control
1:0014	Remote Speed Setpoint Enabled
1:0015	Speed Reference Lower Limit
1:0016	Speed Reference Raise Limit
1:0017	Load Sharing Enabled
1:0018	Overspeed Test Enabled
1:0019	Level SW#1 ON
1:0020	Level SW#2 ON
1:0021	Level SW#3 ON
1:0022	Level SW#4 ON
1:0023	Discrete Input A State
1:0024	Discrete Input B State
1:0025	Discrete Input C State
1:0026	Discrete Input D State
1:0027	Discrete Input E State
1:0028	Discrete Input F State
1:0029	Discrete Input G State
1:0030	Discrete Input H State
1:0031	Relay Output #1 State
1:0032	Relay Output #2 State
1:0033	Relay Output #3 State
1:0034	Relay Output #4 State
1:0035	In Critical Band
1:0036	Stuck In Critical Band Trip
1:0037	SPEED PID SELECT ENABLED
1:0038	DYNAMIC SETTING #2

**Analog Reads**

Address	Description	Multiplier
3:0001	Trip First Out Indication	1.0
3:0002	Alarm First Out Indication	
3:0003	Turbine Speed (RPM)	1.0
3:0004	Speed Reference (RPM)	1.0
3:0005	Turbine Load (KW)	*1.0 (0.0, 1000.0)
3:0006	Actuator Output (%)	*10.0 (0.0, 1000.0)
3:0007	Speed PID Output (%)	*10.0 (0.0, 1000.0)
3:0008	Analog Input #1	*10.0 (0.0, 1000.0)
3:0009	Analog Input #2	*10.0 (0.0, 1000.0)
3:0010	Valve Limiter Position (%)	*10.0 (0.0, 1000.0)

**Analog Writes**

Address	Description	Multiplier
4:0001	Modbus Remote Speed Setpoint	1.0

**DECLARATION OF CONFORMITY**

According to ISO/IEC Guide 22 and EN 45014

**Manufacturer's Name:** WOODWARD GOVERNOR COMPANY (WGC)  
Industrial Controls Group

**Manufacturer's Address:** 1000 East Drake Road  
P.O. Box 3800  
Fort Collins, Colorado, USA 80525-1519

**European Representative's Name:** WOODWARD GOVERNOR NEDERLAND BV

**European Representative's Address:** Hoofdweg 601  
P. O. Box 34  
2130 AA Hoofddorp, The Netherlands

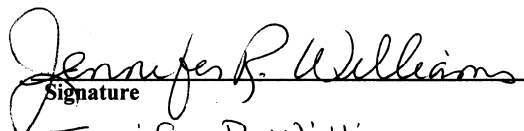
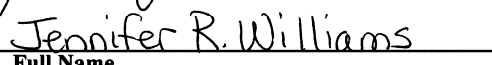

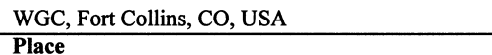
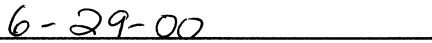
**Model Name(s)/Number(s):** 2301D Digital LSSC





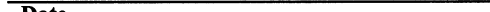
**Conformance to Directive(s):** 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the member states relating to electromagnetic compatibility.  
73/23/EEC COUNCIL DIRECTIVE of 19 February 1973 on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits.

**Applicable Standards:** EN-50081-2, August 1993: EMC Generic Emissions Standard, Part 2: Industrial Environment.  
EN 61000-6-2, April 1999: Electromagnetic Compatibility (EMC), Immunity for Industrial environments.  
EN 50178, October 1997: Electronic Equipment for use in Power Installations

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

**MANUFACTURER****LEGAL REPRESENTATIVE IN EUROPE**

  
**Signature**  
  
**Full Name**  
  
**Position**  
  
**Place**  
  
**Date**

  
**Signature**  
  
**Full Name**  
  
**Position**  
  
**Place**  
  
**Date**

# 2301D-ST Control Specifications

Woodward Part Numbers:	
8273-128	2301D-ST certified for ordinary location
8273-1001	2301D-ST certified for hazardous locations
8923-932	Watch Window Installation
Power Supply Rating	18–40 Vdc (SELV)
Power Consumption	less than or equal 20 W nominal
Input Supply Voltage	Input Supply Current
18 V	589 mA
24 V (nominal)	431 mA
32 V	319.6 mA
Inrush Current	7 A for 0.1 ms (low-voltage model)
Inrush Current	22 A for 15 ms (high-voltage model)
Steady State Speed Band	±0.25% of rated speed
Magnetic Pickup	100–24 950 Hz (900–20000 rpm)
Discrete Inputs (8)	3 mA at 24 Vdc, impedance approximately 5.2 kΩ
Analog Input #1, #2	4–20 mA, 0–5 Vdc, ±2.5 Vdc, 1–5 Vdc
Synchronizer Bias Signal Input	±2.5 Vdc, externally powered
Analog Output #1	4–20 or 20–200 mA to actuator, software configurable
Analog Output #2	4–20 mA to monitor, internally powered
Discrete Outputs (4)	configured to provide various level switches or conditions, power by external +12 Vdc or +24 Vdc source, max output current 200 mA
Discrete Output Ratings	Low-side drivers with overvoltage protection, 200 mA maximum
Communication Port (J2)	RS-232, RS-422, 9-pin connector, 1200 to 38 400 baud, full duplex
Ambient Operating Temperature	–40 to +70 °C (–40 to +158 °F)
Storage Temperature	–40 to +105 °C (–40 to +221 °F)
Humidity	95% at +20 to +55 °C (+68 to +131 °F)
	Lloyd's Register of Shipping Test Specification No. 1, 1996, Humidity Test 1
Mechanical Vibration	Lloyd's Register of Shipping Test Specification No. 1, 1996, Vibration Test 2 (5-25 Hz, ± 1.6 mm; 25-100 Hz, 4.0g)
Mechanical Shock	US MIL-STD 810C, Method 516.2, Procedure I (basic design test), Procedure II (transit drop test, packaged), Procedure V (bench handling)
Equipment Classification	1 (grounded equipment)

**We appreciate your comments about the content of our publications.**

**Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)**

**Please reference publication **26184G**.**



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