




**Product Manual 35018V1
(Revision J, 8/2024)
Original Instructions**




505XT Digital Control for Steam Turbines (Single Valve, Extraction and/or Admission)


**Manual 35018 consists of three volumes:
35018V1, 35018V2, and 35018V3**

Installation and Operation Manual Volume 1

	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.
General Precautions	

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Revisions	

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Warnings and Notices

Important Definitions



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

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

WARNING

**Overspeed /
Overtemperature /
Overpressure**

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

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

WARNING

**Personal Protective
Equipment**

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

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

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

WARNING

Start-up

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

! WARNING

IOLOCK. When a CPU or I/O module fails, watchdog logic drives it into an IOLOCK condition where all output circuits and signals are driven to a known de-energized state as described below. The System MUST be designed such that IOLOCK and power OFF states will result in a SAFE condition of the controlled device.

CPU and I/O module failures will drive the module into an IOLOCK state

CPU failure will assert an IOLOCK signal to all modules and expansion racks to drive them into an IOLOCK state.

Discrete outputs / relay drivers will be non-active and de-energized
analog and actuator outputs will be non-active and de-energized with zero voltage or zero current.

The IOLOCK state is asserted under various conditions including CPU and I/O module watchdog failures

Power Up and Power Down conditions.

System reset and hardware/software initialization

Entering configuration mode

NOTE: Additional watchdog details and any exceptions to these failure states are specified in the related CPU or I/O module section of the manual.

! CAUTION

**Emergency
Disconnecting
Device**

An emergency switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator. The switch or circuit breaker shall be clearly marked as the disconnecting device for the equipment. The switch or circuit breaker shall not interrupt the Protective Earth (PE) conductor.

! CAUTION

**Risk of Calibration
and Checkout**

The calibration and checkout procedure should only be performed by authorized personnel knowledgeable of the risks posed by live electrical equipment.

! CAUTION

**Fuse Power Supply
Mains**

The Power Supply MAINS should be properly fused according the NEC/CEC or authority having final jurisdiction per the input power specifications.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Regulatory Compliance

European Compliance for CE Marking:

These listings are limited only to those units bearing the CE Marking. Refer to the DoC for applicability by part number.

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

ATEX – Potentially Explosive Atmospheres Directive: Declared to Directive 2014/34/EU on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres.
Zone 2, Category 3, Group II G, Ex ic nA IIC T4 X Gc IP20

Low Voltage Directive: Declared to Directive 2014/35/EU on the harmonization of the laws of the Member States relating to the making electrical equipment designed for use within certain voltage limits available on the market.

Other European and International Compliance:

IECEX: Ex ic nA IIC T4 Gc T4 temperature.
Certificate: IECEx CSA 15.0020X IEC 60079-0: 2011 - Explosive Atmospheres – Part 0
Equipment General Requirements.
IEC 60079-11: 2011 – Explosive Atmospheres – Part
Part 11: Equipment Protection by Intrinsic Safety “i”
IEC 60079-15: 2010 - Electrical Apparatus for
Explosive Gas Atmospheres; Part 15: Construction,
Test and Marking Type of protection “n”.

EAC Customs Union

These listings are limited only to those units with labels, marking and manuals in Russian language to comply with their certificates and declaration.

EAC Customs Union: Certified to Technical Regulation TR CU 012/2011 for use in potentially explosive atmospheres per Certificate RU C-US.MЮ62.B.04777 as 2Ex ic nA IIC T4 Gc X

Declared to Technical Regulation TR CU 020/2011 On Electromagnetic Compatibility of Technical Equipment Declaration of Conformity
Registration No: RU Д-US.МЛ66.B.001129

IMPORTANT

This equipment is considered indicator equipment only and is not to be used as metrology equipment. All signals and inputs need to be verified using Metrology Listed or another method of Accredited Calibrated Equipment. The upper-level system must have an independent over-speed safety device installed.

North American Compliance:

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

Units bearing only the CSA identification are restricted for use only in Ordinary Locations in North America.

Units bearing the CSA identification in addition to the marking indicating Class I, Div 2, Groups A,B,C and D are acceptable for use in North American Hazardous Locations.

CSA: CSA Certified for Class I, Division 2, Groups A, B, C, & D, T4 at 70 °C surrounding air temperature. For use in Canada and the United States. CSA Certificate 70006135

This product is certified as a component for use in other equipment. The final combination is subject to acceptance by the authority having jurisdiction or local inspection.

Marine Compliance:

Lloyd's Register of Shipping: LR Type Approval Test Specification No. 1, July 2013; Environmental Categories ENV1, ENV2 and ENV3.

DNV-GL Temperature Class D, Humidity Class B, Vibration Class A, EMC Class A, Enclosure; Required protection according to the Rules shall be provided upon installation on board.

Lloyd's: Type Approval Conditions

Where this controller is used to perform safety critical functions or system shutdowns a valid Lloyd's Register Software Conformity Assessment Certificate is required. Where the controller is used for control and alarm purposes a separate, independent safety system must be provided.

Installation of this equipment for marine applications is to be in accordance with current Lloyd's Register Rules and Regulations.

Radiated and conducted emissions meet the requirement for equipment in the general power distribution zones.

DNV-GL: Type Approval Conditions

The Type Approval covers hardware listed under Product description. When the hardware is used in applications to be classed by DNV, documentation for the actual application is to be submitted for approval by the manufacturer of the application system in each case. Reference is made to DNV Rules for Ships Pt. 4 Ch. 9 Control and Monitoring Systems.

Product Certificate

If specified in the Rules, ref. Pt. 4 Ch. 9 Sec. 1, the control and monitoring system in which the above listed hardware is used shall be delivered with a product certificate. For each such delivery the certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. The test shall be done according to an approved test program. After the certification the clause for application software control will be put into force.

Clause for Application Software Control

All changes in software are to be recorded if the system is in use on board. The records of all changes are to be forwarded to DNV for evaluation and approval. Major changes in the software are to be approved before being installed in the computer.

Application/Limitation

Ex-certification is not covered by this certificate. Application in hazardous area to be approved in each case according to the Rules and Ex-Certification/Special Conditions for Safe Use listed in valid Ex-certificate issued by a notified/recognized Certification Body.

Special Conditions for Safe Use

The 505XT shall not be installed in areas exceeding Pollution Degree 2 as defined in IEC 60664-1.

A fixed wiring installation is required. Field wiring must be in accordance with North American Class I, Division 2 (CEC and NEC), or European Zone 2, Category 3 wiring methods as applicable, and in accordance with the Local Inspection Authority having jurisdiction. On high voltage versions of the control the interior of the enclosure shall not be accessible in normal operation without the use of a tool.

Field wiring must be suitable for the following temperatures:

- Power input rated minimum of +95°C.
- All remaining connection; +10°C above highest ambient

Protective Earth Grounding of the 505XT is required to be connected to the PE terminal.

A switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator. The switch or circuit breaker shall be clearly marked as the disconnecting device for the equipment. The switch or circuit breaker shall not interrupt the Protective Earth (PE) conductor.

Hazardous Locations

Wiring must be in accordance with Zone 2 wiring methods and in accordance with the authority having final jurisdiction.

The Real Time Clock Battery located on the CPU board is not to be recharged and is not user replaceable. Contact a Woodward Authorized Service Center if a replacement service is needed.

The Low Voltage ATEX 505XT is suitable for use in Class I, Div 2, Gas Groups A, B, C and D & European Zone 2, Group IIC environments.

This equipment must be installed in an area or enclosure providing adequate protection against high impact. (7 Joules) The control is rated for 2 Joules impact.

ATEX/IECEx locations require that the 505XT Control be installed in a cabinet or enclosure coded Ex nA or Ex e that provides a minimum IP54 ingress protection for the rear of the control per IEC 60529. The front bezel, keypad and display have been tested and are rated IP54 while the rear of the control is rated IP20 due to the ventilation slots required for heat dissipation. The installer shall ensure that the maximum surrounding air temperature in the enclosure does not exceed the rated temperature of +70°C.

Transient Protection for the 505XT is to be provided externally by the end user at the supply terminals of the control. The transient protection device is to be set at a level not exceeding 140% of the peak rated voltage (36 VDC).

WARNING

Explosion Hazard

For ATEX/IECEx installation compliance, the input voltage shall be limited to 36 VDC. When an external power supply is selected to supply the control, it shall be IECEx approved for Class 1, Division 2 Applications.

WARNING

Explosion Hazard

Due to the Hazardous Location Listings associated with this product, proper wire type and wiring practices are critical to the operation.

WARNING

Explosion Hazard

ENCLOSURE REQUIREMENT—
ATEX/IECEx Zone 2, Category 3G applications require the final installation location provide a minimum IP-54 ingress protection enclosure against dust and water per IEC 60529. The enclosure must be coded Ex nA or Ex e.

**WARNING**

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

Explosion Hazard

**WARNING**

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

Explosion Hazard

**WARNING**

The external ground lugs shown on the installation drawing must be properly connected to ensure equipotential bonding. This will reduce the risk of electrostatic discharge in an explosive atmosphere. Cleaning by hand or water spray must be performed while the area is known to be non-hazardous to prevent an electrostatic discharge in an explosive atmosphere.

Explosion Hazard

**WARNING****MOUNTING**

The control must be mounted in a vertical position. The installer shall ensure the maximum surrounding air temperature of the control does not exceed 70°C at the final location.

Explosion Hazard

**WARNING**

Class I, Div 2 Groups A, B, C, D and Zone 2, Group IIC applications require the input voltage to the relay contacts not exceed 32 VAC rms or 32 VDC.

Explosion Hazard

**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.

**AVERTISSEMENT**

Risque d'explosion

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

**AVERTISSEMENT**

Risque d'explosion

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

Safety Symbols



Direct current



Alternating current



Both alternating and direct current



Caution, risk of electrical shock



Caution, refer to accompanying documents



Protective conductor terminal



Frame or chassis terminal

Chapter 1.

General Information

Introduction

This manual describes the Woodward 505XT Digital Governor for all types of steam turbines, including:

- Single Valve or split-range actuators turbines
- Controlled Extraction or Admission turbines (two control valves)
- Controlled Extraction and Admission turbines (two control valves)

The option charts below show the part numbers and the differences between the models. Volume 1 of this manual describes the control, provides installation instructions, defines hardware specifications, and explains the configuration (programming) and operating procedures. Volume 2 includes notes on applying the control to specific applications and Service mode information. This manual does not contain instructions for the operation of the complete turbine system. For turbine or plant operating instructions, contact the plant-equipment manufacturer.

Part Number Options

Part Number Power

8200-1310	LVDC (18–36 VDC) Standard Compliance
8200-1311	AC/DC (88–264 VAC or 90–150 Vdc) Standard Compliance
8200-2312	ATEX Compliance LVDC (18–36 VDC)

Note on Control Part Numbers -

Control Part Number	All control revisions up to and including this revision, utilize the OS/Footprint p/n 5418-6479 and require GAP p/n 5418-6769 and GUI p/n 5418-6948	All control revisions at this revision and later, utilize the OS/Footprint p/n 5418-7795 and require GAP p/n 5418-7839 and GUI p/n 5418-7842
8200-1310	K	L
8200-1311	K	L
8200-2312	NONE	- (REVISION "DASH")

Terminology

505 Refers to the overall Woodward product family / hardware platform.

505XT Refers specifically to the Control/GUI application software features described in this manual – identified on unit p/n label and logo on the Home screen.

General Installation and Operating Notes and Warnings

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

For the marine type approved version, the field wiring must be installed with an additional shield layer which is grounded to the enclosure. The additional shielding is beyond the standard shielding described elsewhere in the manual, and it may be made from solid or flexible metal conduit, armored cabling, or a cable with an overall shield.

Note: For additional installation and operating information, see the Regulatory Compliance section of this manual.

Controller Overview

General Description

The 505XT is field programmable which allows a single design to be used in many different control applications and reduces both cost and delivery time. It uses a built-in graphical user interface (GUI) with multi-lingual menu driven screens to instruct site engineers on configuring the control to a specific generator or mechanical drive application. The 505XT can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

The 505XT control has seven PID controllers that can affect the controlled operation of the steam turbine. The Speed/load PID controller, the Cascade PID controller, Auxiliary PID controller, Inlet Steam PID controller, Extraction Steam PID controller, Exhaust Steam PID controller and an Acceleration PID controller. Depending on the configuration of the 505XT, these PIDs may be used or not used and could interact differently with each other based upon the type of turbine being controlled. Please refer to the block diagrams listed later in this chapter to fully understand PID relationships. An additional PID is available as an isolated control loop that is optional and can be used to drive an independent analog output signal (that is not driving a steam valve) for any single loop ancillary control that may be required (such as seal gas, gland seals, or lube oil pressure loops). When using the Isolated PID control, it is recommended to select the "Enable Readback Fault" option for the analog output channel configured as the Isolated PID Demand. This will trigger an alarm in the 505XT if a fault of the output circuit is detected. By default, analog output channels are not configured to produce an alarm when the output circuit has a fault.

When applied to single or split range actuator turbines, the 505XT drives one or two steam turbine throttle valves to control one turbine parameter at a time, and if desired, limit turbine operation based on other parameters. The one controlled parameter is typically speed (or load), however, the 505XT could be utilized to control or limit: turbine inlet pressure or flow, exhaust (back) pressure or flow, first stage pressure, generator power output, plant import and/or export levels, compressor inlet or discharge pressure or flow, unit/plant frequency, process temperature, or any other turbine related process parameter.

When applied to two valve turbines, the 505XT can control two turbine parameters at a time. Once the turbine is started and running online (either as a generator or mechanical drive), the control will transition into Ratio Limiter control operation. In this mode, the control will limit the turbine operation within an OEM defined turbine performance map that will define the operational area in which the control can actively control 2 independent parameters (based upon pressures, flows and load).

The 505XT is designed to control extraction, extraction/admission, or admission steam turbines. The difference between these turbines is the capability of the turbine to allow low pressure steam, which is at a lower pressure than the inlet, to enter and/or exit the turbine. An extraction turbine allows the lower pressure (extraction) steam to exit the turbine only and will have a non-return valve in the extraction header/line to prevent steam from entering the turbine. An admission turbine (also called induction) will allow excess header steam to enter the turbine through the low-pressure inlet. An extraction/admission turbine will allow low pressure header steam to enter or exit the turbine depending on system pressures. A turbine with admission capability will have a stop valve or trip-and-throttle valve in the low-pressure line to prevent steam from entering the turbine when the unit is tripped. The type of turbine used will depend on the system requirements and must be designed by the turbine manufacturer to perform the functions required.

It is possible to apply the 505XT to an Ext/Adm turbine that also has a split range inlet arrangement (3 total valves). To do this the, one of the valves must be driven either by analog output channel 1 (a 4-20 mA output) or by a Woodward digital link to a VariStroke or similar digital driver interface.

Refer to Volume 2 of this manual for details on applications.

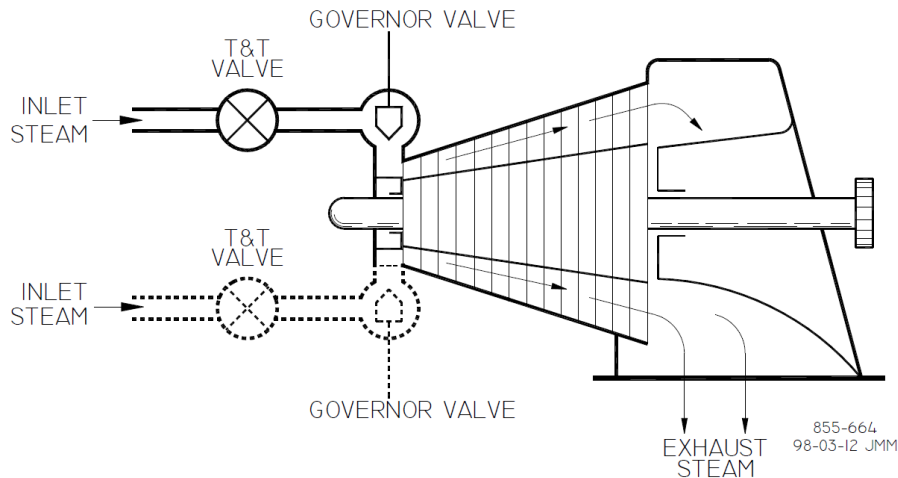


Figure 1-1. Typical Single or Dual Inlet Steam Turbine

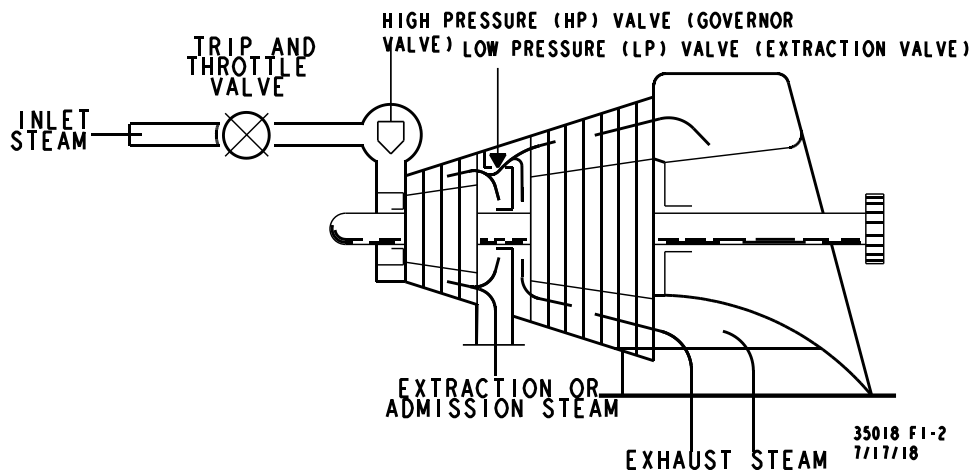


Figure 1-2. Typical Extraction and/or Admission Steam Turbine

Operator Control Panel

The 505 is a field configurable steam turbine control and operator control panel (OCP) integrated into one package. A comprehensive graphical operator control panel display and keypad is located on the 505's front panel. This display can be used to configure the 505, make On-Line program adjustments, and operate the turbine/system. Easy to follow instructions allow operators to view actual process and set point values at any time during turbine operation. Upon power-up from the factory the default HOME screen has a tutorial that will quickly give first-time users an overview of navigation and operation. Once the unit is configured, this tutorial is always available under the Service Menu.

Additional Features

In addition to the control loops mentioned, the 505XT also provides the following features:

- First-Out Trip indication of alarm and trip events with time stamp
- 15 external DI trip inputs and 15 external alarm DI inputs
- Critical speed avoidance (3 speed bands)
- Auto start sequence (hot & cold starts) with temperature input options
- Dual speed/load dynamics with automatic optimization tuning of dynamic gains
- A third set of speed dynamics for Ext/Adm units when operating in Ratio Limiter control modes
- Zero speed detection, peak speed indication, and direction of rotation
- Load droop and isochronous load sharing between units (with an DSLC-2 control)
- Feed-forward loop for compressor units
- High speed (10ms) datalog and slow speed (1 sec) trendlog capture files

- SNTP time synchronization via an Ethernet IP
- Ability to expand system I/O with Woodward Linknet Distributed I/O nodes
- Multiple digital communication links to other Woodward products (Woodward Links)

Using the 505XT

The 505XT control has three normal operating modes: Configuration Mode, Service Mode, and Run Mode. See Chapter 4 for more information about the User Levels required to enter each of these modes.

Configuration Mode –

This mode is used to select the options needed to configure the control to your specific turbine application. While in this mode, the control will force the hardware into IO LOCK, meaning that no outputs will be active, all relays will be de energized, and all analog output signals will be at 0 current. Once the control has been configured, the Configuration Mode is typically not needed again, unless turbine options or operation changes. It is available to be viewed at any time.

A password is required to log into this mode.

 WARNING	Anytime the control is in IOLOCK all relays will be de-energized and all analog outputs will be at 0 current. Ensure that the devices receiving these commands are fail-safe at these states.
--	--

Calibration Mode –

This mode is used to calibrate, tune, and adjust certain parameters either while the unit is shutdown, or during turbine run time. A password is required to log into this mode.

Operation Mode -

This mode is the typical state for normal operations of the control and the turbine. The Run Mode is used to operate the turbine from start-up through shutdown.

Functional Block Diagrams

An overview of the 505XT valve demands is shown in Figure 1-4. Most of the PIDs are optional controllers and are shown in the following diagrams for PID relationship purposes only. Later in this manual, more detailed functional block descriptions will be given in relation to each control loop PID. The Speed PID is always used and on Extraction/Admission type turbines the Extraction PID is required.

SIGNAL FLOW :

— — — — DISCRETE SIGNALS
 ————— ANALOG SIGNALS

SIGNAL FLOW IS FROM LEFT TO RIGHT. ALL INPUTS ENTER FROM THE LEFT. ALL OUTPUTS EXIT TO THE RIGHT. EXCEPTIONS NOTED.

CUSTOMER INPUT/OUTPUT :

INPUTS ORIGINATE ON THE LEFT SIDE OF THE DRAWING. OUTPUTS TERMINATE ON THE RIGHT SIDE OF THE DRAWING.

CONTACT INPUTS.

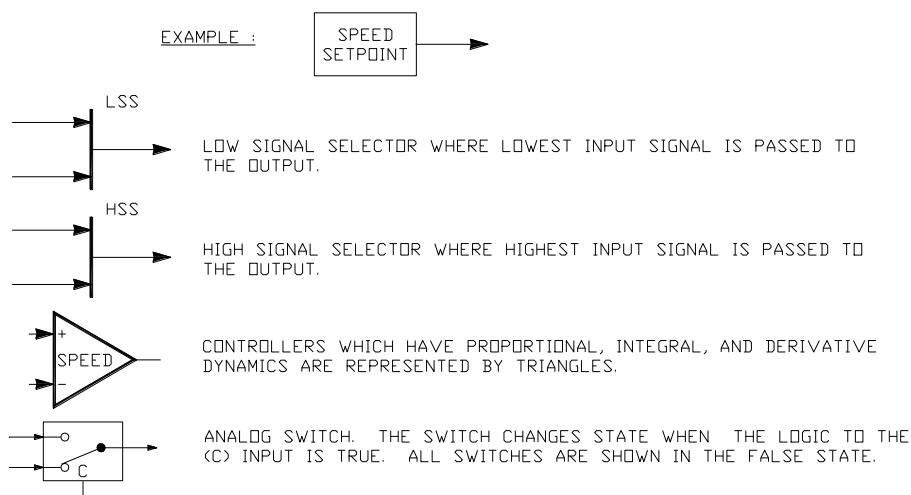
⋈ SYMBOLS INDICATE SWITCH CONTACT INPUTS.
 —⋈ LINE THROUGH SYMBOL INDICATES NORMALLY CLOSED CONTACT.

⎓ INDICATES INTERCONNECTING LOGIC IN FUNCTIONAL.

⎓ INDICATES FINAL DRIVER (ACTUATOR) OUTPUT

FUNCTION SYMBOLS :

COMMON GOVERNOR FUNCTIONS ARE REPRESENTED BY RECTANGULAR BLOCKS. A DESCRIPTION OF THE FUNCTION IS SHOWN INSIDE THE BLOCK.



855-667
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Figure 1-3. Explanation of Symbols

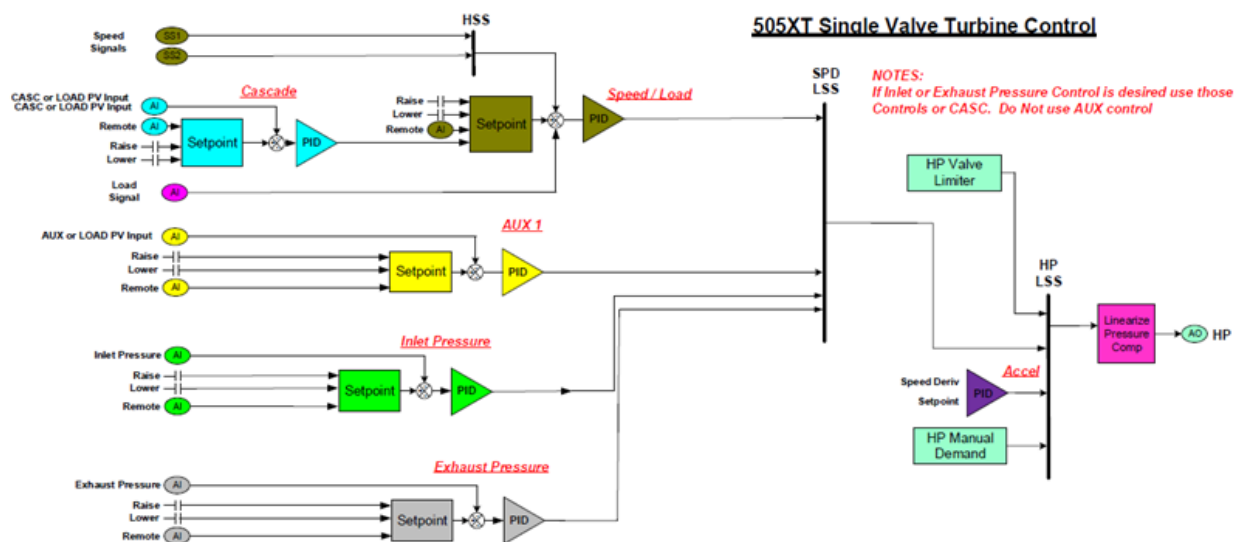


Figure 1-4. Single or Split-Range Turbine Configurations
 (Valve Demand Overview)

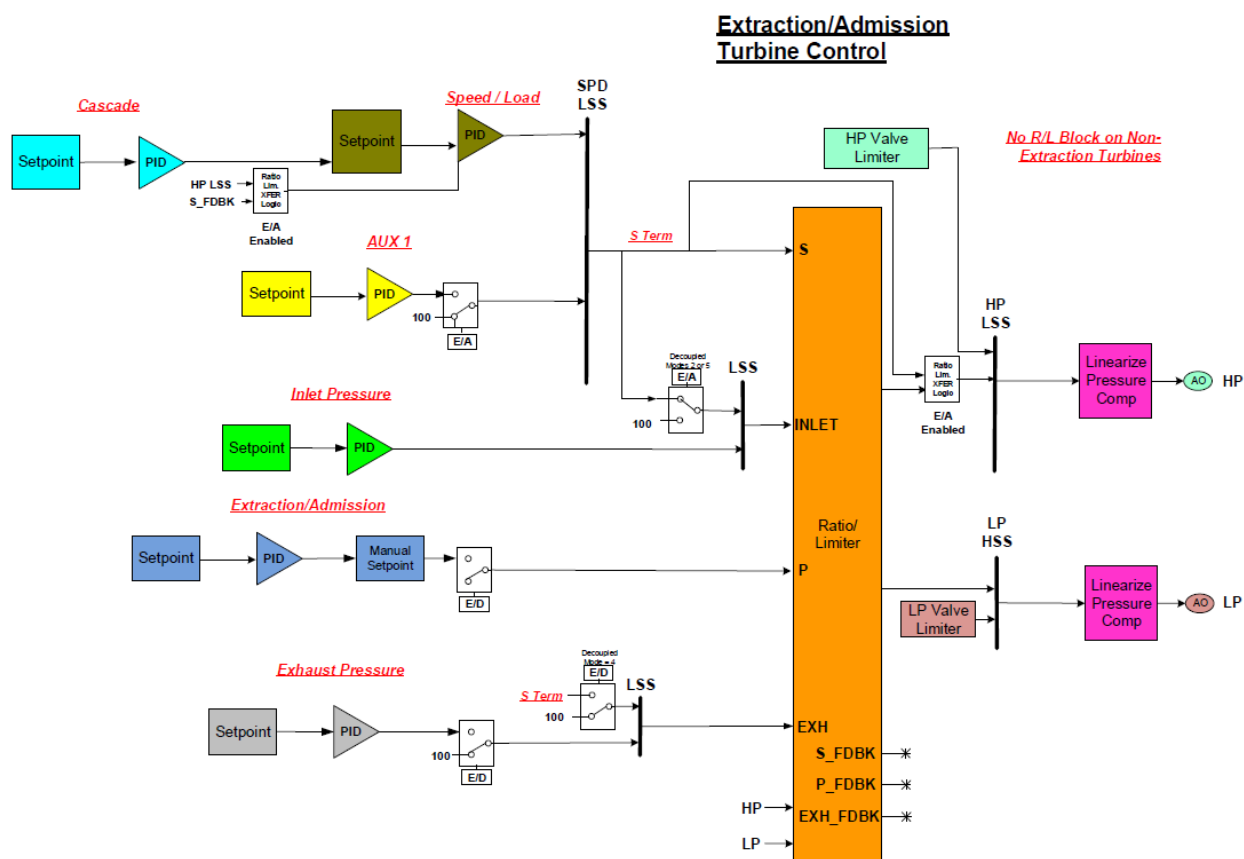


Figure 1-5. Turbine Configurations Using Extraction and/or Admission
(Valve Demand Overview)

505 Inputs and Outputs

Control Inputs

Speed Input Signals

Two redundant speed inputs are configurable to accept MPUs (magnetic pickup units), or active proximity probes.

Analog 4-20 mA Input Signals

There are eight configurable analog inputs available on the 505 hardware, each of which can be configured as one of the following input functions:

Table 1-1. Selectable Functions for 4-20mA Analog Inputs

1	--- Not Used ---	26	Signal Monitoring #3
2	Remote Speed Setpoint	27	Start Temperature 1
3	Synchronizing Input	28	Start Temperature 2
4	Sync / Load Share	29	Extraction/Admission Input
5	Generator Load Input	30	Remote Extr/Adm Setpoint
6	Cascade Input	31	Remote Manual Extr/Adm (P) Demand
7	Remote Cascade Setpoint	32	Remote Exhaust Pressure Setpoint
8	Auxiliary Input	33	Remote Inlet Pressure Setpoint
9	Remote Auxiliary Setpoint	34	LP Valve Position Feedback
10	Spare_10	35	Spare_35
11	Spare_11	36	Spare_36
12	Inlet Pressure Input	37	Spare_37

13	HP Actuator A Feedback	38	Spare_38
14	HP Actuator B Feedback	39	Spare_39
15	Speed Feed-Forward	40	Trip/Throttle Valve Position Feedback
16	Remote Droop	41	Vibration Signal #1
17	Remote Load Setpoint	42	Vibration Signal #2
18	Exhaust Pressure Input	43	Vibration Signal #3
19	Spare 19	44	Vibration Signal #4
20	HP Valve Feedback Position	45	Vibration Signal #5
21	HP2 Valve Feedback Position	46	Vibration Signal #6
22	Isolated PID PV	47	Vibration Signal #7
23	Remote SP for Isolated PV	48	Vibration Signal #8
24	Signal Monitoring #1	49	Spare_49
25	Signal Monitoring #2	50	Spare_50

Discrete Contact Input Signals

Twenty contact inputs are available. The first input is dedicated as an Emergency Shutdown Trip from the plant. DI 01 must be in a TRUE state to be healthy (fail safe) to be able to be cleared from the Trip list. The next 3 channels are configurable as per the list below, but for convenience are defaulted to the following functions: reset, raise speed set point, and lower speed set point. If the control is used in a generator application, two contact inputs must be configured for use as for a generator breaker and utility tiebreaker. The rest of the additional contact inputs are available for configuration to function as various controller discrete input functions as listed below. On the front panel display there are 4 additional keys that are always available for operational functions (GREEN keys) – Start/Stop/Reset and Adjust Up/Down for raising or lowering a highlighted value.

Table 1-2. Selectable Functions for Discrete Inputs

1	---Not Used---	51	Trigger Load Rejection Logic
2	Reset Command	52	Redundant HP Valve A Healthy
3	Speed Raise Command	53	Redundant HP Valve B Healthy
4	Speed Lower Command	54	Speed Forward Enable
5	Generator Breaker	55	Instant Min Gov/Load Speed
6	Utility Tie Breaker	56	Select Hot Start
7	Overspeed Test	57	Remote KW Setpoint Enable
8	External Run	58	Clock SYNC Pulse Contact
9	Start Permissive 1	59	Enable Rem SP for Isolated PID
10	Idle / Rated Command	60	Isolated Controller Raise
11	Halt/Continue Auto Start	61	Isolated Controller Lower
12	Override MPU Fault	62	LP Valve Limiter Open
13	Select On-Line Dynamics	63	LP Valve Limiter Close
14	Local / Remote	64	Extr/Adm Setpoint Raise
15	Rmt Spd Setpt Enable	65	Extr/Adm Setpoint Lower
16	Sync Enable	66	Extr/Adm Control Enable
17	Freq Control Arm/Disarm	67	Extr/Adm Remote Setpoint Enable
18	Casc Setpt Raise	68	Enable Manual Extr/Adm (P) Demand
19	Casc Setpt Lower	69	Inlet Pressure Setpoint Raise
20	Casc Control Enable	70	Inlet Pressure Setpoint Lower
21	Rmt Casc Setpt Enable	71	Inlet Pressure Control Enable
22	Aux Setpt Raise	72	Inlet Pressure Remote Setpoint Enable
23	Aux Setpt Lower	73	Exhaust Pressure Setpoint Raise
24	Aux Control Enable	74	Exhaust Pressure Setpoint Lower
25	Rmt Aux Setpt Enable	75	Exhaust Pressure Control Enable
26	Spare_26	76	Exhaust Pressure Remote SP Enable
27	Spare_27	77	Select Priority
28	Spare_28	78	Enable Decoupling
29	Spare_29	79	Manual P Demand Raise

30	HP Valve Limiter Open	80	Manual P Demand Lower
31	HP Valve Limiter Close	81	Redundant LP Valve A Healthy
32	Controlled Shutdown(STOP)	82	Redundant LP Valve B Healthy
33	External Trip 2	83	SPC11 is Healthy
34	External Trip 3	84	SPC12 is Healthy
35	External Trip 4	85	SPC13 is Healthy
36	External Trip 5	86	SPC14 is Healthy
37	External Trip 6	87	TTV Full Open Limit Switch
38	External Trip 7	88	TTV Full Closed Limit Switch
39	External Trip 8	89	External Trip 11
40	External Trip 9	90	External Trip 12
41	External Trip 10	91	External Trip 13
42	External Alarm 1	92	External Trip 14
43	External Alarm 2	93	External Trip 15
44	External Alarm 3	94	External Alarm 10
45	External Alarm 4	95	External Alarm 11
46	External Alarm 5	96	External Alarm 12
47	External Alarm 6	97	External Alarm 13
48	External Alarm 7	98	External Alarm 14
49	External Alarm 8	99	External Alarm 15
50	External Alarm 9	100	Enable Pre-Start Warm-up
		106	Reduced Overspeed Test Enable

Control Outputs

Actuator Outputs

Two 4–20 mA or 20–200 mA configurable actuator outputs with linearization curves are available for use. Actuator 1 is defaulted to be the main HP inlet valve demand, but both actuator channels are configurable to be HP, HP2 (for split range), LP (for Extraction and/or Admission turbines) or a readout. If used as a readout, the available functions are the same as the analog outputs below.

Analog 4-20 mA Outputs

Six 4–20 mA analog outputs are available for use, and each can be configured as one of the following output functions:

Table 1-3. Selectable Functions for 4-20mA Analog Outputs

1	--- Not Used ---	26	Isolated PID Setpoint
2	Actual Shaft Speed	27	Remote Isolated PID Setpoint
3	Speed Reference Setpoint	28	Remote KW Setpoint
4	Remote Speed Setpoint	29	Exhaust Pressure Input
5	Load Share Input	30	HP Valve Feedback Position
6	Synchronizing Input	31	HP2 Valve Feedback Position
7	Generator Load	32	Signal Monitoring #1
8	Cascade Input Signal	33	Signal Monitoring #2
9	Cascade Setpoint	34	Signal Monitoring #3
10	Remote Cascade Setpoint	35	Start Temperature 1
11	Auxiliary Input Signal	36	Start Temperature 2
12	Auxiliary Setpoint	37	LP Valve Demand
13	Remote Auxiliary Setpoint	38	LP Valve Limiter Setpoint
14	Spare_14	39	Extraction/Admission Input
15	Spare_15	40	Extraction/Admission Setpoint
16	Spare_16	41	Exhaust Pressure Setpoint
17	Valve Limiter Setpoint	42	Inlet Pressure Setpoint
18	LSS Value	43	Speed/Load Demand (S Demand)
19	HP Valve Demand	44	Extraction/Admission Demand (P Demand)

20	HP2 Valve Demand	45	Inlet Pressure Demand (Q_ Demand)
21	Inlet Pressure Input	46	Exhaust Pressure Demand (R_ Demand)
22	I/H Actuator 1 Feedback Readout	47	TTV Demand 1 Output
23	I/H Actuator 2 Feedback Readout	48	TTV Demand 2 Output
24	Isolated PID Dmd Output	49	Spare_49
25	Isolated PID PV Input Signal	50	Spare_50

Relay Outputs

Eight Form-C relay contact outputs are available. The first channel is dedicated as a Trip output and can be configured for use as a complete Summary Trip or a TRIP relay output (where the External Trip inputs are not included). The other seven are configurable relays, however the second relay is defaulted to be an alarm summary output.

Each relay can be programmed to provide a contact related to a conditional state as listed in the first list, or it can be triggered as a level-active switch as per the second list

Conditional States

Table 1-4. Selectable Functions for Relay Output States

1	--- Not Used ---	41	Cascade PID in Control
2	Summary Shutdown	42	Ready to Start
3	Summary Shutdown (Trip Relay)	43	Spare 43
4	Summary Alarm	44	Spare 44
5	All Alarms Clear	45	Unit OK (No SD)
6	Control Status OK	46	Remote KW SP Enabled
7	Overspeed Trip	47	Remote KW Setpoint Active
8	Overspeed Test Enabled	48	Manual Relay Control
9	Speed PID in Control	49	Isolated Controller in Auto
10	Remote Speed Setpoint Enabled	50	LP Valve Limiter in Control
11	Remote Speed Setpoint Active	51	Extr/Adm Control Enabled
12	Underspeed Switch	52	Extr/Adm Control Active
13	Auto Start Sequence Halted	53	Extr/Adm PID In Control
14	On-Line Speed PID Dynamics Mode	54	Remote Extr/Adm Setpoint Enabled
15	Local Interface Mode Selected	55	Remote Extr/Adm Setpoint Active
16	Frequency Control Armed	56	Inlet Pressure Control Enabled
17	Frequency Control	57	Inlet Pressure Control Active
18	Sync Input Enabled	58	Inlet Pressure PID In Control
19	Sync / Loadshare Input Enabled	59	Remote Inlet Pressure Setpoint Enabled
20	Loadshare Mode Active	60	Remote Inlet Pressure Setpoint Active
21	Cascade Control Enabled	61	Exhaust Pressure Control Enabled
22	Cascade Control Active	62	Exhaust Pressure Control Active
23	Remote Cascade Setpoint Enabled	63	Exhaust Pressure PID In Control
24	Remote Cascade Setpoint Active	64	Remote Exhaust Pressure SP Enabled
25	Auxiliary Control Enabled	65	Remote Exhaust Pressure SP Active
26	Auxiliary Control Active	66	Priority Selected
27	Auxiliary PID in Control	67	Alternate Mode Enabled
28	Remote Auxiliary Setpoint Enabled	68	Controlling on Steam Map Limiter
29	Remote Auxiliary Setpoint Active	69	Priority Active
30	Unit Started	70	Extr/Adm Input Failed
31	Spare_31	71	Inlet Pressure Input Failed
32	Spare_32	72	Exhaust Pressure Input Failed
33	Spare_33	73	Zero Speed
34	Spare_34	74	Extraction in P Demand Control
35	HP Valve Limiter in Control	75	Extraction in Remote P Demand Control
36	Command from Modbus BW addresses	76	TTV Open Valve Command
37	Reset Pulse (2 sec)	77	TTV Close Valve Command

38	Open GEN Breaker Cmd	78	Spare_78
39	Feed-Forward Enabled	79	Spare_79
40	Feed-Forward Active	80	Spare_80

Level Activated Switch Using this Value:

Table 1-5. Selectable Functions for Relay Output Level Switches

1	--- Not Used ---	26	Ext/Adm Demand (P Demand)
2	Actual Speed	27	Inlet Pressure Setpoint
3	Speed Setpoint	28	Inlet Pressure Demand (Q Demand)
4	KW Input	29	Exhaust Pressure Setpoint
5	Sync/Load Share Input	30	Exhaust Pressure Demand (R Demand)
6	Cascade Input	31	Spare_31
7	Cascade Setpoint	32	Spare_32
8	Auxiliary Input	33	Spare_33
9	Auxiliary Setpoint	34	Spare_34
10	Spare_10	35	Spare_35
11	Spare_11		
12	HP Valve Limiter		
13	LSS Value		
14	HP Valve Demand Output		
15	HP2 Valve Demand Output		
16	Inlet Pressure		
17	Exhaust Pressure		
18	Customer Defined Monitor Input #1		
19	Customer Defined Monitor Input #2		
20	Customer Defined Monitor Input #3		
21	LP Valve Limiter		
22	LP Valve Demand		
23	Speed/Load Demand (S Demand)		
24	Extr/Adm Input		
25	Extr/Adm Setpoint		

Optional Distributed I/O

Additional I/O has been pre-programmed using Woodward's LinkNet distributed I/O nodes. These are available via the Configuration Menu (under Woodward Links) and the user is free to select any or all the nodes listed below. All distributed I/O channels have the same menu of functional choices as the lists above for the 505 hardware I/O.

These nodes are

Table 1-6. Available (Programmed) Distributed I/O Nodes

Node Device ID	Part Number	Description	I/O Type/Quantity
1	8200-1203	Analog 4-20 mA I/O	8 AI and 2 AO
2	8200-1203	Analog 4-20 mA I/O	8 AI and 2 AO
3	8200-1200	RTD Temperature Inputs	8 RTD
4	8200-1204	Discrete Input	16 DI
5	8200-1205	Discrete Output	16 DO

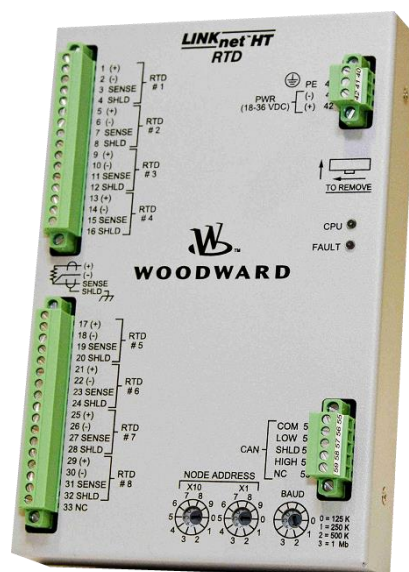


Figure 1-6. LinkNet Distributed I/O Node

Adding Vibration Sensing

By adding one AI/AO LinkNet Node the 505XT can support up to 8 Vibration monitoring input signals (4-20 mA inputs).

- There is a 'Configuration Wizard' to help program these into the LinkNet AI channels – from 1-8 channels
- Signals can be radial or axial – user can enter description in TAG field (see channel info below)
- Each channel has range fault detection and alarm and trip (or Second ALM) Level Settings
- There is a setting to Trip if too many Vibration sensors are failed (in the screen shot below – 4 sensors are brought into the 505 and 2 sensors minimum are required to run turbine)
- There will be a monitor page (as shown below) available from the Startup Curve page



Figure 1-7. Vibration Wizard for LinkNet Node 1



Figure 1-8. LinkNet Node 1 with 4 Vibration Signals



Figure 1-9. Vibration Monitoring Page

If vibration probes are added to the CORE AI channels on the 505 unit instead of a LinkNet device, then alarm and trip levels must be programmed in the Configurable Alarms section (up to 3 available) of the SERVICE menu. With this option, the Vibration monitoring screens are not available.

Using External Trips on LinkNet Discrete Input Module

When External Trip signals are used on the LinkNet modules, the signal is automatically inverted. When the signal goes FALSE, the contact is open, and then the Trip signal will be sent to the control. Unlike External Trips wired into the CORE DI channels on the 505 unit, 1ms time stamping resolution is not available on the LinkNet External Trip signals.

Control Communication Interfaces

Modbus

A complete Modbus list of information is available for HMI, plant DCS or other control interfaces. Three physical ports are available for this communication method, 2 Ethernet (RJ45) ports and 1 serial port. The serial port protocol can be either ASCII or RTU and the communications can be RS-232 or RS-485. The Ethernet links can be configured as TCP or UDP on either ENET ports 1 or 2.

Ethernet port 3 is dedicated to use for pre-programmed communication links to other Woodward devices (found in the Woodward Link section of the Configuration menu). The DSLC-2 and HighProtec are examples of other products that can be networked to the 505XT using this port.

The control also communicates Servlink protocol (Woodward proprietary) via the Ethernet ports. Using Woodward's Servlink to OPC Server tool any PC can use this connection to communicate to the control and relay OPC data to the various service tools that support the product.

CAN

The CAN communication ports are available for interfacing the control application with other products. The 505XT has been programmed these to be used for the following:

- CAN #1 Link to digital drivers/actuators (such as VariStroke family)
- CAN #2 Link to LinkNet distributed I/O nodes
- CAN #3 Link to Power management products (such as LS-5, MFR300)
- CAN #4 Reserved

Keypad and Display

Graphical Display Key Inputs

The front panel display is designed to provide the user with multiple levels of access for configuring, calibrating, tuning, operating, and monitoring the turbine operation. No additional control panels are required to operate the turbine, every turbine control function can be performed from the 505's front panel.



Figure 1-10. 505 Keypad and Display

A description of each key's function follows.

Hard Key Commands

NUMERIC KEYPAD

These are available for entering numeric values or text strings directly into the control when a configurable or programmable edit field has been selected. The bottom row of keys have some special features.



This is a backspace and delete (used when entering text)



In Text Mode this functions as a shift key. When making analog adjustments with the ADJUST key – pressing this key at the same time as the ADJUST will invoke a 'Fast' rate of adjustment



Brightness key – hold this down and then use the ADJUST key to increase/decrease the screen brightness

EMERGENCY TRIP KEY

This will Trip the Turbine and remove all current from the actuator outputs (zero current).

LED

Four LEDs are on the left side – a Summary Trip, Summary Alarm, IO Lock, and CPU Health. The first two are controlled solely by the GAP program and relate to the status of the control. The IOLOCK and CPU LEDs relate to the H/W status and are identical to these same indications on the back of the 505

VIEW buttons will jump to the Trip or Alarm Summary screen to show these events in sequence with time stamp.

MODE button will jump to a Login screen that allows the user to view current permissions and allow access to changing the user login level

ESC Key – this will always step the user 'back' one page from the current page displayed

HOME Key

Brings the user to the Home menu for Run, Service, or Configure. Pressing it a second time will return to the Run (Operate) Menu Home Screen

NAVIGATION CROSS KEYS

These are the primary keys for navigating from page to page, or for navigation of the FOCUS on any page.

Soft Key Commands – Dependent on the screen currently in view – the user must use the navigation cross keys to move the "Focus" to the desired component

GREEN KEYS

Generally, perform operational Actions – such as Enabling, Disabling, Starting, Stopping, Tuning or Adjusting values

MAROON KEYS

Generally, perform navigational actions that escort the user through the screen menus

BLACK KEYS

Are soft-key functions that relate to the display indication above them. They can be navigational or operational. These items do not require "Focus", they are always available on that particular screen.

NOTICE**Screen Tutorial**

The 505 has a detailed Tutorial that is always accessible through the Service Menu. It provides 'On-Screen' help on topics such as Navigation, User Levels, Operating Modes, how to adjust parameters, and more. The User should familiarize themselves with these screens

Watchdog Timer/CPU Fault Control

The IO Lock and CPU Health LEDs on the front left side of the display – are always in an identical state as the LEDs on the back side of the control. They are completely controlled by the 505 control hardware and are not controlled by the GAP application.

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

Chapter 2.

Hardware Specifications

505 Description and Features

The 505 controller is a significant upgrade to the existing 505-product line with enhanced CPU, Graphical display, communications, and I/O functions.

Note: This controller supports expanded I/O options when using Woodward CAN distributed I/O nodes.

Features

- Same installation/mounting as current 505
- 8.4" LCD display (800x600) and keypad
- (LV) input power: 18-36 VDC input, isolated
- (HV) input power: 88-264 VAC / 90-150 VDC, isolated
- Operating range of $-30\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$ (with display)

Communications

- (4) Ethernet 10/100 communication ports, isolated
- (4) CAN communication ports (1 Mbit), isolated
- RS-232/RS-485 port, isolated
- RS-232 Service port, isolated

I/O circuits

- GAP configurable update rates of 5 ms to 160 ms
- (2) Speed Sensor inputs (MPU/Prox) (with prox power)
- (8) Analog input 4-20 mA channels (with loop power)
- (6) Analog output 4-20 mA channels
- (2) Actuator output channels (configurable 4-20 mA/20-200 mA)
- (20) Discrete input channels (with contact power)
- (8) Relay outputs (form-c)

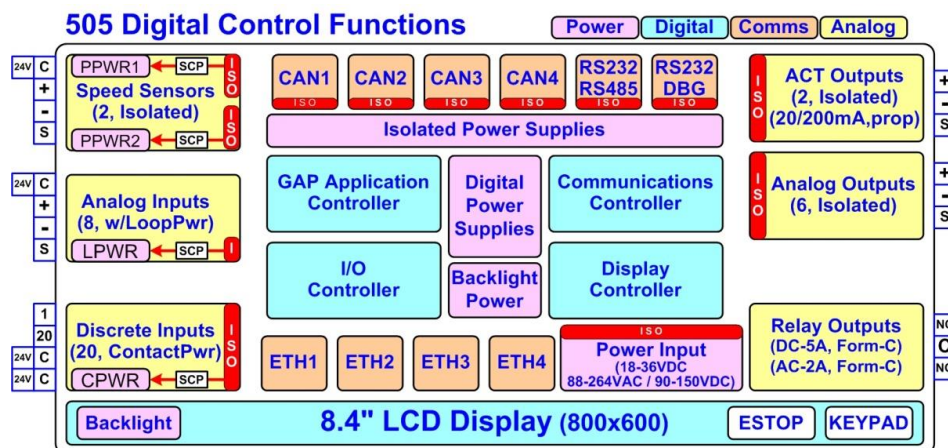


Figure 2-1. Functional Block Diagram (505 Control)

Environmental Specifications

Table 2-1. Environmental Specifications

Operating Temperature ¹	–30 °C to +70 °C (with display)
Storage Temperature	–30 °C to +70 °C (recommended 10 °C to 40 °C)
Vibration	STD (standard location version) 8.2 Grms, industrial skid mount, per Woodward RV1 ATX (ATEX certified version) 1.04 Grms, control room, per Woodward RV5
Shock ²	10 G, 3x each axis, per Woodward MS1 procedure
Humidity ^{3,4}	5 % to 95 %, non-condensing
Altitude	3000m (9842 ft.)
Ingress Rating / Installation ⁵	IP20, Pollution Degree2, Overvoltage Category 2
Conformal coating	Polyacrylate, sulfur resistant (see AppNote #51530)
EMC Emissions ⁶	EN 61000-6-4 (Heavy Industrial) IACS UR E10 (Commercial Marine)
EMC Immunity ⁶	EN 61000-6-2 (Heavy Industrial) IACS UR E10 (Commercial Marine)

¹Limited by LCD display

²Limited by internal relay specification

³Relative humidity levels of < 55% will prolong LCD life

⁴Cyclic condensing humidity is supported with an appropriate enclosure

⁵ATEX and IP54 are supported with an appropriate enclosure using the ATEX qualified unit.

⁶Marine specification applies to the Marine qualified unit

Maintenance Info and Recommendations

The 505 control is designed for continuous operation in a typical industrial environment and includes no components that require periodic service. However, to take advantage of related product software and hardware improvements, we recommend that your product be sent to a Woodward Authorized Service Facility after every five to ten years of continuous service for inspection and component upgrades.

Clock Battery

The Real Time Clock (RTC) battery is designed to last approximately 10 years during normal turbine operation. When powered, the RTC automatically disables the battery usage to preserve it. During power-off the battery is enabled and only used to maintain date and time. For long term storage, the battery is specified to last > 5 years.

The RTC battery is a replaceable lithium coin cell Woodward PN 1743-1017. Contact a Woodward Authorized Service Center if a replacement service is needed.

Calibration and Functional Verification

It is recommended to verify calibration and functional operation every 24-36 months. This is especially important for spare units that need to be ready for immediate use. Contact a Woodward Authorized Service Center for assistance.

Aluminum Electrolytic Capacitors

It is recommended to apply power to spare units every 24-36 months for 3 hours to reform the electrolytic capacitors used in the power module.

Display LCD with Backlight

The 505 uses a low power LED backlight display with a life expectancy of 60K hours to half brightness, at maximum operating temperature. If the display appears dim, use the “SCREEN SETTINGS” menu to verify the brightness setting and adjust as needed with the ADJ ARROW-BRIGHTNESS keypad combination. Contact a Woodward Authorize Service Center for a replacement display when damaged or if display quality is unacceptable.

Electromagnetic Compatibility (EMC)

The Flex500 product family complies with Heavy Industrial EMC requirements per EN 61000-6-4 & EN 61000-6-2 specifications. Marine Type Approval is also met per IACS UR E10 EMC test requirements when a Marine qualified version is used.

Emissions EN 61000-6-4 & IACS UR E10

- Radiated RF Emissions Limits 150 kHz to 5000 MHz per IEC 61000-6-4 & Marine Type Approval.
- Power Line Conducted RF Emissions Limits 10 kHz to 30 MHz per IEC 61000-6-4 & Marine Type Approval.

Immunity EN 61000-6-2 & IACS UR E10

- Electrostatic Discharge (ESD) immunity to ± 6 kV contact / ± 8 kV air per IEC 61000-4-2.
- Radiated RF Immunity to 10 V/m from 80 MHz to 3000 MHz per IEC 61000-4-3.
- Electrical Fast Transients (EFT) Immunity to ± 2.0 kV on I/O and Power Supply inputs per IEC 61000-4-4.
- Surge Immunity on DC Power Supply inputs to ± 1.0 kV line to earth and ± 0.5 kV line to line per IEC 61000-4-5.
- Surge Immunity on AC Power Supply inputs to ± 2.0 kV line to earth and ± 1.0 kV line to line per IEC 61000-4-5.
- Surge Immunity on I/O to ± 1.0 kV line to earth per IEC 61000-4-5.
- Conducted RF Immunity to 10 V (rms) from 150 kHz to 80 MHz per IEC 61000-4-6.
- Conducted Low Frequency Injection Immunity at 10% of the nominal supply level from 50 Hz to 12 kHz on power inputs per Marine Type Approval test requirements.

Outline Drawing for Installation

The physical outline dimensions for the 505D control are shown below. See Woodward Reference drawing 9989-3210 for additional details if necessary.

NOTICE

This 505 unit has the identical mounting hole pattern as the previous version, however the holes do not come through the front of this unit; therefore, mounting screws of correct length must be used.

NOTICE

Mounting of the 505D, 505XT and Flex500 with the LCD Display and Keypad must be in the vertical orientation with the ventilation slots at the top and bottom of the control. The surrounding air temperature of the control cannot exceed 70°C.

Panel Mounting information

- There are 8 x 10-32 UNF-2B tapped holes that are used to mount the 505.
- The holes are tapped to 0.312" min Depth. Choose the proper length screw to not exceed this depth into the Bezel.
- Use screw 1069-949 (.375 Long, 10-32) for panel thickness (including washers) .065" - .100"
- Use screw 1069-948 (.438 Long, 10-32) for panel thickness (including washers) .101" - .125"
- Use screw 1069-946 (.500 Long, 10-32) for panel thickness (including washers) .126" - .187"

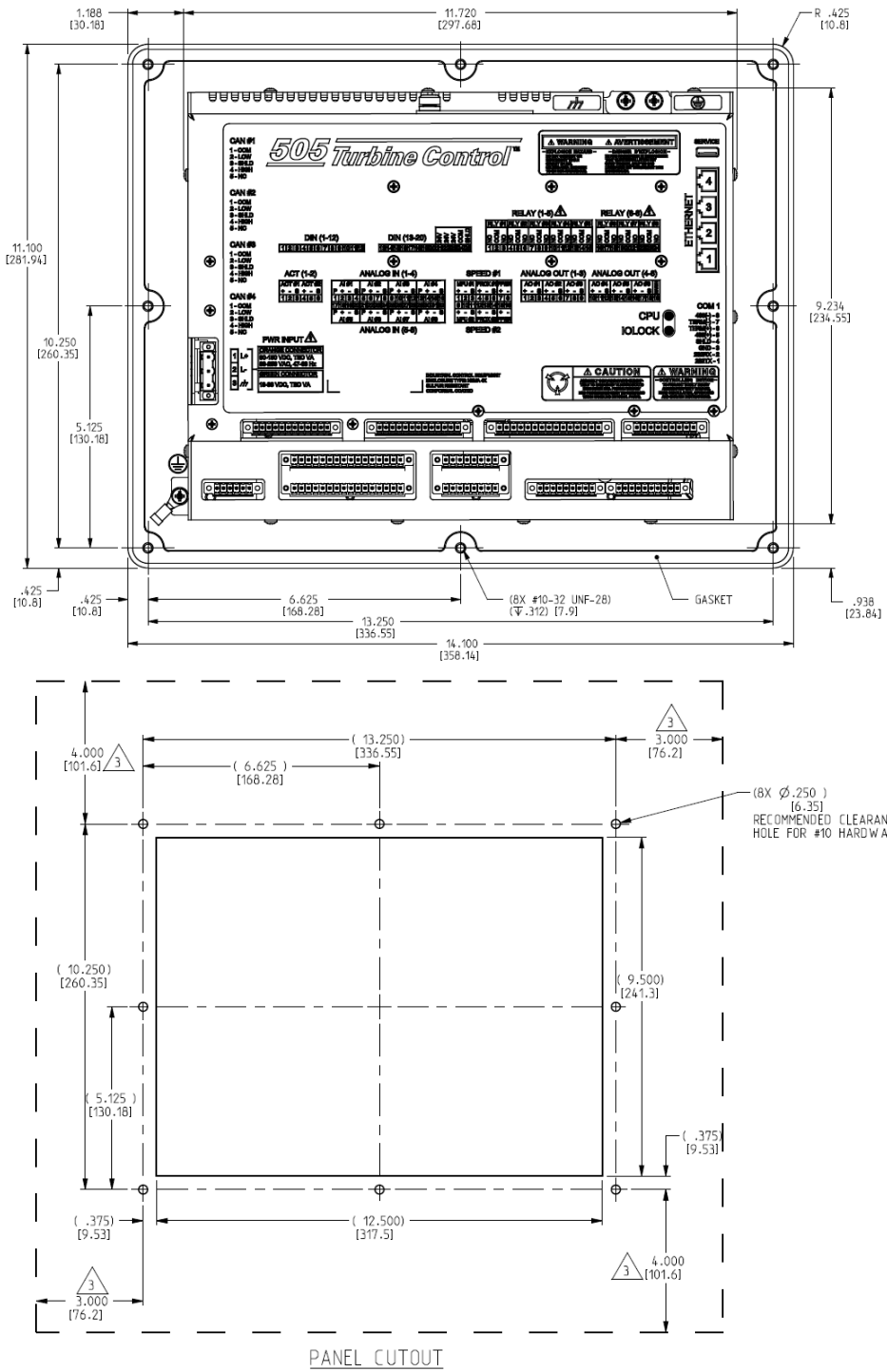


Figure 2-2. 505D Outline Drawing

Input Power Specification

Specifications (LV)

LV input voltage range: 18-36 VDC

Input power (max): < 77 W, 4.3 A max

Output voltage holdup time: > 14 ms with 24 VDC input voltage

Isolation to other circuits: > 500 Vrms to all other circuits

Isolation to EARTH: > 500 Vrms to EARTH

Input overvoltage protection: ± 60 VDC @ 25 °C

Reverse polarity protection: 60 VDC @ 25 °C

Input undervoltage shutdown: ~ 11 VDC, non-latching

Note: Breaker or powerline fusing of 8 A min is recommended to protect the power wiring network from possible wiring shorts.

Specifications (HV)

HV input voltage range: 88-264 VAC / 90-150 VDC

HV input frequency range: 45-65 Hz

Input power (AC max): < 73 W, 1.6 A max

Input power (DC max): < 73 W, 0.8 A max

Output voltage holdup time: > 30 ms with 110 VAC input voltage

Output voltage holdup time: > 120 ms with 220 VAC input voltage

Isolation to other circuits: > 3000 Vrms to all other circuits

Isolation to EARTH: > 1500 Vrms to EARTH

Input overvoltage protection: ± 375 VDC @ 25 °C

Reverse polarity protection: 375 VDC


Input Undervoltage Shutdown: ~ 65 VDC, non-latching

Note: Breaker or powerline fusing of 3.5 A min is recommended to protect the power wiring network from possible wiring shorts.

Power Connector

Input Power is provided through a 3 position, latching terminal block with removable plug. Green connectors are used for low voltage DC units. Orange connectors are used for high voltage AC/DC units.

Table 2-2. Input Power Connector Pinout


Board Connection	PIN	Name	Description
	1	L+	Input Power (+)
	2	L-	Input Power (-)
	3	EARTH	Earth / shield connection

Plug Type: Side entry 7.62 mm, 12 A, pluggable with latching screw down



WARNING

Electric Shock

To reduce the risk of Electrical Shock the Protective Earth (PE) must be connected to the PE  terminal on the enclosure. The conductor providing the connection must have a properly sized ring lug and wire gauge equal to or larger than 4mm² (12AWG).

Visual Indicators (LED's) & CPU Configuration

Visual indicators are located on the Front Panel keypad, the controller board, back cover, and related communications ports for diagnostic use.

CPU OK indicator (green/red)

This bi-color LED indicates the CPU status is operational (green) or faulty (red). The CPU will flash fault codes (red) if they exist. This LED exists on both the Front Panel and back cover.

IOLOCK indicator (red)

Indicate the controller is shut down and held in an IOLOCK state. This LED exists on both the Front Panel and back cover.

ALARM indicator (yellow)

Viewable from the front panel and controlled by GAP software.

TRIPPED indicator (red)

Viewable from the front panel and controlled by GAP software.

Ethernet LED's

(green=link, yellow=traffic) on each RJ45 connector indicate port status and operation.

CPU Hardware Configuration

The CPU Configuration Switch (S1) is reserved for future use and is not active at this time.

Communications (Ethernet)

There are (4) isolated RJ45 Ethernet Ports (10/100 Mbit/sec) available to the application software for system use. These ports are full duplex with auto crossover detection.

Features

- Interface standard: IEEE 802.3 (Ethernet)
- Port Isolation: 1500 Vrms to PS, EARTH, and all other circuits
- Control configuration using Woodward AppManager
- Control monitoring, trending, and datalog collection
- Control configuration of Ethernet IP addresses
- General communications such as Modbus master/slave
- Manage Configuration data and tunables with Control Assistant
- Network time setup and control (SNTP)

Network Configuration.

Ethernet ports (ETH1-4) can be configured for the customer network as desired. See the on-site Network Administrator to define an appropriate I/P address configuration.

IMPORTANT

ETHERNET CABLES—Max cable length is 100 meters. To ensure signal integrity and robust operation, double shielded (SSTP) Cat5 Ethernet cables are required for customer installations. (Woodward PN 5417-394, 10 feet)

IMPORTANT

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

Ethernet #1 (ETH1) = 172.16.100.15, Subnet Mask = 255.255.0.0

Ethernet #2 (ETH2) = 192.168.128.20, Subnet Mask = 255.255.255.0

Ethernet #3 (ETH3) = 192.168.129.20, Subnet Mask = 255.255.255.0

Ethernet #4 (ETH4) = 192.168.130.20, Subnet Mask = 255.255.255.0

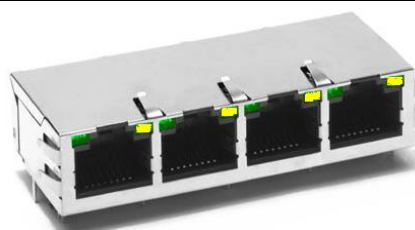
IMPORTANT

Each of the ETHERNET ports is required to be configured for a unique subnet (domain) (view default settings as an example).

Ethernet Connector (RJ45)

Table 2-3. Ethernet Ports #1-4 (10/100)

Board Connection



Description

Pin 1 – TX+
 Pin 2 – TX-
 Pin 3 – RX+
 Pin 4 – not used
 Pin 5 – not used
 Pin 6 – RX-
 Pin 7 – not used
 Pin 8 – not used
 SHIELD = Chassis
 GND

Network Configuration Utility (AppManager)

Woodward's *AppManager*™ software can be used to configure network setting and load control software (GAP), HMI display software (QT), and operating system service packs. The AppManager utility can be downloaded from www.woodward.com/software.

A PC connection must be made to Ethernet #1 (ETH1) using a RJ45 Ethernet cable.

Note: AppManager can always be used to “discover/view” the current CPU IP Address. However, to modify settings or load applications, the PC running AppManager must be reconfigured to be on the same “network” as the CPU.

- Locate the ControlName on the module faceplate and highlight it in AppManager.
- To VIEW the IP address configuration, select menu option CONTROL - CONTROL INFORMATION. Look for the Ethernet adapter addresses under the Footprint Description.
- To CHANGE the IP address configuration, select menu option CONTROL - CHANGE NETWORK SETTINGS.

Communications (CAN)

Four (4) Isolated CAN ports are available for general communications as well as simplex or redundant distributed control. Compatible devices include Woodward RTCnet nodes, LINKnet HT nodes, DVP valve products, and other third-party devices. Removable latching connector plugs are provided for field wiring.

Network Termination: CAN networks must include a 120 Ω termination resistor at each end of the trunk line.

Network Topology: Daisy chain connections between multiple devices are recommended. Any drop cable connection of a device to the trunk line should be as short as possible and much less than six meters. Recommend designing the network trunk to be less than 100 meters with a max cumulative drop length of less than 39 meters.


Important: For one Mbit/sec communication it is required that each drop cable be less than 1 meter and as short as possible.

Table 2-4. CAN Specifications

Interface Standard	CAN 2.0B, CANopen
Network Connections	(4) CAN ports, separate connectors
Network Isolation	500 Vrms to EARTH, other CAN ports, all other I/O
Network Speed/Length	1 Mbit @ 30 m
	500 Kbit @ 100 m
	250 Kbit @ 250 m (thick cable only, otherwise limited to 100 m)
	125 Kbit @ 500 m (thick cable only, otherwise limited to 100 m)
Network Termination:	(120 \pm 10) Ω is required at each end of the network trunk line. **The termination resistor is NOT built into the hardware.
CAN Address	Software configurable
CAN Baud Rate	Software configurable for 125 K, 500 K, 250 K, and 1 Mbit
Cable / Part Number	2008-1512 (120 Ω , 3-wire, shielded twisted pair) —Belden YR58684 or similar
Cable Drops (1 Mbit)	CAN Cable drops shall be < 1 m and as short as possible
Cable Drops (500K, etc)	CAN Cable drops shall be < 6 m and as short as possible

**If needed, an isolated CAN to USB converter is IXXAT, HW221245

Table 2-5. CAN Connector Pinout

Board Connection	PIN	Color	Description
	1	BLACK	CAN Signal Ground
	2	BLUE	CAN Low
	3	Shield	CAN Shield (30 Meg + AC coupled to EARTH)
	4	WHITE	CAN High
	5	n/a	Not used, no internal connection

Plug Type: Side entry 3.5 mm, 8 A, pluggable with latching screw down

Max wire size: 1.3 mm² / 16 AWG for single wires, 0.5 mm² / 20 AWG for two wires

CAN Cable Specifications

Belden YR58684 (Woodward PN 2008-1512) communications / CAN cable is approved and recommended. This is a smaller and more flexible 0.3 mm² / 22 AWG, low capacitance cable suitable for tight routing in industrial environments.

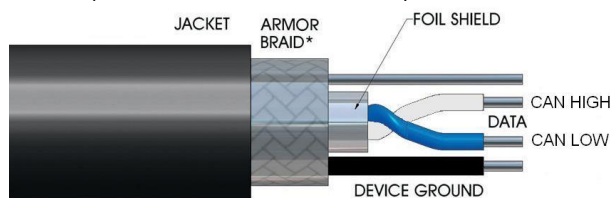
Belden YR58684, bulk cable (Woodward PN 2008-1512)

Table 2-6. CAN Cable Specifications

Impedance:	120 Ω \pm 10 % at 1 MHz
DC Resistance:	17.5 Ω per 1000 ft
Cable Capacitance:	11 pF/ft at 1 kHz
Data Pair:	0.3 mm ² / 22 AWG, 7 strands, individually tinned, FEP insulation (BLUE, WHITE twisted pair)
Ground:	0.3 mm ² / 22 AWG, 7 strands, individually tinned, FEP insulation (BLACK)
Drain / Shield Wire:	0.3 mm ² / 22 AWG, 7 strands, individually tinned
Shielding:	Foil 100 % with outer Braid 65 %
Jacket:	FEP Insulation, BLACK
Cable Type:	1.5 pair, twisted shielded
Outer Diameter:	0.244 inch
Bend Radius:	2.5 inches
Temperature:	-70 °C to +125 °C
Similar Cable:	Belden 3106A (has different colors & lower temperature specs)

CAN Wiring / Shield Terminations & Limitations

For robust communications performance, the CAN cabling needs to minimize the exposed, non-shielded cable section that occurs at terminal blocks. The exposed length of CAN wiring must be limited to less than 3.8 cm / 1.5 inches from the end of the shield to the terminal block.

CAN shields are terminated to chassis (EARTH) through a capacitor-resistor network. This is designed into the Flex500 / 505 hardware products. However, the shield must also be directly terminated to chassis (Earth) at one point in the network. In the case of Woodward equipment, the direct ground is meant to be located at the master device end, as it exits the master device's enclosure.

IMPORTANT

Always use shielded cables for improved communications in industrial environments. Wire terminations should expose as little un-shielded cable as possible (less than 3.8 cm / 1.5 inches).

Communications (RS-232/RS-485)


An isolated, configurable RS-232 / 485 serial port is available for customer use, as configured by the GAP software application. RS-422 communications are NOT supported.

Specifications

- Interface standard: RS-232C and RS-485
- Isolation: 500 Vrms to EARTH and all other I/O
- Baud Rates: 19.2K, 38.4K, 57.6K, and 115.2 K
- Max Distance (RS-232): 15 m (50 feet) max
- Max Distance (RS-485): 1220 m (4000 feet) max
- A shielded cable is required when using this port.
- RS-485 networks require termination at both ends with approximately 90–120 Ω impedance that matches the characteristic impedance of the cable used.

Cable Note: Woodward cable 2008-1512 (3-wire) is a shielded, low capacitance 120 ohm cable that is designed for communications. This cable is also used for CAN communications.

Table 2-7. COM1 Serial Port (RS-232/485)

Board Connection	Description
 <p>(8 pins)</p>	Pin 1 – RS-232 Transmit
	Pin 2 – RS-232 Receive
	Pin 3 – Signal Common
	Pin 4 – Shield (AC)
	Pin 5 – RS-485 (+)
	Pin 6 – Termination Resistor (+)
	Pin 7 – Termination Resistor (-)
	Pin 8 – RS-485 (-)

Plug Type: Side entry 3.5 mm, 8 A, pluggable with latching screw down
Max wire size: 1.3 mm² / 16 AWG for single wires, 0.5 mm² / 20 AWG for two wires

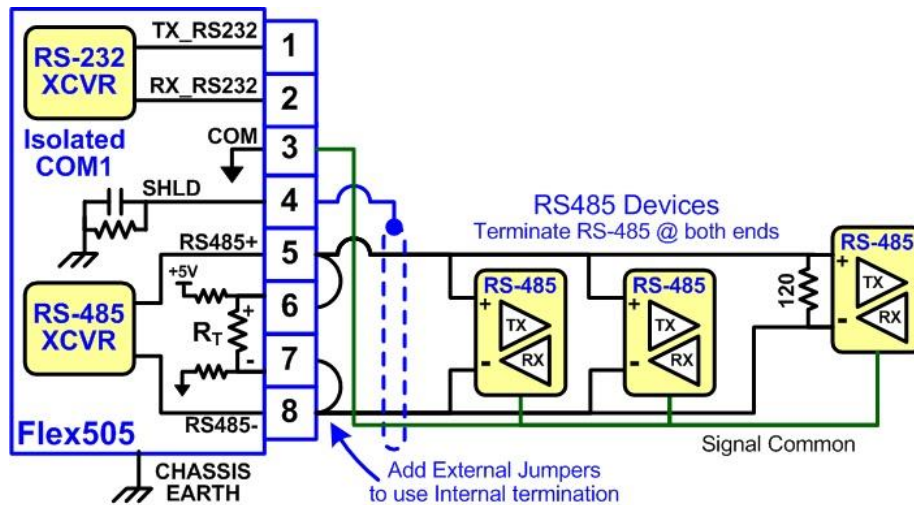


Figure 2-3. COM1 Example RS-485 Wiring


Communications (Service Ports)

RS-232 Service Port

An isolated RS-232 service port is located on the CPU board. Isolation is specified at 500 Vrms and baud rate is fixed at 115.2K baud, 8 data bits, no parity, 1 stop-bit, and no flow control. This port is for VxWorks operating system use only and cannot be configured for application software use.

For debug use, a **Woodward PN 5417-1344**, USB to serial debug cable is required to attach this port to a PC. This port is to be used by trained Field Service personnel only!

Table 2-8. CPU Service Port (3 pin, 2 mm)

	Dura-Click connector (male)
	Pin 1 – RS-232 Transmit
	Pin 2 – RS-232 Receive
	Pin 3 – Signal Ground

USB Service Port

Note: A USB service port is provided for future use, but is disabled.

Hardware - Terminal Blocks & Wiring

Back cover view with wiring label.

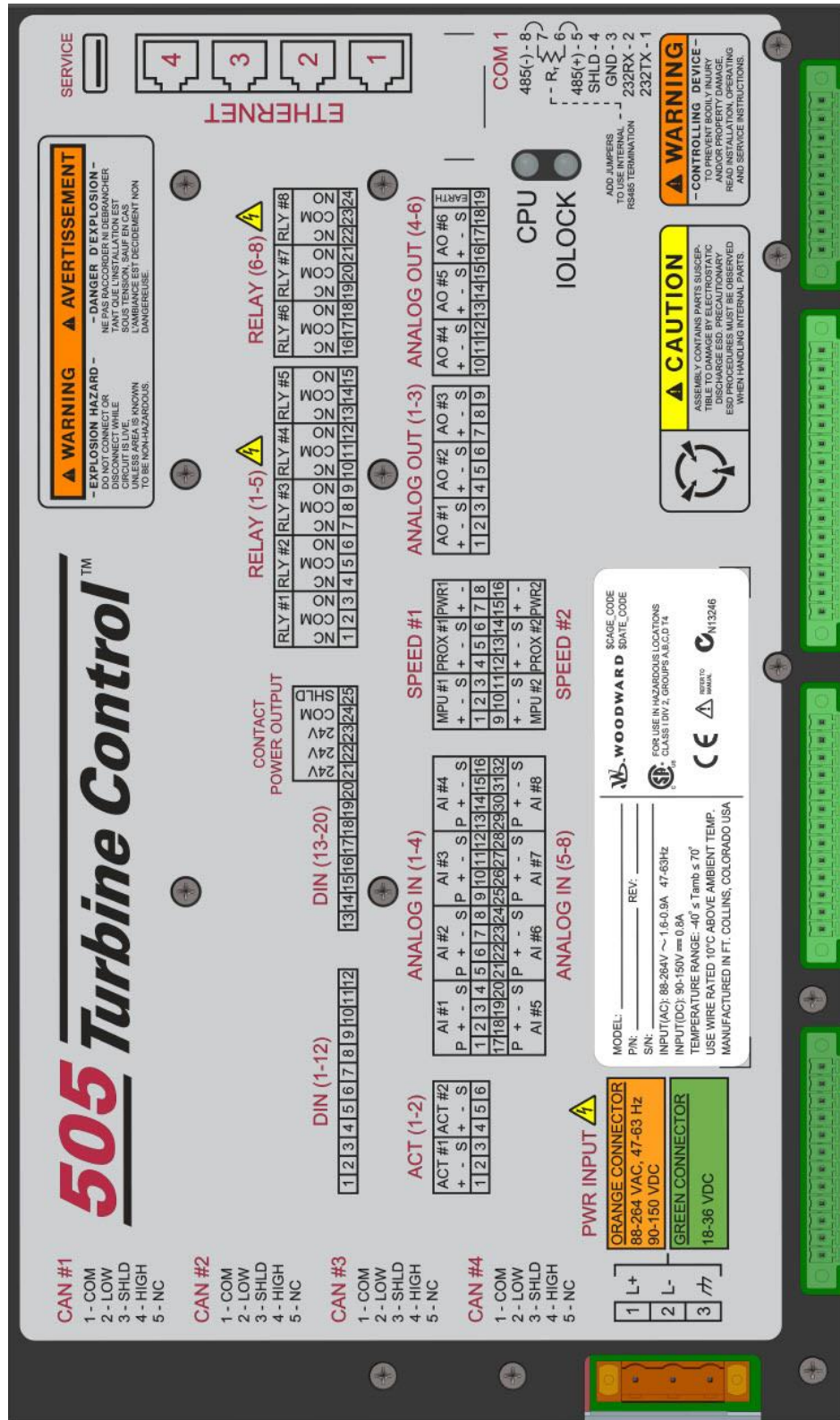


Figure 2-4. 505 Back Cover Label

Terminal Block Connectors

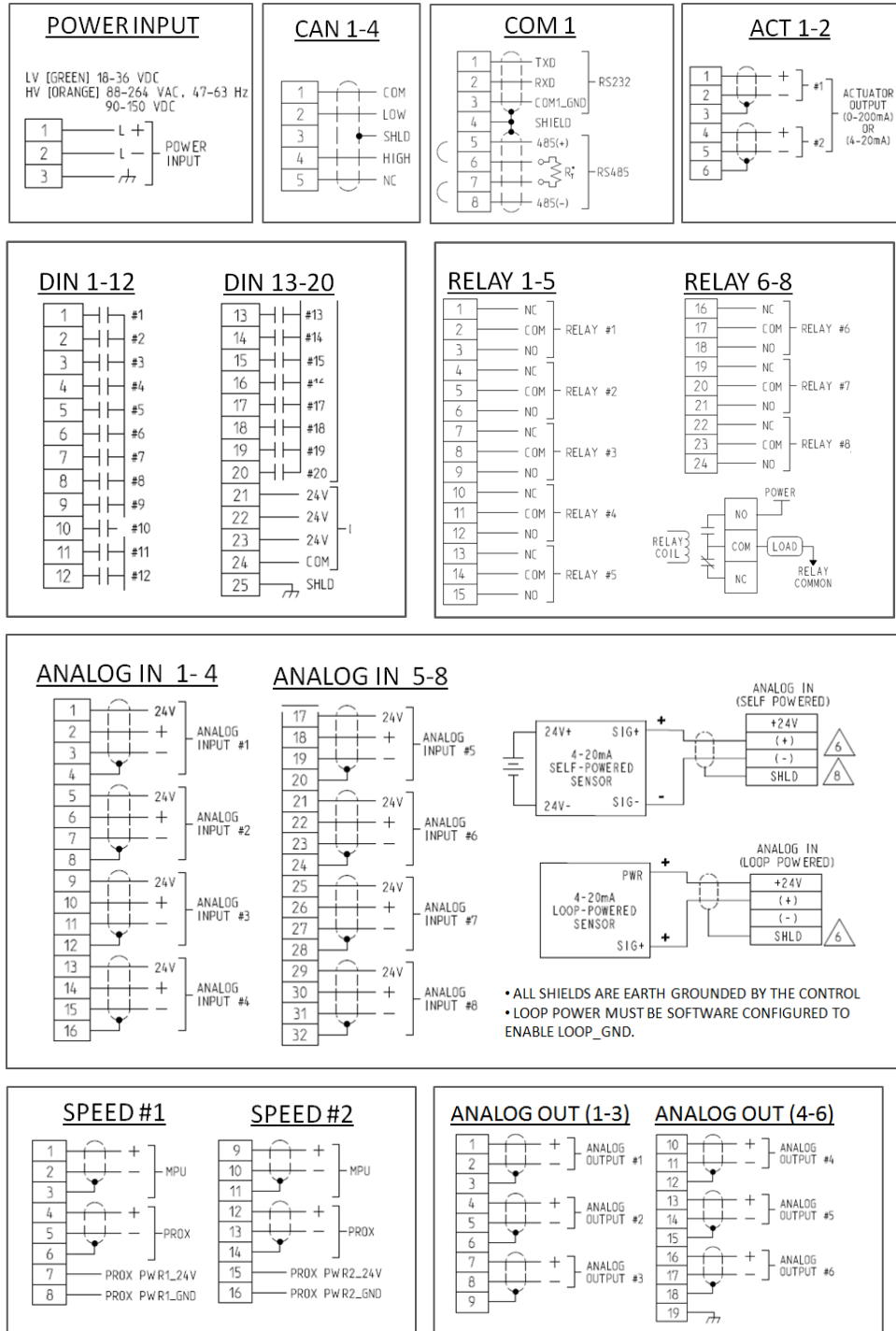


Figure 2-5. Terminal Block Connectors

Hardware - Speed Sensor Inputs

This controller includes two (2) Digital Speed Sensor circuits that are capable of interfacing to MPU and Proximity speed probe sensors. Each channel is isolated from each other and may be configured for either MPU or PROX sensors. A dedicated and isolated, PROX power (+24 V) is provided on each channel for proximity sensor use.

Note: Do not use the prox power outputs to power any other type devices.

Features

- Two (2) Digital Speed Sensor circuits, isolated individually
- GAP configurable for MPU sensors or Proximity sensor operation
- Separate terminals provided for MPU and Prox sensors
- Isolated Prox Power (+24 VDC) is provided with short-circuit protection
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Specifications (MPU / PROX)

MPU Input Voltage: 1 to 35 Vrms

MPU Input Frequency: 10 Hz to 35 KHz

MPU Input Impedance: 2000 Ω , DC

MPU Input Isolation: 500 Vrms to EARTH and all other I/O

500 Vrms to other MPU and PROX channels

Prox Input Voltage: 0-32 VDC

Prox Input Frequency: 0.04 Hz to 35 KHz (low limit depends on range)

Prox Input Impedance: 2000 Ω , DC

Prox Threshold: Low is < 8 VDC, High is > 16 VDC

Prox Input Isolation: 500 Vrms to EARTH and all other I/O

500 Vrms to other MPU and PROX channels.

Prox Power1+2 outputs: 24 VDC \pm 14%, 0-200 mA, short circuit & diode protected

Prox Power Isolation: 500 Vrms to EARTH, all other I/O, & other Prox Power

Max Speed Range: software selectable from 5 kHz to 35 kHz

Accuracy (-40,70c): < \pm 0.01% of full-scale range selected

Resolution: > 22 bits

Speed Filter (ms): 5-10,000 ms (2 poles)

Derivative Filter (ms): 5-10,000 ms (speed filter + 1 pole)

Derivative Accuracy: 0.1% of full-scale range, over full temperature range

Acceleration limit: 1-10,000 %/sec

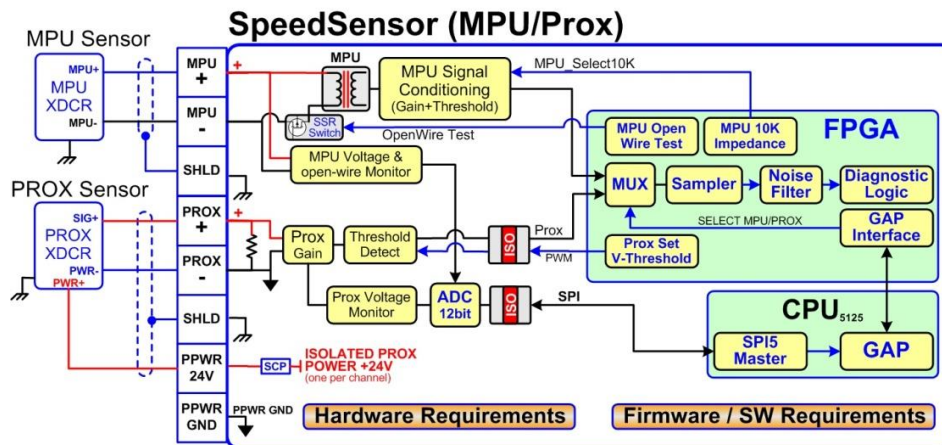


Figure 2-6. Speed Sensor Block Diagram

Hardware - Analog Inputs (4-20 mA)

AI Description and Features

The Flex500 controller includes eight (8) 4–20 mA input channels for I/O monitoring and control. Each channel is differential (self-powered) but can be software configured for Loop Power Mode. An isolated loop power (+24 VDC) is provided for analog input transducers and includes short-circuit/over-voltage protection. Note: Do not use the loop power output to power any other type devices.

Features

- Eight (8) 4–20 mA analog input channels, 16 bit resolution
- Differential inputs with high common-mode voltage capability
- Isolated loop power +24 V is provided with short-circuit protection
- Fast AI channel #8 for special control functions
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms
- GAP configurable for loop power operation

Table 2-9. Specifications (AI)

Number of channels	8
AI Input Range	0 to 24 mA
AI Input Isolation	0 V channel to channel. 500 Vrms to EARTH and all other I/O (except USB)
AI Accuracy (@ 25 °C)	≤ 0.024 mA (0.1% of FS=24 mA)
AI Accuracy (–40, +70 °C)	≤ 0.06 mA (0.25% of FS=24 mA)
AI Resolution	~16 bits of full scale
AI Hardware Filter	2 poles @ ~10 ms **Fast channel (ch 8) has 2 poles @ ~5 ms
AI Input Impedance	200 ohms (Rsense = 162 ohms)
AI Loop Power Output	24 V ±14% (0-250 mA) short circuit & diode protected
AI Loop Power Isolation	500 Vrms to EARTH and all other I/O
AI CMRR over temp	> 70 dB @ 50/60 Hz (typical 86 db)
AI CMVR	> 200 VDC to EARTH
AI Overvoltage	±36 VDC continuous at room temperature

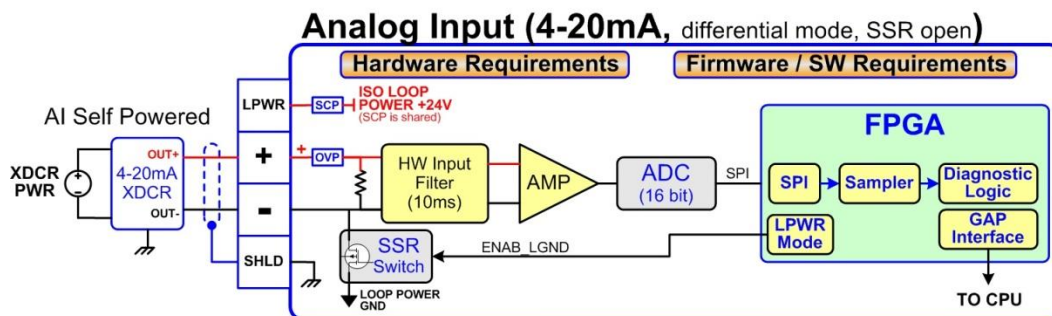


Figure 2-7. Analog Input – Self-Powered Block Diagram

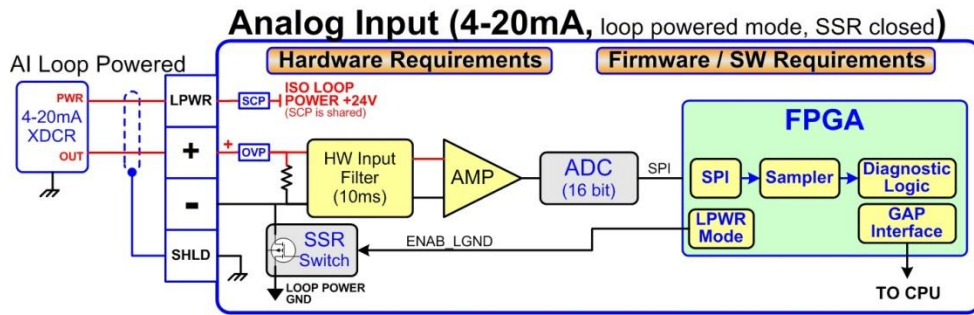


Figure 2-8. Analog Input – Loop-Powered Block Diagram

Hardware - Analog Outputs (4-20 mA)

This control provides an isolated group of (6) 4-20 mA outputs for customer use. Each output can drive up to 600 ohm loads and provides fault monitoring of individual source and return currents.

Features

- (6) Analog Output channels (4-20 mA)
- Source and return current monitors
- Group isolated from other circuits
- Capable of driving higher impedance loads up to 600 ohms
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Table 2-10. Specifications (AO)

Number of channels	6 (each with readback)
AO Output Range	0 to 24 mA, 0 mA during shutdown
AO Output Isolation	0 V channel to channel 500 Vrms to EARTH and all other I/O
AO Accuracy (@ 25 °C)	≤ 0.024 mA (0.1% of FS=24 mA)
AO Accuracy (-40, +70 °C)	≤ 0.120 mA (0.5% of FS=24 mA)
AO Resolution	~14 bits of full scale
AO Hardware filter (max)	3 poles @ 250 μs
AO Load Capability	600 Ω at 20 mA
AO Output Readbacks	(0 to 24) mA, source and return
AO Readback Accuracy	< 1% at 25°C, < 3% over full temperature range
AO Readback HW Filter	~0.5 ms nominal
IOLOCK state	AO circuits are driven to 0 mA during power-up, power-down, core voltage failures, and watchdog failures

Analog Output (4-20mA)

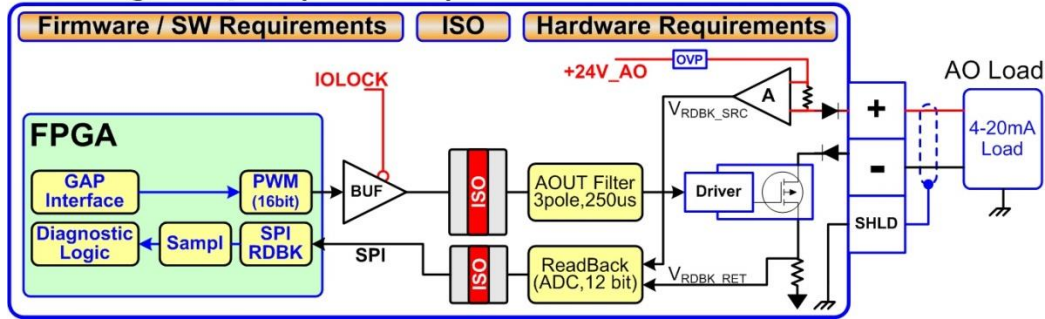


Figure 2-9. Analog Output Block Diagram

Hardware - Actuator Outputs

This control provides an isolated group of two actuator outputs for customer use. Each driver can be configured for low-range (20 mA) or high-range (200 mA) operation. Fault monitoring of individual source and return currents is included.

Features

- Two actuator output channels (4-20 mA, 20-200 mA)
- Source and return current monitoring
- Group isolated from other circuits
- Capable of driving higher impedance loads
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Table 2-11. Specifications (ACT)

Number of channels	(2) proportional drivers with source & return readbacks	
ACT Output Range	Configurable for 24 mA or 200 mA range	
ACT Output Range (Low)	0-24 mA, 0 mA during shutdown (FS = 24 mA)	
ACT Output Range (High)	0-200 mA, 0 mA during shutdown (FS = 210 mA)	
ACT Output Isolation	0 V channel to channel 500 Vrms to EARTH and all other I/O	
ACT Accuracy (25 °C)	Low Range ≤ 0.024 mA (0.1%)	High Range ≤ 0.21 mA (0.1%)
ACT Accuracy (-40, +70 °C)	Low Range ≤ 0.120 mA (0.5%)	High Range ≤ 1.00 mA (0.5%)
ACT Resolution	~14 bits of full scale	
ACT Hardware filter (max)	3 poles @ 500 μs	
ACT Load Capability (low)	600 Ω at 20 mA	
ACT Load Capability (high)	65 Ω at 200 mA	
ACT Output Readbacks	(0 to 24) mA, source and return	
ACT Readback Accuracy	< 1% at 25°C, < 3% over full temperature range, (source & return)	
ACT Readback HW Filter	~0.5 ms nominal	
ESTOP action	Front panel ESTOP button will shut down the actuator circuit, remove actuator power, and set an alarm in GAP software.	
IOLOCK action	During IOLOCK, ACT power is shut down and ACT circuits are driven to 0 mA during power-up, power-down, core voltage failures, and watchdog failures.	

ACT Output (4-20mA / 20-200mA)

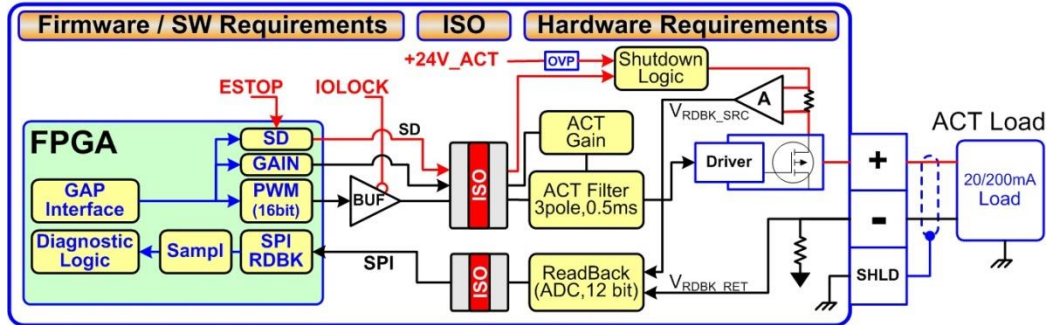


Figure 2-10. Actuator Output Block Diagram

Hardware - Discrete Inputs

This control provides an isolated group of (20) discrete input channels for use with +24 V DC signals. An isolated contact power voltage supply of +24 VDC is provided to use with the discrete inputs. This supply includes short-circuit and over-voltage protection. Note: Do not use the contact power output to power any other devices.

Features

- 20 discrete input channels for +24 VDC signals
- +24 V contact power with short-circuit and diode protection
- Isolated power and discrete input group
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms
- Time-stamping capability (1 ms)

Table 2-12. Specifications (DI)

Number of Channels	20
DI Input Low State	(0 to 8) VDC
DI Input High State	(16 to 32) VDC
DI Input Current	< 5 mA per channel
DI Input Impedance	25K approx
DI Hardware Filter	1.0 ms approx at room temp
DI Channel Isolation	0 V channel to channel 500 Vrms to EARTH and all other I/O
DI Overvoltage	Overvoltage to 36 VDC for inputs
Contact Power Output	24 V \pm 14 %, 150 mA (max), short circuit & diode protected
Contact Power Isolation	500 Vrms to EARTH and all other I/O

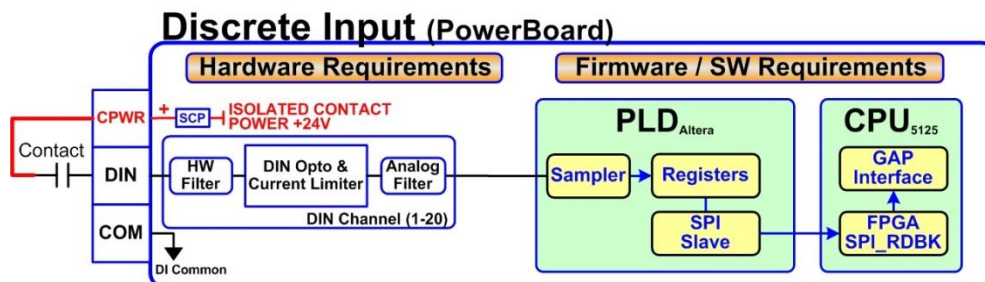


Figure 2-11. Discrete Input Block Diagram

Hardware - Relay Outputs

This control provides (8) Isolated, Form-C relay outputs with NO, COM, NC contacts available at the terminal block.

Features

- 8 relay output channels
- Each relay output provides NO, COM, and NC contacts
- Each relay output channel provides a coil voltage readback fault
- Woodward GAP block, diagnostics, and configuration support
- Contact isolation maintained at terminal blocks
- ATEX approved version available using hermetically sealed relays
- GAP configurable update rates of 5 ms to 160 ms

Table 2-13. Specifications (Relay Outputs)

Number of Channels	(8) relays
Contact Type	Form-C with NO, COM, and NC terminals
STD Relay, contacts (DC)	5 A, 5-30 VDC (resistive)
STD Relay, contacts (AC)	2 A, 115 VAC (resistive)
STD Relay, operate time	< 15 ms typical
RELAY Coil Readback	Coil voltage readback status is available
RELAY Coil Rdbk Filter	1 ms approx at room temp
RELAY Output Isolation	500 Vrms minimum to EARTH and all other I/O
RELAY Contact Isolation	500 Vrms minimum between open contacts
RELAY to RELAY Isolation	500 Vrms minimum between relays
IOLOCK State	Relay outputs are de-energized during power-up, power-down, core voltage failures and watchdog failures
ATEX version:	The ATEX approved control uses a Hermetically sealed relay
ATX Relay, contacts (DC)	5 A, 5-30 VDC (resistive), 0.2-0.5 A (inductive)
ATX Relay, contacts (AC)**	2 A, 115 VAC (resistive), 0.1-0.2 A (inductive)



WARNING

**ATEX/IECEX Compliance requires relay contact loads be limited to ≤ 32 VAC rms / ≤ 32 VDC.

Explosion Hazard

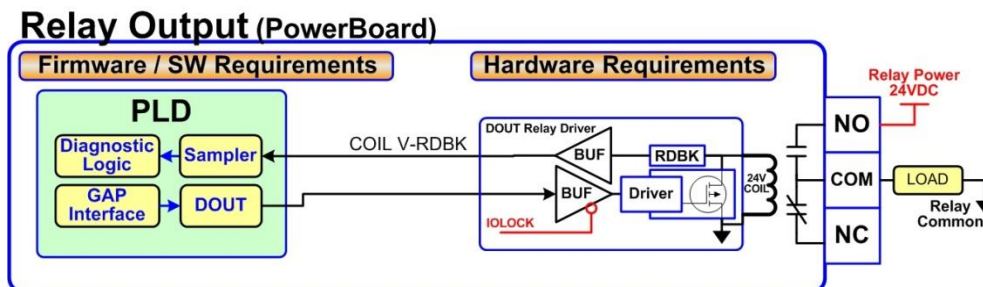


Figure 2-12. Relay Output Block Diagram

Troubleshooting Fault Codes

The CPU board runs diagnostics that display troubleshooting messages through the debug Service Port and AppManager. Additional information on diagnostics tests, subsequent LED flash codes, and serial port messages is contained in the VxWorks manual.

Table 2-14. CPU Fault LED Flash Codes

Failure	Flash Code
CPU not operational, IOLOCK state	Solid Red
RAM Test Failure	2, 1
FPGA Test Failure	2, 9
Watchdog not enabled	2, 10
RAM drive error	2, 11
Flash drive error	2, 12

Troubleshooting & Commissioning Checks

Power Checks

- Verify proper polarity on power connections
- Verify power source and wire size is sufficient for all loads
- Verify input power voltage is correct (i.e.: low voltage unit is 18 V to 36 VDC)
- Verify PS(+) and PS(-) impedance to EARTH is > 10 M Ω

RS-232 Wiring Checks

- Verify the RS-232 wiring uses a high-quality shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify the RS-232 wiring uses the signal common (COM1_GND)
- Verify RS-232 network length is within specifications (typically < 50 feet)
- Verify Signal wires (TX+,RX-) are not shorted to each other
- Verify Signal wires (TX+,RX-) are not shorted to COM1_GND
- Verify Signal wires (TX+,RX-) are not shorted to COM1_SHLD
- Verify Signal wires (TX+,RX-) are not connected to PS(+), PS(-), EARTH
- Verify COM1_GND is not connected to PS(+), PS(-), EARTH
- Verify the overall cable shield is terminated to EARTH at only (1) location.

RS-485 Wiring Checks

- Verify the RS-485 wiring uses a high-quality shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify RS-485 network length is within spec for the baud-rate (typically < 4000 feet)
- Verify the network is terminated properly at both ends with approx. 90–120 Ω
- Verify the RS-485 wiring uses the signal common (COM1_GND)
- Verify Signal wires (RS-485+, RS-485-) are not shorted to each other
- Verify Signal wires (RS-485+, RS-485-) are not shorted to COM1_GND
- Verify Signal wires (RS-485+, RS-485-) are not shorted to COM1_SHLD
- Verify Signal wires (RS-485+, RS-485-) are not connected to PS(+), PS(-), EARTH
- Verify COM1_GND is not connected to PS(+), PS(-), EARTH
- Verify the overall cable shield is terminated to EARTH at only (1) location.

CAN Wiring Checks

- Verify the CAN wiring uses a high quality, 3-wire, shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify CAN network length is < max length spec for the baud rate being used
- Verify network is terminated properly at both ends with 120 Ω , $\pm 10\%$
- Verify the CAN wiring uses the signal common (CAN_GND)
- Verify CAN drop cables to each device are as short as possible and meets spec.
- Verify CANH is not connected to PS(+), PS(-), EARTH
- Verify CANL is not connected to PS(+), PS(-), EARTH
- Verify CAN_COM is not connected to PS(+), PS(-), EARTH
- Verify CAN_SHLD shield wire is not shorted to PS(+), PS(-)
- Verify the CAN overall cable shield is terminated to EARTH at only (1) location for each network.
- For redundant CAN devices, verify CAN1 and CAN2 networks are not mis-wired and connected together.

AI (Non-loop), Analog Input Wiring Checks

- Verify that external XDCR's are NOT used with these self-powered channels.
- Verify each AI(+,-) is not shorted to another input channel.
- Verify each AI(+) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AI(-) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AI shield wire is not shorted to PS(+), PS(-).
- Verify each AI shield wire is terminated at the node properly.
- Functionally verify the wiring for each AI channel using a simulator source.

AI (Loop Power), Analog Input Wiring Checks

- Verify that external XDCR's are connected to these channels.
- Verify the LPWR voltage level (+24 V dc) is correct for the XDCR.
- Verify each LPWR(+) terminal is wired to the XDCR POWER(+).
- Verify each LPWR(+) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AI(-) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AI shield wire is not shorted to PS(+), PS(-).
- Verify each AI shield wire is terminated at the node properly.
- Verify that all XDCR's channels use less than 250 mA of LPWR.
- Functionally verify the wiring for each AI channel using a simulator source.

AO, Analog Output Wiring Checks

- Verify each AO(+,-) is not shorted to another output channel.
- Verify each AO(+,-) is not shorted to another analog input channel.
- Verify each AO(+) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AO(-) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each AO shield wire is not shorted to PS(+), PS(-).
- Verify each AO shield wire is terminated at the node properly.
- Functionally verify the wiring for each AOUT by driving 4 mA and 20 mA to the load from the GAP application. Verify correct output current with a meter. Verify the correct SRC_RDBK & RET_RDBK values in GAP.

DI, Discrete Input Wiring Checks

- Verify each DI(+) is not shorted to another input.
- Verify each DI(+) is not shorted to CPWR(+), CPWR(-), PS(+), PS(-), EARTH.
- Verify each DI(+) wiring is functional by setting each input HIGH (>16 V DC) and then LOW (<8 V DC). Verify GAP software detects the state change.
- When possible, consider using a shielded DIN cable.

DI, Contact Power (CPWR) Wiring Checks

- CPWR(+) is an output voltage, it should never be connected to any other supply.
- To maintain node isolation, verify CPWR(-) is not shorted to PS(-).
- Using the internal isolated contact power output (CPWR,COM) is highly recommended to maintain discrete input isolation for other plant devices / controls
- Verify CPWR(+) is not connected to CPWR(-), PS(-), EARTH.
- Verify CPWR(-) is not connected to CPWR(+), PS(+), EARTH.
- Verify CPWR voltage meets spec at the terminal block (18 to 32 V dc).

DO Relays, Relay Wiring Checks

- Verify each relay output (NO,C,NC) contact is connected to the load properly
- Verify each relay output (NO,C,NC) is not shorted to another output channel.
- Verify the function of each relay output (NC,NO) wiring by driving each output ON then OFF. Verify the GAP software detects the readback state change.
- When possible, consider using shielded wiring for relay cables.

Additional wiring checks when using RTCnet/LINKnet nodes

TC, Thermocouple Input Wiring Checks

- Verify each TC(+,-) is not shorted to another input channel.
- Verify each TC(+) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each TC(-) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each TC shield wire is not shorted to PS(+), PS(-).
- Verify no wires are landed accidentally on the NC, no-connect terminals.
- Verify each TC shield wire is terminated at the node properly.
- Functionally verify the wiring for each TC channel using a simulator source.
- TC OPENS: A TC input will read MAX DegC if the (+) or (-) wire is broken / open.
- TC SHORTS: A TC input will read 0 DegC if the (+) and (-) wires are shorted.

NOTICE

GROUND FAULTS: Input channels accidentally shorted to EARTH will be more susceptible to spurious noise events related to the installation and environment.

RTD, Input Wiring Checks

- Verify each RTD(+,-) is not shorted to another input channel.
- Verify each RTD(+) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each RTD(-) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each RTD(sense) terminal is not shorted to PS(+), PS(-), EARTH.
- Verify each RTD(sense) terminal is connected properly for 3-wire sensors.
- Verify each RTD(sense) terminal is jumpered to RTD(-) for 2-wire sensors.
- Verify each RTD shield wire is not shorted to PS(+), PS(-).
- Verify each RTD shield wire is terminated at the node properly.
- Functionally verify the wiring for each RTD channel using a simulator source.
- RTD OPENS: RTD channels will read MAX DegC if the (+) or (-) wire is broken.

Chapter 3.

505XT Control Description

Introduction

Previous models of the 505 family were separated into dedicated model part numbers for either single valve (the 505 or 505 Enhanced) or multi-valve turbines (the 505E).

The 505XT is designed so that it can be applied to both single and multi-valve turbines.

The configurations support the following turbine types:

- Type 0 Single Valve or Split-Range Valves turbines
- Type 1 Single Extraction (only) turbines
- Type 2 Single Admission (only) turbines
- Type 3 Single Extraction/Admission turbines

The selection of turbine type is found under the Steam Map header under the Configuration menu. The factory default is Type 0 for this selection.

The start modes and the start sequence operations for all of these types of turbines is exactly the same. The only difference with extraction and/or admission type turbines is the handling of the LP valve (also referred to as the V2 valve). Once warm-up is complete and the unit is ready to start, the LP will ramp to 100% (full open to the exhaust end of the turbine) or ramp to an operator defined demand position, in the case of an extraction/admission type turbine.

Once the turbine has reached minimum governor or rated speed it can then be placed in operation – referred to as going 'On-Line'. For a generator application this is initiated by closing the breaker and on a mechanical drive it occurs once unit reaches minimum governor speed. If the unit is a turbine type 1, 2, or 3, this is the point at which the 505XT can be transitioned from speed control to ratio-limiter control. In ratio limiter control both the HP and LP valves are controlled to maintain 2 different parameters, selectable by the user.

Turbine Start Modes

The 505XT has three turbine start modes (manual, semi-automatic or automatic) from which to choose from. One of these start modes must be chosen and programmed to perform a system start-up. Once a 'RUN' command is issued, the speed set point and valve limiter are manipulated automatically by the 505XT or manually by the operator, depending on which start mode is selected. After a turbine start sequenced has been completed, turbine speed will be controlled at a minimum controlling speed. The minimum controlling speed may be idle if idle/rated is being used, low idle if the auto start sequence is used, or minimum governor if neither idle/rated or auto start sequence is used.

A 'RUN' command may be issued from the 505 keypad, an external contact, or through Modbus communications. If an 'External Run' contact is programmed, a 'RUN' command is issued when the contact is closed. If the contact is closed prior to start-up, it must be opened and re-closed to issue a 'RUN' command.

If turbine speed is sensed when a 'RUN' command is issued, the control will instantly match the speed set point to the sensed speed and continue towards the minimum controlling speed. In the event the sensed turbine speed is greater than the minimum controlling speed setting, the speed set point will match this sensed speed, the Speed PID will control at this point, and the control will wait for further action to be taken by the operator. If turbine speed is first sensed within a critical speed avoidance band when a 'Run' command is received, the speed set point will match the actual speed, decrease to the lower end of the critical avoidance band, and wait for action to be taken by the operator.

Start Permissive

An external contact may be used as a turbine start-up permissive. When programmed for this functionality, the contact input must be closed in order for a 'RUN' command to be executed. Should the contact be open when a 'RUN' command is given, an alarm will be issued and the 505 display will indicate that the start permissive was not met (Start Perm Not Met). The alarm does not need to be cleared but the contact must be closed before the 505 will accept the 'RUN' command. After 'RUN' has been accepted, the start permissive contact will have no effect on operation.

Example: This input could be connected to a Trip & Throttle valve's closed limit switch to verify that it is in the closed position before a turbine start-up is performed.

Open Wire Detection on MPU Speed Signals

The 505XT automatically verifies continuity of the speed MPU circuits each time it prepares to issue a "Ready to Start" status message. If an open wire is detected it will issue an alarm for this input, if all MPU's appear to have open wires a Trip is initiated. This open wire test can be done manually any time the turbine is stopped and the speed is zero. It is also possible to disable the automatic test at start the Speed Sensor screen.

The screen is located under Analog Inputs/Speed Signal X/Open Wire Test.

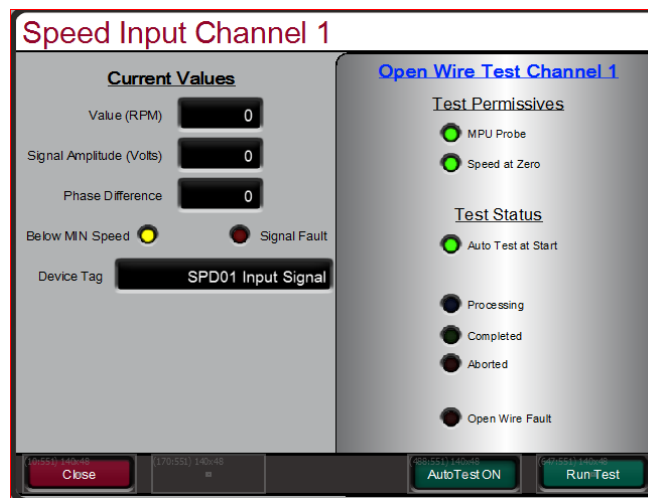


Figure 3-1. Open Wire Detection Test

Zero Speed Signal Override

The 505XT issues a shutdown if no speed signal is detected (magnetic pickup voltage less than 1 Vrms or speed is less than the 'Failed Speed Level'). To allow the control to start with speed not being sensed, this shutdown logic must be overridden. The control can be configured to provide a manual or an automatic speed override. For added protection, a timed limit on the override is available. The status of the MPU override logic may be viewed in the Service mode or through Modbus communications. The override logic applies to both passive and active speed probes.

Direction of Rotation Detection

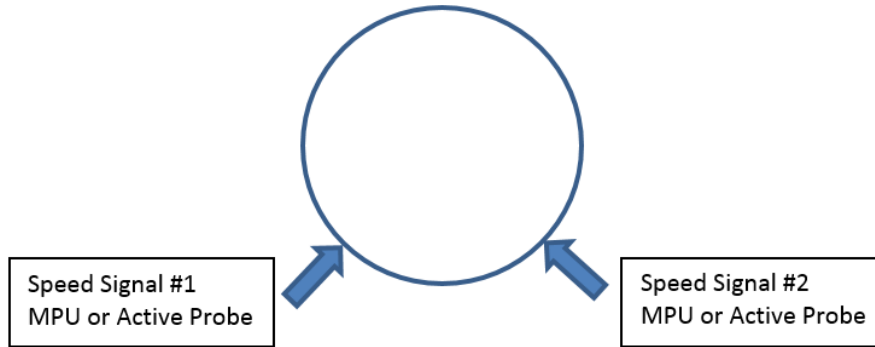


Figure 3-2. Speed Probe Mounting for Detection Test

To enable the 505XT to calculate the direction of rotation – two speed signals must be used and should be mounted in an orientation as shown above, with approximately 90 degrees between them. This will work with both passive and active types of probes, however both channels must be configured as the same type of probe. If MPU's (passive) are used the direction will only be detected once the speed is above the failed speed level threshold. If slow speed detection of rotation is required, then active probes should be used.

The direction of rotation can be determined by viewing the Phase Difference value on either of the speed input channels. For both channels the phase difference output will always indicate the number of degrees from speed signal #1 to speed signal #2. Both channels must be healthy for the Phase Difference value to be meaningful. If probes are setup as the above diagram, a reading of approximately 270 degrees indicates that the turbine is spinning clockwise and a reading of 90 degrees indicates it is spinning counterclockwise.

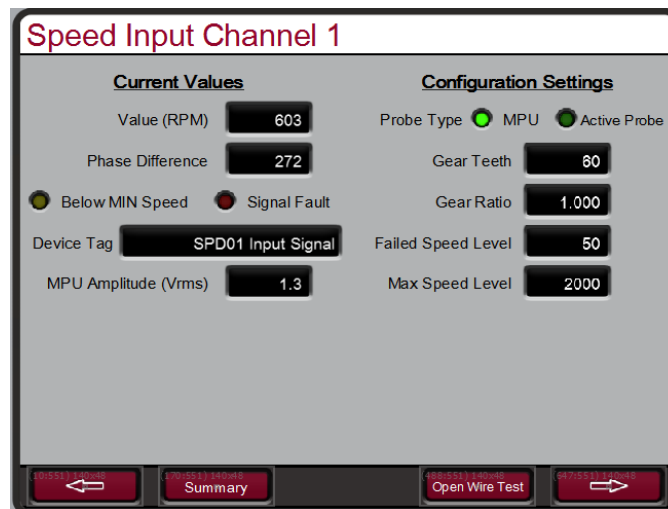


Figure 3-3. Speed Input Channel – Phase Difference

There is an alarm that can be enabled related to the unit running in reverse rotation. It is found under the Service menus. This feature has two other selections required. A confirmation of which direction is the correct direction (clockwise or counterclockwise), and a minimum speed to enable this detection – this value should be a speed that can be detected by the probes being used. This value can be lower than the Failed speed level setting and is valid even when the speed signal override is active. However, the voltage signal on the probes must be one Vrms or greater – that means if this needs to be detected at very slow speed then active probes should be used.

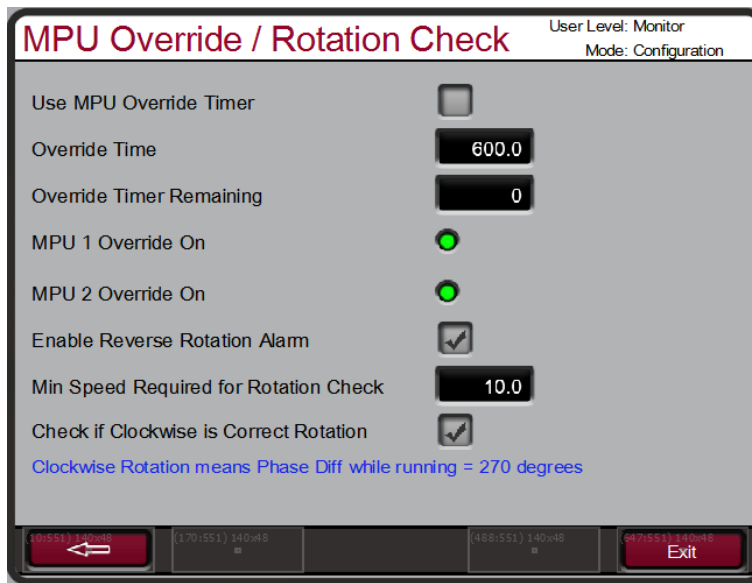


Figure 3-4. Speed Probe Rotation Check

Detecting Zero Speed

To enable the 505XT to detect zero speed an active speed probe signal must be used. The option to enable this detection feature is found on speed input channel 1. If a second active speed probe is used, the logic will require that the second probe also detects zero speed if it is healthy.

The zero speed detection logic requires a healthy speed signal and is intended to be used during a typical trip or normal shutdown event, where the turbine coasts down. This logic can be used to indicate when the turbine has stopped rotating. If a speed probe fails, this detection logic is inhibited on that probe. If both speed sensors are failed, then no zero speed detection will be indicated. A speed sensor is considered failed when the signal is lost (broken wire) or when a valid speed suddenly drops to zero.

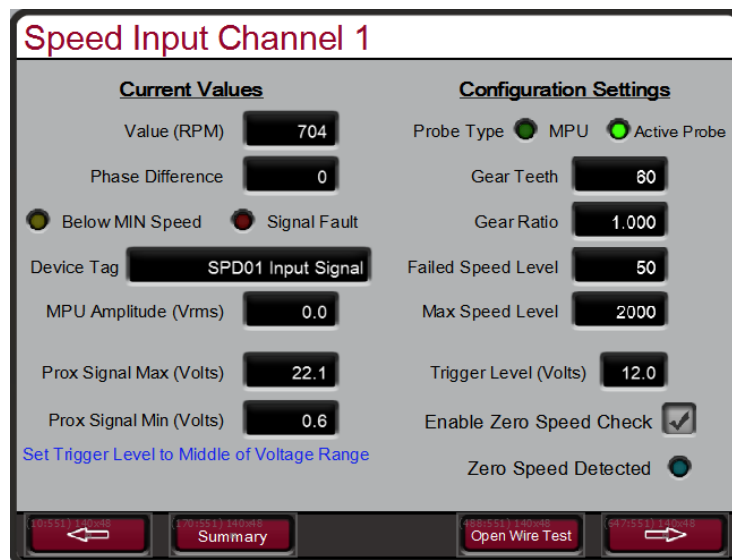


Figure 3-5. Speed Probe Zero Speed Detect

Manual Speed Override

If the 'Override MPU Fault' function is assigned to a contact input, the loss-of-speed detection logic is overridden if this contact is closed (until the maximum time expires). Opening the assigned contact input, disables the override logic, and re-arms the loss-of-speed detection circuit. Once re-armed, a system shutdown is executed if the sensed speed drops below the 'Failed Speed Level' setting.

A maximum override time limit is provided as an extra level of protection, in the event the contact input is left closed. A ten-minute maximum time limit is applied to a Manual Override command (as defaulted in the Service Mode). This time starts when the RUN command is initiated and re-arms the loss-of-speed detection when the time expires. The 505XT will execute a system shutdown if turbine speed is not above the 'Failed Speed Level' setting when the time expires.

Automatic Speed Override

If the manual speed override option is not programmed, the Automatic Speed Override logic is used by the 505XT to override the loss-of-speed signal shutdown logic during a turbine start-up. With the Automatic Override logic, the loss-of-speed signal failure is disarmed when the turbine trips and remains disarmed until the sensed turbine speed exceeds the programmed ('Failed Speed Level' setting + 50 rpm). Once turbine speed exceeds this level, the loss of speed detection circuit is re-armed, and the control will execute a system shutdown if sensed speed drops below the 'Failed Speed Level' setting.

For added protection, a timed limit is available on the automatic speed override function. The timed speed override timer deactivates the loss-of-speed override logic after the programmed time expires. If programmed, this timer starts counting down once a 'START' command has been issued. This timer when programmed provides an extra level of protection, in the event both speed input probes are failed when the unit is started. This timer may be programmed in the 505's Service Mode.

Acceleration Limiter

The acceleration limiter is available for startup to significantly reduce speed overshoot to the minimum controllable speed setpoint at turbine start. The acceleration limiter is disabled after reaching the minimum controllable speed and the 505XT will continue the start sequence via the Speed PID.

If the acceleration limiter is set to be used via the Service menu, then it will control speed at the 'Rate to Min' rate (RPM/s), as set in the Turbine Start configuration, until the Speed PID is in control at the minimum controllable speed. When the Start Sequence is set to "No Start Sequence", the minimum controllable speed is minimum governor. When the Start Sequence is set to "Idle/Rated Sequence" or "Auto Start Sequence", the minimum controllable speed is the lowest idle setting.

CAUTION

Acceleration Control

Using the Acceleration Limiter feature carries some risk without proper tuning of the Acceleration PID. Please monitor actuator behavior at turbine start. Verify there is no instability in the Acceleration Controller that may result in system damage during oscillation of the actuator/valve if it is unstable. When the response of the Acceleration Controller is over-damped, it may follow the speed setpoint very slowly at startup or even move the valve closed, but after this, acceleration should be controlled fairly well until the Acceleration Limiter logic is disabled.

Turbine Start Mode Procedures

Manual Start Mode

The following start-up procedure is employed when the manual start mode is configured:

1. Issue a RESET command (to reset all alarms and shutdowns). The LP demand and LP Limiter behavior is determined by the turbine type.
 - a. Extraction Only: The LP Limiter will ramp to 100%
 - b. Admission Only or Extraction/Admission: The LP Limiter will ramp to 100%. The LP valve position will vary to maintain zero admission flow, defined by the steam map.
 - i. For Full-Decoupled configurations with any admission control, the LP Valve Limiter will remain at the LP Minimum demand.
2. Issue a START command (verify T&T valve is closed before issuing)
 - a. At this point the 505 will ramp open the governor valve to its maximum position at the 'Valve Limiter Rate'.
 - b. The speed set point will ramp from zero to the minimum controlling speed setting at the 'Rate To Min' rate.
3. Open Trip & Throttle valve at a controlled rate
When turbine speed increases to the minimum controlling speed, the 505's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
4. Open Trip & Throttle valve to 100%
Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'Auto Start Sequence', if programmed, begins controlling.

The 'Limiter Max Limit', 'Valve Limiter Rate' and 'Rate To Min' settings are tunable in the Service mode.

WARNING

The trip-and-throttle valve must be closed before pushing the 'RUN' key in manual start mode. If a START command is given while the trip-and-throttle valve is open, there exists a possibility of turbine runaway with resultant serious injury or loss of life.

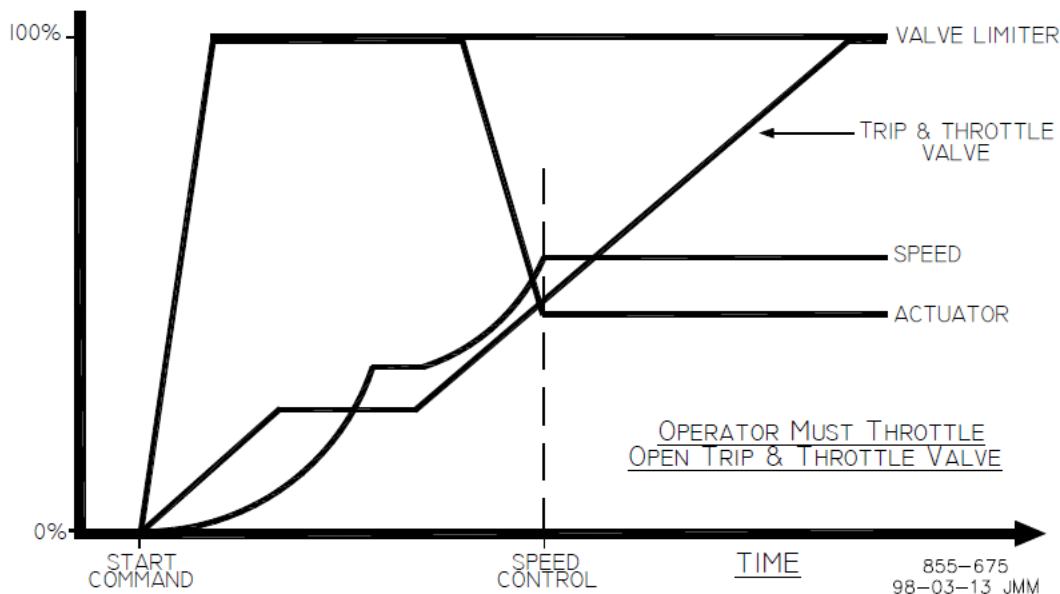


Figure 3-6. Manual Start Mode Example

Semiautomatic Start Mode

The following start-up procedure is employed when the Semiautomatic start mode is configured:

1. Issue a RESET command (to reset all alarms and shutdowns). The LP demand and LP Limiter behavior is determined by the turbine type.

- a. Extraction Only: The LP Limiter will ramp to 100%
- b. Admission Only or Extraction/Admission: The LP Limiter will ramp to 100%. The LP valve position will vary to maintain zero admission flow, defined by the steam map.
 - i. For Full-Decoupled configurations with any admission control, the LP Valve Limiter will remain at the LP Minimum demand.
2. Open the Trip & Throttle valve (verify that the turbine does not accelerate)
3. Issue a START command
At this point, the speed set point will ramp from zero to the minimum controlling speed setting at the 'Rate to Min' rate.
4. Raise the 505's VALVE LIMITER at a controlled rate.
When turbine speed increases to the minimum controlling speed, the 505's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
5. Raise the 505's VALVE LIMITER to 100%.
Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'AUTO START SEQUENCE', if programmed, begins controlling.

The valve limiter will open at the 'Valve Limiter Rate' and may be moved using the 505 keypad, external contacts, or Modbus communications. The 'Limiter Max Limit', 'Valve Limiter Rate' and 'Rate To Min' settings are tunable in the Service mode.

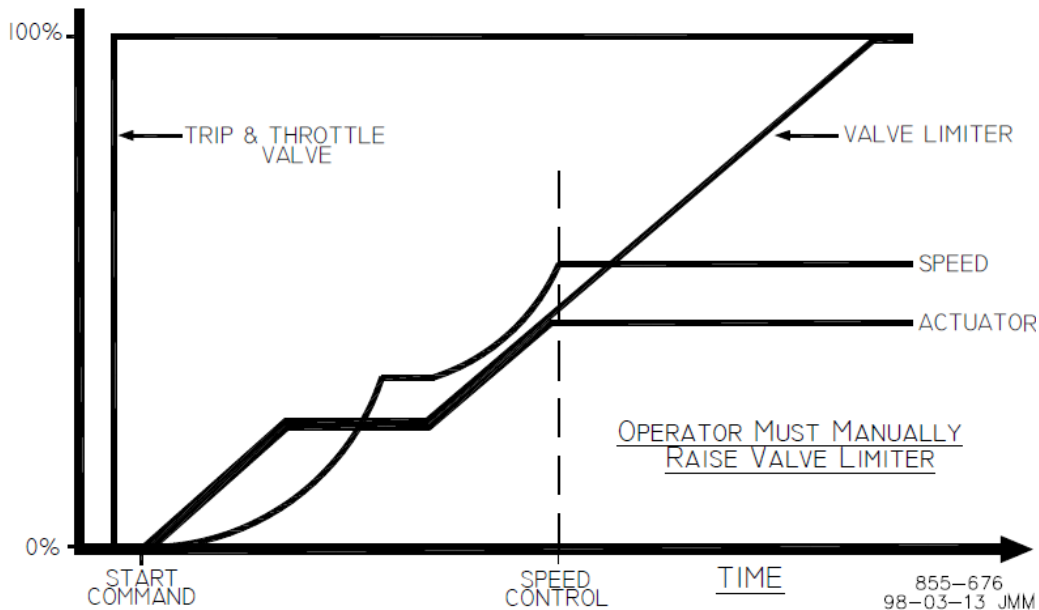


Figure 3-7. Semiautomatic Start Mode Example

Automatic Start Mode

The following start-up procedure is employed when the Automatic Start mode is configured:

1. Issue a RESET command (to reset all alarms and shutdowns). The LP demand and LP Limiter behavior is determined by the turbine type.
 - a. Extraction Only: The LP Limiter will ramp to 100%
 - b. Admission Only or Extraction/Admission: The LP Limiter will ramp to 100%. The LP valve position will vary to maintain zero admission flow, defined by the steam map.
 - i. For Full-Decoupled configurations with any admission control, the LP Valve Limiter will remain at the LP Minimum demand.
2. Open the Trip & Throttle valve (verify that the turbine does not accelerate)
3. Issue a START command
 - At this point the 505 will ramp open the governor valve to its "HP Max at Start" setting at the 'Valve Limiter Rate' setting.
 - The speed set point will ramp from zero to the minimum controlling speed setting at the 'Rate to MIN' rate.

- When turbine speed increases and matches the ramping speed set point, the 505's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
- Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'Auto Start Sequence', if programmed, begins controlling.
- Once the Speed PID begins controlling turbine speed, the HP Limiter will automatically ramp to the 'Vlv Lmtr Max Limt'.

Optionally the 'HP Max at Start' and 'Vlv Lmtr Max Limt', 'Valve Limiter Rate' and 'Rate To Min' settings can be adjusted in the Service mode, while the turbine is in operation. The automatic start routine may be aborted at any time by issuing valve limiter raise or lower commands, or an emergency shutdown.

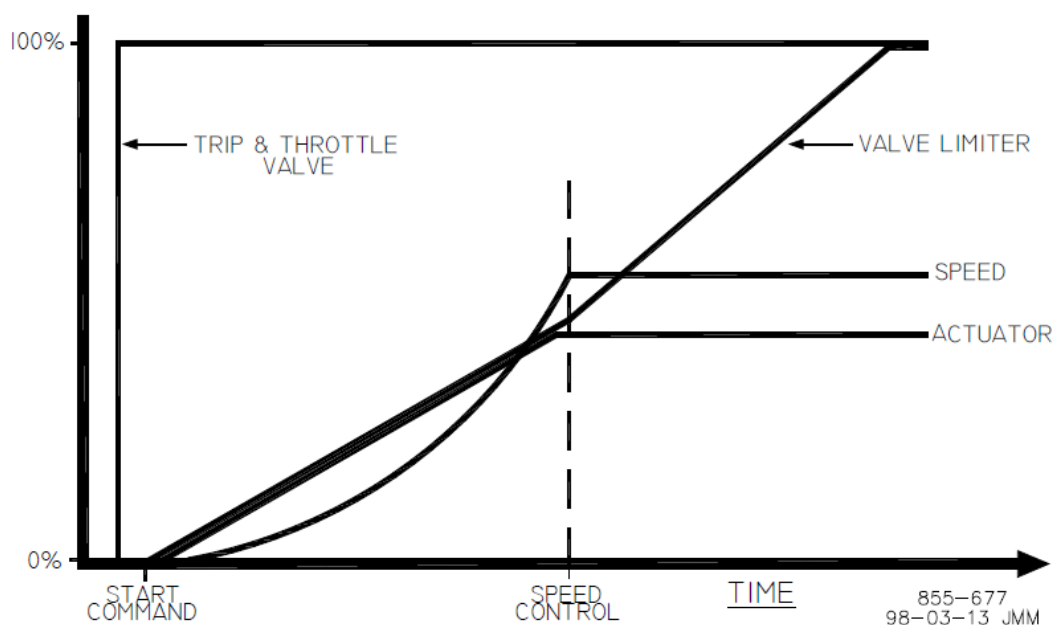


Figure 3-8. Automatic Start Mode Example

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, three critical speed ranges may be configured. These bands may be any speed range that is less than the minimum governor speed setting. Within a critical speed range, the 505XT moves the speed set point at the critical speed rate programmed and does not allow the speed set point 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 set point lower command will bring the unit back to the lower limit of the band.

The speed set point cannot be stopped in the critical band. If a Raise/Lower Speed Set point command is issued while in a critical band, the speed set point will ramp up or down (depending on raise or lower command) to the extent of the critical range. Since the lower speed set point has priority over a raise set point, issuing a lower command while increasing through the band will reverse the set point direction and return it to the lower limit of the band. If a lower speed set point command is given while in a critical band, turbine speed must reach the bottom of the band before another command can be executed.

A speed set point value cannot be directly entered (with the ENTER key) within the programmed critical speed band settings. In the event this is attempted, an error message will appear on the 505 front panel display.

If another controlling parameter, besides the Speed PID, drives the turbine's speed into a critical band for longer than five seconds, the speed set point will instantly go to the idle setting and an alarm will occur (Stuck in Critical).

During a start-up routine if the Speed PID cannot accelerate the unit through a programmed band within a calculated length of time, a “Stuck in Critical” alarm will be issued, and the speed set point will instantly return to idle. The “calculated length of time” is a value of five times the length of time it should normally take to accelerate through the band (based on the “Critical Speed Rate” setting). If the “Stuck in Critical” alarm occurs on a regular basis, it may be indicating that the “Critical Speed Rate” is set too fast for the turbine to respond to.

Critical speed bands are defined in the configure mode. All critical speed band settings must be set below the ‘Min Governor Speed Set Point’. A configure error will occur if an idle set point is programmed within a critical speed band. The rate in which the speed set point moves through a critical speed band is set by the ‘Critical Speed Rate’ setting. The ‘Critical Speed Rate’ setting should be set at but no higher than the turbine’s rated maximum acceleration rate.

No Start Sequence

If neither, the idle/rated or auto start sequence functions are programmed, the speed set point will ramp from zero to the minimum governor set point at the ‘Rate To Min’ setting rate. Critical speed bands cannot be programmed with this configuration.

Idle/Rated

The idle/rated function gives an operator the ability to move between a programmed idle speed and a programmed rated speed at a configured rate. The selection of idle or rated speed set point positions can be made through the front panel keypad, through remote contact inputs, or through the Modbus communications links. The idle/rated function can also be programmed as a ramp-to-rated function only.

If the 505’s idle/rated function is programmed, once a ‘START’ command is given, the 505 ramps turbine speed from zero to the programmed Idle setting, then waits for a command from the operator to ramp turbine speed to the “Rated Speed” setting. When deselected, the turbine speed ramps down to the application’s Idle Speed setting (as defaulted in the Service Mode).

The idle/rated function can be used with any 505 start mode (manual, semiautomatic, automatic). When a START command is issued, the speed set point will ramp from zero rpm up to and hold at the ‘Idle Setpt’ setting. When a ramp- to-rated command is given, the speed set point ramps to the ‘Rated Setpt’ setting at the ‘Idle/Rated Rate’. While ramping to a Rated speed, the set point can be stopped by a raise or lower speed command or a valid entered speed set point.

The 505XT will inhibit a ramp-to-idle speed or ramp-to-rated speed command, if the Generator Breaker is closed, Remote Speed Set Point is enabled, Cascade PID is in control, or the Auxiliary PID is in control (as defaulted in the Service Mode). Alternatively, the 505’s ‘Idle Priority’ and ‘Use Ramp to Idle Function’ Service mode settings can be configured to change the defaulted idle/rated logic.

Ramp to Rated Feature

The idle/rated function can be changed to a “ramp to rated” function (see Service Mode). With this configuration, the speed set point holds at the idle speed setting until a Ramp-to-Rated command is given. Upon command the speed set point will accelerate to the rated speed set point, however, it will not ramp back to the idle speed setting. When rated is de-selected, the speed set point stops as opposed to returning to idle. When this configuration is used, there is no ramp- to-idle option; it is not used.

If rated is de-selected while in a critical speed avoidance band (using ramp to rated only feature), the speed set point will stop at the top end of the avoidance band. If the ramp to rated function is stopped/halted using a raise or lower speed set point command, the set point will continue to the upper limit of the band if a Raise command was used or will reverse direction to the lower limit of the band if a Lower command was used.

If idle is selected while in a critical speed avoidance band (not using ramp to rated only feature), the speed set point will return to the Idle set point, continuing to move at the critical avoidance rate while within the band. The speed set point cannot be stopped within a critical speed avoidance band. Attempting to stop the ramp to rated while in a critical band will continue the speed set point to the upper limit of the band if a Raise command was used or will reverse direction to the lower limit of the band if a Lower command was used.

A Ramp-to-Idle speed or Ramp-to-Rated speed command may be selected from the 505 keypad, contact input or Modbus communications. The last command given from any of these three sources dictates the function performed.

If a 505 contact input is programmed to select between Idle or Rated speeds, Idle Speed is selected when the contact is open and rated speed is selected when it is closed. The Idle/Rated contact can be either open or closed when a trip condition is cleared. If the contact is open, it must be closed to initiate a Ramp-to-Rated speed. If the contact is closed, it must be opened and re-closed to initiate a Ramp-to-Rated speed.

When the turbine is used for mechanical drive applications, rated speed may be set at the minimum governor speed setting. When the turbine is used to drive a generator, the 'rated speed' setting may be set at or between the minimum governor and synchronous speed settings.

All pertinent Idle/Rated parameters are available through the Modbus links, refer to Chapter 6 for a complete listing.

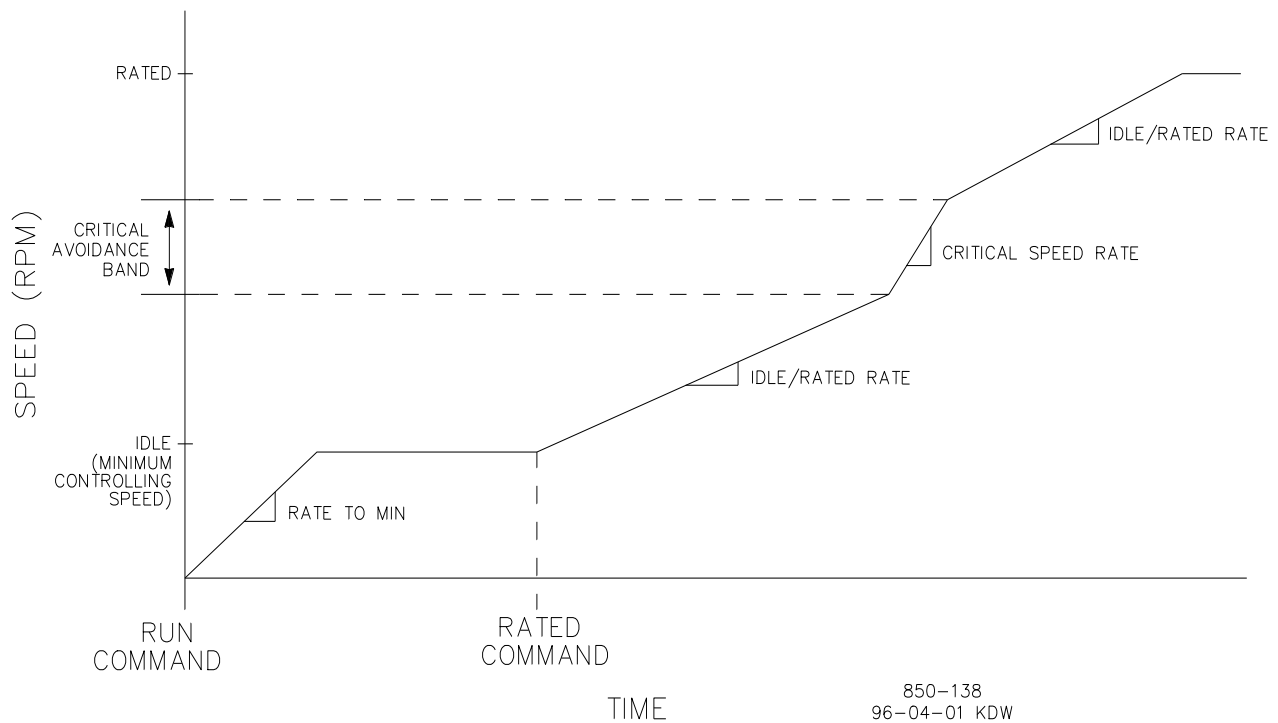


Figure 3-9. Idle/Rated Start

Automatic Start Sequence

IMPORTANT

This function is not the same as the 'AUTOMATIC START MODE'. The Automatic Start Sequence can be used with any one of the three start modes.

The 505 can be configured to utilize an Automatic Start Sequence to start the turbine. This sequencing logic allows the 505 to perform a complete controlled system start-up from zero speed to rated speed. With this function, the turbine's starting ramp rates and idle speed hold times depending on either the length of time the unit was shut down or upon optional temperature input signals. This sequence logic may be used with any of the three start modes (manual, semiautomatic, automatic), and is initiated by a 'RUN' command.

With this function, when a 'START' command is given:

- The Automatic Start Sequence ramps the speed set point to a low idle set point
- Holds at this setting for the set duration
- Ramps the speed set point to the Idle-2 setting
- Holds at this setting for the set duration
- Ramps the speed set point to Idle-3 setting
- Holds at this setting for the set duration
- Then finally ramps the speed set point to the programmed rated turbine speed setting

All ramp rates and hold times are programmable for both hot start and cold start conditions. The control differentiates between hot and cold starts by using a "Hours-Since-Trip" timer or a contact input. When using the "Hours-Since-Trip" timer, the timer starts when a shutdown has been executed and turbine speed has decreased below the low idle speed setting.

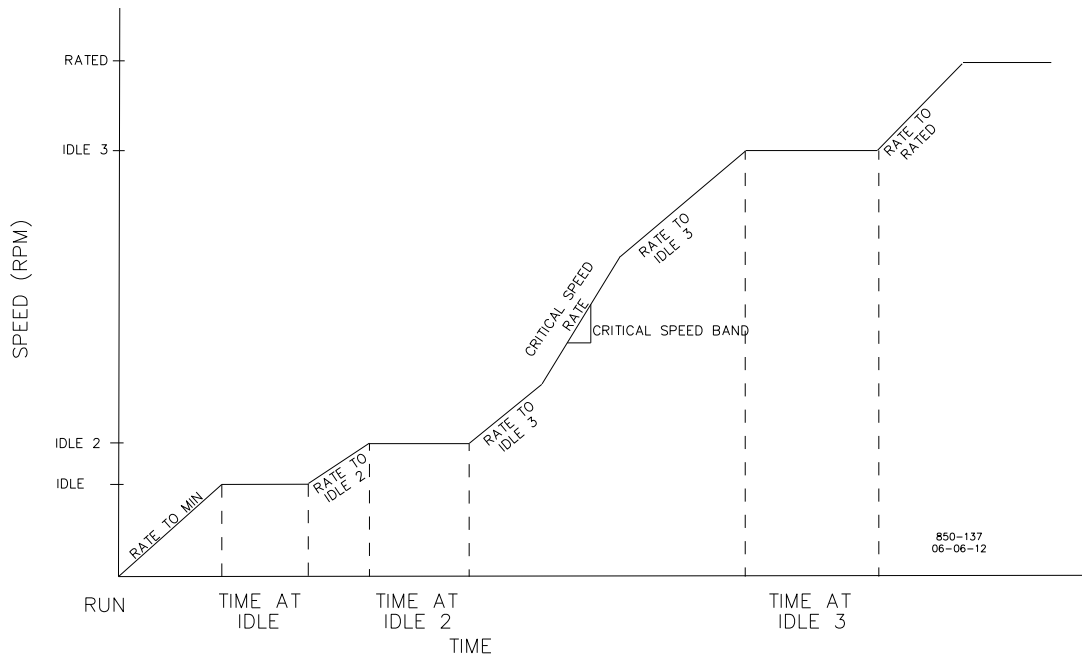


Figure 3-10. Automatic Start Sequence

With this sequence, a set of hot-start ramp rates and hold times is programmed for use when a 'START' command is given and the turbine has been shut down for less than the programmed 'HOT START' time setting. A set of cold-start ramp rates and hold times is also programmed for use when a 'START' command is given and the turbine has been shut down for longer than the programmed 'COLD START' time setting.

If a turbine 'START' command is given when the length of time the system has been shut down is between the 'HOT START' and 'COLD START' time settings, the control can be configured to interpolate between the hot and cold programmed start values to determine starting rates and hold times.

Table 3-1. Automatic Start Sequence Settings

COLD START (> xx HRS)	=	22	HRS
HOT START (< xx HRS)	=	2	HRS
LOW IDLE SETPT	=	1000	RPM
LOW IDLE DELAY (COLD)	=	30	MINIMUM
LOW IDLE DELAY (HOT)	=	10	MINIMUM
USE IDLE 2	=	*TRUE	
RATE TO IDLE 2 (COLD)	=	5	RPM/S
RATE TO IDLE 2 (HOT)	=	15	RPM/S
IDLE 2 SETPT	=	1500	RPM
USE IDLE 3	=	*TRUE	
RATE TO IDLE 3 (COLD)	=	5	RPM/S
RATE TO IDLE 3 (HOT)	=	15	RPM/S
IDLE 3 SETPT	=	2000	RPM
IDLE 3 DELAY TIME (COLD)	=	30	MINIMUM
IDLE 3 DELAY TIME (HOT)	=	20	MINIMUM
RATE TO RATED (COLD)	=	10	RPM/S
RATE TO RATED (HOT)	=	20	RPM/S
RATED SETPT	=	3400	RPM

Table 3-2. Hot And Cold Parameter Interpolation Rates and Delays
(Viewed in the Service Mode, See Volume 2)

LOW IDLE DELAY	=	20	MINIMUM
RATE TO IDLE 2	=	10	RPM/S
IDLE 2 DELAY	=	10	MINIMUM
RATE TO IDLE 3	=	10	RPM/S
IDLE 3 DELAY	=	10	MINIMUM
RATE TO RATED	=	15	RPM/S
RST Timer Level	=	3500	RPM
Hot RST Timer (min)	=	10	MINUTES

Based on the example's configuration and trip time:

- The Speed Set Point would ramp to 1000 rpm at the rate to minimum setting and hold for 20 minutes (turbine speed must also be at or above 1000 rpm)
- Move to 1500 rpm at 10 rpm/s and hold there for 10 minutes
- Move to 2000 rpm at 10 rpm/s and hold there for 10 minutes and lastly
- Move to 3400 rpm at 15 rpm/s. At 3400 rpm, the sequence would be completed
- However, speed reference must be above the HOT RESET LEVEL during more than HOT RESET DELAY, to fully use the HOT parameter
- If the unit was tripped for 2 hours or less and restarted, the control would use the hot start parameters. If the unit was tripped for 22 hours or longer and restarted, the control would use the cold start parameters.

IMPORTANT

The 505 will automatically set the hours-since-trip timer to its maximum setting of 200 hours to ensure a cold start is selected after a power up or upon exiting the Configuration mode. The hours-since-trip timer will reset only when the turbine speed has increased above the minimum governor speed/RST timer level setting for the Not RST timer duration.

Optionally, if a contact input is configured for the "Select Hot Start" function, then the Auto Start Sequence's Hot Start setting will be selected and used during the start routine when the respective contact is closed, and the Cold start curves will be used when the respective contact is open.

Hot/Cold Starts with NO Interpolation Between the Curves

If it is desired to have the control NOT interpolate between the Cold/Hot ramp times, then the **Cold Start** and **Hot Start** hour settings can be set equal to each other and no DI input is needed (the Cold and Hot Start hours setting is found in **Configuration/Turbine Start menu**). The unit will follow the Hot Times below this setting and the Cold Values when this time is exceeded.

Hot/Cold Start Temperature Inputs

An analog input configured as a temperature signal can be used to determine whether the turbine is hot or cold for startup speed setpoint rates and idle delay times. In addition, a warm setting is also available for a total of three turbine temperature conditions. Cold, warm, and hot starts each have programmable speed setpoint rates for each speed level in the startup sequence, whether Idle/Rated or Automatic Start with Idle 1, Idle 2, Idle 3, and Rated speed is used.

To specify cold or hot conditions for the turbine, the Hot/Cold Temperature logic will determine if the “Start Temperature 1” analog input is greater than the configured “Hot Minimum Temperature”. If so, the HOT rates and delays will be used for the startup sequence configured. If not, the COLD rates and delays will be used for the startup sequence configured.

Optionally, a Warm setting is available. If “Use Warm Condition” is selected in the Turbine Start configuration menu, it provides an intermediate level between Hot and Cold rates and delay times for the start sequence. Using the Warm setting requires another temperature level to be configured. If the “Start Temperature 1” analog input is greater than the configured “Hot Minimum Temperature” then the HOT rates and delays will be used for the startup sequence configured. If the “Start Temperature 1” analog input is greater than the configured “Warm Minimum Temperature” but less than the “Hot Minimum Temperature” then the WARM rates and delays will be used for the startup sequence configured. If the temperature is below both settings, then the COLD rates and delays will be used for start sequence configured.

A second temperature analog input can be used with the Hot/Warm/Cold feature as well. This requires configuring a second analog input as “Start Temperature 2” and the “Use Temperature Input 2” checkbox should be selected in the Turbine Start configuration menu. This will provide a second unique setpoint for this temperature input for both the Warm and Hot conditions.

When using the second temperature analog input an option to use the temperature difference, as a condition for a Warm or Hot start, is also available. Select the “Use Temperature Difference” checkbox in the Turbine Start configuration menu. The difference between Start Temperature 1 and 2 must be less than the configured amount for Hot/Warm conditions to be met.

If the “Select Hot/Cold” contact input is configured, the Hot/Cold Temperature logic will respond to this signal. If the contact is open, Cold will be selected. If the contact is closed, it allows for a Warm or Hot start if all the temperature conditions for the Warm or Hot start are satisfied.

When a temperature input fails then the Hot/Warm conditions for that input will not be met, which means that the start sequence will use the Cold start values. The start will proceed normally as if the turbine is running the cold condition.

Table 3-3. All Required Conditions, If Configured, For a Warm or Hot Start

Hot/Warm/Cold Start	Description of Conditions
COLD	HOT or WARM conditions not met or temperature input failed.
WARM	T1 > Warm T1 setpoint T2 > Warm T2 setpoint Td < Warm Td Setpoint CI closed
HOT	T1 > Hot T1 setpoint T2 > Hot T2 setpoint Td < Hot Td Setpoint CI closed

T1 = Start Temperature 1

T2 = Start Temperature 2

Td = Difference between Start Temperature 1 and 2

CI = Select Hot/Cold Contact input

Halting the Auto Start Sequence

The Auto Start Sequence can be halted at any time from the 505 keypad, contact input, or through Modbus. The sequence can be halted by a halt command, a raise or lower speed set point command, or when a speed set point is directly 'Entered' from the 505 keypad or through Modbus communications. When the sequence is halted, the delay timers do not stop if they have already started counting down. The sequence will resume when a 'Continue' command is issued. If there were 15 minutes remaining to hold at an idle speed and the Halt command was issued for 10 minutes before issuing a Continue command, the sequence would remain at the idle speed for the remainder of the 'Hold Time'—which in this example is 5 minutes.

NOTICE

The 'Hold Time' is only used if the speed setpoint exactly equals the associated Idle hold setpoint. If the speed setpoint is different from this hold point, selecting 'Continue' will ramp the setpoint up to the next hold point regardless of the 'Hold Time'. Caution should be taken when raising or lowering the speed set point to 'Halt' the Automatic Start Sequence.

The halting and continuing of the Auto Start Sequence can be performed through the 505 keypad, contact input, or Modbus. The last command given from any of these three sources determines the mode of operation. However, a shutdown condition will disable this function, requiring it to be re-enabled after a start-up has been performed.

If a 505 contact input is programmed to function as a Halt/Continue command, the sequence is halted when the contact is open, and continued when the contact is closed. The Halt contact can be either open or closed when a Reset command is given. If the contact is closed, it must be opened to allow the sequence to be halted. If the contact is open, it must be closed and reopened to issue a halt command. Alternatively, a relay can be programmed to indicate when the Auto Start Sequence is halted.

An option is available to automatically halt the auto start sequence at the idle set points. This feature would result in the unit automatically stopping or halting at the low idle set point and at the high idle set point. If the unit is started and the speed is above the low idle set point, the sequence will initialize as halted. The sequence must be given a 'Continue' command once halted. The hold timers are still active with this option. If 'Continue' is selected and the hold timer has not expired, the sequence will remain in a timed wait until the hold timer has expired and then continue from that point.

When the 'Auto Halt at Idle Setpts' option is programmed, the Auto Start Sequence Continue contact input only requires a momentary closure to continue the sequence.

Automatic Start Sequence Idle Temperatures

In addition to the Automatic Start Sequence Idle delay timers and “Auto Halt at Idle Setpoints” features, temperature analog inputs can be used to determine when the start sequence may continue from an Idle setpoint. These inputs will allow for a temperature permissive to be configured for each idle speed level. The start sequence will not continue from that idle until the temperature permissive is met.

If “Use Temperature for Autostart” is configured, the start sequence will determine if the “Start Temperature 1” analog input is greater than the configured “Temperature 1 Setpoint” for each Idle speed. If so, the start sequence will continue as long all other permissives are met, which include the idle timer and any halt command.

A second temperature analog input can be used with the Automatic Start Sequence temperature feature as well. This requires configuring a second analog input as “Start Temperature 2” and the “Use Temperature Input 2” checkbox should be selected in the Turbine Start configuration menu under “Autostart Sequence Settings”.

If this option is programmed, it will be use in one of the following ways:

1. It will provide a second unique setpoint relative to this temperature input for each idle speed level configured. For the unit to advance from one idle speed to the next, both temperature conditions must be met.
2. Using the second temperature analog input makes available an option to use the temperature difference between these two signals. Select the “Use Temperature Difference” checkbox in the Turbine Start configuration menu under “Autostart Sequence Settings”. For the unit to advance from one idle speed to the next, the difference between Start Temperature 1 and 2 must be less than the configured amount, in addition to the individual temperature set points.

When a temperature input fails then the conditions to continue from any idle speed will not be met, which means that the start sequence will not continue past that idle level. To proceed with the start sequence, the temperature input can be overridden via the Service menu.

If configured, the following conditions must be met to continue from each idle speed:

- “Auto Halt at Idle Setpoints” not selected or operator ‘Continue’ command.
- Idle delay time expired.
- Start Temperature 1 is greater than “Temperature 1 Setpoint”.
- Start Temperature 2 is greater than “Temperature 2 Setpoint”.
- Difference between Start Temperature 1 and 2 is less than “Max Temperature Difference”.

Speed Control Overview

The speed control receives a turbine speed signal from one or two magnetic pickups or proximity probes. The ‘MPU Gear Ratio’ and the ‘Teeth Seen By MPU’ settings are configured to allow the 505 to calculate actual turbine speed. The control will always use the highest speed signal received as the validated turbine speed process variable. The Speed PID (proportional, integral, derivative control amplifier) then compares this signal to the set point to generate an output signal to the speed low signal select bus (LSS). In a single valve application, this signal then goes through a second low signal select bus which produces the output demand to governor valve actuator. In an extraction/admission turbine application the speed LSS value feeds into the ratio limiter equation that will control the output demands to both the HP and LP actuators.

The speed control’s set point is adjustable with raise or lower commands, through the 505 keypad, remote contact inputs or the communication line. This set point can also be directly set by entering a new set point through the 505 keypad or via Modbus. In addition, an analog input can be programmed to remotely position the speed set point.

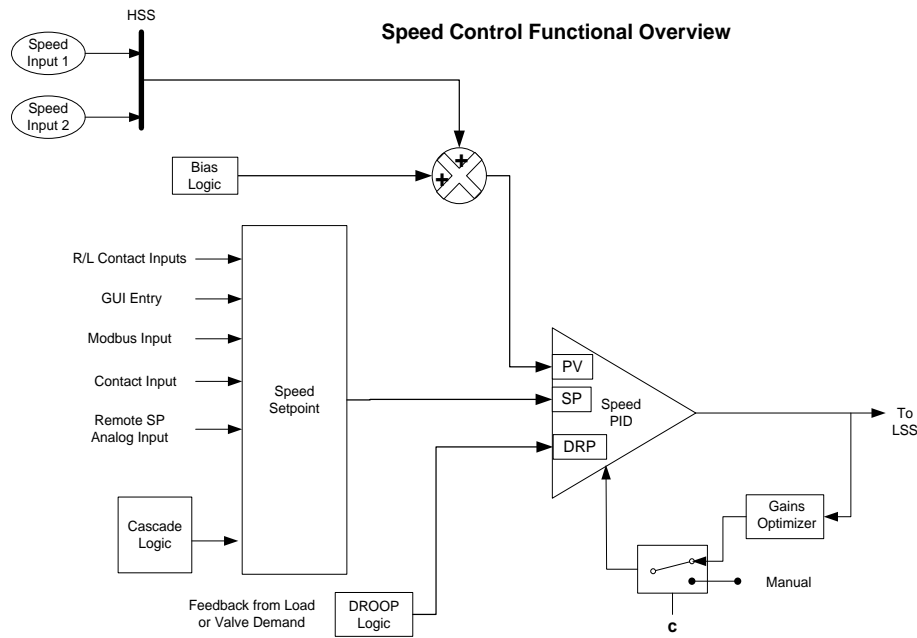


Figure 3-11. Speed Control Functional Diagram

Speed PID Operational Modes

The Speed PID operates in one of the following modes, depending on configuration and system conditions:

1. Speed control
2. Frequency control
3. Unit load control (droop)
 - Turbine inlet valve position (505 LSS position) control
 - Generator load control

When not programmed for generator applications, the 505 Speed PID operates in a Speed Control mode at all times. When programmed for generator applications, the state of the generator and utility tie breakers determine the operational mode of the Speed PID.

- When the Generator breaker contact is open, the Speed PID operates in a Speed Control mode.
- When the generator breaker is closed and the utility tie breaker is open, the Frequency Control mode is selected.
- When both the generator and utility tie breakers are closed, a Unit Load Control mode is selected.

Speed Control

While in the Speed Control mode, the Speed PID will control a turbine at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). With this configuration, no form of droop or second controlling parameter (bias logic) is used by the PID for stability or control.

The following Speed PID mode descriptions are based on the 505 program's default settings. For information on how to change the 505's defaulted breaker logic, refer to Volume 2 of this manual. All pertinent speed control parameters are available through Modbus communications. See Chapter 6 for a list of all Modbus parameters.

Frequency Control

The following Frequency Control mode descriptions are based on the 505 program's default settings. For information on how to change the 505's defaulted breaker logic, refer to Volume 2 of this manual.

The Speed PID operates in the Frequency Control mode when the generator breaker is closed, and the utility tie breaker is open. In the Frequency Control mode, the unit will operate at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). Refer to Table 3-4.

When breaker positions result in the Speed PID switching to Frequency Control, the speed set point is instantly stepped to the last turbine speed (frequency) sensed before Frequency Control was selected. This allows a bumpless transfer between modes. If the last speed sensed was not at the 'Rated Speed Set Point' (synchronous speed) setting, the speed set point will ramp to the 'Rated Speed Set Point' setting at a defaulted rate of 1 rpm/s (tunable through the Service mode).

In the Frequency Control mode the speed set point can be varied with the Speed Set Point Raise/Lower commands, as desired, to allow manual synchronization across a tie breaker to an infinite bus. See the Synchronization section in this chapter.

For indication purposes, a relay can be programmed to energize when the unit is in Frequency Control.

Unit Load Control

The 505's Speed PID can control two independent parameters when the generator breaker is closed; frequency when the generator is isolated, and unit load when the generator is paralleled with an infinite bus. When the generator breaker and utility tie breaker inputs are both closed, the Speed PID operates in a Unit Load mode. This method of allowing a PID to control a second parameter is referred to as Droop.

Giving the Speed PID two parameters to control allows it to control unit load and act as a stabilizing effect for any change in bus frequency. With this configuration, when bus frequency decreases or increases, unit load increases and decreases respectively, based on the unit's droop setting. The net effect is a more stable bus. See Figure 3-13 for a frequency and load relationship diagram.

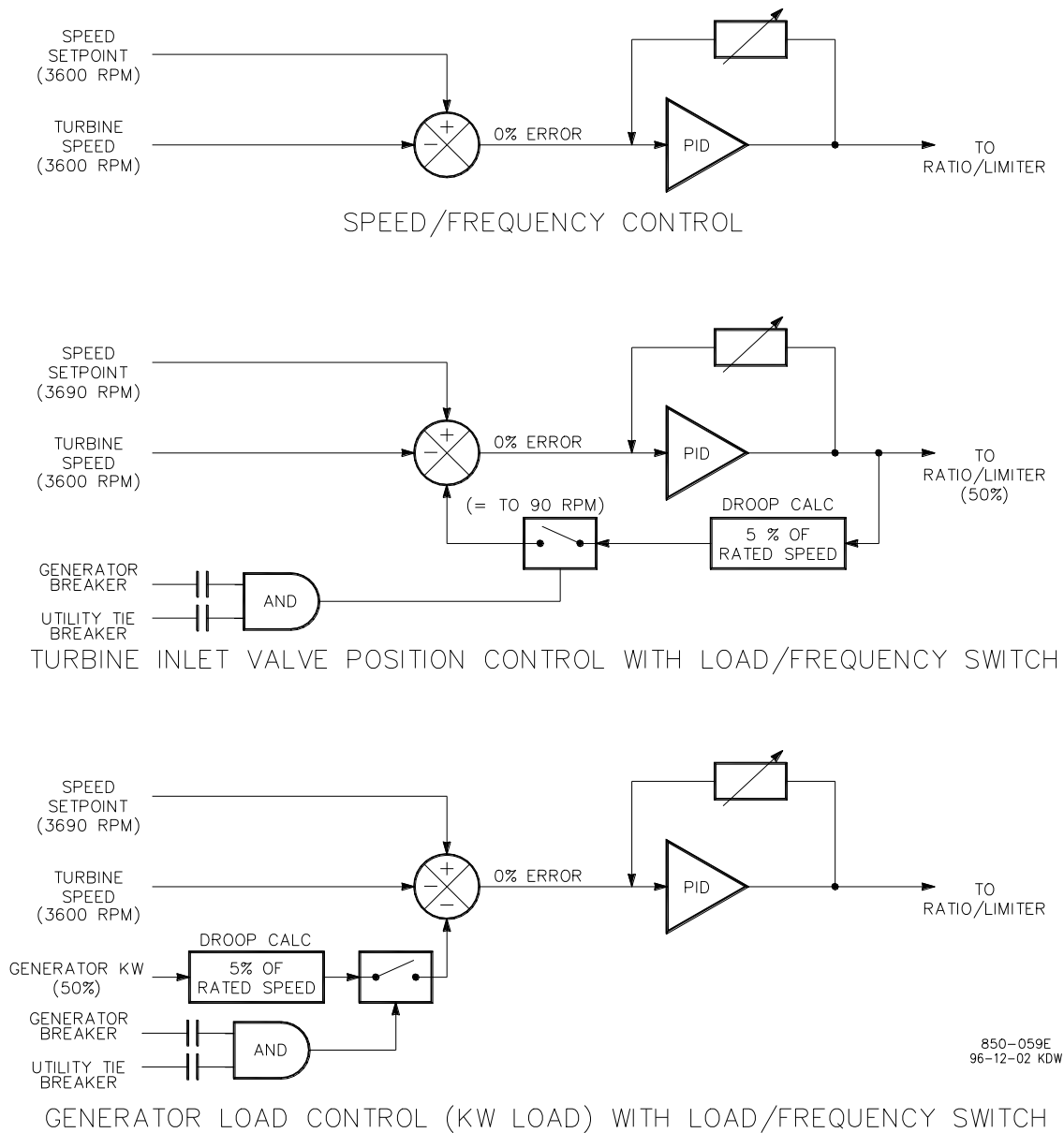
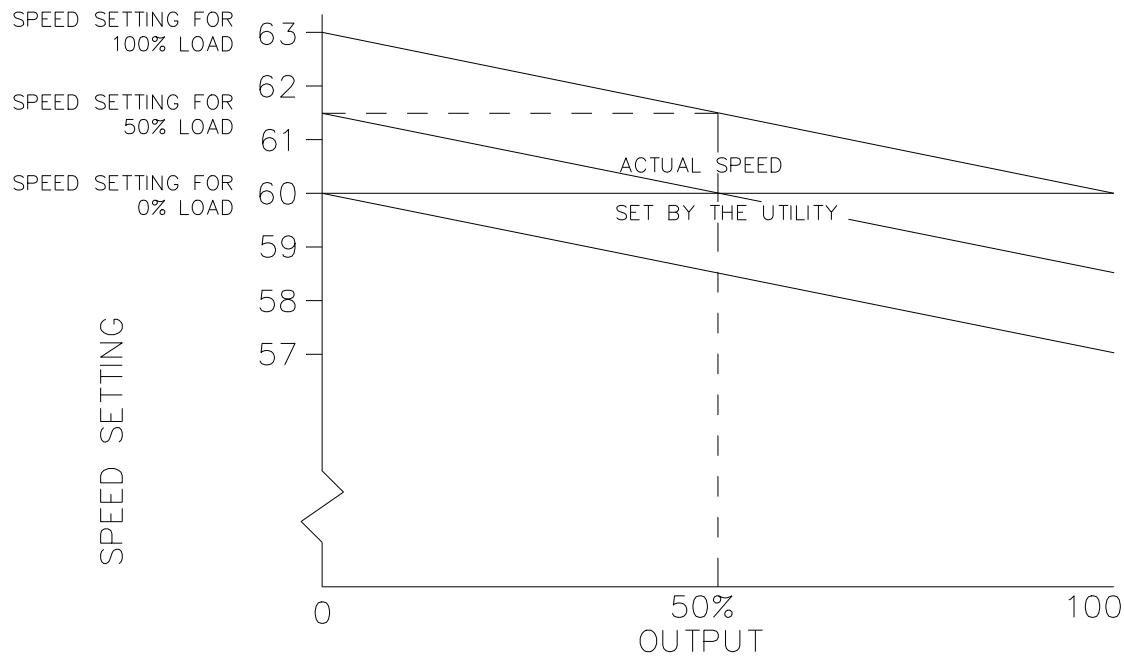


Figure 3-12. Speed PID Control Modes

The term “droop” was derived from an isolated unit’s speed reaction to an increase in load when another parameter (unit load) is fed back to a Speed PID’s summing junction. The Droop term, as used throughout this manual refers to a PID’s second controlling parameter. A second parameter representing unit load is fed back into the 505’s Speed PID to allow it to control two parameters; speed when operating in an isolated mode, and unit load when paralleled to an infinite bus. See Figure 3-12.



FREQUENCY/SPEED IS SET BY THE UTILITY GRID.
LOAD VARIES WITH SPEED SET POINT.

850-136
96-03-29 KDW

Figure 3-13. Frequency and Unit Load Relationship

Because the 505's Speed PID and set point are used to control turbine speed and a second parameter, this second parameter (unit load) is normalized to allow all three terms (speed, set point, unit load) to be summed together within the PID summing junction. This normalization is based on a percentage of rated speed and creates a direct relationship between unit load and the Speed PID's set point. Once unit load (0–100%) is represented as a percent of rated speed, the speed set point can be varied by this percent, above rated speed, to increase load from 0–100% when paralleled to the utility. Unit load is converted to a percentage of rated speed as shown in the following example calculation:

$$\text{DROOP \%} \times (\text{gen load or valve position-\%}) \times \text{Rated Speed} = \text{Speed Set Point change in rpm}$$

$$\text{Example: } 5\% \times 100\% \times 3600 \text{ rpm} = 180 \text{ rpm}$$

For this example, when paralleled to a utility bus, the speed set point can be adjusted from 3600 rpm to 3780 rpm to vary unit load from 0 to 100%.

Droop feedback allows the Speed PID to control unit load (generator power or turbine valve position) once it is paralleled with a utility bus or other generating systems which do not have droop or load sharing capability. When a turbine generator set is paralleled with a utility bus, the utility determines the unit frequency/speed, thus the governor must control another parameter. The 505 uses turbine inlet valve position (LSS bus position) or generator load as a second parameter to control when paralleled to an infinite bus.

The generator load or turbine inlet valve position droop percentage cannot be set greater than 10% and is typically set to 5%.

Optionally, the set droop percentage value can be changed from front panel, while turbine is running, or via a remote 4–20 mA signal (remote droop), to change the control's response to grid frequency changes.

In some extreme cases, where the utility grid frequency is unstable, and changes significantly (day/night), it is possible to change the unit's:

- Frequency set point (50 Hz/60 Hz \pm 2.5 Hz) via front panel
- Frequency dead-band (\pm 3 Hz). Used to reduce/prevent constant valve corrections due to a constantly changing grid frequency.

To configure the 505 for generator load control when paralleled to an infinite bus, check the 'Use KW Droop' option on the Operating Parameters page of the configuration menu. The 505 must also be configured to accept a KW Load signal either from an analog input from a Watt transducer sensing generator load, or from a Woodward Power Management product/device via a digital communication link (Woodward Links). To configure the 505 for turbine valve position control when paralleled to an infinite bus, uncheck the 'Use KW Droop' option. The generator load or turbine inlet valve position droop percentage cannot be set greater than 10% and is typically set to 5%.

If the 505 is programmed to control unit load using turbine inlet valve position droop (LSS bus position), the 505 calculates load based on the valve position at the time the generator breaker was closed. This valve position is considered to be zero load. In a typical application where turbine inlet and exhaust pressures are at rated levels when the generator breaker is closed, this type of calculation allows unit load to be accurately sensed and controlled.

NOTICE

In an application where turbine inlet or exhaust pressures are NOT at rated levels when the generator breaker is closed, the considered zero load level will be incorrect when system pressures do reach rated levels.

If turbine inlet or exhaust pressures are not at rated when the breaker closes, it is recommended that the user do the following:

Use the available tunable in Service mode to correct the valve position at zero load once the system is operating at rated steam pressure. To do this, adjust the Zero Load Value, (under the Service mode's 'BREAKER LOGIC' header) and set this value to the correct valve position demand at Sync no load condition

Load Limiter Function

In application software p/n 5418-7839 Revision "A", a Load Limiter Function has been added to the control application that provides logic to limit the load output of the turbine. On units configured for generator applications, this feature can provide load limiting, while allowing the AUX controller (historically used often as a load limiter) to be used as an additional control or limiter based on another process parameter.

If the unit is configured for GEN operation and has a Load process variable defined then this function will be available in Service, no additional configuration items are required. In the Service menus, under the Breaker Logic screens, the user can set a Load Limit value and Enable the Load Limiter function. These values are active and available during operation.

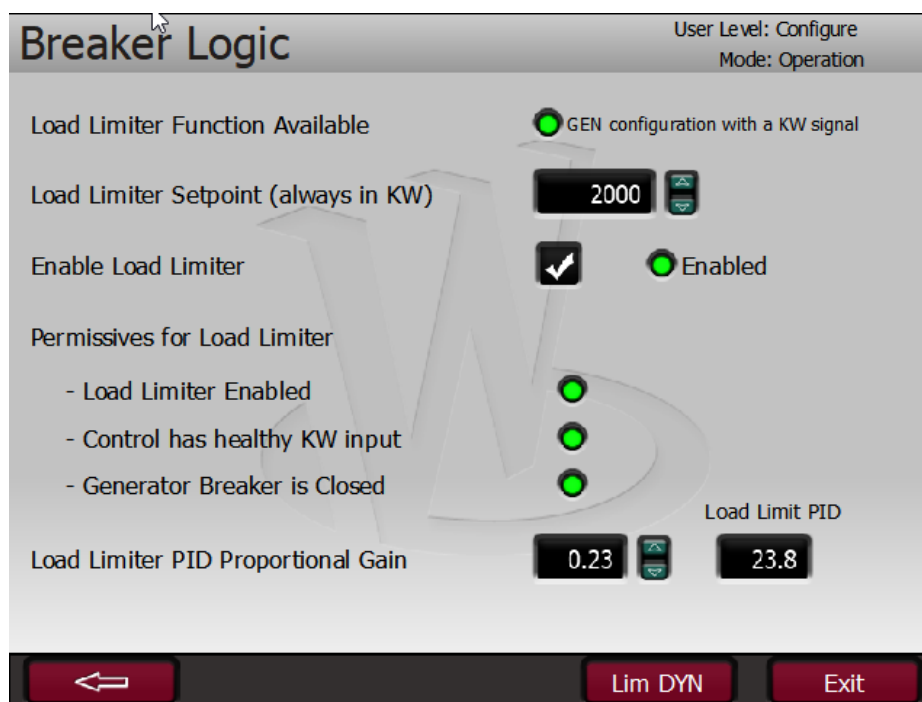


Figure 3-14. Service Menu – Breaker Logic Screen 3

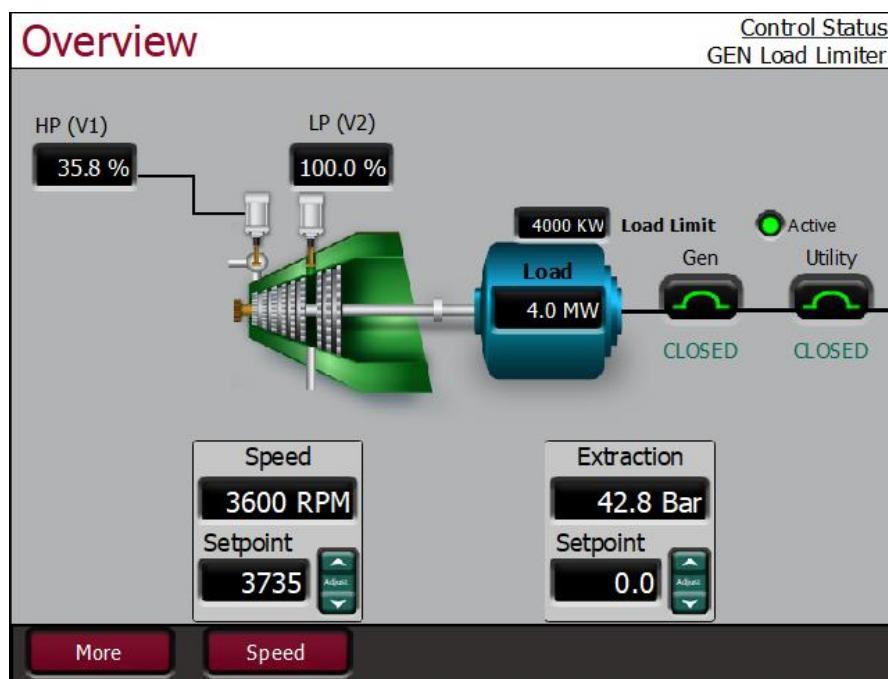


Figure 3-15. Overview Screen in Speed Control with Load Limiter Enabled and Active

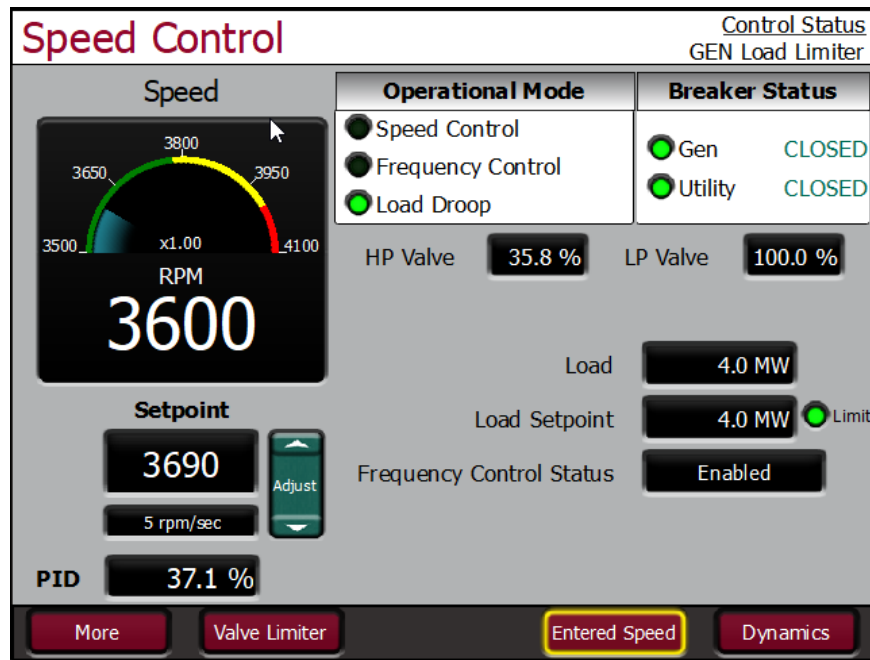


Figure 3-16. Speed Control with Load Limiter Enabled and Active

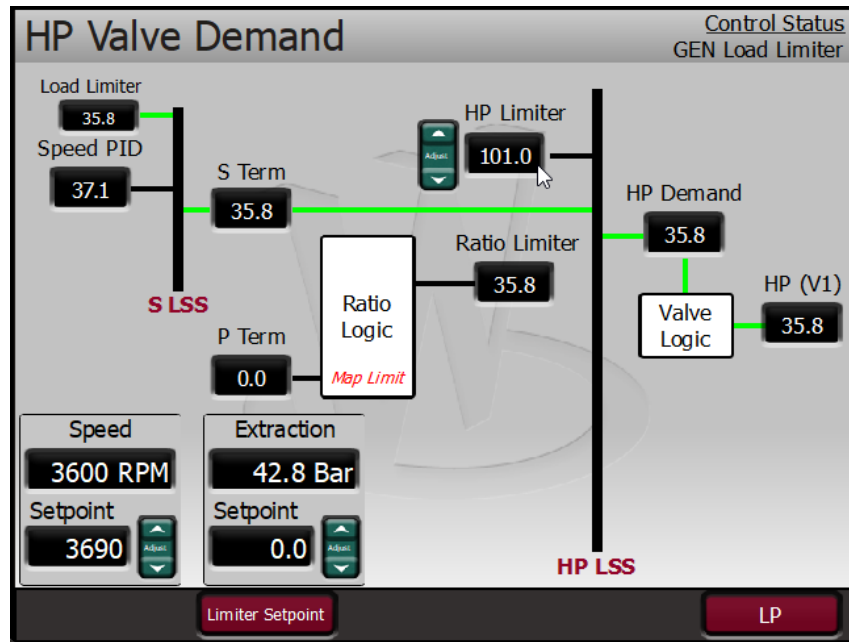


Figure 3-17. Valve Demand with Load Limiter Active

Notes on User Settings:

Load Limit Setpoint (KW) Integer value entered by user (always in KW)
 Enable Load Limiter – using the checkbox or Modbus command enables the Load Limiter PID
 Load Limiter PID dynamic gain adjustments are available on the PID Dyn screen. Typically, only a proportional gain adjustment is needed on the limiter.

The following are the configuration requirements for Load Limiting to be available:

- Configured for GEN operation
- Must have an input defined for GEN Load (AI or digital comm)

The following are the permissives for Load Limiting to be available during operation:

- Must have a healthy active GEN Load signal (not faulted)
- Generator Breaker is closed
- Load Limiter Enabled

The following are options available related to this feature:

- Relay output state configurations for Load Limiter Enabled and Load Limiter Active
- Modbus read indications for Load Limiter Enabled and Load Limiter Active
- Modbus write commands to Enable and Disable the Load Limiter (Use instead of checkbox)

Load Limiter Functional Operation:

When the Load Limiter is enabled and the other permissives are met, the Load Limit Setpoint & the Load Limiter ACTIVE LED will be visible on the Speed Control and Overview Operation screens, but the LED will be in the OFF state. When the turbine load reaches the limiter setpoint, the Load Limiter is ACTIVE, the LED will be ON (green) and the HP Valve demand will not be allowed to go any higher. The operational status of the control will show "GEN Load Limiter" as the control status during this time. The Modbus link contains status indications for when the load limiter is enabled and active, there are also selections for relay output indications that can be used if needed. The Modbus also contains write commands to enable and disable the load limiter. If the intent is to use Modbus commands, then the checkbox in Service should be left unchecked, as when this is box is checked the feature is always enabled if permissives are met.

The load limiter enables a PID that will actively limit the Speed/Load demand (LSS Bus which is the S term on Extraction units) once the load reaches the load limit setpoint, it will stay active as long as the load is within 3% of the setpoint. Once the load is reduced below this threshold the load limiter PID will be disabled from the LSS bus. The service screen has access to the gain terms of the load limiting PID, if adjustment is required. This function requires a healthy generator load input signal. If this signal is failed, the load limiter will not go active. If this signal fails while the load limiter is active, this function will be disabled and the unit will ramp to the speed/load setpoint, which will be at or above the current load limit setpoint. The user entered load limit setpoint will always be in the units of KW. Internal logic will switch this value to MW if that is required. The user setpoint will be rate limited prior to feeding into the PID to 100kw/sec, so it can be adjusted while the unit is in operation.

If the unit is currently in Load Sharing mode when the load limiter becomes active, load sharing will be disabled on this unit and this unit will be removed from the load sharing group.

If the Load Limiter is disabled while it is active, the demand of this limiter will ramp at 1%/sec up to a value of 101. This is done to soften the transition back into normal speed/load control or back to any other process control that is enabled.

Speed Set Point

The Speed PID's set point may be adjusted from the 505 keypad, external contacts, Modbus/OPC commands, or through a 4–20 mA analog input. A specific set point setting can also be directly entered through the 505 keypad or Modbus communications. The Cascade PID also directly controls this set point when it is used.

The Speed PID's set point may be adjusted from the 505 keypad, external contacts, or through Modbus. It can be directly entered to a specific value from the 505 keypad or through Modbus commands. It can be remotely set by the Remote Speed Set Point analog input, or it can be manipulated by the Cascade controller to control the Cascade input parameter.

The speed set point range must be defined in the Configuration mode. Program settings 'Min Governor Speed Set Point' and 'Max Governor Speed Set Point' define the normal operating speed range of the turbine. The speed set point cannot be raised above 'Max Governor Speed Set Point' setting unless an Overspeed Test is being performed. Once the speed set point is taken above the 'Min Governor Speed Set Point' setting, it cannot be varied below this setting again unless the Idle/Rated ramp-to-Idle command is selected or a Controlled Stop is selected.

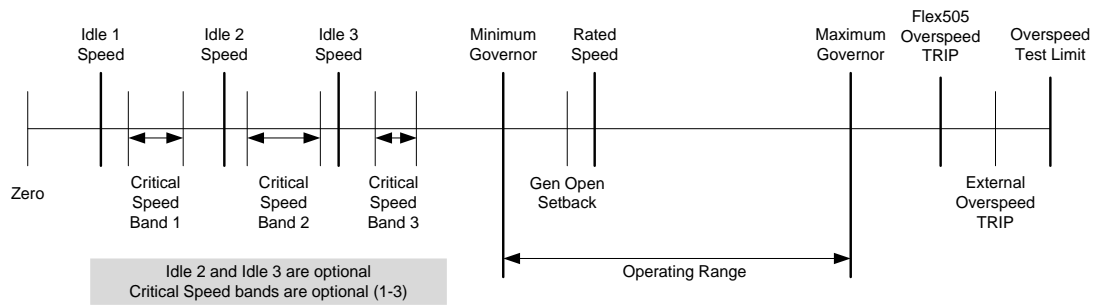


Figure 3-18. Speed Relationships

Once turbine speed is equal to or greater than the 'Min Governor Speed Set Point' setting, the speed set point may be adjusted through discrete raise and lower commands. When a raise or lower speed command is issued, the set point moves at the programmed 'Speed Set Point Slow Rate'. If a speed raise/lower command is selected for longer than three seconds, the speed set point will then move at the fast rate which is three times the speed set point slow rate. The speed set point slow rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a set point will move for an accepted raise or lower command is 40 milliseconds (120 milliseconds for a Modbus command). If the speed set point slow rate is programmed for 10 rpm/s, the smallest increment it will move is 0.4 rpm (1.2 rpm for Modbus).

The speed set point may be set to a specific level, by directly entering a set point value through the 505 keypad or Modbus communications.

To "enter" a specific set point from the 505 keypad, follow these steps:

1. Go to the Speed Control page – select Commands/Entered Setpoint
2. Dialog Box will open with target value – click Enter (to highlight value)
3. Use numeric keypad to enter desired setpoint – click Enter (to accept)
4. Click on the GO button to ramp from current setpoint to the new setpoint

If a valid number was entered, the setting will be accepted as the new target setpoint. If an invalid number is "entered" the setting will not be accepted and the 505's screen will momentarily display a value out-of-range message. This 'Entered' rate is tunable through the Service mode.

Requirements for valid entries are the following:

- Speed must be below the maximum governor setting
- Speed must be above the idle setting and not within any critical speed avoidance band
- Once the speed set point is above the minimum governor setting, the set point cannot be lowered below minimum governor
- If the unit is driving a generator and the unit is on-line, the speed set point cannot be set below the minimum load setting (set in Service)

The speed set point can also be directly entered from Modbus/OPC; however, the allowed range is between the minimum governor and the maximum governor speed settings. The allowed set point range is limited to between the minimum load and the maximum governor settings if the unit is driving a generator and the unit is on-line.

When the 505 is configured for a generator application, a special speed set point rate (Sync Window Rate) is used to increase set point resolution around synchronous speed. This allows for tighter set point control to accommodate synchronizing manually or by an automatic synchronizer which interfaces to the 505 using discrete contacts. This Sync Window Rate is defaulted to two rpm/s and is only used when the generator breaker is open, and the speed set point is within 10 rpm of rated speed. Both the synchronizing rate and the synchronizing window are tunable in the Service mode.

When configured for generator applications a Minimum Load set point can be used by the 505 to reduce the chance of reverse powering a unit upon closing the generator breaker. With the utility tie breaker closed, when a generator breaker closed indication is received, the Speed set point is stepped to the Minimum Load setting. The Minimum Load setting is defaulted to 3% (changeable in the Service Mode). To disable the use of the Minimum Load Set Point, set the 'Use Min Load' setting (under the Service mode's 'BREAKER LOGIC' header) to 'Unchecked' (Not Used).

As a related feature, if 'Use Min Load' is selected and the parameter 'Reverse Power on Controlled Stop' in OPERATING PARAMETERS is NOT selected, then the 505 will use this Minimum Load setting as the lower speed setpoint limit whenever the breaker is closed

When the 505 is configured for a mechanical drive application, a contact input can be configured to instantly step the speed setpoint to the minimum governor speed. This feature can only be used after the startup sequence has been completed. In addition to stepping the speed setpoint to the minimum governor speed, closing the contact input will also disable the Cascade and Auxiliary controls.

See Chapter 6 for a list of all speed set point related Modbus parameters.

Frequency Arm/Disarm

The Frequency Arm/Disarm feature can be used only when load sharing is not being performed, to allow multiple units to operate on the same isolated bus. With this feature, one unit on a multiple unit isolated bus controls frequency and the other units operate in a unit-load mode. The unit controlling frequency is referred to as the "Swing Machine" because its load will swing (vary) depending on the load of the plant. Caution should be taken with this configuration to not overload or reverse power the "Swing Machine".

This feature, when programmed, allows an operator to Arm or Disarm a unit's Frequency Control mode while it is in operation. When armed, a unit will switch to Frequency Control if the plant-to-utility tie breaker opens. When disarmed, a unit will stay in a unit-load control mode when the plant-to-utility tie breaker opens.

To use this feature, the program's 'Use Freq Arm/Disarm' setting box must be checked, the Sync/Load Sharing mode cannot be programmed, and a discrete command must be programmed. The Frequency Arm/Disarm mode can be selected from a programmed contact input, Function key, or Modbus command. When the programmed contact input is closed the unit's Frequency Control mode is armed. When the programmed contact input is open the unit's Frequency Control mode is disarmed.

Depending on a unit's size, health, and running status, an operator may select which unit is designated as the plant Frequency Control Unit if or when the plant- to-utility tie breaker opens. Frequency control can be armed at any time, but it will only go into control when the generator breaker is closed and the utility tie breaker is open.

NOTICE

Only one unit at a time should have its Frequency control mode armed. If multiple units try to control plant frequency at the same time, they may fight and cause system instability, with the potential of damage to the equipment due to overloading or reverse-powering a machine.

If the 'Use Freq Arm/Disarm' setting box is unchecked, Frequency Control is always armed and the unit will go into Frequency Control when the utility tie contact is open. If the program's 'Use Freq Arm/Disarm' setting box is checked, then Frequency Control must first be armed before the unit will switch into Frequency Control when the utility tie contact is open.

Table 3-4. Frequency Arm/Disarm Generator Control Modes

Tie Breaker Contact Status	Gen Breaker Contact Status	Frequency Arm	Speed Control Mode	Initial Speed Reference	Cascade or Auxiliary (if used)
Closed	Open	XXXX	Speed, Off-Line Dynamics	XXXX	Not Active
Closed	Closed	XXXX	Unit Load Control, On-Line Dynamics	Droop Setpoint	Active
Open	Open	XXXX	Speed, Off-Line Dynamics	XXXX	Not Active
Open	Closed	Arm	Frequency Control, Off-Line Dynamics	Current Speed then Rated	Not Active
Open	Closed	Disarm	Droop, Off-Line dynamics	Droop Setpoint	Not Active

Speed Control Dynamics

The 505 has a variety of options for the setting of dynamics (PID gain settings). When a system needs variable response times, due to changing system conditions, these dynamic variables allow the Speed PID to be tuned for optimal response. These values are separated into 2 main operational conditions, Off-Line and On-Line.

Off-Line, On-Line, and Ratio Limiter -

When the 505 is configured for a generator application, the utility tie and generator breakers determine which set of dynamics is used by the Speed PID. The Speed PID's off-line dynamics are selected when either the utility tie or generator breakers are open. The Speed PID's on-line dynamics are selected if both breakers are closed (see Table 3-2).

When not configured for a generator application, the 505 uses the programmed 'Min Governor Speed Set Point' setting to determine which set of dynamic values are used by the Speed PID. The Speed PID's off-line dynamics are selected when turbine speed is below the 'Min Governor Speed Set Point' setting. The Speed PID's on-line dynamics are selected when turbine speed is above the 'Min Governor Speed Set Point' setting. (see Table 3-2).

When not configured for a generator application, the 505 will transfer from off-line to on-line dynamics once minimum governor speed is reached.

Optionally a contact input may be programmed to perform a "Select On-Line Dynamics" function. If this contact is programmed the utility tie and generator breaker positions (gen applications), and the minimum speed setting status (non-gen applications) do not affect dynamics selection. When the programmed contact input is open, off-line dynamics are selected and used by the Speed PID. When the programmed contact input is closed, on-line dynamics are selected and used by the Speed PID.

A relay can be programmed to indicate that the On-Line Dynamics are selected and used by the Speed PID.

Table 3-5. On-Line/Off-Line Dynamics Selection

CONFIGURATION	ON-LINE DYNAMICS SELECTED	OFF-LINE DYNAMICS SELECTED
GEN SET	BOTH BREAKERS CLOSED	EITHER BREAKER OPEN
NOT A GEN SET	SPD > MIN GOV SETTING	SPD < MIN GOV SETTING
*CONTACT INPUT	CLOSED	OPEN

*The contact input option has priority, when programmed.

When configured an Extraction/Admission turbine, a third set of dynamics are optionally available when operating on the Ratio Limiter. Initially, these value match and follow the On-Line dynamic settings. On the Speed Control Dynamics screen, the 'Match On-Line' function can be deselected, allowing for manual adjustment of the Ratio Limiter dynamics.

Dynamic Gain Settings –

Dynamic gain values for the speed PID are initially defined in the configure mode and tunable at any time. For Off-Line settings there is 1 set of values for the Proportional, Integral and Derivative terms. The On-Line settings can be a single set of values, or a curve created by optimizing the dynamics at 2 or 3 different load points.

The procedure for setting these values is as follows.

1. Start by manually setting the gains for both Off-Line and On-Line conditions, referring to the PID Dynamic Adjustments section in this manual for completing this process.
2. Use the automated PID Dynamic Optimizer routine that will automatically analyze the system response and calculate ideal gains for that particular running condition.
3. Once the analysis is complete and the gains are calculated, the user can choose to keep these gains or return to the manual values. For ONLINE operation, this routine can be performed at low, medium, and high load points to create an ideal gain curve for optimum dynamics at all load conditions.

Refer to the Understanding PID Dynamic Settings section in this manual for more information on the **PID Dynamic Optimizer** procedure.

Remote Speed Set Point

The Speed set point can be positioned remotely through an analog signal by programming the Remote Speed Set Point analog input function. This allows the Speed set point to be set remotely by a process control or distributed plant control system.

The remote speed set point input directly affects the 505's speed set point. The maximum rate at which the remote input signal can change the speed set point is programmable. When the remote set point is enabled, the speed set point will move at a much slower rate until the two settings are matched at which time the speed set point will be allowed to move at the maximum rate.

The Remote Speed Set Point (RSS) range is determined by the programmed analog input's 4 mA and 20 mA settings. The Remote Speed Set Point range is tunable in the Service mode (under REMOTE SPEED SETTINGS) but cannot control outside of the min governor and max governor speed set point values.

Since RSS is a secondary speed setting function, the Speed PID must be in-control of the 505's LSS bus to allow the RSS to position the actuator. When configured as a generator application, the RSS will not take control unless both breakers are closed and the Speed PID is in control. When not configured as a generator application, turbine speed must reach min governor before the RSS can take control. The Cascade and Auxiliary (if configured to be enabled/disabled) controls are automatically disabled if RSS is enabled.

The Remote Speed Set Point may be enabled or disabled from the 505 keypad, external contact, or Modbus. The last command given from any of these three sources dictates the enabled/disabled state. It does not matter whether the last command was given from the keypad or other devices.

A contact input can be programmed to perform as an external "Remote Speed Set Point Enable" function. When this programmed contact is open the RSS is disabled, and when it is closed the RSS is enabled. The contact can be either open or closed when trip condition is cleared. If the contact is open it must be closed to enable the RSS. If the contact is closed it must be opened and re-closed to enable the RSS function.

If the milliamp signal to the Remote Speed set point input is out of range (below 2 mA or above 22 mA) an alarm will occur, and the Remote Speed set point will be inhibited until the input signal is corrected and the alarm is cleared.

Remote Speed Set Point Status Messages

The Remote Speed Set Point may be in one of the following states (505 front panel screen messages):

- Disabled - The remote set point function is not enabled and will have no effect on the speed set point.
- Enabled - The remote set point has been enabled.
- Active - The remote set point is in control of the Speed set point, but the speed PID is not in control of the actuator output.
- In Control - The remote set point is in control of the Speed set point and the speed PID is in control of the actuator output.
- Inhibited - RSS cannot be enabled. The input signal has failed, a controlled stop is selected, the unit is shut down, or RSS is not programmed.

When enabled, the Remote Speed set point may not match the Speed set point. In this case, the Speed set point will ramp to the Remote Speed set point at the programmed 'Speed Set Point Slow Rate' setting (as defaulted in the Service mode). Once in control, the maximum rate that the Speed set point will ramp, for a RSS change, is at the programmed 'Remote Speed Set Point Max Rate' setting. If the 'Remote Speed Set Point Max Rate' were set at 10 rpm/s and the Remote Speed set point analog input instantly moved from 3600 rpm to 3700 rpm, the Speed set point will move to 3700 rpm at 10 rpm/s.

Refer to Volume 2 of this manual for information on related Service mode tunables.

All pertinent Remote Speed Set Point parameters are available through the Modbus links, refer to Chapter 6 for a complete listing of Modbus parameters.

Synchronization

Automatic generator synchronization can be performed through a Woodward EGCP-3, easYgen, or DSLC-2. The DSLC-2 product is the easiest to integrate with the 505 as it can be integrated via a digital communication connection by using the Woodward Links wizard. In some cases, the analog input signal interfaces described below are not required but can be used as a redundant signal if desired.

These products connect to a 505 analog input to bias the 505's speed set point directly to vary generator speed, frequency and phase. Optionally these products can interface with the unit voltage regulator to match system voltage across a generator breaker.

When the 505 is configured for a generator application, a special speed set point rate (Sync Window Rate) is used to increase set point resolution around synchronous speed. This allows for tighter set point control to accommodate synchronizing manually or by an automatic synchronizer which interfaces to the 505 discretely. This sync rate is defaulted to two rpm/s and is only adjustable through the 505's Service mode. This rate is only used when the generator breaker is open and the actual speed is within +10 rpm of rated speed (also tunable through the Service mode).

These products can be used as a synchronizer only or as a synchronizer and load control. When used as a synchronizer only, the 505 must be configured to accept the products analog Speed Bias signal and have this input enabled. A 'Sync Enable' contact input can be programmed to enable the 505's synchronizing input when synchronization is desired. The Sync Enable command becomes disabled when the generator breaker closes, however, it may be re-enabled again to allow the load management product to perform tiebreaker synchronizations. To re-enable this input the 'Sync Enable' contact must be opened and re-closed. Typically, a double pole single throw (DPST) switch is used on a site's synchronizer control panel to select automatic synchronizing by enabling both the load management product sync mode and 505 analog input at the same time. Alternatively, this signal can be sent to the 505, and the 505 can configure a relay output to send this Enable command to the synchronizer.

To configure the 505 to utilize a load management product for generator synchronization only, program the 'synchronizing input' function setting and program the 'sync enable' function to a 'CONTACT INPUT X' setting. The 'synchronizing input' function has a menu to allow this signal to come from the digital communication link, or from an analog input. If an AI is used, the range and gain settings are preset and are tunable only in the Service mode. Thus, the 4 mA and 20 mA Configuration mode settings for the synchronizing input are irrelevant and are not used by the function's operation. See Volume #2 of this manual.

When the 505 is programmed to use a load management product for synchronization, the Speed Control screen can also be used to access and enable the synchronizing function and monitor all synchronization mode messages.

The following synchronizing mode messages can be viewed:

- Disabled - The synchronizing input is disabled and will have no effect on the Speed set point.
- Enabled - The synchronizing input has been enabled.
- In Control - The synchronizing input is biasing the Speed set point.
- Inhibited - The synchronizing input is inhibited and cannot be enabled, input signal is failed, both the utility tie and generator breakers are closed, the turbine is shut down, a controlled shutdown is being performed, or synchronizing control is not programmed.

Synchronizing/Load Sharing

The 505 is capable of using an analog input to accept a load sharing signal from Woodward's EGCP-3, easYgen or DSLC-2. The DSLC-2 product is the easiest to integrate with the 505 as it can be integrated via a digital communication connection by using the Woodward Links wizard. With this connection, the analog input signal interfaces described below may not be required but can be used as a secondary backup signal if desired.

This input in conjunction with these power management products allows the control to isochronously load share with any other system using the same product. The 505's internal summing junction adds this signal with the speed/load PID's reference. In addition to load sharing, this signal input to the 505 can be used to synchronize the unit to either the plant bus or to the utility.

Each of these power management products can provide VAR/Power Factor control, allowing all the units to reactive load share as well as real power load share. These products sense unit load through generator PTs & CTs and system load through the network interconnects (a combination of all units on the same bus).

When used as a synchronizer and load control, these products perform automatic synchronization and control unit load based on an internal base-load setting, a system average load setting, a process loop's control setting, or a Master Synchronizer & Load Control's (MSLC) demand setting.

After synchronization, unit load can be controlled by the power management product through the sync/load share input or by the 505's internal speed/load set point. The Utility Tie Breaker Contact is used to select unit load control through the 505's internal load set point. When the 505's internal load control is selected (utility tie contact closed), the Speed PID set point is used to control unit load. Optionally, the Cascade or Auxiliary Control modes may be used to set unit load based on another system parameter.

The EGCP-3 interfaces to the 505 via its Speed Bias signal. To configure the 505 to utilize a load management product for generator synchronizing and load sharing, program the 'sync/load share input' function to one of the analog inputs setting and program the 'sync/load share enable' function to a 'Contact Input #X' setting. The 'sync/load share input' function has preset range and gain settings that are tunable only in the Service mode (see Volume 2). Thus the 4 mA and 20 mA Configuration Mode settings for the synchronizing input are irrelevant and are not used by the function's operation.

A combination of the Utility Tie Breaker contact, Generator Breaker contact, and Sync/Ld Share Enable contact define the state of the 505's synchronizing and load sharing operating modes (See Table 3-3).

The Utility Tie breaker contact input is used to enable and disable Load Sharing when the generator breaker is closed. If the Utility Tie contact is open, load sharing is enabled, and the 505's internal Speed PID droop, Cascade, and Auxiliary modes are disabled (as defaulted in Service mode). If the Utility Tie contact is closed load sharing is disabled and the 505's Speed PID droop, Cascade, and Auxiliary modes are enabled, if used.

The Generator Breaker contact input is used in conjunction with the utility tie contact to activate load sharing.

The 'Sync/Ld Share Enable' contact input option is used to enable the Sync/Load Share analog input before the generator breaker is closed. There is also a button on the Speed Control screen that can be used to enable the 505's Sync/Load Share analog input instead of an external contact. This discrete enable/disable function is ignored after the generator breaker is closed and must be reselected after the generator breaker opens. Typically, a double pole single throw (DPST) switch is used on a site's synchronizer control panel to select automatic synchronizing by enabling both the power management product's sync mode and 505 analog input at the same time.

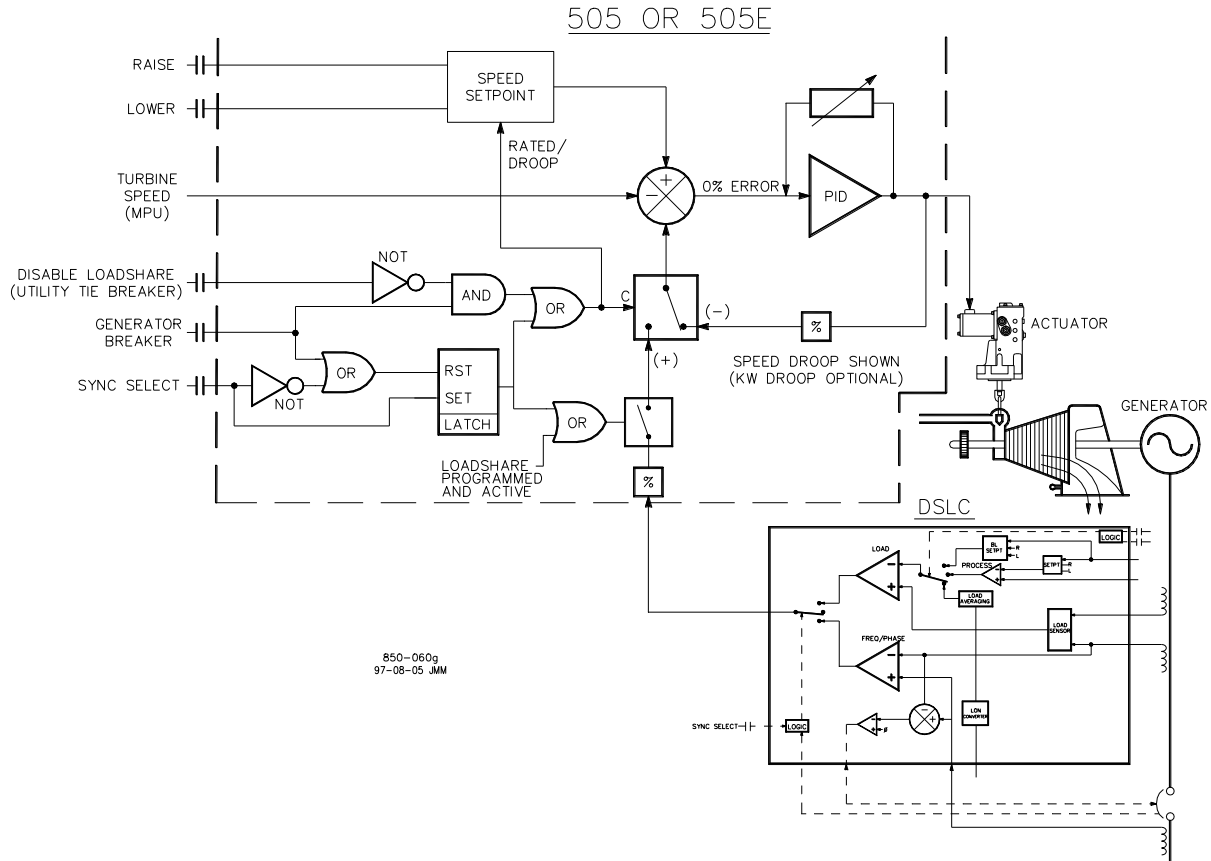


Figure 3-19. Load Sharing Logic

Table 3-6. Speed Control Mode Based on Contacts

Tie Breaker Contact Status	Gen Breaker Contact Status	Sync/Ld Share Enable Contact	Speed Control Mode	Initial Speed Reference	Cascade or Auxiliary (if used)
Closed	Open	Open	Speed, Off-Line Dynamics	XXXX	Not Active
Closed	Closed	XXXX	Unit Load Control, On-Line Dynamics	Droop Setpoint	Active
Open	Open	Open	Speed, Off-Line Dynamics	XXXX	Not Active
Open	Open	Closed	Synchronizing Off-Line Dynamics	XXXX	Not Active
Open	Closed	XXXX	Load Sharing, Off-Line dynamics	Current Speed	Not Active

If using the display screen button to enable Sync/Load Share, then a 505 relay output can also be programmed to select the power management product's synchronizing mode. To configure the 505 for this functionality, program the 'Sync/Ld Share Enabled' function to a 'RELAY X ENERGIZES ON' setting.

When the 505 is programmed to use a load management product for Synchronization and Load Sharing, the Speed Control screen can also be used to access and enable these functions and monitor all synchronization mode messages.

The following synchronizing mode messages can be viewed:

- Disabled—The sync/load share input is disabled and will have no effect on the Speed set point.
- Enabled—The sync/load share input has been enabled.
- In Control—The sync/load share input is biasing the Speed set point.
- Inhibited—The sync/load share input cannot be enabled; the input signal is failed, the turbine is shut down, a controlled shutdown is being performed, or the sync/load share feature is not programmed.
- All pertinent synchronizing and load sharing parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.


Manual Demand

The manual valve demand feature functions just like the valve limiter except that, instead of providing an input to the Low Signal Select to limit how high the valve demand can go, it disables all other controllers (including speed) to ensure that manual demand has full control of the valve demand output. In the case of an Ext/Adm turbine both the HP & LP valves will enter manual mode at the same time. The intent of this feature is to aid in the troubleshooting of plant stability or oscillation issues. It can be used to temporarily hold the valve in its current position.

This feature is enabled under Manual Demand in the Service Menu. In addition to holding the valve demand output, manual demand allows the valve demand to be adjusted manually, preferably at a very slow and safe rate. When selected, the valve ramp rate for this feature can be adjusted. This should be set to a value that is safe and stable for speed, load, or any process and pressures associated with the turbine that will be affected by moving this valve. Also, the timeout time can be adjusted. After this time the feature will disable if no raise/lower manual demand commands are received. Every time a raise or lower manual demand command is issued the timer will restart.

Because of the risk associated with locking the valve in place there are many protections that disable this function, which will return the unit to Speed PID control, in addition to the normal disable command functionality and the timeout protection. All items that will disable this feature are as follows:

- Operator interface disable command
- Manual demand not used (Service Menu setting)
- Any turbine trip
- Startup not completed or overspeed test enabled
- Speed less than minimum governor
- Speed greater than maximum governor
- Both breakers not closed (generator applications only)
- Timeout due to inactivity

 WARNING	<p>Manual Valve Demand</p> <p>Use caution when adjusting manual demand as the 505 is no longer in control of any speed, load, or process. It is the responsibility of the operator to ensure safe operation of all processes related to valve movement. Use caution even while using this feature to hold the valve position as the 505 may not react to any system upsets until the conditions have become unsafe. Failure to do so may result in loss of control with possible personal injury, loss of life, or property damage.</p>
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Load Rejection

The Generator Load Rejection logic along with Woodward's PID_OPTI block automatically react to large load drop events to reduce valve demand (energy) to minimize speed overshoot and prevent an overspeed trip when a load rejection occurs. For a generator application there are 2 types of events that result in large load transients.

Event 1—At Generator Breaker Opening:

This case is typically a 'full load' rejection of a unit running in Unit Load Control (droop) against a utility grid and all load of the steam turbine is lost.

When the generator breaker is opened, and the speed exceeds more than 1% above rated speed, the control will immediately drive the HP valve demand to zero (0%). It will hold the valve at zero until the turbine speed decreases back to a level that is with 1% of the speed setpoint. This speed setpoint is identified as the Generator Breaker Open Setpoint and is defaulted to be 50 rpm below rated speed.

Event 2—At Utility Breaker Opening (With GEN Breaker Still Closed):

In this case, a unit that is normally running in Unit Load Control (droop), against a utility, loses the utility breaker, but the generator breaker remains closed, and the unit is switched to 'Island mode'. In this case there is usually still some load on the turbine.

When the utility breaker is opened, and the speed exceeds more than 1% above rated speed, the control will immediately drive the HP valve demand to zero (0%). It will hold the valve at zero until the turbine speed decreases back to a level that is with 1% of the speed setpoint. This speed setpoint in this case is rated speed.

Feed-Forward Input

For 505 controllers configured for compressor applications, it is possible to experience a coupling effect between an anti-surge controller (external) and the 505's internal Speed or Cascade PID controllers. If a plant condition exists where the anti-surge controller is required to open and control the anti-surge valve, compressor suction pressure will change. If the 505XT cascade controller is also controlling the compressor suction pressure, it will then respond to this pressure change, resulting in the two controllers temporarily affecting (fighting) each other.

The 505XT is capable of being configured to use an analog input (feed-forward signal) from an anti-surge controller. This input allows the 505XT controller to decouple the response of its Speed and Cascade PID controls from that of the anti-surge controller, allowing for increased system stability in all conditions. Refer to this manual's speed controller block diagram to better understand how this input is applied within the 505's controller logic. This signal should represent the anti-surge controller's anti-surge valve demand where 0% = 4 mA = Closed and 100% = 20 mA = Open. Delays in this signal should be kept to a minimum.

This feed forward function is only active when operating within the normal operating range (between Min Gov and Max Gov) and when it has been enabled. This function can be enabled/disabled through a contact input, programmable function key, or Modbus communications.

When enabled, if the feed forward analog input increases or decreases, the speed set point will be increased or decreased respectively. This is an offset added to or subtracted from the speed set point. After a feed-forward event, this speed offset will slowly ramp back to zero based on the delay time configured (typically 120 seconds). For example, if the max offset is 100 rpm with the max forward rate at 50%/s and the min offset is -75 rpm with the min forward rate at -25%/s and "Action Delay" is set to 120 seconds, then the following events describe the feed-forward action:

1. The speed set point is at rated speed, X rpm.
2. The feed-forward analog input increases by 50% in one second.
3. The speed set point is instantly increased by 100 rpm.
4. The set point slowly decreases back to X rpm (at least 120 seconds).
5. The feed-forward analog Input decreases by 25% in one second.
6. The speed set point is lowered by 75 rpm.
7. The set point slowly increases back to X rpm taking at least 120 seconds.

The feed-forward loop can be configured for a temporary response, as described here, or as a direct action (continuous deviation based on the incoming signal).

Emergency Loop

In case of a compressor surge event, a large speed upset may occur, and recovery may be very difficult. If this event occurs, emergency feed-forward action can be programmed to instantly bias the control's speed reference using a larger offset than the regular feed-forward loop.

When configured, the emergency feed-forward bias action will increase the anti-surge controller's effect for a short period, configured as the 'Emergency Action Delay', to assist the anti-surge controller with protecting the compressor. The Emergency Action takes effect when the feed-forward analog input increases or decreases faster than the configured 'FW Rate to Activate' (this should be larger than the 'Min/Max Forward Rate' used for the regular feed forward loop). The 'Emergency Max Speed Offset' will be added to the speed reference. This offset immediately begins ramping down and will reach zero after the configured 'Emergency Action Delay'. At this point, only the normal feed forward action offset will be in effect since the emergency will typically have a much shorter duration.

Direct Action

When configured for direct action, the feed-forward loop will offset the speed set point proportional to its 4–20 mA calibration. This offset will not ramp back to zero; it remains active and offsets the speed reference based on the actual value of the feed-forward analog input. For example, if configured for a max offset of 150 rpm and a min offset of -50 rpm, then direct feed-forward action offsets the set point by 0 rpm if the analog input is at 8 mA. The offset is 100 rpm if the analog input is at 16 mA, and the offset will not ramp down to 0; it remains at 100 rpm as long as the analog input is at 16 mA.

The direct action cannot be used to decrease speed below Min governor and above Max Governor.

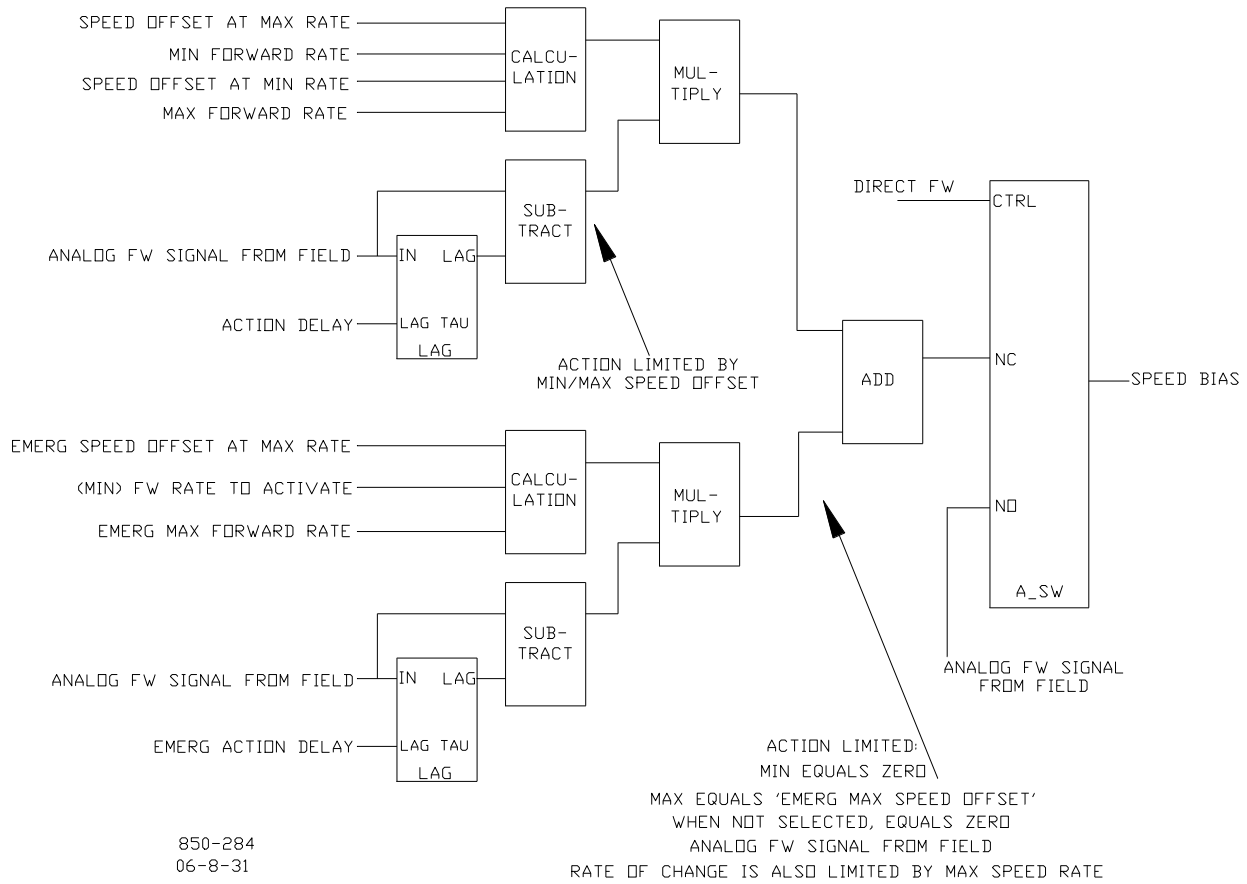


Figure 3-20. Typical Anti-surge Valve and Speed Feed-Forward Logic Trend

Cascade Control

The Cascade 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.

Cascade control is a PID controller that is cascaded with the Speed PID. The Cascade PID compares a 4–20 mA process signal with an internal set point to directly position the speed set point, thus changing turbine speed or load until the process signal and set point match. By Cascading two PIDs in this fashion, a bumpless transfer between the two controlling parameters can be performed.

When enabled, the Cascade PID can move the speed set point at a variable rate up to the 'Max Speed Set Point Rate' setting (programmed under the CASCADE CONTROL header).

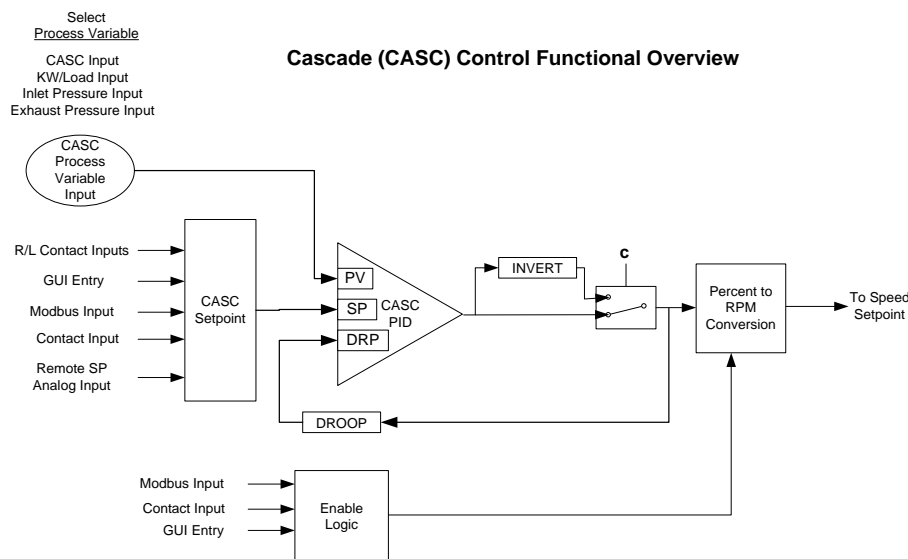


Figure 3-21. Cascade Functional Diagram

Since Cascade is a secondary speed setting function, the Speed PID must be in control of the 505's LSS bus in order for Cascade to take control. When the 505 is configured for a generator application, both the utility tie and generator breakers must be closed, before the Cascade PID can begin controlling a process.

The process variable selection to use for this control is:

- Cascade Analog Input
- KW/Load Input
- Inlet Steam Pressure
- Exhaust Steam Pressure

Cascade control may be enabled and disabled from the 505 keypad, a contact input, or Modbus communications. The last command given from any of these three sources dictates the Cascade PID's control state.

If a contact input is programmed to function as a Cascade Enable contact, when the contact is open Cascade control is disabled, and when it is closed Cascade control is enabled. This contact can either be open or closed when a trip condition is cleared. If the contact is open it must be closed to enable Cascade control. If the contact is closed it must be opened and re-closed to enable Cascade control.

Cascade Control Status Messages

- Cascade is Disabled - Cascade control is not enabled and will have no effect.
- Cascade is Enabled - Cascade has been enabled but is not active or in control. Permissives have not been met (speed < min gov, generator or tie breaker open).
- Casc Active/Not Spd Ctl - Cascade has been enabled but the Speed PID is not in control of the LSS bus (either aux or valve limiter is in control).
- Cascade is In Control - Cascade is in control of the LSS bus.
- Casc Active w/Rmt Setpt - Cascade has been enabled and the Remote Cascade set point is in control of the set point but the Speed PID is not in control of the LSS bus.
- Casc Control w/Rmt Setpt - Cascade is in control of the LSS bus (via the Speed PID) and the Remote Cascade Set Point is positioning the Cascade set point.
- Cascade is Inhibited - Cascade cannot be enabled; the Cascade input signal has failed, a controlled stop is selected, the unit is shut down, or cascade control is not programmed.

Cascade control is automatically disabled on a shutdown condition and must be re-enabled after a successful system start-up. Cascade control is disabled if Remote Speed Set Point is used and enabled.

Should another parameter on the LSS bus take control of governor valve position from the Speed PID, Cascade control will stay active, and begin controlling again when the Speed PID is the lowest parameter on the LSS bus again.

All pertinent cascade control parameters are available through the Modbus links, refer to Chapter 6 for a complete listing of Modbus parameters.

Cascade Dynamics

The Cascade PID control uses its own set of dynamic settings. These values are programmable and may be tuned at any time. Refer to the PID Dynamic Adjustments section in this manual.

Cascade Set Point

The Cascade set point can be adjusted from the 505 keypad, external contacts, Modbus commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the 505 keypad or through Modbus commands.

The Cascade set point range must be defined in the Configuration mode. Program settings 'Min Cascade Set Point' and 'Max Cascade Set Point' define the range of the Cascade set point and control.

IMPORTANT

Cascade set point raise/lower contact inputs act as speed set point raise/lower contacts when Cascade is not active or in control. This allows a single set of contacts (one SPDT switch) to control the Speed set point when the generator breaker is open, the load set point when paralleled to a utility, and the Cascade set point when enabled. Alternatively, a second set of contacts (speed raise and lower) could be used to independently control the speed and load set points.

When a raise or lower Cascade Set Point command is issued, the set point moves at the programmed 'Casc Setpt Rate' setting. If a Cascade raise or lower command is selected for longer than three seconds, the Cascade set point will move at the fast rate which is three times the cascade set point rate. The Cascade set point rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a set point will move for an accepted raise or lower command is 40 milliseconds (120 milliseconds for a Modbus command). If the Cascade set point slow rate is programmed for 10 psi/s, the smallest increment it will move is 0.4 psi (1.2 psi for Modbus).

A specific set point may also be directly entered from the 505 keypad or through Modbus communications. When this is performed, the set point will ramp at the 'Casc Setpt Rate' (as defaulted in Service mode). To "enter" a specific set point from the 505 keypad, press the CAS key to view the Cascade control screen, press the ENTER key, enter the set point level desired, then press the ENTER key again. If a valid number was entered, equal-to or between the min and max set point settings, the setting will be accepted, and the Cascade set point will ramp to the "entered" set point level. If an invalid number is "entered", the setting will not be accepted and the 505's screen will momentarily display a value out-of-range message.

When a valid set point value is entered, the set point will ramp at the Cascade Set Point Rate to the newly entered set point value. This 'Entered' rate is tunable through the Service mode.

To “enter” a specific set point from the 505 Display use the following steps:

1. From the HOME page go to the Cascade Control page
2. Press the Commands button until ‘Entered Setpoint’ appears
3. Select ‘Entered Setpoint’ and a pop-up will appear
4. Press Enter from the Navigation cross and the pop-up value will highlight
5. Adjust the value with the Adjust keys or enter a value from the keypad
6. Press Enter again when desired value has been entered
7. The value in the pop-up will be accepted if it is valid, if it is out of range then an error message will appear stating the entered value is invalid
8. Select the GO button to ramp the setpoint to this entered value

Refer to Volume 2 of this manual for information on which programmed settings are tunable through the 505’s Service mode. Service mode values can be tuned/adjusted while the 505 is shutdown or in the RUN mode.

Cascade Set Point Tracking

To allow a bumpless transfer from turbine Speed/Load control to Cascade control, the Cascade PID can be programmed to track its controlling process input when disabled. When this tracking feature is programmed, the Cascade PID will be satisfied when enabled, and no turbine speed or load correction will be performed. After the Cascade control is enabled, its set point can move as required to another setting.

Cascade Set Point with No Tracking

If the Cascade control is programmed not to use the set point tracking feature the set point will remain at its last setting (running or shutdown). When the 505 is powered-up the set point is reset to the ‘Setpt Initial Value’. With this configuration, when Cascade control is enabled, and its sensed process signal does not match set point, the Cascade control will ramp turbine speed/load up or down to match the two signals, at a controlled “not-matched” rate (defaulted to the ‘Speed Set Point Slow Rate’ setting, and tunable through the Service mode).

If Cascade is the controlling parameter and one of the permissives is lost or Cascade is disabled, the speed set point will remain at its last setting until another parameter adjusts it.

Cascade Droop

When sharing control of a parameter with another external controller, the Cascade PID can also receive a programmable DROOP feedback signal for control loop stability. This feedback signal is a percentage of the Cascade PID’s output. By including this second parameter into the control loop, the Cascade PID becomes satisfied, and does not fight with the other external controller over the shared parameter. If Cascade droop is used, the Cascade input signal will not match the Cascade set point when in control. The difference will depend on the amount (%) of droop programmed and the output of the Cascade PID. The droop value fed back to the Cascade PID is equal to the following defaulted settings:

$$\text{PID OUTPUT \%} \times \text{'CASCADE DROOP \%'} \times \text{'MAX CASC SET POINT'} \times 0.0001$$

Where the ‘CASCADE DROOP %’ and ‘MAX CASC SET POINT’ values are set in the Configuration mode and the ‘PID output %’ is determined by the Cascade demand.

$$\text{Example: } 25\% \times 5\% \times 600 \text{ psi} \times 0.0001 = 7.5 \text{ psi}$$

Refer to Volume 2 of this manual for information on related Service mode tunables.

Invert Cascade

Depending on the control action required, the Cascade input signal can be inverted. If a decrease in inlet governor valve position is required to increase the Cascade process signal, program the ‘INVERT CASCADE INPUT’ setting to ‘YES’. An example of this required control action would be when the Cascade PID is configured to control turbine inlet steam pressure. To increase turbine inlet steam pressure, the inlet control valve position must be decreased.

Remote Cascade Set Point

If desired, the Cascade set point can be positioned through an analog signal. Optionally, one of the 505's six analog inputs can be programmed to position the Cascade PID set point. This allows the Cascade set point to be positioned remotely by a process control or distributed plant control system.

The Remote Cascade Set Point (RCS) range is determined by the programmed analog input's 4 mA and 20 mA settings. The Remote Cascade Set Point range is tunable in the Service mode but cannot be set outside of the min and max Cascade Set Point settings.

The Remote Cascade Set Point input may be enabled from the 505 keypad, contact input, or Modbus communications. The last command given from any of these three sources dictates enable/disable.

If the milliamp signal to the Remote Cascade set point input is out of range (below 2 mA or above 22 mA) an alarm will occur, and the Remote Cascade set point will be inhibited until the input signal is corrected and the alarm is cleared. Depending on configuration and system conditions, the Remote Cascade Set Point may be in one of the following states (505 front panel screen messages):

- Disabled - The Remote Set Point function is not enabled and will have no effect on the Cascade set point.
- Enabled - The Remote Set Point has been enabled but cascade control is not active. The breakers are not closed, speed < min gov, or cascade has not taken control.
- Active - The Remote Set Point has been enabled but Cascade is not in control. Cascade has been enabled and the Remote Cascade set point is in control of the set point, but the Speed PID is not in control of the LSS bus.
- In Control - Cascade is in control of the LSS bus (via the Speed PID) and the Remote Cascade Set Point is positioning the Cascade set point.
- Inhibited - Remote Set Point cannot be enabled; input signal is failed, Cascade input signal is failed, a controlled stop is selected, the unit is shut down, or the remote cascade control is not programmed.

When enabled, the Remote Cascade set point may not match the Cascade set point. In this case, the Cascade set point will ramp to the Remote Cascade set point at the programmed 'Casc Setpt Rate' setting (as defaulted in the Service mode). Once in control, the fastest the Remote Cascade set point will adjust the Cascade set point is at the programmed 'Rmt Cascade Max Rate' setting. If the 'Rmt Cascade Max Rate' was set at 10 and the Remote Cascade set point analog input instantly moved from 0 units to 1000 units, the Remote Cascade set point will move to 1000 units at 10 units/s).

Remote Cascade Enable Logic

There are three different options for enabling Remote Cascade Set Point and Cascade control as follows:

- One Remote Enable contact input or function key command
- Both enable commands programmed; Remote Casc Enable and Cascade Enable
- No enable commands programmed

When only one Remote Enable command is programmed (either F-key or contact input), selecting 'Enable' will enable both Cascade control and Remote Cascade control. This configuration allows both functions to be enabled with one command if this is the normal operation mode. If 'Disable' is selected, both control modes are disabled.

A contact input can be programmed to enable and disable the Remote Cascade Set Point (RCS) input/function. When this contact is open the RCS is disabled, and when it is closed the RCS is enabled. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to enable the RCS input. If the contact is closed it must be opened and re-closed to enable the RCS input.

When both Remote Cascade Enable and Cascade Control Enable commands are programmed, each function is enabled by its respective command selection. If Remote Cascade Enable is selected, only the Remote Cascade Set Point will be enabled. If Cascade Control Enable is selected, only Cascade control will be enabled. If Remote Cascade Disable is selected, only the Remote Cascade Set Point will be disabled. If Cascade Control Disable is selected, both Remote Cascade control and Cascade control will be disabled. However, if before the Cascade PID was 'In-control', a Cascade disabled command is given, only Cascade control will be disabled.

If no external contact input or function keys are programmed for the 'Enable' commands, Cascade Control and Remote Cascade Control must be enabled from either the front panel keypad or from Modbus. Since the front panel and Modbus provide both Remote Cascade Enable and Cascade Control Enable commands, they will operate in the same manner as 'both enables programmed'. Refer to Volume 2 of this manual for information on related Service mode tunables. All pertinent Remote Cascade control parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Auxiliary Control

The Auxiliary PID controller can be used to limit or control generator power, plant import/export power, turbine inlet pressure, turbine exhaust pressure, pump/compressor discharge pressure, or any other auxiliary parameters, directly related to turbine speed/load.

The process variable selection to use for this control is:

- Auxiliary Analog Input
- KW/Load Input
- Inlet Steam Pressure
- Exhaust Steam Pressure

Each of these inputs is a 4 to 20 mA current signal (the KW/Load could be from a 'Woodward Links' digital communication link). The PID control amplifier compares this input signal with the Auxiliary set point to produce a control output to the digital LSS (low-signal select) bus. The LSS bus sends the lowest signal to the actuator driver circuitry.

The Auxiliary set point is adjustable with raise or lower commands through the 505 front keypad, through remote contact inputs or through Modbus. Also, the set point can be directly set by entering the new set point from the keypad or through Modbus communications. In addition, an analog input can be programmed to remotely position the Auxiliary set point.

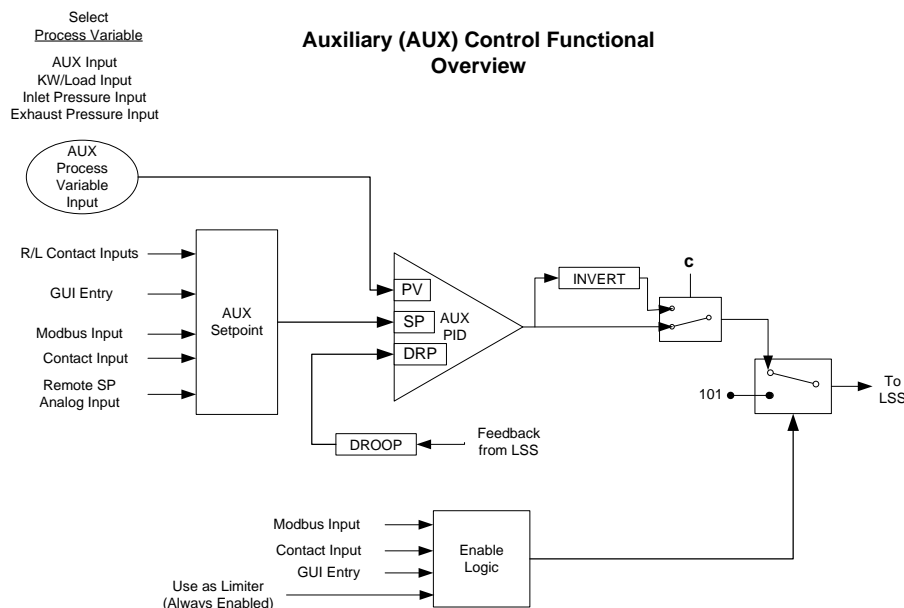


Figure 3-22. Aux Control Overview

Auxiliary as a Limiter (Not Using Enable/Disable)

When configured as a limiter, the Auxiliary control is low signal selected (LSS) with all the other PIDs, allowing it to limit turbine speed/load based on any auxiliary parameter which is directly related. To configure the auxiliary controller to function as a limiter, do NOT check the configuration parameter of 'Use Aux as Controller'.

When Auxiliary is configured to act as a limiter the Auxiliary PID will 'limit' the LSS bus when the input reaches the set point. The Aux set point initializes to the programmed 'Setpoint Initial Value' setting on a power-up-reset. This set point may be adjusted at any time and will remain at a setting (running or shutdown), provided a power-up-reset did not occur.

Depending on configuration and system conditions, the auxiliary limiter may be in one of the following states (505 front panel screen messages):

- Auxiliary is Enabled - Auxiliary has been enabled but the generator and utility tie breaker permissives have not been met (generator applications only).
- Aux Active/Not Lmtng - Auxiliary is configured as a limiter but is not limiting the LSS bus.
- Aux Active w/Rmt Setpt - Auxiliary is not in control of the LSS bus and the remote auxiliary input is in command of the set point.
- Aux Control w/Rmt Setpt - Auxiliary is in limiting the LSS bus and the remote auxiliary analog input is in command of the set point.
- Auxiliary is Inhibited - Auxiliary cannot be enabled. The input signal has failed.

For generator applications, auxiliary control limiting can be configured to be disabled when the generator and/or utility tie breakers are open. Program settings 'Generator Breaker Open Aux Disable' and 'Tie Breaker Open Aux Disable' may be configured to deactivate Auxiliary PID limiting, depending on system breaker positions. When both settings are programmed as unchecked (NO), the auxiliary limiter will always stay 'active'. If either setting is programmed as checked (YES), the auxiliary limiter will be active only when the tie breaker or generator breaker respectively, is closed.

If the unit is not configured for a generator application, the utility tie and generator breaker inputs do not affect Auxiliary limiter status, and the Limiter will be active at all times.

Auxiliary as a Controller (Using Enable/Disable)

When configured as a controller, the Auxiliary PID may be enabled and disabled on command. With this configuration, when Auxiliary control is enabled, it instantly takes full control of the LSS bus, and the Speed PID is switched to a tracking mode. When Auxiliary control is disabled, the Speed PID instantly takes full control of the LSS bus. To allow a bumpless transfer between modes, when the Auxiliary PID is enabled, the Speed PID tracks a few % above the Auxiliary PID's LSS bus signal. When the Auxiliary PID is disabled, its set point tracks the Auxiliary PID's process signal.

To configure the auxiliary controller to function as a controller, check the configuration box 'Use Aux as Controller' on the Auxiliary Control configuration page.

The Speed PID will only track the Auxiliary PID LSS bus signal up to 100% speed/load. Thus, if turbine speed/load reaches 100%, the Speed PID will protect the unit by limiting unit speed/load to less than or equal to 100%.

Depending on the configuration and system conditions, the Auxiliary PID may be in one of the following states (505 front panel screen messages):

- Auxiliary is Disabled - Auxiliary is disabled and will have no effect on the LSS bus.
- Auxiliary is Enabled - Auxiliary has been enabled but the generator and utility tie breaker permissives have not been met (generator applications only).
- Aux Active/Not in Ctrl - Auxiliary has been enabled, permissives met, but is not in control of the LSS bus.
- Aux Active w/Rmt Setpt - Auxiliary has been enabled but is not in control of the LSS bus and the remote auxiliary input is controlling the set point.
- Auxiliary in Control - Auxiliary is in control of the LSS bus.

- Aux Control w/Rmt Setpt - Auxiliary is in control of the LSS bus and the remote auxiliary analog input is in control of the set point.
- Auxiliary is Inhibited - Auxiliary cannot be enabled; input signal is failed, 505 is in Frequency Control, controlled shutdown is selected, unit is shut down or Auxiliary control is not programmed.

For generator applications, Auxiliary control can be configured to be disabled when the generator and/or utility tie breakers are open. Program settings 'Generator Breaker Open Aux Disable' and 'Tie Breaker Open Aux Disable' may be configured to deactivate Auxiliary PID control, depending on system breaker positions. When both settings are programmed as unchecked (NO), the auxiliary limiter will always stay 'active'. If either setting is programmed as checked (YES), the auxiliary limiter will be active only when the tie breaker or generator breaker respectively, is closed.

If the unit is not configured for a generator application, the utility tie and generator breaker inputs do not affect Auxiliary control status, and the controller will be active at all times (capable of being enabled).

Auxiliary control may be enabled from the 505 keypad (GUI), remote contacts, or Modbus/OPC communications. The last command given from any of these three sources dictates which state the Auxiliary control is in. If an external auxiliary enable contact is programmed, disable is selected when the contact is open and enable is selected when it is closed. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to enable. If the contact is closed it must be opened and re-closed to enable.

When configured as enable/disable controller, the Auxiliary control will automatically be disabled upon a shutdown condition. Auxiliary control will be disabled and inhibited when the 505 is in frequency control. If the process variable (PV) milliamp input signal is out of range (below 2 mA or above 22 mA) an alarm will occur, and Auxiliary control will be inhibited until the input signal is corrected and the alarm is cleared. Optionally the unit can be programmed to issue a shutdown on a loss of the auxiliary input process variable signal.

Auxiliary Dynamics

The Auxiliary PID control uses its own set of dynamic settings. These values are programmable and may be tuned at any time. Refer to the PID Dynamic Adjustments section in this manual.

Generator Load Limiter/Control

On generator applications, the Auxiliary PID may be programmed to use the 'KW/Unit Load Input' signal instead of the auxiliary input signal for limiting or control. This is the same input signal (KW/Unit Load input) used by the Speed PID for KW droop. This configuration allows the Auxiliary PID to limit or control generator power.

Auxiliary Droop

When sharing control of a parameter with another external controller, the Auxiliary control amplifier can also receive a programmable droop feedback signal for control loop stability. This feedback signal is a percentage of the LSS bus (control valve position). By including this second parameter into the control loop, the Auxiliary PID becomes satisfied, and does not fight with the other external controller over the shared parameter. The droop % fed back to the Auxiliary PID is equal to the following defaulted settings:

$$\text{LSS BUS OUTPUT \%} \times \text{'AUXILIARY DROOP \%'} \times \text{'MAX AUX SET POINT'} \times 0.0001$$

$$\text{Example: } 25\% \times 5\% \times 600 \text{ psi} \times 0.0001 = 7.5 \text{ psi}$$

Where the 'AUX DROOP %' is set in Configuration mode, 'MAX AUX SET POINT' value is determined by the upper range limit of the process variable selected and the 'LSS bus output %' is determined by the Auxiliary demand.

Invert Auxiliary Input

Depending on the control action required, the Auxiliary PID's input signal can be inverted. If a decrease in inlet control valve position is required to increase the auxiliary process signal, program the 'INVERT AUX INPUT' setting to 'YES'. An example of this control action would be when the Auxiliary PID is configured to control turbine inlet steam pressure. To increase turbine inlet steam pressure, inlet control valve position must be decreased.

Auxiliary Set Point

The Auxiliary set point can be adjusted from the 505 keypad, external contacts, Modbus/OPC commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the 505 keypad or through Modbus commands.

The Auxiliary set point range must be defined in the Configuration mode. Program settings 'Minimum Auxiliary Setpoint' and 'Maximum Auxiliary Setpoint' define the range of the Auxiliary set point and control.

When a raise or lower Auxiliary Set Point command is issued, the set point moves at the programmed 'Auxiliary Setpoint Rate' setting. If an Auxiliary raise or lower command is selected for longer than three seconds, the Auxiliary set point will move at three times at the fast rate which is three times the Auxiliary set point rate. The Auxiliary set point rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a set point will move for an accepted raise or lower command is 40 milliseconds (120 milliseconds for a Modbus command)

A specific set point may also be directly entered from the 505 keypad or through Modbus/OPC communications. When this is performed, the set point will ramp at the 'Auxiliary Setpoint Rate' (as defaulted in Service mode).

To "enter" a specific set point from the 505 Display use the following steps:

1. From the HOME page go to the Auxiliary Control page
2. Press the Commands button until 'Entered Setpoint' appears
3. Select 'Entered Setpoint' and a pop-up will appear
4. Press Enter from the Navigation cross and the pop-up value will highlight
5. Adjust the value with the Adjust keys or enter a value from the keypad
6. Press Enter again when desired value has been entered
7. The value in the pop-up will be accepted if it is invalid a message will appear
8. Select the GO button to ramp the setpoint to this entered value

Refer to Volume 2 of this manual for further information on Service mode and on-line tunables. All pertinent auxiliary control parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Remote Auxiliary Set Point

Remote Aux Set Point

The Auxiliary set point can be positioned through an analog signal. Optionally, one of the 505's analog inputs can be programmed to position the Auxiliary PID set point. This allows the Auxiliary set point to be positioned remotely by a process control or distributed plant control system.

The Remote Auxiliary Set Point (RAS) range is determined by the programmed analog input's 4 mA and 20 mA settings. The Remote Auxiliary Set Point range is tunable in the Service mode but cannot be set outside of the min and max Auxiliary Set Point settings.

When enabled, the Remote Auxiliary Set Point may not match the Auxiliary set point. In this case, the Auxiliary set point will ramp to the Remote Auxiliary Set Point at the programmed 'Aux Set Point Rate' setting (as defaulted in the Service mode). Once in control, the fastest the Remote Auxiliary Set Point will adjust the Auxiliary set point is at the programmed 'Remote Aux Max Rate' setting. If the 'Remote Aux Max Rate' were set at 10 and the Remote Auxiliary Set Point analog input instantly moved from 0 units to 1000 units, the Auxiliary set point will move to 1000 units at 10 units/s.

If the milliamp signal to the Remote Auxiliary Set Point input is out of range (below 2 mA or above 22 mA) an alarm will occur, and the Remote Auxiliary Set Point will be inhibited until the input signal is corrected and the alarm is cleared. Depending on configuration and system conditions, the Remote Auxiliary Set Point may be in one of the following states (505 display screen messages):

- Disabled - The Remote Set Point function is disabled and will have no effect on the Aux set point.
- Enabled - The Remote Set Point has been enabled, but permissives are not met.
- Active - The Remote Set Point has been enabled, permissives are met, but Auxiliary PID is not in control of the LSS bus.
- In Control - The Remote Set Point is in control of the Auxiliary set point, and the Auxiliary PID is in control of the LSS bus.
- Inhibited - Remote Set Point cannot be enabled; Remote Set Point input signal is failed, Auxiliary control is Inhibited, or Remote Auxiliary Set Point is not programmed.

Remote Auxiliary Enable Logic

The Remote Auxiliary Set Point input may be enabled from the 505 keypad, contact input, or Modbus/OPC communications. The last command given from any of these three sources dictates the state of the RAS input. A contact input can be programmed to enable and disable the Remote Auxiliary Set Point input/function. When this contact is open the RAS is disabled, and when it is closed the RAS is enabled. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to enable the RAS input. If the contact is closed it must be opened and re-closed to enable the RAS input.

When the Auxiliary PID is programmed to function as a limiter, the Remote Auxiliary Set Point may be enabled at any time when the 505 is in the RUN mode.

When the Auxiliary PID is programmed as a Controller (enabled/disabled), there are three different options for enabling Remote Auxiliary Set Point and Auxiliary control as follows:

- Contact input configured for Remote Auxiliary Setpoint Enable
- From the 505 Display keypad
- Modbus/OPC command

When only one Remote Enable command is programmed as a contact input, selecting 'Enable' will enable both Auxiliary control and Remote Auxiliary control. This configuration allows both functions to be enabled with one command if this is the normal operation mode. If 'Disable' is selected, both control modes are disabled.

When both Remote Auxiliary Enable and Auxiliary Control Enable commands are programmed, each function is enabled by its respective command selection. If Remote Auxiliary Enable is selected, only the Remote Auxiliary Set Point will be enabled. If Auxiliary Control Enable is selected, only Auxiliary control will be enabled. If Remote Auxiliary Disable is selected, only the Remote Auxiliary Set Point will be disabled. If Auxiliary Control Disable is selected, both Remote Auxiliary control and Auxiliary control will be disabled. However, if before the Auxiliary PID was 'In-control' an Auxiliary Disable command is given, only Auxiliary control will be disabled.

If no external contact inputs are programmed for the 'Enable' commands, Auxiliary Control and Remote Auxiliary Control must be enabled from either the front panel keypad or from Modbus. Since the front panel and Modbus provide both Remote Auxiliary Enable and Auxiliary Control Enable commands, they will operate in the same manner as 'both enables programmed'.

Refer to Volume 2 of this manual for information on related Service mode tunables. All pertinent Remote Auxiliary Set Point parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Extraction/Admission Control

The Ext/Adm PID controller is used to control the Extraction or Admission Steam pressure or flow. This is only used on Extraction/Admission types of turbines. The output of this controller is known as the P demand. This value is passed to the Ratio Limiter logic that also receives the speed PID output known as the S demand. Using the entered steam performance map data, the Ratio Limiter produces appropriate demands for the HP and LP valves. In the case of a fully decoupled configuration the P demand output is also routed to directly position the LP valve (and have no effect on the HP valve demand).

The Ext/Adm set point is adjustable with raise or lower commands through the 505 front keypad, through remote contact inputs or through Modbus. Also, the set point can be directly set by entering the new set point from the keypad or through Modbus communications. In addition, an analog input can be programmed to remotely position the Ext/Adm set point.

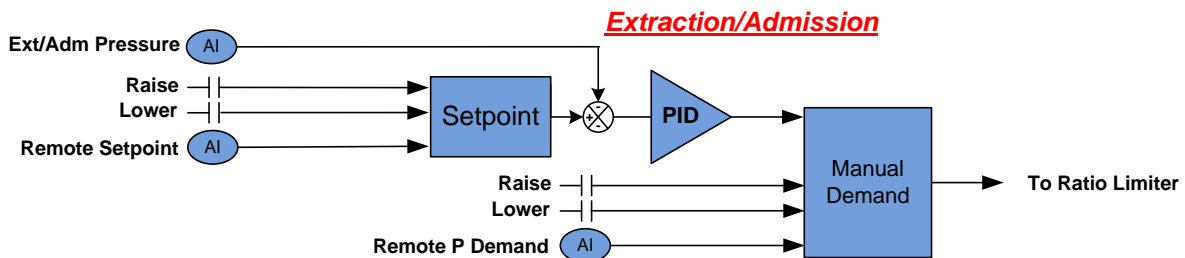


Figure 3-23. Extraction/Admission Control Overview

Enabling/Disabling Extraction Control

Typically, a turbine is controlling speed/load at a rated speed setting and is loaded to a minimum load point before extraction control is enabled. After a startup, the HP and LP valve limiters should normally both be fully open. If the HP valve limiter is not fully opened, it will act as a speed/load limiter and will interfere with automatic governor operation. Extraction control can be automatically or manually enabled and performed after one of the 505XT's three starts have been accomplished, and any related extraction permissives have been met. All related Extraction enable permissives must be met before the control will allow the Extraction PID to take control of a process.

The Extraction and/or Admission enable permissives are:

- Extr/Adm input not failed
- Turbine speed above programmed permissive speed
- Gen breaker closed (if configured)
- Tie breaker closed (if configured)

Enabling Admission or Extraction/Admission Control

The procedure for enabling the Extr/Adm PID with Admission or Extraction/Admission applications is the same. In all cases it is assumed that an external trip valve or a trip-and-throttle valve is used to completely stop any admission steam from entering the turbine upon a system shutdown condition.

Admission (Adm) or extraction/admission (Extr/Adm) control can be enabled and performed after one of the three starts has been performed. After a start-up, the HP and LP valve limiters should normally both be fully open. If either limiter is not fully opened, it will interfere with automatic governor operation.

To perform a bumpless transfer into Adm or Extr/Adm control the pressures on each side of the Adm trip valve or T&T valve should be matched. The following procedure allows a bumpless transfer into Admission or Extraction/Admission control to be performed.

Adm or Extr/Adm Enabling procedure:

1. Verify that all “Extr/Adm enable permissives” are met (listed above).
2. Match the Extr/Adm setpoint to that of the pressure on the plant side of the Extr/Adm T&T valve. (Skip this step if Setpoint Tracking is used.)
3. Vary the Extr/Adm Demand setpoint to match the turbine’s internal Extr/Adm pressure to that of the pressure on the plant side of the Ext/Adm T&T valve.
4. Open the Extr/Adm Trip-and-Throttle valve.
5. Enable Adm or Extr/Adm control.

For full-decoupled configurations with Admission Only or Extraction/Admission turbines, the LP Valve Limiter will remain at 0% and must be manually increased after Admission or Extraction/Admission control has been enabled.

Transitioning to Ratio Limiter Control

When Ext/Adm is enabled, the HP valve demand will transition from being driven solely by the Speed control PID, to being driven by the Ratio Limiter HP demand, which is a calculated value based up the Speed PID, the Ext/Adm PID and the gain values determined by the entered steam performance map.

During this operation, the following actions will take place:

- LP Valve Limiter will ramp closed from 100% to 0%
- This will cause the load to decrease
- Speed PID control will increase demand to compensate for load loss

When disabling Ext/Adm the opposite actions will take place:

- LP Valve Limiter will ramp open from 0% to 100%
- This will cause the load to increase
- Speed PID control will decrease demand to compensate for load loss

During these operations, the LP limiter ramp rate and the speed dynamic settings will have an effect the amount of load change during the transition. Slow LP limiter rates and well-tuned speed dynamics will result in very little load change. If load changes during this action are highly undesirable – then manual enabling/disabling will allow operators to control the LP limiter demand and make the transition slowly.

Auto Enable / Disable -

Enabling is done with a command from any source (display button, hardwired discrete input, Modbus command). When selection, the LP valve limiter will ramp from 100% (which is means full flow toward turbine exhaust) to 0% (which is maximum steam flow out of the LP valve). It will ramp at the “LP Valve limiter rate” setting. The Ext/Adm setpoint is defaulted to track the current extraction steam pressure and the PID will take control at the appropriate point as the limiter moves toward zero.

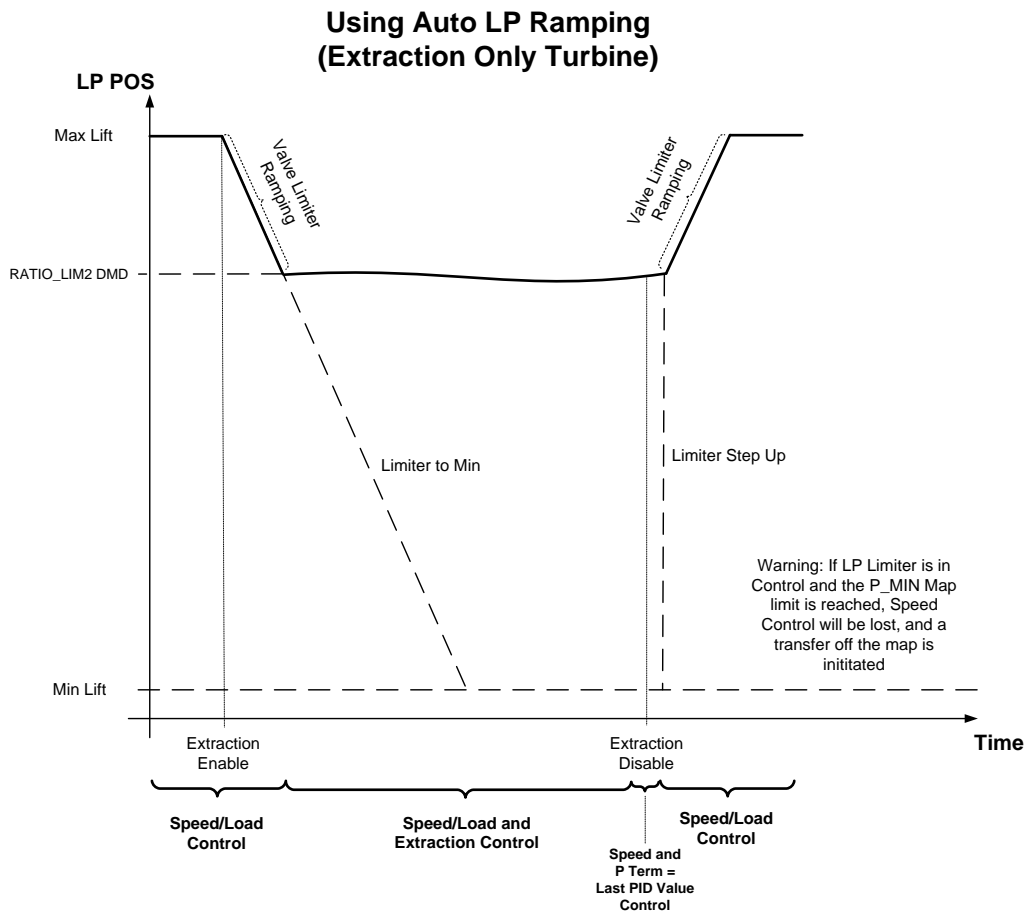


Figure 3-24. Transitions Between Speed Only and Ratio Limiter Control – Auto Mode

The LP valve limiter may be stopped at any time during the automatic enabling routine by momentarily issuing a LP limiter raise or lower command (or by entering a valid setpoint). Stopping the automatic enabling routine halts the LP valve limiter. The Extr/Adm PID's output will continue to be enabled. This allows an operator to manually adjust the LP valve limiter as desired. By reissuing an enable command, the enable routine will continue lowering the LP valve limiter. If a contact is programmed for this function, it will have to be opened and re-closed to re-issue an enable command.

Upon receiving a Disable command, the 505XT will instantly step the LP valve limiter to the LP valve's present position, then raise the LP limiter to its maximum (open) position at the "LP valve limiter rate" setting. At some point, depending on system conditions the Extr/Adm PID will lose control of its process.

Manual Enable / Disable -

Enabling is done by the operator manually lowering the LP limiter value from 100% to 0%. The LP demand output will follow this value until it reaches the LP demand output value of the ratio limiter block. The control will enable Ext/Adm control when this value is reached. The operator should continue to ramp the LP to 0% unless it is desired to limit the amount of extraction flow.

Disabling is done by the operator manually raising the LP limiter value from 0% to 100%. The LP demand output will not follow this value until it exceeds the LP demand output value of the ratio limiter block. At this point it will raise the LP demand as the operator continues to raise the limiter. The control will not disable Ext/Adm until the limiter reaches 100%.

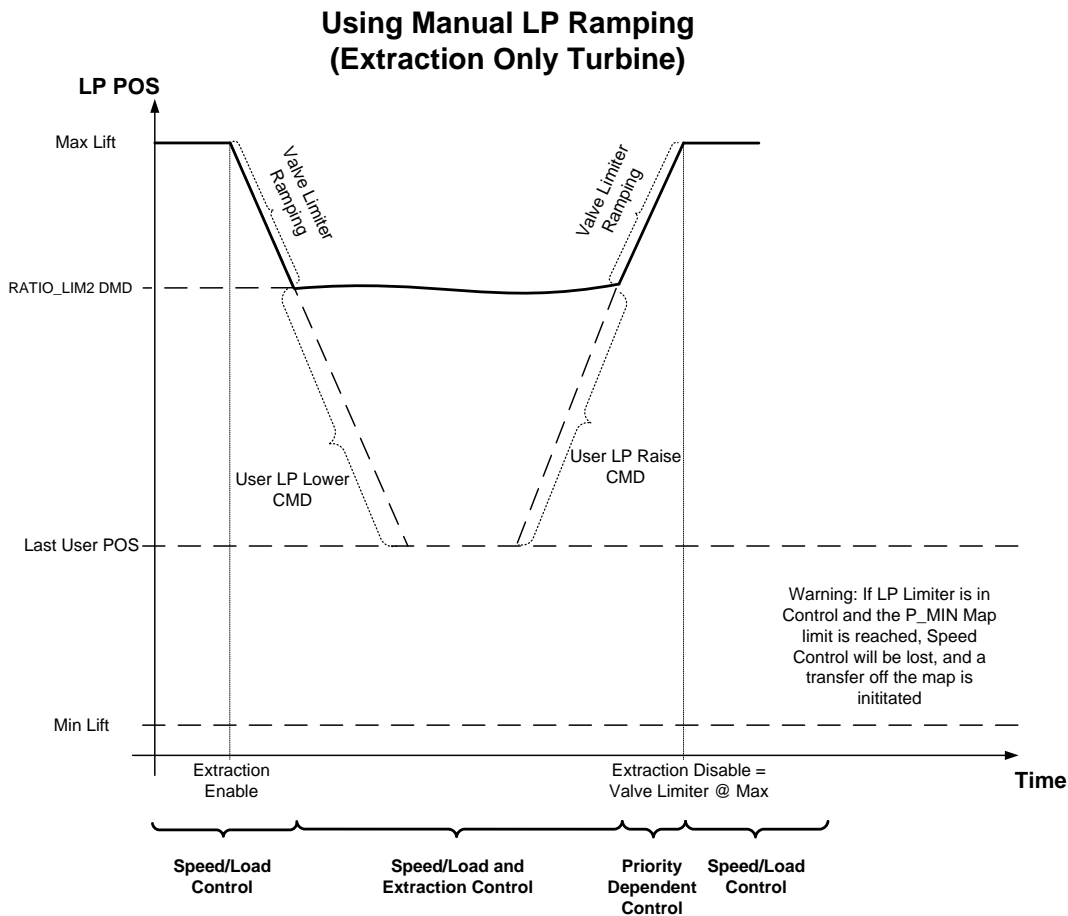


Figure 3-25. Transitions Between Speed Only and Ratio Limiter Control – Manual

Depending on the configuration and system conditions, the Ext/Adm controller may be in one of the following states:

- Disabled - Ext/Adm is disabled and will have no effect on valve demand
- Enabled - Ext/Adm has been enabled but the generator and utility tiebreaker permissives have not been met (generator applications only).
- Inhibited - Ext/Adm cannot be enabled; input signal is failed, 505 is in Frequency Control, controlled shutdown is selected, unit is shut down or control is in manual P control.
- In Control - Ext/Adm is in control of the select bus (either Ratio Limiter or LP demand).
- In Control w/ Remote Setpoint - Ext/Adm is enabled and in control and the remote Ext/Adm input is controlling the set point.
- Active w/Rmt Setpt - Ext/Adm has been enabled but is not in control of the bus and the remote Ext/Adm input is controlling the set point.
- Enabled w/Rmt Setpt - Ext/Adm has been enabled but is not in control of the bus and the remote Ext/Adm input is controlling the set point.
- Active / Map Limited – Ext/Adm is enabled but not in control due to reaching a limit on the steam performance map
- Active / Valve Limited – Ext/Adm is enabled but not in control due to reaching a limit on one of the control valves (HP or LP)
- Active / Transitioning - Ext/Adm has been enabled and the HP valve demand is transitioning from Speed only to Ratio Limiter control
- Manual P Demand Active - Ext/Adm is disabled or inhibited, and the manual P demand value is controlling the select bus

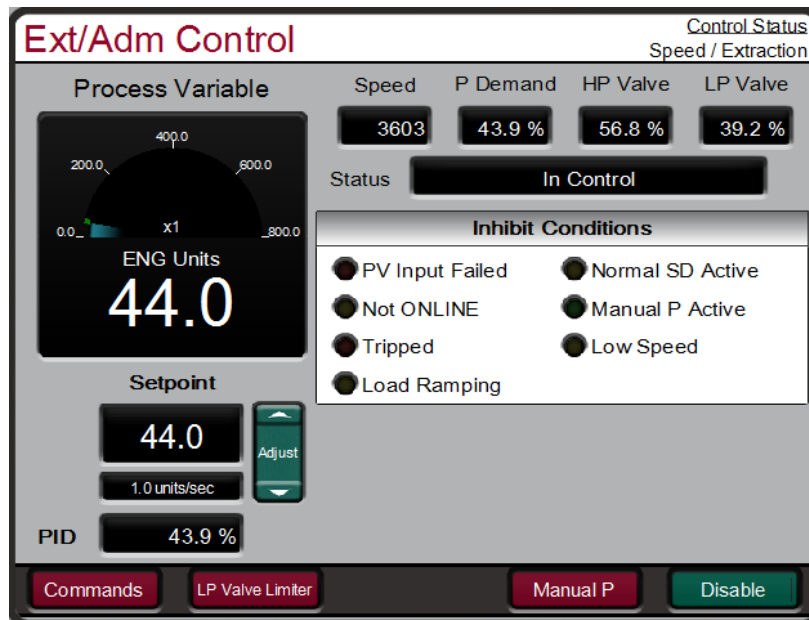


Figure 3-26. Extraction/Admission Control Panel

Manual P Control

The output of the Ext/Adm controller that feeds into the Ratio Limiter logic is referred to as the P demand. manual P control is a feature that allows the operator to take manual control of this value. The transition from Ext/Adm PID control into manual P is always bumpless. However, it is the operator's responsibility to create a bumpless return to closed loop control but ensuring that the Ext/Adm process variable and setpoint match and that the output of the PID is very near the manual P demand value.

This feature is always available and is very usefully in troubleshooting issue related to the stability of the Ext/Adm controller or one of the steam valves. The demanded position for this control can be programmed to come from an analog input, so that it can be adjusted remotely.

If the Ext/Adm process variable (PV) milliamp input signal is out of range (below 2 mA or above 22 mA) an alarm will occur, Ext/Adm control will be inhibited, and the unit will fall back into manual P control. The operator can then decide to maintain the LP valve position relating to this value, raise or lower it, or disable this mode which will ramp the LP valve demand to 100%

Extraction/Admission Control Dynamics

The Ext/Adm PID control uses a single set of dynamic settings. These values are programmable and may be tuned at any time. If the unit is expected to run normally in both fully decoupled and coupled modes (uncommon), it is important to understand that the dynamic settings will be only optimum for one of these conditions.

In tuning this controller during commissioning, it is acceptable to initially start in fully decoupled mode and tune this loop after the correct speed loop controller dynamics have been set. These will provide a good starting point for tuning the Ext/Adm controller in coupled mode (on ratio limiter control). Once this is done the unit can be further optimized by using the OPTI_RATIO feature that will automatically tune both the speed loop and Ext/Adm loop together.

Refer to the PID Dynamic Adjustments section in this manual for more specifics.

Extraction/Admission Droop

When sharing control of a parameter with another external controller, the Ext/Adm control amplifier can also receive a programmable DROOP feedback signal for control loop stability. This feedback signal is a percentage of the LSS bus (control valve position). By including this second parameter into the control loop, the Ext/Adm PID becomes satisfied, and does not fight with the other external controller over the shared parameter. The droop % fed back to the Ext/Adm PID is equal to the following defaulted settings:

$$\text{LSS BUS OUTPUT \%} \times \text{'EXT/ADM DROOP \%'} \times \text{'MAX SET POINT'} \times 0.0001$$

Example: 25% x 5% x 600 psi x 0.0001 = 7.5 psi

Where the 'EXT/ADM DROOP %' is set in Configuration mode, 'MAX SET POINT' value is determined by the upper range limit of the process variable selected and the 'LSS bus output %' is determined by the Ext/Adm demand.

Invert Ext/Adm Input

Depending on the control action required, the Ext/Adm PID's input signal can be inverted. If a decrease in control valve position is required to increase the Ext/Adm process signal, program the 'INVERT EXT/ADM INPUT' setting to 'YES'. In the case of switching to fully decoupled mode, the necessary inversion is taken care of internally in the control logic, thus in most cases, this parameter should typically not be adjusted.

Ext/Adm Set Point

The Ext/Adm set point can be adjusted from the keypad, external contacts, Modbus/OPC commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the keypad or through Modbus commands.

The Ext/Adm set point range must be defined in the Configuration mode. Program settings 'Minimum Ext/Adm Setpoint' and 'Maximum Ext/Adm Setpoint' define the range of the Ext/Adm set point and control.

When a raise or lower Ext/Adm Set Point command is issued, the set point moves at the programmed 'Ext/Adm Setpoint Rate' setting. If an Ext/Adm raise or lower command is selected for longer than three seconds, the Ext/Adm set point will move at three times at the fast rate which is three times the Ext/Adm set point rate. The Ext/Adm set point rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a set point will move for an accepted raise or lower command is 40 milliseconds (120 milliseconds for a Modbus command)

A specific set point may also be directly entered from the 505 keypad or through Modbus/OPC communications. When this is performed, the set point will ramp at the 'Ext/Adm Setpoint Rate' (as defaulted in Service mode).

To "enter" a specific set point from the 505 Display, use the following steps:

1. From the HOME page go to the Ext/Adm Control page
2. Press the Commands button until 'Entered Setpoint' appears
3. Select 'Entered Setpoint' and a pop-up will appear
4. Press Enter from the Navigation cross and the pop-up value will highlight
5. Adjust the value with the Adjust keys or enter a value from the keypad
6. Press Enter again when desired value has been entered
7. The value in the pop-up will be accepted; if it is invalid a message will appear
8. Select the GO button to ramp the setpoint to this entered value

Refer to Volume 2 of this manual for further information on Service mode and online tunables. All pertinent Ext/Adm control parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Remote Ext/Adm Set Point

The Ext/Adm set point can be positioned through an analog signal. Optionally, one of the 505's analog inputs can be programmed to position the Ext/Adm PID set point. This allows the Ext/Adm set point to be positioned remotely by a process control or distributed plant control system.

The Remote Ext/Adm Set Point range is determined by the programmed analog input's 4 mA and 20 mA settings. The Remote Ext/Adm Set Point range is tunable in the Service mode but cannot be set outside of the min and max Ext/Adm Set Point settings.

When enabled, the Remote Ext/Adm Set Point may not match the Ext/Adm set point. In this case, the Ext/Adm set point will ramp to the Remote Ext/Adm Set Point at the programmed 'Ext/Adm Set Point Rate' setting (as defaulted in the Service mode). Once in control, the fastest the Remote Ext/Adm Set Point will adjust the Ext/Adm set point is at the programmed 'Remote Ext/Adm Max Rate' setting. If the 'Remote Ext/Adm Max Rate' were set at 10 and the Remote Ext/Adm Set Point analog input instantly moved from 0 units to 1000 units, the Ext/Adm set point will move to 1000 units at 10 units/s.

If the milliamp signal to the Remote Ext/Adm Set Point input is out of range (below 2 mA or above 22 mA) an alarm will occur, and the Remote Ext/Adm Set Point will be inhibited until the input signal is corrected and the alarm is cleared.

Remote Ext/Adm Enable Logic

The Remote Ext/Adm Set Point input may be enabled from the 505 keypad, contact input, or Modbus/OPC communications. The last command given from any of these three sources dictates the state of the remote input. A contact input can be programmed to enable and disable the Remote Ext/Adm Set Point input/function. When this contact is open the remote is disabled, and when it is closed the remote is enabled. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to enable the remote input. If the contact is closed it must be opened and re-closed to enable the remote input.

There are three different options for enabling Remote Ext/Adm Set Point and Ext/Adm control as follows:

- Contact input configured for Remote Ext/Adm Setpoint Enable
- From the 505 Display keypad
- Modbus/OPC command

When only one Remote Enable command is programmed as a contact input, selecting 'Enable' will enable both Ext/Adm control and Remote Ext/Adm control. This configuration allows both functions to be enabled with one command if this is the normal operation mode. If 'Disable' is selected, both control modes are disabled.

When both Remote Ext/Adm Enable and Ext/Adm Control Enable commands are programmed, each function is enabled by its respective command selection. If Ext/Adm Control Disable is selected, both Remote Ext/Adm control and Ext/Adm control will be disabled.

If no external contact inputs are programmed for the 'Enable' commands, Ext/Adm Control and Remote Ext/Adm Control must be enabled from either the front panel keypad or from Modbus. Since the front panel and Modbus provide both Remote Ext/Adm Enable and Ext/Adm Control Enable commands, they will operate in the same manner as 'both enables programmed'.

Refer to Volume 2 of this manual for information on related Service mode tunables. All pertinent Remote Ext/Adm Set Point parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Steam Performance Map Menu

Extraction / Admission

Before configuring the extraction/admission map, read the Steam Map description below. This discusses steam maps and how to convert your steam map information into a format usable by the 505E control.

The steam map is a graphical representation of the operating range and limitations of an extraction and/or admission steam turbine. This map is often called a steam envelope since normal turbine operation must be contained within the envelope lines.

The 505E uses the values programmed to calculate the turbine's internal pressure ratios and limits. To get these values from your steam map, you must first check the following conditions and, if necessary, modify the map so it meets these conditions:

- The map must be linear (all lines straight).
- Lines extraction/admission flow = 0% and extraction/admission flow =100% must be parallel, and lines LP valve = 0% and LP valve = 100% must be parallel.

If your envelope lines are not all straight and parallel (conditions 1 and 2), redraw the envelope so that they are (use graph paper). Make sure your redrawn envelope approximates the old envelope as closely as possible.

The lines on the envelope define the operating characteristics of your turbine. Refer to the example steam maps in this manual. The different lines or limits of a Steam map are:

- The horizontal axis shows turbine power (S).
- The vertical axis shows HP valve position (HP).
- The vertical line called S=100 is the maximum power limiter. This limiter prevents turbine operation beyond the maximum power limit.
- The horizontal line called HP=100 is the maximum HP flow limiter. The HP flow limiter prevents turbine operation beyond the desired maximum HP flow limit.
- The parallel lines called P=0 and P=100 define the extraction/admission flow range (from no flow or maximum admission flow to maximum extraction flow). The "P" term is used to represent pressure demand.
- The parallel lines called LP=0 and LP=100 define the LP valve position range (from closed to 100% open).

The turbine's operating characteristics are programmed into the 505E as extraction/ admission data. This data is taken from the turbine's steam map or envelope. When entering extraction/admission data into the 505E, it does not matter which units you use, as long as you use the same units throughout for power, and the same units throughout for HP and extraction/admission flow.

The 505E calculates an extraction and/or admission turbine's ratios and limits from the steam map's Max power, Max HP Flow, point A, point B, and point C values (as shown in the following example figures). The points A, B, and C are entered through programming their horizontal and vertical axis values, as explained below.

Steam maps often show a series of parallel lines representing extraction flow, as do our examples. The bottom line of all the flow lines must be P=0, and the top of the flow lines must be P=100. The "P" term is used to represent pressure demand. The higher the pressure at this point in a turbine the higher the extraction steam flow is, or the lower the admitted steam flow is. Notice, that all the "P" lines in our examples are indeed parallel.

The remaining pair of lines on opposite sides of the envelope must correspond to LP=0 (extraction valve closed) and LP=100 (extraction valve fully open). Note that the LP=0 line is parallel to the LP=100 line (condition 2).

The 505E can be configured for three different types of steam turbines, extraction only, admission only, or extraction/admission units. Following are examples for each of these configurations. Please proceed to the appropriate configuration for your application.

Extraction Only Steam Map

Before a turbine's extraction steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 3-22).

Typically Point C the intersection of the LP=0 line and the P=0 line does not exist. If this is the case it will be necessary to convert your steam map. The only conversion necessary is the extension of the LP=0

line and the P=0 line until they cross or intersect. This point where the LP=0 line intersects the P=0 line is defined as Point C and is required by the control to calculate the turbine's internal pressure ratios and limits.

The eight values needed can be taken from the converted steam map. As an example, the following data was derived, using the steam map below in Figure 3-22.

The MAX POWER value is the load where the S=100 line crosses the s-axis (about 20 000 kW in our example).

The MAX HP FLOW value is the flow where the HP=100 line crosses the HP-axis (about 108 000 lb/h; 48 989 kg/h).

Point A is where the P=0 and LP=100 lines intersect (MAX POWER @ MIN EXTRACTION = about 15 062 kW; HP FLOW @ MIN EXTRACTION = about 36 000 lb/h; 16 330 kg/h).

Point B is where the LP=0 and P=100 lines intersect (MIN POWER @ MAX EXTRACTION = about 3623 kW; HP FLOW @ MAX EXTRACTION = about 86 000 lb/h; 39 010 kg/h).

Point C is where the LP=0 and P=0 lines intersect (MIN POWER @ MIN EXTRACTION = about -3000 kW; MIN HP FLOW @ MIN EXTRACTION = about 6000 lb/h; 2722 kg/h).

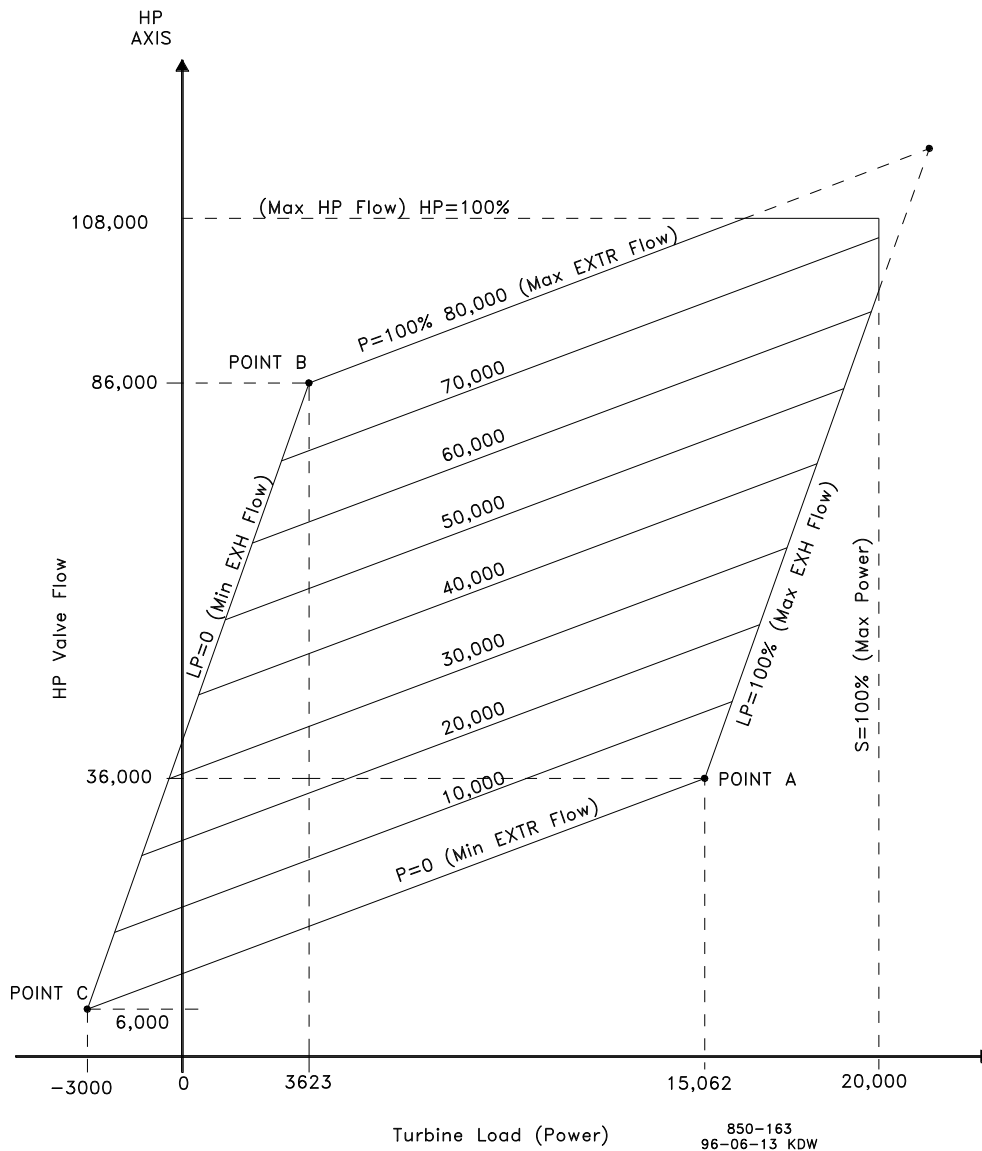


Figure 3-27. Typical Extraction Steam Map

Admission Only Steam Map

Before a turbine's admission steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 3-27).

If points A & B already exist, the only conversion necessary is the extension of the LP=100 line and the P=100 line until they cross or intersect (this is Point C for programming).

If only point A exists, your map must be modified to include points B & C. The LP=0 line will need to be created. To create the LP=0 line, you must know the minimum required steam flow through the back end of the turbine. Based on the example steam map (Figure 3-23), the minimum required flow was 10 000 lb/h (4536 kg/h).

1. Extend the zero admission (or induction) line ($p=100\%$). Refer to Figure 3-23.
2. Find your turbine's minimum back-end steam flow (this will be point B's HP flow).
3. Mark the intersection of the zero admission line and the turbine's minimum back-end (cooling) steam flow. This mark will be Point B for programming.
4. Draw a line parallel to the LP=100 line, through the mark created in step 3. This will be your LP=0 line or LP valve closed line.

5. Mark the intersection of the P=100 and the LP=100 line. This will be Point C for programming. Typically Point C the intersection of the LP=100 line and the P=100 line does not exist.

Points A, B, and C are required by the control to calculate the turbine's internal pressure ratios and limits.

The nine values needed can be taken from the converted steam map. An example has been provided using the steam map in Figure 3-27.

The MAX POWER value is the load where the S=100 line crosses the s-axis (about 10 000 kW in our example).

The MAX HP FLOW value is the flow where the HP=100 line crosses the HP-axis (about 105 000 lb/h; 47 628 kg/h).

Point A is where the P=0 and LP=100 lines intersect (MAX POWER @ MAX ADMISSION = about 9500 kW; HP FLOW @ MAX ADMISSION = about 75 000 lb/hr; 34 020 kg/h).

The ADMISSION FLOW @ MAX ADMISSION = about 50 000 lb/h (22 680 kg/h).

Point B is where the LP=0 and P=100 lines intersect (MIN POWER @ MIN ADMISSION = about 700 kW; HP FLOW @ MIN ADMISSION = about 10 000 lb/h; 4536 kg/h). This point was used because 10 000 lb/h (4536 kg/h) is the minimum back-end cooling steam flow required by the turbine. A negative value is entered by using the "DYNAMICS" key.

Point C is where the LP=100 and P=100 lines intersect (MAX POWER @ MIN ADMISSION = about 11 000 kW; MAX HP FLOW @ MIN ADMISSION = about 125 000 lb/h; 56 700 kg/h).

An additional parameter, MIN HP LIFT (%), would also be set to $8000/105\ 000 = 7.6\%$

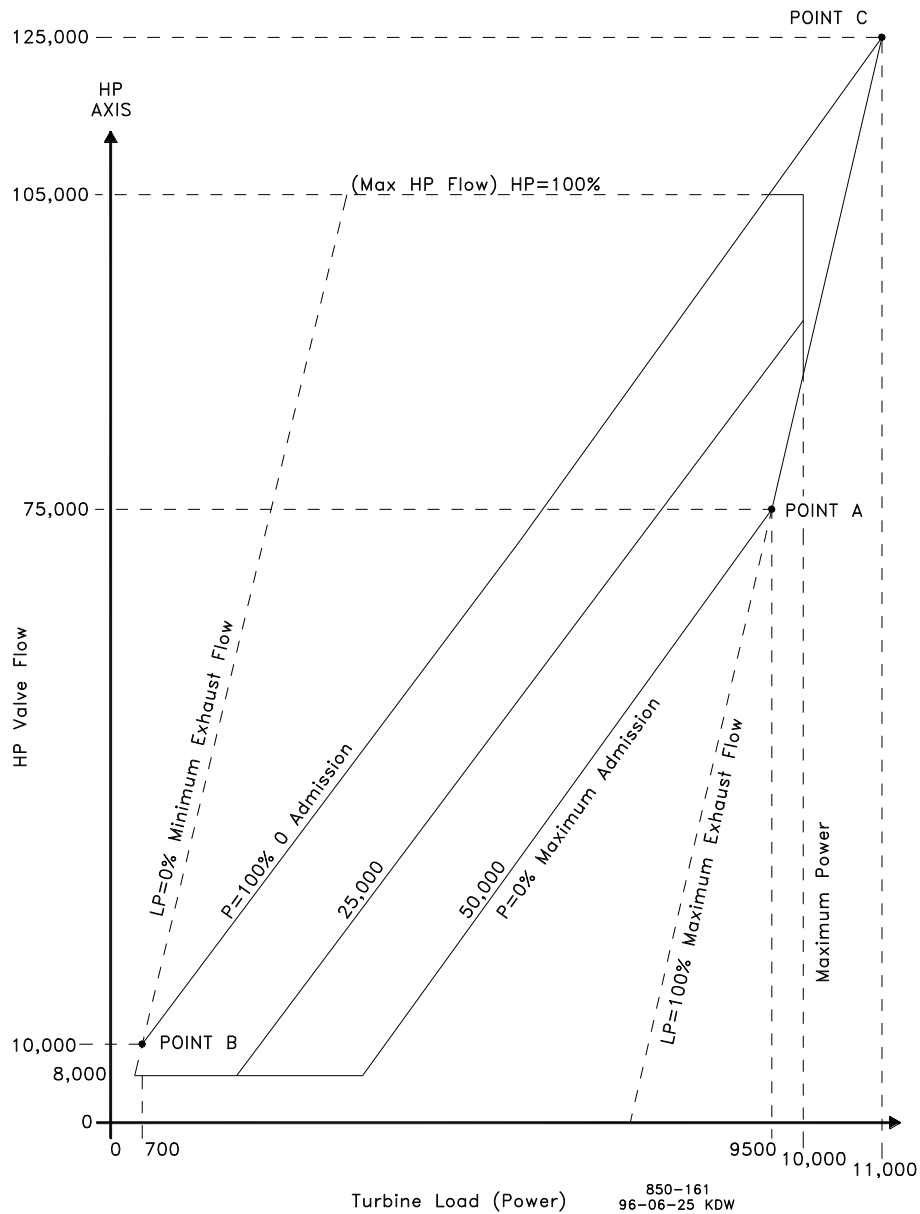


Figure 3-28. Typical Admission Steam Map

Extraction & Admission Steam Map

Before a turbine's extraction/admission steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 3-27).

If points A & B already exist, the only conversion necessary is the extension of the LP=0 line and the zero extraction and admission flow line until they cross or intersect (this is Point C for programming). If point A does not exist, the extension of the LP=100 line and the zero extraction and admission flow line until they cross or intersect is Point A for programming.

If points B & C do not exist, your map will have to be modified to include points B & C. The LP=0 line will need to be created. To create the LP=0 line you must know the minimum required steam flow through the back end of the turbine. In our example steam map (Figure 3-28) the minimum required flow was 8000 lb/h (3629 kg/h).

1. Extend the maximum extraction line. Refer to Figure 3-28.
2. Extend the zero extraction & admission line.
3. Find your turbine's minimum back-end steam flow (this will be point C's HP flow).
4. Mark the intersection of the zero extraction & admission flow line and the turbine's minimum back-end steam flow. This mark will be Point C for programming.
5. Draw a line parallel to the LP=100 line, through the mark created in step 4. This will be your LP=0 line or LP valve closed line.
6. Mark the intersection of the maximum extraction line and the created LP=0 line. This will be Point B for programming.

Points A, B, and C are required by the control to calculate the turbine's internal pressure ratios and limits.

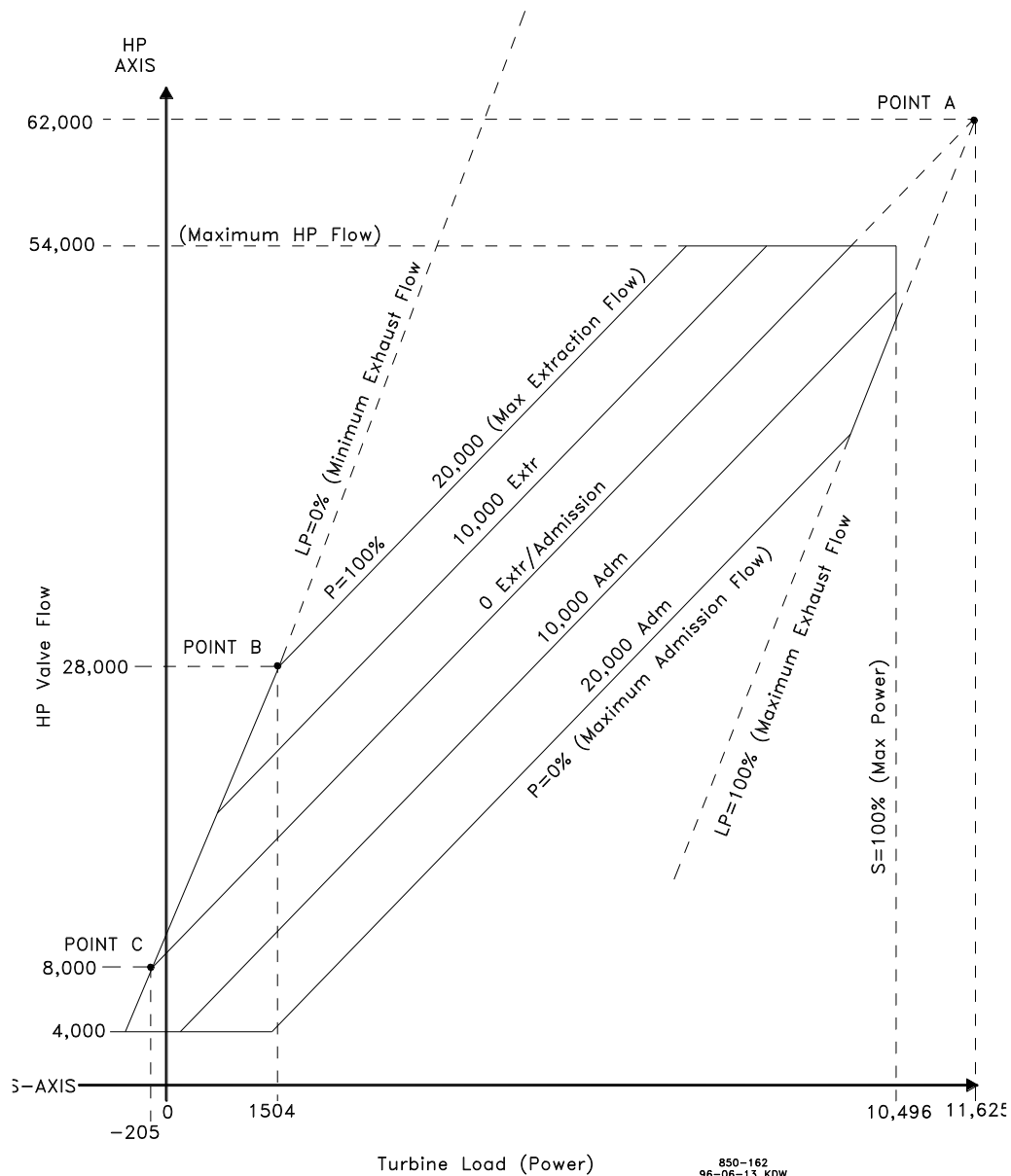


Figure 3-29. Typical Extraction & Admission Steam Map

The ten values needed can be taken from the converted steam map. An example has been provided above, using the steam map in Figure 3-29.

The MAX POWER value is the load where the S=100 line crosses the s-axis (about 10 496 kW in our example).

The MAX HP FLOW value is the flow where the HP=100 line crosses the HP-axis (about 54 000 lb/h; 24 494 kg/h).

Point A is where the P=0 extr/adm and LP=100 lines intersect (MAX POWER @ 0 EXTR/ADM = about 11 625 kW; MAX HP FLOW @ 0 EXTR/ADM = about 62 000 lb/h; 28 123 kg/h).

MAX ADMISSION = about 20 000 lb/h (9072 kg/h).

Point B is where the LP=0 and P=100 lines intersect (MIN POWER @ MAX EXTRACTION = about 1504 kW; MIN HP FLOW @ MAX EXTRACTION = about 28 000 lb/h; 12 701 kg/h).

Point C is where the LP=0 and zero extraction & admission flow lines intersect (MIN POWER @ ZERO EXTRACTION/ADMISSION = about -205 kW; MIN HP FLOW @ ZERO EXTRACTION/ADMISSION = about 8000 lb/h; 3629 kg/h).

An additional parameter, MIN HP LIFT (%), would also be set to $4000/54000 = 7.4\%$.

Operational Modes for Extraction/Admission turbines –

The 505XT will support several different modes of operation for Extraction/Admission turbine configurations. In simple terms, the 505 has two control valves, so therefore it can control two parameters as long as neither a parameter nor a valve has reached a limit. Prior to configuring the 505XT control it is important to understand which parameters are planned to be controlled by the 505 for the specific plant/process steam turbine application. The typical configuration is to control Speed and Extraction pressure (called Base mode below), however Inlet and/or Exhaust Pressure can also be achieved if the unit has the process variable and the control mode is configured for use.

The table below shows the operational modes available in the configuration of the 505XT. To use a mode, the listed control must be enabled for use as a Controller and the appropriate PV for that loop is healthy.

Table 3-7. Alternate Modes for Ext/Adm Turbines

MODE	Control 1	Control 2	Ratio Limiter Used	Comment
Startup Mode	Speed Only		NO	
Mode 0	Speed	Extraction	YES	Base mode
Mode 1	Speed	Inlet	YES	Alternate mode
Mode 2	Extraction	Inlet	YES	Alternate mode
Mode 3	Speed	Exhaust	YES	Alternate mode
Mode 4	Extraction	Exhaust	YES	Alternate mode
Mode 5	Inlet	Exhaust	YES	Alternate mode, but Decoupled
Mode 6	Inlet	Exhaust	YES	Alternate mode
Fully Decoupled	Speed	Extraction	NO	Speed=HP Extraction=LP

During the startup of the turbine – the unit is in Speed control mode (Speed Only) and has full authority over the HP inlet valve (Speed PID = Valve Demand). On mechanical drive applications, once the startup is complete, the unit is considered 'Online'. For a generator application once the generator breaker is closed and the unit is, producing power the unit is considered 'Online'.

Once the unit has reached 'Online' status, Extraction control can be enabled, and the control will transfer into Ratio Limiter control and enter into Speed/Extraction control mode. From this base mode the unit can be transferred into any of the Alternate modes listed in the table above (if configured to do so). The 505XT supports multiple alternate modes – but any transition into an alternate mode must be initiated from the base mode (Speed/Extraction).

Ratio Limiter Functionality

The 505XT ratio/limiter receives four input signals: Speed, Extraction, Inlet, and Exhaust demands. Only two of the inputs are used in control of the HP and LP valves at one time. The ratio logic uses these two active input signals to produce two output signals, one to control the HP actuator, and one to control the LP actuator. The limiter logic keeps the turbine control valves' outputs within the boundaries of the turbine steam map.

The ratio limiter function converts the outputs of 2 PID controls into proportionally accurate demand outputs for both the HP and the LP valves. A change in demand for either parameter will correctly adjust the output of both valves to maintain both parameters. The equations in the Ratio Limiter logic for the valve demands are fixed as shown below. The gain factors (K's) in these equations are determined by the turbine performance curve (or steam map) typically provided by the OEM. It is important to note that the final valve output demands are NOT equal to any one PID output, but a calculation involving two PID outputs

$$\begin{aligned} \text{HP} &= K1*S + K2*P + K3 \\ \text{LP} &= K4*S + K5*P + K6 \end{aligned}$$

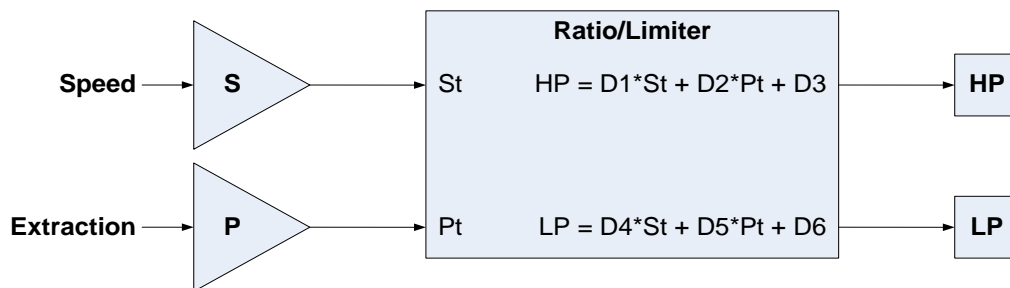
Transferring Modes

The 505XT always controls in Mode 0: Speed and Extraction/Admission after Extr/Adm is enabled. Transferring between modes can be done from the Steam Map page. In the 'Mode' popup which is accessed from the soft-keys, the desired mode can be selected from the drop down list. Modes 1-6 are referred to as Alternate Modes. Once the desired mode is selected, and the transfer is permissible, pressing the 'Enable' soft-key will transfer the control into the Alternate Mode. The transfer is instantaneous and bumpless.

When an Alternate Mode is active, it can be disabled from the 'Mode' popup page from the Steam Map page. Disabling an Alternate Mode always transfers into Mode 0: Speed and Extraction/Admission. A new Alternate Mode can only be enabled from Mode 0: Speed and Extraction/Admission.

If an Alternate Mode is active, a normal stop will first transfer back to Mode 0: Speed and Extraction/Admission, before continuing with the stop sequence. Any trip will also return the control to Mode 0: Speed and Extraction/Admission for the next startup sequence.

Mode 0: Speed and Extraction



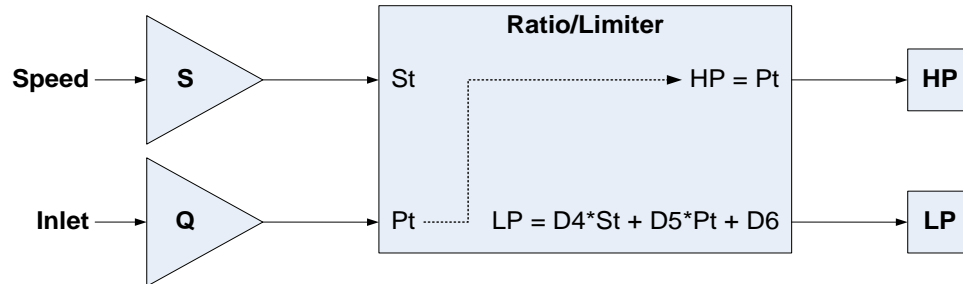
$$\begin{aligned} \text{HP} &= D1.St + D2.Pt + D3 \\ \text{LP} &= D4.St + D5.Pt + D6 \end{aligned}$$

$$\begin{aligned} St &= S && \text{(speed)} \\ Pt &= P && \text{(extraction)} \end{aligned}$$

$$\begin{aligned} D1 &= K1 \\ D2 &= K2 \\ D3 &= K3 \\ D4 &= K4 \\ D5 &= K5 \\ D6 &= K6 \end{aligned}$$

This mode is used when the two controlled parameters during normal operation are turbine speed/load and Extr/Adm pressure (or flow).

Mode 1: Speed and Inlet



$$\begin{aligned} \text{HP} &= \text{D1} \cdot \text{St} + \text{D2} \cdot \text{Pt} + \text{D3} \\ \text{LP} &= \text{D4} \cdot \text{St} + \text{D5} \cdot \text{Pt} + \text{D6} \end{aligned}$$

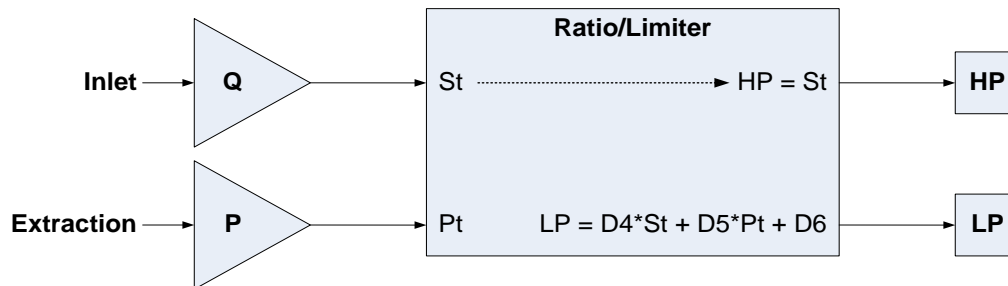
$$\begin{aligned} \text{St} &= \text{S} && \text{(speed)} \\ \text{Pt} &= \text{Q} && \text{(inlet)} \end{aligned}$$

$$\begin{aligned} \text{D1} &= 0 \\ \text{D2} &= 1 \\ \text{D3} &= 0 \\ \text{D4} &= \text{K4} - \text{K5} \cdot \text{K1} / \text{K2} \\ \text{D5} &= \text{K5} / \text{K2} \\ \text{D6} &= \text{K6} - \text{K3} \cdot \text{K5} / \text{K2} \end{aligned}$$

The inlet pressure is determined by HP demand only, without any effect of LP. ($\text{Pt} = \text{HP}$)

This mode is used when the two controlled parameters during normal operation are turbine speed/load and inlet pressure (or flow).

Mode 2: Extraction and Inlet



$$\begin{aligned} \text{HP} &= \text{D1} \cdot \text{St} + \text{D2} \cdot \text{Pt} + \text{D3} \\ \text{LP} &= \text{D4} \cdot \text{St} + \text{D5} \cdot \text{Pt} + \text{D6} \end{aligned}$$

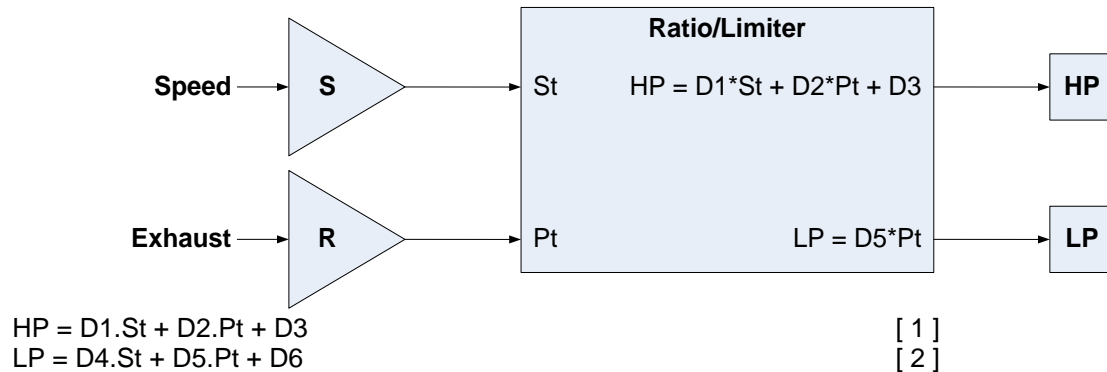
$$\begin{aligned} \text{St} &= \text{Q} && \text{(Inlet)} \\ \text{Pt} &= \text{P} && \text{(Extraction)} \end{aligned}$$

$$\begin{aligned} \text{D1} &= 1 \\ \text{D2} &= 0 \\ \text{D3} &= 0 \\ \text{D4} &= \text{K4} / \text{K1} \\ \text{D5} &= \text{K5} - \text{K4} \cdot \text{K2} / \text{K1} \\ \text{D6} &= \text{K6} - \text{K3} \cdot \text{K4} / \text{K1} \end{aligned}$$

The inlet pressure is determined by HP demand only, without any effect of LP. ($\text{St} = \text{HP}$)

This mode is used when the two controlled parameters during normal operation are inlet pressure (or flow) and extraction pressure (or flow).

Mode 3: Speed and Exhaust



$$\text{St} = \text{S} \quad \text{(Speed)}$$

$$\text{Pt} = \text{R} \quad \text{(Exhaust Pressure)}$$

$$\text{D1} = \text{K1} - (\text{K2} \cdot \text{K4} / \text{K5});$$

$$\text{D2} = (\text{K2} / \text{K5});$$

$$\text{D3} = \text{K3} - (\text{K2} \cdot \text{K6} / \text{K5});$$

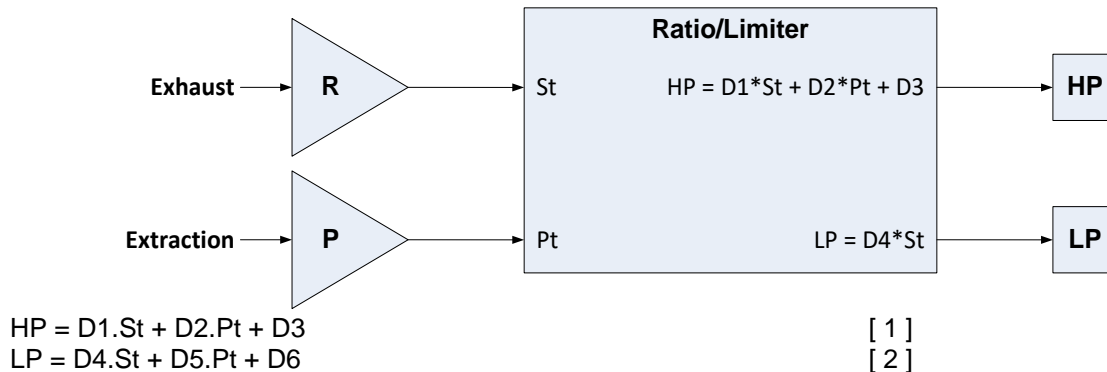
$$\text{D4} = 0;$$

$$\text{D5} = 1;$$

$$\text{D6} = 0;$$

This mode is used when the two controlled parameters during normal operation are turbine speed/load and exhaust pressure (or flow).

Mode 4: Extraction and Exhaust



$$\text{St} = \text{R} \quad \text{(Exhaust)}$$

$$\text{Pt} = \text{P} \quad \text{(Extraction)}$$

$$\text{D1} = \text{K1} / \text{K4}$$

$$\text{D2} = \text{K2} - \text{K1} \cdot \text{K5} / \text{K4}$$

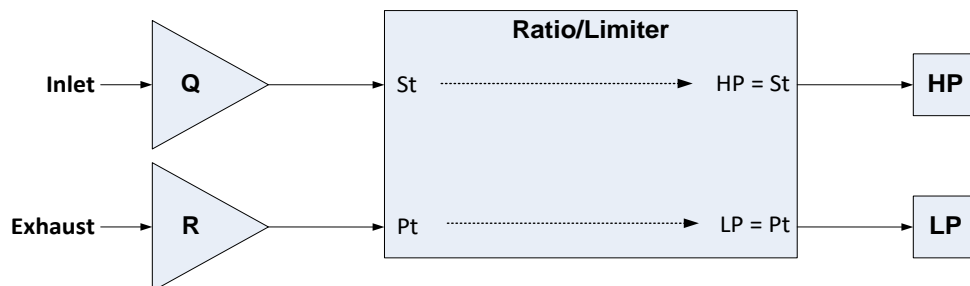
$$\text{D3} = \text{K3} - \text{K6} \cdot \text{K1} / \text{K4}$$

$$\text{D4} = 1;$$

$$\text{D5} = 0;$$

$$\text{D6} = 0;$$

Mode 5: Inlet and Exhaust (Decoupled)



$$HP = D1.St + D2.Pt + D3$$

$$LP = D4.St + D5.Pt + D6$$

$$\begin{aligned} St &= Q && \text{(Inlet)} \\ Pt &= R && \text{(Exhaust)} \\ D1 &= 1 \\ D2 &= 0 \\ D3 &= 0 \\ D4 &= 0 \\ D5 &= 1 \\ D6 &= 0 \end{aligned}$$

Selecting Priorities –

In all modes using ratio limiter functionality, the user must select which parameter is most important to maintain if a limiter (a performance map or valve limit) is reached. If only one parameter can be controlled, the user, depending on the configuration, can select which parameter is maintained.

For example, consider a mechanical drive application turbine running in Mode 0 (Speed/Extraction). If a valve or map limit is reached the control must select Speed Control as priority and sacrifice (lose control of) Extraction pressure.

For a generator application turbine running in Mode 0 in droop against a utility grid, the user could choose to maintain Speed/Load or Extraction as the priority. If Speed/Load is selected, the control would hold load to desired setpoint and lose control of the extraction pressure. If Extraction priority was chosen, the control would allow the load to vary to maintain Extraction pressure.

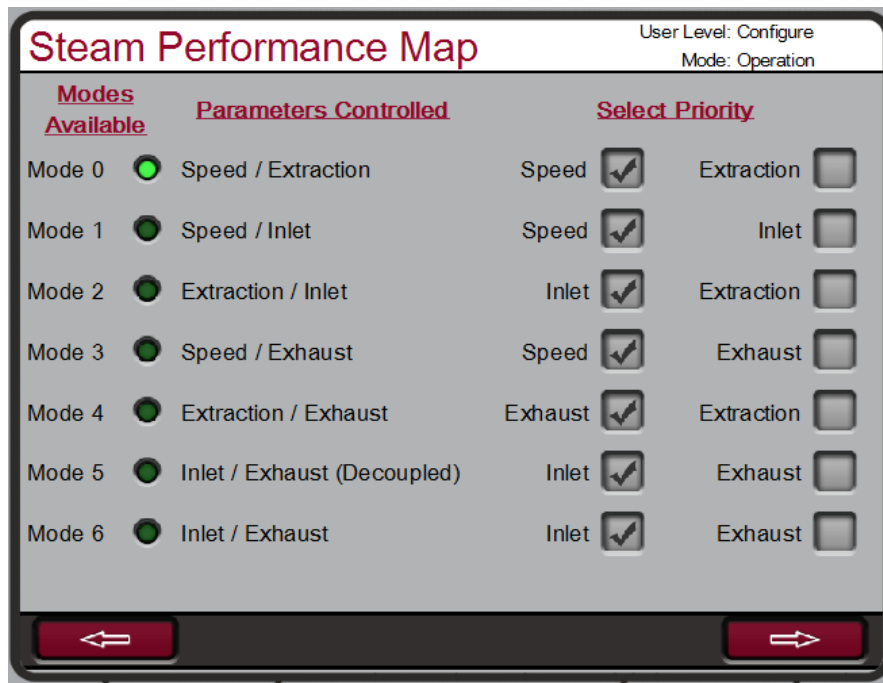


Figure 3-30. Ext/Adm Mode Control Priorities

Fully Decoupled Mode –

It is possible to run in a fully decoupled mode in which there is no interaction between the two PID's and the two valve demand outputs. In this mode, the HP valve demand is directly driven by the Speed PID output, and the LP valve demand is directly driven by the Extraction PID output. In this mode the Ratio Limiting is not used, so no operational map limiters are enforced. Since the PID's are independent of each other there is a high probability of the control demands conflicting with each other (fighting) and one controller tending to slowly oscillate around its desired setpoint (hunting). Typically, the dynamic response of only 1 parameter can be optimized in this mode.

Under the Extraction/Admission Configuration menu, there is a selection to "Allow the use of Full Decoupled Mode". If that box is checked then the screen below will be available in the Service menu under the Extraction/Admission Control menu. The permissives listed apply to either enabling or disabling full-decoupled mode. If the ACTIVE LED is on, it indicates that when Ext/Adm control is enabled that the control will transition into Full Decoupled mode, rather than transitioning into Ratio Limiter base mode (Mode 0).

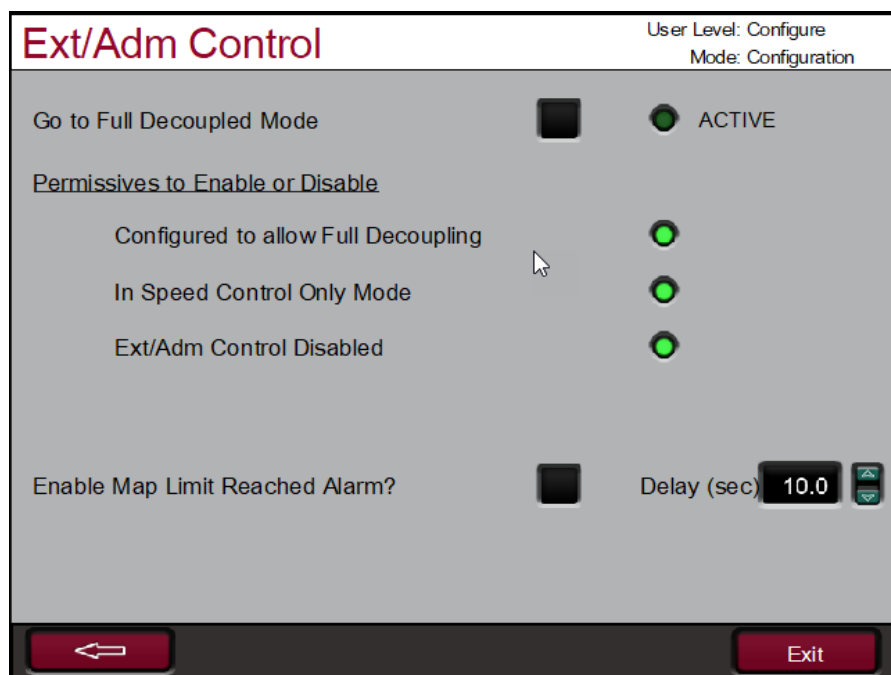


Figure 3-31. Configured for Full Decoupled Mode (No Map)

Inlet Steam Pressure Control

The Inlet Steam Pressure PID controller can be used to control the turbine inlet pressure, which is directly related to turbine speed/load.

The process variable selection to use for this control is:

- Inlet Steam Pressure

This input is a 4 to 20 mA current signal. The PID control amplifier compares this input signal with the Inlet Steam Pressure set point to produce a control output. In a single valve application this signal is sent to the digital Speed LSS (low signal select) bus. If the application is for an Extraction/Admission type turbine then the output is sent directly to the ratio limiter controller.

This control works exactly the same as the Auxiliary Control Limiter in a single valve turbine. In Extraction/Admission units, this PID is always a controller (if used) and is connected directly to the Ratio Limiter block to allow operational modes where this parameter is either the primary or secondary control priority of the 505XT.

Inlet Pressure Control Functional Overview

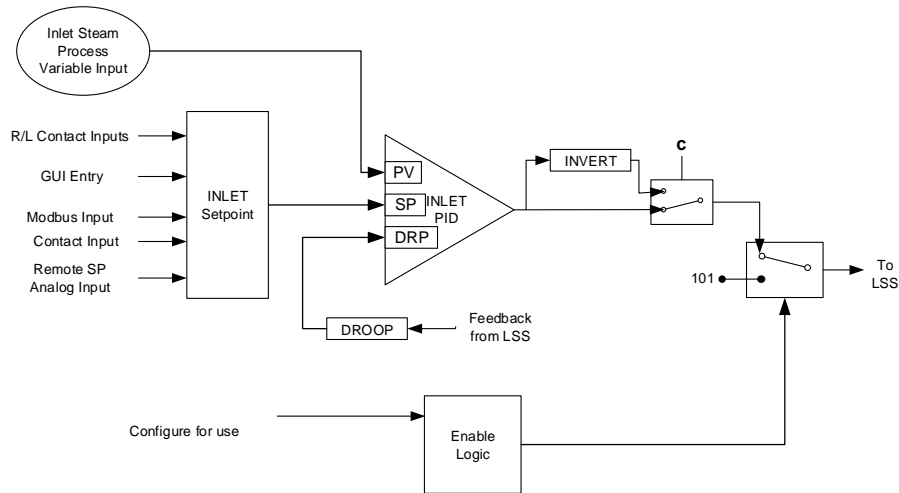


Figure 3-32. Inlet Steam Pressure Control Overview

Exhaust Steam Pressure Control

The Exhaust Steam Pressure PID controller can be used to control the turbine exhaust pressure, which is directly related to turbine speed/load.

The process variable selection to use for this control is:

- Exhaust Steam Pressure

This input is a 4 to 20 mA current signal. The PID control amplifier compares this input signal with the Exhaust Steam Pressure set point to produce a control output. In a single valve application, this signal is sent to the digital Speed LSS (low signal select) bus. If the application is for an Extraction/Admission type turbine then the output is sent directly to the ratio limiter controller.

This control works exactly the same as the Auxiliary Control Limiter in a single valve turbine. In Extraction/Admission units, this PID is always a controller (if used) and is connected directly to the Ratio Limiter block to allow operational modes where this parameter is either the primary or secondary control priority of the 505XT.

Exhaust Pressure Control Functional Overview

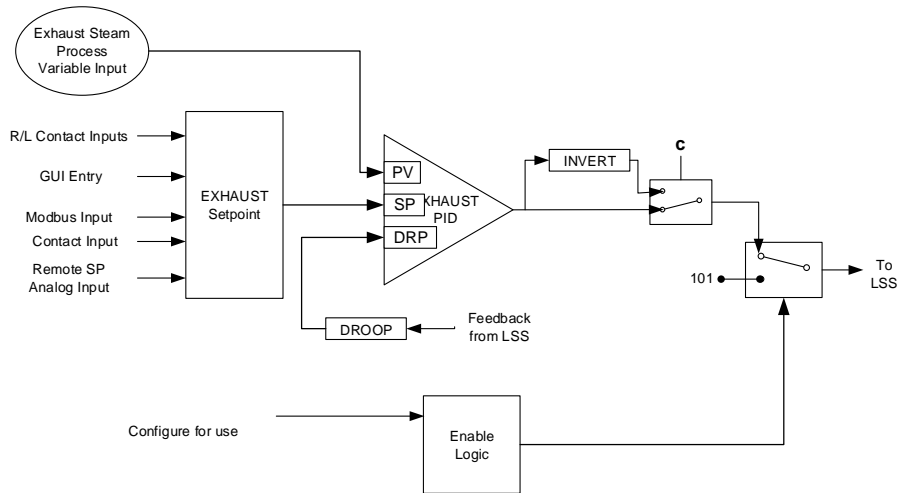


Figure 3-33. Exhaust Steam Pressure Control Overview

HP Valve Limiter

The valve limiter limits the actuator output signal (governor valve position) to aid in starting up and shutting down the turbine. The output of the valve limiter is Low-Signal-Selected with the output of the Speed LSS. The PID or limiter asking for the lowest valve position will control valve position. Thus, the valve limiter, limits the maximum valve position.

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

The valve limiter level is adjusted through the 505 keypad, contact input, or through Modbus communications. When raise or lower commands are received, the limiter ramps up or down, at the 'VALVE LIMITER RATE'. The maximum the limiter can increase is 100%. The Valve Limiter 'Rate' and 'Max Valve position' settings can be adjusted in the Service mode.

A specific set point may also be directly entered from the 505 keypad or through Modbus communications. When this is performed, the set point will ramp at the 'Valve Limiter Rate' (as defaulted in Service mode). To "enter" a specific set point from the 505 keypad, press the LMTR key to view the Valve Limiter screen, press the ENTER key, enter the set point level desired, then press the ENTER key again. If a valid number was entered, equal-to or between the min and max set point settings, the setting will be accepted, and the Valve Limiter will ramp to the "entered" level. If an invalid number is "entered", the setting will not be accepted and the 505's screen will momentarily display a value out-of-range message.

To "enter" a specific set point from the 505 Display uses the following steps:

1. From the HOME page go to the Valve Demand page
2. Press the Commands button until 'Entered Setpoint' appears
3. Select 'Entered Setpoint' and a pop-up will appear
4. Press Enter from the Navigation cross and the pop-up value will highlight
5. Adjust the value with the Adjust keys or enter a value from the keypad
6. Press Enter again when desired value has been entered
7. The value in the pop-up will be accepted; if it is invalid a message will appear
8. Select the GO button to ramp the setpoint to this entered value

When a valid set point value is entered, the set point will ramp at the 'Valve Limiter Rate' to the newly entered set point value. This 'Entered' rate is tunable through the Service mode.

During start-up, if the control is set to use Automatic start-up, and if the valve limiter has been manually set for trouble shooting, it is possible to automatically ramp it back to 100%, by issuing a 'Run' command again.

Refer to Volume 2 of this manual for further information on Service mode and on-line tunables. All pertinent valve limiter parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

LP Valve Limiter

The LP valve limiter limits the actuator output signal (Ext/Adm valve position). Depending on the turbine type, this limiter will feed either an LSS or an HSS. This limiter is used to manually bring a unit into Ext/Adm control and can also be used as an aid in troubleshooting system dynamics.

In an Extraction turbine the output of the LP valve limiter is High-Signal-Selected with the output of the Ratio Limiter controller. Lowering the limiter from maximum (100%) to minimum (0%) will manually enable extraction control.

In an Admission turbine the output of the LP valve limiter is Low-Signal-Selected with the output of the Ratio Limiter controller. In this type of turbine, the limiter is ramped from minimum (0%) to maximum (100%) demand to enable admission control.

Manual Valve Demand

The manual valve demand feature functions just like the valve limiter except that, instead of providing an input to the Low Signal Select to limit how high the valve demand can go, it disables all other controllers (including speed) to ensure that manual demand has full control of the valve demand output. The intent of this feature is to aid in the troubleshooting of plant stability or oscillation issues. It can be used to temporarily hold the valve in its current position.

This feature can be selected using the Service Menu. In addition to holding the valve demand output, manual demand allows the valve demand to be adjusted manually, preferably at a very slow and safe rate. When selected, the valve ramp rate for this feature can be adjusted. This should be set to a value that is safe and stable for speed, load, or any process and pressures associated with the turbine that will be affected by moving this valve. Also, the timeout time can be adjusted. After this time the feature will disable if no raise/lower manual demand commands are received. Every time a raise or lower manual demand command is issued, the timer will restart.

Because of the risk associated with locking the valve in place there are many protections that disable this function, which will return the unit to Speed PID control, in addition to the normal Disable command functionality and timeout protection. All items that will disable this feature are as follows:

- Operator interface disable command
- Manual demand not used (Service Menu setting)
- Any turbine trip
- Startup not completed or overspeed test enabled
- Speed less than minimum governor
- Speed greater than maximum governor
- Both breakers not closed (generator applications only)
- Timeout due to inactivity



Manual Valve Demand

Use caution when adjusting manual demand as the 505 is no longer in control of any speed, load, or process. It is the responsibility of the operator to ensure safe operation of all processes related to valve movement. Use caution even while using this feature to hold the valve position as the 505 may not react to any system upsets until the conditions have become unsafe. Failure to do so may result in loss of control with possible personal injury, loss of life, or property damage.

Inlet Steam Pressure Compensation

The inlet pressure compensation feature is used to adjust the control response based on variations in the inlet steam header pressure. Inlet pressure compensation is enabled in Configure Mode (under Operating Parameters). To use this feature, an analog input must be configured as inlet steam pressure.

Once this is configured, the pressure compensation curve will be available in the Service Menu screens. The compensation factor is determined by a user-defined curve. The X values of the curve points are inlet pressures in engineering units. The Y values of the curve points are a gain multiplier on the HP valve demand. By default, all Y values are initially set to 1.0. The X values should be set to the expected range of inlet pressure for normal operation, with at least one point being the rated pressure and a gain of 1.0. Increase the gain (Y values) for pressures less than rated and decrease the gains for pressures greater than rated. This gain factor is applied to the valve demand prior to the valve linearization curve (if that option is used).

Example:

Curve for a steam turbine rated at 500 psi and operating range of +/-150 psi.

<u>X</u>	<u>Y</u>	
Point 1	350	1.2
Point 2	400	1.1
Point 3	500	1.0
Point 4	600	0.9
Point 5	650	0.8

All X values entered in the curve must be increasing. The curve block has been implemented such that it will limit the gain to the first and last points entered by the user. If the inlet steam pressure signal fails, then the curve is bypassed, and the gain is forced to 1.0.

The gain output of this curve should be left at 1.0 (all Y values at 1.0) until the control PID gains have been tuned at the rated inlet pressure. Once this is done, then the inlet pressure compensation curve points can be set for other inlet pressures.



Pressure compensation will affect the accuracy of the droop calculation when the 505 is configured for droop with valve position control.

Isolated PID Control

The Isolated PID Controller can be configured to control any system process. Typically, this controller is configured and used to control seal gas or gland seal pressure, but it can also be used for any type of PID loop.

The Isolated PID compares a 4–20 mA process signal with an internal setpoint to directly position an analog output configured as Isolated PID output.

The Isolated PID loop can be put in manual and automatic mode via dedicated contact input, Modbus commands or display.

If a contact input is programmed to function as an Isolated PID manual contact, Isolated PID Control is in automatic when the contact is opened and in manual mode when it is closed. If a command is sent via Modbus to put this PID in automatic, then the contact input must be closed/opened to bring back the manual mode.

Isolated Manual Mode

When the Isolated PID is in manual mode, it is possible to manipulate its output directly using Raise/Lower demand commands. These commands are available via Modbus, display, or contact inputs configured as Isolated PID Raise/Lower demand.

Should a process value be lost, it is also possible to configure the 505XT to hold the last value, ramp the PID output up or down automatically.

Isolated PID Dynamics

The Isolated PID control uses its own set of dynamic settings. These values are programmable and may be tuned at any time from display interface only.

Isolated Set Point

The Isolated setpoint can be adjusted from the display interface, external contacts, or Modbus.

When a raise or lower Isolated PID setpoint command is issued, the setpoint moves at the Isolated PID setpoint rate. If an Isolated PID Set Point raise or lower command is selected for longer than three seconds, the setpoint will move at the fast rate, which is three times the cascade setpoint rate. The Isolated setpoint rate, fast rate delay, and fast rate can all be adjusted in the Service Mode.

Invert Isolated PID

Depending on the control action required, the Isolated PV input signal can be inverted. If a decrease of PID output is required to increase the cascade process signal, program the input to be inverted.

Emergency Shutdown

When an Emergency Shutdown condition occurs, the actuator output signal is stepped to zero milliamps, the shutdown relay de-energizes, and the shutdown cause (first shutdown condition sensed) is displayed on the 505's front panel. See Chapter 5 for a detailed list of the possible shutdown (trip) conditions.

In addition to the Emergency Stop button on the front panel, up to fifteen (15) Emergency Shutdown inputs (contact inputs) can be programmed to allow the 505 to indicate the cause of an emergency shutdown. By wiring trip conditions directly into the 505 instead of a trip string, the 505 can pass a trip signal directly to its output relay (to trip the T&T valve), and also indicate the first trip condition sensed. The 505's total throughput time is 20 milliseconds (worse case). Each of these discrete input shutdown inputs will be time-stamped by the real-time clock with 1 ms resolution. All trip conditions are indicated through the 505's front panel, and Modbus communications.

The cause of the last trip is displayed by pressing the VIEW key under the TRIP LED. The last trip indication, is latched-in and can be viewed at any time after a trip and before the next trip condition is latched in. Once latched-in the last trip indication cannot be reset. This allows an operator to confirm what the trip condition was hours or days after the unit has been reset and restarted.

In addition to the dedicated Shutdown relay, the other programmable relays may be configured as Shutdown condition or Trip relays.

The Shutdown condition relay may be programmed to indicate a shutdown condition on a remote panel or to a plant DCS. The Shutdown Indication relay is normally de-energized. This relay will energize upon any shutdown condition and stay energized until all trips have been cleared. The 'Reset Clears Trip' function has no effect on the programmable Shutdown Indication relay.

When programmed as a Trip relay, the respective relay will function like the dedicated Shutdown relay (normally energized and de-energizes on a shutdown) to indicate the position of the dedicated Shutdown relay.

Controlled Shutdown

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 following sequence is performed:

1. Cascade, Auxiliary, Inlet, and Exhaust PID controllers (if used) are disabled. If unit is Ext/Adm unit it will return to coupled mode prior to disabling Inlet or Exhaust (Speed and Extraction control)
2. If unit is Ext/Adm turbine the control will transition from ratio limiter control to speed control only mode. It will then disable Ext/Adm control
3. The Speed Set Point is ramped to min load set point at normal rate (only for generator application).
4. When at min load (only for generator application), the controller will wait until the generator breaker opens (only if "Reverse Power Protection?" = True). If a relay output is configured as "generator open pulse (2s)", then this relay will temporarily energize for 2 seconds.
5. The Speed Set Point is ramped to its low idle level.
6. Once the speed set point has reached its low idle point, the HP valve limiter is then ramped to zero percent at a controlled rate. At this point if the "Controlled Stop & Trip" setting is configured to "no" the control will then wait for a Start command to restart the turbine. However, if the "Controlled Stop & Trip" setting is configured to "yes" the control will then execute a turbine shutdown.

With the control in the run mode and the turbine turning, when the 505's "STOP" key is pressed, the control will display a message prompting the operator to verify the command ("Initialize Normal Stop?"). At this point, if the "OK" command is issued, the control will perform the controlled shutdown sequence explained above. Issuing the "Cancel" command will cause no change in the 505's operation and the Normal Stop confirmation pop-up box will disappear. This verification feature prevents an unwanted shutdown if the STOP key is accidentally pushed.

A controlled shutdown can be initiated or aborted from the 505 front panel, a programmed contact input, or either Modbus communication link. Verification is not required if a controlled shutdown command is initiated by a programmed contact input or Modbus communication link.

The controlled shutdown sequence can be aborted at any time. During a controlled shutdown sequence, by pressing the STOP key, the 505 will display a "Abort Normal Stop?" message. Selecting "OK" from this screen will cause the shutdown sequence to be aborted. At this point the shutdown sequence can be re-initiated when desired, or the unit can be brought back to a fully operational state.

If an external contact is programmed to issue a controlled shutdown command, closing the contact will initiate the controlled shutdown sequence. The shutdown sequence will go through the same steps described above, with the exception that verification of the shutdown sequence is not needed. Opening the programmed contact will stop the sequence. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to issue the command. If the contact is closed it must be opened and re-closed to issue the command. The Modbus initiated Control Shutdown Sequence requires two commands, one to start the sequence and the other to stop it.

The speed sensor failure trip, generator breaker open trip, and tie breaker open trip commands are overridden when a controlled shutdown is initiated.

IMPORTANT

This command can be disabled through the Service Mode, if desired (see Key Options). When disabled, the Controlled Stop feature is disabled from front panel, Modbus, and contact commands.

Overspeed Test Function

The 505's overspeed test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505's internal overspeed trip logic and any external overspeed trip device's settings and logic. An Overspeed Test will allow the control's speed set point to be increased above the normal maximum governor limit. This test can be performed from the front panel of the control or with external contacts. This test is not permissible through the Modbus.

An overspeed test is allowed only under the following conditions:

- The Speed PID must be in control
- The Auxiliary, Cascade, and Remote Speed Set Point PIDs/functions must be disabled
- Extraction/Admission control (if used) must be disabled
- If configured for a generator application the Generator breaker must be open.
- The Speed Set Point must be at the "Max Governor Speed" setting.

The key to enable the test will not appear until the above conditions are met.

At any time, the Max Peak Speed reached can be seen on the Overspeed Test page – it can be reset if the user is logged in at Service Mode level or above.

An overspeed test can be performed through an external contact, if the 'overspeed test' function is programmed to a 'Contact Input # Function' setting. When configured this contact performs the same function as the 505's front panel OSPD key.

There are two programmable relay options available to indicate overspeed status. One programmable relay option indicates an Overspeed Trip condition. The second relay option provides indication that an Overspeed Test is being performed.

Reduced Overspeed Test

In support of compressor applications where often the drive unit must be uncoupled to perform an actual overspeed test, the 505 XT has the ability to perform a 'reduced speed overspeed test'. In Service, it will allow the operator to enable a switch that will use a lower (but not higher) Overspeed setting than the actual Overspeed Trip setting in the configuration mode.

This feature has been enhanced so that users can now activate the reduced overspeed test from a contact input (if configured) and this command will work the same as if initiated from Service Mode screen checkbox. The configuration menu selection for this input is "Reduced Overspeed Test", which is a different function than the normal overspeed test discrete input command above. This contact must be maintained (TRUE) to keep the reduced test mode active.

Other enhancements to this test include:

- Speed must be below the Reduced Overspeed Setpoint by 25 rpm to activate the test mode. If speed is higher than Reduced Overspeed Setpoint then the mode will not be activated. (This is to prevent an immediate TRIP when enabling this mode). The service screen will have an annunciation warning appear when this mode is inhibited.
- An Overspeed Test alarm (ALM_ 13) will be activated anytime the discrete input or the Service mode checkbox is TRUE
- Once activated, information about this test has been added to the Speed Control screen – this is the screen where a user is expected to be when performing the test. When the DI or checkbox is TRUE the information will be visible. The LED will turn ON when the test mode is active.

See Chapter 5 of this manual for a complete Overspeed Test Procedure. All pertinent overspeed test parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

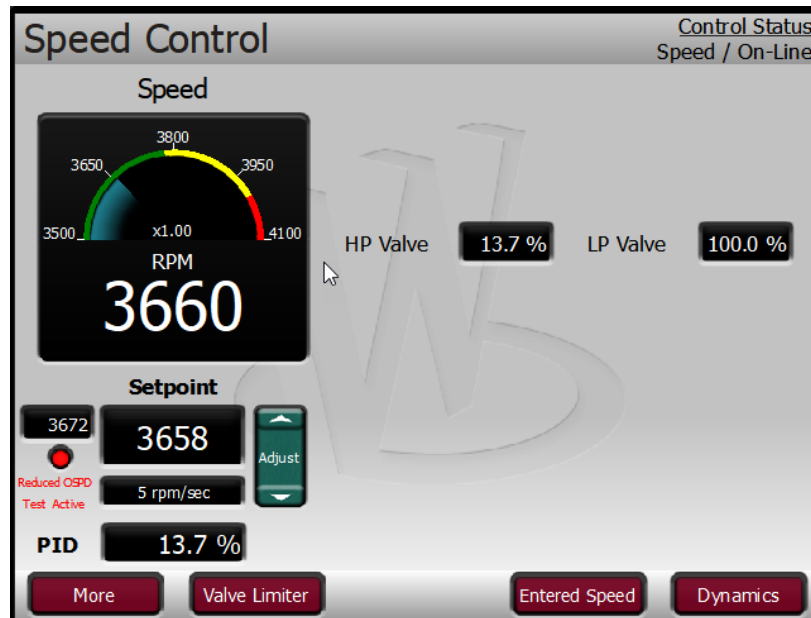


Figure 3-34. Reduced Overspeed Test from Speed Control Screen

Local/Remote Function

The 505's local/remote function allows an operator at the turbine skid or 505 to disable any remote command (from a remote Control Room) that may put the system in an unsafe condition. This function is typically used during a system start-up, overspeed test, or shutdown to allow only one operator to manipulate the 505 control modes and settings.

The local/remote function must first be programmed before a Local or Remote mode can be selected by an operator. This function can be programmed under the OPERATING PARAMETERS BLOCK. If this function is not programmed, all contact inputs and Modbus commands (when Modbus is programmed) are active at all times. If the local/remote function is programmed, local, and remote modes can be selected through a programmed contact input, or Modbus command.

When Local mode is selected, the 505 is defaulted to be operable from its front panel only. This mode disables all contact inputs and Modbus commands, with exceptions noted in Table 3-8 below:

Table 3-8. Exceptions to Local Mode Contact Input and Modbus Command Disabled

External trip Contact In	(defaulted in program)
External trip 2 Contact In	(active at all times, if programmed)
External trip 3 Contact In	(active at all times, if programmed)
External trip 4 Contact In	(active at all times, if programmed)
External trip 5 Contact In	(active at all times, if programmed)
External trip 6 Contact In	(active at all times, if programmed)
External trip 7 Contact In	(active at all times, if programmed)
External trip 8 Contact In	(active at all times, if programmed)
External trip 9 Contact In	(active at all times, if programmed)
External trip 10 Contact In	(active at all times, if programmed)
External trip 11 Contact In	(active at all times, if programmed)
External trip 12 Contact In	(active at all times, if programmed)
External trip 13 Contact In	(active at all times, if programmed)
External trip 14 Contact In	(active at all times, if programmed)
External trip 15 Contact In	(active at all times, if programmed)
External alarm 1 Contact In	(active at all times, if programmed)
External alarm 2 Contact In	(active at all times, if programmed)
External alarm 3 Contact In	(active at all times, if programmed)
External alarm 4 Contact In	(active at all times, if programmed)
External alarm 5 Contact In	(active at all times, if programmed)
External alarm 6 Contact In	(active at all times, if programmed)
External alarm 7 Contact In	(active at all times, if programmed)
External alarm 8 Contact In	(active at all times, if programmed)
External alarm 9 Contact In	(active at all times, if programmed)
External alarm 10 Contact In	(active at all times, if programmed)
External alarm 11 Contact In	(active at all times, if programmed)
External alarm 12 Contact In	(active at all times, if programmed)
External alarm 13 Contact In	(active at all times, if programmed)
External alarm 14 Contact In	(active at all times, if programmed)
External alarm 15 Contact In	(active at all times, if programmed)
Override MPU Fault Contact In	(active at all times, if programmed)
Frequency Arm/Disarm	(active at all times, if programmed)
Generator breaker Contact In	(active at all times, if programmed)
Utility tiebreaker Contact In	(active at all times, if programmed)
Start permissive Contact In	(active at all times, if programmed)
Switched dynamics Contact In	(active at all times, if programmed)
Select In-Control Unit Contact In	(active at all times, if programmed)
Local/Remote Contact In	(active at all times, if programmed)
Modbus Commands	(can be active in Local with Service setting)

NOTICE

For users familiar with the previous 505 version with 2-line displays, this feature is slightly different. In this 505 model, Modbus commands are inhibited when in local mode unless the “Enable When Local” Service settings is selected. This is available for each Modbus link. Note that the trip command and “Local/Remote” command are no longer exceptions to this rule. All addresses for the link will be considered either Local or Remote commands.

When the Remote mode is selected, the 505 can be operated through its front panel, contact inputs, and/or all Modbus commands.

When using a contact input to select between Local and Remote modes, a closed contact input selects the Remote mode, and an open contact input selects the Local mode.

Optionally a relay can be programmed to indicate when Local mode is selected (energizes when the Local mode is selected). There is also indication of the Local/Remote mode selection through Modbus (address = true when the Remote mode is selected and false = when the Local mode is selected).

The 505 is defaulted to only allow control operation through its front panel when the Local mode is selected. If desired, this defaulted functionality can be changed through the 505's Service mode. The 505 can be modified to also allow operation through contacts inputs, or Modbus port #1 or Modbus port #2 when the Local mode is selected.

All pertinent local/remote control parameters are available through the Modbus links. See Chapter 6 for a complete listing of all Modbus parameters.

Relays

The 505 has eight relay outputs available. The first of these relays is dedicated for a system shutdown command from the 505. The second relay is fully configurable but is defaulted for an alarm indication. The other six relays can be programmed for a variety of indications, and system functions.

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

The dedicated alarm relay is normally de-energized. This relay will energize upon an alarm condition and stay energized until the alarm condition is cleared. Optionally this relay can be configured through the 505's Service mode to toggle on and off repeatedly when alarm conditions has occurred. With this configuration if a reset command is given and the alarm condition still exists, the relay will stop toggling and stay energized. The relay will start toggling again, upon a new alarm condition. This option can be used to inform the operator when another alarm condition has occurred.

Any of the configurable relays can be programmed to function as a level switch or mode indication. 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).

Relay Functional Clarifications

The Shutdown Condition relay may be programmed to indicate a shutdown condition on a remote panel or to a plant DCS. The Shutdown Indication relay is normally de-energized. This relay will energize upon any shutdown condition and stay energized until all trips have been cleared. The 'RESET CLEARs TRIP' function has no effect on the programmable Shutdown Indication relay.

When programmed as a Trip relay, the respective relay will function like the dedicated "Shutdown" relay (normally energized and de-energizes on a shutdown) to indicate the position of the dedicated Shutdown relay. This relay output can be programmed to indicate a 505 initiated trip by setting the 'Ext trips in Trip Relay' option to NO. Using this option, 505 trip annunciation will only occur if the 505 tripped the turbine and not annunciate when the other external devices shut down the unit (external trips).

The alarm condition relay may be programmed to indicate an alarm condition on a remote control panel or to a DCS. The alarm indication relay is normally de-energized. This relay will energize upon any alarm condition and stay energized until all alarms have been cleared. If the 'BLINK ALARMS' option is 'YES', the programmable alarm condition relay will toggle on and off repeatedly when an alarm condition has occurred. With this configuration if a reset command is given and the alarm condition still exists, the relay will stop toggling and stay energized.

The 505 Control Status OK relay is normally energized and will only de-energize if unit inlet power is lost, the 505's CPU fails, or the 505 is in the Configuration mode.

The Overspeed Test Enable relay will energize when an Overspeed Test is performed. This relay functions like the 505 OSPD key's LED (it repeatedly toggles on and off when turbine speed is above the turbine Overspeed trip setting).

An underspeed switch function can be programmed to indicate a turbine underspeed or overpower condition. If the underspeed option is configured, once turbine speed reaches a level above the minimum governor speed setting, then decreases 100 rpm below the minimum governor speed setting, the respective relay energizes (indicating an underspeed condition). The 'underspeed setting' is adjustable through the Service mode, under the 'Speed Values' header.

When the sync enabled function is programmed, the assigned relay energizes when a synchronize command is given. After the unit generator or utility tie breaker is closed this function becomes disabled and the relay de-energizes. The 505's synchronization function can be used to synchronize across a generator breaker or utility tie breaker.

When the sync or load share active function is programmed, the assigned relay energizes when a synchronizing or load sharing is active. When both the generator and utility tie breaker inputs are closed (Load Sharing not selected) this function becomes disabled and the relay de-energizes.

When the Modbus Command function is programmed, the assigned relay energizes when the respective Modbus command "Turn On Modbus Relay X" is issued, then de-energizes when the respective Modbus command "Turn Off Modbus Relay X" is issued. This feature allows a 505 relay to be driven directly from Modbus to control a system related function (synchronizing). In addition, the assigned relay can be momentarily energized using the Modbus command "Momentarily Energize Modbus Relay X" is issued (voltage raise/lower commands). Refer to Chapter 6 of this manual for more information on Modbus commands.

Turbine Shutdown Warmup Function

Shutdown Warm-up Function (with no interfacing to the TTV)

This logic allows operators to access the valve ramp functions for both the HP and the LP valves to OPEN them while the turbine is shutdown. This allows operators to open these valves to provide a more even warmup of the turbine prior to starting. This is optional and is intended for units that have a warmup valve or other means to admit a small volume of steam into the steam turbine for heating up the steam chest prior to starting. The typical use of this option would be to provide some initial warmup of the steam turbine while the unit is on turning gear, prior to starting the turbine. If the 505 is configured to have direct I/O interfacing to open the Trip & Throttle (T&T) Valve, then this function will be inhibited (it is okay to have position and/or limit switch feedback, just not output demand to open the TTV). To perform a warmup with a configuration that has direct interfacing to open the TTV, refer to that section in this manual on using the Pre-start Warmup feature.



WARNING

Start-up

This mode allows the operator to manually open the steam turbine control valves while the control is in a shutdown state. It is the operator's responsibility to be certain that only a small volume of steam is admitted into the turbine to warm it up to the desired temperature.

There is an option in the Configuration/Turbine Start screen to allow this function to be available. If the control is configured to allow this option, and the operator desires to enable this function, it will require that the control is in a Shutdown state and that no speed is detected. This function is only permitted if the 505 has no configuration that allows it to control the opening of the trip and throttle valve.

When the function is enabled, the operator will be allowed to ramp open the HP and/or LP valves to any desired setting at the valve limiter rate available in Service. If any of the following actions occur this mode will be disabled and the HP and LP valves will immediately step to zero demand.

Any speed detected 20 rpm above the user Warmup Speed Limit setting will immediately deactivate this function and step the valve demands to 0%

If a Reset is issued that clears the Shutdown/TRIP latch – that will immediately deactivate this function and step the valve demands to 0%

- If the Warmup mode is disabled, that will immediately deactivate this function and step the valve demands to 0% (To avoid this step response, the operator should lower the valves manually prior to disabling the shutdown warmup mode)

Configuration requirements for Shutdown Warm-up option

- If the 505 is configured with no demand signals to the Trip & Throttle Valve (TTV), then the 505 must be in a Shutdown State (TRIP present) to enter this mode

(Located in Configure menus on the 'Turbine Start' page)

- Allow Shutdown Warm-up Mode? Checkbox (CNFG_START.QT_USE_SD_WARM)

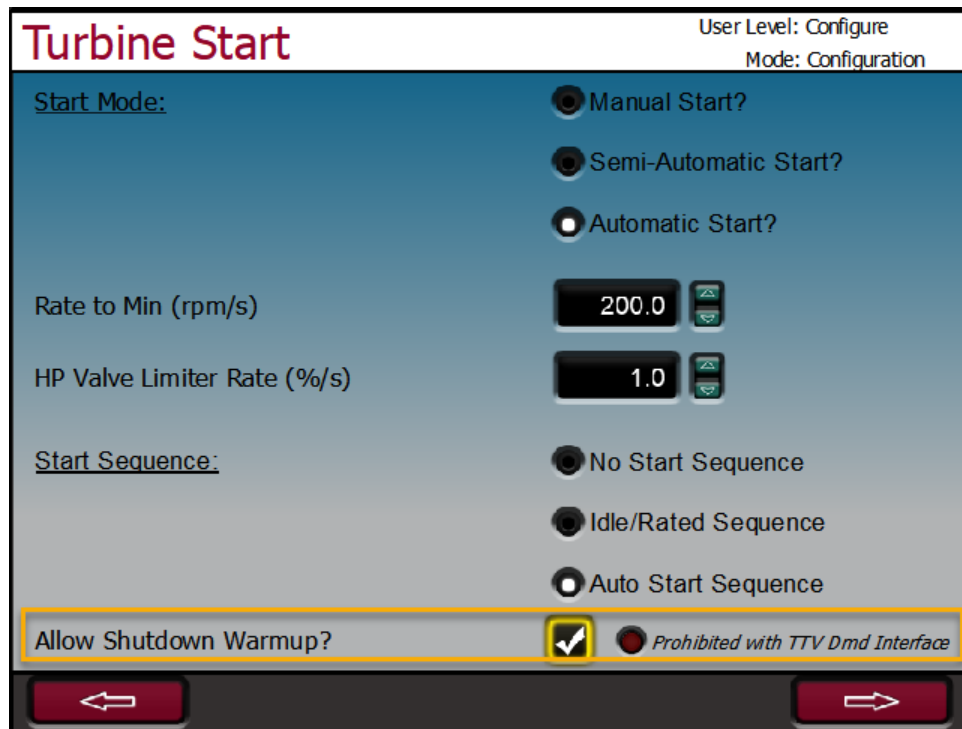


Figure 3-35. Configure Menu – Turbine Start screen

Operation Screens: (Valve Demand and Overview)

Permissives for Shutdown Warm-up (LED) to be ACTIVE/ON:

- Unit is configured for this option
- Unit is in a SHUTDOWN state
- Speed is below the Warmup Speed Limit (adjustable setting in a pop-up screen)
- Operator has Enabled shutdown warm-up mode

To enable the Shutdown Warmup, press the Enable SDW command button from the Valve Demand screen, or alternatively a DI can be configured to enable the Warmup mode (the same DI configuration is used to enable the Shutdown warmup or the Pre-Start warmup modes).

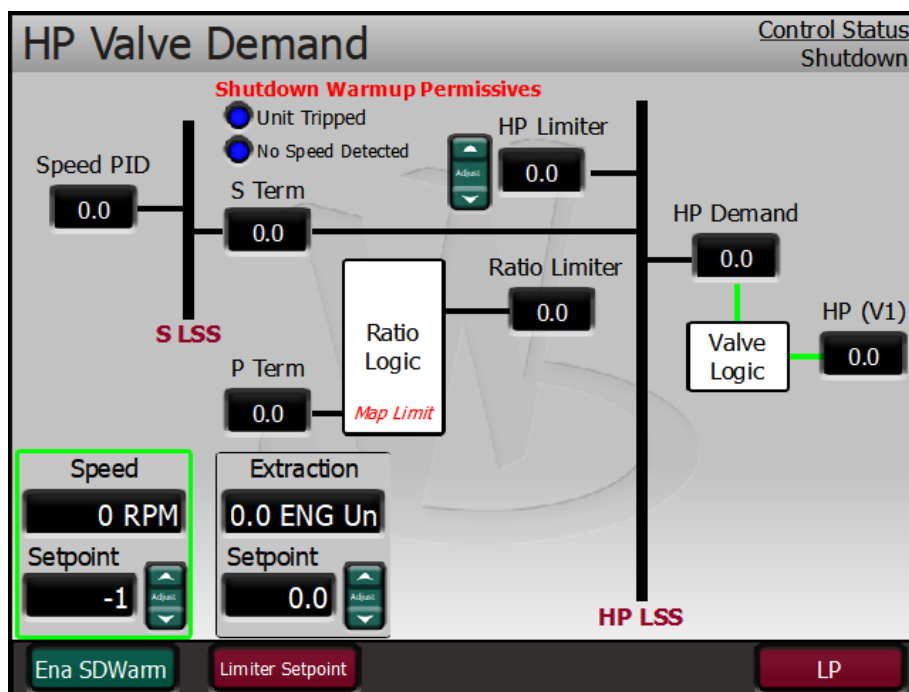


Figure 3-36. Valve Demand Page with SDW Configured but Not Enabled

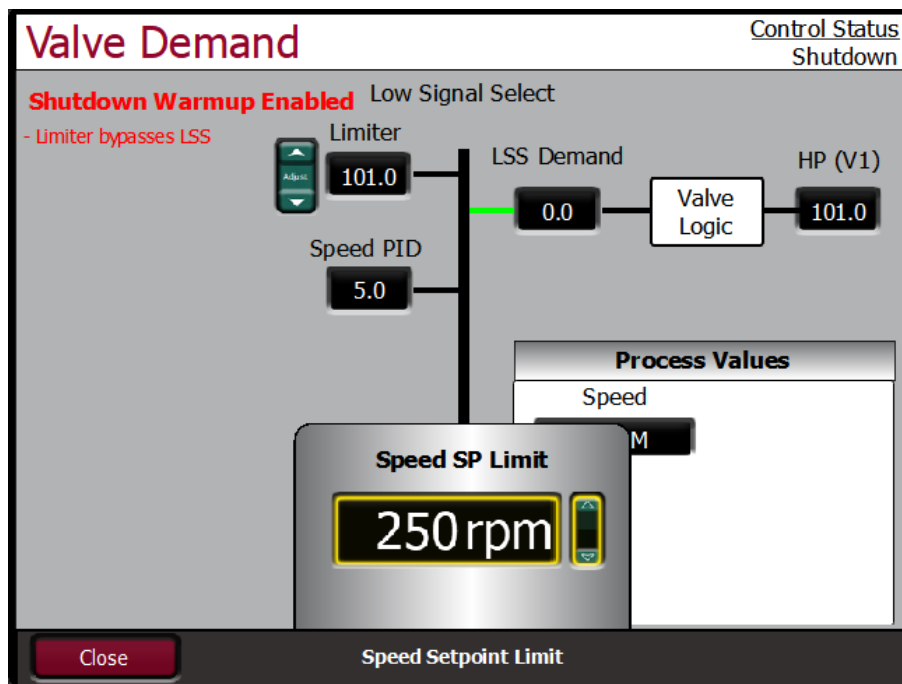


Figure 3-37. Valve Demand Page with Shutdown Warmup (SDW) Enabled

Once the SDW is enabled the message “Shutdown Warmup Enabled” will appear on the Valve Demand and Overview screens. The Valve Demand page will also then allow access to a Warmup speed limit setpoint popup window. Use this to set the upper limit of speed allowed while in this mode (it cannot be higher than MinGov setpoint). In this state the operator can manually use the valve limiter functions on both the HP and LP (if configured for use) valves to ramp the valves open to any desired position. The valves will ramp at the valve limiter rate found in Service settings for each valve. When the SDW function is disabled by the user, if the Shutdown/Trip condition is cleared, or if speed is detected while this function

is active the valves will step closed to 0% demand. It is recommended that the operator lower the HP and LP valves to zero prior to disabling the Shutdown Warmup Mode.

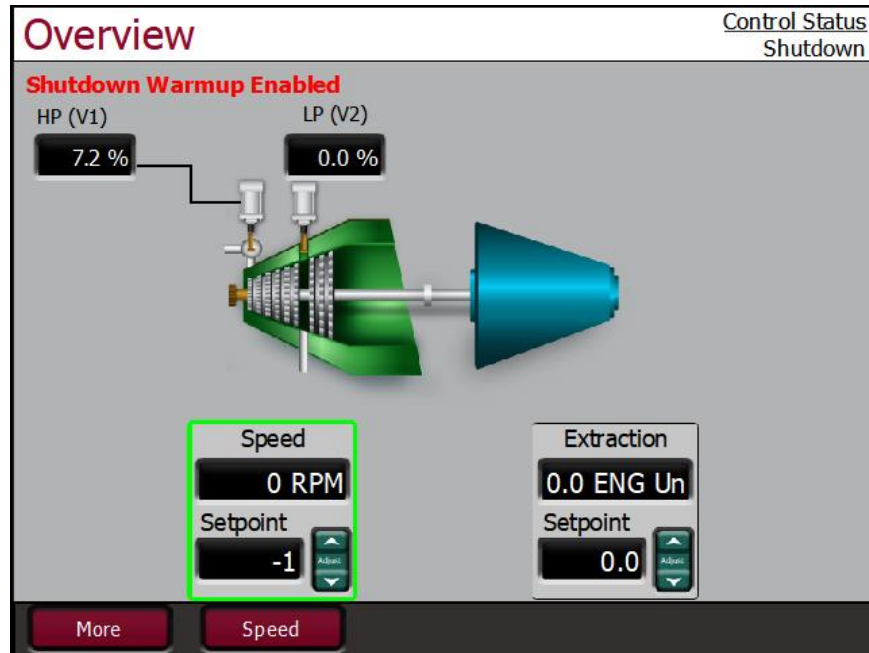


Figure 3-38. Overview Page with Caution Message when SDW is Enabled

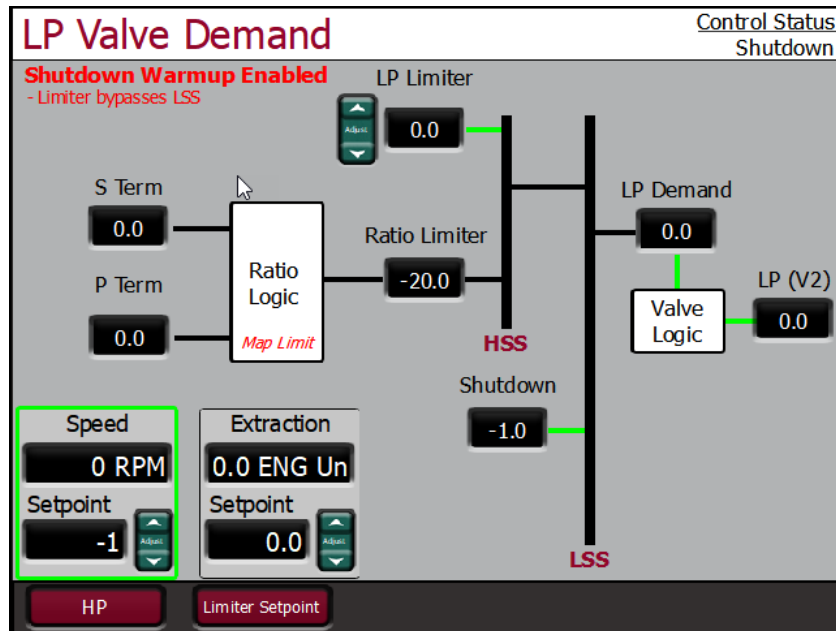


Figure 3-39. LP Valve Demand Page with Shutdown Warmup Enabled

Trip & Throttle Valve Interface & Functions

Overview –

The latest application software update to the 505XT includes options to interface directly with the steam turbine Trip and Throttle Valve (TTV). The primary intent of this feature is to support turbine startup procedures (the **Throttling** function of the TTV) and provide the user with status information about the Trip and Throttle Valve (TTV). These interfaces are **not intended to change the ‘TRIP’ command functions of the TTV**, those are typically a Safety Logic Solver device such as a Woodward Protech or a Critical Path/Trip relay string.

The following functions of TTV control are available, depending on the type of TTV being used and the interfaces selected:

1. Opening the TTV for Pre-Start Warmup (PSW)
2. Manually opening the TTV to reach HP valve control
3. Perform a Partial Stroke Test (PST) while the turbine is running
4. Start the turbine on TTV control (closed loop speed control – Full Arc Start)

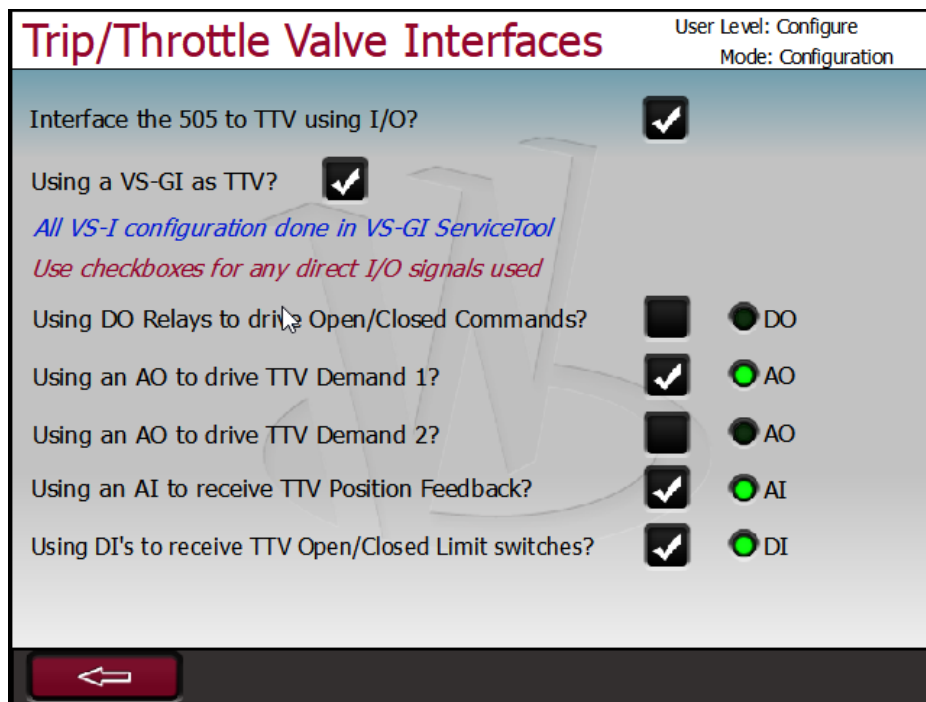


Figure 3-40. Configuration of TTV interface signals

Interface Signals Available

The 505 first requires the user to confirm if any I/O signals are directly connected to the TTV. This must be checked for the 505 to enable any of the features below. It also confirms if the TTV is a Woodward VariStroke – GI. The 505 will only allow the selection of a Full arc start if the TTV is a VS-GI. After these selections, the following 505 I/O signals are supported.

- Configure relay outputs to drive open and close commands to the TTV
- Configure 1 or 2 analog outputs to drive 4-20ma demand inputs into a TTV
- Configure an analog input to receive the TTV position feedback
- Configure discrete inputs to receive open and closed limit switches

Trip and Throttle Operational Functions

1) Support of a Pre-Start Warmup (PSW) Mode –

Required Interfaces:

- Demand output signal (AO or Raise/Lower Relays)

This feature is intended as a Pre-Start (non-rotating) Warmup routine. It will allow the operator to position the HP and LP valves to any position (usually 100% for warmup). The operator can then allow a small amount of steam into the turbine to perform the warmup. This may be a bypass valve or just opening the TTV a small amount. The practicality of using this option depend on the capability and the type of TTV system.

This routine will not require that the turbine remain at zero speed, during this mode the Speed PID will remain active with the speed setpoint at the 'Failed speed sensor level setting' to provide protection against the turbine acceleration past this setting. If the speed remains below this setpoint, the HP valve demand will go to the HP valve limiter value and the turbine can be heated. If when opening the TTV, the speed goes above this setting, then the Speed PID will pull back or limit the HP demand to prevent the turbine from accelerating.

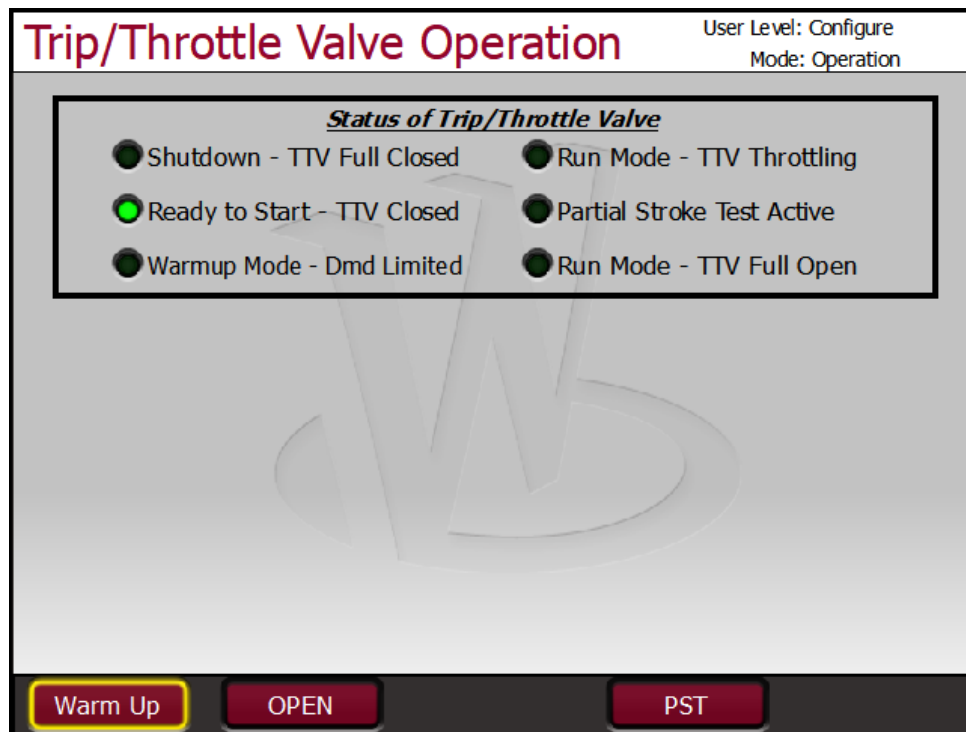


Figure 3-41. Trip & Throttle Valve Operation Page

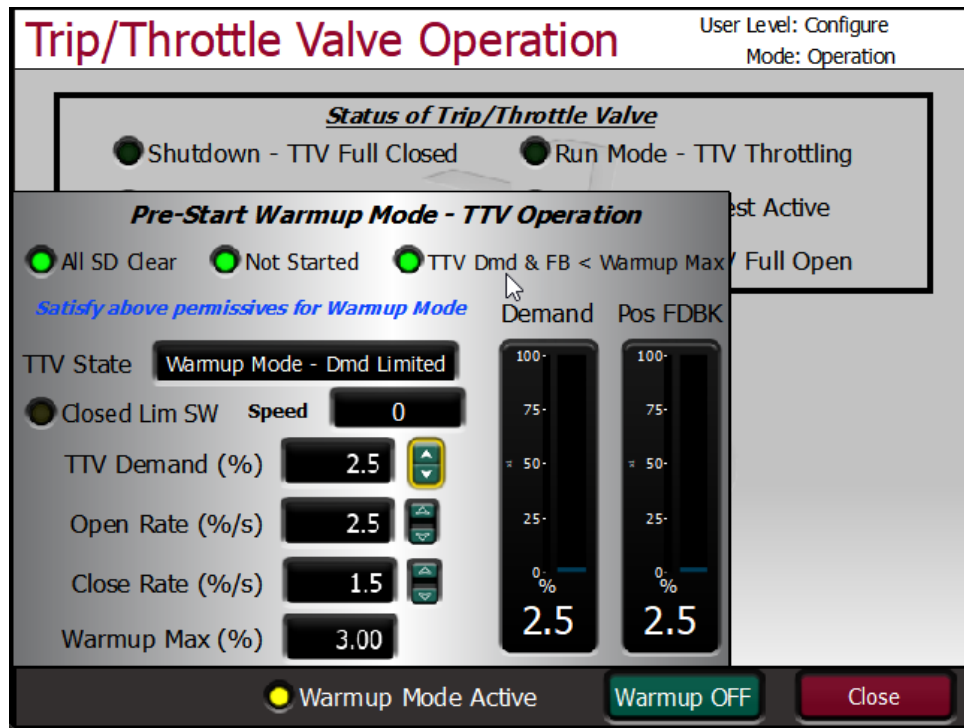


Figure 3-42. Pre-Start Warmup Page

The permissives to enter the Pre-Start warmup mode are shown with LED status at the top of the Warmup screen.

- All Shutdowns must be clear
- Unit has not received a turbine start command
- The TTV valve demand & Position feedback (if used) is less than the Warmup Max value (Max value must be set while control is in Shutdown, prior to entering this mode)

Steps to use this function:

- To enable this mode, the 505 must have all shutdowns clear, not been given a Start command, and the TTV demand must be below the Warmup Maximum demand percentage setting. (Typically the control status is at "Ready to Start")
- From the TTV operation screen open the Warmup popup screen and click the Warmup ON button, or use a DI (configured for "Enable Pre-Start/SD Warmup") or a Modbus command
- From this screen the TTV can be opened to any demand up to the warmup maximum limit setting
- Go to the Valve Demand operation screen and open the HP and LP valves to begin admitting steam and warming up the turbine. As long as the TTV is not delivering too much steam to accelerate the turbine, the HP valve can be open to 100%.
- If the steam flow through the TTV accelerates the turbine above the 'Failed speed sensor level setting', the speed PID will reduce the HP demand to prevent the speed from continuing to accelerate
- Once the turbine warmup is complete, the pre-start warmup mode MUST be disabled before the control will allow a turbine start. Disabling the warmup mode will instantly step the HP valve demand to 0%.
- If it is desired to start the unit from this point (without closing the TTV), there is a 10 second window from the time the warmup mode is deactivated until the TTV is stepped to the fully closed position. Issuing a start within this window will cancel that step.

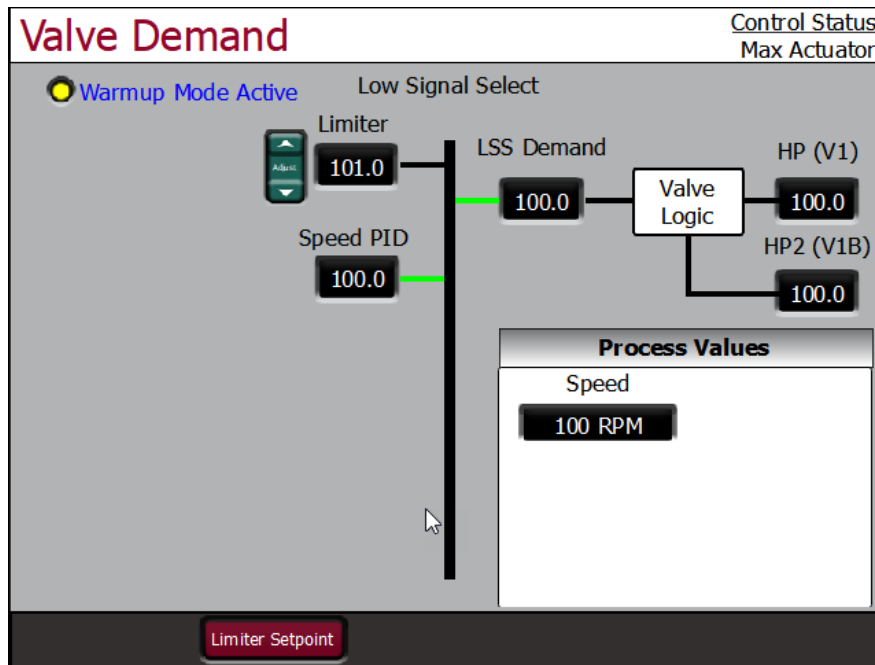


Figure 3-43. HP Valve Demand Screen During Pre-Start Warmup

While the control is in this Pre-Start Warmup mode the following conditions and actions are enabled:

- The Speed PID shall remain active with the setpoint being equal to the 'Failed Speed Level' setting of the speed sensors, this shall prevent the unit from accelerating above that limit.
- An ALARM shall be initiated if the speed ever exceeds the failed speed setting
- A TRIP shall be initiated if the speed ever exceeds the Minimum Governor speed setpoint
- When in Warmup mode the operator shall have the ability to adjust the open and close rates of the TTV valve.

When the Pre-Start Warmup mode is disabled, the following actions will take place:

- The V1 (HP) valve demand shall step to 0%
- The V2 (LP) valve demand shall step to 0%, if the turbine type is an Admission or Extraction/Admission
- The control shall hold the TTV at the current demand for the 'Warmup Start Delay setting' (default of 10 seconds), and if no Start command is received within this time, it will step the TTV demand to zero.
- if a Start command is issued within the 'Warmup Start Delay setting' (default of 10 seconds), the control shall initiate a start with the TTV valve at its present demanded position. The operator shall have to manually raise the TTV from this value to the full open position.

2) Manually Opening of TTV Valve to Reach HP Valve Control –

Required Interfaces:

- Demand output signal (AO or Raise/Lower Relays)

The 505 will support manually opening the TTV to allow the HP Inlet Valve (a.k.a. the Governor Valve) to take over speed control of the turbine. This allows operators to be located safely away from the unit when starting the turbine. The operator can control the analog output demand signal or the relay output open/close commands from the GUI either locally or remotely. If the relay outputs are used, then the open/closed commands can also be issued via Modbus. The user configurable open and close ramp rates apply to both the AO and DO demand outputs.

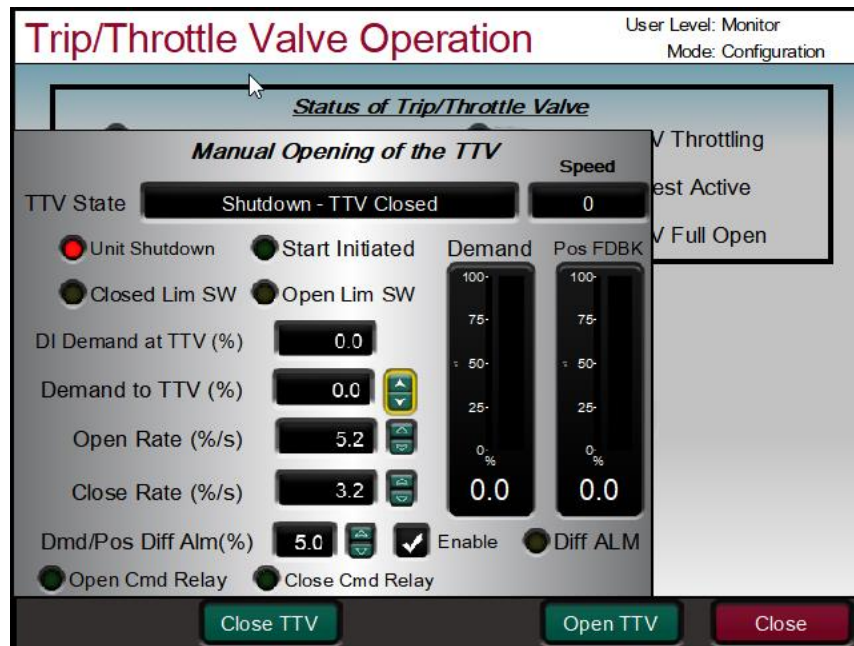


Figure 3-44. Open TTV Page – Unit Shutdown (all options enabled)

If the 505 is configured to have both analog demand and position feedback signals, then the control will provide an optional alarm to annunciate if the demand and position feedback exceed a difference tolerance setting defined by the user (default of 5%). If this alarm is enabled, the 'open' command will be inhibited anytime this alarm is active. Lower the command or disable the alarm and issue a reset to re-enable the open command.

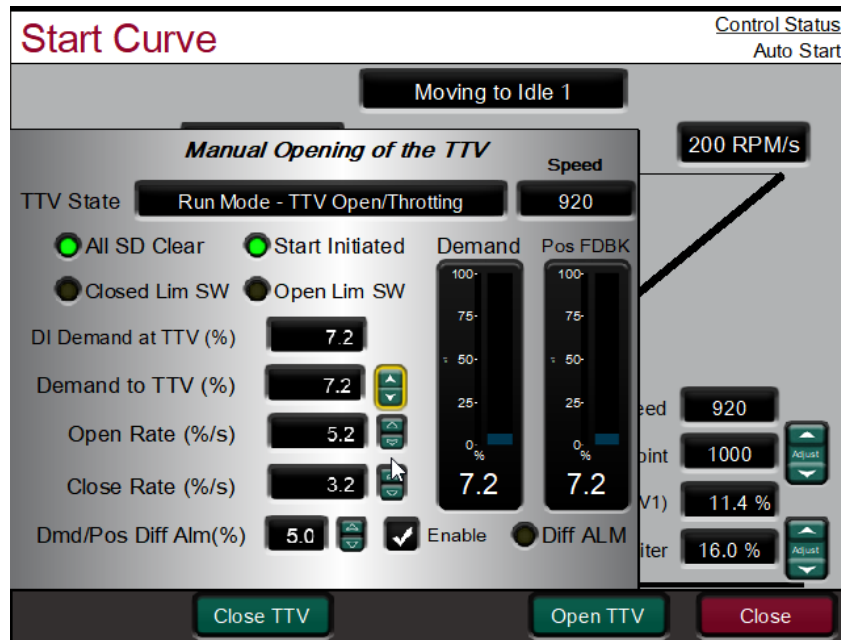


Figure 3-45. Open TTV Page – Throttling

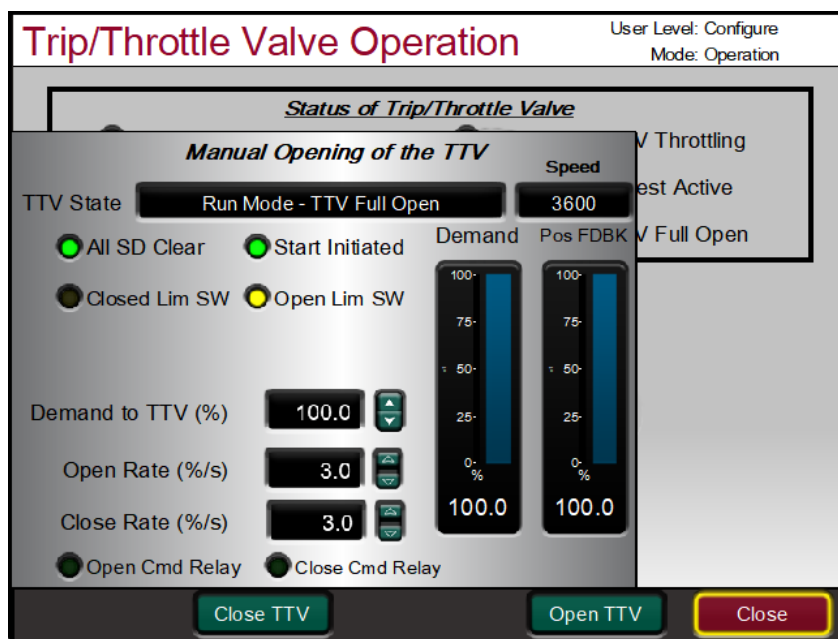


Figure 3-46. Open TTV Page – Full Open

The Open TTV screen is a pop-up screen that is available from the TTV operation screen or the Start Curve page. Since this is a popup screen, the background screen will also show live data. During a startup, this screen can be accessed from the Start Curve screen, so that the speed, speed setpoint, V1 demand, and valve limiter values can be seen in the background.

3) Support of Partial Stroke Testing (PST) of the TTV Valve –

Required Interfaces:

- Analog Demand output signal
- Feedback signal (AI position feedback or Open Limit switch feedback)

If the above interfacing to TTV is enabled, then the 505 shall provide an option for performing a Partial Stroke Test (PST) of the TTV on a running unit. The feature below is handled by the 505 and is independent of the TTV valve used, it only requires that a TTV demand signal and the TTV valve position feedback are available. If discrete relay outputs are configured on the 505 to provide open/close commands to a VS-GI, then those commands can be used to activate the partial stroke test that is built into the VariStroke.

The PST allows the user to ramp the TTV closed at a configured rate to a target demand setting, hold it there and then ramp the valve back to full open. The lower target limit for the test is determined by the PST Demand percentage which is configured by the user. This value is also the lower threshold to allow a PST to be performed. Below this demand value all the action buttons on the PST pop-up screen will be inhibited.

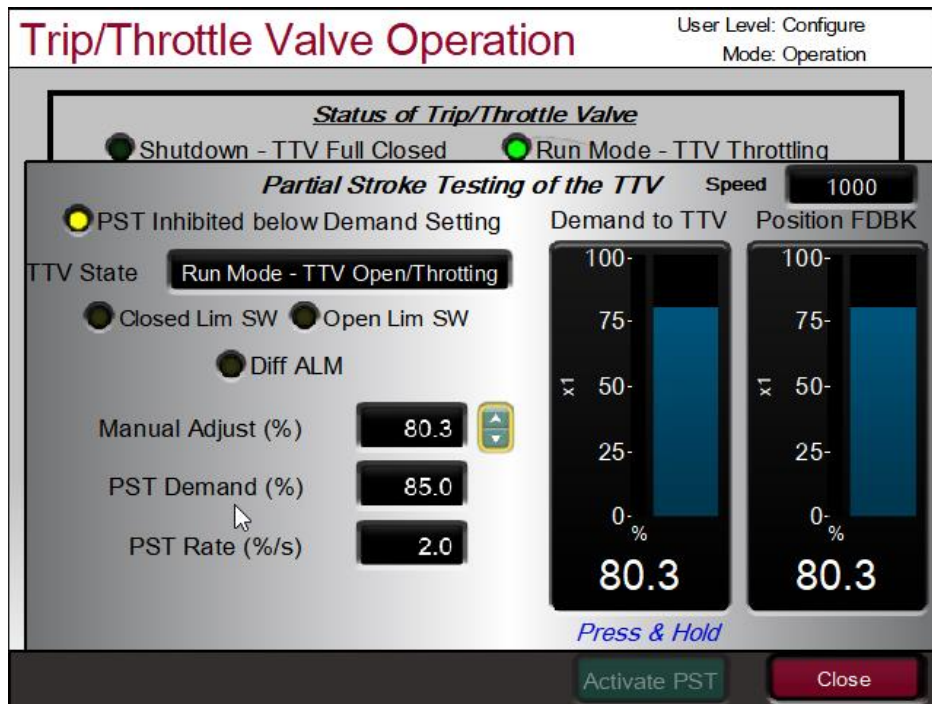


Figure 3-47. Partial Stroke Test Page - Shown Inhibited

Once the TTV is fully opened (typically to 100%), this procedure can be used to exercise the valve to verify it is operating correctly. The test is performed by pressing and holding down the momentary Activate PST button. While it is held down the TTV will ramp down to the PST demand percentage and hold there until the button is released. Anytime the button is released the TTV will ramp at the same rate, back up to 100% open.

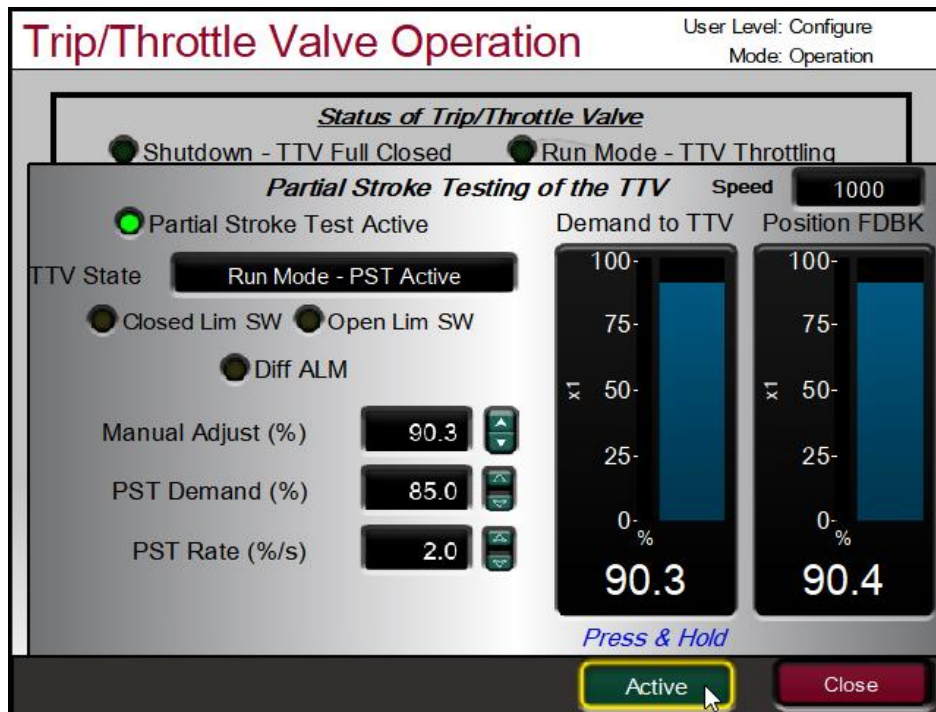


Figure 3-48. Partial Stroke Test Page - Shown Active

4) Starting and Speed Control on the TTV (Full Arc)

This will be available at a future application software release.

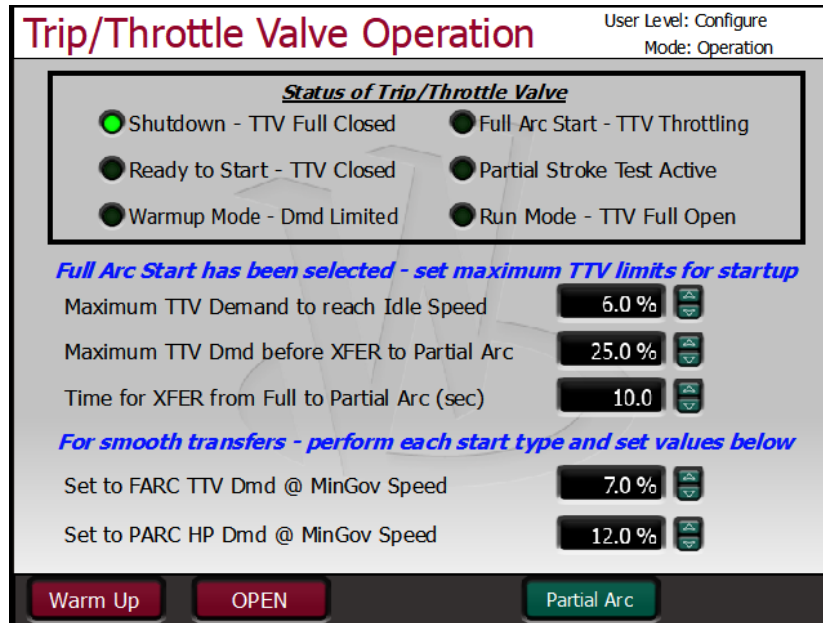


Figure 3-49. TTV Operational Status Screen

Commissioning Notes

- Be sure that the independent overspeed system is enabled and functioning properly prior to commissioning the 505 with demand interfaces to the TTV.
- The 505 datalog feature and live trending using control assistant, are very useful tools in capturing data and verifying the performance of the startup sequence. For control assistant trending, the table below shows some useful parameters:

Table 3-9. GAP Variables Useful for Control Assistant Trending

GAP Parameter	Description	Units
IFACE_OUT_VLV.HP_DMD.A_NAME	HP valve DMD for Single Coil or Redund Act	Percent
IFACE_OUT_VLV.HP_DMD_COIL_A.A_NAME	HP valve DMD for Coil A (Dual Coil)	Percent
IFACE_OUT_VLV.HP_DMD_COIL_B.A_NAME	HP valve DMD for Coil b (Dual Coil)	Percent
IFACE_OUT_VLV.LP_DMD.A_NAME	LP valve DMD for Single Coil or Redund Act	Percent
IFACE_OUT_VLV.LP_DMD_COIL_A.A_NAME	LP valve DMD for Coil A (Dual Coil)	Percent
IFACE_OUT_VLV.LP_DMD_COIL_B.A_NAME	LP valve DMD for Coil b (Dual Coil)	Percent
IFACE_IN_SPEED.SPEED.A_NAME	Turbine Speed	RPM
IFACE_OUT_SPEED.SPEED_REF.A_NAME	Speed Reference Setpoint	RPM
SPD_CTRL.DROOP_VAL.A_SW	Speed Droop Value (converted to rpm)	RPM
IFACE_OUT_SPEED.SPD_PID.A_NAME	Speed PID output	Percent
IFACE_OUT_START.UNIT_STARTED.B_NAME	Turbine Start/Run Command	T/F
SHUTDOWNNS.ANY_SD.B_NAME	Any Shutdowns Present	T/F
IFACE_IN_SPEED.GEN_BRKR.B_NAME	Generator Breaker Closed	T/F

Table 3-9. GAP Variables Useful for Control Assistant Trending (cont'd.)

GAP Parameter	Description	Units
IFACE_IN_SPEED.UTIL_TIE.B_NAME	Utility Tie Closed	T/F
AI_MUX.KW_PV.A_NAME	Generator Load Input	KW or MW
CNFG_TTV.DMD_OUT.A_NAME	Trip & Throttle Valve demand	Percent
IFACE_OUT_VLV.LSS_OUT.A_NAME	Power (S) LSS Bus demand	Percent
IFACE_OUT_VLV.HP_LSS_OUT.A_NAME	Final LSS Bus demand to HP	Percent
IFACE_OUT_AUX.AUX_PID_LSS.A_NAME	Auxiliary Control PID output	Percent
IFACE_OUT_INL.INL_PID_LSS.A_NAME	Inlet Control PID output	Percent
IFACE_OUT_EXH.EXH_PID_LSS.A_NAME	Exhaust Control PID output	Percent
IFACE_OUT_EXT.EXT_PID.A_NAME	Extraction Control PID output	Percent
IFACE_IN_RATIO.S_TERM.A_NAME	Speed demand input to Ratio Limiter	Percent
IFACE_IN_RATIO.P_TERM.A_NAME	Pressure demand input to Ratio Limiter	Percent
IFACE_OUT_RATIO.HP_DMD.A_NAME	Ratio Limiter HP demand output	Percent
IFACE_OUT_RATIO.LP_DMD.A_NAME	Ratio Limiter LP demand output	Percent
IFACE_OUT_VLV.V1LMTR_VAL.A_NAME	V1 (HP) Limiter to LSS	Percent
IFACE_OUT_VLV.LP_LMT.A_NAME	V2 (LP) Limiter to LSS or HSS (based on turbine type)	Percent

Chapter 4.

Configuration Procedures

Program Architecture

The 505XT is easy to configure from the built-in graphical user interface (GUI). When the control is powered up and after the CPU self-test has been completed, the control displays the home screen and the CPU LED on the left side of the front panel should be green. At this point the configuration can be done locally on the display or remotely using the 505RemoteView tool on a user PC. Using the remote tool may be more convenient as you can use a mouse to navigate and the full keyboard to enter data. Refer to the appropriate appendix in Volume 2 for installing and using 505RemoteView.

The operating procedures are divided into two sections: the Configuration Mode, discussed in this chapter, and the Run Modes (Operation and Calibration) (refer to Chapter 5 for RUN Mode information). The Configure Mode is used to configure the 505 for the specific application and set all operating parameters. The Run Mode is the normal turbine operation mode and is used to view operating parameters and run the turbine.

The configuration cannot be changed or altered while the turbine is running; however, it can be accessed and all programmed values monitored. This minimizes the possibility of introducing step disturbances into the system. To monitor or review the program while in the run mode, enter the Configuration menu from the first (leftmost) soft key on the Home screen.

Display Modes and User Levels

The 505 Display operates in several modes and access user levels, each of which has a different purpose. The modes are OPERATION, CALIBRATION, and CONFIGURATION. In order to enter and exit a particular mode, the user must be logged in with an appropriate user level. These user levels are MONITOR, OPERATOR, SERVICE, and CONFIGURE. In addition to granting authority to enter and exit modes, user levels also determine what parameters the user is authorized to adjust. See Table 4-1, Mode Access by User Level.

Table 4-1. Mode Access by User Level

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

Mode Descriptions

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

The CALIBRATION mode is used to force signal outputs to calibrate signals and field devices. In this mode, the actuator, analog, and relay outputs can be manually controlled. To enter this mode the turbine speed must be shutdown with no speed detected. User levels: Service or Configure.

The CONFIGURE mode is used to set up the parameters for a specific application prior to operation of the unit. To enter this mode the turbine speed must be shutdown with no speed detected. When the unit enters CONFIGURE mode the control is placed in IOLOCK which will disable all output I/O channels. If the control is not shutdown, navigating through the configuration pages will allow viewing of CONFIGURE, but will not permit any changes to be made.

User Level Descriptions

The Monitor user level is view-only access. All commands from the front panel are inhibited. All values displayed on each screen are continuously updated.

The Operator user level allows for control of the turbine. Front panel commands to start, change setpoints, enable/disable functions, and stop the turbine are accepted.

The Service user level allows the same commands as the Operator user level plus tuning of Service menu parameters and issuing of additional commands.

The Configure user level allows the same commands and access as the Service user level plus tuning of Configuration menu parameters.

Configuring the 505XT

Before the 505XT can be used to operate any turbine, it must be configured with a valid configuration. A 505XT Configure Mode Worksheet is provided in Appendix A of this manual. This chapter contains additional information related to completing this worksheet and configuring the specific application. Recommended completing this worksheet, documenting your specific configuration.

It is also possible to configure a unit by loading the configuration (tunable) file from another unit. This is the recommended method for configuring a spare unit. Refer to the appropriate appendix in Volume 2 for installing and using the Control Assistant service tool. It will describe how to retrieve and send these files to and from the control.

Figure 4-1 illustrates the 505 screen displayed when power is first applied, and the unit is not configured. This is the HOME screen. It includes tips on how to enter the Configure Mode from this point. A password is required to protect against both intentional and inadvertent configuration changes. The password can be changed if desired, refer to Volume 2 for information on changing passwords. This screen will become the main menu once the unit is configured. From this HOME screen, operational screens as well as the Service and Configure menus can be accessed.



Figure 4-1. Initial HOME Screen (Unit Not Configured)

Use the following procedure to begin configuring the 505XT:

1. Press the MODE key.
2. Press the LOGIN softkey to open the User Login popup.
3. Login to the 'Configure' user level.
4. Close the User Login popup screen.
5. Press the Configuration softkey to enter configuration mode. Verify that the following Calibration and Configuration Mode Permissives are met:
 - a. Unit Shutdown
 - b. No Speed Detected
 - c. "Configure" User Level or greater is logged in
6. Press MODE or HOME to return to the HOME screen.
7. Press the Configuration softkey to access the configuration menus.
8. Using the navigation cross, navigate up/down/left/right and use ENTER to select a menu or item.

The 505 configure mode may be accessed if the unit is in a Shutdown state, no speed is detected, and the correct user level is logged in (Configure or higher). For safety reasons the configuration may be monitored only, and no changes will be accepted if the turbine is running. By pressing the MODE key, pressing the soft key for LOGIN, and logging in as the "Configure" user level by entering the password (wg1113). Select a field using the navigation cross arrows and then press ENTER to enter text. When finished, press ENTER again.

All configuration values and saved service mode changes are stored as a file on the 505 control. To ensure that values are saved, exit Configure mode or select 'Save Settings' from the MODE screen. If power is removed from the 505 all saved values will return once power is restored. No batteries or back up power is required.

NOTICE

The field-configured portion of the configuration settings will be zeroed out after factory repair. You must reconfigure these values before the unit is put back into service.

Using Configure Menus

Once the Configure Mode has been entered with the password, the specific application information must be entered into the 505. To access the configure menu, select the 'Configuration' softkey from the HOME screen.

The navigation arrow keys (red navigation cross keypad; up, down, left, and right) are used for navigation of the Configure menus. Press ENTER to go into a menu. Then use the navigation cross to move up or down (left/right, if needed) in the menu. In the Configuration mode, the control will generate an error message shown on the Configuration menu home screen as well as the MODE screen if an invalid configuration exists. A configuration error will cause the control to remain tripped. It is possible to exit Configuration mode with such an error, but the control will be tripped until the Configuration mode is entered again and the Configuration error is corrected.

See the Tutorial to learn how to adjust a value. The tutorial can be accessed from the HOME screen by pressing the Tutorial softkey before the unit is configured or from the Service menu any time.

To return to the previous screen, press the ESC key. While in a Configure menu, to return to the main Configure menu screen, press the HOME key. To return to the main Home screen, press the HOME key again. To exit the Configure mode, go to the MODE screen, and select the 'Exit Configuration' soft key. This will save values, exit I/O Lock, and reboots the 505.

Configure Menus

To program the control, navigate through the menus and configure the control features for the desired application. The first four configure menus listed below, as well as drivers and other I/O, must be programmed for every installation. The remaining menus contain optional features which can be selected if desired. The configure menus and their basic functions are described below.

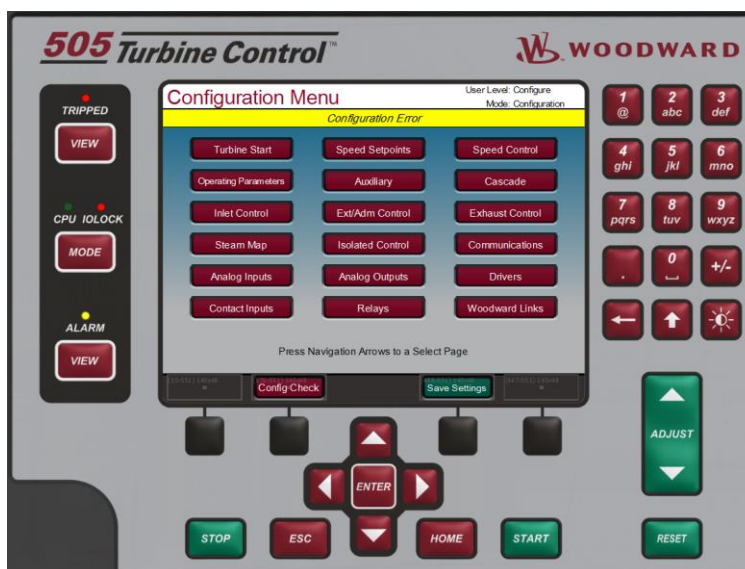


Figure 4-2. Configuration Menu – Configuration Mode (Edit)

Table 4-2. Configuration Menu Commands

Turbine Start	Configure start mode, idle/rated, and auto start sequence settings
Speed Set Point Values	Configure speed set points, overspeed trip set point, remote speed setting control and critical speed avoidance bands
Speed Control	Configure MPU or PROX PROBE information and speed control dynamics settings
Operating Parameters	Configure the unit for generator application, feed-forward and to use the local/remote function
Auxiliary Control	Configure auxiliary control information
Cascade Control	Configure pressure, temperature control information
Inlet Control	Configure Inlet steam pressure control information
Ext/Adm Control	Configure Extraction/Admission control information
Exhaust Control	Configure Exhaust steam pressure control information
Steam Map	Configure steam turbine performance map information
Isolated Control	Configure isolated PID control information
Communications	Configure Modbus communication options
Analog Inputs	Configure analog input options
Analog Outputs (Readouts)	Configure analog readout options
Drivers	Configure driver outputs, pressure compensation, and, if not using driver 2, to use driver 2 for a 4–20 mA readout
Contact Inputs	Configure contact input options
Relays	Configure relay options
Woodward Links	Configure digital communication links to other Woodward products

The configure menus are described in detail below and contain information detailing each question and/or 505XT configuration option. Each question/option shows the default (dflt) value and the adjustable range of that parameter (shown in parentheses). In addition, any additional constraints on the configuration are shown in italics following the description. There is a Configuration mode worksheet in Appendix A of this manual that should be completed/filled-in and used as a guide for your particular application. This worksheet can also be used for future reference to document your application program.

Turbine Start Menu

Start Mode:

(One of the three start modes must be selected before the unit will run.)

MANUAL START?

dflt= NO (Yes/No)

Select this to configure a manual start mode. When configured for a manual start mode, the operator controls the turbine speed from zero up to the minimum control speed using an external trip-throttle valve. The manual start sequence would be: Push RUN. The actuator(s) automatically move to max position. Lastly, the operator slowly opens the trip-throttle valve until the governor takes control.

AUTOMATIC START?

dflt= NO (Yes/No)

Select this to configure an automatic start mode. When configured for an automatic start mode, the 505 controls the turbine speed from zero up to the minimum control speed. The Automatic Start Sequence would be: Operator opens the T&T valve, then push RUN. The valve limiter opens automatically until the governor takes control.

SEMI-AUTOMATIC START?

dflt= NO (Yes/No)

Select this to configure a semiautomatic start mode. When configured, the 505 valve limiter must be manually opened by the operator, slowly, to open the control valve and bring the turbine speed from zero up to the minimum control speed. The Semi-automatic Start Sequence would be: Open the T&T valve, then push RUN. The valve limiter must then be raised by the operator until governor takes control.

RATE TO MIN (rpm/s)

dflt= 10.0 (0.01, 2000)

Enter the speed set point acceleration rate to minimum. This is the rate the set point moves from zero to the lowest controlling speed on a start command (assuming the turbine is at zero speed). The minimum controlling speed will be either 'idle' if idle/rated is used or 'low idle' if the auto start sequence is used. If neither of these start-up features is used, the min speed will be the minimum governor speed set point.

VALVE LIMITER RATE (%/s)

dflt= 2.0 (0.1, 25)

Enter the Valve Limiter Rate, in percent per second. This is the rate at which the HP valve limiter moves when RUN is selected or when the limiter setting is changed through open/close commands. When using a semiautomatic or automatic start, this setting should be very slow—typically less than 2 %/s. When using a manual start, this setting is less critical and can be left at the default of 5 %/s.

Start Sequence:

(One of the three start modes must be selected)

NO START SEQUENCE ?

dflt= YES (Yes/No)

Select this if this no start sequence is desired. If not, skip to 'Use Idle/Rated'. If no start sequence is selected, the control will ramp to a programmable Minimum Governor speed set point when a START command is issued.

USE IDLE/RATED ?

dflt= NO (Yes/No)

If this is selected, the control will ramp from a programmable Idle speed to a programmable Rated speed set point when Rated is selected through keypad, Modbus or external switch. If not, skip to 'Use Auto Start Sequence'.

USE AUTO START SEQUENCE ?

dflt= NO (Yes/No)

If this function is configured and RUN is selected, the 505 automatically accelerates the speed set point to a programmable low idle speed and holds for a programmable time then ramps to a programmable high idle speed and holds for a programmable time then ramps to programmable rated speed set point. The start sequence can be actuated or halted through the keypad, Modbus or external switch. If this is not selected, then the program will step to the 'Use Temperature for Hot/Cold' question.

USE TEMPERATURE FOR HOT/COLD

dflt= NO (Yes/No)

If this function is selected, it allows the turbine Hot/Cold status for startup to be determined by using temperature analog inputs. Step to 'Use Temperature Input 2'. If not selected, step to the 'Reset Timer Level (rpm)' question.

Hot Reset Level (rpm)

dflt= 1 (0.0, 20000)

Enter the Level setting for the Hot Reset Timer. This is the speed setting which is used to determine that the turbine has reached its HOT level. Speed must be above this level for five seconds to trigger the Hot Reset Timer.

(Must be greater than or equal to the 'Minimum Governor' Setting)

- Hot Reset Timer (min)** **dflt= 0 (0.0, 200)**
Enter the reset LEVEL Setting. This is the time needed, when RST Timer level is reached, to transfer the start-up parameters from fully COLD to fully HOT.
- COLD START (> xx HRS)** **dflt= 10 (0.0, 200)**
Enter the time in hours allowed after a trip before the 'cold start' sequence curves are to be used. If this much time has expired (or more) after a trip condition, then the control will use the cold start values. If less than this time has expired, the control will interpolate between the hot and cold start values to determine rates and hold times.
- HOT START (< xx HRS)** **dflt= 1.0 (0.0, 200)**
Enter the maximum time allowed after a trip for the 'hot start' sequence curves to be used. If less than this time has expired after a trip condition, then the control will use the hot start values.
(Must be less than or equal to the 'Cold Start' Hours)
- USE TEMPERATURE INPUT 2** **dflt= NO (Yes/No)**
If this function is selected, it allows the turbine Hot/Cold status for startup to be determined by using 2 temperature analog inputs. To use the temperature difference feature, temperature input 2 must be used. If not selected, only 1 temperature AI will be used.
- HOT MINIMUM TEMPERATURE 1** **dflt= 1400.0 (0.0, 1.0e+38)**
Set the minimum temperature for the turbine to be considered HOT based on temperature analog input 1. Above this temperature, the turbine is considered HOT for this input. See the functional description in this manual for other conditions that may be required for the turbine to be considered HOT.
- HOT MINIMUM TEMPERATURE 2** **dflt= 1400.0 (0.0, 1.0e+38)**
Set the minimum temperature for the turbine to be considered HOT based on temperature analog input 2. Above this temperature, the turbine is considered HOT for this input. See the functional description in this manual for other conditions that may be required for the turbine to be considered HOT.
- USE WARM CONDITION** **dflt= NO (Yes/No)**
If this function is selected, an additional warm condition is available between cold and hot, which means that each ramp rate and idle will allow a warm rate and hold time to be configured. If not selected, only Hot/Cold conditions will be used.
- WARM MINIMUM TEMPERATURE 1** **dflt= 1200.0 (0.0, 1.0e+38)**
Set the minimum temperature for the turbine to be considered WARM based on temperature analog input 1. Above this temperature, the turbine is considered WARM for this input. See the functional description in this manual for other conditions that may be required for the turbine to be considered WARM.
- WARM MINIMUM TEMPERATURE 2** **dflt= 1200.0 (0.0, 1.0e+38)**
Set the minimum temperature for the turbine to be considered WARM based on temperature analog input 2. Above this temperature, the turbine is considered WARM for this input. See the functional description in this manual for other conditions that may be required for the turbine to be considered WARM.
- USE TEMPERATURE DIFFERENCE** **dflt= NO (Yes/No)**
If this function is selected, it allows the turbine Hot/Cold status for startup to be determined by the difference between temperature analog inputs 1 and 2. Two temperature inputs must be configured. If not selected, Hot/Warm/Cold conditions will be based on the value of each temperature analog input and not the difference between the two.
- HOT TEMPERATURE DIFFERENCE** **dflt= 10.0 (0.0, 1.0e+38)**
Set the temperature difference between temperature analog inputs 1 and 2 for the turbine to be considered HOT. If the difference is less than this value, the turbine is considered HOT. See the functional description in this manual for other conditions that may be required for the turbine to be considered HOT.
- WARM TEMPERATURE DIFFERENCE** **dflt= 10.0 (0.0, 1.0e+38)**
Set the temperature difference between temperature analog inputs 1 and 2 for the turbine to be considered WARM. If the difference is less than this value, the turbine is considered WARM. See the functional description in this manual for other conditions that may be required for the turbine to be considered WARM.
- IDLE SETPOINT (rpm)** **dflt= 1000 (0.0, 20000)**
Enter the Idle Speed set point desired. This is the lowest speed control set point when using the idle/rated function.

RATED SETPOINT (rpm)**dflt= 3600 (0.0, 20000)**

Enter the Rated Speed set point desired. This is the speed control set point that the unit accelerates to when using the idle/rated function.

(Must be greater than or equal to the 'Minimum Governor Speed' Setting)

IDLE/RATED COLD RATE (rpm/s)**dflt= 5.0 (0.01, 2000)**

Enter the Idle/Rated cold rate (rpm/second). This is the at which the speed set point moves between Idle and Rated speed set points when using the Idle/Rated commands and a COLD start is determined by the Hot/Cold start timer or temperature analog inputs if configured/used.

IDLE/RATED WARM RATE (rpm/s)**dflt= 5.0 (0.01, 2000)**

Enter the Idle/Rated warm rate (rpm/second). This is the at which the speed set point moves between Idle and Rated speed set points when using the Idle/Rated commands and a WARM start is determined by the temperature analog inputs if configured/used. The warm condition is only available when using temperature analog inputs.

IDLE/RATED HOT RATE (rpm/s)**dflt= 5.0 (0.01, 2000)**

Enter the Idle/Rated rate (rpm/second). This is the at which the speed set point moves between Idle and Rated speed set points when using the Idle/Rated commands and a HOT start is determined by the Hot/Cold start timer or temperature analog inputs if configured/used.

LOW IDLE SETPT (rpm)**dflt= 1000 (0.0, 20000)**

Enter the Low Idle Speed Setting. This is the first hold speed when using the automatic start sequence. The speed set point will remain at this setting until the low idle delay/hold time has expired.

LOW IDLE DELAY TIME—COLD (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at low idle. This is the programmable time, in minutes, that the turbine will wait/hold at the low idle speed when a cold start is determined.

LOW IDLE DELAY TIME—WARM (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the warm start hold time desired at low idle. This is the programmable time, in minutes, that the turbine will wait/hold at the low idle speed when a warm start is determined. The warm condition is only available when using temperature analog inputs.

LOW IDLE DELAY TIME- HOT (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the hot start hold time at low idle. This is the programmable time, in minutes/seconds, that the turbine will wait/hold at the low idle speed when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold delays to determine the low idle hold time.

Use IDLE 2?**dflt= False**

When TRUE, the speed reference will ramp to Idle 2 level when timer is passed.

When FALSE is selected, the speed reference will go to rated speed.

RATE TO IDLE 2—COLD (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the cold start rate to Idle 2. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a cold start is determined.

RATE TO IDLE 2—WARM (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the warm start rate to Idle 2. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a warm start is determined. The warm condition is only available when using temperature analog inputs.

RATE TO IDLE 2—HOT (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the hot start rate to Idle 2. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to Idle 2 when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the Idle 2 set point.

IDLE 2 SETPT (rpm)**dflt= 1100 (0.0, 20000)**

Enter the Idle 2 Speed Setting. This is the second hold speed when using the automatic start sequence. The speed set point will remain at this setting until the Idle 2 Delay/hold time has expired. *(Must be greater than the 'Low Idle' Setting)*

IDLE 2 DELAY TIME—COLD (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at Idle 2. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 2 speed when a cold start is determined.

IDLE 2 DELAY TIME—WARM (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at Idle 2. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 2 speed when a warm start is determined. The warm condition is only available when using temperature analog inputs.

IDLE 2 DELAY TIME—HOT (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the hot start hold time desired at Idle 2. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 2 speed when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold delays to determine the hi idle hold time.

Use IDLE 3?**dflt= False**

When TRUE, the speed reference will ramp to Idle 3 level when timer is passed.

When FALSE is selected, the speed reference will go to RATED speed.

RATE TO IDLE 3—COLD (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the cold start rate to Idle 3. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a cold start is determined.

RATE TO IDLE 3—WARM (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the warm start rate to Idle 3. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a warm start is determined. The warm condition is only available when using temperature analog inputs.

RATE TO IDLE 3—HOT (rpm/s)**dflt= 5.0 (0.01, 500)**

Enter the hot start rate to Idle 3. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to Idle 3 when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the Idle 3 set point.

IDLE 3 SETPT (rpm)**dflt= 1200 (0.0, 20000)**

Enter the Idle 3 Speed Setting. This is the third hold speed when using the automatic start sequence. The speed set point will remain at this setting until the Idle 3 Delay/hold time has expired. (Must be greater than the 'Idle 2' Setting)

IDLE 3 DELAY TIME—COLD (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at Idle 3. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 3 speed when a cold start is determined.

IDLE 3 DELAY TIME—WARM (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the warm start hold time desired at Idle 3. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 3 speed when a warm start is determined. The warm condition is only available when using temperature analog inputs.

IDLE 3 DELAY TIME—HOT (MINUTES)**dflt= 1.0 (0.0, 500)**

Enter the hot start hold time desired at Idle 3. This is the programmable time, in minutes, that the turbine will wait/hold at the Idle 3 speed when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold delays to determine the Idle 3 hold time.

USE TEMPERATURE FOR IDLES**dflt= NO (Yes/No)**

If this function is selected, it allows the temperature analog inputs to be used to determine when the automatic start sequence can proceed from an idle setpoint. If not selected, only idle timers and halt/continue commands will be used.

USE TEMPERATURE INPUT 2**dflt= NO (Yes/No)**

If this function is selected, it allows 2 temperature analog inputs to be used to determine when the automatic start sequence can proceed from an idle setpoint. To use the temperature difference feature, Temperature Input 2 must be used. If not selected, only 1 temperature AI will be used.

USE TEMPERATURE DIFFERENCE**dflt= NO (Yes/No)**

If this function is selected, it allows the difference between temperature analog inputs 1 and 2 to be used to determine when the automatic start sequence can proceed from an idle setpoint. Two temperature inputs must be configured. If not selected, idle hold conditions will be based on the value of each temperature analog input and not the difference between the two.

TEMPERATURE 1 SETPOINT FOR IDLE 1**dflt= 1500.0 (0.0, 1.0e+38)**

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 1 speed setpoint based on temperature analog input 1. Above this temperature, the Idle 1 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue from Idle 1.

TEMPERATURE 2 SETPOINT FOR IDLE 1**dflt= 1500.0 (0.0, 1.0e+38)**

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 1 speed setpoint based on temperature analog input 2. Above this temperature, the Idle 1 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue from Idle 1.

MAX TEMPERATURE DIFFERENCE FOR IDLE 1 dflt= 1500.0 (0.0, 1.0e+38)

Set the temperature difference that must be achieved for the automatic start sequence to continue through the Idle 1 speed setpoint based on the difference between temperature analog inputs 1 and 2. If the difference between temperature input 1 and 2 is less than this value, the Idle 1 condition will be satisfied. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue from Idle 1.

TEMPERATURE 1 SETPOINT FOR IDLE 2 dflt= 1500.0 (0.0, 1.0e+38)

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 2 speed setpoint based on temperature analog input 1. Above this temperature, the Idle 2 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 2.

TEMPERATURE 2 SETPOINT FOR IDLE 2 dflt= 1500.0 (0.0, 1.0e+38)

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 2 speed setpoint based on temperature analog input 2. Above this temperature, the Idle 2 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 2.

MAX TEMPERATURE DIFFERENCE FOR IDLE 2 dflt= 10.0 (0.0, 1.0e+38)

Set the temperature difference that must be achieved for the automatic start sequence to continue through the Idle 2 speed setpoint based on the difference between temperature analog inputs 1 and 2. If the difference between temperature input 1 and 2 is less than this value, the Idle 2 condition will be satisfied. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 2.

TEMPERATURE 1 SETPOINT FOR IDLE 3 dflt= 1500.0 (0.0, 1.0e+38)

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 3 speed setpoint based on temperature analog input 1. Above this temperature, the Idle 3 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 3.

TEMPERATURE 2 SETPOINT FOR IDLE 3 dflt= 1500.0 (0.0, 1.0e+38)

Set the temperature that must be reached for the automatic start sequence to continue through the Idle 3 speed setpoint based on temperature analog input 2. Above this temperature, the Idle 3 condition will be satisfied for this temperature input. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 3.

MAX TEMPERATURE DIFFERENCE FOR IDLE 3 dflt= 10.0 (0.0, 1.0e+38)

Set the temperature difference that must be achieved for the automatic start sequence to continue through the Idle 3 speed setpoint based on the difference between temperature analog inputs 1 and 2. If the difference between temperature input 1 and 2 is less than this value, the Idle 3 condition will be satisfied. See the functional description in this manual for other conditions that may be required for the automatic start sequence to continue through Idle 3.

RATE TO RATED SETPT—COLD (rpm/s) dflt= 5.0 (0.01, 500)

Enter the cold start rate to the rated speed set point. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to rated when a cold start is determined.

RATE TO RATED SETPT—WARM (rpm/s) dflt= 5.0 (0.01, 500)

Enter the warm start rate to the rated speed set point. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to rated when a warm start is determined. The warm condition is only available when using temperature analog inputs.

RATE TO RATED SETPT—HOT (rpm/s) dflt= 5.0 (0.01, 500)

Enter the hot start rate to the rated speed set point. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to rated when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the rated set point.

(Must be greater than or equal to the 'Rate to Rated—Cold' Setting)

RATED SETPOINT (rpm) dflt= 3000 (0.0, 20000)

Enter the Rated Speed Setting. This is the final speed setting when using the automatic start sequence. Once this speed set point is reached, the start sequence is complete.

(Must be greater than or equal to the 'Minimum Governor' Setting)

AUTO HALT AT IDLE SETPOINTS?**dflt= NO (Yes/No)**

Select YES to automatically halt the auto start sequence at the idle set points. This feature would result in the unit automatically stopping/halting at the low idle set point and at the high idle set point. Also, if the unit is started and the speed is above the low idle set point, the sequence will be halted. Select NO to allow the control to perform its automatic start sequence routine without interruption.

Speed Set Point Values Menu

(The maximum speed input frequency is 35000 hertz.)

OVERSPEED TEST LIMIT (rpm)**dflt= 1100 (0.0, 20000)**

Set the overspeed test limit (in rpm). This is the maximum speed set point the control will increase to when overspeed testing the unit. The set point can only be raised to this level when the overspeed test function is being performed.

OVERSPEED TRIP (rpm)**dflt= 1000 (0.0, 20000)**

Set the 505's overspeed trip level (in rpm). This is the governor overspeed trip set point only and is not to be used as ultimate overspeed protection.

(Must be less than the 'Overspeed Test Limit' Setting)

MAXIMUM GOVERNOR SPEED (rpm)**dflt= 1.0 (0.0, 20000)**

Set the maximum governor control speed. This is the normal governor operation upper limit. For turbine/generator applications, this value must be at least equal to [Rated Speed + (Droop % x Rated Speed)].

(Must be less than the 'Overspeed Trip Level' Setting)

RATED SPEED (rpm)**dflt= 3600 (0.0, 20000)**

Set the generator's rated speed set point.

(Must be greater than or equal to the 'Minimum Governor Speed' Setting and less than the/Maximum Governor Speed' setting)

MINIMUM GOVERNOR SPEED (rpm)**dflt= 1.0 (0.0, 20000)**

Set the minimum governor control speed. This is the normal governor operation lower limit.

(Must be less than the 'Maximum Governor Speed' Setting)

OFF-LINE SLOW RATE (rpm/s)**dflt= 5.0 (0.01, 100)**

Enter the speed set point slow rate in rpm per second. This is the rate of speed change for normal operation when turbine is Off-line.

ON-LINE SLOW RATE (rpm/s)**dflt= 5.0 (0.01, 100)**

Enter the speed set point slow rate in rpm per second. This is the rate of speed change for normal operation when turbine is On-line.

REMOTE SETPOINT ?**dflt= NONE (None/Speed/kW)**

Set to Speed or kW if using an analog input to set the Speed/Load Set Point. Select None if no remote speed or load setpoint will be used.

REMOTE SETPOINT MAX RATE (rpm/s or kW)**dflt= 50.0 (0.01, 500)**

Enter the Maximum Rate of speed or kW change for the remote setpoint operation.

USE CRITICAL SPEEDS ?**dflt= NO (Yes/No)**

Set to YES to use the critical speed avoidance logic. When set to YES, allows up to two critical speed avoidance bands to be programmed. Within the band, the speed set point cannot be stopped. These bands are used to protect the turbine and driven device from speeds that have inherently high vibration.

(Must program either 'Idle/Rated' or 'Auto Start Sequence' to use critical speed avoidance. The lowest critical speed min must be greater than idle or low idle.)

CRITICAL SPEED RATE (rpm/s)**dflt= 50.0 (0.1, 2000)**

Set the rate that the speed set point will move through the critical speed avoidance ranges (in rpm/second)

(Must be greater than the 'Speed Setpt Slow Rate' Setting)

CRITICAL SPEED 1 MAX (rpm)**dflt= 1.0 (1.0, 20000)**

Set the upper limit of the critical speed avoidance band.

(Must be less than the 'Minimum Governor Speed' Setting)

CRITICAL SPEED 1 MIN (rpm)**dflt= 1.0 (1.0, 20000)**

Set the lower limit of the critical speed avoidance band.

(Must be less than the 'Critical Speed 1 Max' Setting)

USE CRITICAL SPEED 2 ?**dflt= NO (Yes/No)**

Select YES to use the second critical speed avoidance band.

CRITICAL SPEED 2 MAX (rpm) **dflt= 1.0 (1.0, 20000)**

Set the upper limit of the critical speed avoidance band.
(*Must be less than the 'Minimum Governor Speed' Setting*)

CRITICAL SPEED 2 MIN (rpm) **dflt= 1.0 (1.0, 20000)**

Set the lower limit of the critical speed avoidance band.
(*Must be less than the 'Critical Speed 2 Max' Setting*)

USE CRITICAL SPEED 3 ? **dflt= NO (Yes/No)**

Select YES to use the second critical speed avoidance band.

CRITICAL SPEED 3 MAX (rpm) **dflt= 1.0 (1.0, 20000)**

Set the upper limit of the critical speed avoidance band.
(*Must be less than the 'Minimum Governor Speed' Setting*)

CRITICAL SPEED 3 MIN (rpm) **dflt= 1.0 (1.0, 20000)**

Set the lower limit of the critical speed avoidance band.
(*Must be less than the 'Critical Speed 3 Max' Setting*)

Speed Control Menu

(*The maximum speed input frequency is 35000 hertz.*)

PROBE TYPE **dflt= MPU (MPU, ACTIVE)**

Set the probe type, whether passive or active.

NUMBER OF GEAR TEETH SEEN BY MPU **dflt= 60.0 (1, 300)**

Enter the number of teeth on gear that the speed probe is mounted on.

MPU GEAR RATIO **dflt= 1.0 (0.05, 100)**

Enter the speed sensor gear ratio. This value is the ratio of the speed sensor gear to the turbine shaft. This gear ratio is the result of dividing the speed of the speed sensor gear by the speed of the turbine shaft.

MAXIMUM SPEED LEVEL (rpm) **dflt= 250 (0.5, 1000)**

Enter the Maximum Speed Level (in rpm) to set the speed probe input maximum detectable level. If speed goes above this level, it will not be read in the control.

(*Must be greater than the Overspeed Test Limit Setting*) A suggested value is shown

FAILED SPEED LEVEL (rpm) **dflt= 250 (0.5, 1000)**

Enter the Failed Speed Level (in rpm) to set the speed probe input failure level. If speed drops below this level, the control will determine the speed input device is failed and issue an alarm. If all speed inputs fail, the 505 will issue a trip on loss of speed inputs.

(*Must be greater than or equal to 0.0204 x Maximum Speed Level*)

Note: The MPU override level is this value + 50 RPM. When speed increases above this level the speed input override is removed, and the failure detection is armed. A suggested value is shown

USE SPEED INPUT #2? **dflt= NO (Yes/No)**

Select YES if both speed inputs are to be used.

SPEED DIFFERENCE ALARM (% OF MAXSPD) **dflt=2.0 (0.1, 10)**

Enter a speed difference alarm setpoint. This is entered as a percentage of the maximum speed level setting. For example, if the maximum speed is 5000 rpm, then a setting here of 2.0%, will trigger a speed difference alarm if the two speed inputs are different by more than 100 rpm.

ENABLE ALM **dflt=No (Yes/No)**

Check this box to enable the triggering of a speed sensor difference alarm as per this setting. If one of the speed sensors fails, then this alarm will be inhibited.

PROBE TYPE **dflt= MPU (MPU, ACTIVE)**

Set the probe type, whether passive or active.

NUMBER OF GEAR TEETH SEEN BY MPU **dflt= 60.0 (1, 300)**

Enter the number of teeth on gear that the speed probe is mounted on.

MPU GEAR RATIO **dflt= 1.0 (0.05, 100)**

Enter the speed sensor gear ratio. This value is the ratio of the speed sensor gear to the turbine shaft. This gear ratio is the result of dividing the speed of the speed sensor gear by the speed of the turbine shaft.

MAXIMUM SPEED LEVEL (rpm) **dflt= 250 (0.5, 1000)**

Enter the Maximum Speed Level (in rpm) to set the speed probe input maximum detectable level. If speed goes above this level, it will not be read in the control.

(*Must be greater than the Overspeed Test Limit Setting*) A suggested value is shown

FAILED SPEED LEVEL (rpm) **dflt= 250 (0.5, 1000)**

Enter the Failed Speed Level (in rpm) to set the speed probe input failure level. If speed drops below this level, the control will determine the speed input device is failed and issue an alarm. If all speed inputs fail, the 505 will issue a trip on loss of speed inputs.

(Must be greater than or equal to 0.0204 x Maximum Speed Level)

Note: The MPU override level is this value + 50 RPM. When speed increases above this level the speed input override is removed and the failure detection is armed. A suggested value is shown

OFF-LINE PROPORTIONAL GAIN **dflt= 5.0 (0.0, 100)**

Enter the off-line PID proportional gain percentage. This value is used to set speed/load control response when the Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 5%.

OFF-LINE INTEGRAL GAIN **dflt= 0.5 (0.01, 50)**

Enter the off-line PID integral gain percentage. This value is used to set speed/load control response when the Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5%.

OFF-LINE DERIVATIVE RATIO **dflt= 5.0 (0.01, 100)**

Enter the off-line PID derivative ratio. This value is used to set speed/load control response when the Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is open. This value can be changed in the Service Mode while the turbine is operating. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to $1.0/[(\text{Deriv Ratio}) * (\text{Integral Gain})]$.

ON-LINE PROPORTIONAL GAIN **dflt= 5.0 (0.0, 100)**

Enter the on-line PID proportional gain percentage. This value is used to set speed/load control response when the Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is closed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 5%.

ON-LINE INTEGRAL GAIN **dflt= 0.5 (0.01, 50)**

Enter the on-line PID integral gain percentage. This value is used to set speed/load control response when the Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is closed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5%.

ON-LINE DERIVATIVE RATIO **dflt= 5.0 (0.01, 100)**

Enter the on-line PID derivative ratio. This value is used to set speed/load control response when the Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the select dynamics function is used, and the contact is closed. This value can be changed in the Service Mode while the turbine is operating. See Chapter 5—PID Dynamics Settings for more information. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to $1.0/[(\text{Deriv Ratio}) * (\text{Integral Gain})]$.

Operating Parameters Block

GENERATOR APPLICATION? **dflt= NO (Yes/No)**

Select YES if the turbine is driving a generator. If YES, requires a Generator breaker and Utility Tie breaker to be programmed as contact inputs. If NO, skip to the 'Use Local/Remote' question.

USE GEN BREAKER OPEN TRIP? **dflt= NO (Yes/No)**

Select YES if opening the generator breaker is to initiate a turbine trip. If YES, the unit will trip when the generator breaker opens after being closed, unless a Controlled Stop is selected. If NO, the

speed set point will instantly reset to the 'Gen Open Set Point' which is defaulted to 50 rpm below rated speed.

USE TIE BREAKER OPEN TRIP?**dflt= NO (Yes/No)**

Select YES if opening the utility tie breaker is to initiate a turbine trip. If YES, the unit will trip when the utility tie breaker opens after being closed, unless a Controlled Stop is selected. If NO and the generator breaker is closed, the speed set point will instantly reset to the speed last seen by the unit and move to the 'Rated Speed Set Point' and an alarm is issued. If NO and the generator breaker is open, there is only an alarm when the utility tie breaker opens.

RATED SPEED

(Configured in Speed Setpoints menu).

FREQUENCY AT RATED**dflt= 50 Hz (50 Hz, 60 Hz)**

Set the generator's frequency at rated speed set point.

DROOP (%)**dflt= 5.0 (0.0, 10)**

Enter the droop percentage. Typically set between 4–6% and not more than 10%.

USE MW AS LOAD UNITS?**dflt= NO (Yes/No)**

When set to Yes, the control will use and display MW as the load units. When set to No, the control will use and display KW as the load units.

USE LOAD DROOP?**dflt= NO (Yes/No)**

Set to YES to use load droop (generator load control) or NO to use internal Speed droop (turbine inlet valve position). If YES, generator load feedback is used as the controlling parameter for stability when the unit is on-line. If NO, internal LSS demand/actuator position droop is used.

MAX LOAD (dflt = KW)**dflt= 20000 (0.1, 20000)**

Enter the max load. This setting limits the maximum load the turbine/generator can carry.

(Must be less than or equal to the 'KW input at 20 mA' setting)

PRIMARY Load SIGNAL**dflt= None**

Select the source for the kW input signal, if used.

SECONDARY Load SIGNAL**dflt= None**

Select the backup source for the kW input signal (optional).

PRIMARY SYNC/LOAD SHARE SIGNAL**dflt= None**

Select the source for the synchronization/load share input signal, if used.

SECONDARY SYNC/LOAD SHARE SIGNAL**dflt= None**

Select the backup source for the synchronization/load share input signal (optional).

PRIMARY SYNC SIGNAL**dflt= None**

Select the source for the synchronization input signal, if used. If load sharing is used in this application, this input will not be used, and the sync/load share input should be used.

SECONDARY SYNC SIGNAL**dflt= None**

Select the backup source for the synchronization input signal (optional).

USE FREQ ARM/DISARM?**dflt= NO (Yes/No)**

Set to YES is using frequency control arm/disarm. If YES, frequency control must be armed before the unit will switch into frequency control. If NO, frequency control is always armed, and the unit will go into frequency control whenever the generator breaker is closed and the utility tie breaker is open. (CANNOT PROGRAM BOTH FREQ ARM/DISARM AND LOAD SHARING)

TIE OPEN LOAD REJECTION?**dflt = Yes (Yes/No)**

Set to NO to disable the load rejection logic when the Tie Breaker opens. Typically, the load rejection logic should always be enabled.

MIN HP VALVE UPON LOAD REJECTION?**dflt = 0.0 (0,20)**

Set this value to the minimum demand desired upon a load rejection due to the utility breaker opening. The default of 0 is ideal if there is no significant plant load when this occurs. If there is plant load this value can be increased to avoid an underspeed trip condition.

USE FEED-FORWARD?**dflt = No (Yes/No)**

Set to YES if using the feed-forward loop followed by the ENTER.

The feed-forward loop allows an analog input representing the anti-surge valve demand to offset (bias) the 505's speed reference in order to assist the anti-surge controller. This bias then slowly decreases back to 0 rpm offset in the configured feed-forward action delay.

FEED FORWARD SPEED DEADBAND (rpm)**dflt = 0.1 (0.1,100)**

Set the dead band for the feed-forward speed bias, followed by the ENTER. This setting is needed if the feed-forward analog input signal is noisy.

USE ONLY WHEN CASCADE?**dflt = Yes (Yes/No)**

Set to YES if the feed-forward loop can only be enabled when cascade is enabled, followed by the ENTER. If set to NO, then feed-forward can be enabled in either speed or cascade control.

CASC DEADBAND WHEN FORWARD ACTIVE?**dflt = 0.1 (0,50)**

Set the cascade dead band when feed-forward is enabled, followed by the ENTER. This value directly sets the DB input on the Cascade PID.

DIRECT FEED-FORWARD?**dflt = No (Yes/No)**

Set to YES if using the feed-forward loop as direct command followed by the ENTER. If YES is selected, the feed-forward speed bias will be directly proportional to the 4–20 mA signal. The speed bias, when using direct feed-forward, does not slowly reduce over time. This feature proportionally affects the speed reference.

SPEED OFFSET AT 4 mA (rpm)**dflt = -100 (-1000,0)**

Only when direct action is selected, set the speed bias applied when the feed-forward analog input is at 4 mA. The range of the values configured for the speed offset at 4 mA and 20 mA determines the amount that speed reference is changed when the feed-forward analog input current changes. If the analog input current is increased/decreased by 25% while direct feed-forward is enabled, for example, then the speed reference will be increased/decreased by 25% of the range between 'Speed Offset at 4 mA' and 'Speed Offset at 20 mA'.

SPEED OFFSET AT 20 mA (rpm)**dflt = 100 (0,2000)**

Only when direct action is selected, set the speed bias applied when the feed-forward analog input is at 20 mA. The range of the values configured for the speed offset at 4 mA and 20 mA determines the amount that speed reference is changed when the feed-forward analog input current changes. If the analog input current is increased/decreased by 25% while direct feed-forward is enabled, for example, then the speed reference will be increased/decreased by 25% of the range between 'Speed Offset at 4 mA' and 'Speed Offset at 20 mA'.

ACTION DELAY? (s)**dflt = 180 (0,1000)**

Only when 'direct feed-forward?' = NO. Set the minimum response time (lag) needed to remove the effect of the feed-forward loop. After a feed-forward event, when the speed reference is biased by the feed-forward loop, this parameter determines how long it takes (minimum) for the offset to ramp back to 0 rpm (no speed reference offset). Essentially it is the duration of the feed-forward action.

MIN FORWARD RATE (%/s)**dflt = -100(-100,-1)**

Set the minimum effective rate (negative value) of the feed-forward signal, when decreasing, followed by the ENTER. This sets the highest level of response for the feed-forward loop based on the 4-20 mA signal's rate of decrease.

SPEED OFFSET AT MIN RATE (rpm)**dflt = -100(-1000,0)**

Set the speed offset at the Min Forward Rate (%/s) followed by the ENTER. This sets the largest negative offset that can be provided by the feed-forward loop. It is the amount the speed reference will be biased (RPM) when the analog input decreases by the "Min Forward Rate".

MAX FORWARD RATE (%/s)**dflt = 100(1,100)**

Set the maximum effective rate (positive value) of the feed-forward signal, when increasing, followed by the ENTER. This sets the highest level of response for the feed-forward loop based on the 4-20 mA signal's rate of increase.

SPEED OFFSET AT MAX RATE (rpm)**dflt = 100 (0,2000)**

Set the speed offset at the Max Forward Rate (%/s) followed by the ENTER. This sets the largest positive offset that can be provided by the feed-forward loop. It is the amount the speed reference will be biased (RPM) when the analog input increases by the "Max Forward Rate".

USE EMERGENCY?**dflt = No (Yes/No)**

Only when 'Direct feed-forward?' = NO. Set to YES if using the feed-forward emergency loop followed by the ENTER. This loop can be configured to provide a larger feed-forward response. For example, when the compressor is extremely close to a surge condition and the anti-surge valve demand moves at a greater rate, this can be detected by this loop and a larger offset than the normal feed-forward response can be introduced. This response can also have a much shorter duration so that it does not cause problems for the anti-surge controller rather than help it. The emergency feed-forward loop effects overlap the normal feed-forward loop; they are not summed. The emergency feed-forward loop acts only in the positive direction.

EMERGENCY ACTION DELAY (s)**dflt = 10 (2,100)**

Set the response time (lag) needed to remove the effect of the emergency feed-forward loop. After an emergency feed-forward event, when the speed reference is biased by the emergency feed-forward loop, this parameter determines how long it takes for the emergency offset to ramp back to 0

rpm (no speed reference offset). Essentially it is the duration of the emergency feed-forward action. After this time expires, only the normal feed-forward will be in effect until its Action Delay time expires.

FORWARD RATE TO ACTIVATE (%/s)**dfilt = 10(2,100)**

Set the minimum required rate of increase (%/s) to activate the emergency loop, followed by the ENTER. This is the rate at which the feed-forward analog input must increase in order to trigger the emergency feed-forward action.

EMERGENCY MAX FORWARD RATE (%/s)**dfilt = 100 (7,100)**

Set the maximum effective rate (positive direction) of the feed-forward analog input, when increasing, followed by the ENTER. This sets the highest level of response for the emergency feed-forward loop based on the 4-20 mA signal's rate of increase. Must be greater than 'FW RATE TO ACTIVATE'.

EMERGENCY MAX SPEED OFFSET**dfilt = 300 (0,2000)**

Set the speed bias at "Emerg Max Forward Rate", followed by the ENTER. When the emergency feed-forward action is triggered, this parameter defines the maximum speed offset that will be applied by the emergency feed-forward loop when the analog input increases at the "Erg Max Forward Rate".

EMERGENCY MAX SPEED RATE (rpm/s)**dfilt = 500 (0,2000)**

Set the max speed bias rate when emergency feed-forward is activated, followed by the ENTER. This limits how fast the emergency action can change the speed offset and, hence, limits how fast the speed reference is increased when the emergency feed-forward Loop is activated.
(end of FW)

CONTROLLED STOP & TRIP?**dfilt= No(Yes/No)**

Set to YES if when controlled SD is completed, the unit must be Tripped, followed by the ENTER. If set to NO, the unit will remain in a stopped but reset state after a controlled shutdown.

EXTERNAL TRIPS IN TRIP RELAY ?**dfilt= YES (Yes/No)**

Select YES to allow the external trip input(s) to de-energize the trip relay output. When set to NO, an external trip contact input to the 505 will shut down the 505 control but will not de-energize the 505's trip relay output.

RESET CLEARS TRIP OUTPUT ?**dfilt= NO (Yes/No)**

Select YES to configure the Reset Clears Trip Relay output function. When set to YES, a Reset command will energize the trip relay output even when a trip condition is still sensed by the 505—typically due to one of the external trip inputs. Once reset, the unit will be 'Ready to Start' as soon as all external trip inputs are closed. When NO, the trip relay output will be de-energized on a 505 trip and will not energize until all trips have cleared and a 'Reset' command is given.

TRIP = ZERO CURRENT TO ACTUATORS**dfilt= YES (Yes/No)**

When set to YES any TRIP condition will 'open' the actuator circuit and result in 0 mA of current to the actuators. If set to NO then a TRIP condition will set the demand to 0% and the current will go to the minimum current value, for example 4 mA for a 4-20 mA configuration.

NOTE: (The Emergency Stop button on the front panel is unique. It is a hard wired circuit that is independent of the control application s/w and will directly 'open' the actuator output current drivers. This button always results in 0 mA to the two actuator output channels)

USE LOCAL/REMOTE?**dfilt= NO (Yes/No)**

Set to YES if using Local/Remote control logic. If YES, permits the unit to go from REMOTE (Modbus, contact input and front panel) control to LOCAL (front panel) control only. If NO, all programmed inputs are active at all times. Refer to the Service Mode information in Volume 2 for additional settings on the local/remote function.

USE PRESSURE COMPENSATION ?**dfilt= NO (Yes/No)**

Select YES to enable inlet pressure compensation. Selecting NO disables this function so an inlet pressure signal will not affect the actuator demand.

Auxiliary Control Menu**USE AUXILIARY CONTROL?****dfilt= NO (Yes/No)**

Select YES to configure the auxiliary control function. Select NO if the auxiliary function is not used.

LOST INPUT SHUTDOWN?**dfilt= NO (Yes/No)**

Select YES if a shutdown command is to be given when the auxiliary input fails. If NO, then no shutdown command will be given when the auxiliary input fails, only an alarm. If auxiliary is used as a limiter ("USE AS CONTROLLER" = NO, see below) and it is limiting the valve demand at the time of the input failure, then selecting NO will cause the valve limiter to step to the valve demand at the

time of the failure to ensure that the limiting condition is not exceeded until the operator has time to take action.

PROCESS SIGNAL**dflt= Auxiliary Input**

Select which input the control should use. The input selected here should be configured as an analog input, which is used as the process value for this controller.

INVERTED?**dflt= NO (Yes/No)**

Select YES if the auxiliary control will be reverse acting. If NO, then the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine inlet pressure control.

MINIMUM SETPOINT (UNITS)**dflt= 0.0 (-20000, 20000)**

Set the min AUX set point. This value is the minimum set point value that the auxiliary set point can be decreased/lowered to (lower limit of AUX set point).

MAXIMUM SETPOINT (UNITS)**dflt= 100 (-20000, 20000)**

Set the max AUX set point. This value is the maximum set point value that the auxiliary set point can be increased/raised to (upper limit of AUX set point).

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

SETPOINT RATE (UNITS/s)**dflt= 5.0 (0.01, 1000)**

Set the AUX set point rate. This value is the rate (in units per second) at which AUX set point moves when adjusted.

USE AS CONTROLLER?**dflt= NO (Yes/No)**

Select YES if using the auxiliary control enable/disable feature. If YES, Aux will require an enable command to enable Aux control. If NO, then the auxiliary function will be enabled constantly and will act as a controlling limiter. An example of using Aux as a limiter is using Aux to limit the maximum KW load that the unit carries. The Aux PID is not normally in control of the valve output. But if the Aux (KW) input exceeds the set point, the Aux PID controller would decrease and take control of the valve until the KW level decreases below the maximum kW(Aux) setting. Alternatively, if the Aux enable is used, the Aux set point tracks the Aux input. When enabled, the Aux PID takes control of the valve, and the speed set point tracks the speed/load of the unit for bumpless transfer between modes.

SETPT INITIAL VALUE (UNITS)**dflt= 0.0 (-20000, 20000)**

Set the set point initialization value. When not using the Aux enable function, this is the value that the auxiliary set point initializes to upon power-up or exiting the Configuration mode.

(Must be less than or equal to the 'Max Aux Set Point' Setting)

DROOP (%)**dflt= 0.0 (0.0, 100)**

Enter the droop percentage. If required, typically set between 4–6%.

PID PROPORTIONAL GAIN (%)**dflt= 1.0 (0.0, 100)**

Enter the AUX PID proportional gain value. This value is used to set auxiliary control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.

PID INTEGRAL GAIN (%)**dflt= 0.3 (0.001, 50)**

Enter the AUX PID integral gain value. This value is used to set auxiliary control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 3%.

PID DERIVATIVE RATIO (%)**dflt= 100 (0.01, 100)**

Enter the AUX PID derivative ratio. This value is used to set auxiliary control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%.

TIEBRKR OPEN AUX DSBL ?**dflt= YES (Yes/No)**

Select YES if the auxiliary control will be disabled when the utility tie breaker opens. If NO is selected, then auxiliary control will not be disabled when the utility tie breaker is opened.

GENBRKR OPEN AUX DSBL ?**dflt= YES (Yes/No)**

Select YES if the auxiliary control will be disabled when the generator breaker opens. If NO is selected, then auxiliary control will not be disabled when the generator breaker is opened.

USE REMOTE SETPOINT ?**dflt= NO (Yes/No)**

Set to YES to allow the set point to be adjusted from an analog input.

(Must program a 'remote auxiliary set point' analog input)

REMOTE MAX RATE (UNITS/s)**dflt= 5.0 (0.1, 1000)**

Enter the maximum rate at which the remote input will move the remote set point.

UNITS OF MEASURE (Configured with analog inputs)
DECIMALS DISPLAYED (Configured with analog inputs)

Cascade Control Menu

- USE CASCADE CONTROL?** **dflt= NO (Yes/No)**
 Select YES to configure the cascade control function. Select NO if the cascade function is not used.
- PROCESS SIGNAL** **dflt= Cascade Input**
 Select which input the control should use. The input selected here should be configured as an analog input, which is used as the process value for this controller.
- INVERTED?** **dflt= NO (Yes/No)**
 Select YES if the cascade control will be reverse acting. If NO is selected, the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine inlet pressure control.
- MIN CASCADE SETPOINT (UNITS)** **dflt= 0.0 (-20000, 20000)**
 Set the minimum cascade set point. This value is the minimum set point value that the cascade set point can be decreased/lowered to (lower limit of cascade set point).
- MAX CASCADE SETPOINT (UNITS)** **dflt= 100 (-20000, 20000)**
 Set the maximum cascade set point. This value is the maximum set point value that the cascade set point can be increased/raised to (upper limit of cascade set point).
(Must be greater than the 'Min Cascade Setpt' Setting)
- CASCADE SETPOINT RATE (UNITS/s)** **dflt= 5.0 (0.01, 1000)**
 Set the cascade set point rate. This value is the rate (in units per second) at which cascade set point moves when adjusted.
- USE SETPOINT TRACKING?** **dflt= NO (Yes/No)**
 Select YES or NO. If YES, the cascade set point tracks the cascade input to provide bumpless transfer to cascade control when it is enabled. If NO, the cascade set point remains at the last position except on power-up or exiting the Configuration mode.
- SETPOINT INITIAL VALUE (UNITS)** **dflt= 100.0 (-20000, 20000)**
 Set the set point initialization value. When not using the set point tracking function, this is the value that the cascade set point initializes to upon power-up or exiting the program mode.
(Must be less than or equal to the 'Max Cascade Setpt' Setting)
- SPEED SETPOINT LOWER LIMIT (rpm)** **dflt= 3605 (0.0, 20000)**
 Set the minimum speed set point that the cascade controller can lower the speed set point 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)
- SPEED SETPOINT UPPER LIMIT (rpm)** **dflt= 3780 (0.0, 20000)**
 Set the maximum speed set point that cascade controller can raise the speed set point to.
(Must be less than or equal to the 'Maximum Governor Speed Setpt' Setting)
- MAX SPEED SETPOINT RATE (rpm/s)** **dflt= 20 (0.1, 100)**
 Set the maximum rate at which the cascade control can vary the speed set point.
- CASCADE DROOP (%)** **dflt= 0.0 (0.0, 100)**
 Enter the droop percentage. If needed, typically set between 4–6%.
- PID PROPORTIONAL GAIN (%)** **dflt= 5.0 (0.0, 100)**
 Enter the cascade PID proportional gain value. This value is used to set cascade control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 5%.
- PID INTEGRAL GAIN (%)** **dflt= 0.3 (0.001, 50.0)**
 Enter the cascade PID integral gain value. This value is used to set cascade control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 0.3%.
- PID DERIVATIVE RATIO (%)** **dflt= 100 (0.01, 100)**
 Enter the cascade PID derivative ratio. This value is used to set cascade control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%. When this value is between 0.01 and 1.0 the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100 the derivative term is considered to be 'feedback dominant' and the derivative is equal to $1.0/[(\text{Deriv Ratio}) * (\text{Integral Gain})]$.

USE REMOTE CASCADE SETPOINT? dflt= NO (Yes/No)

Set to YES to allow the Cascade set point to be adjusted from an analog input.

(Must program a 'remote cascade set point' analog input

REMOTE CASCADE MAX RATE (UNITS/s) dflt= 5.0 (0.1, 1000)

Enter the maximum rate at which the remote input will move the cascade set point.

UNITS OF MEASURE (Configured with analog inputs)**DECIMALS DISPLAYED (Configured with analog inputs)****Inlet Control Menu****USE INLET PRESSURE/FLOW CONTROL? dflt= NO (Yes/No)**

Select YES to configure the inlet pressure control function. Select NO if this function is not used.

LOST INPUT SHUTDOWN? dflt= NO (Yes/No)

Select YES if a shutdown command is to be given when the inlet pressure input fails. If NO, then no shutdown command will be given when the inlet pressure input fails, only an alarm. If inlet pressure is used as a limiter ("USE AS CONTROLLER" = NO, see below) and it is limiting the valve demand at the time of the input failure, then selecting NO will cause the valve limiter to step to the valve demand at the time of the failure to ensure that the limiting condition is not exceeded until the operator has time to take action.

INVERTED? dflt= YES (Yes/No)

Select YES if the inlet pressure control will be reverse acting. If NO, then the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine inlet pressure control.

MIN SETPOINT (UNITS) dflt= 0.0 (-20000, 20000)

Set the min INLET set point. This value is the minimum set point value that the inlet pressure set point can be decreased/lowered to (lower limit of INLET set point).

MAX SETPOINT (UNITS) dflt= 100 (-20000, 20000)

Set the max INLET set point. This value is the maximum set point value that the inlet pressure set point can be increased/raised to (upper limit of INLET set point).

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

SETPOINT RATE (UNITS/s) dflt= 5.0 (0.01, 1000)

Set the INLET set point rate. This value is the rate (in units per second) at which INLET set point moves when adjusted.

USE AS CONTROLLER? dflt= NO

Inlet pressure is only available as a controller on Ext/Adm turbines, it can be used as a limiter on single valve turbines.

SETPT INITIAL VALUE (UNITS) dflt= 0.0 (-20000, 20000)

Set the set point initialization value. When not using the inlet enable function, this is the value that the inlet pressure set point initializes to upon power-up or exiting the Configuration mode.

(Must be less than or equal to the 'Max Inlet Set Point' Setting)

DROOP (%) dflt= 0.0 (0.0, 100)

Enter the droop percentage. If required, typically set between 4–6%.

PID PROPORTIONAL GAIN (%) dflt= 1.0 (0.0, 100)

Enter the INLET PID proportional gain value. This value is used to set inlet pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.

PID INTEGRAL GAIN (%) dflt= 0.3 (0.001, 50)

Enter the INLET PID integral gain value. This value is used to set inlet pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 3%.

PID DERIVATIVE RATIO (%) dflt= 100 (0.01, 100)

Enter the INLET PID derivative ratio. This value is used to set inlet pressure control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%.

TIEBRKR OPEN INLET DSBL ? dflt= YES (Yes/No)

Select YES if the inlet pressure control will be disabled when the utility tie breaker opens. If NO is selected, then inlet pressure control will not be disabled when the utility tie breaker is opened.

GENBRKR OPEN INLET DSBL ?	dflt= YES (Yes/No)
Select YES if the inlet pressure control will be disabled when the generator breaker opens. If NO is selected, then inlet pressure control will not be disabled when the generator breaker is opened.	
USE REMOTE SETPOINT ?	dflt= NO (Yes/No)
Set to YES to allow the set point to be adjusted from an analog input. (<i>Must program a 'remote inlet pressure set point' analog input</i>)	
REMOTE MAX RATE (UNITS/s)	dflt= 5.0 (0.1, 1000)
Enter the maximum rate at which the remote input will move the remote set point.	
UNITS OF MEASURE	(Configured with analog inputs)
DECIMALS DISPLAYED	(Configured with analog inputs)

Extraction/Admission Control Menu

USE EXTRACTION or ADMISSION CONTROL?	dflt= NO (Yes/No)
Select YES to configure the Ext/Adm pressure control function. Select NO if this turbine is a single valve turbine.	
LOST INPUT SHUTDOWN?	dflt= NO (Yes/No)
Select YES if a shutdown command is to be given when the Ext/Adm pressure input fails. If NO, then no shutdown command will be given when the Ext/Adm pressure input fails, only an alarm. Anytime the Ext/Adm input fails the Ext/Adm controller will be disable and the unit will fallback to manual P demand	
INVERTED?	dflt= YES (Yes/No)
Select YES if the Ext/Adm pressure control will be reverse acting. If NO, then the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine Ext/Adm pressure control.	
MINIMUM SETPOINT (UNITS)	dflt= 0.0 (-20000, 20000)
Set the min EXT/ADM set point. This value is the minimum set point value that the Ext/Adm pressure set point can be decreased/lowered to (lower limit of EXT/ADM set point).	
MAXIMUM SETPOINT (UNITS)	dflt= 100 (-20000, 20000)
Set the max EXT/ADM set point. This value is the maximum set point value that the Ext/Adm pressure set point can be increased/raised to (upper limit of EXT/ADM set point). (<i>Must be greater than the 'Min Ext/Adm Setpt' Setting</i>)	
SETPOINT RATE (UNITS/s)	dflt= 5.0 (0.01, 1000)
Set the EXT/ADM set point rate. This value is the rate (in units per second) at which EXT/ADM set point moves when adjusted.	
USE SETPOINT TRACKING?	dflt= YES
Select YES or NO. If YES, the Ext/Adm set point tracks the Ext/Adm PV input to provide bumpless transfer to control when it is enabled. If NO, the Ext/Adm set point remains at the last position except on power-up or exiting the Configuration mode.	
INITIAL SETPOINT VALUE (UNITS)	dflt= 0.0 (-20000, 20000)
Set the set point initialization value. When not using the Ext/Adm enable function, this is the value that the Ext/Adm pressure set point initializes to upon power- up or exiting the Configuration mode. (<i>Must be less than or equal to the 'Maximum Set Point' Setting</i>)	
DROOP (%)	dflt= 0.0 (0.0, 100)
Enter the droop percentage. If required, typically set between 4–6%.	
PID PROPORTIONAL GAIN (%)	dflt= 1.0 (0.0, 100)
Enter the EXT/ADM PID proportional gain value. This value is used to set Ext/Adm pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.	
PID INTEGRAL GAIN (%)	dflt= 0.3 (0.001, 50)
Enter the EXT/ADM PID integral gain value. This value is used to set Ext/Adm pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 3%.	
PID DERIVATIVE RATIO (%)	dflt= 100 (0.01, 100)
Enter the EXT/ADM PID derivative ratio. This value is used to set Ext/Adm pressure control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%.	

- TIE BREAKER OPEN EXT/ADM DISABLE ?** **dflt= YES (Yes/No)**
 Select YES if the Ext/Adm pressure control will be disabled when the utility tie breaker opens. If NO is selected, then Ext/Adm pressure control will not be disabled when the utility tie breaker is opened.
- GEN BREAKER OPEN EXT/ADM DISABLE ?** **dflt= YES (Yes/No)**
 Select YES if the Ext/Adm pressure control will be disabled when the gen tie breaker opens. If NO is selected, then Ext/Adm pressure control will not be disabled when the gen breaker is opened.
 NOTE: *(GEN Breaker Open Always Inhibits Ext/Adm control)*
- GENERATOR BREAKER OPEN EXT/ADM INHIBIT** **dflt= YES (Yes/No)**
 Select YES if the Ext/Adm pressure control will be inhibited when the generator breaker opens. If NO is selected, then Ext/Adm pressure control will not be inhibited when the generator breaker is open and the control will control on the Ratio Limiter.
- USE REMOTE SETPOINT ?** **dflt= NO (Yes/No)**
 Set to YES to allow the set point to be adjusted from an analog input.
(Must program a 'remote Ext/Adm pressure set point' analog input)
- REMOTE MAX RATE (UNITS/s)** **dflt= 5.0 (0.1, 1000)**
 Enter the maximum rate at which the remote input will move the remote set point.
- UNITS OF MEASURE** **(Configured with analog inputs)**
DECIMALS DISPLAYED **(Configured with analog inputs)**
- ALLOW USE OF FULL DECOUPLED MODE ?** **dflt= NO (Yes/No)**
 Set to YES to allow access to this selection in Service mode while the turbine is in operation.
- USE AI SIGNAL FOR MANUAL P DEMAND ?** **dflt= NO (Yes/No)**
 Select YES if an analog input will be configured to provide a manual input for the P demand to the ratio limiter. When active, this value will be used in place of the Ext/Adm pressure control PID output.

Exhaust Control Menu

- USE EXHAUST PRESSURE/FLOW CONTROL?** **dflt= NO (Yes/No)**
 Select YES to configure the exhaust pressure control function. Select NO if this function is not used.
- LOST INPUT SHUTDOWN?** **dflt= NO (Yes/No)**
 Select YES if a shutdown command is to be given when the exhaust pressure input fails. If NO, then no shutdown command will be given when the exhaust pressure input fails, only an alarm. If exhaust pressure is used as a limiter ("USE AS CONTROLLER" = NO, see below) and it is limiting the valve demand at the time of the input failure, then selecting NO will cause the valve limiter to step to the valve demand at the time of the failure to ensure that the limiting condition is not exceeded until the operator has time to take action.
- INVERTED?** **dflt= NO (Yes/No)**
 Select YES if the exhaust pressure control will be reverse acting. If NO, then the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine exhaust pressure control.
- MIN SETPOINT (UNITS)** **dflt= 0.0 (-20000, 20000)**
 Set the min EXHAUST set point. This value is the minimum set point value that the exhaust pressure set point can be decreased/lowered to (lower limit of EXHAUST set point).
- MAX SETPOINT (UNITS)** **dflt= 100 (-20000, 20000)**
 Set the max EXHAUST set point. This value is the maximum set point value that the exhaust pressure set point can be increased/raised to (upper limit of EXHAUST set point).
(Must be greater than the 'Min Exhaust Setpt' Setting)
- SETPOINT RATE (UNITS/s)** **dflt= 5.0 (0.01, 1000)**
 Set the EXHAUST set point rate. This value is the rate (in units per second) at which EXHAUST set point moves when adjusted.
- USE AS CONTROLLER?** **dflt= NO**
 Exhaust pressure is only available as a controller on Ext/Adm turbines, it can be used as a limiter on single valve turbines.
- SETPT INITIAL VALUE (UNITS)** **dflt= 0.0 (-20000, 20000)**
 Set the set point initialization value. When not using the exhaust enable function, this is the value that the exhaust pressure set point initializes to upon power- up or exiting the Configuration mode.
(Must be less than or equal to the 'Max Exhaust Set Point' Setting)
- DROOP (%)** **dflt= 0.0 (0.0, 100)**
 Enter the droop percentage. If required, typically set between 4–6%.

PID PROPORTIONAL GAIN (%)	dflt= 1.0 (0.0, 100)
Enter the EXHAUST PID proportional gain value. This value is used to set inlet pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.	
PID INTEGRAL GAIN (%)	dflt= 0.3 (0.001, 50)
Enter the EXHAUST PID integral gain value. This value is used to set exhaust pressure control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 3%.	
PID DERIVATIVE RATIO (%)	dflt= 100 (0.01, 100)
Enter the EXHAUST PID derivative ratio. This value is used to set exhaust pressure control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%.	
TIEBRKR OPEN EXHAUST DSBL ?	dflt= YES (Yes/No)
Select YES if the exhaust pressure control will be disabled when the utility tie breaker opens. If NO is selected, then exhaust pressure control will not be disabled when the utility tie breaker is opened.	
GENBRKR OPEN EXHAUST DSBL ?	dflt= YES (Yes/No)
Select YES if the exhaust pressure control will be disabled when the generator breaker opens. If NO is selected, then exhaust pressure control will not be disabled when the generator breaker is opened.	
USE REMOTE SETPOINT ?	dflt= NO (Yes/No)
Set to YES to allow the set point to be adjusted from an analog input. (Must program a 'remote exhaust pressure set point' analog input)	
REMOTE MAX RATE (UNITS/s)	dflt= 5.0 (0.1, 1000)
Enter the maximum rate at which the remote input will move the remote set point.	
UNITS OF MEASURE	(Configured with analog inputs)
DECIMALS DISPLAYED	(Configured with analog inputs)

Steam Performance Map Menu

Turbine Type	dflt= Single-Valve
Select the type of turbine being controlled – Single Valve, Extraction only, Admission only or Extraction/Admission. For Ext/Adm types – either a steam turbine performance map or ratio limiter gains must be entered.	
NO MAP AVAILABLE (ENTER GAINS ONLY)	dflt= NO (Yes/No)
Set to YES if no performance map is available and only the ratio limiter gains (K values) are to be entered	
MAXIMUM POWER	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum power limit for the engineering units (corresponds to the S=100% line on the steam map)	
MAXIMUM HP FLOW	dflt= 0.0 (-100000.0, 100000.0)
This is the maximum steam flow through the HP steam valve into the turbine (corresponds to the HP=100% line on the steam map)	
USE ALTERNATE MODES?	dflt= NO (Yes/No)
Set to YES if planning to control Inlet and/or Exhaust pressures through the Ratio Limiter logic	
MAX EXTRACTION FLOW	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum steam flow through the extraction valve of the turbine in engineering units. (Only used for Exhaust Control Modes)	
MAX ADMISSION FLOW	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum possible admission steam flow in engineering units. (Only used for Admission only or Ext/Adm units)	
USE AUTOMATIC ENABLE?	dflt= NO (Yes/No)
Set to YES to use display buttons, DI's or Modbus to enable/disable extraction control. If NO – lowering the valve limiter will enable Extraction and raising the valve limiter will disable Extraction. Select YES to allow the active valve limiter adjustment to be available during normal operation	
LP VALVE LIMITER RATE (%/sec)	dflt= 1.0 (0.10, 100.0)
Enter the LP Valve Limiter Rate, in percent per second.	
USE DIRECT MAP ENTRY?	dflt = NO (Yes/No)
Set to YES to use the direct Steam Map points of A, B, and C as the control map without adjusting for the S0 value.	

USE MINIMUM FLOW LINE?	dflt= NO (Yes/No)
Set to YES to enforce a minimum flow line on the map	
LOAD WHEN HP=0 (Min Flow Line)	dflt= 100.0 (-100000.0, 100000.0)
This is the load at HP=0% in engineering units.	
LOAD WHEN HP=100 (Min Flow Line)	dflt= 100.0 (-100000.0, 100000.0)
This is the load at HP=0% in engineering units.	
Extraction Priority on LP Max Limit?	dflt= NO (YES/NO)
Setting applies to Compressor applications only. When set to YES, the map priority will change from Speed to Extraction when the Max LP Limit is true. This allows for Extraction control to take priority over speed control when the LP Value is at a Maximum. If set to NO, the control will maintain speed priority while on the Max LP Limit.	
MAX POWER at Min Ext/Adm (Pt A)	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum turbine power at min extraction in engineering units. (Power must be greater than Pt C)	
MAX HP FLOW at Min Ext/Adm (Pt A)	dflt= 100.0 (-100000.0, 100000.0)
This is the max HP valve steam flow at min extraction in engineering units (Flow must be greater than Pt C)	
MIN POWER at MAX EXTRACTION (Pt B)	dflt= 100.0 (-100000.0, 100000.0)
This is the minimum turbine power at max extraction in engineering units. (Power must be greater than Pt C)	
MIN HP FLOW at MAX EXTRACTION (Pt B)	dflt= 100.0 (-100000.0, 100000.0)
This is the min HP valve steam flow at max extraction in engineering units (Flow must be greater than Pt C)	
MIN POWER at Min Ext/Adm (Pt C)	dflt= 100.0 (-100000.0, 100000.0)
This is the minimum turbine power at min extraction in engineering units. (Power must be less than Pt A)	
MIN HP FLOW at Min Ext/Adm (Pt C)	dflt= 100.0 (-100000.0, 100000.0)
This is the min HP valve steam flow at min extraction in engineering units (Flow must be less than Pt A)	
MIN LP LIFT (%)	dflt= 0.0 (0, 100)
Enter the minimum position limit of the LP Valve output	
SELECT PRIORITIES	
MODE 0 SPEED/EXTRACTION	dflt= Speed (or Extraction)
All Ext/Adm type turbines will initially run in this mode (same as Coupled mode in the old 505E). The Mode determines what 2 parameters are being controlled with the HP & LP valves. If at any point 1 of these valves becomes limited the selected priority parameter will be the one that stays in control.	
MODE 1 SPEED/INLET	dflt= Speed (or Inlet)
MODE 2 EXTRACTION/INLET	dflt= Inlet (or Extraction)
MODE 3 SPEED/EXHAUST	dflt= Speed (or Exhaust)
MODE 4 EXTRACTION/EXHAUST	dflt= Exhaust (or Extraction)
MODE 5 INLET/EXHAUST	dflt= Inlet (or Exhaust)
K1 GAIN Map Value / Service Value	dflt= 0.0 (0.001, 100)
Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed	
K2 GAIN Map Value / Service Value	dflt= 0.0 (0.001, 100)
Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed	
K3 GAIN Map Value / Service Value	dflt= 0.0 (-100, 100)
Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed	
K4 GAIN Map Value / Service Value	dflt= 0.0 (0.001, 1000)
Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed	
K5 GAIN Map Value / Service Value	dflt= 0.0 (-100, 100)
Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed	

K6 GAIN Map Value / Service Value**dfilt= 0.0 (-100, 100)**

Shows the calculated gain value from the entered steam map. Allows manual adjustment of this value if needed

RETAIN SERVICE VALUES?**dfilt= NO (Yes/No)**

Set to YES to use these values on a power cycle or exiting configuration mode, if NO then values will return to map calculated values

MAP Adjust Pop-up Menu

Enable Map Adjustments

dfilt= NO (Yes/No)

Enable this option to allow qualified personnel make minor adjustments to the steam performance map while the turbine is running

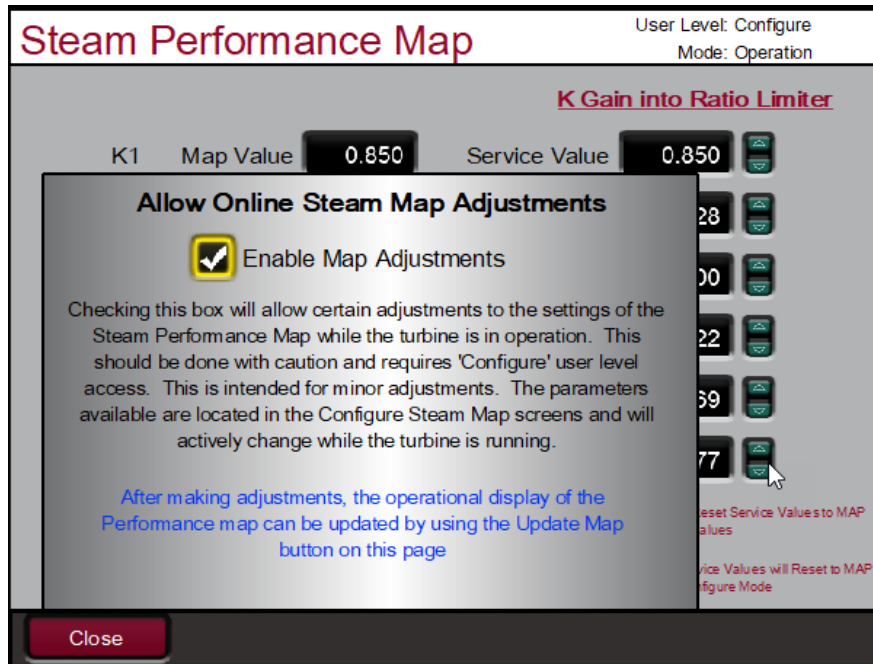


Figure 4-2a. Configuration Menu – On Line Steam Map Adjustments

Isolated Control Menu**USE ISOLATED PID****dfilt= NO (Yes/No)**

Select YES to configure the Isolated PID function. Select NO if this function is not used. When using the Isolated PID Control, it is recommended to select the “Enable Readback Fault” option for the analog output channel configured as the Isolated PID Demand. This will trigger an alarm in the 505 if a fault of the output circuit is detected. By default, analog output channels are not configured to produce an alarm when the output circuit has a fault.

USE REMOTE SETPOINT**dfilt= NO (Yes/No)**

Set to YES to allow the Cascade set point to be adjusted from an analog input.

OUTPUT VALVE DEMAND ACTION ON INPUT FAULT dfilt= HOLD DEMAND

Set to “HOLD Demand” maintain the demand at the time of failure. Set to “Go to Maximum Demand” to move the demand to 100% output. Set to “Go to Minimum Demand” to move the demand to 0% output.

INVERT CONTROLLER?**dfilt= NO (Yes/No)**

Select YES if the control will be reverse acting. If NO is selected, the control will be forward acting. Typically, this will be set to NO, the only time the input would be inverted is if the valve needs to open when the input exceeds the set point.

ALLOW MANUAL CONTROL?**dfilt= NO (Yes/No)**

Set to YES to allow the Isolated PID output to be manipulated by the operator. Set to NO to keep this controller in automatic, controlled by the PID, at all times except in the event of an input failure.

MAXIMUM SETPOINT	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum limit for the Isolated Control setpoint in engineering units.	
MINIMUM SETPOINT	dflt= 0.0 (-100000.0, 100000.0)
This is the minimum limit for the Isolated Control setpoint in engineering units.	
INITIAL SETPOINT	dflt= 100.0 (-100000.0, 100000.0)
This is the value in engineering units at which the Isolated Control setpoint ramp will initialize.	

Communications Menu

IMPORTANT

Each of the ETHERNET ports is required to be configured for a unique subnet (domain) (view default settings as an example). The IP's can be set by other service tools.

The top of the screen shows the current IP addresses in use on for each port.

Ethernet IP Configuration

ENET 1 ADDRESS	dflt= 172.16.100.15 (0, 255)
Enter the integers corresponding to the network TCP/IP address.	
ENET 1 SUBNET MASK	dflt= 255.255.0.0 (0, 255)
Enter the integer corresponding to the network subnet mask.	
SET IP1	dflt= NO (Yes/No)
Press this button to trigger resetting the IP of ENET 1 to the entered value	
ENET 2 ADDRESS	dflt= 192.168.128.20 (0, 255)
Enter the integers corresponding to the network TCP/IP address.	
ENET 2 SUBNET MASK	dflt= 255.255.255.0 (0, 255)
Enter the integer corresponding to the network subnet mask.	
SET IP2	dflt= NO (Yes/No)
Press this button to trigger resetting the IP of ENET 2 to the entered value	
ENET 3 ADDRESS	dflt= 192.168.129.20 (0, 255)
Enter the integers corresponding to the network TCP/IP address.	
ENET 3 SUBNET MASK	dflt= 255.255.255.0 (0, 255)
Enter the integer corresponding to the network subnet mask.	
SET IP3	dflt= NO (Yes/No)
Press this button to trigger resetting the IP of ENET 3 to the entered value	
GATEWAY	dflt= 0.0.0.0 (0, 255)
Enter the integers corresponding to the network gateway. The Gateway setting only applies to ENET Port 1.	

Note: The ENET 4 address is not changeable at the front panel. It is always available for service tools and is defaulted to the following:

ENET 4 ADDRESS	192.168.130.20
ENET 4 SUBNET MASK	255.255.255.0

Modbus Configuration

USE MODBUS?	dflt= NO (Yes/No)
Set to YES to use the Modbus communications feature of the 505. There are 3 identical Modbus ports available; 1 via the Serial port and 2 available via Ethernet. Select NO if Modbus communications will not be used.	
USE SERIAL LINK 1?	dflt= NO (Yes/No)
Set to YES to use the serial Modbus port.	
USE ETHERNET LINK 2?	dflt= NO (Yes/No)
Select a protocol to use the Modbus Link 2 via Ethernet. This will be available on an RJ45 connection to Ethernet Port 1. Selecting UDP will use port 5001.	
USE ETHERNET LINK 3?	dflt= NO (Yes/No)
Select a protocol to use the Modbus Link 3 via Ethernet. This will be available on an RJ45 connection to Ethernet Port 2. Selecting UDP will use port 5002.	

Modbus – Link 1 - Serial**DEVICE ADDRESS****dflt= 1 (1, 247)**

Enter the integer corresponding to the Modbus device number/address required.

ENABLE WRITE COMMANDS**dflt= NO (Yes/No)**

Select YES to allow this Modbus link to write values to the control. If NO, it will be read only.

PROTOCOL**dflt= ASCII (ASCII, RTU)**

Select ASCII or RTU to determine the format of the Modbus communications.

BAUD RATE**dflt= 115,200**

Select the communications baud rate.

BITS**dflt= 7 (7, 8)**

Select the integer corresponding to the bits required.

STOP BITS**dflt= 1 (1, 2, 1.5)**

Select the stop bits required.

PARITY**dflt= NONE (NONE, ODD, EVEN)**

Select the parity required.

DRIVER**dflt= RS-232 (RS-232, RS-422, RS-485)**

Select the serial communications mode required. Enter RS-232, RS-422, or RS-485 communications.

Modbus Ethernet Link 2**ETHERNET Port 1 – IP Address =****<display only>****ETHERNET PROTOCOL****dflt= TCP (TCP, UDP port 5001)**

Select TCP or UDP to determine the Ethernet communication protocol. Selecting UDP will use port 5001 for Link 2.

DEVICE ADDRESS**dflt= 2 (1, 247)**

Enter the integer corresponding to the Modbus device number/address required.

ENABLE WRITE COMMANDS**dflt= NO (Yes/No)**

Select YES to allow this Modbus link to write values to the control. If NO, it will be read only.

Modbus Ethernet Link 3**ETHERNET Port 2 – IP Address =****<display only>****ETHERNET PROTOCOL****dflt= TCP (TCP, UDP port 5001)**

Select TCP or UDP to determine the Ethernet communication protocol. Selecting UDP will use port 5002 for Link 3.

DEVICE ADDRESS**dflt= 2 (1, 247)**

Enter the integer corresponding to the Modbus device number/address required.

ENABLE WRITE COMMANDS**dflt= NO (Yes/No)**

Select YES to allow this Modbus link to write values to the control. If NO, it will be read only.

Analog Inputs Menu

No two analog inputs can be programmed for the same function. In addition, the function that the analog input uses must be programmed, or an error message will occur. For example, to use the Cascade input, the 'Use Cascade' function must be programmed.

ANALOG INPUT # 1**INPUT FUNCTION****(must choose from list)**

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

See tables in Chapter 1 for the list of functional options:

Many of the functions in this list are described in other sections of the manual containing the functional description. Functions that are not described elsewhere in the manual or need clarification are described as follows:

Inlet Steam Pressure – This can be configured as the input for a controller to control the inlet steam header pressure or it must be used if the Inlet Pressure Compensation feature is used.

Exhaust Steam Pressure – This can be configured as the input for a controller to control the exhaust steam header pressure.

- 4 mA VALUE (UNITS)** **dflt= 0.0 (-1.0e+38, 1.0e+38)**
Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog input.
- 20 mA VALUE (UNITS)** **dflt= 100 (-1.0e+38, 1.0e+38)**
Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog input.
(*Must be greater than the 'Input 4 mA Value' Setting*)
- LOOP POWERED** **dflt= NO (Yes/No)**
Check this box if the 505 should provide loop power for the transmitter.

NOTICE

In previous 505 models, there were jumpers that determined if this function was used or not. When upgrading the user will need to remove the cover of the old 505 to determine the proper setting for this option

- LAG FILTER (sec)** **dflt = 0.0 (0.0, 100.0)**
This is a tau filter that can be applied to input signals that may be noisy.
- DEVICE TAG**
This is a user entered field. It allows entry of a short description or tag name for this channel.
- UNITS**
This is a user entered field. It allows entry of a unit label for this channel.
- MDOBUS MULTIPLIER** **dflt= 1.0 (0.01, 0.1, 1.0, 10, 100)**
This is the multiplier that will be used for this parameter address on the 505 slave modbus communication link
- DECIMALS DISPLAYED** **dflt= 1.0 (0, 1, 2, 3)**
This is the number of decimals to be displayed on the 505 screens for this parameter

Analog Inputs # 2 through # 8 are configured following the same rules as described for Analog Input # 1.

NOTICE

Entering Text

The Device Tag is a text field that is available for the user to enter a unique name or identifier for each I/O channel. An example would be to use the signal device tag such as PT-1234 for an Inlet Steam Pressure sensor. Enter Text characters by focusing on the field, press Enter, then press and hold down the alphanumeric keys – they will cycle through the available characters on that key

Analog Outputs Menu

All 4–20 mA analog readouts may be configured. The function that the readout uses must be programmed or an error message will occur. For example, to use the Cascade Set Point readout, the 'Use Cascade' function must be programmed.

ANALOG OUTPUT # 1**OUTPUT FUNCTION** **(must choose from list)**

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

ANALOG READOUT OPTIONS

See tables in Chapter 1 for the list of functional options:

- 4 mA VALUE (UNITS)** **dflt= 0.0 (-1.0e+38, 1.0e+38)**
Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog output.
- 20 mA VALUE (UNITS)** **dflt= 100 (-1.0e+38, 1.0e+38)**
Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog output.
(*Must be greater than the 'Readout 4 mA Value' Setting*)

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

UNITS

This is a user entered field. It allows entry of a unit label for this channel.

ENABLE READBACK FAULT ?**dflt= NO (Yes/No)**

Select YES to issue an alarm when an actuator fault is detected. If YES, the 505 will issue an alarm if the analog channel has a fault. If NO, no fault alarm will be issued. A fault will be determined if the current drops below the failure level or if the difference between the current detected on the source and return wires of the circuit is greater than approximately 5%. It is recommended to enable this feature when the analog output channel is configured as the "Isolated PID Demand Output" function.

Analog Outputs # 2 through # 6 are configured following the same rules as described for Analog Output # 1.

Driver Configuration Menu**(in application software version 5418-7839 Rev "A" and newer)**

In application software p/n 5418-7839 Revision "A", the Driver configuration menu pages have been changed to support a variety of actuators. The assignment of drivers was also expanded to include using any of the six analog output channels to be used as drivers. If you are running an older version of 505XT software, you will not see this section, only the actuator channel driver selections that follow this section.

The first page of the driver configuration will require the user to configure the type of actuator used for the HP inlet valve to the turbine. From this page, the user can step through and configure any other drivers used in the system – namely drivers for HP2, LP, and LP2.

The actuator types supported are Single Coil, Dual Coil and Redundant Actuators. The menu also contains options for interfacing to specific Woodward products such as a Servo Position Control (SPC) using a CAN digital driver interface, or connection to a VariStroke DX redundant skid (VS-DX). Once the actuator type is selected, the appropriate channel or channels drop-down menu options will appear to allow the assignment of output channels to this driver. Further configuration of the specific channel can be accessed from the HW channel menus (for example: selecting the low or high current range of the actuator channels)

A description of each of the actuator types is below.

Single Coil Actuator – Requires a single output channel (AO or ACT) from the 505. The full 0-100% drive demand will be output from this channel.

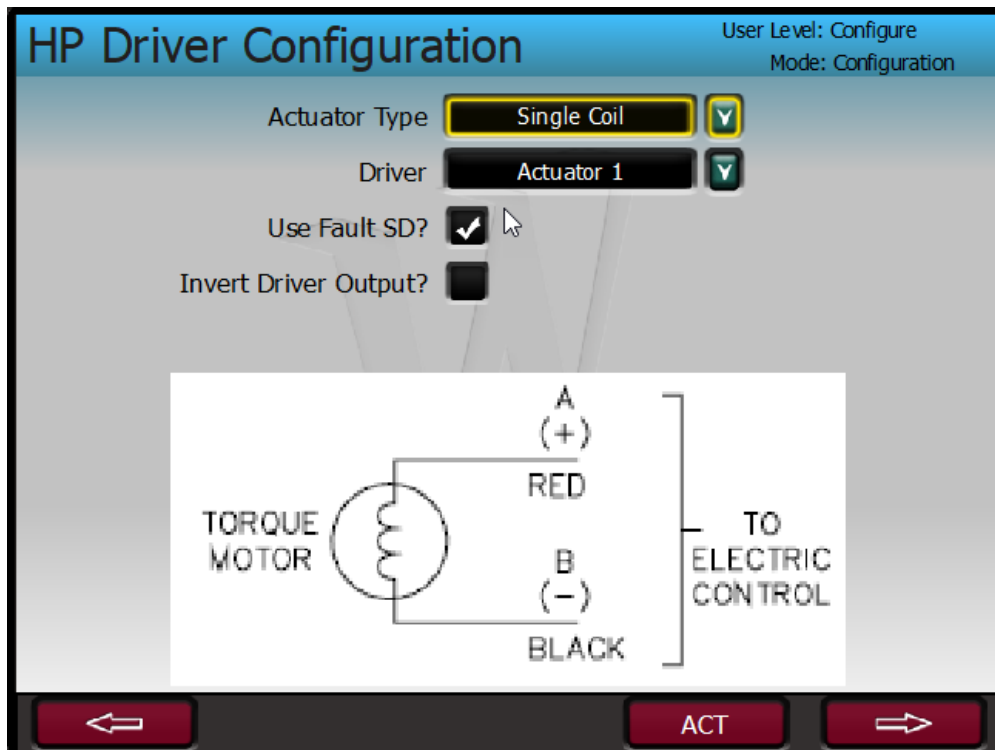


Figure 4-3. HP Driver as Actuator Type "Single Coil"

Dual Coil Actuator – Requires two output channels (AO or ACT) from the 505. When both channels are functioning correctly the 0-100% drive demand will be split in half with each channel outputting an equal share of the total demand. A single channel fault will result in an alarm and a failure of both channels will cause a Trip.

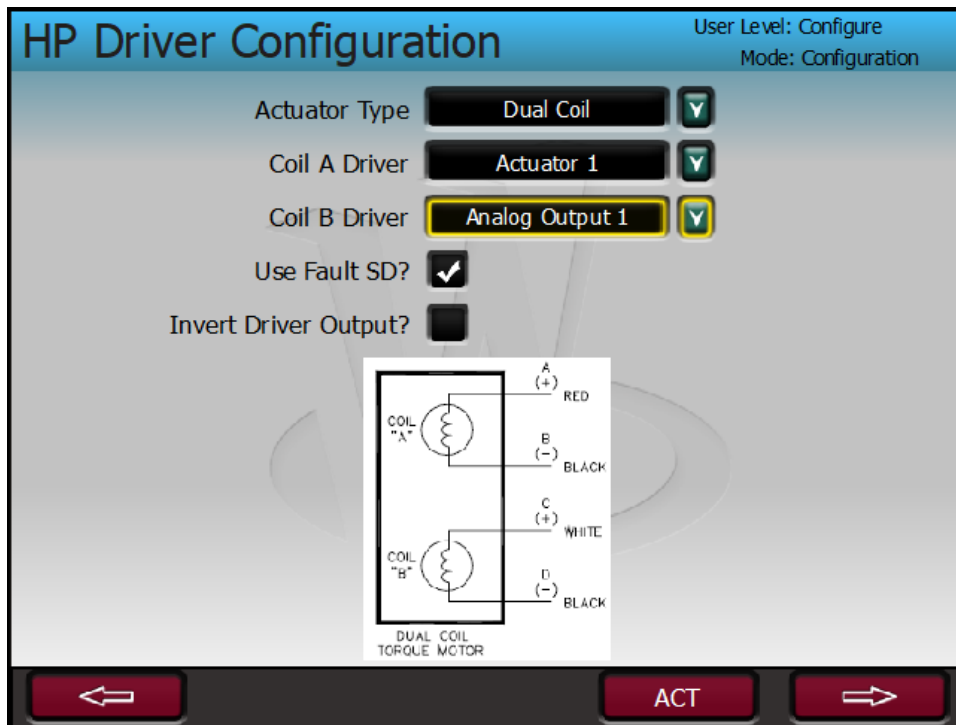


Figure 4-4. HP Driver as Actuator Type "Dual Coil"

Redundant Actuators – Requires two output channels (AO or ACT) from the 505. The full 0-100% drive demand will be output from both channels. A single channel fault will result in an alarm and a failure of both channels will cause a Trip.

If user selects “Actuator Type” as Redundant Actuator, then the configuration of contact inputs for the DI healthy status indications are optional. They are typically only used when a remote active driver device is being used.

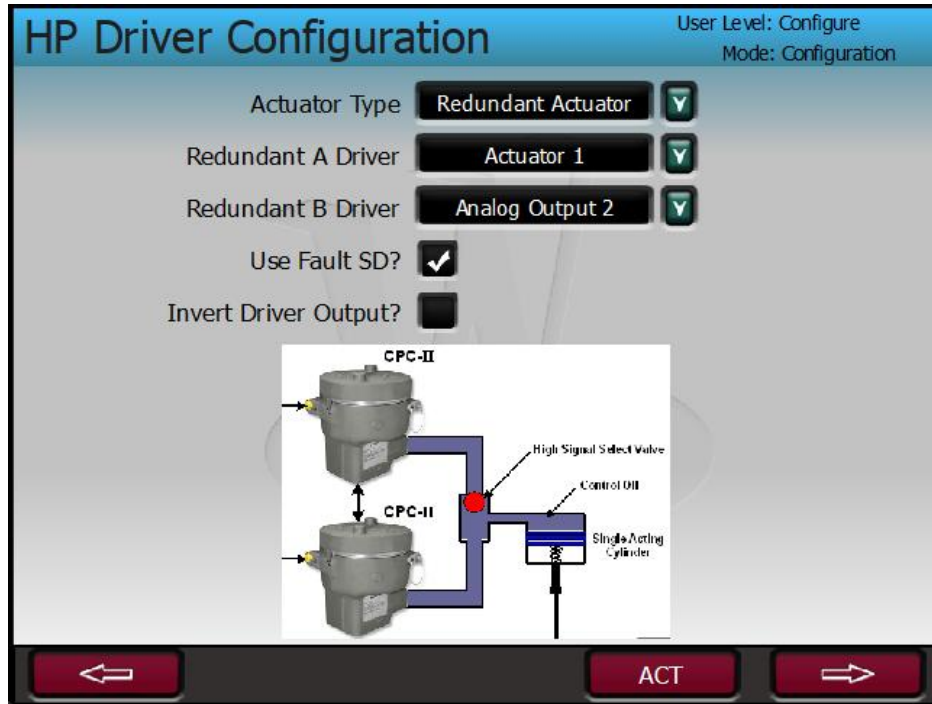


Figure 4-5. HP Driver as Actuator Type “Redundant Actuator”

VS-DX Skid – Requires two output channels (AO or ACT) and two discrete inputs, to and from the 505. Each VariStroke unit should receive 1 analog demand and have its Shutdown output wired back to one of the contact inputs as a ‘Actuator A Healthy’ or ‘Actuator B Healthy’ indication. The full 0-100% drive demand will be output from both analog output channels. A single channel fault or failed DI health indication will result in an alarm and a failure of both channels will cause a Trip. If user selects “Actuator Type” as VS-DX, then the configuration of contact inputs for the DI healthy status indications are required.

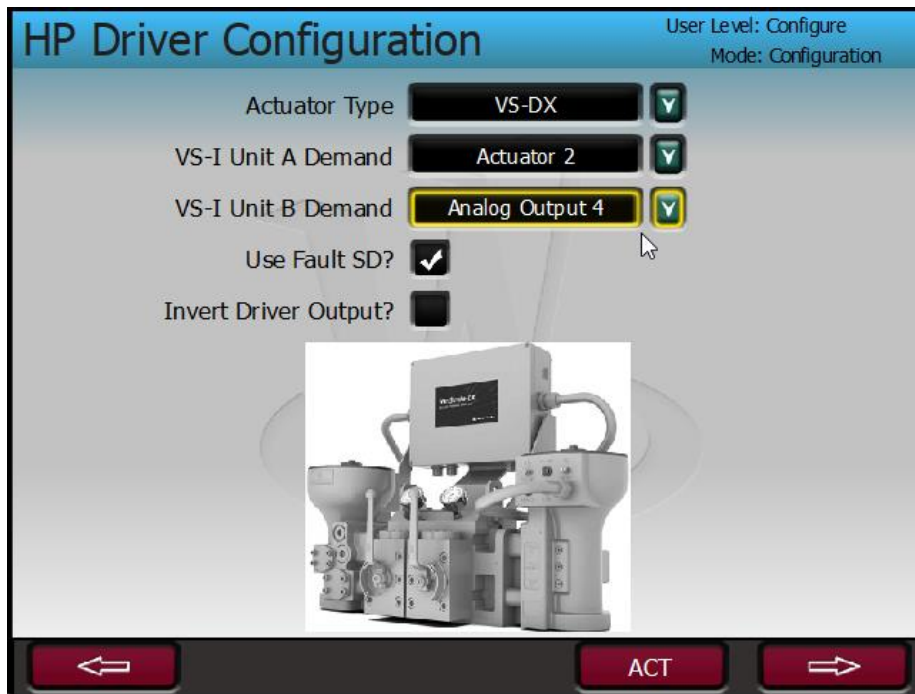


Figure 4-6. HP Driver as Actuator Type “VS-DX” – Redundant VariStroke Skid

HP Driver Configuration

Actuator Type

dflt = Single Coil

Scroll through the menu and select the type of actuator used for HP valve control. The options are: Single Coil, Dual Coil, Redundant Actuator, VS-DX, or SPC w/CAN

Driver/Drivers

Scroll through the menu and select the output channel for this actuator. The options for current output drivers are actuator channels 1 or 2 or any of the 6 analog output channels. For the SPC digital drivers the nodes available on the CAN network are Nodes 11, 12, 13, and 14.

If Single Coil

Driver **dflt = Actuator Chan 1**

If Dual Coil

Coil A Driver **dflt = none**

Coil B Driver **dflt = none**

If Redundant Actuator

Redundant A Driver **dflt = none**

Redundant B Driver **dflt = none**

If VS-DX

VS-I Unit A Demand **dflt = none**

VS-I Unit B Demand **dflt = none**

If SPC w/CAN

Driver **dflt = none**

mA Backup Driver? **dflt = none**

Use Fault SD?

Dflt = Yes

Select YES to issue a trip whenever an actuator fault is detected. If YES, the 505 will issue a shutdown if Actuator 1 has a fault. If NO, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

Invert Driver Output?

Dflt = No

Set to YES to invert actuator driver output. This is normally set to NO.

When Set to YES, unless the front panel Emergency Stop button is used, the actuator output will go to maximum mA at shutdown.

Driver Configuration Menu

(in application software versions 5418-6768 all Revisions, 5418-6768 all Revisions, and 5418-7839 Rev “-“ (new)

When this header appears in the display, press the down arrow key to configure this block or press a left or right arrow key to select another block to configure.

ACTUATOR 01

ACTUATOR FUNCTION

dflt= HP Demand

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection. Select 'Not Used', 'HP Demand', 'HP2 Demand', LP Demand or Readout. The readout option is available for customers who do not need more actuator drivers and would like an additional readout.

ACTUATOR RANGE

dflt= 4-20 mA (0-20, 0-200)

Select the actuator channel output current range. Select 4–20 mA or 20–200 mA. The range can be adjusted via calibration, for example, for a 20-200 mA actuator select the 0-200 mA range.

mA AT 0% DEMAND (mA)

dflt= 4.0/20.0 (0, 25 or 200)

Set the mA value that corresponds to 0% demand.

mA AT 100% DEMAND (mA)

dflt= 20.0/160.0 (0, 25 or 200)

Set the mA value that corresponds to 100% demand

ACTUATOR 1 DITHER (mA)

dflt= 0.0 (0.0, 10)

Enter the dither mA amount for the actuator channel. Enter 0.0 if no dither is required. Woodward TM-type actuators typically require dither.

USE ACTUATOR FAULT SHUTDOWN ?

dflt= YES (Yes/No)

Select YES to issue a trip whenever an actuator fault is detected. If YES, the 505 will issue a shutdown if Actuator 1 has a fault. If NO, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

INVERT ACTUATOR OUTPUT ?

dflt= NO (Yes/No)

Set to YES to invert actuator driver output. This is normally set to NO.

When Set to YES, unless the front panel Emergency Stop button is used, the actuator output will go to 20 mA at shutdown.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

HP2 OFFSET (%)

dflt= 0.0 (0.0, 100)

Enter the percentage actuator #1 is opened when actuator #2 begins to open. Enter 0.0 if both actuators open together.

READOUT FUNCTION:

(must choose from list)

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

OPTIONS FOR ACTUATOR READOUT

See tables in Chapter 1 for the list of functional options (same as AO options):

(The function that the readout uses must be programmed or an error message will occur. For example, to use the Cascade Setpoint readout, the 'Use Cascade' function must be programmed)

READOUT 4 mA VALUE (UNITS)

dflt= 0.0 (-1.0e+38, 1.0e+38)

Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog output. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

READOUT 20 mA VALUE (UNITS)

dflt= 0.0 (-1.0e+38, 1.0e+38)

Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog output. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

(Must be greater than the 'Readout 4 mA Value' Setting)

ENABLE READBACK FAULT?

dflt= NO (Yes/No)

Set to YES to enable alarm annunciation when this channel detects a current fault.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

UNITS


This is a user entered field. It allows entry of a unit label for this channel.

ACTUATOR 02

Actuator 2 is configured following the same rules as Actuator 1.

The 505 supports actuators which are designed to only have hydraulic power while the turbine is rotating. These types of actuators in Woodward terms, are referred to as “Self-Powered Actuators”. They are often integrated with trip and throttle valve and require full demand from the control in order to be able to physically ‘reset’ this valve assembly or to be able to supply any steam to the turbine for a restart.

This requires special logic, because the 505 must raise its actuator demand to full open, while the 505 is still in a tripped condition. Even though the 505-output demand is at full open, no steam enters the turbine because there is no hydraulic power on the valve.

 WARNING	<p>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 over speeding 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.</p>
Overspeed	

This section describes how to configure the 505 for these types of actuators.

To use this type of actuator, the Idle/Rated Start sequence must be selected and the option for inverting the actuator must not be selected. The self-powered actuator screen option is found under the Drivers menu when Idle/Rated start sequence is selected.

Actuator Driver Summary						User Level: Operator
						Mode: Operation
	Fault	Function	mA Value	Demand	Units	
ACT_01		HP Demand	4.0	0.0	Eng Units	
ACT_02		Not Used	0.0	0.0	Eng Units	

Back
Powered Act

Figure 4-7. Actuator Driver Summary/Menu

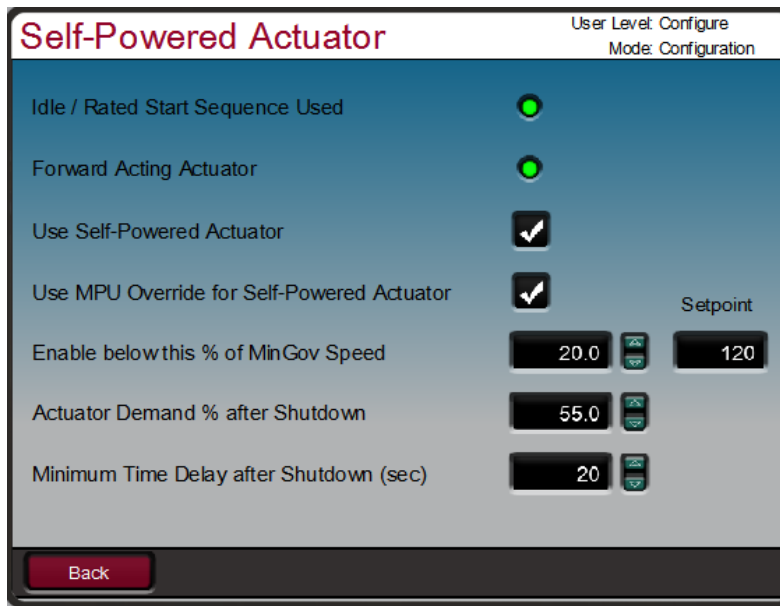


Figure 4-8. Self-Powered Actuator Screen

Use Self-Powered Actuator (Y/N) -

Check this box to use the self-powered actuator functionality upon shutdown/trip conditions

Use MPU Override for Self-Powered Actuator (Y/N) -

Check this box to override the failed MPU condition until speed is over the % of Speed configured

Enable below this % of MinGov Speed (%) – default 20% (1,100)

If the unit is TRIPPED and speed is below this % x MinGov speed AND the minimum delay time after shutdown has expired, then ramp open the HP actuator to the target valve percentage. The corresponding speed value setpoint calculated is shown to the right of this percentage.

Actuator Demand % after Shutdown (%) – default 100% (0,100)

This is the percent that the HP valve will ramp open to after a shutdown/trip has occurred and the minimum time delay has expired

Minimum Time Delay after Shutdown (sec) – default 20 sec (1, 50000)

This time is used to ensure that if the turbine trips due to the loss of the speed signal, that this logic does not immediately open the valve. The HP valve will ramp open to the target demand, this many seconds after a TRIP has occurred.

Contact Inputs Menu

If unit is configured as a 'Generator Set', then contact inputs must be programmed for generator and tie breaker contacts. Also, each contact input option may be configured only once. In addition, the function that the contact input uses must be programmed, or an error message will occur. For example, to use the Cascade Control Enable contact input, the 'Use Cascade' function must be programmed.

**CONTACT INPUT 01
FUNCTION****Emergency Stop**

This channel is a dedicated trip input.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

**CONTACT INPUT xx
FUNCTION****(must choose from list)**

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

CONTACT INPUT OPTIONS

These 3 channels are defaulted as shown – but can be modified if desired.

CONTACT INPUT 02	dflt= Reset Command
CONTACT INPUT 03	dflt= Speed Raise Command
CONTACT INPUT 04	dflt= Speed Lower Command

See tables in Chapter 1 for the list of functional options:

Many of the functions in this list are described in other sections of the manual containing the functional description. Functions that are not described elsewhere in the manual or need clarification are described as follows:

Instant Minimum Governor – This feature will quickly ramp the speed setpoint to the configured Minimum Governor setpoint, if configured as a mechanical drive application, or to the Minimum Load Setpoint if configured as a generator application.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

INVERT LOGIC? dflt= NO (Yes/No)

Select this to invert this contact input. Inverting means that a function normally activated when CLOSED or TRUE will not be activated when the contact is OPEN or FALSE. Note that this is not required for External Trip inputs because the “Normal” or “Non-Inverted” functionality is already fail-safe (CLOSED/TRUE = healthy, OPEN/FALSE = trip).

Contact Inputs # 3 through # 20 are entered following the same rules as described for Contact Input # 2.

Relays Menu

You may configure up to seven relays in addition to the one pre-assigned relay (Shutdown). Each relay can be configured as either a level switch or as an indication. An example of a level switch is a Speed Switch and an example of an indication is Cascade Control Enabled.

RELAY OUTPUT 01**RELAY OUTPUT FUNCTION****Trip Relay**

This channel is a dedicated trip output.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

RELAY OUTPUT 02**USE AS LEVEL SWITCH?****dflt= NO (Yes/No)**

Select this to use this relay output as a level switch. Otherwise, the relay output will be a status indication.

RELAY OUTPUT FUNCTION**(must choose from list)**

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

OPTIONS FOR RELAYS IF USED TO INDICATE STATE

See tables in Chapter 1 for the list of functional options:

LIST OF OPTIONS FOR LEVEL SWITCH

See tables in Chapter 1 for the list of functional options:

LEVEL ON (UNITS)**dflt= 0.0 (-1.0e+38, 1.0e+38)**

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.

LEVEL OFF (UNITS)**dflt= 0.0 (-1.0e+38, 1.0e+38)**

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

RELAY 1 ENERGIZES ON :**(must choose from list)**

Scroll through the menu by navigating the focus highlighter to the desired item, pressing ENTER, using the Adjust Up/Down Arrows, and then pressing the ENTER key again to select the option/function. Press the ESC key to cancel the selection.

DEVICE TAG

This is a user entered field. It allows entry of a short description or tag name for this channel.

INVERT LOGIC?

dflt= NO (Yes/No) Use to invert the normal status of the

relay. Note that Normally Open and Normally Closed contacts are available when wiring to the relays and that these states will be inverted. In the event of a control power failure, the contact will return to its normal state.

Relay outputs # 3 through # 8 are entered following the same rules as described for Relay output # 2.

Woodward Links Menu

The 505XT is able to easily interface with other Woodward product via a variety of digital communications links. This section allows the user to quickly configure the control to send and receive data from these devices. Most of the default settings shown for these devices below match the described products default settings (such as baud rates and subnet masks) to allow 'out of the box' compatibility.

LINKNET I/O NODES

Enable Using LinkNet HT I/O Nodes?

dflt= NO (Yes/No)

Enable Node 1 (AIO)

dflt= NO (Yes/No)

If YES – set the Node Address on this device to 1

Enable Node 2 (AIO)

dflt= NO (Yes/No)

If YES – set the Node Address on this device to 2

Enable Node 3 (RTD)

dflt= NO (Yes/No)

If YES – set the Node Address on this device to 3

Enable Node 4 (BI)

dflt= NO (Yes/No)

If YES – set the Node Address on this device to 4

Enable Node 5 (BO)

dflt= NO (Yes/No)

If YES – set the Node Address on this device to 5

General comments about using Linknet distributed I/O –

- Once configured a LinkNet I/O button will appear on the HOME run screen to provide quick access to the channel and node status info
- It is not intended that these channels be used for closed loop control PV signals or valve driver output signals – use 505 local channels for those signals
- There is no 'Loop Powered' configuration selection for AI's – this is determined by the p/n of the AIO node that is purchased
- It is not recommended to program External Trips on these channels, since a loss of a node or the CAN communication link will result in a Trip
- Linknet I/O specific alarms and/or trips, relating to channels or nodes will produce a summary event on the VIEW screens. From the VIEW screen a button will be available to display these specific events
- The addition of vibration monitoring signals was designed to be done via the Vibration Wizard tool to help configure Vibration monitoring channels (1-8) on NODE 1. They must be done this way to have access to the gauge/monitoring screen for vibration that is available from the Startup Curve page, therefore it is recommended that all vibration sensors be connected to NODE 1.

For Nodes 1 and 2 –

Each node has eight analog inputs and two analog output channels. For information on these configuration parameters refer to the 'Analog Inputs Menu' and the 'Analog Outputs Menu' sections above.

Under the VIB Wizard screen -

Use Node 1 for Vibration Signals?

dflt= NO (Yes/No)

How many signals (1-8)?

dflt= 1 (1,8)

Enter the number of vibration sensors that will be connected to the 505

Number of healthy signals required to run (1-8)? dflt= 0 (1,8)

Enter minimum total number of channels required to keep running. If this number equals the number of channels used, then a single channel fault will result in a Trip

Under the Node Events Screen –

Analog Input xx Signal – (for each AI channel)

Use Alarm Setpoint 1? dflt= NO (Yes/No)
 Use Alarm Setpoint 2? dflt= NO (Yes/No)
 Use Level 2 Setpoint as a TRIP? dflt= NO (Yes/No)

Level 1 Setpoint (eng units) dflt= 0.0 (-90000, 90000)

Enter the alarm level 1 setting in engineering units.

Invert Action on this alarm? dflt= NO (Yes/No)

Level 2 Setpoint (eng units) dflt= 0.0 (-90000, 90000)

Enter the alarm level 2 setting in engineering units.

Invert Action on this alarm? dflt= NO (Yes/No)

Setpoint hysteresis (eng units) dflt= 0.0 (-100, 100)

Enter the hysteresis setting in engineering units for both alarms. A negative setting will allow the event to occur at the programmed setpoint and stay true until the value falls below the setpoint by this amount

Delay for Event Action (sec) dflt= 2.0 (0, 300)

Enter any desired delay to avoid nuisance events – this delay is applied to both events

Enable Speed Setpoint (rpm) dflt= 100.0 (0, 10000)

Enter a value here to inhibit any event from this channel until the turbine has reached this speed

Enable Speed Hysteresis (rpm) dflt= 10.0 (-100, 100)

Enter a hysteresis value here that will be applied to the speed setpoint. This is useful if the speed setpoint is at an Idle speed setting, where the turbine speed may be held and fluctuate around this speed

LINK TO DSLC-2 (TCP Modbus on Ethernet Port 3)

Use a DSLC-2 (Digital Synchronizer/Load Control)? dflt= NO (Yes/No)
(Radio buttons select one)

Use Synchronization? _____

Use Sync/Load Share? _____

Use KW Signal Only? _____

Device Slave Address (1-255) dflt= 247 (1, 255)

Device IP Address dflt= 192.168.1.3 (0, 255)

Enter the integers corresponding to the network TCP/IP address.

505 ENET3 IP Address dflt= 192.168.129.20 (0, 255)

LINK TO VS-II (Digital valve positioner (DVP) on CAN Port 1)

Enable the CAN 1 network interface Link? dflt= NO (Yes/No)

Using a VariStroke II Actuator dflt= NO (Yes/No)

DVP1 Device ID (1-31) dflt= 1 (1, 31)

Enable DVP1 AI Backup dflt= NO (Yes/No)

If selected – program an actuator channel as same demand and connect to VS-II

DVP1 FUNCTION dflt= none

Select desired function – HP, HP2, or LP demand

Using 2 VariStroke II Actuator? dflt= NO (Yes/No)

If yes a pop-up will be available with following parameters

DVP2 FUNCTION dflt= none

Select desired function – HP, HP2, or LP demand

DVP2 Device ID (1-31) dflt= 2 (1, 31)

Enable DVP2 AI Backup dflt= NO (Yes/No)

If selected – program an actuator channel as same demand and connect to VS-II

LINK TO HIGHPROTEC (TCP Modbus on Ethernet Port 3)

Use a HighProtac (Generator Protection Unit)? dflt= NO (Yes/No)

Device Slave Address (1-255) dflt= 247 (1, 255)

Device IP Address **dflt= 192.168.1.5 (0, 255)**
Enter the integers corresponding to the network TCP/IP address.

LINK TO MFR300 (CAN on Port 3)

Use an MFR300 (Multifunction Protection Relay)? **dflt= NO (Yes/No)**
Device ID **dflt= 0 (1, 127)**
 Defaulted to 0 so it will not conflict with LS-5 (more commonly used) the MFR300 is factory defaulted to device ID 1
Baud Rate (0-3) **dflt= 1 (0, 3)**
0=100K, 1=250K, 2=500K, 3=1M
System Configuration **dflt= Wye (Delta/Wye)**

LINK TO LS-5 (CAN on Port 3)

Use an LS-5 (Circuit Breaker & Protection)? **dflt= NO (Yes/No)**
Transmit PDO1 **dflt= 1 (1, 127)**
Baud Rate (0-3) **dflt= 1 (0, 3)**
0=100K, 1=250K, 2=500K, 3=1M
System A Configuration **dflt= Wye (Delta/Wye)**
System A Description **dflt= Generator**
System B Configuration **dflt= Wye (Delta/Wye)**
System B Description **dflt= Utility**

Exiting the Configure Mode

Once the programming steps have been completed, the Configuration mode can be exited. To exit the Configure mode the User Level must still be logged in with Configure privileges. Then the 'Exit Configuration' softkey will be available on the MODE screen. Pressing this initiates the 505 to save the configuration and exit IO Lock. If there are no errors in the configuration, the 505 will be in the Shutdown state. At this point it may be ready to reset and run but, if this is the first time the 505 has been configured with the unit's actuator/linkage/valve, then it is recommended to run the valve stroking procedure in calibration mode and adjust current limits as needed. However, if there is an error in the program, the 505 will be in a shutdown state and unable to reset. Configuration errors can be viewed by going to the Configuration Menu (softkey on the HOME/main menu screen) and pressing the 'Config Check' softkey. The next section identifies the various configuration error messages and explains the meaning of the error.

There is a procedure in the Appendix on how to restore a unit to the original factory defaults, using a service tool.

Configuration Error Messages

The control automatically performs a check on the configured values to assure that required program blocks have values loaded into them. This check cannot determine if the values entered are realistic, but it makes sure that values have been loaded into required parameters. If any errors are found in the program, the 505XT will remain in a shutdown state and a banner message will appear on the Configuration Menu and MODE screens. They can be displayed by pressing the 'Config Check' softkey on the Configuration Menu screen.

The configuration error message alerts you that a configuration change is required before the 505 can operate the turbine. All errors must be corrected before in order to be able to reset the 505 to the "Ready to Start" condition.

The figure below identifies the various configuration error messages that may appear and explains the meaning of the error.

Table 4-3. Configuration Error Messages

Event ID	Description	Error Meaning
1	Duplicate Contact Input Channel	Two contact inputs were programmed for the same function.
2	Contact Input Error	Should never appear (always FALSE) since Contact Input 01 is hard coded as a trip input.
3	Contact Input 02 Error	The specified contact input was configured for a function that is not configured as used. Either the contact input was mis-configured or the function required is mis-configured. For example, contact input #1 is programmed for Remote Cascade Set Point Enable but Remote Cascade Set Point was not programmed under the Cascade configure menu.
4	Contact Input 03 Error	See "Contact Input 02 Error".
5	Contact Input 04 Error	See "Contact Input 02 Error".
6	Contact Input 05 Error	See "Contact Input 02 Error".
7	Contact Input 06 Error	See "Contact Input 02 Error".
8	Contact Input 07 Error	See "Contact Input 02 Error".
9	Contact Input 08 Error	See "Contact Input 02 Error".
10	Contact Input 09 Error	See "Contact Input 02 Error".
11	Contact Input 10 Error	See "Contact Input 02 Error".
12	Contact Input 11 Error	See "Contact Input 02 Error".
13	Contact Input 12 Error	See "Contact Input 02 Error".
14	Contact Input 13 Error	See "Contact Input 02 Error".
15	Contact Input 14 Error	See "Contact Input 02 Error".
16	Contact Input 15 Error	See "Contact Input 02 Error".
17	Contact Input 16 Error	See "Contact Input 02 Error".
18	Contact Input 17 Error	See "Contact Input 02 Error".
19	Contact Input 18 Error	See "Contact Input 02 Error".
20	Contact Input 19 Error	See "Contact Input 02 Error".
21	Contact Input 20 Error	See "Contact Input 02 Error".
22	Duplicate Analog Input Channel	Two analog inputs were programmed for the same function.
23	Analog Input 01 Error	The specified analog input was configured for a function that is not configured as used. Either the analog input was mis-configured or the function required is mis-configured. For example, analog input #1 is programmed for Remote Cascade Set Point but Remote Cascade Set Point was not configured under the Cascade configuration menu.
24	Analog Input 02 Error	See "Analog Input 01 Error".
25	Analog Input 03 Error	See "Analog Input 01 Error".
26	Analog Input 04 Error	See "Analog Input 01 Error".
27	Analog Input 05 Error	See "Analog Input 01 Error".
28	Analog Input 06 Error	See "Analog Input 01 Error".
29	Analog Input 07 Error	See "Analog Input 01 Error".
30	Analog Input 08 Error	See "Analog Input 01 Error".

Event ID	Description	Error Meaning
31	Relay 01 Error	The specified relay was programmed for a function that is not configured as used. Either the relay was mis-configured or the function required is mis-programmed. For example, relay #1 is configured for Remote Cascade Set Point Enabled but Remote Cascade Set Point was not configured under the Cascade configure menu.
32	Relay 02 Error	See "Relay 01 Error".
33	Relay 03 Error	See "Relay 01 Error".
34	Relay 04 Error	See "Relay 01 Error".
35	Relay 05 Error	See "Relay 01 Error".
36	Relay 06 Error	See "Relay 01 Error".
37	Relay 07 Error	See "Relay 01 Error".
38	Relay 08 Error	See "Relay 01 Error".
39	Analog Output 01 Error	The specified readout was configured for a function that is not configured as used. Either the readout was mis-configured or the function required is mis-configured. For example, readout #1 is configured for Cascade Set Point but Cascade Control was not configured under the Cascade configure menu.
40	Analog Output 02 Error	See "Analog Output 01 Error".
41	Analog Output 03 Error	See "Analog Output 01 Error".
42	Analog Output 04 Error	See "Analog Output 01 Error".
43	Analog Output 05 Error	See "Analog Output 01 Error".
44	Analog Output 06 Error	See "Analog Output 01 Error".
45	HP Valve Not Configured	No HP actuator channel has been configured. This is required for control of the steam turbine.
46	Duplicate HP Configured	Both actuator channels have been configured for the HP valve functionality. This function is only allowed on one channel.
47	Duplicate HP2 Configured	Both actuator channels have been configured for the HP2 valve functionality. This function is only allowed on one channel.
48	Actuator 01 Readout Error	The actuator/driver channel readout was configured for a function that is not configured as used. Either the readout was mis-configured or the function required is mis-configured. For example, readout is configured for Cascade Set Point but Cascade Control was not configured under the Cascade Program Block.
49	Actuator 02 Readout Error	See "Actuator 01 Readout Error".
50	Max KW Load > Max KW AI Scale	The KW Max Load setting was programmed at a higher value than the maximum KW input (KW input at 20 mA).
51	Selected KW Source Not Configured	Occurs when a Primary or Secondary kW Signal source has been selected under Operating Parameters but that source is not configured. For example, Primary kW Source is set as 'Analog Input' but no analog input is configured as a kW Input.

Event ID	Description	Error Meaning
52	Turbine Type Requires LP Valve	The unit is configured for Extraction/Admission and requires an LP valve driver to be configured
53	No LP Valve on this Turbine Type	The unit is configured for as a Single Valve unit, but an LP valve driver has been configured
54	Auxiliary Configured, No AI	The Auxiliary control function was configured but no Auxiliary analog input was configured.
55	KW AUX Configured, AUX AI Configured	The Auxiliary control function was configured to use the kW analog input but an Auxiliary analog input was also configured. With this configuration, only the kW analog input is used for the Auxiliary controller.
56	Remote AUX Configured, No AI	The Remote Auxiliary set point control function was configured but no Remote Auxiliary set point analog input was configured.
57	Duplicate LP Configured	There is more than 1 selection for the LP valve demand output
58	Wrong Product Model Detected	The Hardware model number does not match the Application.
59	Alternate Mode Map Error	The D1-D6 values defining the Steam Map that will result from entering an alternate mode are incorrect. Either the sign (+/-) or the magnitude (less than 1e-6) is incorrect on one of these terms. For Exhaust Control modes, this is generally caused by incorrect settings of the Inlet, Extraction, or Exhaust Max Flow values.
60	Spare60	N/A
61	Spare61	N/A
62	Spare62	N/A
63	Spare63	N/A
64	Cascade Configured, No AI	The Cascade control function was programmed but no Cascade analog input was configured.
65	KW CASC Configured, CASC AI Configured	The Cascade control function was configured to use the kW analog input but a Cascade analog input was also configured. With this configuration, only the kW analog input is used for the Cascade controller.
66	Remote Casc Configured, No AI	The Remote Cascade set point control function was configured but no Remote Cascade set point analog input was configured.
67	Inlet Pres CASC Config, CASC AI Config	The Cascade control function was configured to use the Inlet Pressure analog input but a Cascade analog input was also configured. With this configuration, only the Inlet Pressure analog input is used for the Cascade controller.
68	Exhaust Press CASC Config, CASC AI Config	The Cascade control function was configured to use the Exhaust Pressure analog input but a Cascade analog input was configured also. With this configuration, only the Exhaust Pressure analog input is used for the Cascade controller.
69	Exhaust Press CASC Config, No AI Config	The Cascade control function was configured to use the Exhaust Pressure analog input but no AI is configured to be the Exhaust Pressure input

Event ID	Description	Error Meaning
70	Remote Speed Configured, No AI	The remote speed set point control function was configured but no remote speed set point analog input was configured.
71	Feed Forward Programmed, No AI	The feed forward function was configured but no feed forward analog input is configured.
72	Sync and Sync/Load Share Configured	Both the synchronizing analog input and the sync/load share or load share analog inputs are configured. If the application needs to perform both synchronizing and load sharing with analog signals, only the sync/load sharing analog input needs to be configured.
73	Load Share and Frequency Arm Cnfg	Both the frequency arm/disarm function and the load share control functions are configured. Only one of these modes can be programmed — either freq arm/disarm OR load sharing.
74	Generator Application, No Tie Breaker	The unit is configured for a generator application, but no utility tie breaker contact input is configured. This is a requirement.
75	Generator Application, No Gen Breaker	The unit is configured for a generator application, but no generator breaker contact input is configured. This is a requirement.
76	Idle 1 in Critical Band	Either the Idle speed set point (when using Idle/Rated) or the Idle 1 set point (when using the Automatic Start sequence) is configured within a critical speed avoidance band.
77	Idle 2 in Critical Band	The Idle 2 speed set point (when using the Automatic Start sequence) is configured within a critical speed avoidance band.
78	Idle 3 in Critical Band	The Idle 3 speed set point (when using the Automatic Start sequence) is configured within a critical speed avoidance band.
79	Min Control Speed < Failed Speed Level	Either the Idle speed set point (when using Idle/Rated) or the Idle 1 set point (when using the Automatic Start sequence) is configured lower than the Failed Speed Level for speed input 1 or 2.
80	Idle 1 Setpoint > Minimum Governor	The Idle Speed setpoint is configured at a higher speed than the minimum governor speed setpoint.
81	Idle 2 Setpoint > Minimum Governor	The Idle Speed setpoint is configured at a higher speed than the minimum governor speed setpoint.
82	Idle 3 Setpoint > Minimum Governor	The Idle Speed setpoint is configured at a higher speed than the minimum governor speed setpoint.
83	Idle 1 > Idle 2	The Idle 1 speed setpoint is configured at a higher speed than the Idle 2 speed setpoint.
84	Idle 2 > Idle 3	The Idle 2 speed setpoint is configured at a higher speed than the Idle 3 speed setpoint.
85	Rate to Idle 2 Error	The Cold Rate to Idle 2 (rpm/second) is configured at a higher rate than the Hot Rate to Idle 2. Or the Warm Rate to Idle 2 (if used) is configured at a higher rate than the Hot Rate to Idle 2.
86	Rate to Idle 3 Error	The Cold Rate to Idle 3 (rpm/second) is configured at a higher rate than the Hot Rate to Idle 3. Or the Warm Rate to Idle 3 (if used) is configured at a higher rate than the Hot Rate to Idle 3.

Event ID	Description	Error Meaning
87	Rate to Rated Error	The Cold Rate to Rated (rpm/second) is configured at a higher rate than the Hot Rate to Rated. Or the Warm Rate to Rated (if used) is configured at a higher rate than the Hot Rate to Rated.
88	Critical Band Rate < Slow Rate	The acceleration rate (rpm/second) through the critical speed avoidance band must be faster than the normal speed set point rate.
89	Critical Speeds Enabled, No Idle	A critical speed avoidance band is configured but neither idle/rated nor auto start sequence is configured. To use the critical speed avoidance logic one of these functions that uses an idle speed must be programmed.
90	Critical Band Below 1st Idle Setpoint	A critical speed avoidance band is configured below either the Idle speed set point (when using Idle/Rated) or the Idle 1 set point (when using the Automatic Start sequence).
91	Critical Band > Minimum Governor	A critical speed avoidance band is configured higher than the Minimum Governor speed level.
92	Critical Band Min > Max	A critical speed avoidance band minimum limit is configured higher than the maximum limit of that band.
93	Minimum Governor > Maximum Governor	The Minimum Governor speed level is configured higher than the Maximum Governor speed level.
94	Rated Speed < Min Gov	The Rated speed set point is configured at a lower speed than the Minimum Governor speed set point.
95	Rated Speed > Max Gov	The Rated speed set point is configured at a higher speed than the Maximum Governor speed set point.
96	Max Gov > Overspeed Test Limit	The Maximum Governor speed level is configured greater than the Overspeed Test Limit.
97	Overspeed Trip > Overspeed Test SP	The Overspeed Trip setpoint is greater than the Overspeed Test Limit.
98	Overspeed Test Limit > Maximum Speed	The Overspeed Test Limit is configured greater than the Maximum Speed Level for speed input 1 or 2 (if used).
99	Maximum Speed > Probe 1 Freq Range	The maximum speed input is 35000 hertz. This is a limitation of the 505's hardware/speed sensing circuitry. The frequency input of the speed sensor must be less than this value. The gear the speed sensor is mounted on may need to be changed to one with less teeth, this will decrease the frequency seen by the speed probes. The Maximum Speed Level for Speed Input Channel 1, converted to frequency (Hz), is greater than 35000 Hz.
100	Maximum Speed > Probe 2 Freq Range	The maximum speed input is 35000 hertz. This is a limitation of the 505's hardware/speed sensing circuitry. The frequency input of the speed sensor must be less than this value. The gear the speed sensor is mounted on may need to be changed to one with less teeth, this will decrease the frequency seen by the speed probes. The Maximum Speed Level for Speed Input Channel 2, converted to frequency (Hz), is greater than 35000 Hz.

Event ID	Description	Error Meaning
101	Speed Sensor #1 Failed < Freq Range	The failed speed setting for speed input #1 is below the minimum allowed setting. The minimum allowed setting is calculated as follows: (Maximum Speed Level) * (0.0204).
102	Speed Sensor #2 Failed < Freq Range	The failed speed setting for speed input #2 is below the minimum allowed setting. The minimum allowed setting is calculated as follows: (Maximum Speed Level) * (0.0204).
103	No Start Mode Configured	No start mode is selected in the Configure mode. One of the three start modes must be selected in the Configure mode under the Start menu.
104	Remote KW Setpoint Configured, No AI	The Remote kW Setpoint is configured as used but no analog input is configured as a Remote kW Setpoint.
105	Remote Speed and KW Setpoint	Both Remote Speed Setpoint and Remote kW Setpoints are configured as used. Only one of these inputs may be configured.
106	Hot Start greater than Cold Start	The time configured for a Hot Start is greater than the Cold Start. The time remaining after shutdown for a Hot Start must be less than the time for a Cold Start.
107	Hot Reset Timer Level Error	Hot Reset Timer Level is greater than the Maximum Governor speed level or less than the Minimum Governor speed level. The Hot Reset Timer Level must be between Minimum and Maximum Governor.
108	Temperature 1 or 2 used, no AI	A start temperature function is configured but no analog input is configured as a temperature input.
109	Cascade Speed Limit Error	The Cascade minimum speed limit is configured less than Minimum Governor, the Cascade maximum speed limit is configured greater than Maximum Governor, or the Cascade minimum speed limit is greater than the Cascade maximum speed limit.
110	KW Signal Source Not Selected	A controller has been configured to use a kW input, but no Primary or Secondary Signal source has been selected under Operating Parameters.
111	SYNC Signal Source Not Selected	A controller has been configured to use a Synchronization input, but no Primary or Secondary Signal source has been selected under Operating Parameters.
112	SYNC LS Signal Source Not Selected	A controller has been configured to use a Synchronization/Load Sharing input, but no Primary or Secondary Signal source has been selected under Operating Parameters.
113	Isolated Process Control Error	An analog input for the process value and/or an analog output for the PID demand have not been configured.
114	Selected SYNC Source Not Configured	Occurs when a Primary or Secondary Synchronization Signal source has been selected under Operating Parameters, but that source is not configured. For example, Primary Synchronization Source is set as 'Analog Input' but no analog input is configured as a synchronization input.

Event ID	Description	Error Meaning
115	Selected SYNC LS Source Not Configured	Occurs when a Primary or Secondary Synchronization/Load Sharing Signal source has been selected under Operating Parameters, but that source is not configured. For example, Primary Synchronization/Load Sharing Source is set as 'Analog Input' but no analog input is configured as a synchronization/load sharing input.
116	Duplicate Node ID's on CAN3 Network	Multiple nodes on the CAN3 network have the same Node ID. Node ID's on the same network must be unique.
117	Remote KW SP Selected, Not Genset	The unit is not a generator unit but the Remote kW Setpoint is selected.
118	Generator Load Casc Input. Not Genset	The unit is not a generator unit but the CASC control is trying to use Generator Load
119	Generator Load Aux Input. Not Genset	The unit is not a generator unit but the AUX control is trying to use Generator Load
120	Map Entry Values Incorrect	Steam Performance Map values not entered correctly
121	Inlet AI for both CASC and INL Cntrl	The Inlet AI is programmed for both Cascade and Inlet Control
122	Exhaust AI for both CASC and EXH Cntrl	The Exhaust AI is programmed for both Cascade and Exhaust Control
123	Extraction Configured, No AI	Configured to use Extraction control but no Ext/Adm AI is programmed
124	Inlet Configured, No AI	Configured to use Inlet control but no Inlet AI is programmed
125	Exhaust Configured, No AI	Configured to use Exhaust control but no Exhaust AI is programmed
126	Remote Extraction Configured, No AI	Programmed to use a remote Extraction setpoint, but no AI for this function is configured
127	Remote Inlet Configured, No AI	Programmed to use a remote Inlet setpoint, but no AI for this function is configured
128	Remote Exhaust Configured, No AI	Programmed to use a remote Exhaust setpoint, but no AI for this function is configured
129	Idle/Rated Seq w/ >1 Idle Setpoint	Idle/Rated start sequence is programmed – but more than 1 Idle setpoint has been configured for use. Change to Auto Start Sequence to get access to selections for Idle 2 and Idle 3 and uncheck those to clear this error.

Valve/Actuator Calibration & Test

Before initial operation or after a turbine overhaul where any actuator or valve travel may have been affected, the below Valve Calibration procedure should be followed to ensure that the 505 is correctly calibrated to the turbine control valve(s). When calibration is complete, 0 to 100% actuator position as displayed by the 505 must equal 0 to 100% actual valve travel.

After a valid configuration has been entered, the actuator and valve minimum and maximum positions can be adjusted and tested, if needed. Actuator and valve positions are determined by the drive current to the actuator. The maximum actuator current cannot be adjusted lower than the minimum actuator current (see Table 4-2 below). The minimum actuator current cannot be adjusted higher than the maximum actuator current. The driver current ranges are determined by the setting in the Configuration Mode under the Driver Configuration menu.

When adjusting or testing actuator and valve travel, verify that sufficient valve overtravel at the minimum stop is achieved (1%). This assures that each valve can fully close to completely shut off the steam flow to the turbine.

Table 4-4. Actuator Driver Limits

Driver Limits	20–200 mA Range	4–20 mA Range
Overcurrent	210 mA	24 mA
Undercurrent	5 mA	0.6 mA
Max Output Current Range	10–200 mA	2–24 mA
Max Output Impedance	65 Ω	600 Ω
Min Stop Adjust Range	10–80 mA	2–20 mA
Max Stop Adjust Range	100–200 mA	10–24 mA

To ensure proper control to actuator resolution, do not calibrate the span of the actuator output to less than a range of 100 mA (20–200 mA output) or 12 mA (4–20 mA output). If necessary, the actuator to valve linkage may need to be adjusted to ensure proper 505 to valve resolution.

Calibration Mode, required to force/stroke the actuator(s), is only available when the 505 control is in a shutdown state. After enabling Calibration Mode, there are options available to adjust the minimum and maximum stops and to manually stroke the output(s). The manual adjustment mode can be used to stroke the actuator and valves from 0 to 100% after the minimum and maximum positions have been adjusted. This allows both the actuator and valve to be tested for binding, play, resolution, linearity, and repeatability.

As a safety precaution, if turbine speed ever exceeds either of the speed probe failed speed settings the Calibration mode will be automatically disabled, which disables forcing of the actuator and takes actuator currents to zero.

Calibration/Stroking Procedure



WARNING

Before calibrating or testing, the unit must be tripped and the steam supply removed. This is to ensure that opening the control valve(s) will not allow steam into the turbine. Overspeeding the turbine may cause damage to turbine and can cause severe injury or death to personnel. **STEAM TO THE TURBINE MUST BE SHUT OFF BY OTHER MEANS DURING THIS PROCESS.**

1. The 505 must be shutdown to enter Calibration Mode.
2. Go to the MODE screen by pressing the MODE key.
3. Enter Calibration Mode by pressing the 'Calibration' softkey. The following permissives must be met:
 - a. Unit Shutdown
 - b. No Speed Detected
 - c. Appropriate User Level Login
4. Navigate to the Actuator Driver Summary page by pressing the 'Drivers' in either the HOME menu or Configure menu.
5. Select the desired actuator channel.
6. In the actuator channel screen, press the 'Calibration' softkey to access the calibration options.
7. Verify the green "Calmode Enabled" LED is ON to confirm that the unit is in Calibration Mode.
8. Press the 'Forcing' softkey and then confirm on the popup that actuator forcing can be enabled. Select 'OK' and press ENTER to enable forcing.
9. Verify that the green "Forcing Enabled" LED is now also ON.
10. Use the focus navigation to select and adjust items on the screen (Manual Adjust, Go to Demand, Force Rate, etc.).
11. Actuator current output at min and max can be adjusted by selecting "mA at 0% Demand" or "mA at 100% Demand". Use the up/down Adjust arrows or numerical keypad and ENTER key to change the values.
12. Press the 'Commands' softkey to access other commands such as "Go to Min", "Go to Max", and "GO". "GO" can be used with the "Goto Demand" value.
13. When finished, make sure to save the settings by pressing any 'Save Settings' softkey. A 'Save Settings' softkey can be accessed on the MODE screen.
14. Exit Calibration Mode by pressing the 'Exit Calmode' softkey from the MODE page or, if it is desired to stroke another channel, return to the Driver or I/O screen to continue stroking other channels.

If changes are made to the minimum or maximum current values, they can be recorded on the Configure Mode worksheets. Exiting the Calibration Mode or Forcing Mode will not permanently save any calibration changes.

NOTICE

Press the 'Save Settings' softkey to permanently save any minimum or maximum actuator settings into the 505. If variables are tuned or changed but not saved, then those changes will be lost if power is removed from the control or if the control receives a CPU reset.

Chapter 5. 505 Operation

Software Architecture

The 505XT is a field configurable steam turbine control and graphical user interface (GUI) integrated into one package. The 505XT control has been designed to run 2 separate, independent programs on the same platform. One controls the I/O and therefore controls turbine operation. The other program provides all the visual and command interaction with the user.

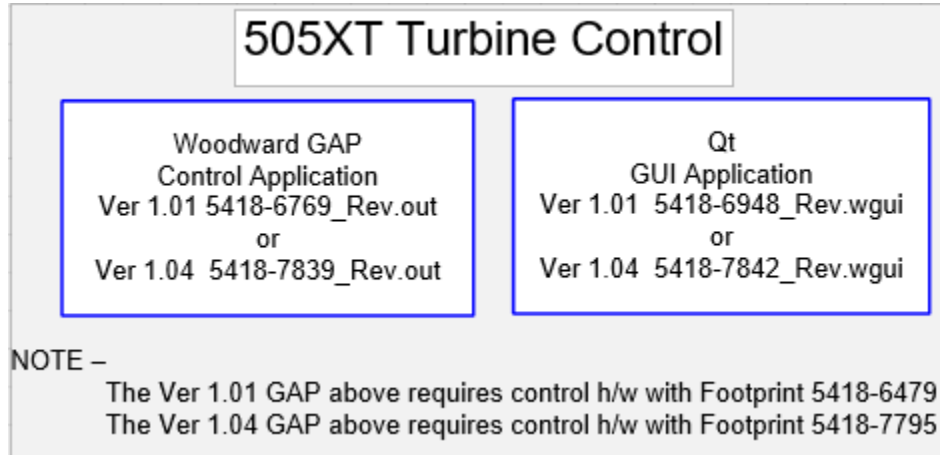


Figure 5-1. Software Architecture

The primary application program is the GAP based control application program. This controls all the system I/O and functional algorithms which control the operation of the turbine.

The secondary application program is the Digia/Qt based graphical user interface (GUI) program. This controls all the screen information that is displayed to the user. It links to the GAP via an internal communication link to pass all required interface variables to and from the display.

Both of these programs are automatically launched at power-up. The GAP program MUST always be executing to run the turbine. However, the GUI program may be 'Stopped' using a service tool (AppManager) and restarted at any time without affecting GAP or the turbine operation. This unique and useful feature of the 505 allows the following operations to be accomplished (if needed or desired) while the 505 control is operating the turbine.

- Change the language on the screen
- Update the GUI program (newer build revisions with improvement/enhancements)
- Upgrade the GUI program – load a custom version that may be created for a specific OEM or customer jobsite

Power-Up Screen

Viewed from the front the 505 – the following is the correct boot-up sequence of a 505 unit loaded with the standard 505 GAP and Qt GUI applications. Times are approximat.

- At Power-up** Screen = **BLANK /BLACK**
IOLOCK = **ON (RED)**
- After about 1:00** Screen = **"505 Splash Screen"**
TRIPPED/CPU/ALARM LED's will flash check
IOLOCK = **ON**

After about 1:15 TRIPPED=ON (RED)
 IOLOCK = OFF
 CPU = ON (GREEN)

After about 1:50 ALARM LED (YELLOW) Flashes/Blinks

After about 4:30 Screen = HOME



Figure 5-2. 505 Splash Screen

Any time that a Display application program is not running, the 'Splash Screen' will appear. If at power-up the alarm LED stops flashing and this screen still appears – then the GUI program has not initialized correctly.

Once the unit has been configured, all following power cycles will result in a screen similar to the following, dependent on what functionality has been configured. The numbers in () indicate that there is a quick keypad command to get to that screen. For example, pressing 2 will jump to the Speed Control screen, from that screen if you press 7 it will jump to the Startup Curve screen. From any operational screen, pressing HOME will always return to this screen

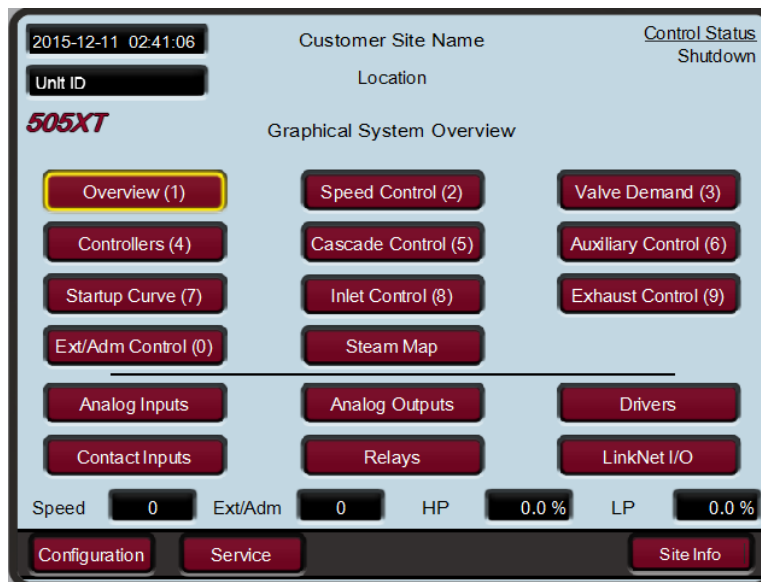


Figure 5-3. Boot-up to HOME Screen

Refer to Figure 4.1 for the view of an initial power-up of a non-configured unit.

There is a screen saver function that is invoked after a period of inactivity. It is defaulted to 4 hours (adjustable in Service / Screen Settings) – when this comes it a small version of the ‘Splash Screen’ will bounce around on the screen. Press any key to revive the display (maroon keys are recommended). When awaking from screen saver the user login level will be reduced to Operator. This also is adjustable in Service / Screen Settings if desired, it can be changed to awaken to Monitor.

On the HOME screen there is Site Information (Site Info) button that will open a pop-up screen containing the following parameters:

- The GAP and GUI application software part numbers running in the control
- The product model (either 505D or 505XT)
- The Control part number and serial number (only if the 5418-7839 GAP is running)
- An editable field for the user to enter a site name
- An editable field for the user to enter a location
- An editable field for the user to enter a unit identifier
- Newest software version will include a QR code on this pop-up for web access to technical info

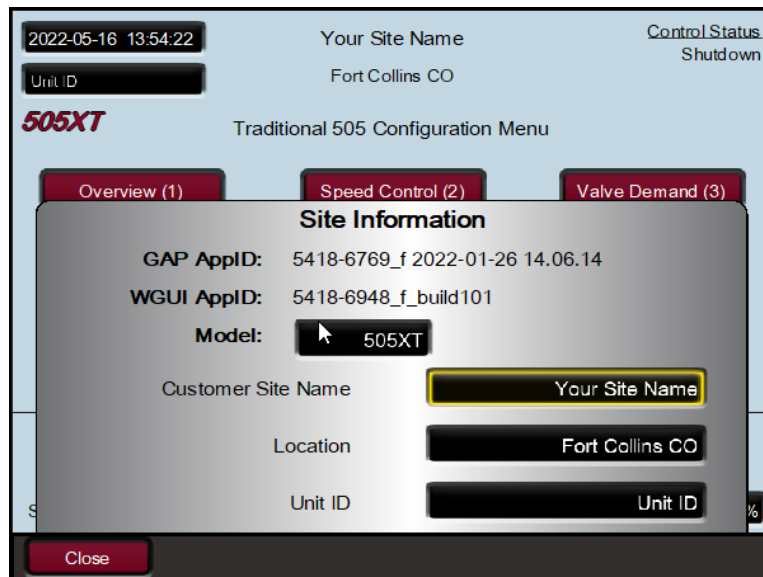


Figure 5-3a. Site Info Screen – For GAP 5418-6769 F (Coder 1.01 Versions)

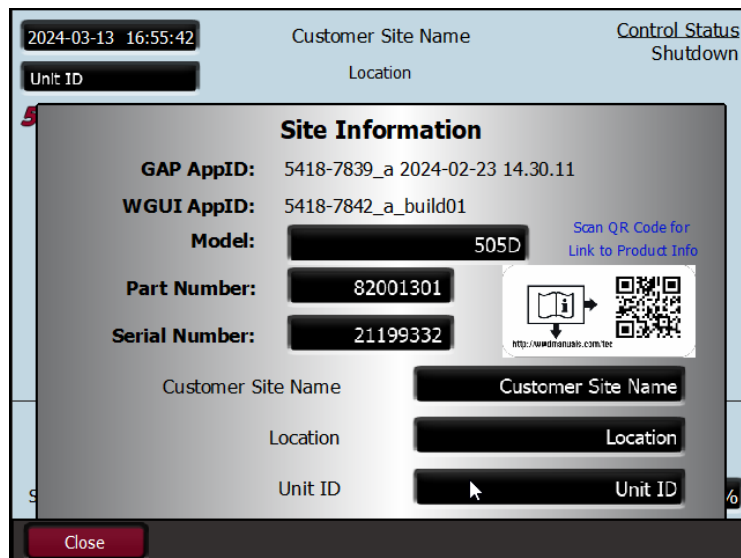


Figure 5-3b. Site Info Screen – For GAP 5418-7839 a - (Coder 1.04 Versions)

Control Mode Architecture

Basic control program architecture is illustrated in Figure 5-1. The 505's normal operating architecture divides the control into two states.

- Run – which includes Operation and Calibration modes
- Program - Configuration mode

Pressing the MODE key at any time will open the Login and Mode Screen

The Configuration Mode is used to configure the 505 for the specific application and set all operating parameters (see Chapter 4). In this mode the control will issue an IOLOCK (LED) and the state of all outputs from the 505 are disabled. This means that all relays are de-energized, and all analog/driver outputs are at zero current. Initially all 505's must be placed in this mode to enter a valid configuration of the I/O and functions desired for the specific turbine application.

The Calibration Mode is used after the configuration of the 505 is complete. It is used to perform calibration of signals, verification of speed signals and the forcing of outputs of the control in preparation to run the turbine. All I/O is functional in this state. To enter this mode the turbine must be TRIPPED (LED).

The Operation Mode is used to view operating parameters and run the turbine. This is the typical mode the control uses and is the default mode it enters at Power-up. All I/O is functional in this state. The turbine may be either running or not running in this mode.

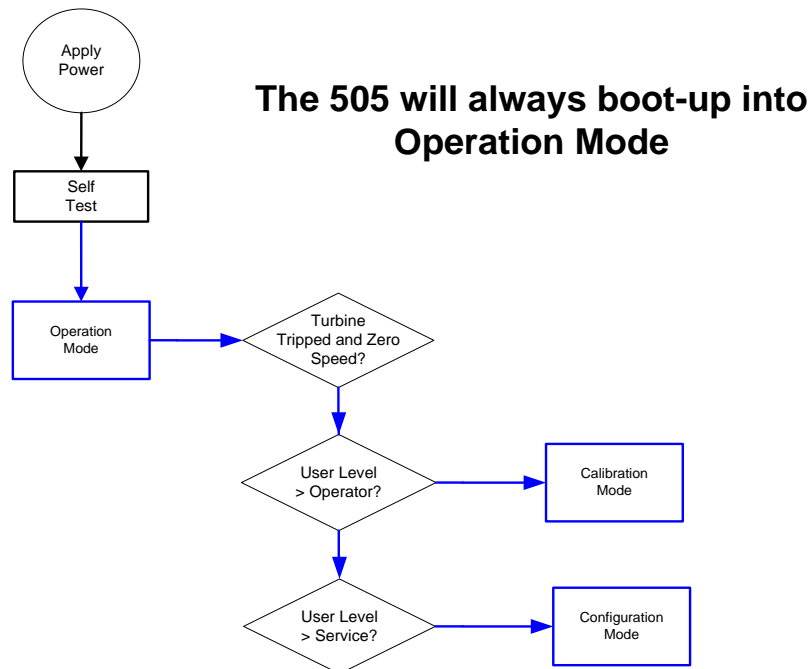


Figure 5-4. Control Mode Architecture

User Login Levels

Pressing the MODE key at any time will open the Login and Mode Screen

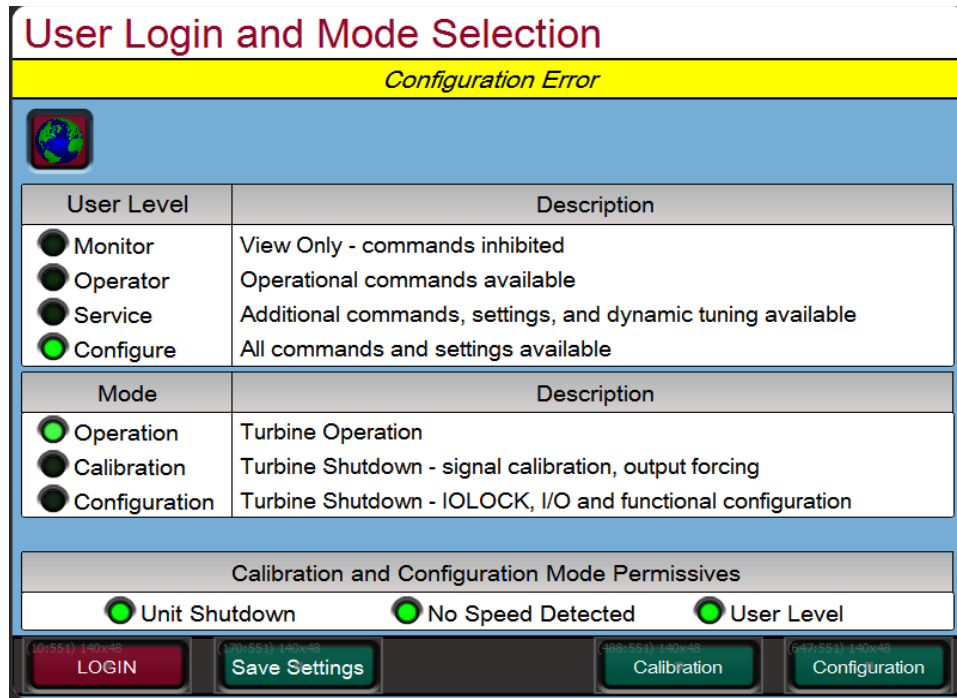


Figure 5-5. Mode Screen

Monitor – (logout to enter this)

Even Keypad Green keys inhibited

Operator – (passwords are provided in Vol 2 Appendix C)

Intended for normal turbine operation – default mode

Screen saver initiates to this level

Service – (passwords are provided in Vol 2 Appendix C)

Allows tuning of parameters, while turbine is running (PID dynamics) and entering of Calibration Mode

Configure – (passwords are provided in Vol 2 Appendix C)

Highest user authority / can enter any Mode

NOTICE

EMERGENCY STOP is always available in all modes and logins as it has direct H/W action to open the actuator circuits.

To Login –

1. Press the **LOGIN** button
2. ** Navigate so the Login or Password field is highlighted (in-focus)
3. Press **Enter** on the Navigation Cross
4. Use the keypad to enter the text field (**hold key down to scroll options**)
5. Press **Enter** on the Navigation Cross – to accept your entry

** Or you can navigate to the Autofill buttons and press Enter – it will auto-populate the Login information, so you only need to enter the Password.

To Change Languages on Display –

The 505XT supports six different display languages (English, Chinese, Japanese, Portuguese, Spanish, and Russian). To change the language, on this MODE Screen, navigate to the Globe Icon and press Enter. If you are logged in at user level Service or greater, you will see a list of language options to select from. After selecting the desired language, the GUI must be restarted to load the translation file for the

chosen language. The control will retain this setting after any future power cycles of the control. The RemoteView tool can also be run in any language and may be different than the local display.

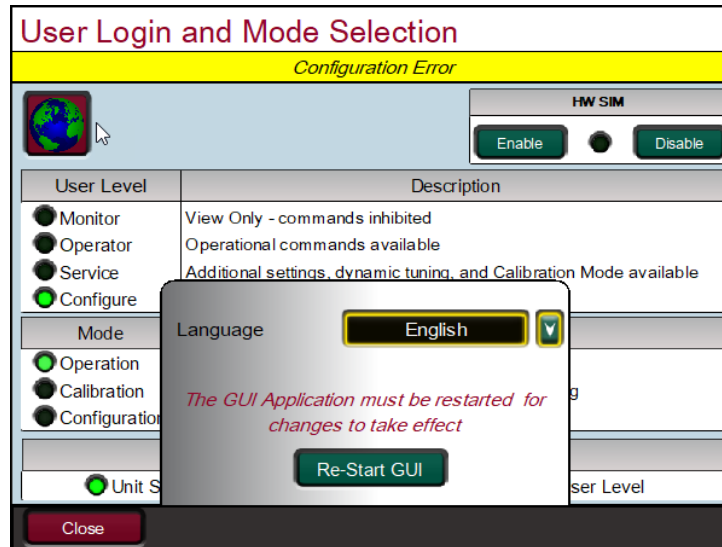


Figure 5-5a. Selecting Alternate Languages

Navigation

This is NOT a touchscreen! Due to quality, robustness, screen cleanliness and long-term reliability concerns Woodward chose not to implement a touchscreen directly on this product. Using the RemoteView tool a user can take advantage of either a mouse device or a touchscreen on an external computer, but for navigation and selection directly on the 505 display, buttons and an IN-Focus highlighter indication are used.

In general, the maroon buttons provide navigation from page-to-page and throughout the components on a page. Most of the navigation is done with the Navigation cross.

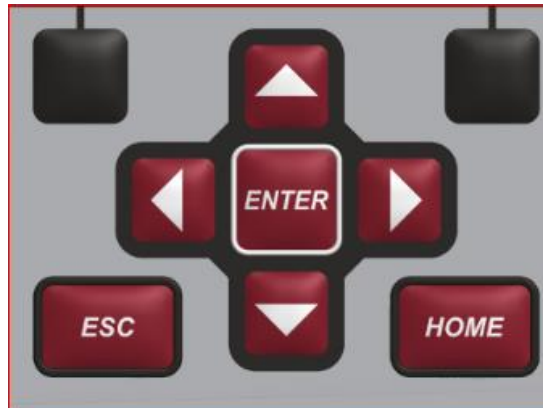


Figure 5-6. Navigation Cross

1. Use the "Arrow" buttons to move the IN-Focus highlighter to the desired page
2. Press the "Enter" button to launch the page selected
3. Press the "ESC" (Escape) button to go back 1 page from current page
4. Press the "HOME" button to return to the main menu *Note: If in Service or Configure menu a second press of HOME will return to the Operational Home screen*

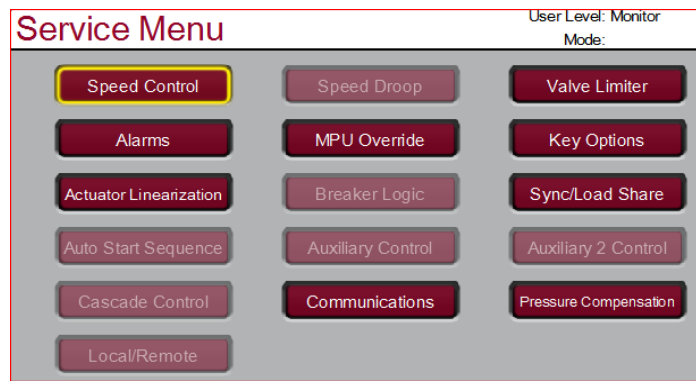


Figure 5-7. Service Menu Showing “Speed Control” IN-Focus

Page Organization

There are three primary menu lists that organize the access to all of the information that is available on the display. These menu lists are available at all times. The user simply uses the navigation cross to Focus on the desired page and press Enter or use the Black ‘soft keys’ (no Focus needed).

Run/Operation Menus - The HOME page contains the Run/Operation menus and is automatically updated to match the configuration of the control.

Service Menus - The Service ‘HOME’ page contains navigation buttons to all of the service-related parameters and special feature of the control and it too is automatically updated to match the configuration of the

Configuration Menus - The Configuration ‘HOME’ page contains navigation buttons to all features and options of the 505. When the unit is in Configure Mode (IOLOCK) the background of all pages will be a blue gradient as shown below, in addition to the status in the upper right.

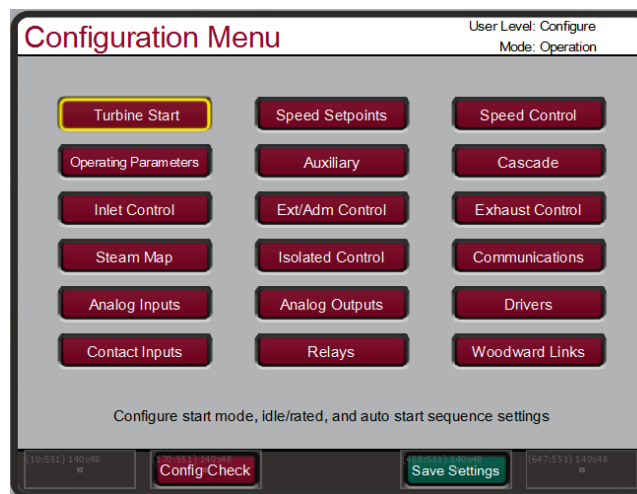


Figure 5-8. Configuration Menu – Operation Mode (View Only)

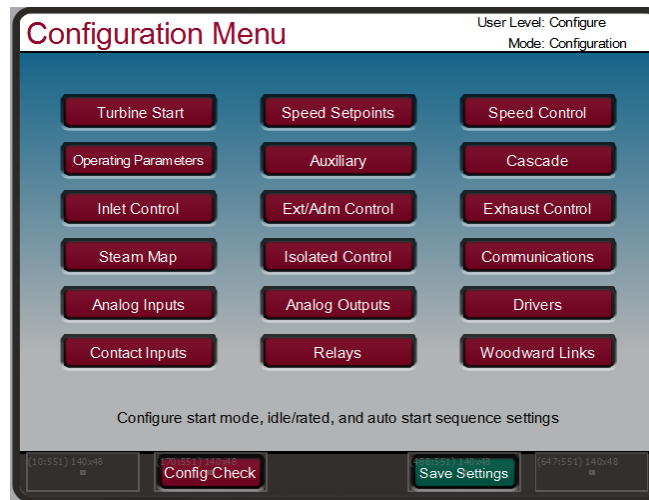


Figure 5-9. Configuration Menu – Configuration Mode (Edit)

Refer to Chapter 1 for more details about all of the keys – below are some general reminders about the keypad functions

Green keys – initiate operational commands

Red keys - navigate or enter values via the alpha numeric keys

Black keys – are software dependent and may do either, they never require 'IN-Focus' the command shown in above the key is always available

Start and Stop Keys – always require a Confirmation and user must be logged-in at appropriate User level (Operator or greater)

EMERGENCY STOP is always available in all modes and logins as it has direct H/W action to open the actuator circuits.

When entering string text from the keypad, holding down the key will make is slowly cycle through the characters available on that key. Releasing the key will select the character shown at that time.

Overview Screen

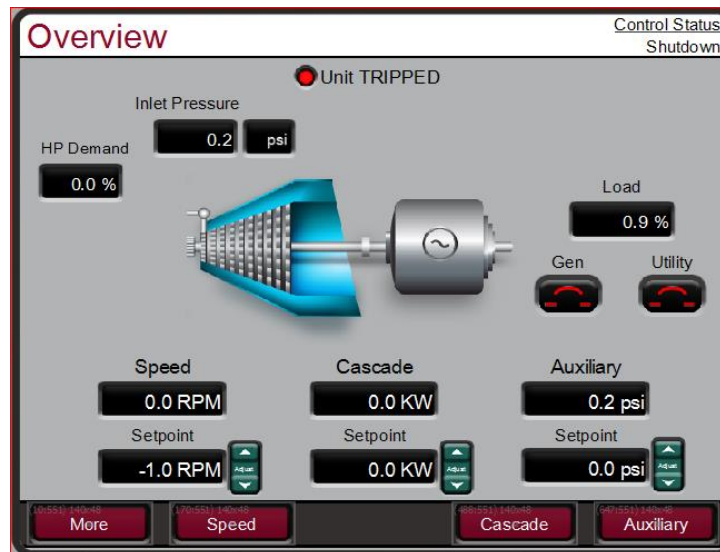


Figure 5-10. Overview Screen

The Overview screen will adapt to the configuration of the 505XT and show all configured options. During normal run operation, this screen should provide the user with all of the primary turbine parameter values and operational status.

The menu bar functions will allow the user to use typical operational commands related to the control loop selected – such as directly entering a setpoint or enabling or disabling a controller while remaining on the Overview page.

Speed Control Screen

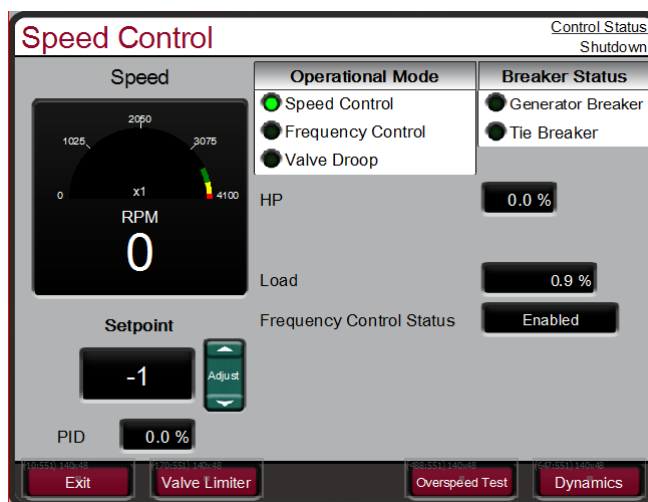


Figure 5-11. Speed Control Screen

The Speed Control screen will adapt to the configuration of the 505XT and show all configured options. During normal run operation, this screen provides the user with all details that are related to the turbine when operating in speed control.

The menu bar functions will allow the user to access a number of other screens that are related to speed control, such as directly entering a setpoint, access to the valve limiter feature, adjusting speed control dynamic settings, enabling or disabling a remote speed setpoint or performing an Overspeed test. For generator units, the breaker status of the breakers is shown and the menu bar will give the user access to Enabling the synchronizer.

Valve Demand Screen

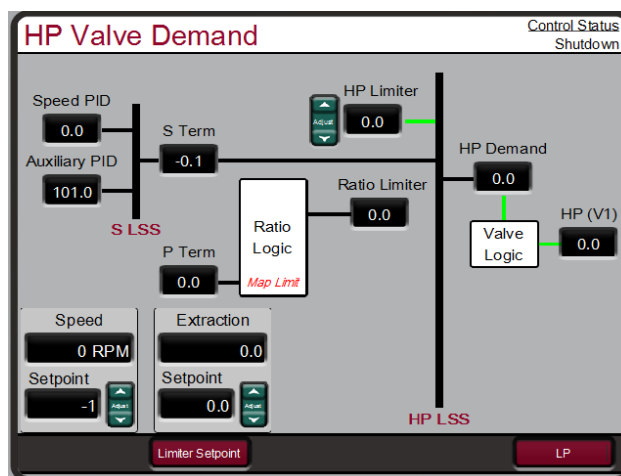


Figure 5-12. Valve Demand Screen

The Valve Demand screen will adapt to the configuration of the 505XT and show all configured options that can affect the final output demand to the HP valve. For Ext/Adm turbine configurations, it will have a navigation button to switch to the LP valve demand. During normal run operation, this screen provides the user with a clear picture of what control or ramp is controlling the valve demand output. The Low Signal Select (LSS) bus will output the lowest value seen at its inputs. The valve logic box represents options that may be used to adjust this value (such as valve linearization and/or pressure compensation) prior to output to the HP valve. If these options are not used, the HP valve demand output will always equal the LSS value.

During normal operation the Valve Limiter setting is at 100% and not limiting. Typically, the only time this parameter is adjusted is during a start sequence or to troubleshoot system dynamics problems.

The menu bar will allow the user to access the valve limiter setpoint and the manual valve demand (if configured for use).

Controllers Screen

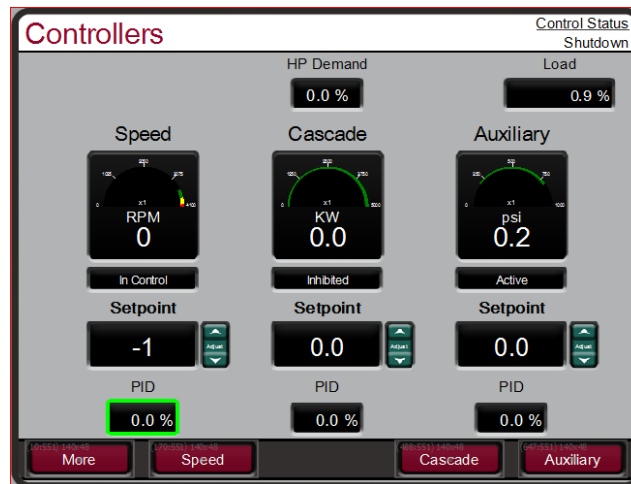


Figure 5-13. Controllers Screen

The Controllers screen will adapt to the configuration of the 505XT and show all configured options. During normal run operation, this screen provides the user with information similar to the Overview, but in a graphical gauge view. It provides larger values for distance viewing and control PID information which is useful for monitoring when the 505 is near transition points between controllers or limiters.

The menu bar functions will allow the user to use typical operational commands related to the control loop selected – such as directly entering a setpoint or enabling or disabling a controller while remaining on the Controllers page

Cascade Control Screen

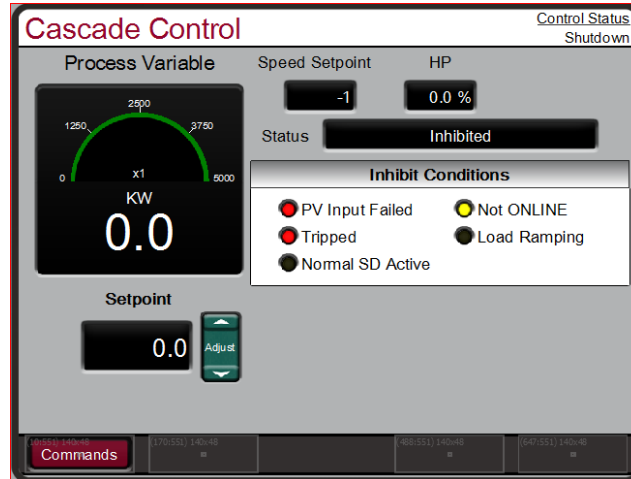


Figure 5-14. Cascade Control Screen

The Cascade Control screen will adapt to the configuration of the 505XT. During normal run operation, this screen provides the user with all details that are related to the cascade control loop. The cascade control output determines the setpoint for the speed control. This allows the 505 to vary the speed control setpoint as it relates to another process variable selected by the user.

The menu bar functions will allow the user to access a number of other screens that are related to cascade control, such as directly entering a setpoint, access to the valve limiter, or adjusting cascade control dynamic settings.

Auxiliary Control Screen

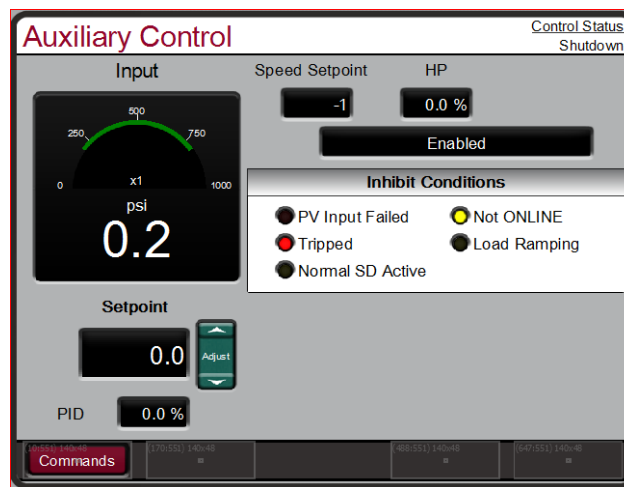


Figure 5-15. Auxiliary Control Screen

The Auxiliary Control screen will adapt to the configuration of the 505XT. During normal run operation, this screen provides the user with all details that are related to the auxiliary control loop. The auxiliary control output goes to the LSS bus and can directly affect the HP valve demand output. This can be configured as a limiter or a controller. If it is a limiter, it will always be enabled and provide protection related to the process variable being used for this function. When configured as a controller it will disable the speed PID whenever it is enabled.

The menu bar functions will allow the user to access a number of other screens that are related to auxiliary control, such as directly entering a setpoint, access to the valve limiter, or adjusting auxiliary control dynamic settings.

Inlet Control Screen

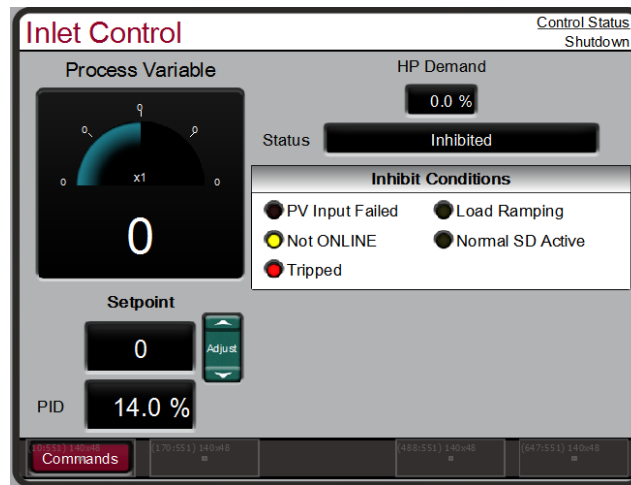


Figure 5-16. Inlet Steam Pressure Control Screen

The Inlet Pressure Control screen will adapt to the configuration of the 505XT. During normal run operation, this screen provides the user with all details that are related to the inlet pressure control loop. This can be configured as a limiter or a controller, depending on the turbine type.

On a single valve turbine it can be setup as a limiter, during which it will always be enabled and provide protection related to the process variable being used for this function. When configured as a controller it will disable the speed PID whenever it's enabled. The inlet pressure control output goes to the LSS bus and can directly affect the HP valve demand output.

On an Ext/Adm turbine, this is always a controller and the output of this PID goes into the Ratio Limiter logic, where it can be used in alternate control modes as a primary or secondary controller.

The menu bar functions will allow the user to access a number of other screens that are related to inlet pressure control, such as directly entering a setpoint, access to the valve limiter, or adjusting auxiliary control dynamic settings

Extraction/Admission Control Screen

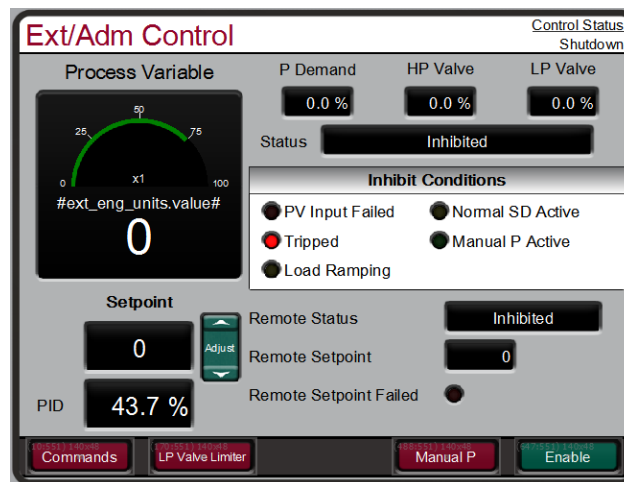


Figure 5-17. Ext/Adm Pressure Control Screen

The Extraction/Admission Control screen will adapt to the configuration of the 505XT. During normal run operation, this screen provides the user with all details that are related to the ext/adm control loop. The ext/adm control output goes into the Ratio Limiter control logic and will affect both the HP and LP valve demand outputs. This is only configured to be a controller.

The menu bar functions will allow the user to access a number of other screens that are related to ext/adm control, such as directly entering a setpoint, access to the valve limiter, or adjusting ext/adm control dynamic settings

Exhaust Control Screen

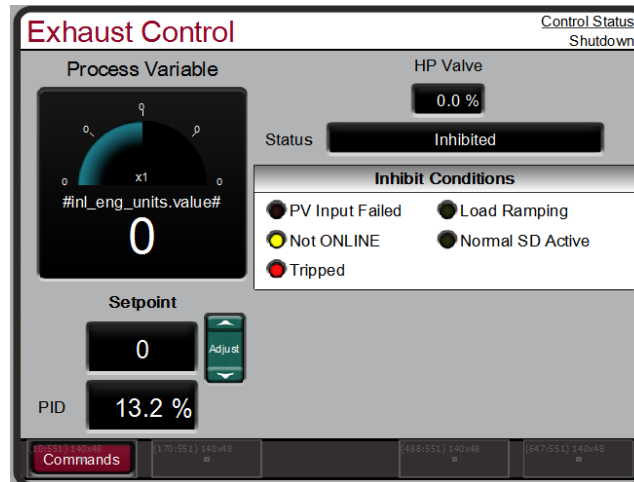


Figure 5-18. Exhaust Pressure Control Screen

The Exhaust Pressure Control screen will adapt to the configuration of the 505XT. During normal run operation, this screen provides the user with all details that are related to the exhaust pressure control loop. This can be configured as a limiter or a controller, depending on the turbine type. On a single valve turbine it can be setup as a limiter, during which it will always be enabled and provide protection related to the process variable being used for this function. When configured as a controller it will disable the speed PID whenever it's enabled. The exhaust pressure control output goes to the LSS bus and can directly affect the HP valve demand output. On an Ext/Adm turbine this is always a controller and the output of this PID goes into the Ratio Limiter logic, where it can be used in alternate control modes as a primary or secondary controller.

The menu bar functions will allow the user to access a number of other screens that are related to exhaust pressure control, such as directly entering a setpoint, access to the valve limiter, or adjusting exhaust pressure control dynamic settings.

Steam Map Screen

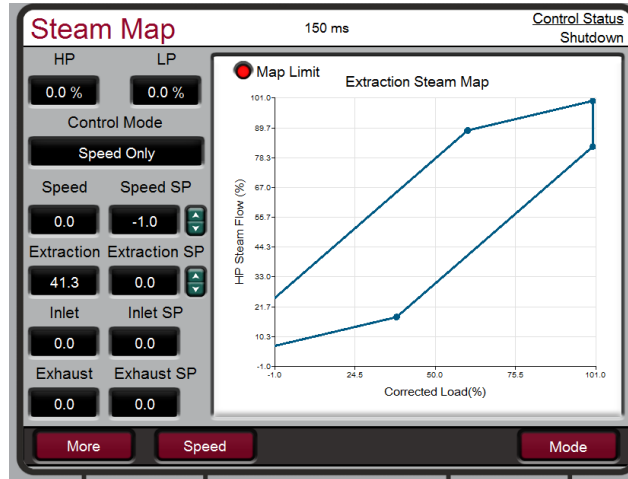


Figure 5-19. Steam Map Screen

The Steam Map Screen will be available for Extraction/Admission turbines. This page allows for real time viewing of the Operating Point within the steam map. This page can be used to adjust the Operating Point by manipulating the controller setpoints. This page is also used to initiate transfers to Alternate Modes of control from the 'Mode' Pop-up, shown below.

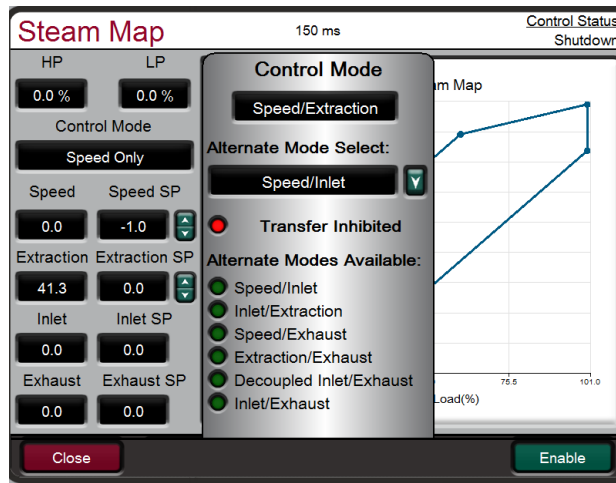


Figure 5-20. Steam Map – Mode Pop-up

Analog Input Summary Screen

Fault	Function	Tag	Value	Units
AI_01	KW/Unit Load Input	AI_01	6562.5	KW
AI_02	Inlet Pressure Input	AI_02	0.2	psi
AI_03	Not Used	AI_03	0.0	ENG Units
AI_04	Not Used	AI_04	-25.0	ENG Units
AI_05	Not Used	AI_05	0.0	ENG Units
AI_06	Not Used	AI_06	0.0	ENG Units
AI_07	Not Used	AI_07	0.0	ENG Units
AI_08	Not Used	AI_08	-25.0	ENG Units

Navigation buttons: Back, Speed Signal 1, Speed Signal 2

Figure 5-21. Analog Input Summary Screen

The Analog Input Summary screen will display the status of all channels available on the 505 hardware. The fault status, function, device tag, engineering value and units are shown for each channel as well as navigation buttons for each channel that take the user to a page showing all parameters available for that input.

The menu bar functions will allow the user to access the detailed page of the speed input signals

Contact Input Summary Screen

Status	Function	Tag
Contact 01	Emergency Stop	Contact BI01
Contact 02	Not Used	Contact BI02
Contact 03	Not Used	Contact BI03
Contact 04	Not Used	Contact BI04
Contact 05	Not Used	Contact BI05
Contact 06	Not Used	Contact BI06
Contact 07	Not Used	Contact BI07
Contact 08	Not Used	Contact BI08

Navigation buttons: Back, Contacts 9-16, Contacts 17-20

Figure 5-22. Contact Input Summary Screen

The Contact Input Summary screen will display the status of channels available on the 505 hardware. The fault status, function, and device tags are shown for each channel as well as navigation buttons for each channel that take the user to a page showing all parameters available for that input.

The contact input summary is broken into three pages and the menu bar contains navigation buttons to view all the channels

Analog Output Summary Screen

	Fault	Function	Tag	Value	Units
AO_01	●	Not Used	AO 01	0.0	Eng Units
AO_02	●	Not Used	AO 02	0.0	Eng Units
AO_03	●	Not Used	AO 03	0.0	Eng Units
AO_04	●	Not Used	AO 04	0.0	Eng Units
AO_05	●	Not Used	AO 05	0.0	Eng Units
AO_06	●	Not Used	AO 06	0.0	Eng Units

Figure 5-23. Analog Output Summary Screen

The Analog Output Summary screen will display the status of all channels available on the 505 hardware. The fault status, function, device tag, engineering value and units are shown for each channel as well as navigation buttons for each channel that take the user to a page showing all parameters available for that output.

Relay Output Summary Screen

	Status	Function	Tag
Relay 01	●	Trip Relay	Relay 01
Relay 02	●	Not Used	Relay 02
Relay 03	●	Not Used	Relay 03
Relay 04	●	Not Used	Relay 04
Relay 05	●	Not Used	Relay 05
Relay 06	●	Not Used	Relay 06
Relay 07	●	Not Used	Relay 07
Relay 08	●	Not Used	Relay 08

Figure 5-24. Relay Output Summary Screen

The Relay Output Summary screen will display the status of all channels available on the 505 hardware. The coil status, function, and device tag are shown for each channel as well as navigation buttons for each channel that take the user to a page showing all parameters available for that output.

Actuator Driver Summary Screen

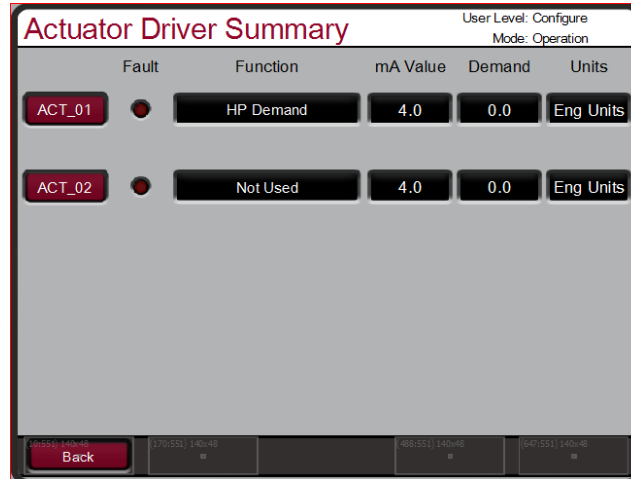


Figure 5-25. Actuator Driver Summary Screen

The Actuator Driver Summary screen will display the status of the 2 channels available on the 505 hardware. The fault status, function, current value (in mA), engineering value and units are shown for each channel as well as navigation buttons for each channel that take the user to a page showing all parameters available for that input.

Starting Procedures (Start Curve Screen)



Figure 5-26. HOME Menu Showing “Startup Curve” IN-Focus

Refer to the turbine manufacturer’s operating procedures for complete information on turbine start up, and Chapter 3 of this manual for a step-by-step procedure, depending on the start mode selected. The following is a typical start-up procedure:

**WARNING**

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.

1. Press the RESET key to clear all alarms and trips. If the 505's RESET CLEARS TRIP setting is programmed "YES", the 505's shutdown relay will reset or energize upon pressing the RESET key after a shutdown. If the RESET CLEARS TRIP OUTPUT setting is programmed "NO", the 505's shutdown relay will reset or energize upon pressing the Reset key ONLY after all trip conditions are cleared.
2. Press the START key and Confirm, to initiate the selected start-up mode. This will function from any screen, but it is recommended to be on the Startup Curve page during the turbine startup. It will automatically be matched to show the correct information relative to the start sequence that has been configured. If a semi-automatic start mode is configured, the valve limiter must be manually increased to open the control valve.

A 'Start Perm Not Closed' alarm will be issued if the application is using a Start Permissive contact input and this contact input was not closed when the RUN command was issued.

3. After the selected start-up mode has been performed, the turbine will operate at the minimum or idle speed setting. The 505's speed set point will move to minimum governor speed unless an idle speed is programmed. The idle/rated or auto start sequence functions must be programmed for the turbine to control at idle speed. An operator at this time may vary turbine speed through the 505's keypad, external switches or communication links.

Overspeed Test Function (Speed Control Screen)

The 505's overspeed test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505's internal overspeed trip logic and any external overspeed trip device's settings and logic. Figure 5-11 shows the screen that is displayed when the 'Overspeed Test' key is pressed from the Speed Control page. It shows the permissives required to be able to perform an overspeed test (in the case of a mechanical drive application the Generator Breaker Open is not shown)

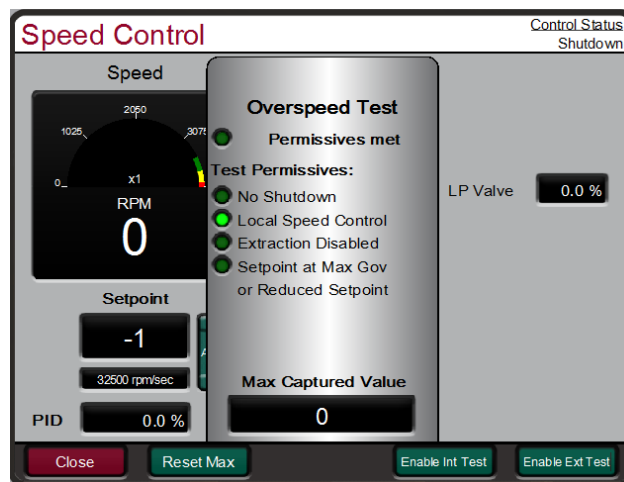


Figure 5-27. Overspeed Test Permissives

**WARNING**

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.

Overspeed Test Procedure (From the 505 Display)

- Be sure the generator breaker is open if unit is a generator drive
- Raise the Speed Set Point to the maximum governor setting
- If desired, clear the 'Highest Speed Reached' value, to record the highest speed reached during this overspeed test. (Reset Max key)
- This function has a safety timeout to ensure the unit does not run in this mode unattended. Once the mode is entered, the user must begin to raise the speed within 30 seconds. As long as the user is adjusting the speed the timeout value will be reset.
- Timeout value is shown, if it expires the test mode will be aborted and the unit will return to the maximum governor limit

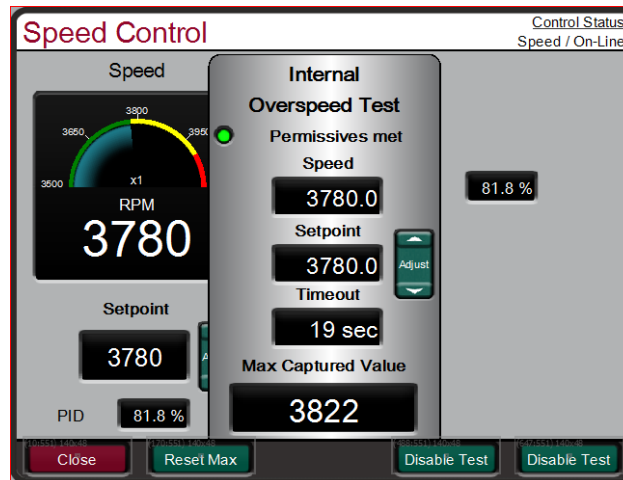


Figure 5-28. Internal (505) Overspeed Test

- To perform an Internal Overspeed Test Press the Enable Int Test key and the above pop-up page will appear. An alarm will be annunciated that indicates Overspeed Test Enabled.
- Put the Adjust button in focus and use the ADJUST key to raise the speed above the normal max governor limit.
- Once turbine speed reaches the 505's internal OVERSPEED TRIP (rpm) setting, the 505 will TRIP the turbine.

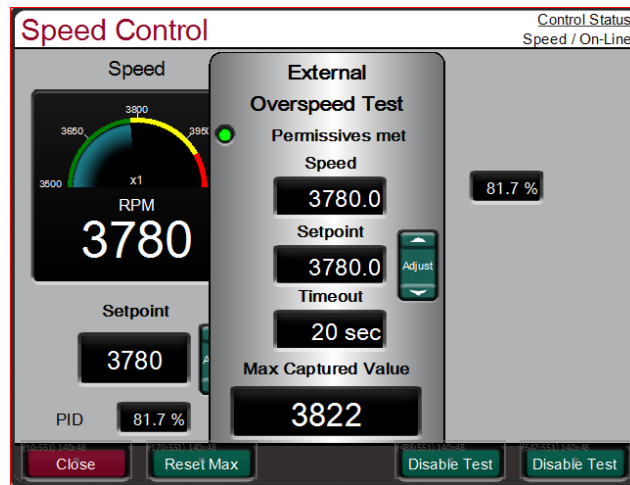


Figure 5-29. External Overspeed Test

An external trip test is intended to be used to test the unit's safety overspeed protection device (in many cases a Woodward ProTech). In this mode the 505 internal overspeed trip will be changed to be just an alarm and the 505 will allow the speed to continue increasing up to the Overspeed Test Limit (rpm). If the 505 speed OR the Setpoint reaches the Overspeed Test Limit it will TRIP

- To perform an External Overspeed Test Press the Enable Ext Test key and the above pop-up page will appear. An alarm will be annunciated that indicates Overspeed Test Enabled
- Put the Adjust button in Focus and use the ADJUST key to raise the speed above the normal Max Governor limit.
- Once turbine speed reaches the 505's internal OVERSPEED TRIP (rpm) setting, the 505 will trigger an alarm that this has been reached
- If the timeout expires while the unit is above the Overspeed Trip setting, but below the Overspeed Test Limit, the 505 will Trip on Overspeed
- If the Speed or the Setpoint reach the Overspeed Test Limit the 505 will issue a Trip

NOTICE

In the configuration of Speed Setpoints be sure that the Overspeed Test Limit rpm value is above the expected Overspeed setting of the external safety overspeed protection device.

It is recommended to perform Overspeed Tests from these screens, either at the control (preferred) or via the RemoteView service tool. Alternatively, the turbine's overspeed logic and circuitry can be tested remotely, by programming an Overspeed Test contact input. The overspeed test contact functions as the enable external test on the display. When the conditions outlined in the above procedure are met, closing this contact allows the Speed set point to be increased up to the "overspeed test limit" setting. The testing procedure is similar to using the OSPD key. An Overspeed Test Enabled relay can be programmed to provide the status feedback that testing is enabled.

The overspeed test function cannot be performed over the Modbus communications, however, the Overspeed Test Permissive, Overspeed Test In Progress, Overspeed Alarm, and Overspeed Trip indications are available through Modbus.

Stop Key

The STOP key is used to perform a controlled/manual turbine shutdown or stop. To perform a manual shutdown, press the STOP key and confirm from the keypad or close the Controlled Shutdown contact input (if programmed) or select Controlled Shutdown from a Modbus communications link. Once initiated, the display dialog box will change to give the user the option to abort the normal stop sequence. This dialog box will close after 10 seconds but can be reopened by pressing the STOP key. This function can

also be stopped by opening the contact or selecting Abort Controlled Shutdown from a Modbus communications link.

Alarm Summary

The ALARM screen is always available with the VIEW button under the ALARM LED. When an alarm is detected, it gets latched in the event logic, the alarm relay is energized, and the ALARM LED illuminates (Yellow). The cause of the event will be indicated with an Event ID, description and time/date stamp on the Alarm Summary page. The list will always place the first event at the top of the list, if more than one alarm condition is present, they will all be listed with their corresponding time stamp.

To clear any alarms that are no longer present, press the RESET key, close the Reset contact input, or select Reset from either Modbus communications link. If the cause of the event has been corrected the alarm will clear, if not it will remain, and the timestamp will remain unchanged.

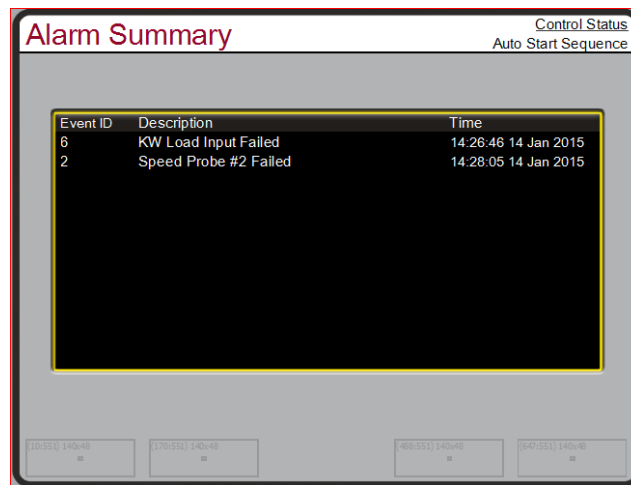


Figure 5-30. ALARM Screen

Each individual alarm condition is available through the Modbus links to monitor the control status. A common alarm indication is also provided.

Relay indications can be programmed to indicate a 505 Common Alarm, in addition to the dedicated alarm relay output.

The table below lists all the potential alarm conditions and their Event ID.

Table 5-1. ALARM Messages

Event ID	DESCRIPTION	MEANING
1	Speed Probe #1 Failed	Speed probe #1 failure—(< Failed Speed Level or 1 Vrms)
2	Speed Probe #2 Failed	Speed probe #2 failure—(< Failed Speed Level or 1 Vrms)
3	Remote Spd Input Failed	Remote Speed Setpt analog input failure (> 22 mA or < 2 mA)
4	Sync Input Failed	Sync analog input failure detected (> 22 mA or < 2 mA)
5	Load Share Input Failed	Sync/LS analog input failure detected (> 22 mA or < 2 mA)
6	KW Load Input Failed	KW analog input failure detected (> 22 mA or < 2 mA)
7	Cascade Input Failed	Cascade analog input failure detected (> 22 mA or < 2 mA)
8	Remote Cascade Input Failed	Remote Cascade Setpt analog input failure (> 22 mA or < 2 mA)
9	AUX Input Failed	Auxiliary analog input failure detected (> 22 mA or < 2 mA)
10	Remote AUX Input Failed	Remote Aux Setpt analog input failure (> 22 mA or < 2 mA)
11	Spare_11	N/A
12	Spare_12	N/A

Event ID	DESCRIPTION	MEANING
13	Inlet Press Input Failed	Inlet Header Pressure analog input failure detected (> 22 mA or < 2 mA)
14	IH-A Input press AI FLT	Fault indication from hydraulic pressure unit A
15	IH-B Input press AI FLT	Fault indication from hydraulic pressure unit B
16	Feed-forward input failed	Feed-forward analog input failure detected (> 22 mA or < 2 mA)
17	Remote Droop Fault	Remote Droop Setting analog input failure detected (> 22 mA or < 2 mA)
18	Remote KW Setpoint Failed	Remote KW Setpt analog input failure (> 22 mA or < 2 mA)
19	Exhaust Press Input Failed	Exhaust Pressure analog input failure detected (> 22 mA or < 2 mA)
20	Temp for Hot/Cold Starts Failed	Temp for Hot/Cold analog input failure detected (> 22 mA or < 2 mA)
21	HP Valve Feedback Failed	HP position FDBK analog input failure detected (> 22 mA or < 2 mA)
22	HP2 Valve Feedback Failed	HP2 position FDBK analog input failure detected (> 22 mA or < 2 mA)
23	Isolated PID PV Failed	Isolated PV analog input failure detected (> 22 mA or < 2 mA)
24	Rem SP Isolated PID Failed	Rem Setpoint for Iso analog input failure detected (> 22 mA or < 2 mA)
25	Customer Input #1 Failed	Customer analog input 1 failure detected (> 22 mA or < 2 mA)
26	Customer Input #2 Failed	Customer analog input 2 failure detected (> 22 mA or < 2 mA)
27	Customer Input #3 Failed	Customer analog input 3 failure detected (> 22 mA or < 2 mA)
28	Start Temperature 1 Failed	Start Temp 1 analog input failure detected (> 22 mA or < 2 mA)
29	Start Temperature 2 Failed	Start Temp 2 analog input failure detected (> 22 mA or < 2 mA)
30	Extraction/Admission Input Failed	Ext/Adm analog input failure detected (> 22 mA or < 2 mA)
31	Remote Extr/Adm SP Input Failed	Remote Ext/Adm Setpoint analog input failure detected (> 22 mA or < 2 mA)
32	External Alarm # 1	External Alarm #1 from contact input
33	External Alarm # 2	External Alarm #2 from contact input
34	External Alarm # 3	External Alarm #3 from contact input
35	External Alarm # 4	External Alarm #4 from contact input
36	External Alarm # 5	External Alarm #5 from contact input
37	External Alarm # 6	External Alarm #6 from contact input
38	External Alarm # 7	External Alarm #7 from contact input
39	External Alarm # 8	External Alarm #8 from contact input
40	External Alarm # 9	External Alarm #9 from contact input
41	IH-act1 Failed from BI	Fault indication from current-to-hydraulic Actuator 1 (CPC)
42	IH-act2 Failed from BI	Fault indication from current-to-hydraulic Actuator 2 (CPC)
43	HP Actuator Fault (Act1 or 2)	HP Actuator fault detected (open or short circuit was sensed)
44	HP2 Actuator Fault (Act1 or 2)	HP2 Actuator fault detected (open or short circuit was sensed)
45	Start Perm Not Closed	Run selected while the Start Perm contact in was not closed
46	Mod Comm Link #1 Failed	Modbus com link #1 was detected as failed—time out error
47	Mod Comm Link #2 Failed	Modbus com link #2 was detected as failed—time out error
48	Mod Comm Link #3 Failed	Modbus com link #3 was detected as failed—time out error
49	AO_01 Readback Fault	Analog Output Chan 1 readback failure detected (> 22 mA or < 2 mA)
50	AO_02 Readback Fault	Analog Output Chan 2 readback failure detected (> 22 mA or < 2 mA)
51	AO_03 Readback Fault	Analog Output Chan 3 readback failure detected (> 22 mA or < 2 mA)
52	AO_04 Readback Fault	Analog Output Chan 4 readback failure detected (> 22 mA or < 2 mA)
53	AO_05 Readback Fault	Analog Output Chan 5 readback failure detected (> 22 mA or < 2 mA)
54	AO_06 Readback Fault	Analog Output Chan 6 readback failure detected (> 22 mA or < 2 mA)
55	Chassis Summary Alarm	1- Display Backlight Fault 2- CPU OS fault

Event ID	DESCRIPTION	MEANING
		3- 505 Internal temp is high (> 70 deg C) 4- Unit Calibration Fault (Factory Calibration)
56	Turbine Tripped	Turbine is tripped alarm indication
57	Overspeed	Turbine overspeed alarm
58	Overspeed Test Enabled	Overspeed Test mode is Active
59	TIE Breaker Opened	Utility Tie breaker was opened after it was closed
60	GEN Breaker Opened	Generator breaker was opened after it was closed
61	Tie Open / No Auxiliary	Utility Tie breaker was opened when Auxiliary was active
62	Gen Open / No Auxiliary	Generator breaker was opened when Auxiliary was active
63	Tie Open / No Cascade	Utility Tie breaker was opened when Cascade was active
64	Gen Open / No Cascade	Generator breaker was opened when Cascade was active
65	Tie Open / No Remote	Util. Tie breaker was opened when Remote Spd Setpt was active
66	Gen Open / No Remote	Generator breaker was opened when Remote Spd Setpt was active
67	Stuck In Critical Band	Turbine is stagnating within critical speed window
68	505 Display Comm Fault	GAP to Display communication failed
69	HP Valve Pos Fdbk Diff ALM	HP Demand versus Feedback Difference
70	HP2 Valve Pos Fdbk Diff ALM	HP2 Demand versus Feedback Difference
71	Limiter in Control	HP Valve is on a Limiter
72	Inlet Steam Pressure Lvl1 ALM	Inlet Steam Pressure passed alarm level 1 limit
73	Inlet Steam Pressure Lvl2 ALM	Inlet Steam Pressure passed alarm level 2 limit
74	Exh Steam Pressure Lvl1 ALM	Exhaust Steam Pressure passed alarm level 1 limit
75	Exh Steam Pressure Lvl2 ALM	Exhaust Steam Pressure passed alarm level 2 limit
76	Selected PV 1 Level 1 ALM	Signal Monitoring #1 passed alarm level 1 limit
77	Selected PV 1 Level 2 ALM	Signal Monitoring #1 passed alarm level 2 limit
78	Selected PV 2 Level 1 ALM	Signal Monitoring #2 passed alarm level 1 limit
79	Selected PV 2 Level 2 ALM	Signal Monitoring #2 passed alarm level 2 limit
80	Selected PV 3 Level 1 ALM	Signal Monitoring #3 passed alarm level 1 limit
81	Selected PV 3 Level 2 ALM	Signal Monitoring #3 passed alarm level 2 limit
82	Tunable Alarm	reserved - not used (available in debug for testing)
83	Tie Open / No Inlet	Utility Tie breaker was opened when Inlet Pressure control was active
84	Gen Open / No Inlet	Generator breaker was opened when Inlet Pressure control was active
85	Actuator 1 Readout Fault	Actuator Driver Chan 1 readback failure detected
86	Actuator 3 Readout Fault	Actuator Driver Chan 2 readback failure detected
87	CAN1_DVP1 Summary ALM	Summary Alarm from VariStroke device – Digital Valve Positioner 1 (DVP1)
88	CAN1_DVP2 Summary ALM	Summary Alarm from VariStroke device – Digital Valve Positioner 2 (DVP2)
89	HP Actuator Fault (DVP1 or 2)	HP Actuator fault detected (CAN1 link to VariStroke)
90	HP2 Actuator Fault (DVP1 or 2)	HP2 Actuator fault detected (CAN1 link to VariStroke)
91	Comm Link to DSLC2 Failed	Digital Comm Link to DSLC-2 Failed
92	KW Load AI Failed	Primary Load signal failure detected (comm link or AI)
93	Turbine Maintenance Interval Alm	Turbine Run Hours Reached Maintenance Interval
94	Start Temp #1 Override Active	Override of Start Temperature #1 Signal is Active
95	Start Temp #2 Override Active	Override of Start Temperature #2 Signal is Active
96	Comm Link to easYgen Failed	Digital Comm Link to easYgen Failed
97	Comm Link to LS-5 Failed	Digital Comm Link to LS-5 Failed
98	Comm Link to MFR300 Failed	Digital Comm Link to MFR300 Failed
99	Comm Link to HiProtec Failed	Digital Comm Link to HiProtec Failed
100	MPU1 Failed Open Wire Test	Open wire detected on speed signal circuit channel 1
101	MPU2 Failed Open Wire Test	Open wire detected on speed signal circuit channel 2
102	Internal HW Simulation Enabled	Internal 505 SIMULATION Mode Active

Event ID	DESCRIPTION	MEANING
103	Pressure Compensation Curve Error	Pressure Comp curve error on X-Y points
104	Actuator Linearization Curve Error	Output valve curve error on X-Y points
105	Remote Manual P Demand Input Failed	Remote manual P Demand analog input failure detected (> 22 mA or < 2 mA)
106	Remote Exhaust SP Input Failed	Remote Exhaust Setpoint analog input failure detected (> 22 mA or < 2 mA)
107	Remote Inlet Pressure SP Input Failed	Remote Inlet Setpoint analog input failure detected (> 22 mA or < 2 mA)
108	LP Position Feedback Input Failed	LP Valve Position Feedback analog input failure detected (> 22 mA or < 2 mA)
109	Reverse Rotation Detected	Turbine is rotating in reverse direction
110	LinkNet Summary Alarm	An alarm exists on a LinkNet node – check the LinkNet summary screen for details
111	Tie Open / No Extraction	Utility Tie breaker was opened when Extraction Pressure control was active
112	Gen Open / No Extraction	Generator breaker was opened when Extraction Pressure control was active
113	Tie Open / No Exhaust	Utility Tie breaker was opened when Exhaust Pressure control was active
114	Gen Open / No Exhaust	Generator breaker was opened when Exhaust Pressure control was active
115	LP Actuator Fault (Act1 or 2)	LP Actuator fault detected (open or short circuit was sensed)
116	LP Actuator Fault ALM (DVP1 or 2)	LP Actuator fault detected (CAN1 link to VariStroke)
117	Speed Below Min - No Extraction	Extraction inhibited or disabled because speed is below Min speed allowed for Extraction
118	LP Lmtr->No Spd Cntl->Ratio Lmtr Dsbl	Control disabled Extraction and transferred to Speed control only because LP Limiter reached Min P Limit
119	External Alarm # 10	External Alarm #10 from contact input
120	External Alarm # 11	External Alarm #11 from contact input
121	External Alarm # 12	External Alarm #12 from contact input
122	External Alarm # 13	External Alarm #13 from contact input
123	External Alarm # 14	External Alarm #14 from contact input
124	External Alarm # 15	External Alarm #15 from contact input
125	Alternate Mode Map Error	Steam Map values entered will cause potentially unstable control in an Alternate Mode. Verify correct sign on resulting D values
126	LP Valve Pos Fdbk Diff ALM	LP Demand versus Feedback Difference
127	LP Linearization Alarm	Output valve curve error on X-Y points
128	Operating on Perf Map Limit	Unit is running on a performance map limit
129	Online Map Adjust Enabled	Operator has enabled 'online' steam map definitions adjustments
130	HP Coil A Fault	Driver output signal to HP coil A failed
131	HP Coil B Fault	Driver output signal to HP coil B failed
132	Excessive Speed during Warmup	Turbine speed exceeded limit for Warmup
133	Spare_133	Spare
134	LP Coil A Fault	Driver output signal to LP coil A failed
135	LP Coil B Fault	Driver output signal to LP coil B failed
136	LP Actuator A Fault	Driver output signal to LP Actuator A failed
137	LP Actuator B Fault	Driver output signal to LP Actuator B failed
138	LP2 Actuator Fault	Driver output signal to LP2 Actuator failed
139	TTV Pos FDBK Fault	Position Feedback from Trip/Throttle Valve failed
140	TTV Dmd vs Pos FDBK Diff	TTV Demand vs Position Feedback Difference

Event ID	DESCRIPTION	MEANING
141	Grid Freq Deviation - Activate PFC	Grid/Utility frequency deviated from rated – activating Primary Frequency Control actions
142	Speed Sensor Difference Alarm	Speed Difference exists between speed probes
143	SPC11 Alarm Summary	Summary alarm from SPC Node 11 device
144	SPC12 Alarm Summary	Summary alarm from SPC Node 12 device
145	SPC13 Alarm Summary	Summary alarm from SPC Node 13 device
146	SPC14 Alarm Summary	Summary alarm from SPC Node 14 device
147	Secondary Load Input Failed	Secondary Load signal failure detected (comm link or AI)
148	Primary SYNC Input Failed	Primary SYNC signal failure detected (comm link or AI)
149	Secondary SYNC Input Failed	Secondary SYNC signal failure detected (comm link or AI)
150	Primary Sync/LS Input Failed	Primary SYNC/LS signal failure detected (comm link or AI)
151	Secondary Sync/LS Input Failed	Secondary SYNC/LS signal failure detected (comm link or AI)

Shutdown Summary

The Shutdown Summary screen is always available with the VIEW button under the TRIPPED LED. When a trip is detected, it gets latched in the event logic, the trip relay is de-energized, all steam valve demand outputs go to zero, and the TRIPPED LED illuminates (red). The cause of the event will be indicated with an Event ID, description, and time/date stamp on the Shutdown Summary page. The list will always place the first event at the top of the list, if more than one trip condition is present, they will all be listed with their corresponding time stamp.

To clear any shutdowns that are no longer present, press the RESET key, close the reset contact input, or select Reset from either Modbus communications link. If the cause of the event has been corrected the event will clear, if not it will remain, and the timestamp will remain unchanged.

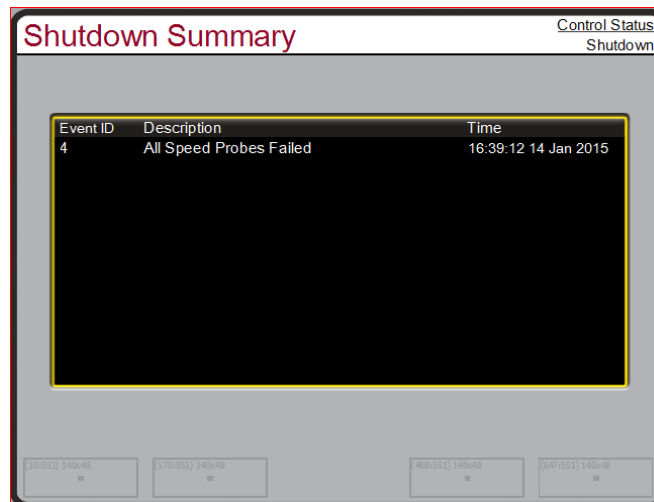


Figure 5-31. Shutdown Summary Screen

The table below lists all the potential shutdown conditions.

Table 5-2. TRIPPED Messages

Event ID	DESCRIPTION	MEANING
1	External Trip Input 1	External Trip contact input was opened
2	Emergency Stop Button	Front Panel Display Emergency Stop was pressed
3	Overspeed	Turbine overspeed was sensed

Event ID	DESCRIPTION	MEANING
4	All Speed Probes Failed	Loss of all speed probes was sensed
5	HP Actuator Fault	HP Actuator fault detected (an open or short circuit was sensed)
6	HP2 Actuator Fault	HP2 Actuator fault detected (an open or short circuit was sensed)
7	Aux Input Failed	Aux analog input failure detected (> 22 mA or < 2 mA)
8	Power Up Trip	505 lost power or the Configuration mode was exited
9	Normal Shutdown Complete	Controlled shutdown was performed and completed
10	Trip Command from Modbus	Modbus communication link trip was commanded
11	Unit in Calibration Mode	505 is in Calibration Mode
12	Configuration Error	505 has a configuration error
13	Tie Breaker Opened	Utility tie breaker was opened after it was closed
14	GEN Breaker Opened	Generator breaker was opened after it was closed
15	External Trip 2	External Trip #2 contact input was opened
16	External Trip 3	External Trip #3 contact input was opened
17	External Trip 4	External Trip #4 contact input was opened
18	External Trip 5	External Trip #5 contact input was opened
19	External Trip 6	External Trip #6 contact input was opened
20	External Trip 7	External Trip #7 contact input was opened
21	External Trip 8	External Trip #8 contact input was opened
22	External Trip 9	External Trip #9 contact input was opened
23	External Trip 10	External Trip #10 contact input was opened
24	HP Ramp at Max/No Speed	HP Valve Limiter ramp is at Max but no speed is detected
25	Actuator Scaling Min>Max	For Act 1&2 the Min current setting must be Less than Max current setting (use Invert option to reverse these)
26	Inlet Pressure Input Signal Failed	Inlet Pressure Input Signal failure detected (> 22 mA or < 2 mA)
27	Ext/Adm Pressure Input Signal Failed	Ext/Adm Pressure Input Signal failure detected (> 22 mA or < 2 mA)
28	Exhaust Pressure Input Signal Failed	Exhaust Pressure Input Signal failure detected (> 22 mA or < 2 mA)
29	Inlet Steam Pressure Level2 TRIP	Inlet Steam Pressure passed trip level limit
30	EXH Steam Pressure Level2 TRIP	Exhaust Steam Pressure passed trip level limit
31	Selected PV 1 Level 2 TRIP	Customer Monitor Signal 1 passed trip level limit
32	Selected PV 2 Level 2 TRIP	Customer Monitor Signal 2 passed trip level limit
33	Selected PV 3 Level 2 TRIP	Customer Monitor Signal 3 passed trip level limit
34	Tunable Trip	reserved for simulation use
35	Configuration Mode (IO Lock)	505 is in Configuration Mode (in IOLOCK)
36	Linknet Summary Trip	Trip from a LinkNet
37	Open Wire on MPUs	Open wires detected on all MPUs
38	LP Actuator Fault	LP Actuator fault detected (an open or short circuit was sensed)
39	Overspeed Test Limit Reached	Speed Setpoint has reached Max Overspeed Test Limit
40	spare_40	reserved for future use

Event ID	DESCRIPTION	MEANING
41	External Trip 11	External Trip #11 contact input was opened
42	External Trip 12	External Trip #12 contact input was opened
43	External Trip 13	External Trip #13 contact input was opened
44	External Trip 14	External Trip #14 contact input was opened
45	External Trip 15	External Trip #15 contact input was opened
46	spare_46	reserved for future use
47	spare_47	reserved for future use

Each individual trip condition is available through the Modbus links to monitor the control status. A common trip indication is also provided.

Relay indications can be programmed to indicate a 505 Shutdown Condition (energizes for a shutdown condition) or a trip relay (de-energizes for a shutdown/trip), in addition to the dedicated emergency trip relay output.

Manual Dynamic Adjustments of Speed, Cascade, Auxiliary, Inlet, Exhaust and Ext/Adm Controls

This section will cover the basics of the manual tuning of the PID dynamics that need to be performed initially on the unit. Only the speed control loop is used on every system, the other controls need not be tuned if they are not configured for use. For the speed and extraction control loops the OPTI tune feature is available to calculate idea dynamic settings for the overall system. Refer to the OPTI Tune section of this manual.

Dynamic control values are programmed in the configuration mode and adjusted in the RUN (Operation or Service) mode. The Proportional and Integral Gain and the Derivative Ratio dynamic adjustments are available under found under Dynamics pages for each controller (SPEED, CASC, AUX, INLET, EXHAUST and EXT/ADM). To adjust the gain settings, the In-Focus highlighter must be on the component value to tune. The In-Focus highlighter is moved using the navigation Cross. The ADJUST UP and DOWN keys can then be used to adjust the function In-Focus.

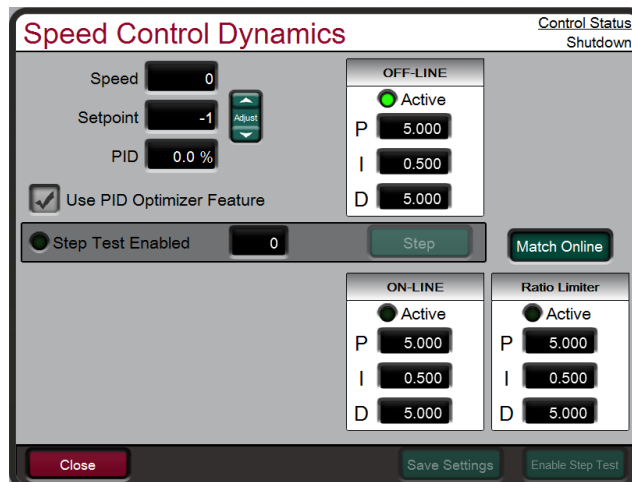


Figure 5-32. Speed Dynamics Adjustment Screen

The Speed, Cascade, Auxiliary, Inlet, Exhaust and Ext/Adm controls are PID controllers. The response of each control loop can be adjusted by selecting the dynamics mode as described above. Proportional gain, integral gain (stability), and DR (derivative ratio) are the adjustable and interacting parameters used

to match the response of the control loop with the response of the system. They correspond to the P (proportional), I (integral), and D (derivative) terms, and are displayed by the 505 as follows:

P = Proportional gain (%)

I = Integral gain (%)

D = Derivative (determined by DR and I)

Tuning P & I Gains

Proportional gain must be tuned to best respond to a system transient or step change. If system response is not known, a typical starting value is 5%. If proportional gain is set too high the control will appear to be overly sensitive and may oscillate with a cycle time of less than 1 second.

Integral gain must be tuned for best control at steady state. If system response is not known a typical starting value is 5%. If the integral gain is set too high the control may hunt or oscillate at cycle times of over 1 second.

For best response the proportional gain and integral gain should be as high as possible. To obtain a faster transient response, slowly increase the proportional gain setting until the actuator or final driver output begins to oscillate or waver. Then adjust the integral gain as necessary to stabilize the output. If stability cannot be obtained with the integral gain adjustment, reduce the proportional gain setting.

A well-tuned system, when given a step change, should slightly overshoot the control point then come into control.

A PID control loop's gain is a combination of all the gains in the loop, also known as the system gain. The loop's total gain includes actuator gain, valve gain, and valve linkage gain, transducer gain, internal turbine gains, and the 505's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 505's gain must be very low to be added to the system gain required for system stability.

In cases where a small change in the 505's output results in a large speed or load changes (high mechanical gain) it may not be possible to take the 505's gains low enough to reach stable operation. In those cases, the mechanical interface (actuator, linkage, servo, valve rack) design and/or calibration should be reviewed and changed to achieve a gain of one where 0–100% 505 output corresponds to 0–100% valve travel.

Multiple Dynamics for Speed/Load Control

The Speed PID has two primary sets of dynamics, On-Line and Off-Line; each include Proportional Gain, Integral Gain, and Derivative Ratio (DR) variables. There are three cases that determine when the dynamics switch between On-Line and Off-Line:

- A "Select On-Line Dynamics" contact input is programmed
- Unit is driving a generator
- Unit is driving a mechanical drive (not a generator)

If a contact input is programmed to "Select On-Line Dynamics", it has priority regardless of the driven device. When the contact is closed, On-Line dynamics are selected; when open, Off-Line dynamics are selected.

If the unit is driving a generator and no "Select On-Line Dynamics" contact input is programmed, the Speed Off-Line dynamics are used by the Speed PID when the generator or utility tie breaker contacts are open. The speed On-Line dynamics are used by the speed PID when the generator and utility tie breaker contacts are closed. If the speed dynamics select contact is programmed, the generator and utility tie contacts do not affect the dynamics selection.

If the unit is not driving a generator and no "Select On-Line Dynamics" contact input is programmed, the Speed Off-Line dynamic settings are used when the turbine speed is below minimum governor speed; .On-Line dynamics are used if the turbine speed is above minimum governor speed. If the speed dynamics select contact is programmed, the turbine speed does not affect the dynamics selection.

A relay can be programmed to indicate that the On-Line Dynamics mode is selected.

For Extraction/Admission type turbines, there is a third set of dynamics that can be set to optimize operation within the steam performance map. These settings are identified as the ratio limiter dynamics and are only used when the unit is On-Line and Extraction/Admission control is enabled. When first tuning these settings (either manually or using OPTI Tune, they should be initialized to start with the same settings as the On-Line dynamic settings.

Speed Droop

The Speed Loop controller can be programmed to use droop for control loop stability. For generator applications, the ideal parameter to use is a Generator Load signal. If this is not available, then the speed loop will use actuator position droop. The actuator position droop feedback is converted to a load percentage value

Cascade/Auxiliary Droop

The Cascade and Auxiliary controllers can be programmed to use droop for control loop stability. If the parameter being controlled (Cascade or Auxiliary) is also being controlled by another device (letdown station, boiler, or other turbine), droop is typically required for control loop stability. If required, no less than 5% droop is recommend for stable operation.

Tuning Derivative

The value of the Derivative Ratio (DR) term can range from 0.01 to 100. If unsure of the correct value, set the Speed control's DR term to 5% and the Aux & Cascade controllers' DR terms to 100%. In order to simplify adjustment of the dynamics, adjusting the integral gain value sets both I and D terms of the PID controller. The DR term establishes the degree of effect the integral gain value has on the "D" term and changes the configuration of a controller from input rate sensitive (input dominant) to feedback rate sensitive (feedback dominant) and vice versa.

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

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

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

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

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

Tuning Example

If the system is unstable, make sure the governor is the cause. This can be checked by closing the valve limiter until it has control of the actuator output. If the governor is causing the oscillation, time the oscillation cycle time. A rule-of- thumb is, if the system's oscillation cycle time is less than 1 second reduce the Proportional gain term. A rule-of-thumb is, if the system's oscillation cycle time is greater the 1 second reduce the Integral gain term (proportional gain may need to be increased also).

On an initial start-up with the 505, all PID dynamic gain terms will require adjustment to match the respective PID's response to that of its control loop. There are multiple dynamic tuning methods available

that can be used with the 505's PIDs to assist in determining the gain terms that provide optimum control loop response times (Ziegler Nichols, etc.).
Figure 5-33 shows the typical response to a load change when the dynamics are optimally adjusted.

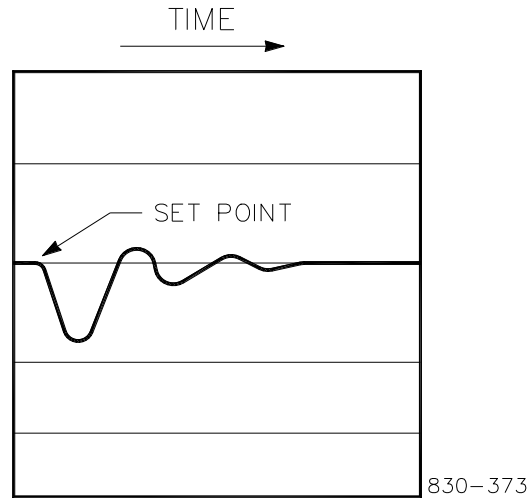


Figure 5-33. Typical Response to Load Change

IMPORTANT

For additional information on PID settings, refer to Volume 2.

Automated PID Dynamic Optimizer

The Automated PID Dynamic Optimizer is a routine which allows the control to automatically analyze the system and calculate the P, I, and D terms. The PID Optimizer routine can be initiated from the controller Dynamics Optimizer screen and will provide reasonable and stable results. To calculate optimized system dynamics, small and progressively larger adjustments are made to the valve demand in order to measure the turbine system. The optimizer routine remains within user specified process and valve movement limits to ensure that the turbine system remains within acceptable operating limits.

By running the PID Optimizer, the resulting dynamics provide the following benefits:

- 1) **IMPROVED SYSTEM RESPONSE TO EVENTS SUCH AS LOAD CHANGES AND LOAD REJECTION**
- 2) **TIGHTER CONTROL AT THE SETPOINT**
- 3) **RESPONSE BEHAVIOR WHICH MATCHES THE CONTROL LOOP AND APPLICATION (OFFLINE SPEED CONTROL VS LOAD CONTROL, ETC.)**
- 4) **IMPROVED SYSTEM DIAGNOSTICS. THE ROUTINE PROVIDES INSIGHT INTO TURBINE SYSTEM CONTROL PROBLEMS OUTSIDE OF PID TUNING AND CAN HELP TO IDENTIFY THEM. SOME EXAMPLES INCLUDE:**
 - a. **NON-LINEAR TURBINE RESPONSE DUE TO POPPET STAGING OR SLEW RATE LIMITED VALVE RESPONSE**
 - b. **HIGH SYSTEM DEAD-TIME**
 - c. **HIGH SIGNAL NOISE**
 - d. **RESPONSE TIME VARIATION DUE TO HIGH SYSTEM FRICTION, LOOSE LINKAGE, OR COUPLING, VARYING HYDRAULIC PRESSURE, OR VARYING STEAM CONDITIONS**

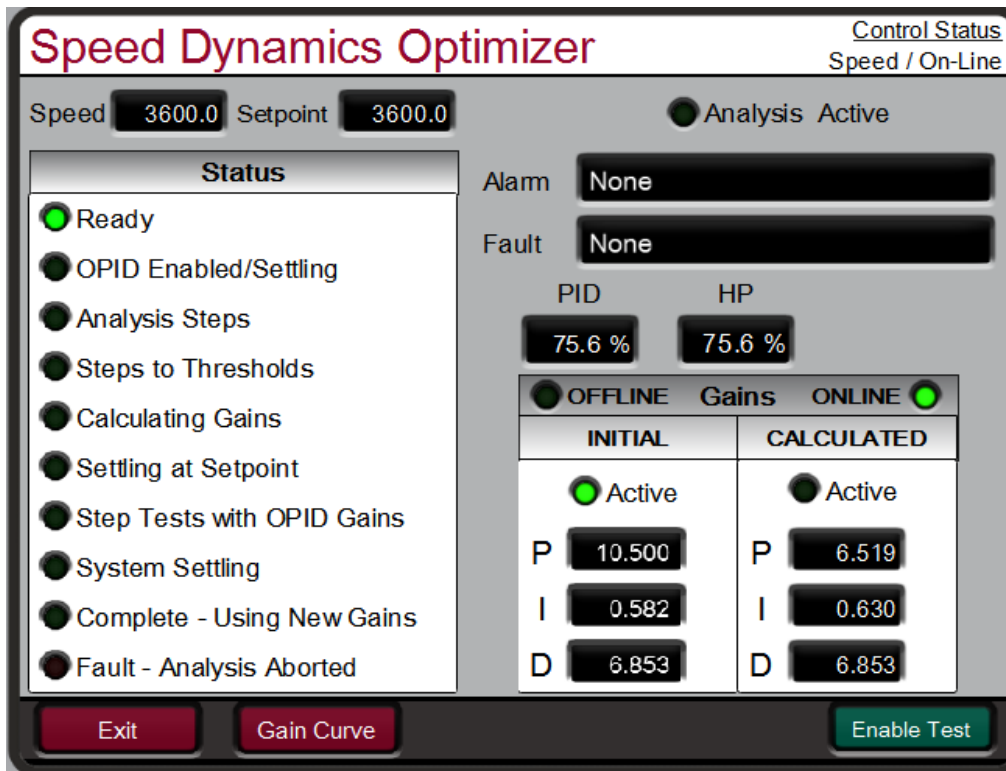


Figure 5-34. Overview of the Automated PID Optimizer Routine

The Dynamics Optimizer screen is shown above. The current status is overviewed on the left-hand side of the screen and results are given on the right. The menu bar on the bottom of the screen contains buttons which allow the configuration and operation of the Optimizer routine.

The process of finding optimized system dynamics includes two modes—first the analysis mode and then the setpoint step mode. The trend below gives an overview of the entire Optimization routine. The actuator demand is given in yellow, speed setpoint in white, and speed in red. The left portion of the trend is the Analysis Mode. The right portion of the trend is the Setpoint Step Mode.



Figure 5-35. Optimization Routine Overview Trend

Analysis Mode

During the Analysis Mode, the optimizer begins by making small actuator movements which progressively increase until the measured process signal movement can be differentiated from signal noise. The initial movement direction (up or down) depends on system conditions. Once there is enough process signal movement, the optimizer begins moving the actuator up and down until the process signal moves beyond the +/- the threshold values (calculated from signal noise) and performs the system analysis to calculate gains.

On the front panel, the status will progress through the following steps during the Analysis Mode:

- **OPID ENABLED/SETTLING**
- **ANALYSIS MOVEMENT**
- **MOVEMENT TO THRESHOLDS**
- **CALCULATING GAINS**

Setpoint Step Mode

Once new gains have been calculated for P, I, and D the PID will control at the setpoint using the newly calculated gains. The routine then performs setpoint step tests to validate the system response.

During the Setpoint Step Mode there are 4 setpoint step tests:

- 1) **STEP THE SETPOINT UP OR DOWN (AMOUNT DEPENDS ON SYSTEM NOISE, BUT LESS THAN THE PROCESS LIMIT CONFIGURED). WHETHER IT MOVES UP OR DOWN DEPENDS ON THE SIGN OF THE PROCESS LIMIT.**
- 2) **STEP THE SETPOINT BACK TO THE INITIAL SETPOINT**
- 3) **STEP THE SETPOINT BY A HIGHER AMOUNT THAN THE FIRST SETPOINT STEP TEST**
- 4) **STEP THE SETPOINT BACK TO THE INITIAL SETPOINT**

At any stage in this mode, if a fault occurs, the optimizer will abort and change the PID gains from the calculated values back to the initial values.

On the front panel, the status will progress through the following steps during the Setpoint Test Mode:

- **SETTLING AT SETPOINT**
- **STEP TESTS WITH OPTI GAINS**
- **SYSTEM SETTLING**
- **COMPLETE – USING NEW GAINS**

Once the routine is complete, the new gains can either be accepted by pressing the 'Accept' button within the Test Menu at the bottom of the screen. Alternatively, the gains can be rejected by pressing the 'Reset Test' button at the bottom of the screen, and the PID gains will change back to the initial values. If accepted, the current dynamics (offline or online, depending on the current operating mode) will be updated to the calculated values and the optimizer will reset.

Configuring the Automated PID Optimizer

The configuration parameters are provided in the 'Configure' pop-up. The defaults for these values should allow most systems to successfully optimize. If needed, adjustments can be made to these values to ensure that the automatic tuning completes successfully. Changing any of these values while the Optimizer test is running will cause the test to fault and abort.

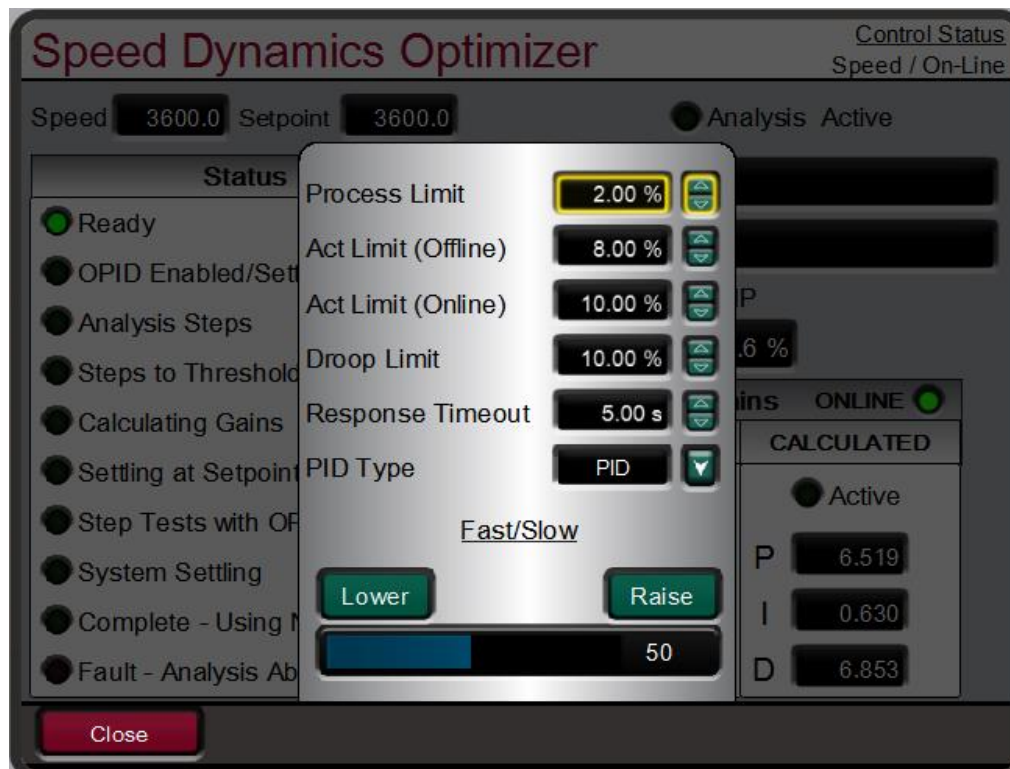


Figure 5-36. Configuration Parameters 'Configure' Pop-up

Process Limit (%) dflt= 2.0 (0.0, 10.0)

This value limits the process signal movement allowed. If movement occurs during automatic tuning that is more than this value, the Automated PID Optimizer routine will abort and control at the initial SP. This value should be set based on what the system can tolerate. If it is too low, the automatic tuning process may fault and abort due to normal process changes. The limit is centered around the current process value at the time the optimizer is enabled.

For example, if the PID Optimizer is calculating Speed PID gains, and the **Process Limit** is 2% and current speed signal is 3600RPM

Upper Process Movement Limit: $3600 + 2\% = 3672$ RPM

Lower Process Movement Limit: $3600 - 2\% = 3528$ RPM

If the turbine speed moves outside of the Upper Process Movement Limit or Lower Process Movement Limit, the PID Optimizer routine will be aborted.

Act Limit (offline) (%) **dflt= 8.0 (0.0, 100.0)**

This value limits how much the actuator demand will move during the Analysis Mode when the turbine is using Offline dynamics. The percentage will limit the output +/- from the actuator position when the optimizer is enabled. The optimizer will not abort if this limit is reached, but an alarm will be annunciated.

Act Limit (online) (%) **dflt= 10.0 (0.0, 100.0)**

This value limits how much the actuator demand will move during the Analysis Mode when the turbine is using Online dynamics. The percentage will limit the output +/- from the actuator position when the optimizer is enabled. The optimizer will not abort if this limit is reached, but an alarm will be annunciated.

Droop Limit (%) **dflt= 10.0 (0.0, 50.0)**

This value limits the droop signal movement allowed when using generator load droop. If movement occurs during automatic tuning that is more than this value, the Automated PID Optimizer routine will be aborted and control at the initial SP. This value should be based on what the system can tolerate. If it is too low, the automatic tuning process may fault and abort, due to normal process changes. The limit is centered around the current droop value at the time the optimizer is enabled.

For example, if the PID Optimizer is calculating Speed PID gains in droop mode, and the **Process Limit** is 10% and the current kW signal is 50% of Max Load

Upper Droop Process Movement: $50\% + 10\% = 60\%$ of Max Load

Lower Droop Process Movement: $50\% - 10\% = 40\%$ of Max Load

If the generator load signal moves outside of the upper or lower limit, the PID Optimizer routine will be aborted.

It is not necessary to run the PID Optimizer if using Valve Droop.

Response Timeout (sec) **dflt= 5.0 (0.005, 100.0)**

This value determines how long the PID Optimizer will wait for a response during the automatic tuning process. This value should be at least 2 times longer than the system slew and settling time. During the Setpoint Step Mode, this value determines the step times and times between steps. A fault and abort will occur if the total PID optimizer time exceeds a value of 40 times the Response Timeout.

PID Type **dflt= PID (P, PI, PID)**

This setting determines the mode of the PID controller and allows the automatic tuning of the appropriate control loop.

- **P = PROPORTIONAL ONLY**
 - **P TERM CALCULATED**
 - **I TERM 0**
 - **D TERM IS 0.01 IF D IS LESS THAN 1 OR 100 IF D IS GREATER THAN 1**
- **PI = PROPORTIONAL AND INTEGRAL**
 - **P TERM CALCULATED**
 - **I TERM CALCULATED**
 - **D TERM IS 0.01 IF DR IS LESS THAN 1 OR 100 IF DR IS GREATER THAN 1**
- **PID = PROPORTIONAL, INTEGRAL, AND DERIVATIVE**
 - **P TERM CALCULATED**
 - **I TERM CALCULATED**
 - **D TERM CALCULATED**

In addition, even if automatic tuning mode is not enabled, if this is set to P, the PID will switch to a proportional controller. Note that selecting PI will not switch the PID to a PI controller, this is done by changing S_D_R.

Fast/Slow

dflt= 50 (0, 100)

This value allows for the calculated system response to be more or less aggressive. If faster response time is needed, this value should be increased. If slower response time is needed, this value should be decreased.

System Diagnostics

The Automated PID Optimizer has alarm and fault codes that can be generated at various stages. An alarm being generated will not abort the optimizer and does not mean that the calculated gains are unreliable. Alarms are given to indicate response conditions that are less than ideal, but might be acceptable, the user should monitor the response to decide. A fault will abort the Automated PID Optimizer routine and indicates that reliable gains could not be calculated.

Most of the time, an alarm or fault indicates a problem with the steam turbine system that is outside of PID tuning. The descriptions below help identify what in the system may be causing the less than ideal control conditions. In some cases, suggestions to the Automated PID Optimizer configuration are included, in order to try and achieve successful automatic tuning.

Alarms

Alarm 1 - Rate group not fast enough

This alarm indicates that the rate group of the block is not fast enough to provide optimum control for the control loop, as measured. The rate group should be at least 20 times as fast as the system response.

Some causes of this alarm could be:

- **THE PROCESS LOOP (LIKE SPEED) CONTROLLED BY THE PID IS TOO FAST FOR THE RATE GROUP (RG) OF PID**
- **IF THE CONTROL LOOP IS POSITION DROOP, THE PROBLEM MAY BE THAT THERE IS NO LAG OR OTHER FILTER ON THE BETWEEN THE PID OUTPUT AND THE PROCESS INPUT.**

Some solutions for this alarm could be:

- If it is not possible to change the rate group, the second solution would be to accept the suggested dynamics if adequate, or detune the PID
- If there is no lag or other filter on the between the PID output and the process input for position droop, the solution would be to add a lag.

Alarm 2 – High overshoot on test step

This alarm indicates that the overshoot on the test step was greater than 50% of the step size. The performance might be acceptable, depending on the system.

Some causes of this alarm could be:

- The valve or turbine response is non-linear. This could occur due to:
- Poppet valve staging, resulting in higher flow with the larger movement of the step, and lower flow with the earlier smaller movements.
- The actuator or valve response is slew rate limited

If the amount of overshoot were unacceptable, some solutions would be:

- Verify that the poppet valve staging is correct.
- If the poppet valve staging cannot be fixed, the turbine operating point could be adjusted (i.e. the speed (process) and speed setpoint (SP) could be increased) to tune at the higher/lower flow point.
- The FAST/SLOW input may need to be reduced, to achieve the desired response.

Alarm 4 – Response to test step sluggish

The test step response did not reach 50% of the setpoint during the test step, the response was sluggish. The performance might be acceptable, depending on the system demands.

Some causes of this alarm could be:

- The valve or turbine response is non-linear. This could occur due to:
- Poppet valve staging, resulting in higher flow with the lower movement of the step, and higher flow with the earlier smaller movements.
- The actuator or valve response is slow rate limited
- The process or sensor has a long dead time

If the speed or the response is unacceptable, some solutions would be:

- Verify that the poppet valve staging is correct.
- If the poppet valve staging can't be fixed, the turbine operating point could be adjusted (i.e. the speed (process) and speed setpoint (SP) could be increased) to tune at the higher or lower flow point.
- The FAST/SLOW input could be increased, to achieve the desired response.

Alarm 8 - Actuator movement is limited

This alarm indicates that the actuator movement was limited during the Analysis Mode. This can result in a response that is not optimum, depending on the system conditions.

Some causes of this alarm could be:

- The **Act Limit** input is too low
- The valve or actuator is close to its end of travel, limiting movement or effect.

If the response is not acceptable, some solutions would be:

- If the response is not acceptable, the **Act Limit** could be increased
- The system operating point could be moved away from the ends of the actuator and valve travel. This would mean increasing or decreasing the SP input to the block.

Alarm 16 – High relative dead time

This alarm indicates high dead time in the system, relative to the system bandwidth. Dead time is typically measured on a step and is defined as the amount of time between when the SP starts to move, and when the process starts to move.

Some causes of this alarm could be:

- High friction on the valve or actuator
- Lost motion on the valve or actuator or linkage
- Hysteresis in the valve or actuator
- Long lines, such as a pressure transducer or other transducer not located near the pressure of interest.
- A relatively slow recursion rate in the sensor, control, and/or driver
- Asynchronous I/O in the sensor, control, and/or driver
- Asynchronous communications between the sensor and control or control and driver (if digital)

Some solutions for this alarm could be:

- With an oscilloscope, datalog, or logic analyzer, measure the system dead times.
- The optimum solution to this problem would be to fix the system and remove the dead time. If that is not possible, the control should be de-tuned, to ensure adequate stability.

Alarm 32– Process movement greater than droop movement during droop parameter tuning

This alarm indicates that the movement of the process parameter exceeded the movement of the droop parameter during droop tuning.

Some causes of this alarm could be:

- Improper connections in the GAP. The process (speed) should be connected to the process input, and the droop parameter (load, scaled in RPM) should be connected to the droop input
- The amount of initial actuator movement is set by the system noise. If this is too high the machine might move more than the system can support.
- The utility or plant frequency could be moving around.

Some solutions for this alarm could be:

- Ensure that the block is connected correctly.

- Reduce system noise.
- Ensure that the **Act Limit** field is set correctly.

Alarm 64– Response Timeout too short

This alarm indicates that the movement of the system did not respond enough during the **Response Timeout**.

Some causes of this alarm could be:

The **Response Timeout** is too short for the turbine system response time

Some solutions for this alarm could be:

Increase **Response Timeout**.

Faults**Fault 1 – CLR_STATE** was toggled TRUE

This fault will only occur if the CLR_STATE input is toggled TRUE

Some causes of this fault could be:

The CLR_STATE input was toggled TRUE

This can occur when system dynamics are changed from Offline to Online

Some solutions for this fault would include:

Ensure that the CLR_STATE logic is correct, CLR_STATE has priority over automatic tuning.

Fault 2 – Process or droop movement limit low with respect to noise

This fault indicates that the process/droop movement (or noise on the process/droop input) is greater than 10% of the **Process Limit** or **Droop Limit** during the first seconds after the Automated PID Optimizer routine is enabled. This is usually due to noise or drift on the process or droop input.

Some causes of this fault could be:

- The **Response Timeout** is too long, the PID cannot increase the output movement fast enough to counteract system drift.
- The noise or system swing on the process/droop input is greater than 10% of the **Process Limit** and/or **Droop Limit**.
- The system is not at steady state. As an example, if the Integral Gain input is low, there could be a large error between process and setpoint.

Some solutions would include:

- Decrease **Response Timeout** if the system is much faster than the time-out time.
- Proportional Gain could be adjusted to make the system stable, if applicable.
- Integral Gain could be adjusted to allow system to minimize error and/or slow hunt, if applicable.
- The **Process Limit** or **Droop Limit** could be increased, if the system allows.
- Check for excessive noise on process or droop signal, check shielding and grounding on the applicable sensors and actuator(s).

Fault 3 – High response time variation

This fault indicates that the response variation exceeded the allowable limit. This fault will occur if the response time variation is greater than a factor of 4, tuning would be unrepeatable.

Some causes of this fault could be:

- The system has high friction, resulting in initial movements which are lower than later movement, after the actuator or valve has broken free
- The system has loose linkage or coupling, sometimes the system moves a lot, and sometimes it does not.
- The hydraulic pressure is moving during the tuning process.
- The steam supply pressure is moving during the tuning process.

Some solutions for this fault would include:

- Monitor the performance of the system, including the valve, steam pressure, hydraulic pressure, etc.
- Use a datalog to verify proper I/O to the PID

Fault 4 – Process movement didn't correlate to actuator movement

This fault indicates that the response did not correlate to the actuator movement.

Some causes of this fault could be:

The hydraulic pressure or steam supply is moving during the tuning process, if the actuator demand is increasing but the supply is dropping, the actuator could close, or vice versa.

Some solutions for this fault would include:

- Monitor the performance of the system, including the valve, steam pressure, hydraulic pressure, etc.
- Use a datalog to verify proper I/O to the PID

Fault 5 – Process movement greater than **Process Limit**

This fault indicates that the process input exceeds the **Process Limit**.

Some causes of this fault could be:

- The **Response Timeout** is too long, the PID cannot increase the output movement fast enough to counteract system drift.
- The system is not at steady state. As an example, if the Integral Gain input is relatively low, there could be a large error between process and setpoint.
- The **Process Limit** is too low
- The **Act Limit** is too high, resulting in actuator movements that are too large for the **Process Limit** (this is unlikely).

Some solutions for this fault would include:

- Decrease **Response Timeout** if the system is much faster than the time-out
- Proportional Gain could be adjusted to make the system stable, if applicable.
- Integral Gain could be adjusted to allow system to minimize error and/or slow hunt, if applicable.
- **Process Limit** could be increased, if the turbine system allows
- Check for excessive noise on the process input, check shielding and grounding on the applicable sensors and actuator(s).

Fault 6 – Optimizer time-out

This fault indicated that the optimizer time exceeded the allowable time-out time, of 40 times the specified **Response Timeout**, or 20 cycles of movement.

Some causes of this fault could be:

- The **Act Limit** is too low, this is the most common cause of this fault
- The **Response Timeout** is too short for the process input response.
- The system response is restricted, by low steam pressure, a partially closed trip and throttle valve, etc.
- The valve or actuator is against a stop or at the end of its travel, not allowing the PID to control the process completely.

Some solutions for this fault would include:

- The **Act Limit** could be increased.
- The **Response Timeout** could be increased, if the system was still increasing/decreasing at the time-out times.
- The operating point (Setpoint) could be adjusted, if an actuator or valve is close to the end of its travel.
- The system variables should be checked, ensure that inlet pressure is high enough, hydraulic pressure is high enough, the trip and throttle valve is open, etc.

Fault 7 – Droop input movement, greater than limit.

This fault indicates that the droop input exceeded its allowable movement, similar to fault 5 for the process input.

Some causes of this fault could be:

- The **Response Timeout** is too long, the PID cannot increase the output movement fast enough to counteract system drift.

- There is noise on the droop input
- The system is not stable, the droop input is moving around too much with respect to the **Droop Limit** input.
- The system is not at steady state. As an example, if the Integral Gain input is relatively low, there could be a large error between process + droop and setpoint.
- The **Droop Limit** is too low.
- The **Act Limit** is too high, resulting in actuator movements that are too large for the **Droop Limit** (this is unlikely).

Some solutions for this fault would include:

- Decrease **Response Timeout** if the system is much faster than the time-out
- Check the droop input for noise and for the correct level.
- Proportional Gain could be adjusted to make the system stable, if applicable.
- Integral Gain could be adjusted to allow system to minimize error and/or slow hunt, if applicable.
- **Droop Limit** could be increased if system allows.
- Check for excessive noise on droop input, check shielding and grounding on the applicable sensors and actuator(s).

Faults 8 through 20 – Input or system status change occurred during the Automatic Tuning routine. Input conditions and System status are monitored while the optimizer is active to detect changes that could invalidate the results of the tuning routine.

Fault 16

A copy of the S_D_R input is made when the optimizer is started and is used to detect if the S_D_R input value crosses 1.0 in either direction. For example, this fault will be annunciated if S_D_R is 0.5 when the optimizer is started and subsequently S_D_R changes to 1.1 while the optimizer is active. Similarly, this fault will also be annunciated if S_D_R transitions from greater than 1.0 to less than 1.0 while the optimizer is active.

NERC/ECROT Frequency Excursion Test

The Frequency Excursion Test is run while the unit is online with both the generator and utility breakers closed in order to verify the control response to changes in grid frequency. This test simulates changes in turbine speed (determined by the grid frequency) to verify the controls response (change in valve demand) to add or reduce load in response. The amount of response from the speed/load control PID is determined by the droop percentage setting.

In order to run the test, the Frequency Excursion Test Visible checkbox in the Service Menu > Breaker Logic menu must be checked.



Figure 5-37. Breaker Logic Menu Screen

Once checked, press the Home key twice to return to the runtime home page. Then, in Speed Control, press the “More” softkey until the “Freq Test” is visible.

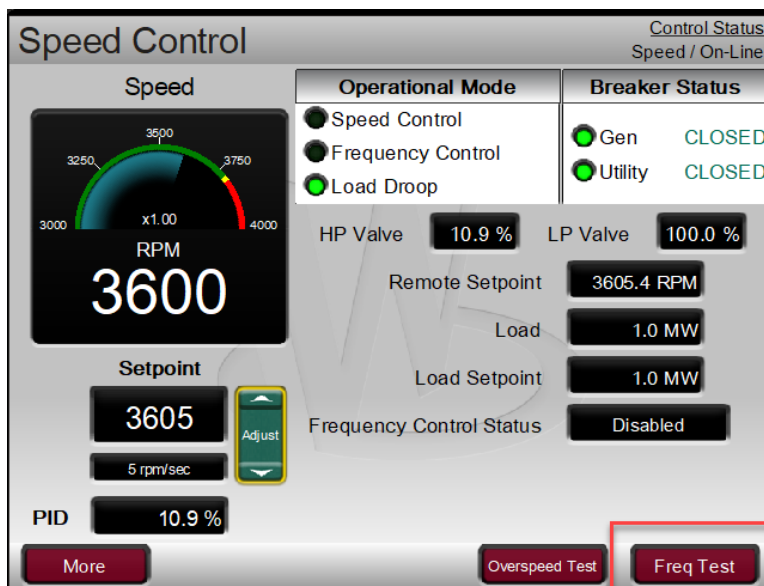


Figure 5-38. Speed Control Screen

Pressing the “Freq Test” will open the test popup menu.

The unit should be online with both the generator and utility breakers closed before the test is enabled. The control should also be stable. To enable the test, check the “Enable Freq. Bias Test” checkbox. This will enable the test for the next 5 minutes. Once the 5-minute time has elapsed, the test is automatically disabled. Once the test is enabled, the “Active” LED will indicate that the test values are active.

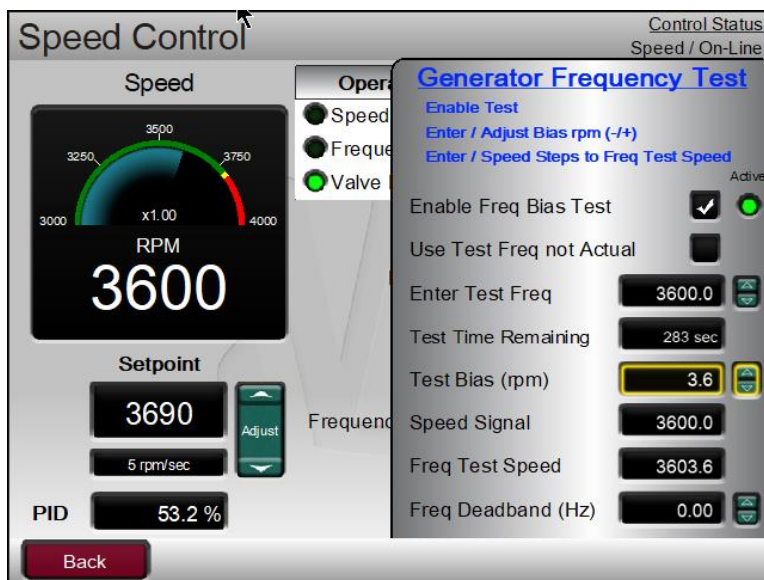


Figure 5-39. Generator Frequency Test “Active” LED Screen

The test allows two forms of simulated test values. By default, a test bias (rpm) can be added (or subtracted if negative) to the current frequency value. For example, if turbine speed is 3600RPM, to

simulate an increase in grid frequency of 0.1%, a bias signal of 3.6RPM can be added. Note below that the PID amount decreased in response to the increase in grid frequency.

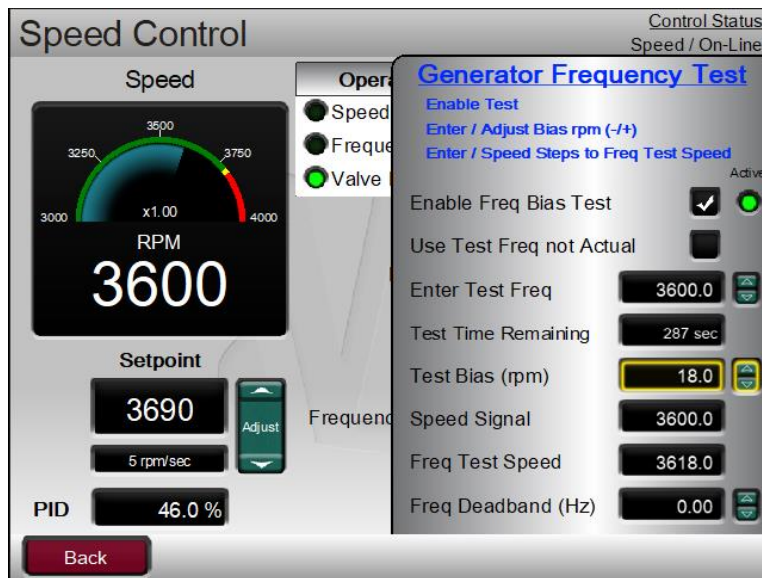


Figure 5-40. Generator Frequency Test PID Amount Decreased

The second test signal that can be used is to enter a test frequency directly. To enable a direct frequency input, check the "Use Test Freq not Actual" checkbox. The test frequency will initialize to the current frequency. From there, the test frequency can be input into the Enter Test Frequency setting. For example, if turbine speed is 3600RPM, to simulate a decrease in grid frequency of -0.5%, a test frequency of 3596.4 can be entered. Note below that the PID output increased in response to the decrease in grid frequency.

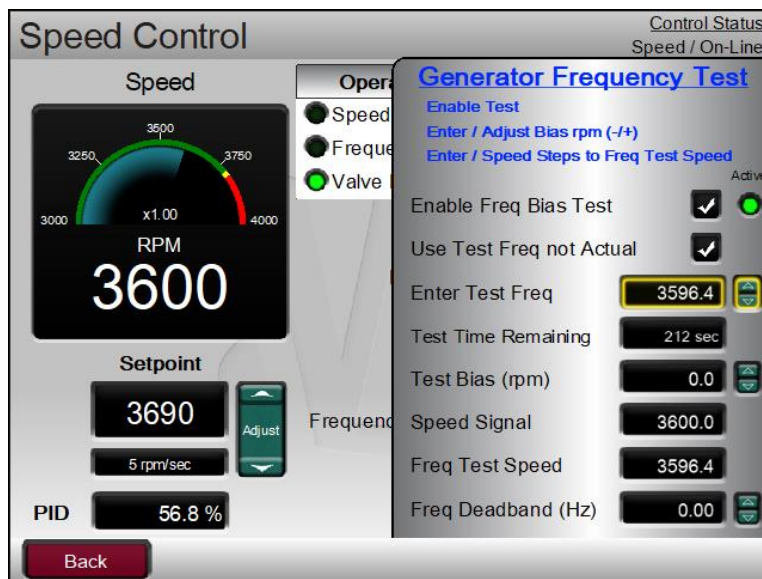


Figure 5-41. Generator Frequency Test PID Amount Increased

Chapter 6. Communications

Modbus Communications

The 505 control can communicate with plant distributed control systems and/or CRT based operator control panels through Modbus communication ports. There is one serial port that supports RS-232 and RS-485 communications using ASCII or RTU MODBUS transmission protocols. There are 2 ports available for either Modbus UDP or TCP/IP protocol which can be utilized from Ethernet port 1 or 2. 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.

IMPORTANT

Our experience has been that not all serial interfaces on laptops or desktop PCs work the same. Many USB-to-Serial converters work, but some do not.

To use a 505 Modbus port to monitor and/or operate, check the "Use Modbus" checkbox under the Configurations menu / Communications page.

Monitor Only

The three Modbus communication ports are defaulted as read-only. As read-only ports, the 505 can be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, and to the 505's defaulted protocol settings (parity, stop bits, etc.), this device can be used to monitor all the 505's controlling parameters, modes, etc. without affecting control.

Configuration of the protocol is found on the Communications page under both the Configuration and Service menus. There are options for the serial settings, slave address number and a checkbox to enable write commands from each individual link.

Monitor and Control

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

Each Modbus port is independent of the other and can be used simultaneously. Each only must have its own slave device address, and each has its own enable write checkbox. The last command given from any of the ports has priority or is the mode or function selected.

Modbus Communication

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

Table 6-2. Modbus Frame Definition

	Beginning of Frame	Slave Address	Function Code	Data	Error Check Code	End of Frame
ASCII	:	2 CHARS 8 BITS	2 CHARS 8 BITS	4 BITS DATA PER CHAR	2 CHARS 8 BITS	CR LF
RTU	3-CHAR DEAD TIME	1 CHAR 8 BITS	1 CHAR 8 BITS	8 BITS DATA PER CHAR	2 CHAR 16 BITS	3 CHAR DEAD TIME

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

Table 6-3. Modbus Function Codes

Code	Definition	Reference Address
01	Read digital outputs (Raise/Lower and Enable/Disable Commands)	0XXXX
02	Read digital inputs (Status Indications/Alarms and Trips)	1XXXX
03	Read analog outputs	4XXXX
04	Read analog inputs (Speed, Setpoint, etc.)	3XXXX
05	Write single discrete output (Raise/Lower and Enable/Disable Commands)	0XXXX
06	Write single register (Enter Setpoint Directly)	4XXXX
08	Loopback diagnostic test (Subfunction 0 only)	N/A
15	Write digital outputs	0XXXX
16	Write analog outputs	4XXXX

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the control issues an alarm message. The error codes are defined in the following table. The exception error status and respective error codes can be viewed on the Communication pages under the Service Menu.

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 2 seconds and only applies to units using both monitor and control (adjustable through the Service Menu).

Table 6-4. Modbus Error Codes

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

Port Adjustments

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

Table 6-5. Modbus Communication Port Adjustments

Parameter	Adjustment Range
Baud Rate	110 TO 57600
Parity	NONE, ODD or EVEN
Stop Bits	1 TO 2
Driver	RS-232, RS-422, or RS-485

505 Control Modbus Addresses

The Modbus communication ports in the 505 control 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 505 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 505. See Tables 6-8 and 6-9 for defaulted communication constants and ranges.

The maximum number of discretets and registers that can be transmitted in one packet is dependent on each implementation of Modbus. The following table defines these limits.

Table 6-6. Maximum Modbus Discrete and Analog Values

Mode Of Transmission	Max Discretets	Max Registers
ASCII	944	59
RTU	1188	118

Boolean Writes (Holding Coils)

Holding coils are logical signals that are both readable from and writable to the 505 control. An example of a Boolean write value would be raise or lower commands. A logical true denoted by the value 1 will cause the command listed in the description to be executed. For example, if a 1 is written to address 0:0010 and this corresponded to a speed raise command, the manual speed set point will increase until a 0 is written to address 0:0010. The 505 control supports function codes 1, 5, and 15. These correspond to reading selected holding coils, writing to a single holding coil, and writing to multiple holding coils, respectively. The holding coils available are listed in Table 6-6.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writable to, the 505 control. An example of a Boolean read value would be a turbine trip status indication. The input coil will have the value 1 if the statement in the description column is true and a 0 if false. The '1:' term in the address identifies an input coil. The 505 control supports Modbus function code 2, which involves reading selected input coils. The input coils available are listed in Table 6-6.

Analog Reads (Input Registers)

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

See the 505 Service mode for defaulted communication constants and ranges. The 505 control supports Modbus function code 4, which involves reading selected input registers. The input registers available are listed in Table 6-8.

Analog Writes (Holding Registers)

Holding registers are analog values that are writable to the 505 control. These values can also be read from by a device performing error checking. An example of an analog write value would be a direct speed set point value as opposed to raise and lower commands. The value of the holding registers are also stored in the control as numbers representing engineering units (psi or rpm). The 505 control supports Modbus function codes 3, 6, and 16. These correspond to reading selected holding registers, writing to a single holding register, and writing to multiple holding registers, respectively. The holding registers available are listed in Table 6-8.

The following tables give the address and description of all Boolean and analog, reads and writes:

Table 6-7. Boolean Write Addresses

Addr	Description	Addr	Description
0:0001	Emergency Shutdown	0:0056	Spare
0:0002	Emergency Shutdown Acknowledge	0:0057	Enable Extraction Control
0:0003	Controlled Shutdown	0:0058	Disable Extraction Control
0:0004	Abort Controlled Shutdown	0:0059	Lower Extraction Setpoint
0:0005	System Reset	0:0060	Raise Extraction Setpoint
0:0006	Start / Run	0:0061	Enable Remote Extr Setpoint Control
0:0007	Manual Open VLV Limiter	0:0062	Disable Remote Extr Setpoint Control
0:0008	Manual Close VLV Limiter	0:0063	Go To Modbus Entered Extraction Setpt
0:0009	Lower Speed Setpoint	0:0064	Open LP Valve Limiter
0:0010	Raise Speed Setpoint	0:0065	Close LP Valve Limiter
0:0011	Go To Rated (Idle / Rated)	0:0066	Decrease Extr/Adm Demand
0:0012	Go To Idle (Idle / Rated)	0:0067	Increase Extr/Adm Demand
0:0013	Halt Auto Start Seq	0:0068	Enable Extr/Adm Priority
0:0014	Continue Auto Start Seq	0:0069	Disable Extr/Adm Priority
0:0015	Enable Remote Speed Setpoint Control	0:0070	* Enable Droop Setpoint change
0:0016	Disable Remote Speed Setpoint Control	0:0071	* Disable Droop Setpoint change
0:0017	Go To Modbus Entered Speed Setpt	0:0072	* Enable Speed Forwarding
0:0018	Spare	0:0073	* Disable Speed Forwarding
0:0019	Arm Frequency Control	0:0074	
0:0020	Disarm Frequency Control	0:0075	Momentarily Energize Relay 2
0:0021	Sync Enable	0:0076	Momentarily Energize Relay 3
0:0022	Sync Disable	0:0077	Momentarily Energize Relay 4
0:0023	Enable Cascade Control	0:0078	Momentarily Energize Relay 5
0:0024	Disable Cascade Control	0:0079	Momentarily Energize Relay 6
0:0025	Lower Cascade Setpoint	0:0080	Momentarily Energize Relay 7
0:0026	Raise Cascade Setpoint	0:0081	Enable Inlet Control
0:0027	Enable Remote Cascade Setpoint Control	0:0082	Disable Inlet Control
0:0028	Disable Remote Cascade Setpoint Control	0:0083	Lower Inlet Setpoint
0:0029	Go To Modbus Entered Cascade Setpt	0:0084	Raise Inlet Setpoint
0:0030	Spare	0:0085	Enable Remote Inlet Setpoint Control
0:0031	Enable Aux Control	0:0086	Disable Remote Inlet Setpoint Control
0:0032	Disable Aux Control	0:0087	Go To Modbus Entered Inlet Setpt
0:0033	Lower Aux Setpoint	0:0088	Enable Remote KW Setpoint Control

Addr	Description	Addr	Description
0:0034	Raise Aux Setpoint	0:0089	Disable Remote KW Setpoint Control
0:0035	Enable Remote Aux Setpoint Control	0:0090	Isolated Controller SP Raise
0:0036	Disable Remote Aux Setpoint Control	0:0091	Isolated Controller SP Lower
0:0037	Go To Modbus Entered Auxiliary Setpt	0:0092	Select Hot Start
0:0038	Spare	0:0093	Select Cold Start
0:0039	Select Remote Ctrl (Remote/Local)	0:0094	Energize Relay 8
0:0040	Select Local Ctrl (Remote/Local)	0:0095	De-Energize Relay 8
0:0041	Spare	0:0096	Momentarily Energize Relay 8
0:0042	Modbus Alarm Acknowledge	0:0097	Enable Exhaust Control
0:0043	Energize Relay 1	0:0098	Disable Exhaust Control
0:0044	De-Energize Relay 1	0:0099	Lower Exhaust Setpoint
0:0045	Energize Relay 2	0:0100	Raise Exhaust Setpoint
0:0046	De-Energize Relay 2	0:0101	Enable Remote Exhaust Setpoint Control
0:0047	Energize Relay 3	0:0102	Disable Remote Exhaust Setpoint Control
0:0048	De-Energize Relay 3	0:0103	Go To Modbus Entered Exhaust Setpt
0:0049	Energize Relay 4	0:0104	Request Alternate Mode Transfer
0:0050	De-Energize Relay 4	0:0105	Mode 0 Request
0:0051	Energize Relay 5	0:0106	Enable Manual P Demand
0:0052	De-Energize Relay 5	0:0107	Disable Manual P Control
0:0053	Energize Relay 6	0:0108	Spare 108
0:0054	De-Energize Relay 6	0:0109	Lower Manual P Setpoint
0:0055	spare	0:0110	Raise Manual P Setpoint
		0:0111	Enable Remote Manual P Setpoint Control
		0:0112	Disable Remote Manual P Setpoint Control
		0:0113	Go To Modbus Entered Manual P Setpt

Table 6-8. Boolean Read Addresses

Addr	Description	Addr	Description
1:0001	Alarm - MPU #1 Failed	1:0272	Alarm - Selected PV 2 Level 2
1:0002	Alarm - MPU #2 Failed	1:0273	Alarm - Selected PV 3 Level 1
1:0003	Alarm - Cascade Input Failed	1:0274	Alarm - Selected PV 3 Level 2
1:0004	Alarm - Aux Input Failed	1:0275	Alarm - Tunable Alarm
1:0005	Alarm - KW Input Failed	1:0276	Alarm - Tie Open / No Inlet
1:0006	Alarm - Sync Input Failed	1:0277	Alarm - Gen Open / No Inlet
1:0007	Alarm - Inlet Press Input Failed	1:0278	Alarm - Actuator 1 Readout Fault
1:0008	Alarm - Remote Speed Input Failed	1:0279	Alarm - Actuator 2 Readout Fault
1:0009	Alarm - Remote Cascade Input Failed	1:0280	Alarm - CAN1_DVP1 Summary ALM
1:0010	Alarm - Remote Aux Input Failed	1:0281	Alarm - CAN1_DVP2 Summary ALM
1:0011	Alarm - Loadshare Input Failed	1:0282	Alarm - HP Actuator Fault (DVP1 or 2)
1:0012	Alarm - HP Actuator Failed	1:0283	Alarm - HP2 Actuator Fault (DVP1 or 2)
1:0013	Alarm - HP2 Actuator Failed	1:0284	Alarm - Comm Link to DSLC2 Failed
1:0014	Alarm - Start Permissive Not Met	1:0285	Alarm - KW Load AI Failed
1:0015	Alarm - Communication Link #1 Failed	1:0286	Alarm - Turbine Maintenance Interval Alm
1:0016	Alarm - Communication Link #2 Failed	1:0287	Alarm - Start Temperature #1 Override Active
1:0017	Alarm - Generator Breaker Open	1:0288	Alarm - Start Temperature #2 Override Active
1:0018	Alarm - Turbine Trip	1:0289	Alarm - Comm Link to EasyGen Failed
1:0019	Alarm - Tie Breaker Open	1:0290	Alarm - Comm Link to LS-5 Failed
1:0020	Alarm - Overspeed Alarm	1:0291	Alarm - Comm Link to MFR300 Failed
1:0021	Alarm - Tie Breaker Open / No Aux	1:0292	Alarm - Comm Link to HiProtec Failed
1:0022	Alarm - Gen Breaker Open / No Aux	1:0293	Alarm - MPU1 Failed Open Wire Test

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Addr	Description	Addr	Description
1:0023	Alarm - Tie Breaker Open / No Casc	1:0294	Alarm - MPU2 Failed Open Wire Test
1:0024	Alarm - Gen Breaker Open / No Casc	1:0295	Alarm - Internal HW Simulation Enabled
1:0025	Alarm - Tie Breaker Open / No Remote	1:0296	Alarm - Pressure Compensation Curve Error
1:0026	Alarm - Gen Breaker Open / No Remote	1:0297	Alarm - Actuator Linearization Curve Error
1:0027	Alarm - Stuck in Critical Alarm	1:0298	Alarm - Remote Manual P Demand Input Failed
1:0028	Alarm - Tie Breaker Open / No Extr	1:0299	Alarm - Remote Exhaust SP Input Failed
1:0029	Alarm - Gen Breaker Open / No Extr	1:0300	Alarm - Remote Inlet Pressure SP Input Failed
1:0030	Alarm - Extr Input Failed	1:0301	Alarm - LP Position Feedback Input Failed
1:0031	Alarm - Remote Extr Input Failed	1:0302	Alarm - Reverse Rotation Detected
1:0032	Alarm - External Alarm 1	1:0303	Alarm - LinkNet Summary Alarm
1:0033	Alarm - External Alarm 2	1:0304	Spare
1:0034	Alarm - External Alarm 3	1:0305	Spare
1:0035	Alarm - External Alarm 4	1:0306	Alarm - Tie Breaker Open / No Exhaust
1:0036	Alarm - External Alarm 5	1:0307	Alarm - Gen Breaker Open / No Exhaust
1:0037	Alarm - External Alarm 6	1:0308	Alarm - LP Actuator Fault (Act1 or 2)
1:0038	CTC Alarm latch	1:0309	Alarm - LP Actuator Fault ALM (DVP1 or 2)
1:0039	Modbus Alarm Acknowledge	1:0310	Alarm - Speed Below Min - No Extraction
1:0040	Alarm Exists (Common Alarm Indication)	1:0311	Alarm - LP Lmtr->No Spd Cntl->Ratio Lmtr Dsbl
1:0041	Trip - External Trip	1:0312	Alarm - External alarm # 10
1:0042	Trip - ESD Button	1:0313	Alarm - External alarm # 11
1:0043	Trip - Overspeed Trip	1:0314	Trip - Unit in Calibration Mode
1:0044	Trip - Loss of Speed Signals	1:0315	Trip - Configuration Error
1:0045	Trip - HP Actuator Fault	1:0316	Trip - Inlet Stm Pressure Level2
1:0046	Trip - HP2 Actuator Fault	1:0317	Trip - EXH Stm Pressure Level2
1:0047	Trip - Aux Input Failed	1:0318	Trip - Selected PV 1 Level 2
1:0048	Trip - External Trip 2	1:0319	Trip - Selected PV 2 Level 2
1:0049	Trip - External Trip 3	1:0320	Trip - Selected PV 3 Level 2
1:0050	Trip - Modbus Link #1 Trip	1:0321	Trip - Tunable Trip
1:0051	GAP Heartbeat (2 sec)	1:0322	Trip - Configuration Mode (IO Lock)
1:0052	SPARE	1:0323	Trip - Linknet Summary Trip
1:0053	Trip - Tie Breaker Open	1:0324	Trip - Open Wire on MPUs
1:0054	Trip - Gen Breaker Open	1:0325	Trip - LP Actuator Failed
1:0055	Trip - Power up	1:0326	Trip - Overspeed Test Limit Reached
1:0056	Trip - Manual Stop	1:0327	Trip - spare_40
1:0057	Trip - External Trip 4	1:0328	Contact In 17 Closed
1:0058	Trip - External Trip 5	1:0329	Contact In 18 Closed
1:0059	Trip - Extraction Input Failed	1:0330	Contact In 19 Closed
1:0060	Trip - External Trip 6	1:0331	Contact In 20 Closed
1:0061	Trip - External Trip 7	1:0332	Relay 2 Energized
1:0062	Trip - External Trip 8	1:0333	Inlet Is Enabled
1:0063	Trip - External Trip 9	1:0334	Inlet Is Active
1:0064	Shutdown Exists (Trip Indication)	1:0335	Inlet Is In Control
1:0065	Modbus ESD Acknowledge Enable	1:0336	Inlet Active / Not Limiting

Addr	Description	Addr	Description
1:0066	Moving to Min Setpoint	1:0337	Inlet Active / Not In Control
1:0067	Ramping to Idle (Idle / Rated)	1:0338	Inlet is Inhibited
1:0068	Idle / Rated at Idle	1:0339	Remote Inlet Is Enabled
1:0069	Ramping to Rated (Idle / Rated)	1:0340	Remote Inlet Is Active
1:0070	At Rated	1:0341	Rmt Inlet Is In Control
1:0071	Auto Seq - Setpt at Idle 1	1:0342	Rmt Inlet Is Inhibited
1:0072	Auto Seq - Ramp to Idle 2	1:0343	Inlet Limiter Configured
1:0073	Auto Seq - Setpt at Idle 2	1:0344	Inlet Control Configured
1:0074	Auto Seq - Ramp to rated	1:0345	Remote Inlet Configured
1:0075	Auto Seq - At Rated	1:0346	Remote KW Setpt Is Enabled
1:0076	Speed PID In Control	1:0347	Remote KW Setpt Is Active
1:0077	Speed Sensor 1 Failed Override ON	1:0348	Remote KW Setpt Is In Control
1:0078	Speed Sensor 2 Failed Override ON	1:0349	Remote KW Setpt Is Inhibited
1:0079	Overspeed Test Permissive	1:0350	Remote KW Control Configured
1:0080	Overspeed Test In progress	1:0351	* IHB Configured
1:0081	Speed At or above Min Gov	1:0352	Enables Mod Port2 In Local
1:0082	Turbine In Critical Speed Band	1:0353	Enables Mod Port3 In Local
1:0083	Remote Speed Setpt Is Enabled	1:0354	Relay 2 is Level Switch
1:0084	Remote Speed Setpt Is Active	1:0355	Relay 3 is Level Switch
1:0085	Remote Speed Setpt Is In Control	1:0356	Relay 4 is Level Switch
1:0086	Remote Speed Setpt Is Inhibited	1:0357	Relay 5 is Level Switch
1:0087	Speed PID In Control (not being lmted)	1:0358	Relay 6 is Level Switch
1:0088	Auto Seq - at idle 3	1:0359	Relay 7 is Level Switch
1:0089	Turbine Started/Running	1:0360	Relay 8 is Level Switch
1:0090	Generator Breaker Closed	1:0361	Extraction Active / Not Limiting
1:0091	Utility Tie Breaker Closed	1:0362	Extraction Active / Not In Control
1:0092	Synchronizing Rate Selected	1:0363	Extraction Limiter Configured
1:0093	Synchronizing Is Enabled	1:0364	Extraction Control Configured
1:0094	Sync or Load Share Is In Control	1:0365	Remote Extraction Configured
1:0095	Sync / Load Share Is Inhibited	1:0366	Exhaust Is Enabled
1:0096	Unit has Started (Off once Idle reached)	1:0367	Exhaust Is Active
1:0097	Frequency Control Armed	1:0368	Exhaust Is In Control
1:0098	Frequency Control	1:0369	Exhaust Active / Not Limiting
1:0099	Reset	1:0370	Exhaust Active / Not In Control
1:0100	Cascade Is Enabled	1:0371	Exhaust is Inhibited
1:0101	Cascade Is Active	1:0372	Remote Exhaust Is Enabled
1:0102	Cascade Is In Control	1:0373	Remote Exhaust Is Active
1:0103	Cascade Is Inhibited	1:0374	Rmt Exhaust Is In Control
1:0104	Rmt Cascade Is Enabled	1:0375	Rmt Exhaust Is Inhibited
1:0105	Rmt Cascade Is Active	1:0376	Exhaust Limiter Configured
1:0106	Rmt Cascade Is In Control	1:0377	Exhaust Control Configured
1:0107	Rmt Cascade Is Inhibited	1:0378	Remote Exhaust Configured

Addr	Description	Addr	Description
1:0108	IH Configured	1:0379	At MIN Flow Limit
1:0109	Auxiliary Is Enabled	1:0380	Mode Transfer Inhibited
1:0110	Auxiliary Is Active	1:0381	Alternate Mode Active
1:0111	Auxiliary Is In Control	1:0382	spare
1:0112	Aux Active / Not Limiting	1:0383	Illegal Steam Map
1:0113	Aux Active / Not In Control	1:0384	Ratio Limiter Active
1:0114	Auxiliary is Inhibited	1:0385	RTD Units: True = F, False = C
1:0115	Remote Aux Is Enabled	1:0386	LinkNet Node 4: BI 01
1:0116	Remote Aux Is Active	1:0387	LinkNet Node 4: BI 02
1:0117	Rmt Aux Is In Control	1:0388	LinkNet Node 4: BI 03
1:0118	Rmt Aux Is Inhibited	1:0389	LinkNet Node 4: BI 04
1:0119	Startup Complete	1:0390	LinkNet Node 4: BI 05
1:0120	Extraction Is Enabled	1:0391	LinkNet Node 4: BI 06
1:0121	Extraction Is Active	1:0392	LinkNet Node 4: BI 07
1:0122	Extraction Is In Control	1:0393	LinkNet Node 4: BI 08
1:0123	Extraction is Inhibited	1:0394	LinkNet Node 4: BI 09
1:0124	Remote Extraction Is Enabled	1:0395	LinkNet Node 4: BI 10
1:0125	Remote Extraction Is Active	1:0396	LinkNet Node 4: BI 11
1:0126	Rmt Extraction Is In Control	1:0397	LinkNet Node 4: BI 12
1:0127	Rmt Extraction Is Inhibited	1:0398	LinkNet Node 4: BI 13
1:0128	Pressure Priority Enabled	1:0399	LinkNet Node 4: BI 14
1:0129	Pressure Priority Active	1:0400	LinkNet Node 4: BI 15
1:0130	Speed Priority Active	1:0401	LinkNet Node 4: BI 16
1:0131	Priority Transfer Permissible	1:0402	LinkNet Node 5: BO 01
1:0132	* Auto seq:ramp to Idle3	1:0403	LinkNet Node 5: BO 02
1:0133	Controlled Stop In Progress	1:0404	LinkNet Node 5: BO 03
1:0134	LP Valve Limiter Is Open	1:0405	LinkNet Node 5: BO 04
1:0135	LP Valve Limiter Is Closed	1:0406	LinkNet Node 5: BO 05
1:0136	LP Valve Limiter In Control	1:0407	LinkNet Node 5: BO 06
1:0137	HP Valve Limiter Is Open	1:0408	LinkNet Node 5: BO 07
1:0138	HP Valve Limiter Is Closed	1:0409	LinkNet Node 5: BO 08
1:0139	HP Valve Limiter In Control	1:0410	LinkNet Node 5: BO 09
1:0140	Remote/Local Remote Selected	1:0411	LinkNet Node 5: BO 10
1:0141	MODBUS Active	1:0412	LinkNet Node 5: BO 11
1:0142	Start Permissive	1:0413	LinkNet Node 5: BO 12
1:0143	At Steam Map Limit	1:0414	LinkNet Node 5: BO 13
1:0144	At Min Press Limit	1:0415	LinkNet Node 5: BO 14
1:0145	At HP MAX Limit	1:0416	LinkNet Node 5: BO 15
1:0146	At HP MIN Limit	1:0417	LinkNet Node 5: BO 16
1:0147	At LP MAX Limit	1:0418	LinkNet Node 1 Comm Fault
1:0148	At LP MIN Limit	1:0419	LinkNet Node 2 Comm Fault
1:0149	At Max Power Limit	1:0420	LinkNet Node 3 Comm Fault
1:0150	At Max Press Limit	1:0421	LinkNet Node 4 Comm Fault

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Addr	Description	Addr	Description
1:0151	Shutdown Relay Energized(Relay 1)	1:0422	LinkNet Node 5 Comm Fault
1:0152	Alarm Relay Driver	1:0423	LinkNet Node 1 Failed
1:0153	Relay 3 Energized	1:0424	LinkNet Node 2 Failed
1:0154	Relay 4 Energized	1:0425	LinkNet Node 3 Failed
1:0155	Relay 5 Energized	1:0426	LinkNet Node 4 Failed
1:0156	Relay 6 Energized	1:0427	LinkNet Node 5 Failed
1:0157	Relay 7 Energized	1:0428	LinkNet Node 1 AI_1 Fault
1:0158	Relay 8 Energized	1:0429	LinkNet Node 1 AI_2 Fault
1:0159	ESD Contact Input Closed	1:0430	LinkNet Node 1 AI_3 Fault
1:0160	Contact In 2 Closed	1:0431	LinkNet Node 1 AI_4 Fault
1:0161	Contact In 3 Closed	1:0432	LinkNet Node 1 AI_5 Fault
1:0162	Contact In 4 Closed	1:0433	LinkNet Node 1 AI_6 Fault
1:0163	Contact In 5 Closed	1:0434	LinkNet Node 1 AI_7 Fault
1:0164	Contact In 6 Closed	1:0435	LinkNet Node 1 AI_8 Fault
1:0165	Contact In 7 Closed	1:0436	LinkNet Node 1 AO_1 Fault
1:0166	Contact In 8 Closed	1:0437	LinkNet Node 1 AO_2 Fault
1:0167	Contact In 9 Closed	1:0438	LinkNet Node 2 AI_1 Fault
1:0168	Contact In 10 Closed	1:0439	LinkNet Node 2 AI_2 Fault
1:0169	Contact In 11 Closed	1:0440	LinkNet Node 2 AI_3 Fault
1:0170	Contact In 12 Closed	1:0441	LinkNet Node 2 AI_4 Fault
1:0171	Contact In 13 Closed	1:0442	LinkNet Node 2 AI_5 Fault
1:0172	Contact In 14 Closed	1:0443	LinkNet Node 2 AI_6 Fault
1:0173	Contact In 15 Closed	1:0444	LinkNet Node 2 AI_7 Fault
1:0174	Contact In 16 Closed	1:0445	LinkNet Node 2 AI_8 Fault
1:0175	Aux Controller Configured	1:0446	LinkNet Node 2 AO_1 Fault
1:0176	Sync Function Configured	1:0447	LinkNet Node 2 AO_2 Fault
1:0177	Modbus- ESD Control Configured	1:0448	LinkNet Node 3 RTD_1 Fault
1:0178	Manual Start Configured	1:0449	LinkNet Node 3 RTD_2 Fault
1:0179	Auto Start Configured	1:0450	LinkNet Node 3 RTD_3 Fault
1:0180	Semi-Auto Start Configured	1:0451	LinkNet Node 3 RTD_4 Fault
1:0181	Idle/Rated Start Configured	1:0452	LinkNet Node 3 RTD_5 Fault
1:0182	Auto Start Sequence Configured	1:0453	LinkNet Node 3 RTD_6 Fault
1:0183	Inlet Pressure Configured	1:0454	LinkNet Node 3 RTD_7 Fault
1:0184	Remote Control Configured	1:0455	LinkNet Node 3 RTD_8 Fault
1:0185	Loadsharing Configured	1:0456	LinkNet Node 1 AI 1 Alarm Level 1
1:0186	HP2 Configured	1:0457	LinkNet Node 1 AI 1 Alarm Level 2
1:0187	Gen Set Configured	1:0458	LinkNet Node 1 AI 2 Alarm Level 1
1:0188	Cascade Control Configured	1:0459	LinkNet Node 1 AI 2 Alarm Level 2
1:0189	Remote Cascade Configured	1:0460	LinkNet Node 1 AI 3 Alarm Level 1
1:0190	Aux Control Configured	1:0461	LinkNet Node 1 AI 3 Alarm Level 2
1:0191	Remote Aux Configured	1:0462	LinkNet Node 1 AI 4 Alarm Level 1
1:0192	Enables Mod Port1 In Local	1:0463	LinkNet Node 1 AI 4 Alarm Level 2
1:0193	Start Permissive Configured	1:0464	LinkNet Node 1 AI 5 Alarm Level 1

Addr	Description	Addr	Description
1:0194	Frequency Arm/Disarm Configured	1:0465	LinkNet Node 1 AI 5 Alarm Level 2
1:0195	Frequency Control Configured	1:0466	LinkNet Node 1 AI 6 Alarm Level 1
1:0196	MPU 2 Configured	1:0467	LinkNet Node 1 AI 6 Alarm Level 2
1:0197	Local/Remote Configured	1:0468	LinkNet Node 1 AI 7 Alarm Level 1
1:0198	Local Trip Enabled	1:0469	LinkNet Node 1 AI 7 Alarm Level 2
1:0199	Casc Tracking Configured	1:0470	LinkNet Node 1 AI 8 Alarm Level 1
1:0200	KW Signal OK	1:0471	LinkNet Node 1 AI 8 Alarm Level 2
1:0201	Extr/Adm Configured	1:0472	LinkNet Node 2 AI 1 Alarm Level 1
1:0202	Admission-only Configured	1:0473	LinkNet Node 2 AI 1 Alarm Level 2
1:0203	Extr Enable/Disable Configured	1:0474	LinkNet Node 2 AI 2 Alarm Level 1
1:0204	Priority Selection Configured	1:0475	LinkNet Node 2 AI 2 Alarm Level 2
1:0205	Remote Extr/Adm Setpt Configured	1:0476	LinkNet Node 2 AI 3 Alarm Level 1
1:0206	E/A Setpt Tracking Config'd	1:0477	LinkNet Node 2 AI 3 Alarm Level 2
1:0207	* TRUE = NEW 505 R	1:0478	LinkNet Node 2 AI 4 Alarm Level 1
1:0208	FALSE = 505D, TRUE = 505XT	1:0479	LinkNet Node 2 AI 4 Alarm Level 2
1:0209	Alarm - External Alarm 7	1:0480	LinkNet Node 2 AI 5 Alarm Level 1
1:0210	Alarm - External Alarm 8	1:0481	LinkNet Node 2 AI 5 Alarm Level 2
1:0211	Alarm - External Alarm 9	1:0482	LinkNet Node 2 AI 6 Alarm Level 1
1:0212	Alarm - IH-act1 Failed from BI	1:0483	LinkNet Node 2 AI 6 Alarm Level 2
1:0213	Alarm - IH-act2 Failed from BI	1:0484	LinkNet Node 2 AI 7 Alarm Level 1
1:0214	Spare	1:0485	LinkNet Node 2 AI 7 Alarm Level 2
1:0215	Alarm - IH-A Pressure Input Failed	1:0486	LinkNet Node 2 AI 8 Alarm Level 1
1:0216	Alarm - AI FW Fault	1:0487	LinkNet Node 2 AI 8 Alarm Level 2
1:0217	Alarm - Remote Droop fault	1:0488	LinkNet Node 3 RTD 1 Alarm Level 1
1:0218	Alarm - Hwr com1 fault	1:0489	LinkNet Node 3 RTD 1 Alarm Level 2
1:0219	Alarm - Temp for Hot/Cold Starts Failed	1:0490	LinkNet Node 3 RTD 2 Alarm Level 1
1:0220	Alarm - Start Temperature 1 Failed	1:0491	LinkNet Node 3 RTD 2 Alarm Level 2
1:0221	Alarm - Start Temperature 2 Failed	1:0492	LinkNet Node 3 RTD 3 Alarm Level 1
1:0222	Trip - External Trip 10	1:0493	LinkNet Node 3 RTD 3 Alarm Level 2
1:0223	Trip - HP Ramp at Max/No Speed	1:0494	LinkNet Node 3 RTD 4 Alarm Level 1
1:0224	SPARE	1:0495	LinkNet Node 3 RTD 4 Alarm Level 2
1:0225	SPARE	1:0496	LinkNet Node 3 RTD 5 Alarm Level 1
1:0226	SPARE	1:0497	LinkNet Node 3 RTD 5 Alarm Level 2
1:0227	SPARE	1:0498	LinkNet Node 3 RTD 6 Alarm Level 1
1:0228	SPARE	1:0499	LinkNet Node 3 RTD 6 Alarm Level 2
1:0229	SPARE	1:0500	LinkNet Node 3 RTD 7 Alarm Level 1
1:0230	SPARE	1:0501	LinkNet Node 3 RTD 7 Alarm Level 2
1:0231	SPARE	1:0502	LinkNet Node 3 RTD 8 Alarm Level 1
1:0232	SPARE	1:0503	LinkNet Node 3 RTD 8 Alarm Level 2
1:0233	Controlled Stop In Progress	1:0504	LinkNet CAN2 Link Error
1:0234	SPARE	1:0505	LinkNet Errors on TX/RX msg
1:0235	SPARE	1:0506	LinkNet Errors on RT TX/RX msg
1:0236	SPARE	1:0507	SPARE_90

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Addr	Description	Addr	Description
1:0237	SPARE	1:0508	Trip - Actuator Scaling Min > Max
1:0238	SPARE	1:0509	Trip - Inlet Input Signal Failed
1:0239	SPARE	1:0510	Trip - Exhaust Input Signal Failed
1:0240	* Spare	1:0511	Trip - External Trip 11
1:0241	* IH-B Pressure Input Failed	1:0512	Trip - External Trip 12
1:0242	Alarm - Spare 011	1:0513	Trip - External Trip 13
1:0243	Alarm - Spare 012	1:0514	Trip - External Trip 14
1:0244	Alarm - Remote KW Setpoint Failed	1:0515	Trip - External Trip 15
1:0245	Alarm - Exhaust Press Input Failed	1:0516	Trip - spare_46
1:0246	Alarm - Overspeed Test Enabled	1:0517	Trip - spare_47
1:0247	Alarm - HP Valve Feedback Failed	1:0518	Trip - spare_48
1:0248	Alarm - HP2 Valve Feedback Failed	1:0519	Trip - spare_49
1:0249	Alarm - Isolated PID PV Failed	1:0520	Trip - spare_50
1:0250	Alarm - Rem SP Isolated PID Failed	1:0521	Trip - spare_51
1:0251	Alarm - Customer Input #1 Failed	1:0522	Trip - spare_52
1:0252	Alarm - Customer Input #2 Failed	1:0523	Trip - spare_53
1:0253	Alarm - Customer Input #3 Failed	1:0524	Trip - spare_54
1:0254	Alarm - Mod Comm Link #3 Failed	1:0525	Trip - spare_55
1:0255	Alarm - AO_01 Readback Fault	1:0526	Alarm - External alarm # 12
1:0256	Alarm - AO_02 Readback Fault	1:0527	Alarm - External alarm # 13
1:0257	Alarm - AO_03 Readback Fault	1:0528	Alarm - External alarm # 14
1:0258	Alarm - AO_04 Readback Fault	1:0529	Alarm - External alarm # 15
1:0259	Alarm - AO_05 Readback Fault	1:0530	Alarm - Alternate Mode Map Error
1:0260	Alarm - AO_06 Readback Fault	1:0531	Alarm - LP Valve Pos Fdbk Diff ALM
1:0261	Alarm - Chassis Temp	1:0532	Alarm - spare_127
1:0262	Alarm - HP Valve Pos Fdbk Diff	1:0533	Alarm - spare_128
1:0263	Alarm - HP2 Valve Pos Fdbk Diff	1:0534	Alarm - spare_129
1:0264	Alarm - Limiter in Control	1:0535	Alarm - spare_130
1:0265	Alarm - Inlet Steam Pressure Lvl1	1:0536	Alarm - spare_131
1:0266	Alarm - Inlet Steam Pressure Lvl2	1:0537	Alarm - spare_132
1:0267	Alarm - Exh Steam Pressure Lvl1	1:0538	Alarm - spare_133
1:0268	Alarm - Exh Steam Pressure Lvl2	1:0539	Alarm - spare_134
1:0269	Alarm - Selected PV 1 Level 1	1:0540	Alarm - spare_135
1:0270	Alarm - Selected PV 1 Level 2	1:0541	Alarm - spare_136
1:0271	Alarm - Selected PV 2 Level 1	1:0542	Extraction in P Demand Control
		1:0543	Extraction in Remote P Demand Control
		1:0544	Controlling on Steam Map Limiter ALM
		1:0545	Spare_545

Table 6-9. Analog Read Addresses

Addr	Description	Units	Multiplier
3:0001	Control Parameter		1
3:0002	Speed Sensor #1 Input (RPM)	rpm	1
3:0003	Speed Sensor #2 Input (RPM)	rpm	1
3:0004	Actual Turbine Speed (RPM)	rpm	1
3:0005	Actual Speed (%) x 100	%	100
3:0006	Speed Setpoint (%) x 100	%	100
3:0007	Speed Setpoint (RPM)	rpm	1
3:0008	Speed Droop Setpoint (RPM)	rpm	1
3:0009	Speed Droop (%) x 100	%	100
3:0010	Speed PID Output (%)	%	100
3:0011	Min Governor Speed Setpoint (RPM)	rpm	1
3:0012	Highest Speed reached	rpm	1
3:0013	Idle / Rated - Idle Speed (RPM)	rpm	1
3:0014	Idle / Rated - Rated Speed (RPM)	rpm	1
3:0015	Auto Seq - Idle 1 Speed Setpt (RPM)	rpm	1
3:0016	Auto Seq- Idle 1 Dly Time (MIN) X 100	min	100
3:0017	Auto Seq-Time Left Idle 1 (MIN) X 100	min	100
3:0018	Auto Seq- Idle1 to Idle2 Rate RPM/SEC	rpm/s	1
3:0019	Auto Seq - Idle 2 Speed Setpt (RPM)	rpm	1
3:0020	Auto Seq- Idle 2 Dly Time (MIN) X 100	min	100
3:0021	Auto Seq-Time Left Idle 2(MIN) X 100	min	100
3:0022	Auto Seq-Time ramp to Rated (RPM/S)	rpm/s	1
3:0023	Auto Seq- Rated speed stpt (RPM)	rpm	1
3:0024	Auto Seq - Run Time Hours	hrs	1
3:0025	Auto Seq-Hours Since trip	hrs	1
3:0026	Cascade Setpoint (Scaled)	Casc units	AI_SCALE
3:0027	Cascade PID Output (%) x 100	%	100
3:0028	Cascade Input (%)	%	100
3:0029	Cascade Setpoint (%)	%	100
3:0030	Cascade Scale Factor		1
3:0031	Cascade Input (Scaled)	Casc units	AI_SCALE
3:0032	Remote Cascade Input (Scaled)	Casc units	AI_SCALE
3:0033	Aux Setpoint (Scaled)	aux units	AI_SCALE
3:0034	Aux PID Output (%) x 100	%	100
3:0035	Aux Input (%)	%	100
3:0036	Aux Setpoint (%)	%	100
3:0037	Aux Scale Factor		1
3:0038	Aux Input (Scaled)	aux units	AI_SCALE
3:0039	Remote Aux Input (Scaled)	aux units	AI_SCALE
3:0040	Remote Speed Setpoint Input	rpm	1
3:0041	Inlet Pressure Scale Factor		1
3:0042	Inlet Pressure Input (Scaled)	IP units	AI_SCALE
3:0043	Loadshare Scale Factor		1
3:0044	Sync / Loadshare Input (Scaled)	rpm	AI_SCALE
3:0045	KW Scale Factor		1
3:0046	KW Input (Scaled)	kW units	AI_SCALE
3:0047	HP VLV Limiter Output x 100	%	100
3:0048	LSS Demand (%) x100	%	100
3:0049	HP Actuator Demand (%) x100	%	100
3:0050	HP2 Actuator Demand (%) x100	%	100
3:0051	Extr/Adm Manual Demand x 100	%	100

Addr	Description	Units	Multiplier
3:0052	Extraction Setpoint (Scaled)	ext units	AI_SCALE
3:0053	Extraction PID Output (%) x 100	%	100
3:0054	Extraction Input (%)	%	100
3:0055	Extraction Setpoint (%)	%	100
3:0056	Extraction Scale Factor		1
3:0057	Extraction Input (Scaled)	ext units	AI_SCALE
3:0058	Remote Extr Input (Scaled)	ext units	AI_SCALE
3:0059	Spare		
3:0060	Modbus Entered Speed Setpoint (fdbk)	rpm	1
3:0061	Modbus Entered Cascade Setpoint (fdbk)	Casc units	AI_SCALE
3:0062	Modbus Entered Aux Setpoint (fdbk)	Aux units	AI_SCALE
3:0063	Modbus Entered Extr Setpoint (fdbk)	Ext	AI_SCALE
3:0064	S-demand Limited (from ratio/lmtr)	%	100
3:0065	P-demand Limited (from ratio/lmtr)	%	100
3:0066	HP Map Demand (from ratio/lmtr)	%	100
3:0067	LP Map Demand (from ratio/lmtr)	%	100
3:0068	S-term (from LSS to ratio/lmtr)	%	100
3:0069	P-term (from E/A dmd to ratio/lmtr)	%	100
3:0070	Controlling Parameter 1 (505E)		
3:0071	Controlling Parameter 2 (505E)		
3:0072	Analog Input 1 (percent x 100)	%	100
3:0073	Analog Input 2 (percent x 100)	%	100
3:0074	Analog Input 3 (percent x 100)	%	100
3:0075	Analog Input 4 (percent x 100)	%	100
3:0076	Analog Input 5 (percent x 100)	%	100
3:0077	Analog Input 6 (percent x 100)	%	100
3:0078	Analog Output 1 (mA x 100)	mA	100
3:0079	Analog Output 2 (mA x 100)	mA	100
3:0080	Analog Output 3 (mA x 100)	mA	100
3:0081	Analog Output 4 (mA x 100)	mA	100
3:0082	Analog Output 5 (mA x 100)	mA	100
3:0083	Analog Output 6 (mA x 100)	mA	100
3:0084	Actuator #1 Output (mA x 100)	mA	100
3:0085	Actuator #2 Output (mA x 100)	mA	100
3:0086	Last Trip		1
3:0087	KW Units (3=MW 4=KW)		1
3:0088	Analog Input 1 Configuration		1
3:0089	Analog Input 2 Configuration		1
3:0090	Analog Input 3 Configuration		1
3:0091	Analog Input 4 Configuration		1
3:0092	Analog Input 5 Configuration		1
3:0093	Analog Input 6 Configuration		1
3:0094	Analog Output 1 Configuration		1
3:0095	Analog Output 2 Configuration		1
3:0096	Analog Output 3 Configuration		1
3:0097	Analog Output 4 Configuration		1
3:0098	Analog Output 5 Configuration		1
3:0099	Analog Output 6 Configuration		1
3:0100	Relay 1 Configuration		1
3:0101	Relay 2 Configuration		1
3:0102	Relay 3 Configuration		1
3:0103	Relay 4 Configuration		1

Addr	Description	Units	Multiplier
3:0104	Relay 5 Configuration		1
3:0105	Relay 6 Configuration		1
3:0106	Contact 2 Configuration		1
3:0107	Contact 3 Configuration		1
3:0108	Contact 4 Configuration		1
3:0109	Contact 5 Configuration		1
3:0110	Contact 6 Configuration		1
3:0111	Contact 7 Configuration		1
3:0112	Contact 8 Configuration		1
3:0113	Contact 9 Configuration		1
3:0114	Contact 10 Configuration		1
3:0115	Contact 11 Configuration		1
3:0116	Contact 12 Configuration		1
3:0117	Contact 13 Configuration		1
3:0118	SPARE		1
3:0119	SPARE		1
3:0120	* Spare E		1
3:0121	* S/W PN54186768		1
3:0122	*S/W Revision		1
3:0123	* Auto Seq-Time ramp to idle 3(RPM/S)	rpm/s	1
3:0124	* Auto Seq Idle 3 speed RPM	rpm	1
3:0125	* Auto Seq-HH Idle Dly Time (MIN)X 100	min	100
3:0126	* Auto Seq-Time Left Idle 3(MIN) X100	min	100
3:0127	* Max Governor Speed	rpm	1
3:0128	SPARE		1
3:0129	* IH-A Scale Factor		1
3:0130	* IH-A Press Units Configured		1
3:0131	SPARE		1
3:0132	SPARE		1
3:0133	SPARE		1
3:0134	* Feed Forward Bias		1
3:0135	SPARE		1
3:0136	* Droop Setting		100
3:0137	* Autostart seq rate to Idle 1	rpm/s	1
3:0138	* Autostart seq CF Cold rte to Idle 2	rpm/s	1
3:0139	* Autostart seq CF Hot rate to Idle 2	rpm/s	1
3:0140	* Autostart seq CF Cold rte to Idle 3	rpm/s	1
3:0141	* Autostart seq CF Hot rate to Idle 3	rpm/s	1
3:0142	* Autostart seq CF Cold rate to rated	rpm/s	1
3:0143	* Autostart seq CF Hot rate to rated	rpm/s	1
3:0144	Speed Derivative signal	rpm/s	1
3:0145	Speed Accel Rate	%/s	1
3:0146	Analog Input 7 (percent x 100)	%	100
3:0147	Analog Input 8 (percent x 100)	%	100
3:0148	Analog Input 7 Configuration		1
3:0149	Analog Input 8 Configuration		1
3:0150	Relay 7 Configuration		1
3:0151	Relay 8 Configuration		1
3:0152	Contact 14 Configuration		1
3:0153	Contact 15 Configuration		1
3:0154	Contact 16 Configuration		1
3:0155	Contact 17 Configuration		1

Addr	Description	Units	Multiplier
3:0156	Contact 18 Configuration		1
3:0157	Contact 19 Configuration		1
3:0158	Contact 20 Configuration		1
3:0159	Inlet Setpoint (Scaled)	INL units	AI_SCALE
3:0160	Inlet PID Output (%) x 100	%	100
3:0161	Inlet Input (%)	%	100
3:0162	Inlet Setpoint (%)	%	100
3:0163	Inlet Scale Factor		1
3:0164	Inlet Input (Scaled)	INL units	AI_SCALE
3:0165	Remote Inlet Input (Scaled)	INL units	AI_SCALE
3:0166	Modbus Entered Inlet Setpoint (fdbk)	INL units	AI_SCALE
3:0167	SPARE		1
3:0168	SPARE		1
3:0169	* IH-B Scale Factor		1
3:0170	* IH-B Press Units Configured		1
3:0171	* Autostart seq CF Warm rte to Idle 2	rpm/s	1
3:0172	* Autostart seq CF Warm rte to Idle 3	rpm/s	1
3:0173	* Autostart seq CF Warm rate to rated	rpm/s	1
3:0174	Idle / Rated Cold Rate	rpm/s	1
3:0175	Idle / Rated Warm Rate	rpm/s	1
3:0176	Idle / Rated Hot Rate	rpm/s	1
3:0177	Remote KW Setpoint Scale Factor		1
3:0178	Remote KW Setpoint Input		AI_SCALE
3:0179	SPARE		1
3:0180	SPARE		AI_SCALE
3:0181	HP Valve FDBK Position Scale Factor		1
3:0182	HP Valve FDBK Position Input		AI_SCALE
3:0183	HP2 Valve FDBK Position Scale Factor		1
3:0184	HP2 Valve FDBK Position Input		AI_SCALE
3:0185	Signal Monitoring #1 Scale Factor		1
3:0186	Signal Monitoring #1 Input		AI_SCALE
3:0187	Signal Monitoring #2 Scale Factor		1
3:0188	Signal Monitoring #2 Input		AI_SCALE
3:0189	Signal Monitoring #3 Scale Factor		1
3:0190	Signal Monitoring #3 Input		AI_SCALE
3:0191	Start Temperature 1 Scale Factor		1
3:0192	Start Temperature 1 Input		AI_SCALE
3:0193	Start Temperature 2 Scale Factor		1
3:0194	Start Temperature 2 Input		AI_SCALE
3:0195	Exhaust Setpoint (Scaled)	EXH units	AI_SCALE
3:0196	Exhaust PID Output (%) x 100	%	100
3:0197	Exhaust Input (%)	%	100
3:0198	Exhaust Setpoint (%)	%	100
3:0199	Exhaust Scale Factor		1
3:0200	Exhaust Input (Scaled)	EXH units	AI_SCALE
3:0201	Remote Exhaust Input (Scaled)	EXH units	AI_SCALE
3:0202	Modbus Entered Exhaust Setpoint (fdbk)	EXH units	AI_SCALE
3:0203	Exhaust-demand Limited (from ratio/lmtr)	%	100
3:0204	LinkNet Node 1: AI 01 Value		AI_SCALE
3:0205	LinkNet Node 1: AI 02 Value		AI_SCALE
3:0206	LinkNet Node 1: AI 03 Value		AI_SCALE
3:0207	LinkNet Node 1: AI 04 Value		AI_SCALE

Addr	Description	Units	Multiplier
3:0208	LinkNet Node 1: AI 05 Value		AI_SCALE
3:0209	LinkNet Node 1: AI 06 Value		AI_SCALE
3:0210	LinkNet Node 1: AI 07 Value		AI_SCALE
3:0211	LinkNet Node 1: AI 08 Value		AI_SCALE
3:0212	LinkNet Node 2: AI 01 Value		AI_SCALE
3:0213	LinkNet Node 2: AI 02 Value		AI_SCALE
3:0214	LinkNet Node 2: AI 03 Value		AI_SCALE
3:0215	LinkNet Node 2: AI 04 Value		AI_SCALE
3:0216	LinkNet Node 2: AI 05 Value		AI_SCALE
3:0217	LinkNet Node 2: AI 06 Value		AI_SCALE
3:0218	LinkNet Node 2: AI 07 Value		AI_SCALE
3:0219	LinkNet Node 2: AI 08 Value		AI_SCALE
3:0220	LinkNet Node 3: RTD 01 Value		RTD_SCALE
3:0221	LinkNet Node 3: RTD 02 Value		RTD_SCALE
3:0222	LinkNet Node 3: RTD 03 Value		RTD_SCALE
3:0223	LinkNet Node 3: RTD 04 Value		RTD_SCALE
3:0224	LinkNet Node 3: RTD 05 Value		RTD_SCALE
3:0225	LinkNet Node 3: RTD 06 Value		RTD_SCALE
3:0226	LinkNet Node 3: RTD 07 Value		RTD_SCALE
3:0227	LinkNet Node 3: RTD 08 Value		RTD_SCALE
3:0228	Active Speed Setpoint Rate	rpm	1
3:0229	Active Cascade Setpoint Rate	Casc units	1
3:0230	Active AUX Setpoint Rate	aux units	1
3:0231	Active Extraction/Admission Setpoint Rate	ext/adm units	1
3:0232	Active Inlet Setpoint Rate	inlet units	1
3:0233	Active Exhaust Setpoint Rate	EXH units	1
3:0234	505XT Control Parameter		1
3:0235	505XT Ratio Limiter Control Parameter		1
3:0236	505XT Map Limit Parameter		1
3:0237	LP Actuator Demand (%) x100	%	100
3:0238	Turbine Starts Counter		1
3:0239	HOT Turbine Starts Counter		1
3:0240	Total Trips Counter		1
3:0241	Trips with Load >25% Counter		1
3:0242	Trips with Load >75% Counter		1
3:0243	Total Run Time Hours Counter	hrs	1
3:0244	Run Time Hours with Load >25% Counter	hrs	1
3:0245	Run Time Hours with Load >75% Counter	hrs	1
3:0246	Peak Speed Reached	rpm	1
3:0247	Maximum Acceleration Reached	rpm	1
3:0248	Number of Overspeed Trips		1
3:0249	LP Valve Limiter x100	%	1

Table 6-10. Analog Write Addresses

Addr	Description	Units	Multiplier
4:0001	Modbus Entered Speed Setpoint	rpm	none
4:0002	Modbus Entered Casc Setpoint	Casc units	Casc scale factor
4:0003	Modbus Entered Aux Setpoint	Aux units	Aux scale factor
4:0004	Modbus Entered Extraction Setpoint	Ext/Adm units	Ext/Adm scale factor
4:0005	Modbus droop demand	%	x0.01
4:0006	Modbus Entered Inlet Setpoint	Inlet Units	Inlet scale factor
4:0007	Modbus Entered Exhaust Setpoint	Exhaust Units	Exhaust scale factor
4:0008	SPARE		

Last Turbine Trip Cause

The cause of the last turbine trip (address 3:0086) is an integer that represents the Event ID found in Table 5-2.

505XT Controlling Parameters

The controlling status parameter messages that appear on the display of the 505 are sent over the Modbus links. Customers implementing new interfaces, or those with the ability to change their operator interface should use the new addresses shown. These addresses will have messaging in a straight forward order and will contain the complete list of all messages available.

Logic was designed into the 505XT to support 'legacy' messaging so that customers replacing old 505's would not be required to change the Master Modbus gathering this data. This will work, but those interfaces will not receive messages related to new features in the 505XT, it is a subset of the information available on the new addresses.

Table 6-11. Control Status Message Addresses

Message	New address (full info)	Legacy address (limited)
Control Status	(3:0234)	
Ratio Limiter Status	(3:0235)	
Map Limiter Messages	(3:0236)	
505 Control Parameter		(3:0001)
505E Control Parameter 1		(3:0070)
505E Control Parameter 2		(3:0071)

The controlling parameter status of the 505XT uses an analog read register (3:0001) to identify the parameters that are in control. This variable follows what is displayed on the controlling parameter screen, under the 'CONT' key. The variable gives the current status of the control and is defined in the following table.

Table 6-12. Analog Read Register (3:0234) Control Status

Value	Description	Value	Description
1	Shutdown	21	Auto Start
2	Controlled Shutdown	22	Semi Auto Start
3	Transferring to Ratio Limiter Control	23	Idle / Rated Start
4	Transferring to Speed Only Control	24	Auto Start Sequence
5	Preparing to Transfer	25	Synchronizing
6	Max Actuator	26	Load Share / Speed
7	HP Valve Limiter and LP Valve Limiter	27	Frequency / Speed
8	HP Valve Limiter	28	Full Decoupled - Speed/Extraction
9	Acceleration Limiter	29	Ratio Limiter
10	Manual Demand	30	Remote Cascade/Speed
11	Remote Auxiliary	31	Cascade / Speed
12	Auxiliary Control	32	Remote Speed
13	Remote Inlet	33	Remote / KW
14	Inlet in Control	34	Speed / On-Line
15	Remote Exhaust	35	Speed / Off-Line
16	Exhaust in Control		
17	Configuration Error		
18	Start Perm Not Met		
19	Ready to Start		
20	Manual Start		

Table 6-13. Analog Read Register (3:0235) Ratio Limiter Control Status

Value	Description	Value	Description
1	No Ratio Limiter Control	21	Remote Inlet / Remote Exhaust
2	Remote Speed / Remote Extraction	22	Inlet / Remote Exhaust
3	Remote Speed / Extraction	23	Remote Inlet / Exhaust
4	Speed / Remote Extraction	24	Inlet / Exhaust
5	Speed / Extraction	25	Remote Inlet / Remote Exhaust
6	Remote Speed / Remote Inlet	26	Inlet / Remote Exhaust
7	Remote Speed / Inlet	27	Remote Inlet / Exhaust
8	Speed / Remote Inlet	28	Inlet / Exhaust
9	Speed / Inlet	29	Remote Speed Only
10	Remote Extraction / Remote Inlet	30	Speed Only
11	Extraction / Remote Inlet	31	Remote Extraction Only
12	Remote Extraction / Inlet	32	Extraction Only
13	Extraction / Inlet	33	Remote Inlet Only
14	Remote Speed / Remote Exhaust	34	Inlet Only
15	Remote Speed / Exhaust	35	Remote Exhaust Only
16	Speed / Remote Exhaust	36	Exhaust Only
17	Speed / Exhaust		
18	Remote Extraction / Remote Exhaust		
19	Extraction / Remote Exhaust		
20	Remote Extraction / Exhaust		

Table 6-14. Analog Read Register (3:0236) Map Limiter Status Messages

Value	Description	Value	Description
0	No Map Limits	16	Map Limit - Min Flow & Min P -
1	LP Limiter -	17	Map Limit - Min Flow & Min LP -
2	Map Limit - Min LP & Max HP -	18	Map Limit - Max P -
3	Map Limit - Min LP & Min P -	19	Map Limit - Min P -
4	Map Limit - Min LP & Min HP -	20	Map Limit - Max S -
5	Map Limit - Min LP & Max P -	21	Map Limit - Max LP -
6	Map Limit - Max P & Max HP -	22	Map Limit - Min LP -
7	Map Limit - Max P & Max S -	23	Map Limit - Max HP -
8	Map Limit - Max P & Max LP -	24	Map Limit - Min HP -
9	Map Limit - Max HP & Max S -	25	Map Limit - Min Flow -
10	Map Limit - Max HP & Max LP -		
11	Map Limit - Max LP & Max S -		
12	Map Limit - Max LP & Min P -		
13	Map Limit - Max LP & Min HP -		
14	Map Limit - Min HP & Min P -		
15	Map Limit - Min P & Max S -		

Table 6-15. Analog Read register (3:0001) Control Status

Value	Description	Value	Description
23	Shutdown	14	Ready to Start
22	Controlled Shutdown	13	Manual Start
24	Transferring to Ratio Limiter Control	12	Auto Start
25	Transferring to Speed Only Control	11	Semi Auto Start
26	LP Limiter Ramping	10	Idle / Rated Start
20	Max Actuator	9	Auto Start Sequence
27	HP Valve Limiter and LP Valve Limiter	8	Synchronizing
19	HP Valve Limiter	7	Load Share / Speed
28	Acceleration Limiter	6	Frequency / Speed
29	Manual Demand	34	Full Decoupled - Speed/Extraction
18	Remote Auxiliary	35	Ratio Limiter Control
17	Auxiliary Control	5	Remote Cascade/Speed
30	Remote Inlet	4	Cascade / Speed
31	Inlet in Control	3	Remote Speed
32	Remote Exhaust	36	Remote / KW
33	Exhaust in Control	2	Speed / On-Line
16	Configuration Error	1	Speed / Off-Line
15	Start Perm Not Met		

Analog Read addresses 3:0088—0093 and 3:0148—0149 give the configuration value of the analog inputs in order. The configuration for the analog inputs are defined in the table below.

Table 6-16. Analog Input Configuration

Value	Description	Value	Description
1	--- Not Used ---	26	Signal Monitoring #3
2	Remote Speed Setpoint	27	Start Temperature 1
3	Synchronizing Input	28	Start Temperature 2
4	Sync / Load Share	29	Extraction/Admission Input
5	Generator Load Input	30	Remote Extr/Adm Setpoint
6	Cascade Input	31	Remote Manual Extr/Adm (P) Demand
7	Remote Cascade Setpoint	32	Remote Exhaust Pressure Setpoint
8	Auxiliary Input	33	Remote Inlet Pressure Setpoint
9	Remote Auxiliary Setpoint	34	LP Valve Position Feedback
10	Spare 10	35	Spare_35
11	Spare 11	36	Spare_36
12	Inlet Pressure Input	37	Spare_37
13	I/H Actuator 1 Feedback	38	Spare_38
14	I/H Actuator 2 Feedback	39	Spare_39
15	Speed Feed-Forward	40	Spare_40
16	Remote Droop	41	Vibration Signal #1
17	Remote KW Setpoint	42	Vibration Signal #2
18	Exhaust Pressure Input	43	Vibration Signal #3
19	Spare 19	44	Vibration Signal #4
20	HP Valve Feedback Position	45	Vibration Signal #5
21	HP2 Valve Feedback Position	46	Vibration Signal #6
22	Isolated PID PV	47	Vibration Signal #7
23	Remote SP for Isolated PV	48	Vibration Signal #8
24	Signal Monitoring #1	49	Spare_49
25	Signal Monitoring #2	50	Spare_50

Analog read addresses 3:0094—0099 give the configuration value of the analog outputs in order. The configuration for the analog outputs is defined in the table below.

Table 6-17. Analog Output Configuration

Value	Description	Value	Description
1	--- Not Used ---	26	Isolated PID Setpoint
2	Actual Shaft Speed	27	Remote Isolated PID Setpoint
3	Speed Reference Setpoint	28	Remote KW Setpoint
4	Remote Speed Setpoint	29	Exhaust Pressure Input
5	Load Share Input	30	HP Valve Feedback Position
6	Synchronizing Input	31	HP2 Valve Feedback Position
7	Generator Load	32	Signal Monitoring #1
8	Cascade Input Signal	33	Signal Monitoring #2
9	Cascade Setpoint	34	Signal Monitoring #3
10	Remote Cascade Setpoint	35	Start Temperature 1
11	Auxiliary Input Signal	36	Start Temperature 2
12	Auxiliary Setpoint	37	LP Valve Demand
13	Remote Auxiliary Setpoint	38	LP Valve Limiter Setpoint
14	Spare 14	39	Extraction/Admission Input
15	Spare 15	40	Extraction/Admission Setpoint
16	Spare 16	41	Exhaust Pressure Setpoint
17	Valve Limiter Setpoint	42	Inlet Pressure Setpoint
18	LSS Value	43	Speed/Load Demand (S Demand)
19	HP Valve Demand	44	Extraction/Admission Demand (P Demand)
20	HP2 Valve Demand	45	Inlet Pressure Demand (Q Demand)
21	Inlet Pressure Input	46	Exhaust Pressure Demand (R Demand)
22	I/H Actuator 1 Feedback Readout	47	Spare_47
23	I/H Actuator 2 Feedback Readout	48	Spare_48
24	Isolated PID Dmd Output	49	Spare_49
25	Isolated PID PV Input Signal	50	Spare_50

Analog read addresses 3:0100—0105 give the configuration value of the relays in order. The configuration for the relays is defined in the table below. Boolean Read addresses 1:0355—0361 specify whether each relay is a level switch.

Table 6-18. Relay Configuration – For Level Switches

Value	Description	Value	Description
1	--- Not Used ---	19	Customer Defined Monitor Input #2
2	Actual Speed	20	Customer Defined Monitor Input #3
3	Speed Setpoint	21	LP Valve Limiter
4	KW Input	22	LP Valve Demand
5	Sync/Load Share Input	23	Speed/Load Demand (S Demand)
6	Cascade Input	24	Extr/Adm Input
7	Cascade Setpoint	25	Extr/Adm Setpoint
8	Auxiliary Input	26	Ext/Adm Demand (P Demand)
9	Auxiliary Setpoint	27	Inlet Pressure Setpoint
10	Spare 10	28	Inlet Pressure Demand (Q Demand)
11	Spare 11	29	Exhaust Pressure Setpoint
12	HP Valve Limiter	30	Exhaust Pressure Demand (R Demand)
13	LSS Value	31	Spare_31
14	HP Valve Demand Output	32	Spare_32
15	HP2 Valve Demand Output	33	Spare_33
16	Inlet Pressure	34	Spare_34
17	Exhaust Pressure	35	Spare_35
18	Customer Defined Monitor Input #1		

Table 6-19. Relay Configuration – For State Indications

Value	Description	Value	Description
1	--- Not Used ---	41	Cascade PID in Control
2	Summary Shutdown	42	Ready to Start
3	Summary Shutdown (Trip Relay)	43	Spare 43
4	Summary Alarm	44	Spare 44
5	All Alarms Clear	45	Unit OK (No SD)
6	Control Status OK	46	Remote KW SP Enabled
7	Overspeed Trip	47	Remote KW Setpoint Active
8	Overspeed Test Enabled	48	Manual Relay Control
9	Speed PID in Control	49	Isolated Controller in Auto
10	Remote Speed Setpoint Enabled	50	LP Valve Limiter in Control
11	Remote Speed Setpoint Active	51	Extr/Adm Control Enabled
12	Underspeed Switch	52	Extr/Adm Control Active
13	Auto Start Sequence Halted	53	Extr/Adm PID In Control
14	On-Line Speed PID Dynamics Mode	54	Remote Extr/Adm Setpoint Enabled
15	Local Interface Mode Selected	55	Remote Extr/Adm Setpoint Active
16	Frequency Control Armed	56	Inlet Pressure Control Enabled
17	Frequency Control	57	Inlet Pressure Control Active
18	Sync Input Enabled	58	Inlet Pressure PID In Control
19	Sync / Loadshare Input Enabled	59	Remote Inlet Pressure Setpoint Enabled
20	Loadshare Mode Active	60	Remote Inlet Pressure Setpoint Active
21	Cascade Control Enabled	61	Exhaust Pressure Control Enabled
22	Cascade Control Active	62	Exhaust Pressure Control Active
23	Remote Cascade Setpoint Enabled	63	Exhaust Pressure PID In Control
24	Remote Cascade Setpoint Active	64	Remote Exhaust Pressure SP Enabled
25	Auxiliary Control Enabled	65	Remote Exhaust Pressure SP Active
26	Auxiliary Control Active	66	Priority Selected
27	Auxiliary PID in Control	67	Alternate Mode Enabled
28	Remote Auxiliary Setpoint Enabled	68	Controlling on Steam Map Limiter
29	Remote Auxiliary Setpoint Active	69	Priority Active
30	Unit Started	70	Extr/Adm Input Failed
31	Spare 31	71	Inlet Pressure Input Failed
32	Spare 32	72	Exhaust Pressure Input Failed
33	Spare 33	73	Zero Speed
34	Spare 34	74	Extraction in P Demand Control
35	HP Valve Limiter in Control	75	Extraction in Remote P Demand Control

36	Command from Modbus BW addresses	76	Spare_76
37	Reset Pulse (2 sec)	77	Spare_77
38	Open GEN Breaker Cmd	78	Spare_78
39	Feed-Forward Enabled	79	Spare_79
40	Feed-Forward Active	80	Spare_80

Analog read addresses 3:0106—0117 give the configuration value of the contact inputs in order. The configuration for the contact inputs are defined in the table below.

Table 6-20. Contact Input Configurations

Value	Description	Value	Description
1	---Not Used---	51	Spare 51
2	Reset Command	52	I/H Actuator 1 Fault
3	Speed Raise Command	53	I/H Actuator 2 Fault
4	Speed Lower Command	54	Speed Forward Enable
5	Generator Breaker	55	Instant Min Gov/Load Speed
6	Utility Tie Breaker	56	Select Hot Start
7	Overspeed Test	57	Remote KW Setpoint Enable
8	External Run	58	Clock SYNC Pulse Contact
9	Start Permissive 1	59	Enable Rem SP for Isolated PID
10	Idle / Rated Command	60	Isolated Controller Raise
11	Halt/Continue Auto Start	61	Isolated Controller Lower
12	Override MPU Fault	62	LP Valve Limiter Open
13	Select On-Line Dynamics	63	LP Valve Limiter Close
14	Local / Remote	64	Extr/Adm Setpoint Raise
15	Rmt Spd Setpt Enable	65	Extr/Adm Setpoint Lower
16	Sync Enable	66	Extr/Adm Control Enable
17	Freq Control Arm/Disarm	67	Extr/Adm Remote Setpoint Enable
18	Casc Setpt Raise	68	Enable Manual Extr/Adm (P) Demand
19	Casc Setpt Lower	69	Inlet Pressure Setpoint Raise
20	Casc Control Enable	70	Inlet Pressure Setpoint Lower
21	Rmt Casc Setpt Enable	71	Inlet Pressure Control Enable
22	Aux Setpt Raise	72	Inlet Pressure Remote Setpoint Enable
23	Aux Setpt Lower	73	Exhaust Pressure Setpoint Raise
24	Aux Control Enable	74	Exhaust Pressure Setpoint Lower
25	Rmt Aux Setpt Enable	75	Exhaust Pressure Control Enable
26	Spare 26	76	Exhaust Pressure Remote SP Enable
27	Spare 27	77	Select Priority
28	Spare 28	78	Enable Decoupling
29	Spare 29	79	Manual P Demand Raise
30	HP Valve Limiter Open	80	Manual P Demand Lower
31	HP Valve Limiter Close	81	Spare_81
32	Controlled Shutdown(STOP)	82	Spare_82
33	External Trip 2	83	Spare_83
34	External Trip 3	84	Spare_84

Value	Description	Value	Description
35	External Trip 4	85	Spare_85
36	External Trip 5	86	Spare_86
37	External Trip 6	87	Spare_87
38	External Trip 7	88	Spare_88
39	External Trip 8	89	External Trip 11
40	External Trip 9	90	External Trip 12
41	External Trip 10	91	External Trip 13
42	External Alarm 1	92	External Trip 14
43	External Alarm 2	93	External Trip 15
44	External Alarm 3	94	External Alarm 10
45	External Alarm 4	95	External Alarm 11
46	External Alarm 5	96	External Alarm 12
47	External Alarm 6	97	External Alarm 13
48	External Alarm 7	98	External Alarm 14
49	External Alarm 8	99	External Alarm 15
50	External Alarm 9	100	Spare_100

Specific Address Information

Entering Set Point from Modbus

- The set point for the Speed, Extraction, Inlet, Exhaust, Cascade and Auxiliary can be entered from the Modbus. When the set point is entered for any of these functions the set point will not move to the entered set point instantly, but the set point will move towards the entered set point at the entered rate defined for the function in the Configuration mode. This functions the same as entering the set point from the front panel of the control.
- There is feedback provided to let the operator know what value was entered. This value will not change until a new value is entered from the Modbus. The addresses, 3:0060-:0062, are for speed, cascade, and auxiliary respectively. When the new value is entered from the Modbus, the set point will move to the new value. If the entered set point that is the same as the feedback, the operator can use a go to the set point command instead of entering the set point again. This command needs to be used when the set point to be entered is the same as the feedback.

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 service mode between 1 and 100. The following input and set point values that are sent across the Modbus have independent scale factors: Casc (3:0030), Aux (3:0037), Inlet Steam Pressure (3:0041), Exhaust Steam Pressure (3:0179) KW (3:0045), and Sync/Load Share (3:0043). These scaled parameters and their scale factor are available through the Modbus. Values that require a decimal point must be multiplied by the scale factor (10 or 100) prior to being sent across the Modbus. The value sent must then be divided by the scale factor in the Master.

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

For example, if the Cascade set point of 60.15 needs to be sent across the Modbus and have two decimal places, the Cascade Scale Factor would be set to 100 in the Service Mode. This will change the

value so that the decimal places can be sent across the Modbus communications link ($60.15 * 100 = 6015$). After the value is sent across the Modbus, it must be rescaled in the Master to the original value ($6015/100 = 60.15$). A Directly Entered Cascade Set Point (4:0002) of 61.5 would be sent across the link as 6150 and the 505 automatically divides the value by the Casc Scale Factor and uses the value of 61.5 as the set point desired.

Modbus Percentage

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

Modbus Emergency Shutdown

Two different types of shutdown commands (emergency and controlled) can be issued through Modbus. The Emergency Shutdown command instantly takes the speed set point and actuator current to zero. Optionally the 505 can be configured to ignore this Emergency Shutdown command if it is desired to not allow the unit to be tripped through Modbus.

To avoid an inadvertent trip, the emergency shutdown command from Modbus can be configured to require a two-step process before a shutdown command is issued. When the shutdown is a two-step process Boolean write address 0001 starts the shutdown process. An "ESD ACKN ENABLE" feedback (1:0065) is given and an acknowledgement on address 0002 has to be given within five seconds for the control to issue a shutdown command.

See Volume 2 for Service mode tunables.

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 7.

Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

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

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

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

A current list of Woodward Business Partners is available at:

<https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner>

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (Woodward North American Terms and Conditions of Sale 5-09-0690) 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 North American Terms and Conditions of Sale 5-09-0690).

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 North American Terms and Conditions of Sale 5-09-0690) 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 North American Terms and Conditions of Sale 5-09-0690). 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 one of the Full-Service Distributors listed at <https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner>

Contacting Woodward's Support Organization

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

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

Products Used in Electrical Power Systems		Products Used in Engine Systems		Products Used in Industrial Turbomachinery Systems	
Facility	Phone Number	Facility	Phone Number	Facility	Phone Number
Brazil	+55 (19) 3708 4800	Brazil	+55 (19) 3708 4800	Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515	China	+86 (512) 8818 5515	China	+86 (512) 8818 5515
Germany	+49 (711) 78954-510	Germany	+49 (711) 78954-510	India	+91 (124) 4399500
India	+91 (124) 4399500	India	+91 (124) 4399500	Japan	+81 (43) 213-2191
Japan	+81 (43) 213-2191	Japan	+81 (43) 213-2191	Korea	+82 (51) 636-7080
Korea	+82 (51) 636-7080	Korea	+82 (51) 636-7080	The Netherlands	+31 (23) 5661111
Poland	+48 (12) 295 13 00	The Netherlands	+31 (23) 5661111	Poland	+48 (12) 295 13 00
United States	+1 (970) 482-5811	United States	+1 (970) 482-5811	United States	+1 (970) 482-5811

Technical Assistance

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

General

Your Name

Site Location

Phone Number

Fax Number

Prime Mover Information

Manufacturer

Turbine Model Number

Type of Fuel (gas, steam, etc.)

Power Output Rating

Application (power generation, marine,
etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Symptoms

Description

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

Appendix A.

505XT Configuration Mode Worksheets

Control Part Number _____

Serial Number _____

Application _____

Date _____

For details on individual settings, refer to Chapter 4.

<u>TURBINE START</u>	Default	Site Value
Manual Start		YES/NO
Automatic Start		YES/NO
Semiautomatic Start		YES/NO
Rate to Min (rpm/s)	10	rpm/s
Valve Lmtr Rate (%/s)	2	%/s
Use Idle/Rated?	NO	YES/NO
Idle Setpt (rpm)	1000	rpm
Rated Setpt (rpm)	3600	rpm
Cold Idle/Rated Rate (rpm/s)	20	rpm/s
Hot Idle/Rated Rate (rpm/s)	20	rpm/s
Use Temp Input for Hot/Cold	NO	YES/NO
Use Temp Input 2?	NO	YES/NO
Hot Min Temp on Temp 1	1400	Temp deg
Hot Min Temp on Temp 2	1400	Temp deg
Use Warm Condition	NO	YES/NO
Warm Min Temp on Temp 1	1200	Temp deg
Warm Min Temp on Temp 2	1200	Temp deg
Use Temperature Difference (1/2)	NO	YES/NO
Hot Temp Diff (between 1 & 2)	10	value
Warm Temp Diff (between 1 & 2)	10	value
Use Auto Start Sequence	NO	YES/NO
Cold Start = (> xx Hrs)	0	HRS
Hot Start = (< xx Hrs)	0	HRS
Low Idle Setpt (rpm)	1000	rpm
Low Idle Delay (Cold)	0	MIN
Low Idle Delay (Hot)	0	MIN
Use Idle 2	NO	YES/NO
Rate to Idle 2 (Cold)	5	rpm/s
Rate to Idle 2 (Hot)	5	rpm/s
Idle 2 Setpt (rpm)	1500	rpm
Idle 2 Delay (Cold)	0	MIN
Idle 2 Delay (Hot)	0	MIN
Use Idle 3	NO	YES/NO
Rate to Idle 3 (Cold)	5	rpm/s
Rate to Idle 3 (Hot)	5	rpm/s
Idle 3 Setpt (rpm)	2000	rpm

TURBINE START	Default	Site Value
Idle 3 Delay (Cold)	0	MIN
Idle 3 Delay (Hot)	0	MIN
Use Temp for Idle	NO	YES/NO
Use Temp Input 2?	NO	YES/NO
Use Temp Difference	NO	YES/NO
Idle 1 Temp 1 Setpoint	1500	Temp deg
Idle 1 Temp 2 Setpoint	1500	Temp deg
Idle 1 Max Temp Difference	10	Value
Idle 2 Temp 1 Setpoint	1500	Temp deg
Idle 2 Temp 2 Setpoint	1500	Temp deg
Idle 2 Max Temp Difference	10	Value
Idle 3 Temp 1 Setpoint	1500	Temp deg
Idle 3 Temp 2 Setpoint	1500	Temp deg
Idle 3 Max Temp Difference	10	Value
Rate to Rated (Cold)	5	rpm/s
Rate to Rated (Hot)	5	rpm/s
RST Timer Level (rpm)	1	rpm
Hot RST Timer (min)	0	min
Auto Halt at Idle Setpts	NO	YES/NO

SPEED SETPOINT VALUES	Default	Site Value
Overspeed Test Lmt (rpm)	1100	rpm
Overspeed Trip (rpm)	1000	rpm
Max Governor Speed (rpm)	1	rpm
Nominal Speed (rpm)	3600	
Min Governor Speed (rpm)	1	rpm
Off-line Slow Rate (rpm/s)	5	rpm/s
On-line Slow Rate (rpm/s)	5	rpm/s
Use Remote Speed Setpt ?	NO	YES/NO
Remote Speed Setpt Max Rate	50	rpm/s
Use Critical Speeds?	NO	YES/NO
Critical Speed Rate	50	rpm/s
Critical Speed 1 Max	1	rpm
Critical Speed 1 Min	1	rpm
Use Critical Band 2 ?	NO	YES/NO
Critical Speed 2 Max	1	rpm
Critical Speed 2 Min	1	rpm
Use Critical Band 3 ?	NO	YES/NO
Critical Speed 3 Max	1	rpm
Critical Speed 3 Min	1	rpm

SPEED CONTROL	Default	Site Value
Probe Type Speed Sig 1	MPU	MPU/Active
Device Tag ID		User text
Teeth Seen by MPU	60	
Gear Ratio 1 :	1.000	
Max Speed Level (rpm)	1000	rpm
Failed Speed Level (rpm)	250	rpm
Use Speed Input #2?		YES/NO
Probe Type Speed Sig 2	MPU	MPU/Active
Device Tag ID		User text
Teeth Seen by MPU	60	
Gear Ratio 1 :	1.000	
Max Speed Level (rpm)	1000	rpm
Failed Speed Level (rpm)		rpm
Off-Line Prop Gain	5.000	%
Off-Line Int Gain	0.500	rps
Off-Line Deriv Ratio	5.000	%
On-Line Prop Gain	5.000	%
On-Line Int Gain	0.500	rps
On-Line Deriv Ratio	5.000	%

OPERATING PARAMETERS	Default	Site Value
Generator Application?	NO	YES/NO
Use Gen Brkr Open Trip ?	NO	YES/NO
Use Tie Brkr Open Trip ?	NO	YES/NO
Nominal Frequency	60	50/60
Droop (%)	5.0	%
Use MW as Load Units	NO	YES/NO
Use Load Droop?	NO	YES/NO
Maximum Load	5000	KW/MW
Primary Gen Load Signal	none	AI/DSL2C-2
Secondary Gen Load Signal	none	AI/DSL2C-2
Primary Sync/LS Signal	none	AI/DSL2C-2
Secondary Sync/LS Signal	none	AI/DSL2C-2
Primary Sync Signal	none	AI/DSL2C-2
Secondary Sync Signal	none	AI/DSL2C-2
Use Freq Arm/Disarm ?	NO	YES/NO
Tie Open activates Load Rejection	YES	YES/NO
Min HP Valve upon Load Rejection	0.0	%
Controlled Stop & Trip?	NO	YES/NO
Ext Trips in Trip Relay	YES	YES/NO
Reset Clears Trip Output	NO	YES/NO
Trip = Zero Current to Actuators	YES	YES/NO
Use Local/Remote	NO	YES/NO
Use Pressure Compensation	NO	YES/NO

AUXILIARY CONTROL	Default	Site Value
Use Auxiliary Control?	NO	YES/NO
Lost Aux Input Shutdown?	NO	YES/NO
Select Process Signal		
Invert Aux?	NO	YES/NO
Min Aux Setpt	0	Units
Max Aux Setpt	100	Units
Aux Setpt Rate units/s	5	Units/s
Use Aux as a Controller?	NO	YES/NO
Setpt Initial Value	0	Units
Aux Droop	0	%
Aux PID Prop Gain	1.00	%
Aux PID Integral Gain	0.300	rps
Aux Derivative Ratio	100	%
Tiebrkr Open Aux Disable	NO	YES/NO
Genbrkr Open Aux Disable	NO	YES/NO
Use Remote Aux Setpoint	NO	YES/NO
Remote Aux Max Rate	5	Units/s
Aux Units of Measure		User text
Decimals Displayed	1	value

CASCADE CONTROL	Default	Site Value
Use Cascade Control ?	NO	YES/NO
Lost Casc Input Shutdown?	NO	YES/NO
Select Process Signal		YES/NO
Invert Casc?	NO	YES/NO
Min Casc Setpt	0	Units
Max Casc Setpt	100	Units
Casc Setpt Rate units/s	5	Units/s
Use Casc as a Controller?	NO	YES/NO
Setpt Initial Value	0	Units
Speed Setpoint Lower Limit	0	Rpm
Speed Setpoint Upper Limit	0	Rpm
Max Speed Setpoint Rate	20	Rpm/s
Casc Droop	0	%
Casc PID Prop Gain	1.00	%
Casc PID Integral Gain	0.300	rps
Casc Derivative Ratio	100	%
Tiebrkr Open Casc Disable	NO	YES/NO
Genbrkr Open Casc Disable	NO	YES/NO
Use Remote Casc Setpoint	NO	YES/NO
Remote Casc Max Rate	5	Units/s
Casc Units of Measure		User text
Decimals Displayed	1	value

<u>INLET PRESSURE CONTROL</u>	Default	Site Value
Use Inlet Pressure Control?	NO	YES/NO
Lost Inlet Input Shutdown?	NO	YES/NO
Invert Inlet ?	NO	YES/NO
Min Inlet Setpt	0	Units
Max Inlet Setpt	100	Units
Inlet Setpt Rate units/s	5	Units/s
Use Inlet as a Controller?	NO	YES/NO
Setpt Initial Value	0	Units
Use Droop?	NO	YES/NO
Inlet Droop	0	%
Inlet PID Prop Gain	1.00	%
Inlet PID Integral Gain	0.300	rps
Inlet Derivative Ratio	100	%
Use Remote Inlet Setpoint	NO	YES/NO
Remote Inlet Max Rate	5	Units/s
Inlet Units of Measure		User text
Decimals Displayed	1	value
<u>EXHAUST PRESSURE CONTROL</u>	Default	Site Value
Use Exhaust Pressure Control ?	NO	YES/NO
Lost Exhaust Input Shutdown?	NO	YES/NO
Invert Exhaust ?	NO	YES/NO
Min Exhaust Setpt	0	Units
Max Exhaust Setpt	100	Units
Exhaust Setpt Rate units/s	5	Units/s
Use Exhaust as a Controller?	NO	YES/NO
Setpt Initial Value	0	Units
Use Droop?	NO	YES/NO
Exhaust Droop	0	%
Exhaust PID Prop Gain	1.00	%
Exhaust PID Integral Gain	0.300	rps
Exhaust Derivative Ratio	100	%
Use Remote Exhaust Setpoint	NO	YES/NO
Remote Exhaust Max Rate	5	Units/s
Exhaust Units of Measure		User text
Decimals Displayed	1	value

EXTR / ADM CONTROL	Default	Site Value
Use Extraction /Admission Control ?	NO	YES/NO
Lost E/A Input = Trip ?	NO	YES/NO
Min Extr/Adm Setpt Units	0	Units
Max Extr/Adm Setpt Units	100	Units
Setpoint Rate (units/sec) Units	5	Units/s
Use Setpoint Tracking?	NO	YES/NO
Setpoint Initial Value Units	0	Units
Use Droop?	NO	YES/NO
Extr/Adm Droop %	0	%
PID Proportional Gain %	1	%
PID Integral Gain rps	0.30	rps
PID Derivative Ratio %	100	%
Tiebrkr Open E/A Disable	YES	YES/NO
Genbrkr Open E/A Disable	YES	YES/NO
Generator Breaker Open Extr/Adm Inhibit?	YES	YES/NO
Use Remote Setpoint?	NO	YES/NO
Remote Setpt Max Rate Units	5	Units/s
Ext/Adm Units Of Measure		Units
Decimals Displayed	1	
Allow use of Full Decoupled Mode?	NO	YES/NO
Decoupled with LP = Exhaust PID	NO	YES/NO
Use AI signal for Manual P Demand	NO	YES/NO

STEAM PERFORMANCE MAP	Default	Site Value
Turbine Type	single	menu
Maximum Power	20000	YES/NO
Maximum HP Flow	100	Units
Use Alternate Modes?	NO	YES/NO
Maximum Extraction Flow	20000	Units
Maximum Admission Flow	20000	Units
Use Automatic Enable?	YES	YES/NO
LP Valve Limiter Rate	1	Units/s
Use Min Flow Line?	0	%
Load when HP=0 (Min Flow Line)	2000	%
Load when HP=100 (Min Flow Line)	8000	%
Extraction Priority on LP Max Limit?	NO	YES/NO
Max Power at Min Extract/Adm (Pt A)	84	Units
Max HP Flow at Min Extract/Adm (Pt A)	43.6	Units
Min Power at Max Extract/Adm (Pt B)	44	Units
Min HP Flow at Max Extract/Adm (Pt B)	87.6	Units
Min Power at Min Extract/Adm (Pt C)	4	Units
Min HP Flow at Min Extract/Adm (Pt C)	11.6	Units
Min LP Lift	0	%
Min HP Lift (if Adm)	0	%
Mode 0 Speed/Extraction	Speed	Spd/Ext
Mode 1 Speed/Inlet	Speed	Spd/Inlet
Mode 2 Extraction/Inlet	Inlet	Inlet/Ext
Mode 3 Speed/Exhaust	Speed	Spd/Exhaust
Mode 4 Extraction/Exhaust	Exhaust	Exhaust/Ext
Mode 5 Inlet/Exhaust	Inlet	Inlet/Exhaust
Mode 6 Inlet/Exhaust	Inlet	Inlet/Exhaust
K1 Gain Map calculated value shown		
K2 Gain Map calculated value shown		
K3 Gain Map calculated value shown		
K4 Gain Map calculated value shown		
K5 Gain Map calculated value shown		
K6 Gain Map calculated value shown		
Retain Service Values		
MAP Adjust	NO	
ISOLATED CONTROL	Default	Site Value
Use Isolated PID Control ?	NO	YES/NO
Use Remote Setpoint		
Valve Action upon PV Fault?	NO	YES/NO
Inverted ?	NO	YES/NO
Allow Manual Valve Control		
Maximum Setpt	100	Units
Minimum Setpt	0	Units
Setpt Initial Value	0	Units

COMMUNICATIONS	Default	Site Value
Ethernet IP Configuration		
ENET 1 Address	172.16.100.15	
ENET 1 Subnet Mask	255.255.0.0	
ENET 2 Address	192.168.128.20	
ENET 2 Subnet Mask	255.255.255.0	
ENET 3 Address	192.168.129.20	
ENET 3 Subnet Mask	255.255.255.0	
ENET 4 Address	192.168.128.20	
ENET 4 Subnet Mask	255.255.255.0	
Gateway Address (ENET 1 Only)	xxx.xxx.xxx.xxx	
Modbus Configuration		
Use Modbus	NO	YES/NO
Use Serial Link 1	NO	YES/NO
Use Ethernet Link 2	NO	YES/NO
Use Ethernet Link 3	NO	YES/NO
Device Address (1-247)	1	
Enable Write Commands	NO	YES/NO
Protocol	Ascii	Ascii/rtu
Baud Rate	115200	110-115K
Bits	8	7/8
Stop Bits	1	1/1.5/2
Parity	OFF	Off/odd/even
Driver	RS-232	232/485
Modbus Ethernet Link 2		
Ethernet Protocol	Ethernet TCP	TCP/UDP
Device Address (1-247)	2	
Enable Write Commands	NO	YES/NO
Modbus Ethernet Link 3		
Ethernet Protocol	Ethernet TCP	TCP/UDP
Device Address (1-247)	3	
Enable Write Commands	NO	YES/NO

CORE H/W I/O – Channel Configuration Tables

Speed Channels – These inputs are configured in Configuration Menu – Speed Control section

Analog Input Channels -

Ch	Function	Val@4	Val@20	Loop Pwr	TAG	Units	Modbus Mult.	Dec Disp
1								
2								
3								
4								
5								
6								
7								
8								

Discrete Input Channels -

Ch	Function	Invert Logic	TAG
1	Emergency Stop	Yes	
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Analog Output Channels -

Ch	Function	Val@4	Val@20	Ena Rdbk Flt	TAG	Units
1						
2						
3						
4						
5						
6						

Actuator Output Channels -

Ch	Function	Range	mA@0	mA@100	Dither	Act Flt = SD	Inv	TAG
1								
2								

Discrete Output Relays

Ch	Level or State	Function	Invert Logic	Level ON	Level OFF	TAG
1						
2						
3						
4						
5						
6						
7						
8						

LinkNet I/O Modes – Channel Configuration Tables (OPTIONAL)

Node 1 – 8 channels Analog Input 4-20mA & 2 channels Analog Output 4-20mA

Ch	Function	Val@4	Val@20	Units	Modbus Mult.	Dec Disp	TAG
1							
2							
3							
4							
5							
6							
7							
8							
1							
2							

Node 2 – 8 channels Analog Input 4-20mA & 2 channels Analog Output 4-20mA

Ch	Function	Val@4	Val@20	Units	Modbus Mult.	Dec Disp	TAG
1							
2							
3							
4							
5							
6							
7							
8							
1							
2							

Node 3 – 8 channels RTD Input (100 or 200 ohm)

Function	Min Val	Max Val	Deg F/C	Mod Mult	Dec Disp	Crv E/A	ohm val	TAG
1								
2								
3								
4								
5								
6								
7								
8								

For each of the Analog Input Node channels above, events can be configured if desired.

NODE 1 Events

Ch	Use Alm1	Use Alm2	Use Trip	Level 1 SP	Inv	Level 2 SP	Inv	Setpoint Hysteresis	Delay	Ena Spd	Spd Hys
1											
2											
3											
4											
5											
6											
7											
8											

NODE 2 Events

Ch	Use Alm1	Use Alm2	Use Trip	Level 1 SP	Inv	Level 2 SP	Inv	Setpoint Hysteresis	Delay	Ena Spd	Spd Hys
1											
2											
3											
4											
5											
6											
7											
8											

NODE 3 Events

Ch	Use Alm1	Use Alm2	Use Trip	Level 1 SP	Inv	Level 2 SP	Inv	Setpoint Hysteresis	Delay	Ena Spd	Spd Hys
1											
2											
3											
4											
5											
6											
7											
8											

Node 4 – 16 channel Discrete Input (24 VDC)

Ch	Function	Invert Logic	TAG
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Node 5 – 16 channel Discrete Output (24 VDC)

Ch	Level or State	Function	Invert Logic	Level ON	Level OFF	TAG
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						

When Actuator Outputs have been (In Service) Calibrated and Stroked, record values here.

	Default	505 Unit #1	Value in 505
Actuator # 1 mA at Minimum Position	*4.00		
Actuator # 1 mA at Maximum Position	*20.00		
Actuator # 1 Dither (mA)	*0.00		
Actuator # 2 mA at Minimum Position	*4.00		
Actuator # 2 mA at Maximum Position	*20.00		
Actuator # 2 Dither (mA)	*0.00		

Appendix B.

Primary Frequency Control

Primary Frequency Control Functions

Primary Frequency Control (PFC) is a common term defined and adopted by some utility grid and transmission requirements as a method of control of synchronous power generation to standardize and maintain frequency stability on a utility network.

In an effort to provide better grid stability and frequency regulation, many utility regulators are requiring power producers to provide primary frequency control (PFC) on any exported power through their utility grid tie breaker. Historically this requirement has usually only been applied to larger power producers, but the increase in grid stability concerns in recent years has been making it apply to smaller turbines also. Since the 505 can be applied to steam turbines of any size, this section will explain how the specific configuration of the 505 control determines whether the unit provides PFC support to the utility when the 505 is applied in a steam turbine generator drive application.

Application of the 505 on a Turbine/Generator Unit – Process Control or Power Generation?

The 505D and 505XT have always provided PFC when the unit is run in speed control while paralleled to the utility grid (the mode of Load Droop). The speed control acts on the error that exists between the speed setpoint and the actual generator speed, both in units of rpm, even if the operational setpoint is coming to the control remotely as a speed or 'load' setpoint. The KW setpoint (target load) is converted to an rpm setpoint value relative to the rated speed of the unit. If the grid frequency decreases, the control will automatically increase the inlet valve (HP) demand, which will result in an increase in load.

Very often (probably most of the time) the 505 control is configured to provide closed loop control of a plant process using the Cascade or Auxiliary Control functions. When running in these modes, the demand position of the HP valve is 'closed loop' around a parameter other than speed (often inlet or exhaust pressure). The amount of output load is allowed to vary in order to control a steam flow or pressure within the plant. In these cases, the HP valve demand will be responding to a plant process variable rather than a grid frequency change. In most, but not all, of these applications the unit will not be providing PFC support. The information in this section is provided to clarify the PFC status based on how the turbine is being operated, and to also provide options for how to provide PFC support (if required or desired) while still maintaining plant process control.

Table B-1. PFC Status Relative to Control Mode

Operational Control Mode (w/ GEN & UTIL Breakers Closed)	505 Providing PFC Support?	Conditions
Speed/Load Control	YES	All modes, including use of: Remote Speed Setpoint Remote KW Setpoint
Cascade (Process Control via Speed): With Zero Deadband	NO	If some cascade process deadband is added, then it will provide PFC support within that window
With a Deadband Setting	YES	
Auxiliary Control	NO	
Inlet Control	NO	
Exhaust Control	NO	
Extraction/Admission Control	YES NO	Modes 0, 1, and 3 All other Modes

The following options have been added to the 505 to assist customers with compliance to utility regulations where needed.

An alarm can be enabled, based upon the user settings for grid frequency deviation limit and a time duration for which that limit is exceeded. This condition will trigger a PFC action required alarm. If desired, this alarm can also initiate the inhibiting of any process controller that is configured for use. These selections are available in the Service menu under the Speed Control Droop settings.

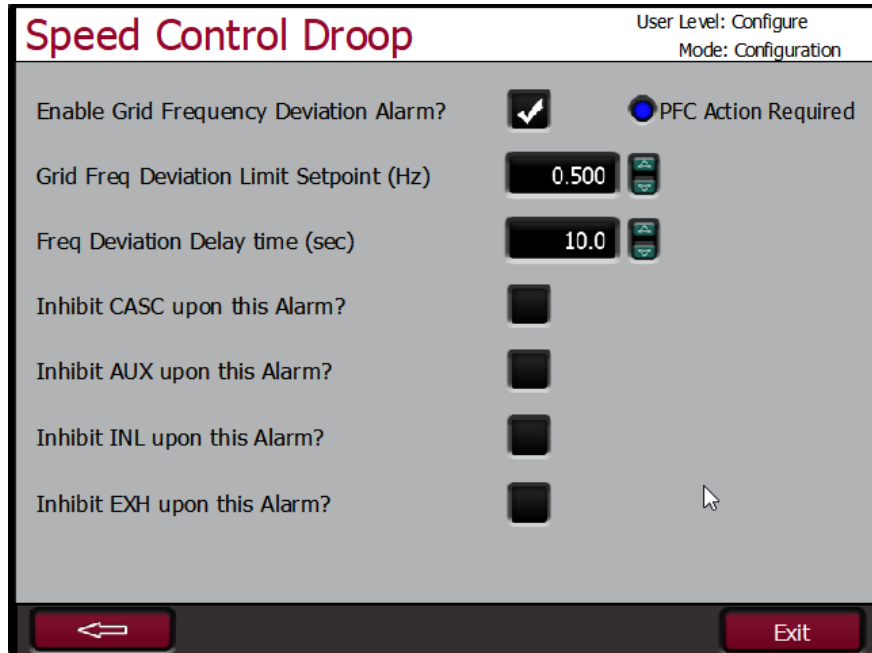


Figure B-1. Primary Frequency Control Options

Response to Grid Frequency Deviations

The following examples and figures will help illustrate how the control responds to grid frequency deviations.

1. Example of steam turbine in speed control with load droop –

- Grid speed is at 3600 rpm
- Speed setpoint is 3667 rpm (can be local or remote)
- Load is at 3711 kw (load setpoint of 3711)
- HP valve is at 23.4%

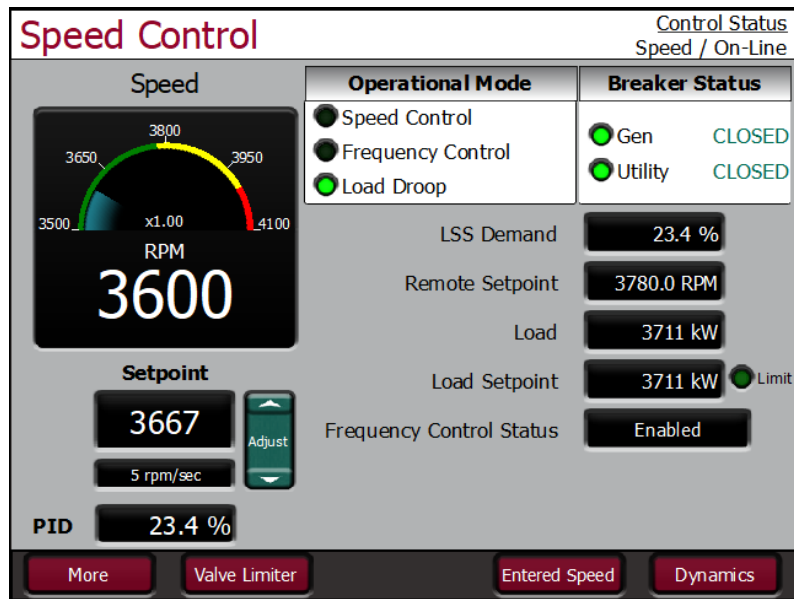


Figure B-2. Speed Control with Grid at Rated Frequency (Speed)

In Figure B-2 the speed setpoint is local from the GUI, but it would work exactly the same if the Remote Speed Setpoint was enabled and requesting a setpoint of 3667 rpm.

If the grid speed drops below rated frequency, the control will respond by picking up more load. This is because the speed control works on the error between the real speed of the turbine and the speed setpoint. The setpoint did not move, but the speed decreased which caused the HP valve demand to increase. Note the real load is now above the load setpoint.

- Grid speed is at 3590 rpm
- Speed setpoint is 3667 rpm (can be local or remote)
- Load is at 4267 kW (load setpoint of 3711)
- HP valve is at 26.2%

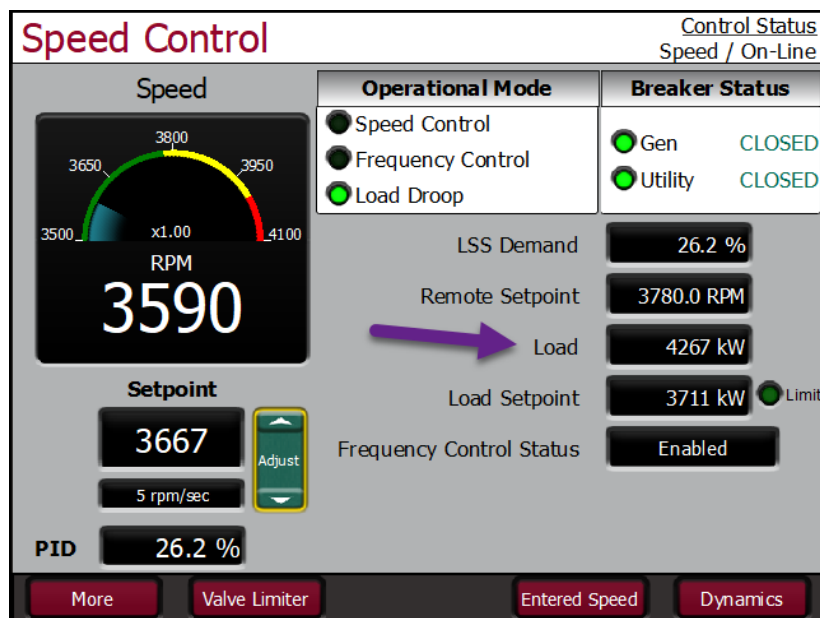


Figure B-3. Speed Control with Grid Below Rated Frequency

In the Service Menu screens (Breaker Logic) – there is an adjustment for a “Frequency Deadband (Hz)”. If this parameter is adjusted from its default of 0.0, it will create a window around rated speed in which the control will NOT compensate for grid frequency fluctuations. Many utility regulating bodies refer to this as a flat deadband, which creates a flat spot on the load compensation curve. Typical deadband settings are in the range of 20-40 mHz.

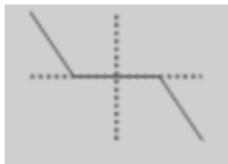


Figure B-4. Speed Control with a Frequency Deadband Setting

The result of this configuration is that the control will automatically add load when the grid speed drops below rated, so in this case the unit does provide PFC support.

2. Example of steam turbine in Cascade Control to maintain exhaust pressure –

Unit is steady state cascade control with the cascade controller maintaining exhaust pressure.

- Grid speed is at 3600 rpm (speed setpoint of 3654)
- Load is at 3022 kw
- HP valve is at 20%
- Exhaust Pressure = 10 bar(cascade setpoint of 10)
- **Cascade Control Deadband (in Service menu) = 0.0 (default value)**

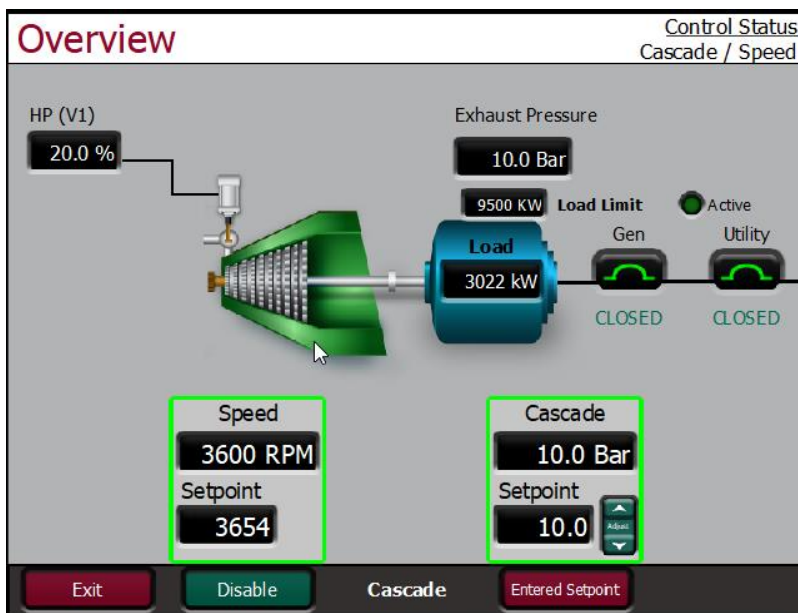


Figure B-5. Cascade Control with Grid at Rated Frequency (Speed)

The Cascade control maintains a process by varying the speed setpoint. Since the speed control is actually controlling the HP valve demand, this configuration may initially pickup load if the grid speed decreases but will return to no net gain of load once its back to steady state control of the cascade process.

If the grid speed decreases, the control reaction is to pick up more load, similar to the speed control response in the previous example. In simulation, if we hold the exhaust pressure at 10 bar the initial control response is the same as the speed control with load droop example in that both the HP valve demand and the load increase.

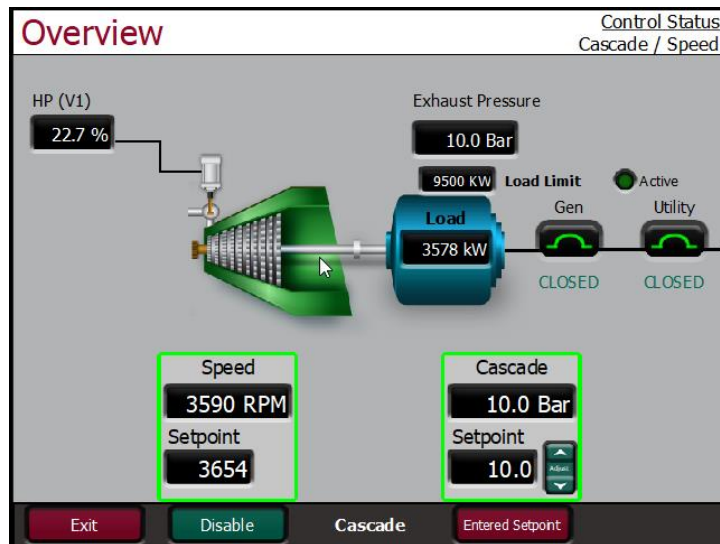


Figure B-6. Cascade Control Initial Response with Grid Below Rated Frequency (Speed)

However, the real turbine/plant process response is that the exhaust pressure will increase, due to the HP valve increasing from 20.0% to 22.7%.

The cascade control will respond to the increase in exhaust pressure and begin to reduce the speed setpoint back to a point where the exhaust pressure is back to its setpoint.

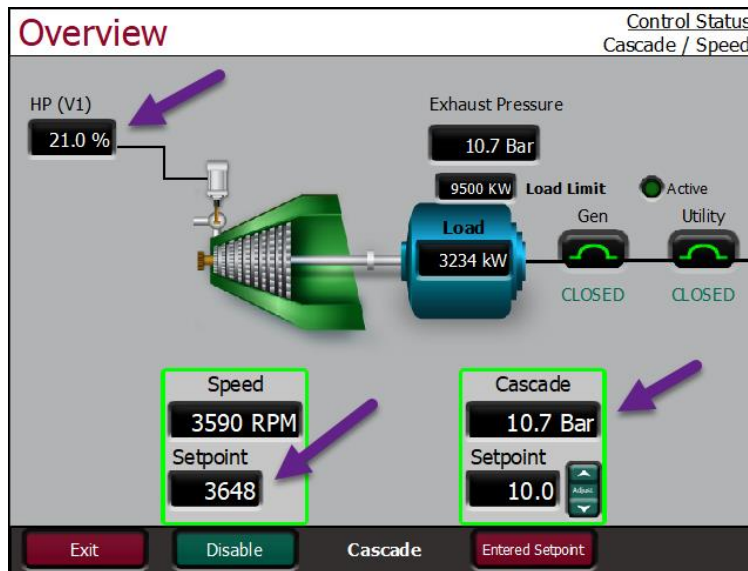


Figure B-7. Cascade Control Responding to Rise in Exhaust Pressure

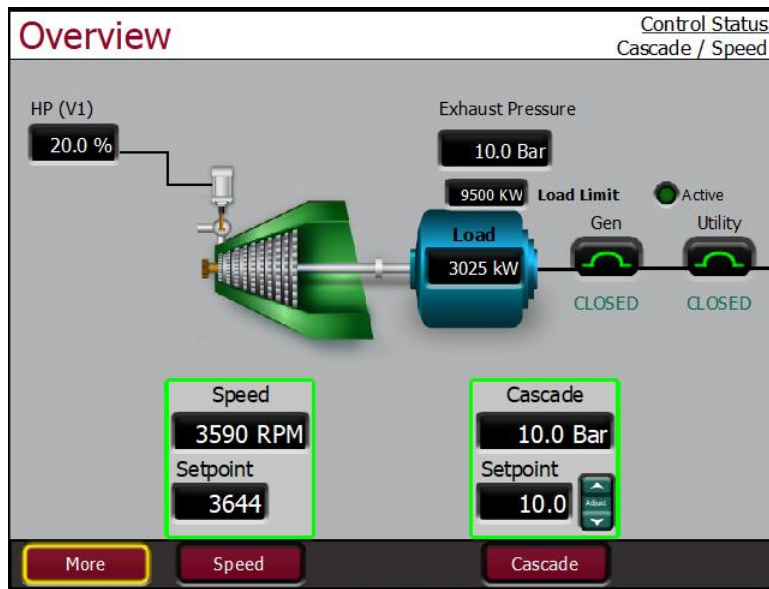


Figure B-8. Cascade Control Steady State Response with Grid Below Rated Frequency (Speed)

The cascade control will reduce the HP demand to correct the exhaust pressure back to the setpoint, so that ultimately the HP demand has returned to the same % that it was originally.

- Grid speed is at 3590 rpm (speed setpoint of 3644)
- Load is at 3025 kw
- HP valve is at 20%
- Exhaust Pressure = 10 bar (cascade setpoint of 10)

The result of this configuration is that no additional load is picked up when grid speed drops below rated, thus no PFC grid support is done, unless an additional setting is modified.

Adding Cascade Deadband to the Process Control:

In the above example, if the Cascade Control Deadband setting is adjusted from 0.0, this will create a window where the speed control can provide PFC grid support. In the example below a 0.5 bar deadband has been added to the cascade control settings. This will prevent the cascade control from continually adjusting the speed setpoint (as in the example above) which was canceling out the speed control PFC compensation.

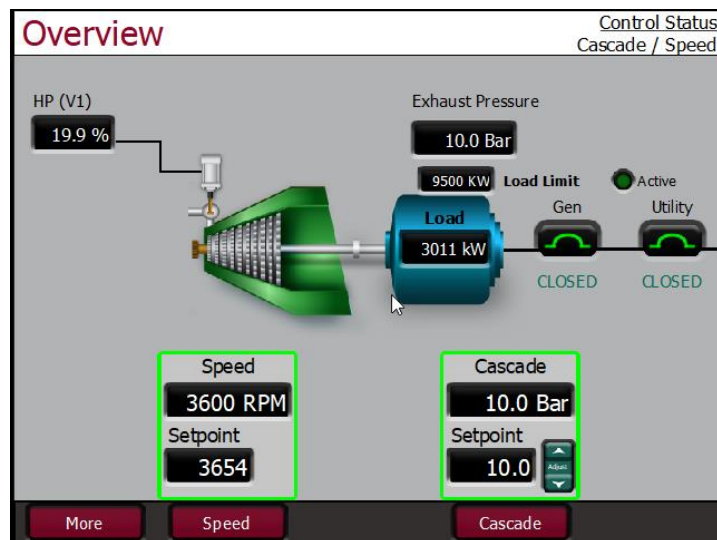


Figure B-9. Cascade Control with Grid at Rated Frequency (Speed)

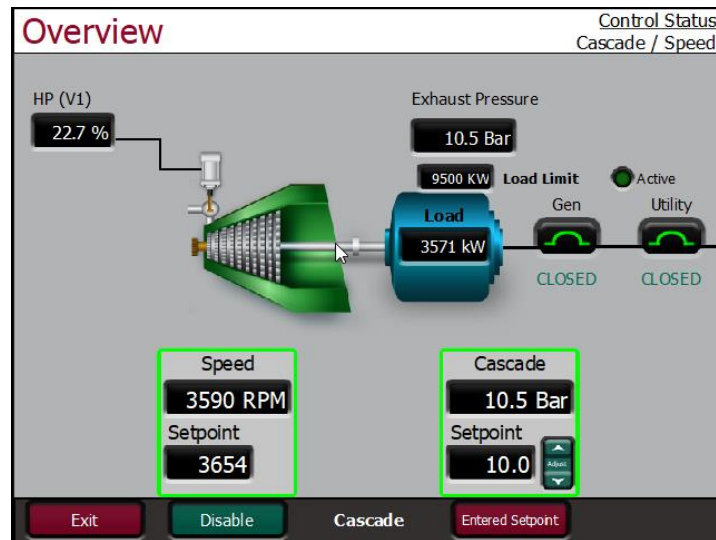


Figure B-10. Cascade Control Using Deadband with Grid Below Rated Frequency

The result of this configuration is that additional load is picked up when grid speed drops below rated, so in this case the unit does provide limited PFC support. The limited support is relative to the cascade deadband setting. In the above example the 0.5 Bar deadband produced a 10 rpm window which provided a +/- 0.166 Hz PFC support. This is an example only, so if this is required, specific site testing would need to be done to calculate the amount of deadband needed to provide the desired PFC support and plant then needs to decide if that deadband value is acceptable to the plant process being controlled by the cascade function.

If PFC support is desired in cascade mode, the reserve load capacity can be achieved by setting the "Speed Setpoint Upper Limit" in the cascade control configuration to be a value less than maximum governor speed. In the example above the maximum governor speed is set to 3780 (5% droop of 3600rpm). If the cascade upper limit is set to 3771 then there would be a 5% reserve load available for the PFC function (0-100% load = 180 rpm) while the unit operates in cascade control.

NOTICE

If the Cascade control was configured to maintain Inlet pressure instead of exhaust pressure, the results above would be the same, even though the cascade control PID must be inverted to control inlet pressure. This is because of the cascade control design of only acting on the speed setpoint and not directly on the valve positioning.

3. **Example of steam turbine in Auxiliary Control to maintain exhaust pressure –**
Unit is steady state auxiliary control with the controller maintaining exhaust pressure.
- Grid speed is at 3600 rpm (speed setpoint of 3650)
 - Load is at 2762 kw
 - HP valve is at 18.6%
 - Exhaust pressure = 10 bar (auxiliary setpoint of 10)

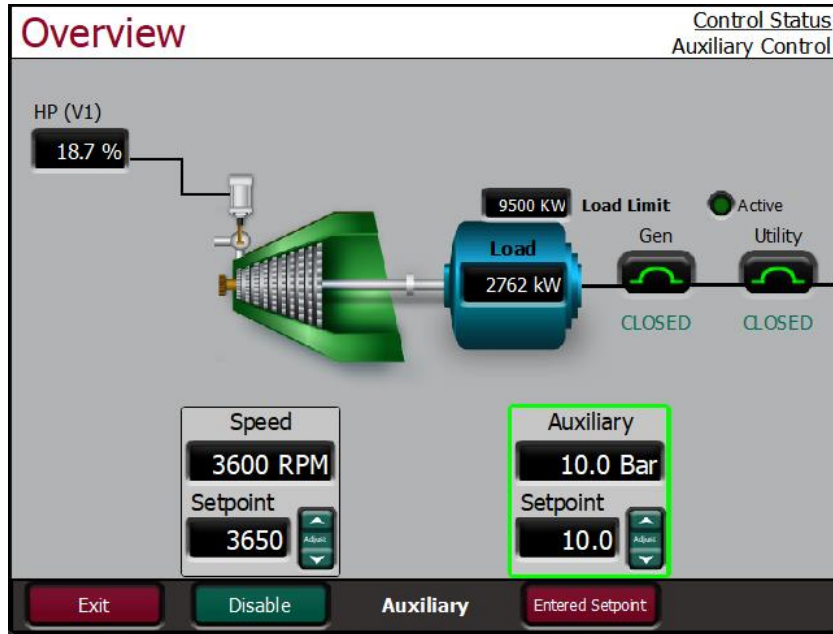


Figure B-11. Auxiliary Control with Grid at Rated Frequency (Speed)

If the Auxiliary Controller is used, it is completely independent of the speed/load control. In this case, the turbine never picks up any load during a drop in grid speed since the speed/load control is not in control of the HP valve. As shown below, the speed setpoint will change since the speed control is in a tracking mode while the Auxiliary control is active, but the HP valve demand remains constant.

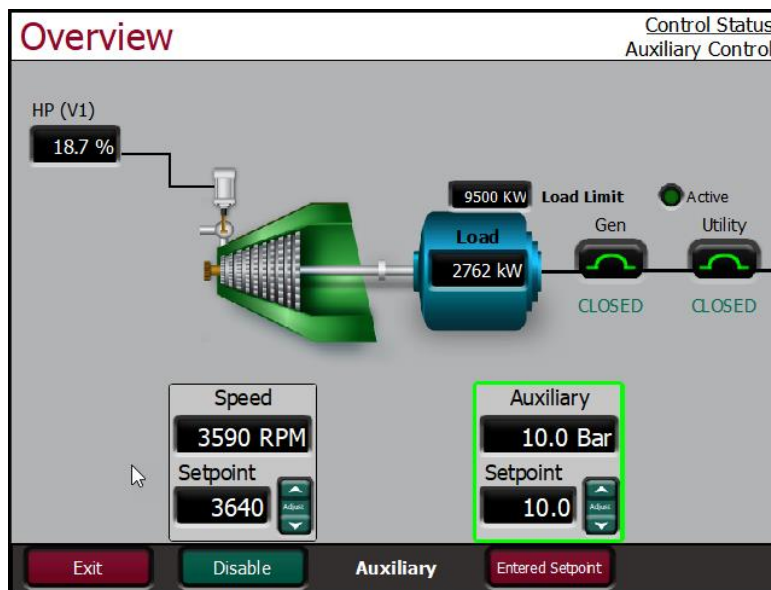


Figure B-12. Auxiliary Control with Grid Below Rated Frequency (Speed)

The end result is that no additional load is picked up when grid speed drops below rated. If the control typically runs in Auxiliary control mode, then it will not provide any PFC support to the utility grid.

4. Example of steam turbine in Auxiliary Control to maintain load –

Unit is steady state auxiliary control with the controller maintaining load.

- Grid speed is at 3600 rpm (speed setpoint of 3690)
- Load is at 10.0 MW
- HP valve is at 74.7%
- Service/Speed Control Droop set for PFC alarm at 0.10 Hz and inhibit Aux

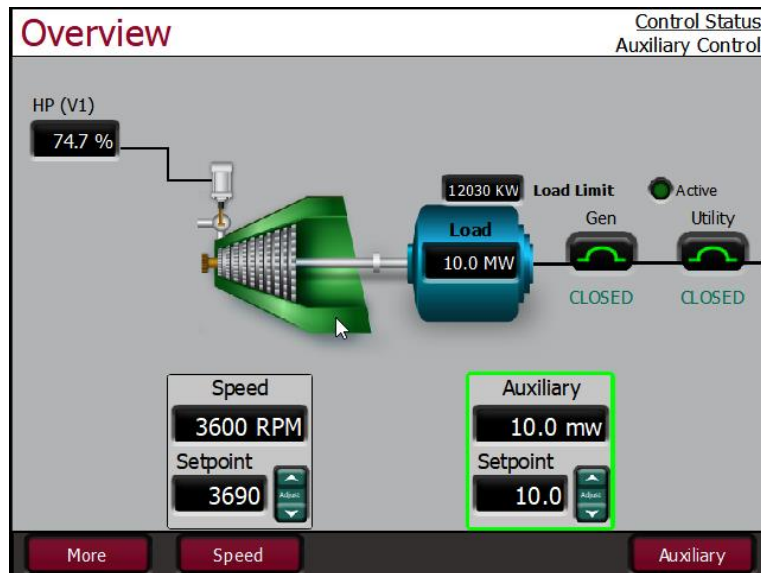


Figure B-13. Auxiliary Control with Grid at Rated Frequency (Speed)

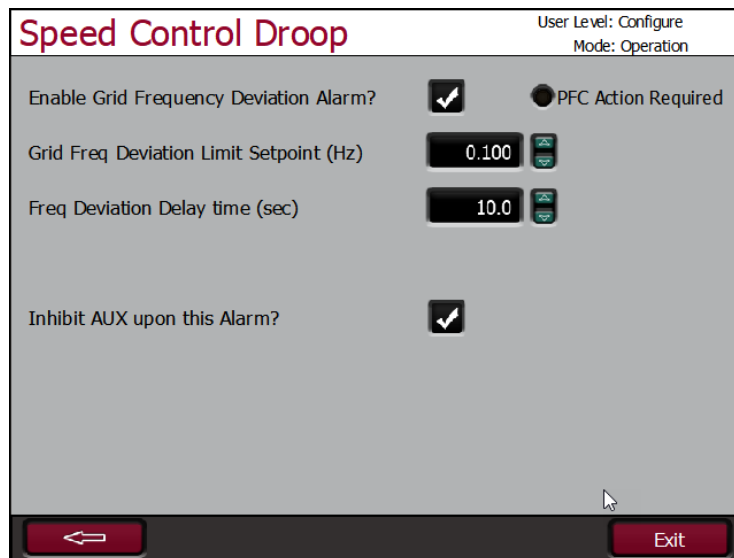


Figure B-14. Speed Control Droop Setting for PFC Alarm and Action

In this example the Auxiliary Controller has been configured to control load, but primary frequency control action has been set to trigger an alarm and inhibit the Auxiliary controller if the grid speed deviates by more than 0.10 Hz (in this example = 10 rpm). In this case, the turbine will not pick up or shed any extra load as long as the speed stays within 3590-3610 rpm. However, as shown below, if the utility grid

frequency drops lower than the deviation limit setting, then the turbine will inhibit the Auxiliary control, switch to Speed/Online control and begin to pick up additional load.

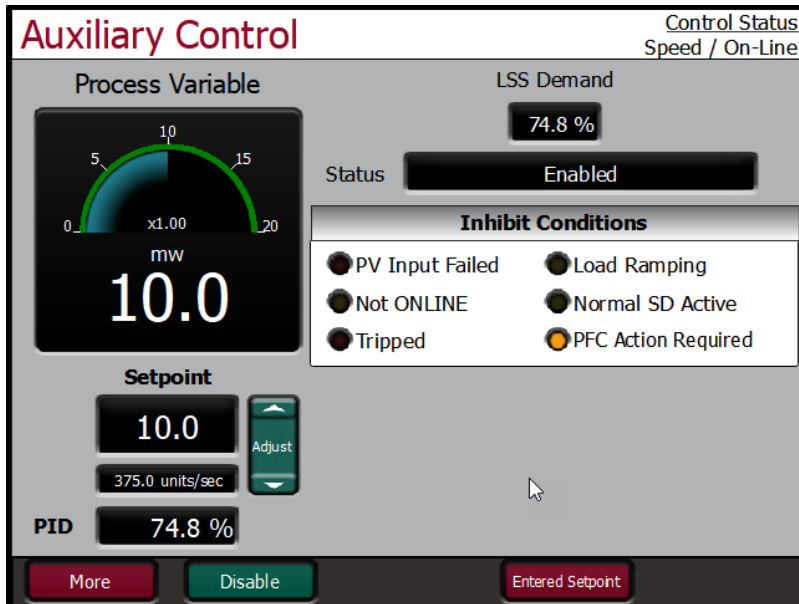


Figure B-15. Auxiliary Control with Grid Speed at 3590 RPM Taking PFC Action

Auxiliary control screen with annunciation that PFC action has been taken and this controller is now inhibited. The Aux control will stay inhibited as long as the alarm condition is true. To clear the alarm the condition the grid speed must return to being within the allowed deviation and the operator must issue a reset command.

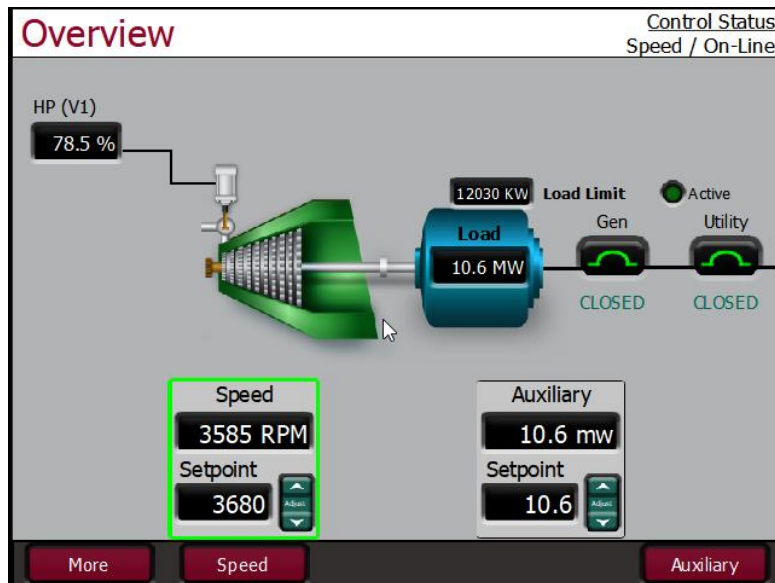


Figure B-16. Turbine Back to Speed Control with Grid Speed at 3585 RPM Picks Up Load

Extraction/Admission Type Turbines

If the control is configured for an Extraction and/or Admission turbine, the above descriptions are all still applicable. As long as the unit runs in a mode that includes Speed control (Modes 0, 1 and 3) and Speed has priority, then the PFC actions as explained above will take place. This includes any use of Cascade for the speed control if used.

Revision History

Changes in Revision J—

- Revised part number 8200-2312 in Chapter 1 Introduction
- Revised Table 2-1 Vibration section

Changes in Revision H—

- Revised Tables 1-1, 1-2, 1-3, and 1-4
- Revised Detecting Zero Speed section
- Revised Reduced Overspeed Test section
- Added Load Limiter Function
- Added Turbine Shutdown Warmup
- Added Trip & Throttle Valve Interface and Functions
- Revised Speed Control Menu
- Added Driver Configuration Menu for applications in software version 5418-7839 Rev “A” and newer
- Replaced Figure 5-3b
- Revised Table 5-1
- Added Appendix B - Primary Frequency Control

Changes in Revision G—

- Added a note on Control Part Numbers to Introduction section
- Various revisions to Table 1-4
- Updated Figure 3-33
- Various revisions to Table 4-2 and 4-3
- Added Figure 4-2a, 5-3a, 5-3b, and 5-5a
- Updated Figure 5-1
- Added content about Site Info button and changing languages on display to Chapter 5
- Revised Table 5-1
- Various revisions in Appendix

Changes in Revision F—

- Removed EAC information from the Regulatory Compliance section

Changes in Revision E—

- Revised actuator output value in Actuator Outputs section on pg. 21
- Revised multiple figure reference within the manual
- Added content to GATEWAY near the top of pg. 142
- Revised output value in the middle of pg. 159
- Added NERC/ECROT Frequency Excursion Test section to Chapter 5

Changes in Revision D—

- Deleted “Pollution Degree 3” from Note 5 from Table 2-1 Environmental Specifications

Changes in Revision C—

- Inserted IMPORTANT box in the Regulatory Compliance section
- Replaced references from Figure 4-5 to Figure 3-23 in Chapter 3
- Replaced references from Figure 4-6 to Figure 3-24 in Chapter 3
- Replaced “appropriate mA” with “minimum current” in TRIP = ZERO CURRENT TO ACTUATORS section on pg. 133
- Replaced % with mA in ACTUATOR 1 DITHER section on pg. 145
- Replaced ACTUATOR 02 content with content included a WARNING box on Pgs. 145 - 147
- Replaced % with mA in table on pg. 239
- Replaced both Declarations

Changes in Revision B—

- Automated PID Dynamic Optimizer added to Chapter 5

- Compliance updates and updated DOC

Changes in Revision A—

- New content on pg. 26 immediately below Fig. 1-9
- New Notice box in Outline Drawing for Installation section on pg. 31
- Updated content in tables 5-1, 5-2, 6-6, 6-7 (Entire table), 6-8, and 6-9
- Updated text on bullet #4 under Controlled Shutdown
- Added Generator Beaker in Operator Log section on pg 153
- Change actuator range from 20-160mA to 20-200mA
- Updated Table 4-3 20-160mA range to 20-200mA
- Inserted new paragraph in General Description section of Controller Overview
- Replaced step #1 in Manual Start Mode of Turbine Start Mode Procedure
- Replaced step #1 in Semiautomatic Start Mode of Turbine Start Mode Procedure
- Replaced step #1 in Automatic Start Mode of Turbine Start Mode Procedure
- Removed ADM/Admission referenced from Enabling/Disabling Extraction Control section
- Added new paragraph to from Enabling/Disabling Extraction Control section
- Changed “Armed” to “Disarmed” in Automatic Speed Override section
- Removed bottom two rows from Turbine Start worksheet in Appendix A
- Removed row in Operating Parameters worksheet in Appendix A
- Changed third row in Auxiliary Control worksheet in Appendix A
- Added row to EXT/ADM Control worksheet in Appendix A
- Removed Maximum Exhaust Flow row from Steam Performance Map worksheet in Appendix A
- Inserted row to Steam Performance Map worksheet in Appendix A
- Removed Max Exhaust Flow setting from Pg. 154
- Inserted Excitation Priority... setting to Pg. 154
- Replaced chart and values to Mode 3 on Pg. 112
- Replaced chart to Mode 4 on Pg. 113
- Deleted Mode 6 from Pg 114

Declarations

EU DECLARATION OF CONFORMITY

EU DoC No.: 00466-04-EU-02-01
Manufacturer's Name: WOODWARD INC.
Manufacturer's Contact Address: 1041 Woodward Way
 Fort Collins, CO 80524 USA
Model Name(s)/Number(s): 505D, 505XT, Flex500, Flex500 Bulkhead, Vertex and Vertex Bulkhead
 (HV-STD) 88-264Vac, 90-150Vdc
 505D, 505XT, Flex500, Flex500 Bulkhead, Vertex and Vertex Bulkhead
 (LV-STD) 18-36Vdc

The object of the declaration described above is in conformity with the following relevant Union harmonization legislation: Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)


Directive 2006/95/EC (until April 19th, 2016) and
 Directive 2014/35/EU (from April 20th, 2016)
 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

Applicable Standards: EN 61000-6-4, 2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments
 EN 61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments
 EN61010-1, 2010 : Safety Requirements for Electrical Equipment for measurement, control and laboratory use – Part 1 : General Requirements

Last two digits of the year in which the CE marking was affixed for the first time: 15

This declaration of conformity is issued under the sole responsibility of the manufacturer
 We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER



Signature
Joseph Driscoll

Full Name
Engineering Manager

Position
Woodward, Fort Collins, CO, USA

Place
09-March-2018

Date

5-09-1183 Rev 26

EU DECLARATION OF CONFORMITY

EU DoC No.: 00466-04-EU-02-02
Manufacturer's Name: WOODWARD INC.
Manufacturer's Contact Address: 1041 Woodward Way
 Fort Collins, CO 80524 USA
Model Name(s)/Number(s): 505D (LV-ATEX/MARINE) 18-36Vdc P.N. 8200-1302
 505XT (LV-ATEX/MARINE) 18-36Vdc P.N. 8200-1312
 Flex500 (LV-ATEX/MARINE) 18-36Vdc P.N. 8200-1342
 Flex500 Bulkhead (LV-ATEX/MARINE) 18-36Vdc P.N. 8200-1352
 Vertex (LV-ATEX) 18-36Vdc P.N. 8200-1372
 Vertex Bulkhead (LV-ATEX) 18-36Vdc P.N. 8200-1382


The object of the declaration described above is in conformity with the following relevant Union harmonization legislation: Directive 2014/34/EU on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres
 Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)

Markings in addition to CE marking:  Category 3 Group II G, Ex ic nA nC IIC T4X Gc IP20

Applicable Standards: EN 61000-6-4, 2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments
 EN 61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments
 EN60079-0, 2012 : Explosive Atmospheres - Part 0: Equipment – General requirements
 EN60079-11, 2012 :Explosive Atmospheres – Part 11 : Equipment protection by intrinsic safety "i"
 EN60079-15, 2010 : Explosive Atmospheres - Part 15: Equipment protection by type of protection "n"

This declaration of conformity is issued under the sole responsibility of the manufacturer
 We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

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Signature

Joseph Driscoll

Full Name

Engineering Manager

Position

Woodward, Fort Collins, CO, USA

Place

09-Mar-2018

Date

5-09-1183 Rev 26

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication **35018V1**.



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