



General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.



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Proper Use

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



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 Out-of-date translations are marked with .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

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

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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 to 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.

EMC Directive: 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)

Low Voltage Directive: Directive 2014/35/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 the making available on the market of electrical equipment designed for use within certain voltage limits.

Other European Compliance:

Compliance with the following European Directives or standards does not qualify this product for application of the CE Marking:

RoHS Directive: Restriction of Hazardous Substances 2011/65/EU: Woodward Turbomachinery Systems products are intended exclusively for sale and use only as a part of Large Scale Fixed Installations per the meaning of Art.2.4(e) of directive 2011/65/EU. This fulfills the requirements stated in Art.2.4(c) and as such the product is excluded from the scope of RoHS2.

Special Conditions for Safe Use:

This equipment is to be installed by professional service personnel according to the instructions given in this manual.

Wiring must be in accordance with the authority having jurisdiction. PERMANENTLY CONNECTED EQUIPMENT requires the special considerations to satisfy the CEC and the Canadian deviations to IEC 61010-1, including overcurrent and fault protection as required.

This device is considered permanently connect and requires a fixed wiring installation. Protective Earth Grounding is required by the input PE terminals. (See Installation Chapter).

A disconnection device is not supplied with the system. A disconnecting switch or circuit breaker shall be included in the building installation. It shall be in close proximity to the equipment and within easy reach of the operator. This device shall be clearly marked as the disconnecting device for the equipment. The disconnecting switch or circuit breaker shall not interrupt the protective earth conductor.

To ensure stability and to prevent accidental tipping, lift equipment only as described in the installation chapter and bolt the system cabinet to the building structure before operation of the equipment.

125 Vdc digital Input connections located on FTM104-1A, FTM104-1B, FTM104-2A, and FTM104-2B (Woodward # 5453-276) are not to be connected on CSA certified systems or on systems requiring compliance with the European Low Voltage Directive.

Measurement inputs are classified as permanently connected IEC measurement Category I and are designed to safely withstand occasional transient overvoltages up to 707 Vpk.



WARNING

To avoid the danger of electric shock, do not use measurement inputs to make measurements within measurement categories II, III, or IV.

The system CCT and 5009 Control Chassis CPU contain single cell primary batteries. These batteries are not to be charged and are not customer replaceable.

**WARNING**

The control cabinet contains hazardous live voltages. Only individuals who have received proper training should open the cabinet door and perform service. Equipment should be isolated or disconnected from hazards live voltages before servicing.

This equipment is intended to be installed in a metal cabinet or enclosure. See manual 26167, Volumes 1 & 2, for installation requirements related to CE Marking requirements.

Safety Symbols



Direct Current



Alternating Current



Both Alternating and Direct Current



Caution, risk of electrical shock



Caution, refer to accompanying documents



Protective conductor terminal



Frame or chassis terminal

Chapter 1.

General Information

Introduction

The technical documentation for the 5009XT control system consists of the following volumes:

Volume 1—provides information on system application, control functionality, control configuration, I/O assignment, control logic, PID setting instructions, and system operation procedures.

Volume 2—provides hardware descriptions, mechanical and electrical installation instructions, hardware specifications, fault tolerance, hardware troubleshooting help, and basic repair procedures and provides installation procedures for the 5009XT control's software interface tool suite.

The 5009XT product is a fault tolerant hardware version of the same steam turbine control functionality release in the Flex500 platform in 2016. Both the GAP (control logic) and GUI (user friendly user interface) were leveraged into Woodward's MicroNet TMR platform to provide customers the option of a fully fault tolerant control using the same control algorithms, functions, features and interface as our simplex control.

This volume of the manual describes the functionality and graphical user interface for Woodward's 5009XT CORE application software for all types of steam turbines, including:

- Single Valve or split-range actuators turbines
- Controlled Extraction or Admission turbines (2 Control valves)
- Controlled Extraction and Admission turbines (2 Control valves)

The option charts below shows the part numbers and the differences between the models. Volume 1 of this manual describes the control, provides, and explains the configuration (programming) and operating procedures. Volume 2 includes installation instructions, defines hardware specifications and provides specific control wiring 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 Numbers

Active 5009XT Control part numbers are listed in Volume 2 of this manual.

5418-7830 Parent Software Part Number for both the GAP & GUI applications

Table 1-1. Terminology Definitions

MicroNet TMR	Refers to the overall Woodward Product family / hardware platform
5009XT or 5009XT CORE	Refers specifically to the Control/GUI application software features described in this manual – the software part number is identified on Home screen/Site Info

Related Manuals

These manuals provide additional information related to this product.

Table 1-2. Reference Manuals

26167V1 and V2	MicroNet TMR Digital Control
26336	Woodward VxWorks Real Time Operating System (RTOS)
26236	Servo Position Controller (SPC) – if used/optional

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.

Controller Overview

General Description

The 5009XT 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 5009XT can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

The 5009XT 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 5009XT, 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 the main HP or LP Steam Valves) for any single loop ancillary control that may be required. Examples of use for this function are Seal Gas, Gland Seals, or an additional steam extraction valve that is not required to be ratio-limiter controlled in concert with the primary LP valve.

When applied to single or split range actuator turbines, the 5009XT 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 5009XT 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 5009XT is able to 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 5009XT 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.

The 5009XT CORE is designed to support a variety of valve configurations including single coil, dual coil and redundant actuators for both the main inlet valve (HP or V1) and an Ext/Adm valve (LP/V2).

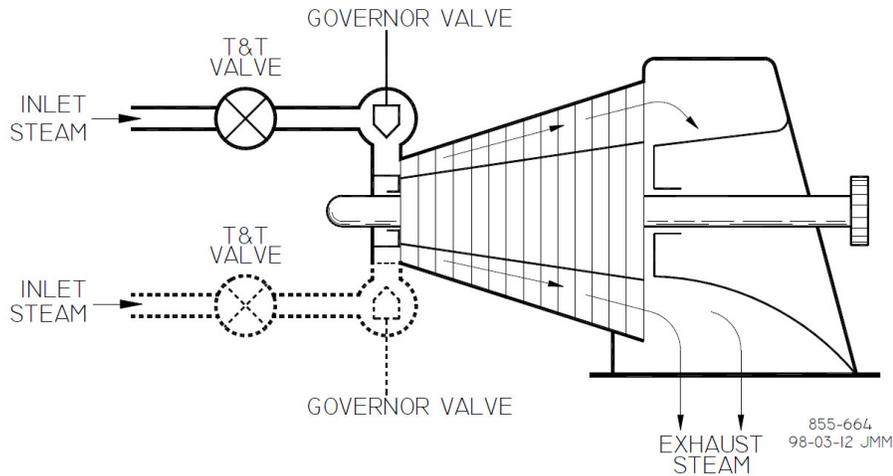


Figure 1-1. Typical Single or Dual Inlet Steam Turbine

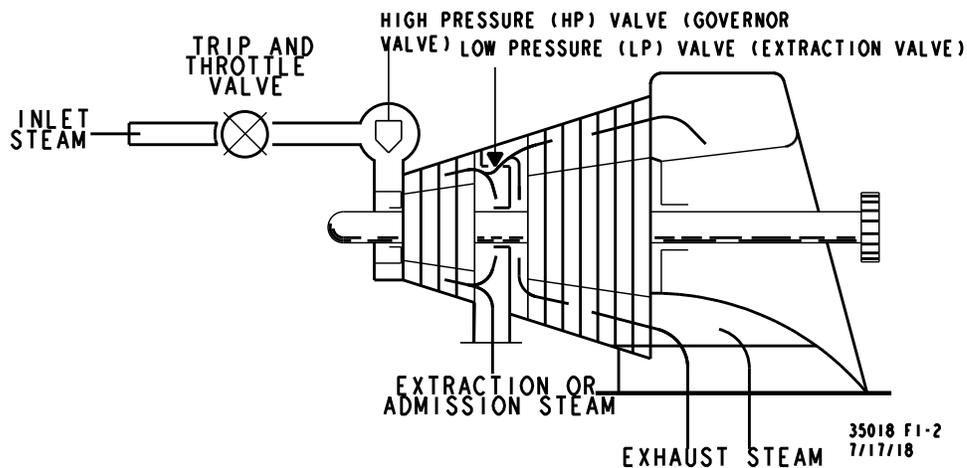


Figure 1-2. Typical Extraction and/or Admission Steam Turbine

Additional Features

In addition to the control loops mentioned, the 5009XT 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 trendlog capture files
- SNTP time synchronization via an Ethernet IP
- CAN communication interface to Woodward's Servo Position Controllers (SPC)
- Planned integration of digital communication links to other Woodward products (Woodward Links)

Using the 5009XT

The 5009XT control has three normal operating modes, Configuration Mode, Service Mode and the 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.
--	--

Service (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.

Run/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 5009XT 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.

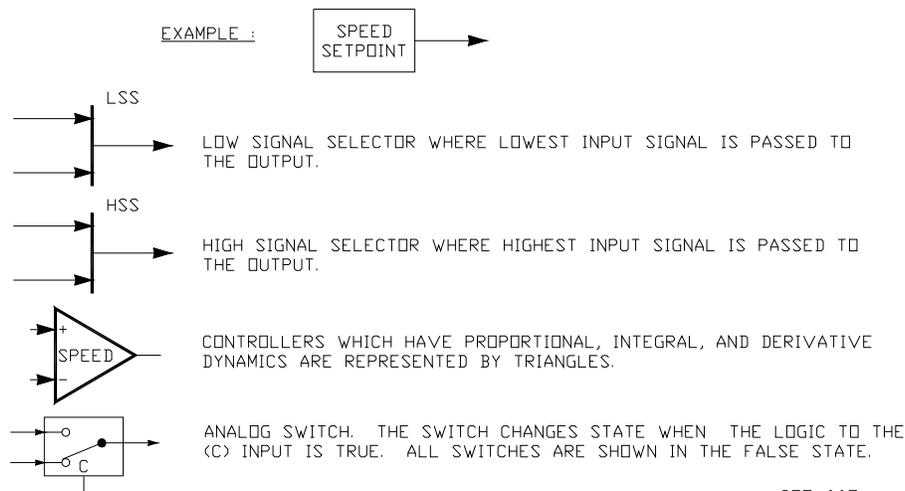
⊥⊥ SYMBOLS INDICATE SWITCH CONTACT INPUTS.
 LINE THROUGH SYMBOL INDICATES NORMALLY CLOSED CONTACT.

⬡ DC INDICATES INTERCONNECTING LOGIC IN FUNCTIONAL.

⬡ FD 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
 02-12-31

Figure 1-3. Explanation of Symbols

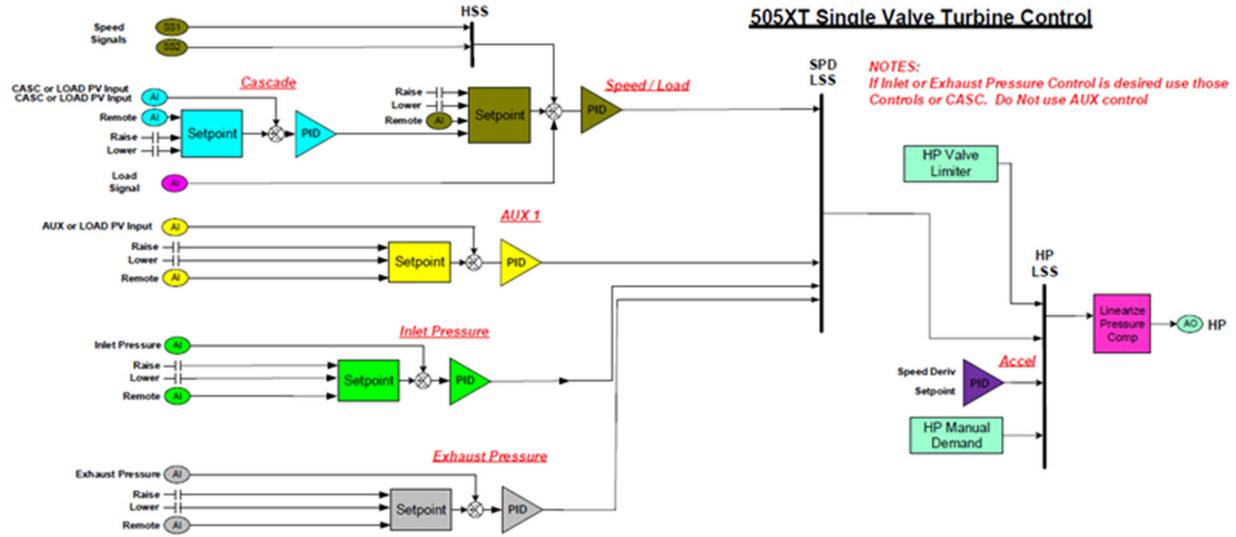


Figure 1-4. Single or Split-Range Turbine Configurations (Valve Demand Overview)

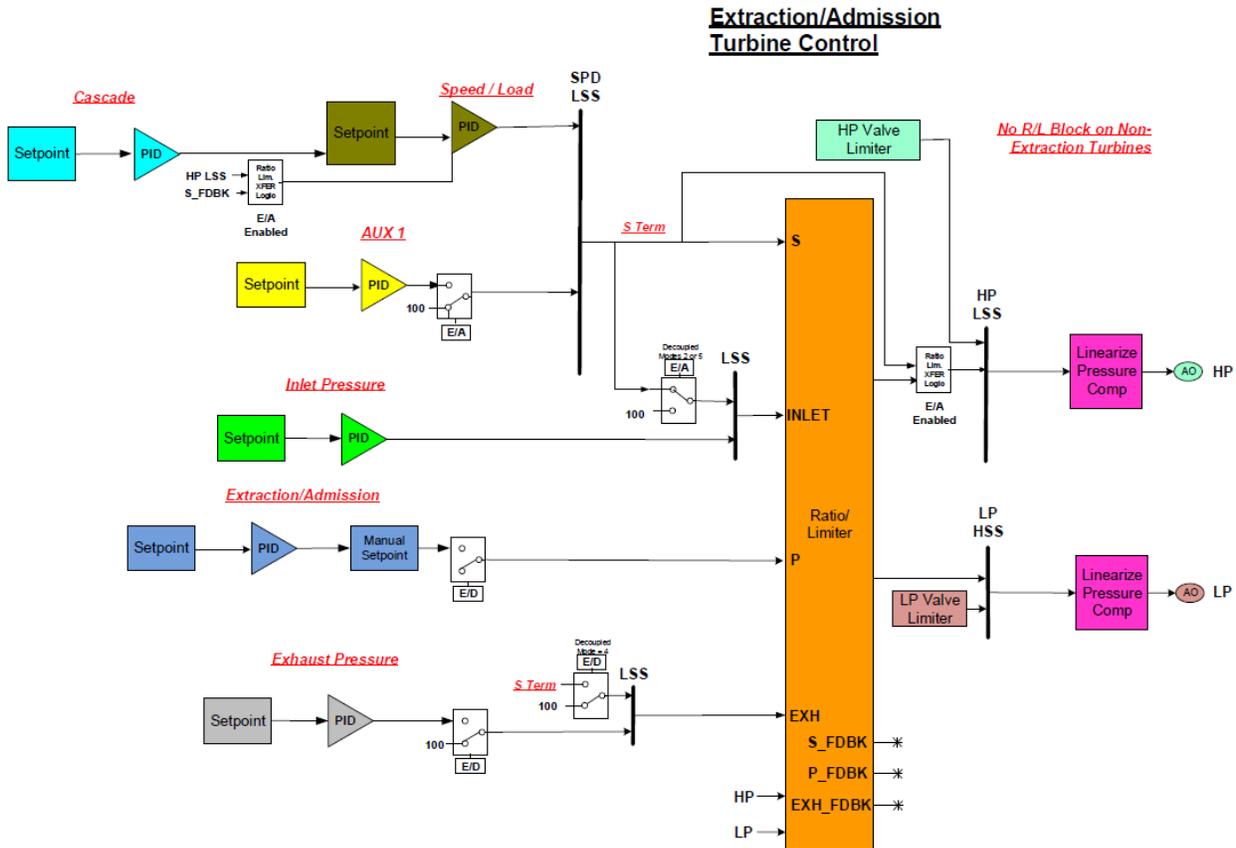


Figure 1-5. Turbine Configurations using Extraction and/or Admission (Valve Demand Overview)

5009XT Input and Output Signals

Control Inputs

Speed Input Signals

Four speed inputs are available. The first three are configurable to accept MPUs (magnetic pickup units), or active proximity probes and provide the controllable speed of the running turbine. A fourth speed input is available to be used as a slow speed detection signal, typically done with a proximity/low speed detectable probe

Analog 4-20 mA Input Signals

There are twelve configurable analog inputs available, each of which can be configured as one of the input menu functions listed in Appendix B.

Discrete Contact Input Signals

Twenty four 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 three 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 tie-breaker. The rest of the additional contact inputs are available for configuration to function as various controller discrete input functions as listed in Appendix B. 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.

Control Outputs

The base hardware supplied with this control supports four analog output drivers of 4-20 mA range. An optional kit can be purchased that will add support for 2 channel actuator controller modules that support 0-200 mA range proportional drives or integrating type actuators. The next revision of the application software will add the logic for four CAN driver outputs for Woodward SPC's and two additional drivers that connect to Woodward VariStroke-II electro-hydraulic actuators. There will be an optional kit created that will include the SPC units and the CAN cables.

Analog 4-20 mA Outputs

Four 4–20 mA analog outputs are available for use and each can be configured as one of the functions in the analog output menu listed in Appendix B.

Relay Outputs

Twelve completely fault tolerant Form-C relay contact outputs are available. The first channel is dedicated to be 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 11 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 or as a level switch based on an analog valued as listed in in Appendix B.

Types of Actuators supported

The 5009XT supports 3 types of actuators

Single Coil Actuators –

Full demand current to each output.

For the AO module channels, each channel will drive its share of the demand current related to the number of healthy channels supplying current to the output.

For the ACT module option, each channel will drive half of the demand current required when both are healthy. When 1 is unhealthy the other will drive the full current.

Wire the coil to the correct AO output channel on FTM103-2 or for the ACT (option) wire to both module driver channels (FTM106-1 and FTM106-2).

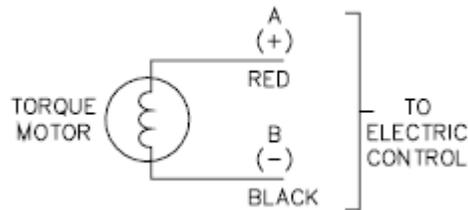


Figure 1-6. Single torque motor

Single Torque Motor (TM) –

Wire Coil to both module driver channels (FTM106-1 and FTM106-2). Each channel will drive half of the demand current required when both are healthy. When one is unhealthy the other will drive the full current.

Single TM with feedback –

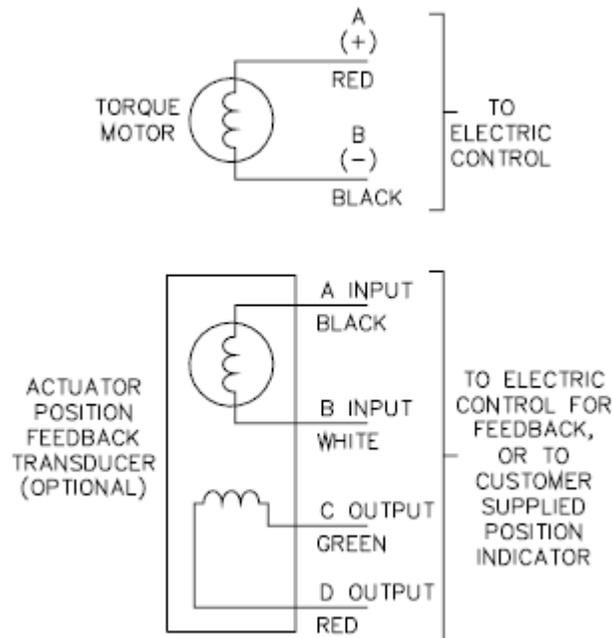


Figure 1-7. Single torque motor with feedback

Dual Coil Torque Motor (TM) –

Half demand current to each output.

For AO's two channels must be defined, each channel will drive half of the demand current required when both are healthy. When 1 is unhealthy the other will drive the full current.

For ACT's (option) only one channel is required. In the software the slot six modules in Kernel A and B are defined as redundant channels. Each will drive half of the demand current required when both are healthy. When one is unhealthy the other will drive the full current.

For AO's wire Coil A to one channel and Coil B to another channel.

For ACT's wire Coil A to KA module (FTM106-1) and wire Coil B to KB module (FTM106-2)

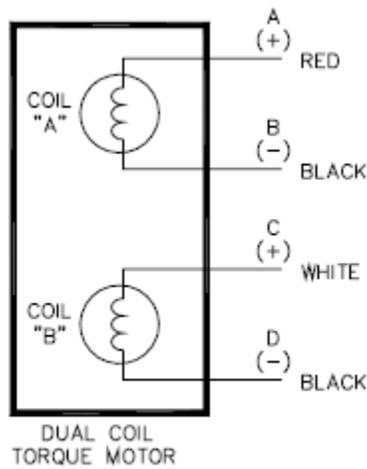


Figure 1-8. Dual coil torque motor

Redundant Actuators –

Full demand current to each output – hydraulic redundancy downstream (CPCII example below) will select which actuator will be used

For AO's, two channels must be defined, each channel will drive full demand current when healthy.

For ACT's (option) two channels must be defined. Each will drive full demand current when healthy.

For AO's wire Act A to one channel and Act B to another channel.

For ACT's wire Act A to channel one on both FTM106-1 and FTM106-2 and wire Act B to channel two on both FTM106-1 and FTM106-2

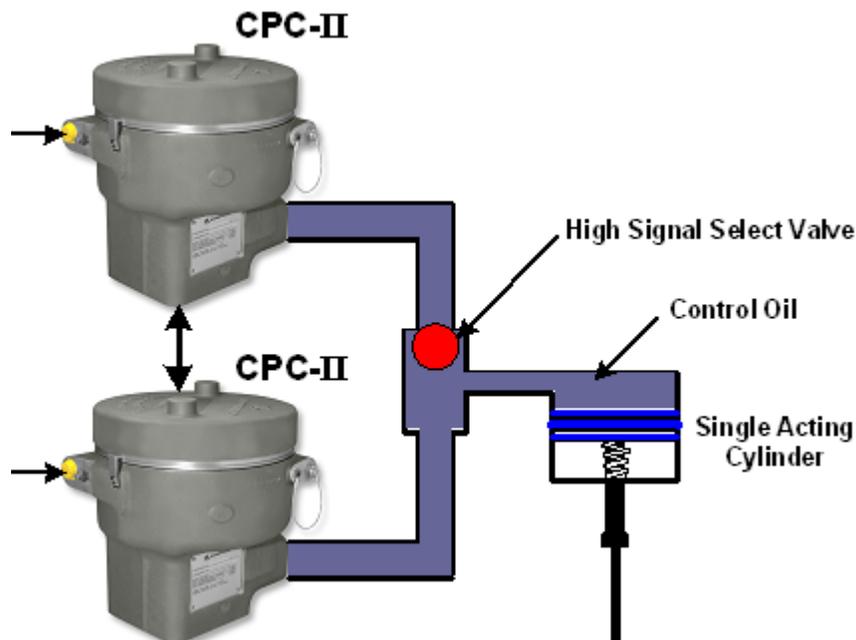


Figure 1-9. Redundant actuators

Optional I/O and Digital Drivers

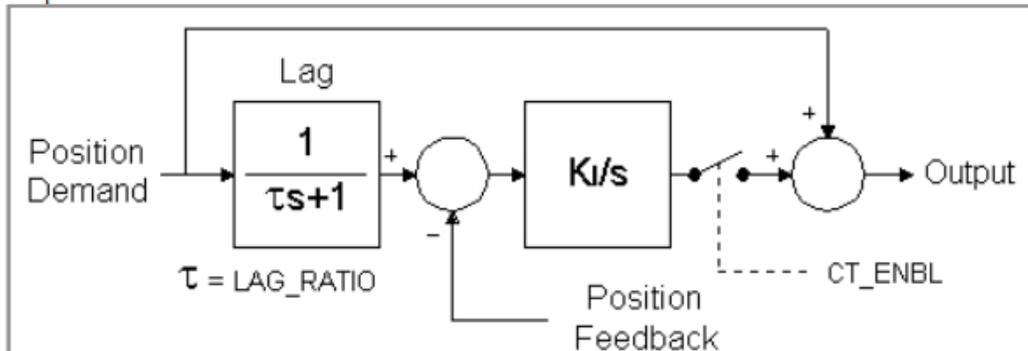
2 Channel Actuator Controller

This kit is an optional hardware package that adds 2 Actuator Controller modules to the chassis and provides 2 redundant channels for driving 0-200 range proportional actuators or integrating actuators with feedback. The part number and details of installing this kit are found in volume 2 of this manual.

Proportional Actuators –

This module will drive proportional actuators with or without feedback and a drive current range of 0-200mA. If feedback is used the controller can enable a command trim feature that will reduce steady state position errors. The effect of the command trim is limited to +/- 10% of the mA range set in calibration. If no feedback is used the command trim will be automatically disabled.

Proportional actuators:



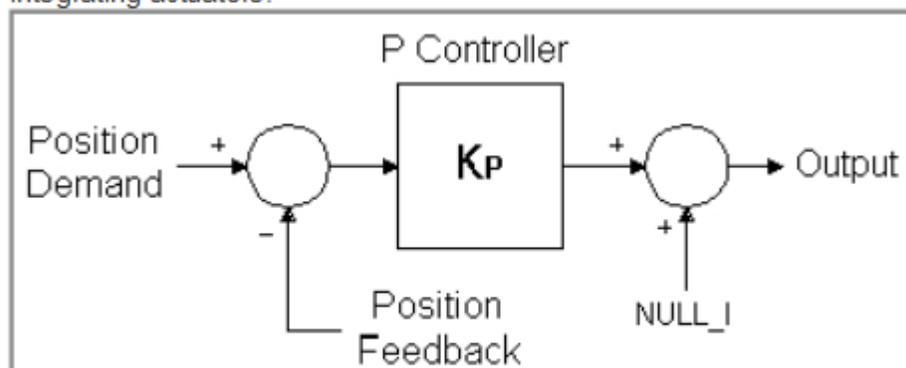
CTRL_TYPE= PROP
 KP= N/A
 KI= integral time constant
 T_LEAD= N/A
 LAG_RATIO= lag time constant

Figure 1-10. Proportional actuator with command trim

Integrating Actuators –

Integrating actuators require some type of feedback device and always drive the same current output at steady state (the null current). When the demand changes the current will increase or decrease until the feedback position equals the demanded position.

Integrating actuators:



CTRL_TYPE= P
 KP= proportional gain
 KI= N/A
 T_LEAD= N/A
 LAG_RATIO= N/A

Figure 1-11. Integrating actuator using P controller

The P controller is the simplest controller, is very robust and works well for systems that aren't very sensitive to position errors. Steady-state errors will exist if the null setting during calibration does not equal the actual null current of the actuator.

Tuning can be accomplished by increasing the gain until the actuator just starts to oscillate, then reducing the gain by a factor of two

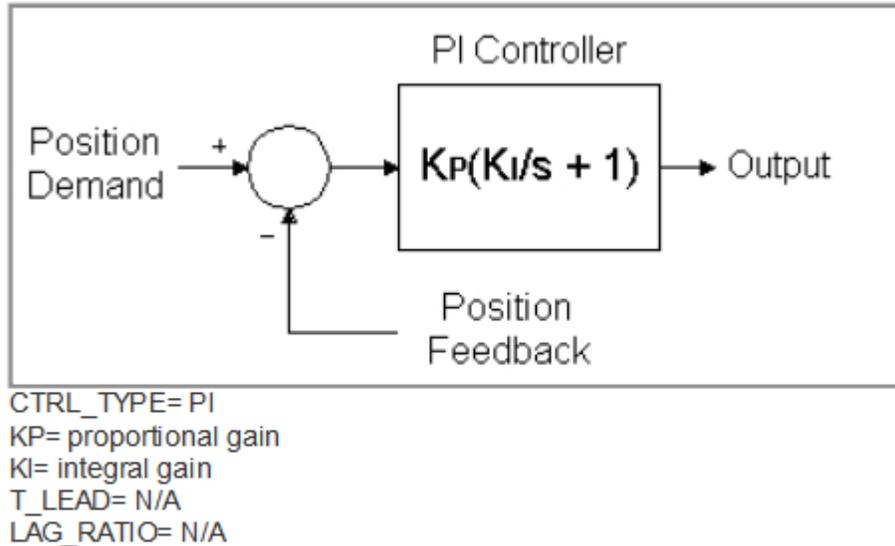


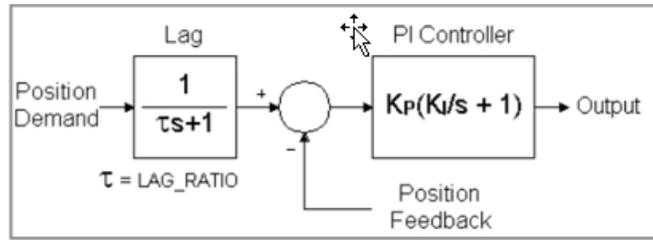
Figure 1-12. Integrating actuator using PI controller

The PI controller is suitable for most applications. The following procedure may be used as a starting point to finding the optimal dynamic settings:

1. Adjust K_i to a minimum value
2. Increase K_p until the actuator just starts to oscillate
3. Record the Period of the oscillation (P_{osc}) and K_p (K_{osc})
4. Set $K_p = 0.45 * K_{osc}$ and $I = 1.2/P_{osc}$

This gives stable response. Test the actuator response and further refine the tuning until the desired performance is obtained

Below is information on the more complex dynamic options the control can provide for specific integrating actuator applications. These are not typically used for steam turbine actuators.



CTRL_TYPE=PI_LAG

KP= proportional gain

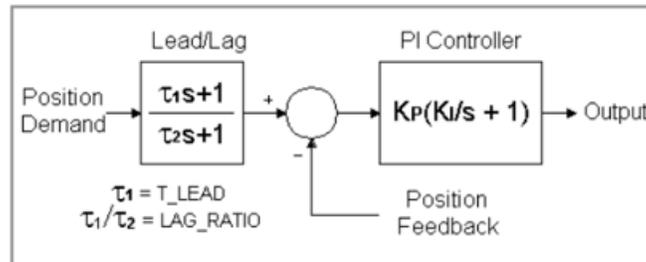
KI= integral gain

T_LEAD= N/A

LAG_RATIO= lag time constant

Figure 1-13. Integrating Actuator Using LAG Controllers

The PI-Lag controller is a PI controller with a lag block conditioning the demand signal. The lag term may be used to cancel or partially cancel, a zero and in the closed-loop transfer function. Tuning of this control is exactly the same as the PI control. Use this control only if you have a critical process which cannot tolerate overshoots. This control will limit actuator response although the lag can be set to a very low value to avoid excessive delay.



CTRL_TYPE=PI_LEADLAG

KP= proportional gain

KI= integral gain

T_LEAD= lead time constant

LAG_RATIO= lead/lag ratio

Figure 1-14. Integrating Actuator Using LEADLAG Controllers

The PI-Lead/Lag controller is a PI controller with a lead/lag block conditioning the demand signal. The T_LEAD input sets the lead time constant. Note that the lag time constant is not entered directly. The LAG_RATIO input sets the lead lag ratio. Tuning this control is the same as the PI control. The lead/lag term may be used to set the actuator response to some ideal value. The lead/lag may be used for increasing or decreasing the apparent bandwidth of the actuator thereby tailoring performance for the application. Of course, the control cannot force the actuator to exceed its physical limits, e.g., slew rate and dead time

Position Feedback Transducer types supported –

The position transducer must be an LVDT or an RVDT. The EXC_VOLTS field sets the amplitude of the excitation voltage in Vrms it is defaulted to 7 volts. The position feedback type field determines how the signals from the transducer are interpreted. Enter:

"A" for devices with a single pair of return wires,

"A-B" or "(A-B)/(A+B)" for devices with two pairs of return wires.

"A-B" is for devices which have a simple difference output.

"(A-B)/(A+B)" is for difference/sum (also known as constant sum, or D/S) type devices.

For devices with two pairs of return wires, the device manufacturer's drawing should be consulted to determine if it is a difference type or difference/sum type.

The wiring methods for different transducers are shown below.

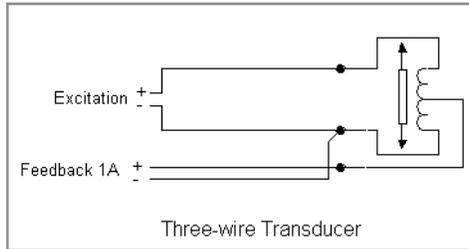
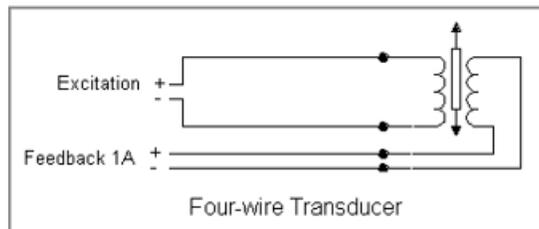


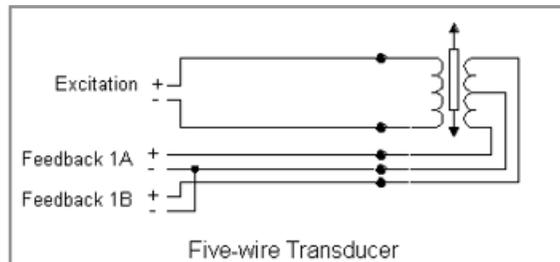
Figure 1-15. Three wire feedback device

The three-wire device has no primary-to-secondary isolation, which prevents the open-wire detection circuit from functioning properly. Set the Enable Feedback open wire check to FALSE.



The "+" and "-" designations shown here are arbitrary.

Note: The output voltage of devices with a single pair of return wires must not pass through zero volts.



The "+" and "-" designations shown here are arbitrary. The (-) side of the feedbacks 1A and 1B should be tied to the output center tap as shown.

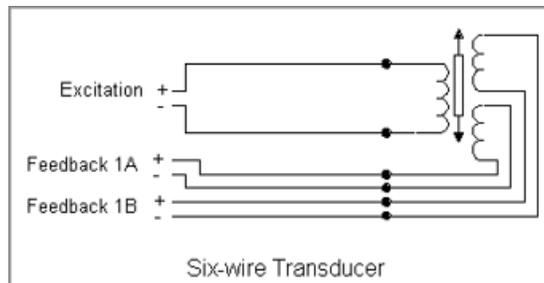


Figure 1-16. Other Feedback Device Examples

CAN Digital Drivers (released with Revision C GAP & GUI applications)

A CAN communication network has been programmed to provide high speed links to integrate with Woodward digital driver products. Currently the network will support 2 VaristrokeII (VSII) units and/or 2 SPC units and is planned to support an additional 4 VaristrokeI (VSI) units in the future. As delivered all these are disabled in the control, the user can then configure the unit to activate this CAN network enable any combination of these programmed driver devices.

This is a single CAN network cable connection from the CAN port 2 on the Kernel C CPU to the CAN demand connection of Varistroke and Servo Position Controller (SPC) products. Each of these devices should be configured with CAN as the primary demand and an Analog Backup as the secondary demand, although the user does have the option to make Analog as primary, if desired. This network runs at 250KBaud and the devices placed on it must be configured for the same rate. The devices will also need to have their node ID set to match the control ID designations defined in the GAP application, VSII as ID 1 and/or 2 and SPC as ID 11 and/or 12. A termination resistor must be placed appropriately on the last device on the network.

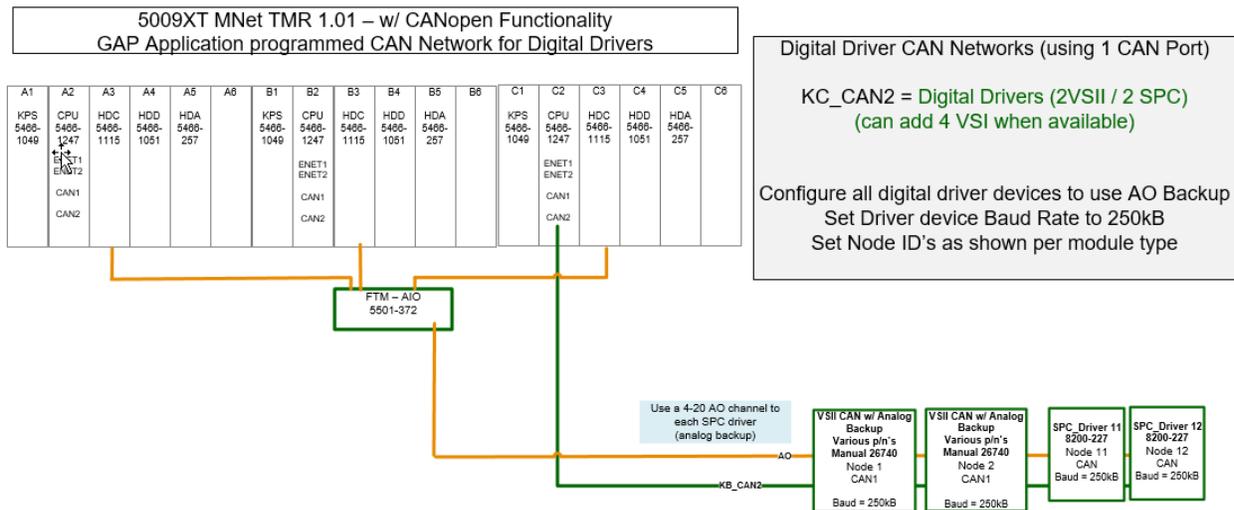


Figure 1-17a. CAN links to Distributed Drivers

For the VSII devices there are 4 demand selections available in the configuration menu. These are HP Demand, HP2 Demand, LP Demand and LP2 Demand.

For the SPC devices, all (12) of the driver function menu options that are available for the Analog Outputs are supported menus in the SPC configuration menus.

More details can be found in this manual about configuring the control to use these products

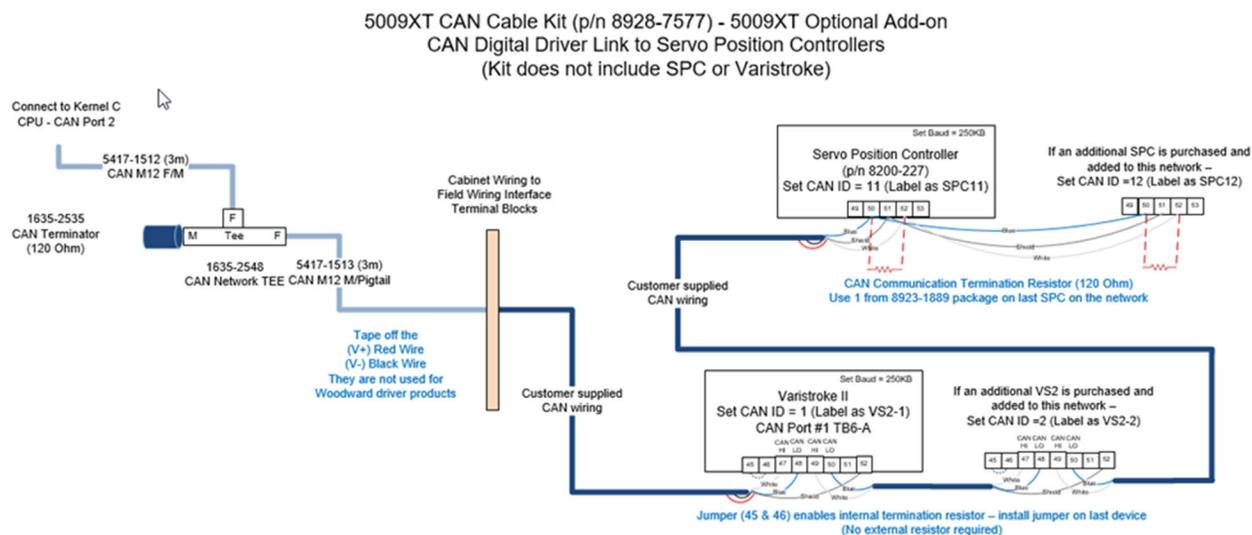


Figure 1-17b. CAN wiring of Digital Driver Network

Table 1-3a. Available CAN cable kit for 5009XT – P/N 8928-7577

Qty	Part Number	Description
2	5417-1512-3.0	CABLE - CAN, THICK TRUNK CABLE, M12 FEMALE TO M12 MALE (3.0M)
1	5417-1513-3.0	CABLE - CAN, THICK DROP, M12 MALE TO PIGTAIL (3.0M)
1	1635-2548	CONNECTOR - CAN, NETWORK TEE, M12, M/F BUS, F DROP
2	1635-2535	CONNECTOR - CAN, NETWORK TERMINATOR, M12 FEMALE 120 OHM
1	8923-1889	KIT - RTCNET CAN TERMINATION RESISTOR

When this kit is used for the Digital Driver CAN Network, only a quantity of 1 for each of the items listed in the above table will be required. This same kit can also be used to connect to the LinkNet Distributed I/O CAN network. If both options are added to the 5009XT system, then 2 kits will need to be purchased.

For customer CAN wiring Woodward recommends Belden YR58684 (Woodward p/n 2008-1512), for other options and complete information on CAN wire specification requirements refer to Woodward's MicroNet TMR hardware manual 26167 V1 & V2.

Table 1-3b. Available (programmed) SPC drivers

Node Device ID	Part Number	Description
SPC11 ID=11	8200-227	Servo Position Controller (manual 26236)
SPC12 ID=12	8200-227	Servo Position Controller (manual 26236)



Figure 1-18. Servo Position Controller

The list of the options available for demand signals to these SPC devices is identical to the first 15 function options for the Analog Output menus listed above.

Control Communication Interfaces

Modbus

A complete Modbus list of information is available for HMI, plant DCS or other control interfaces. Seven physical ports are available for this communication method, 2 Ethernet (RJ45) ports and 1 serial port of each of the Kernel A and Kernel B CPU's and the serial port on Kernel C. 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 IP addresses.

On each of the CPU's - Ethernet port 3 is not used and port 4 is not available as it is dedicated for use as an RTN link to any expansion chassis (not available with this standard application).

The control also communicates Servlink protocol (Woodward proprietary) via any of 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 5009XT has been programmed to use these ports as described above.

RemoteView interface to the GUI

Woodward's RemoteView tool - Graphical User Interface

RemoteView provides access to the user-friendly GUI to configure, service and operate the turbine. This tool will connect to the control and provide user options for scaling, platform selection and type of panel view desired. It will run with full authority for 2 hours at a time, or a software runtime license can be purchased to provide continuous operation 24/7 with this tool.

Software Runtime License part number 8928-5311

The GUI 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 this interface.



Figure 1-19. 5009XT Home Screen

A description of each key's function follows.

Hard Key Commands

Numeric Keypad

(Not available when using the 5009XT platform panel type)

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

LED

Four LED's are on the left side – a Summary Trip, Summary Alarm, IO Lock, and CPU Health. All of these are controlled by the GAP program. The IOLOCK and CPU LED's relate to the H/W status.

Table 1-4. IOLOCK and CPU LED's - H/W status

TRIPPED	(RED) Summary Trip condition exists
ALARM	(YELLOW) Summary Alarm condition exists
IOLOCK	(RED) Control is in Configuration MODE all outputs at failsafe
CPU	(GREEN - steady) indicates all 3 CPU's are healthy (GREEN – pulsing) indicates only 2 of the 3 CPU's are healthy

When all these LED's are OFF it indicates that the control has no application running or there is no healthy communication link to the control. In this condition all parameters will show Red X and ????

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

(not available when using the 5009XT platform panel type)

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 GUI 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

Chapter 2.

5009XT Control Description

Introduction

The software applications of the previous models of the 5009 and the 5009FT TMR products were based on different parent files than this version. While all of the intended functionality of these older units is included in this product (along with many enhancements), these controls must be configured manually the first time. The structure and nomenclature used in this product is very similar and using hardcopy settings from previous units only takes about 20 minutes once the user is familiar with the GUI program.

The 5009XT CORE 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 5009XT will 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 5009XT 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 5009XT 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 5009XTGUI, 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. Up to three different Start Permissives are supported. 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 Start dialog box 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 control 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.

Zero Speed Signal Override

The 5009XT 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.

Detecting Zero Speed

To enable the 5009XT to detect zero speed – an active speed probe signal must be used on all of the first 3 channels, or just 1 active probe can be configured on speed channel #4. The option to enable this detection feature is found on speed input channel 1. The logic will require that all probes for control speed be proximity probes and that all used signals detect zero speed. This indication is sent out via Modbus and can also be used to drive a relay output state.

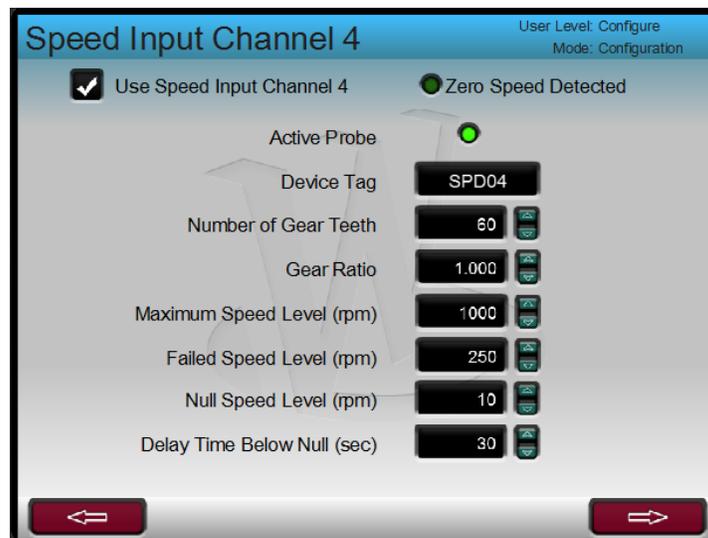


Figure 2-1. Speed Probe Zero Speed Detect

Manual Speed Override

If the 'Override MPU Fault' function is assigned to a contact input, the loss-of-speed detection logic is overridden as long as 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 5009XT 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 5009XT 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 adjusted in the 5009XTService screen.

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 5009XT 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 5009XTcontrol 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 5009XTcontrol'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.

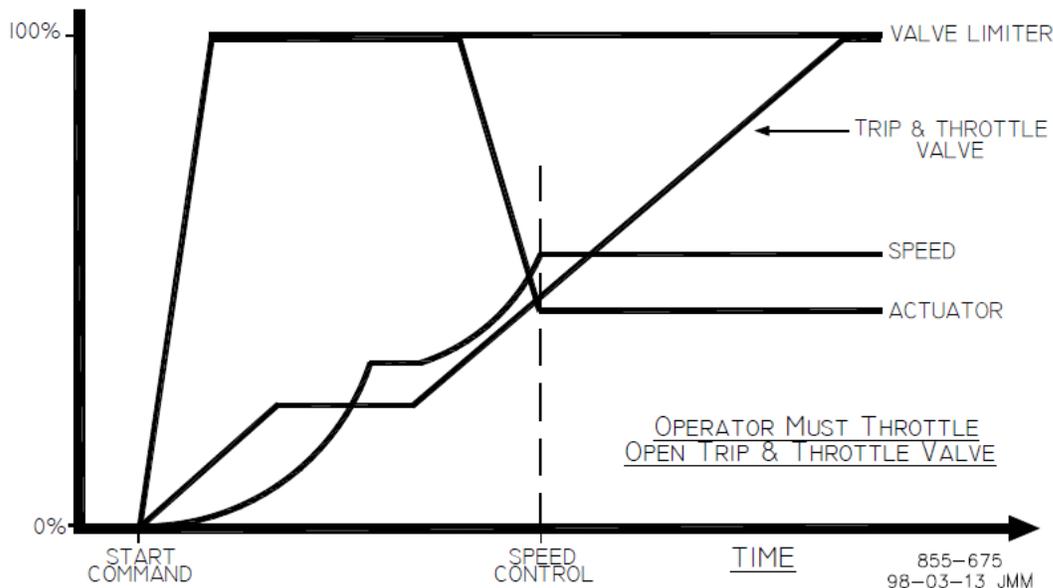


Figure 2-2. Manual Start Mode Example

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 5009XTcontrol's VALVE LIMITER at a controlled rate.
When turbine speed increases to the minimum controlling speed, the 5009XTcontrol's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
5. Raise the 5009XTcontrol'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 GUI5009XTGUI, external contacts or Modbus communications. The 'Limiter Max Limit', 'Valve Limiter Rate' and 'Rate To Min' settings are tunable in the Service mode.

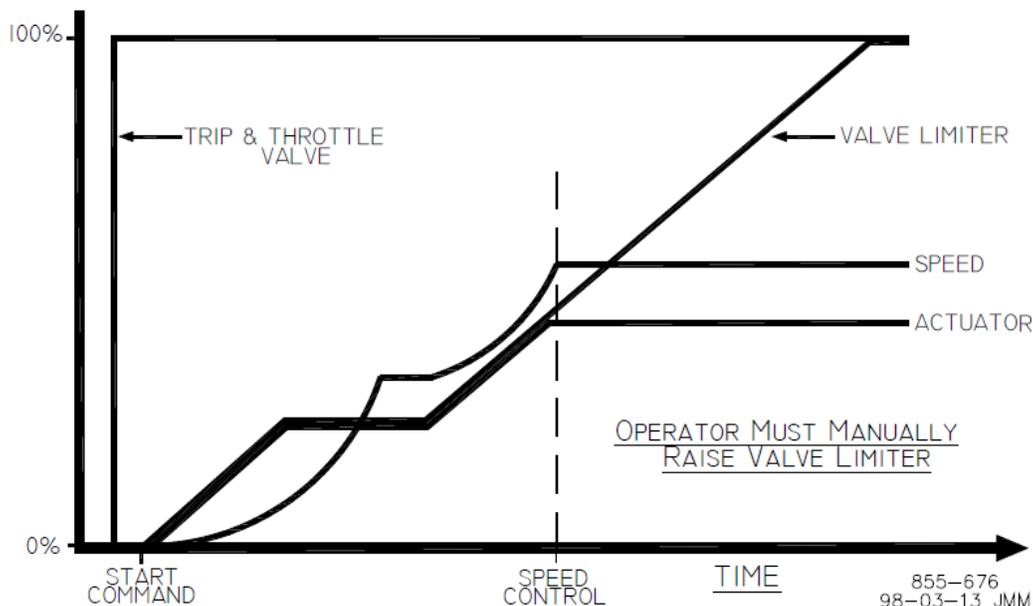


Figure 2-3. Semiautomatic Start mode Example

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 5009XT control 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 5009XT control’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.

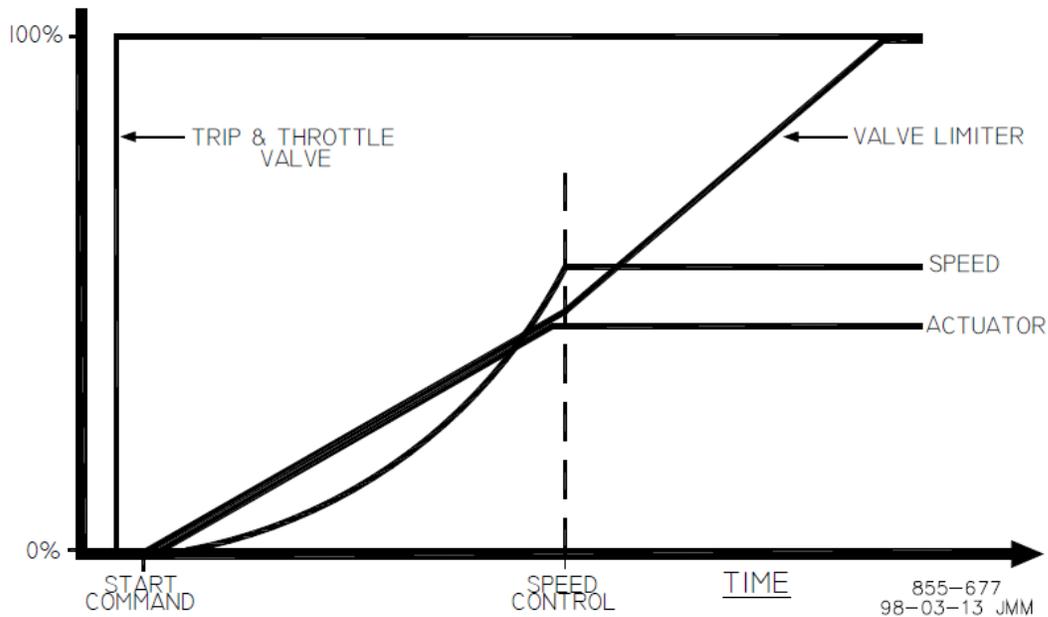


Figure 2-4. Automatic Start Mode Example

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 5009XT 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 5009XTGUI 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 5009XTcontrol's Idle/Rated function is programmed, once a 'START' command is given, the 5009XTcontrol 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 5009XTstart 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 5009XT 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 5009XTcontrol'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 5009XTGUI, contact input, or Modbus communications. The last command given from any of these three sources dictates the function performed.

If a 5009XT 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.

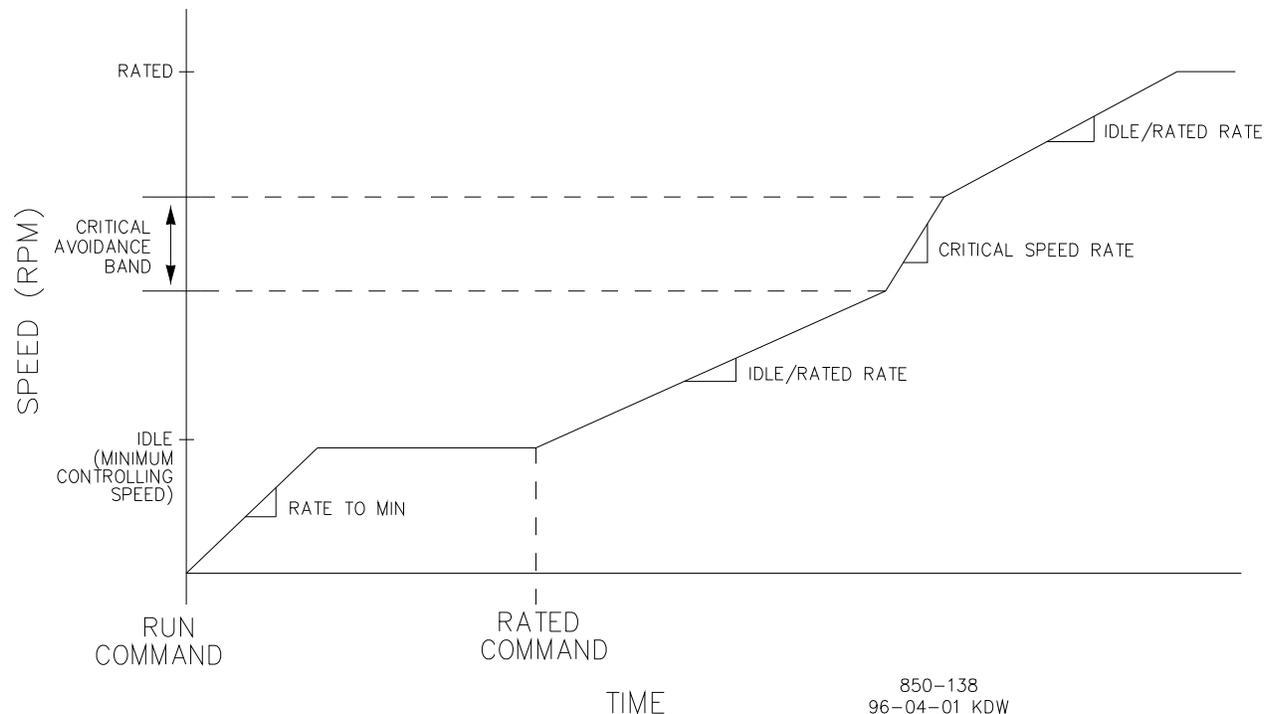


Figure 2-5. Idle/Rated Start

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 5009XT control can be configured to utilize an Automatic Start Sequence to start the turbine. This sequencing logic allows the 5009XT control 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 a 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 an "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.

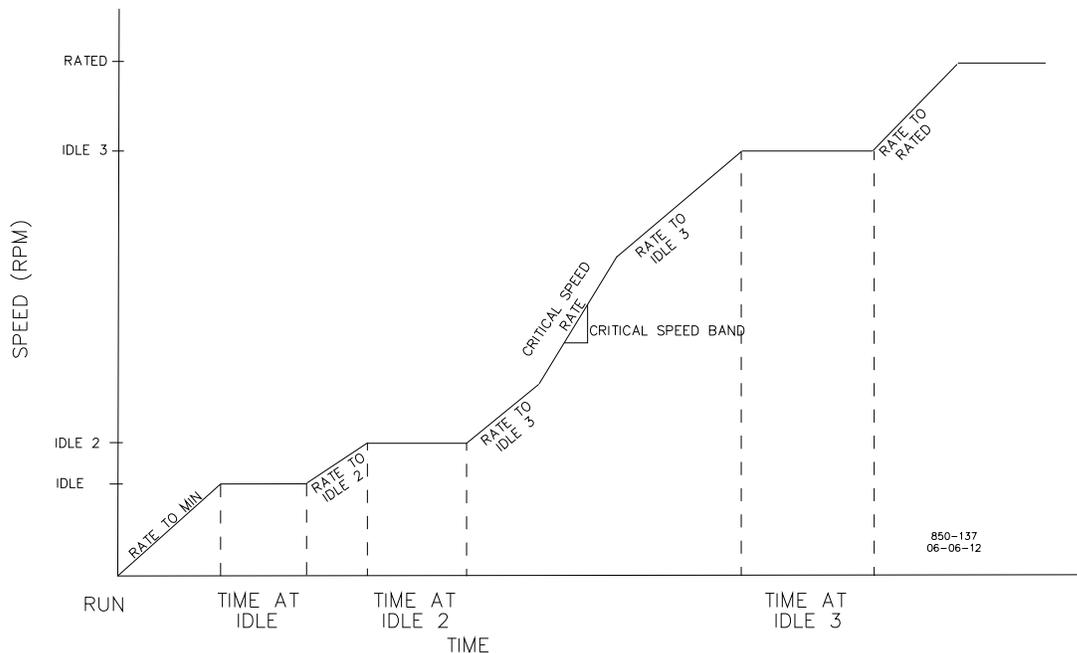


Figure 2-6. Automatic Start Sequence

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 shutdown 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 2-1. 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 2-2. 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 5009XT 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 2-3. 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 ¹ > Warm T1 ¹ setpoint T2 ² > Warm T2 ² setpoint Td ³ < Warm Td ³ Setpoint CI ⁴ closed
HOT	T1 ¹ > Hot T1 ¹ setpoint T2 ² > Hot T2 ² setpoint Td ³ < Hot Td ³ Setpoint CI ⁴ closed

¹T1 = Start Temperature 1

²T2 = Start Temperature 2

³Td = Difference between Start Temperature 1 and 2

⁴CI = Select Hot/Cold Contact input

Halting the Auto Start Sequence

The Auto Start Sequence can be halted at any time from the 5009XTGUI, 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 5009XTGUI 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 a Continue command, the sequence would remain at the idle speed for the remainder of the 'Hold Time'—which in this example is five 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 5009XTGUI, 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 5009XT 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 Setpoints' 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. In order 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, two or three magnetic pickups or proximity probes. The ‘MPU Gear Ratio’ and the ‘Teeth Seen By MPU’ settings are configured to allow the 5009XT to calculate actual turbine speed. The control will always use the highest speed signal received as the validated turbine speed process variable if only 2 speed signals are available. If 3 signals are configured for use and are healthy, the control will use the median signal as the validated turbine speed. 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 5009XTGUI, remote contact inputs or the communication line. This set point can also be directly set by entering a new set point through the GUI5009XTGUI or via Modbus. In addition, an analog input can be programmed to remotely position the speed set point.

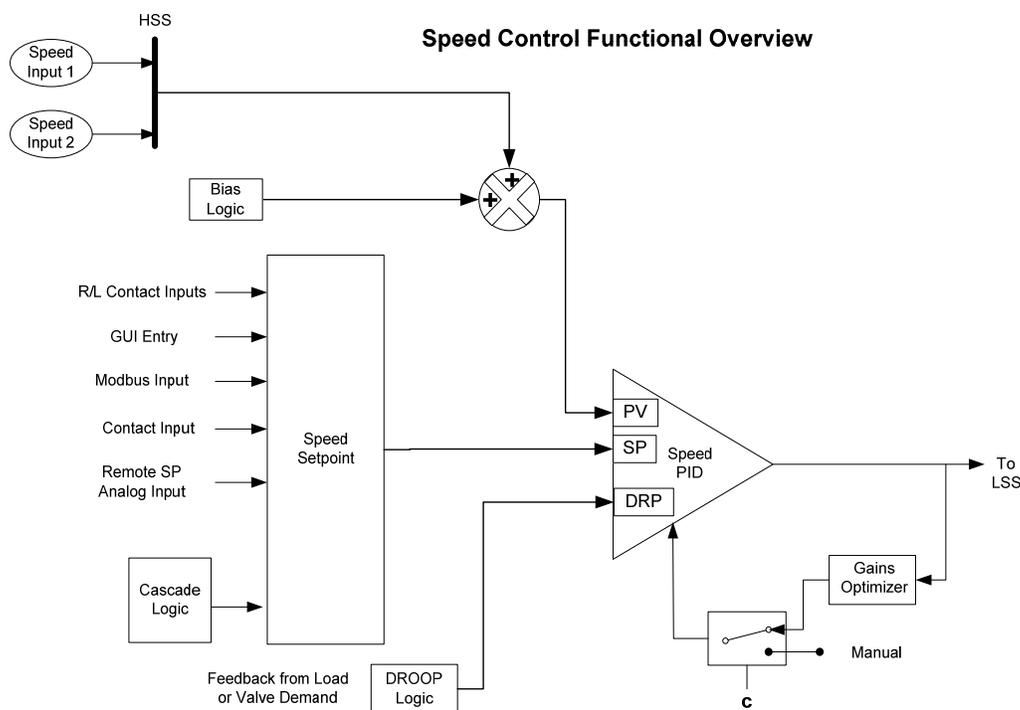


Figure 2-7. Speed Control Functional Diagram

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)
 - a. Turbine inlet valve position (5009XT LSS position) control
 - b. Generator Load control

When not programmed for generator applications, the 5009XT 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 5009XT control program's default settings. For information on how to change the 5009XT 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 5009XT application program's default settings. For information on how to change the 5009XT 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 Figure 3-8.

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 5009XT'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 2-9 for a frequency and load relationship diagram.

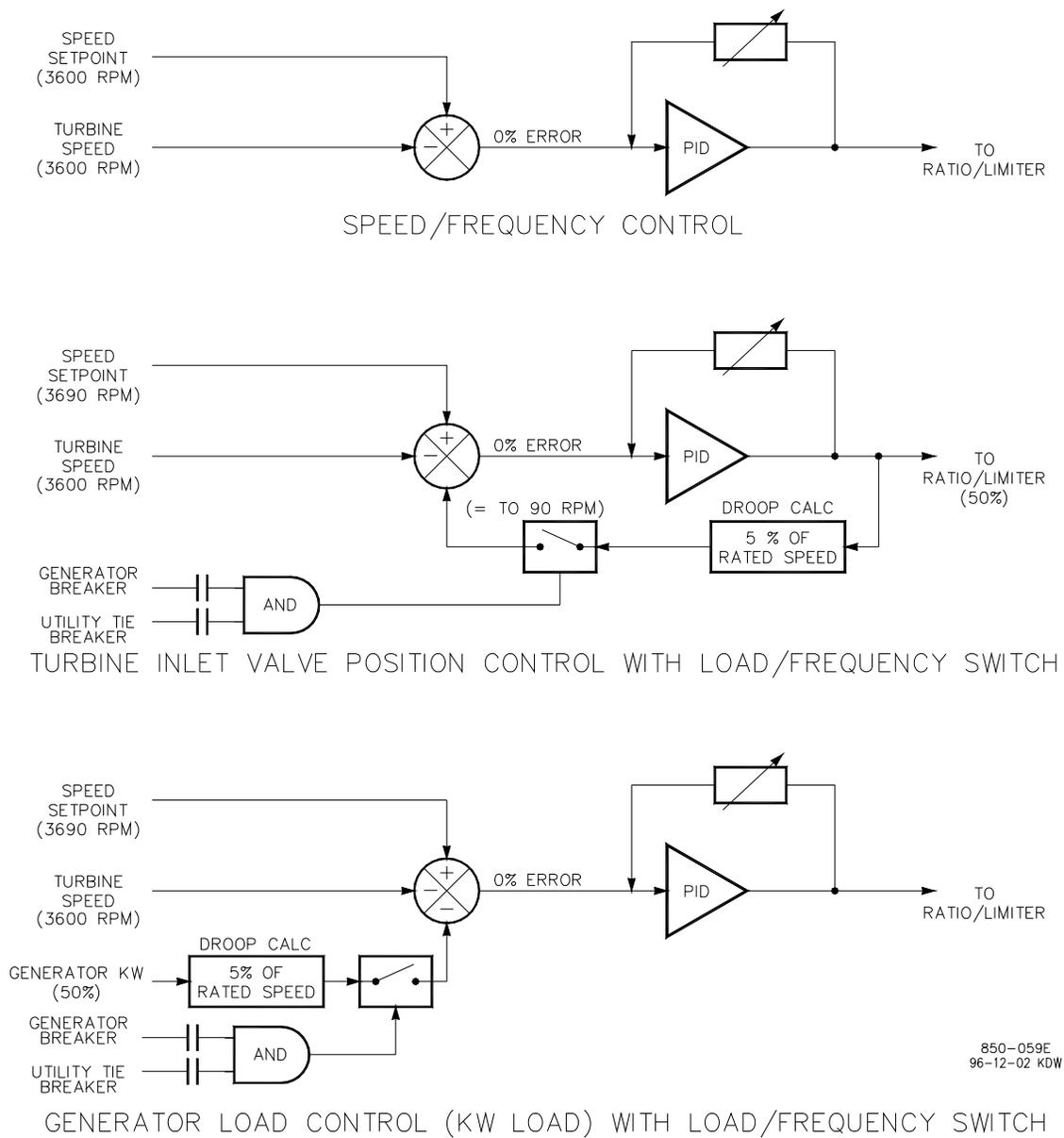
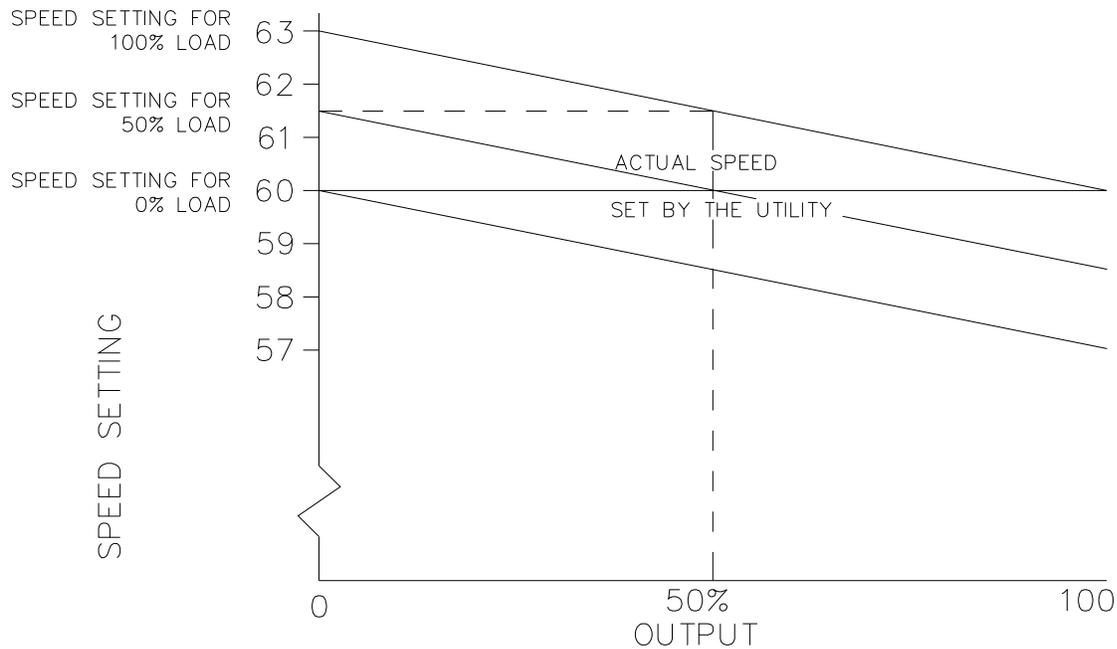


Figure 2-8. Speed PID Control Modes

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 5009XTcontrol’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 3-9.



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

850-136
96-03-29 KDW

Figure 2-9. Frequency and Unit Load Relationship

Because the 5009XT control'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 control 5009XT 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 5009XT09XT 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 5009XT 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 5009XT control 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 5009XT09XT is programmed to control unit load using turbine inlet valve position droop (LSS bus position), the 5009XT 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

Speed Set Point

The Speed PID's set point may be adjusted from the 5009XTGUI, 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 5009XTGUI 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 5009XTGUI, external contacts, or through Modbus. It can be directly entered to a specific value from the 5009XTGUI 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.

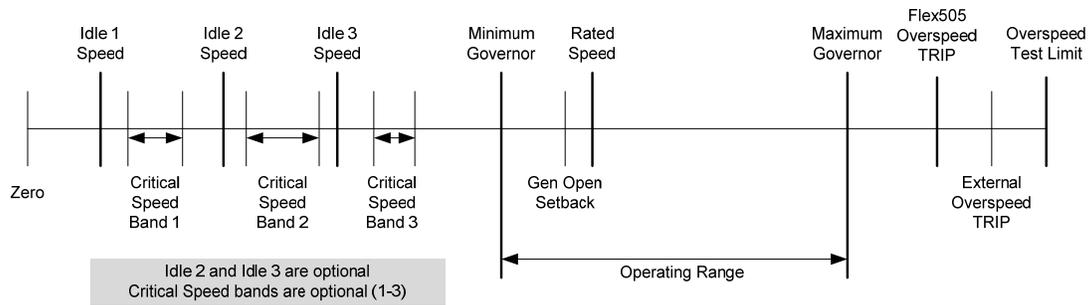


Figure 2-10. Speed Relationships

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 5009XTGUI or Modbus communications.

To "enter" a specific set point from the 5009XTGUI, 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 5009XTGUI 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 5009XT09XT 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 5009XT5009XT 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 5009XT5009XT 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 5009XT5009XT will use this Minimum Load setting as the lower speed setpoint limit whenever the breaker is closed

When the 5009XT5009XT 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 2-4. 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	N/A	Speed, Off-Line Dynamics	N/A	not active
closed	closed	N/A	Unit Load Control, On-Line Dynamics	Droop Setpoint	active
open	open	N/A	Speed, Off-Line Dynamics	N/A	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 5009XT 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 two main operational conditions, Off-Line and On-Line.

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

When the 5009XT 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 5009XT 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 5009XT 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 effect 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 2-5. 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 as 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 one 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 two or three 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 5009XT'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 5009XT'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 5009XTGUI, 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 (5009XT 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 5009XT 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 5009XT analog input to bias the 5009XT'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 5009XT 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 5009XT discretely. This Sync rate is defaulted to two rpm/s and is only adjustable through the 5009XT'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 5009XT 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 5009XT's synchronizing input when synchronization is desired. The Sync Enable command becomes disabled when the generator breaker closes, however, it may 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 5009XT analog input at the same time. Alternatively, this signal can be sent to the 5009XT, and the 5009XT can configure a relay output to send this Enable command to the synchronizer.

To configure the 5009XT 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 5009XT 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 5009XT 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 5009XT 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 5009XT's internal summing junction adds this signal with the speed/load PID's reference. In addition to load sharing, this signal input to the 5009XT can be used to synchronize the unit to either the plant bus or to the utility.

Each of these power management products is able to provide VAR/Power Factor control, allowing all of 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 5009XT's internal speed/load set point. The Utility Tie Breaker Contact is used to select unit load control through the 5009XT's internal load set point. When the 5009XT'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 5009XT via its Speed Bias signal. To configure the 5009XT 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/Ld Share Enable' function to a 'Contact Input #X' setting. The 'Sync/Ld 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 5009XT's synchronizing and load sharing operating modes (See Table 2-3).

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 5009XT'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 5009XT'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 5009XT'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 5009XT analog input at the same time.

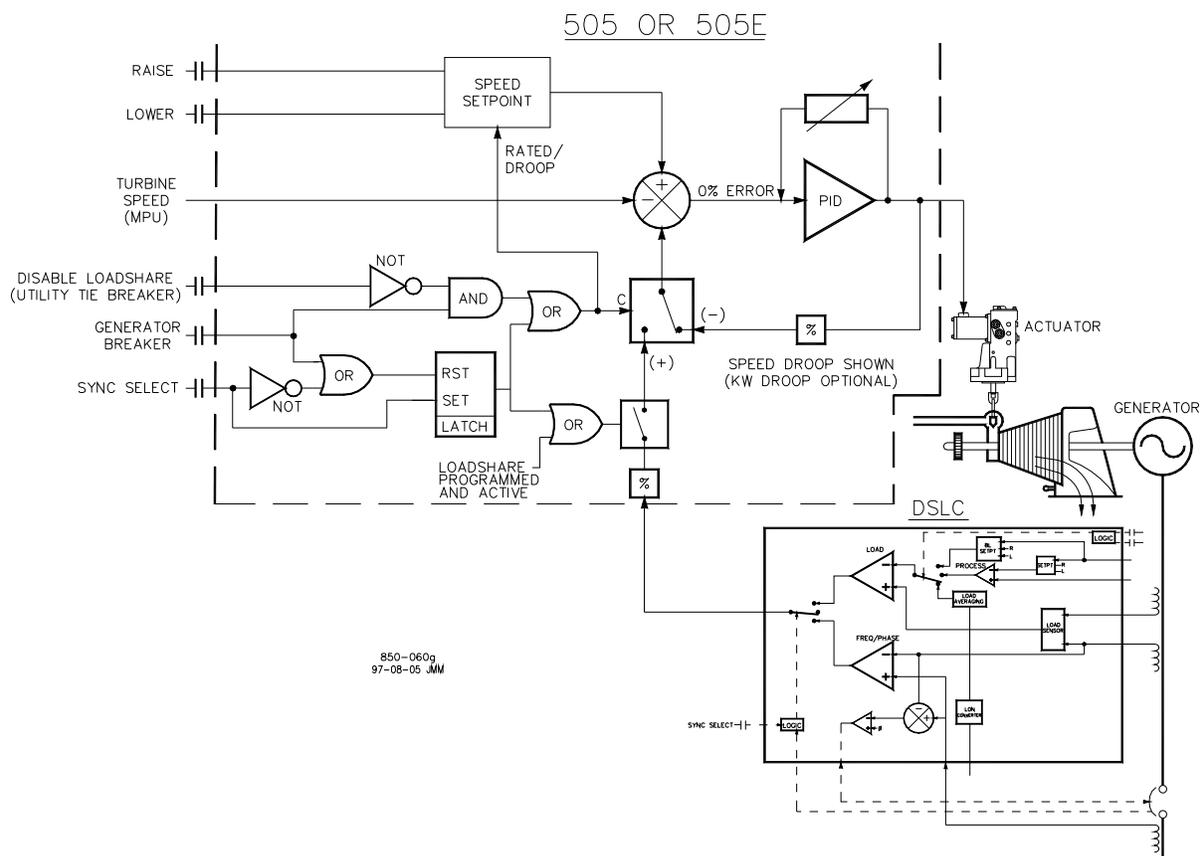


Figure 2-11. Load Sharing Logic

Table 2-6. 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	N/A	not active
closed	closed	N/A	Unit Load Control, On-Line Dynamics	Droop Setpoint	active
open	open	open	Speed, Off-Line Dynamics	N/A	not active
open	open	closed	Synchronizing Off-Line Dynamics	N/A	not active
open	closed	N/A	Load Sharing, Off-Line dynamics	Current Speed	not active

If using the display screen button to enable Sync/Load Share, then a 5009XT relay output, can be also be programmed to select the power management product's synchronizing mode. To configure the 5009XT for this functionality, program the 'Sync/Ld Share Enabled' function to a 'RELAY X ENERGIZES ON' setting.

When the 5009XT 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

Manual Valve Demand

Use caution when adjusting manual demand as the 5009XT 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 5009XT 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.

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 two 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.

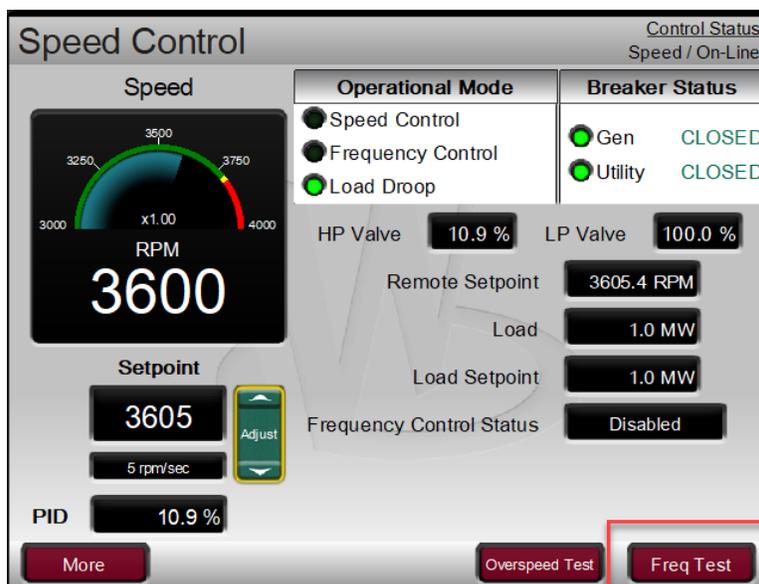
NERC/ECROT Frequency Excursion Test

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.

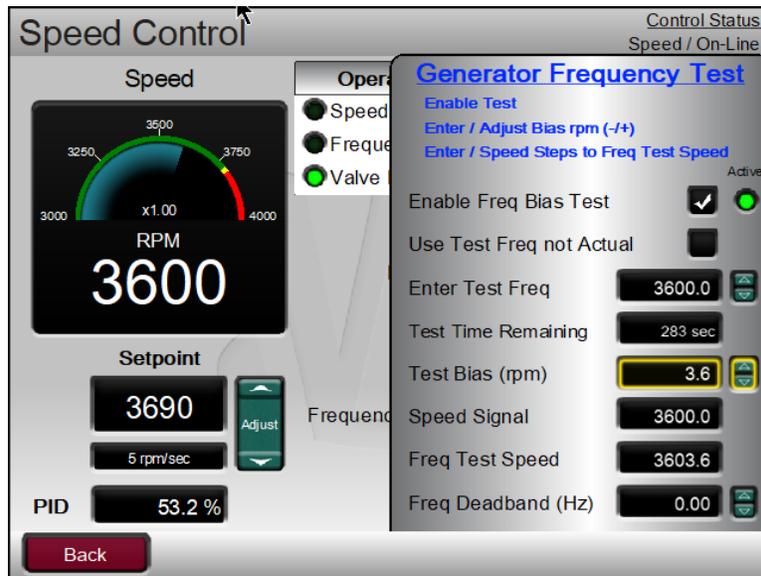


Once checked, press the Home key twice to return to the runtime home page. Then, in Speed Control, press the “More” softkey until the “Freq Test” is visible.

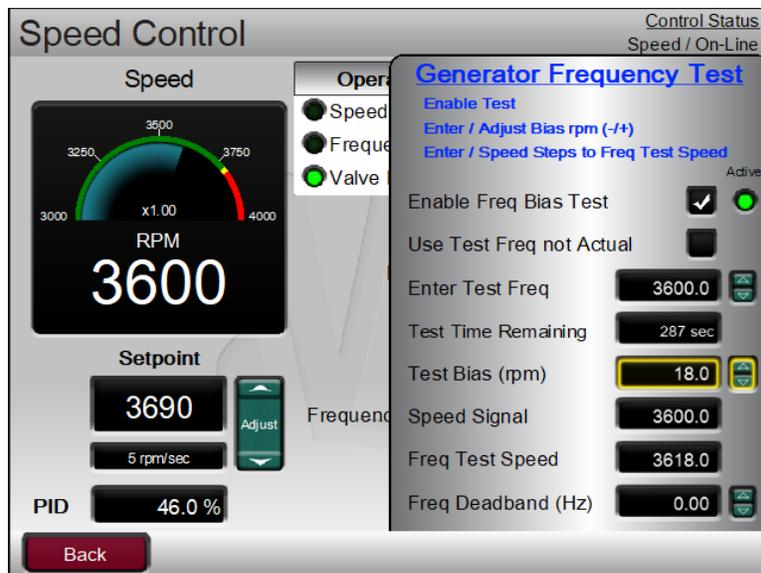


Pressing the “Freq Test” will open the test popup menu.

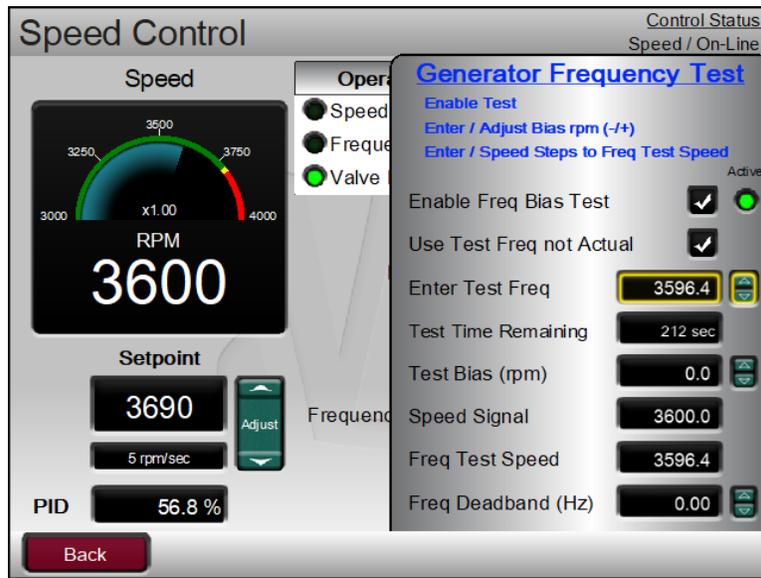
The unit should be Online with both the Generator and Utility breakers closed before the test is enabled. The control should also be stable. To enable the test, check the “Enable Freq. Bias Test” checkbox. This will enable the test for the next 5 minutes. Once the 5-minute time has elapsed the test is automatically disabled. Once the test is enabled, the “Active” LED will indicate that the test values are active.



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, the PID amount decreased in response to the increase in grid frequency.



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.



Feed-Forward Input

For 5009XT controllers configured for compressor applications, it is possible to experience a coupling effect between an anti-surge controller (external) and the 5009XT'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 5009XT 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 5009XT is capable of being configured to use an analog input (feed-forward signal) from an anti-surge controller. This input allows the 5009XT 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 5009XT'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.

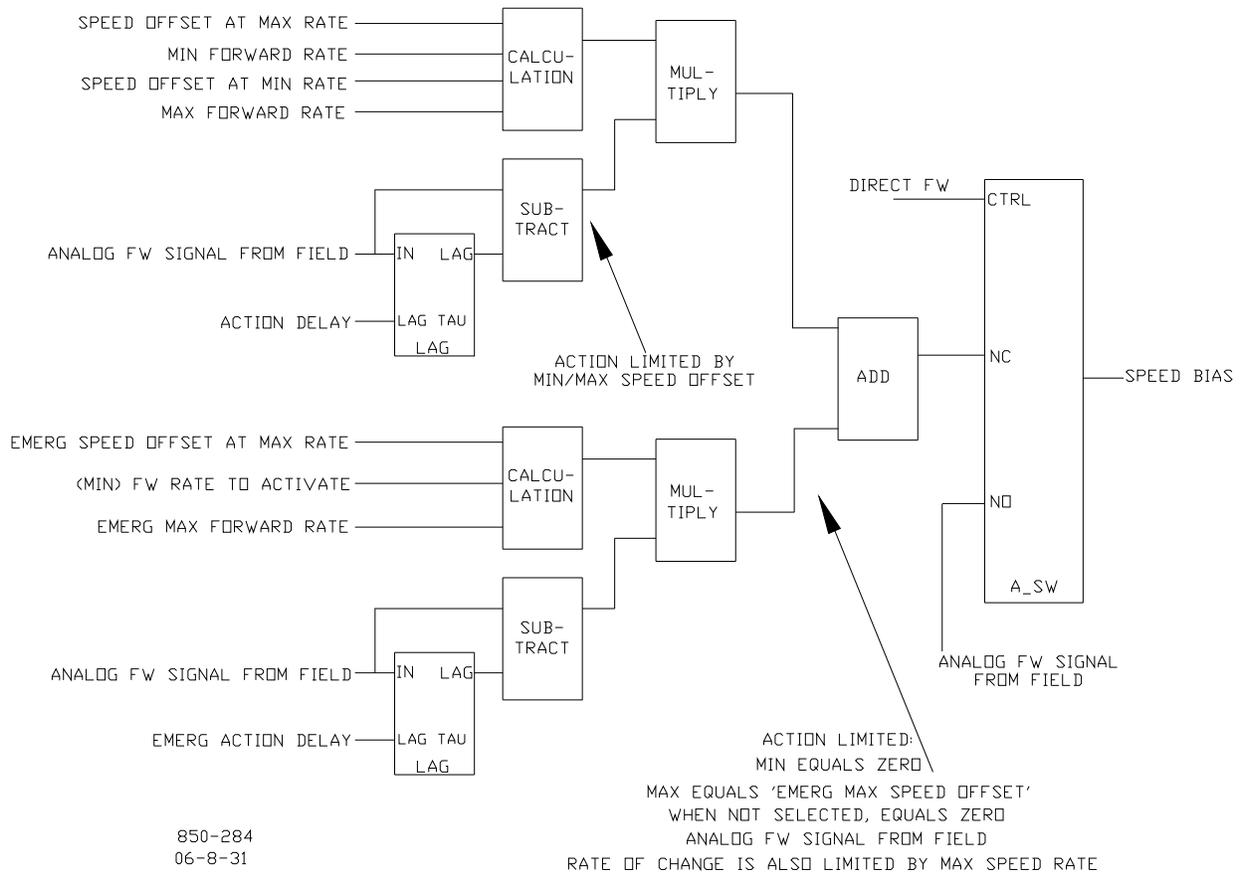


Figure 2-12. Typical Anti-surge Valve and Speed Feed-Forward Logic Trend

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 PID's 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).

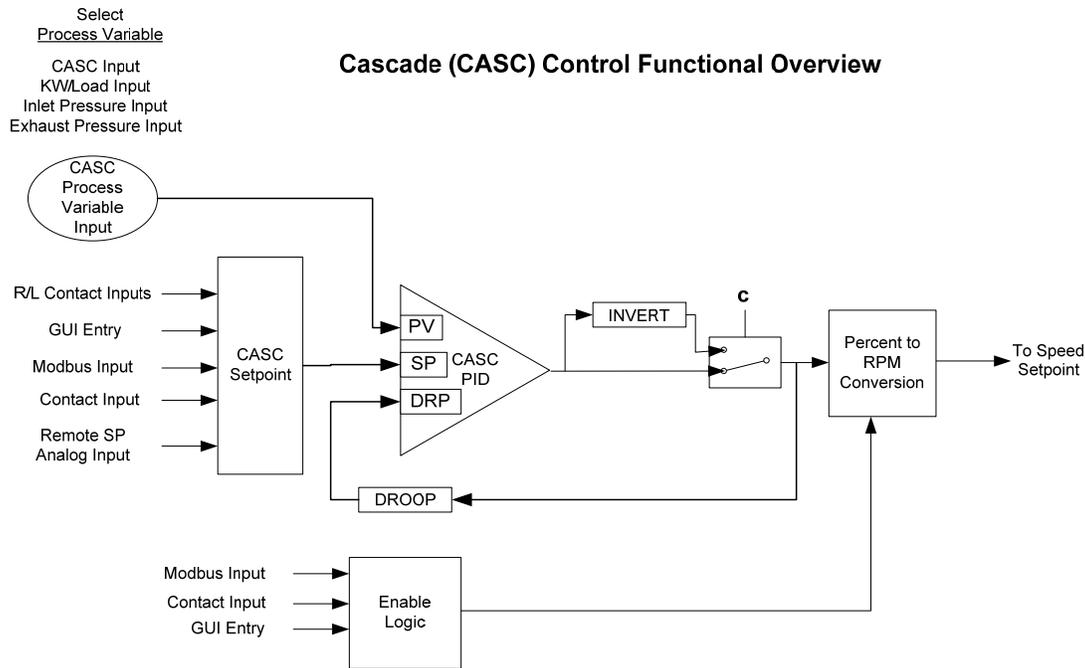


Figure 2-13. Cascade Functional Diagram

Since Cascade is a secondary speed setting function, the Speed PID must be in control of the 5009XT's LSS bus in order for Cascade to take control. When the 5009XT 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 selection of the Process Variable 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 5009XTGUI, 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.

Table 2-7. 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 5009XTGUI, external contacts, Modbus commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the 5009XTGUI 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 5009XTGUI 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 5009XTGUI, 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 5009XT'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 5009XT 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 5009XT's Service mode. Service mode values can be tuned/adjusted while the 5009XT 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 moved, 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 5009XT 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.

Example: 25% x 5% x 600 psi x 0.0001 = 7.5 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 5009XT'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 5009XTGUI, 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 (5009XT front panel screen messages):

Table 2-8. Remote Cascade Set Point 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 selection of the Process Variable 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 5009XT GUI, through remote contact inputs or through Modbus. Also, the set point can be directly set by entering the new set point from the GUI or through Modbus communications. In addition, an analog input can be programmed to remotely position the Auxiliary set point.

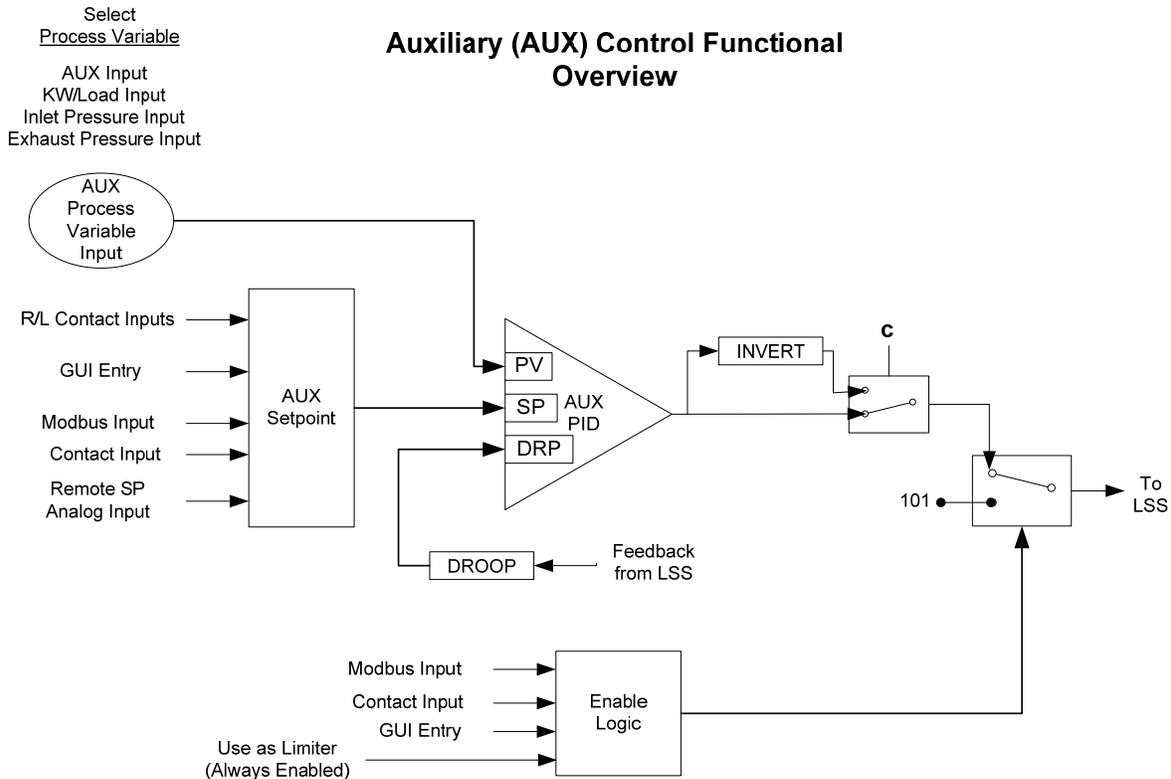


Figure 2-14. Aux Control Overview

Auxiliary as a Limiter (not using Enable/Disable)

When configured as a limiter, the Auxiliary control is low signal selected (LSS) with all of 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 (5009XT front panel screen messages):

Table 2-9. Auxiliary Limiter 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 (5009XT 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, 5009XT 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 5009XTGUI (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 5009XT 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 5009XTGUI, external contacts, Modbus/OPC commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the 5009XTGUI 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 a 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 5009XTGUI 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 5009XT 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

Note: 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 5009XT'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 (5009XT display screen messages):

Table 2-10. Remote Auxiliary Set Point 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 5009XTGUI, 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 5009XT 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 5009XT 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 5009XT 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.

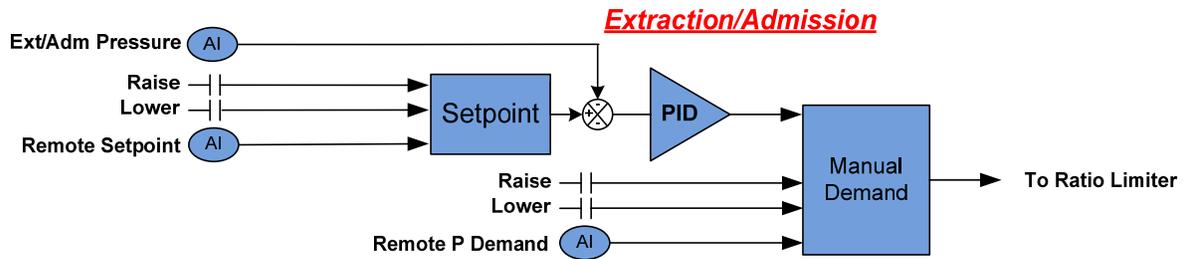


Figure 2-15. Extraction/Admission Control Overview

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 5009XT'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 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.

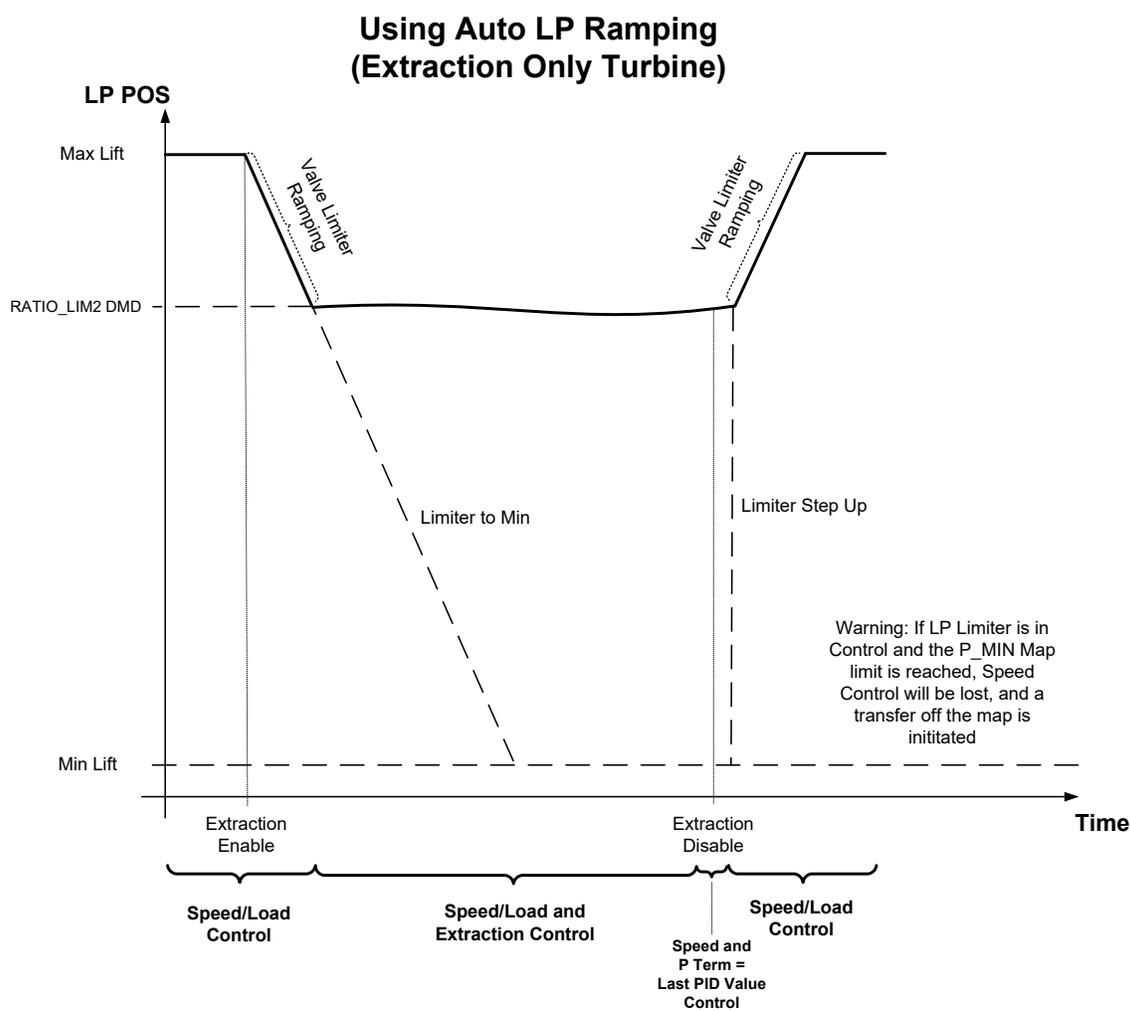


Figure 2-16. Transitions between Speed only and Ratio Limiter Control – Auto Mode

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 5009XT 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%.

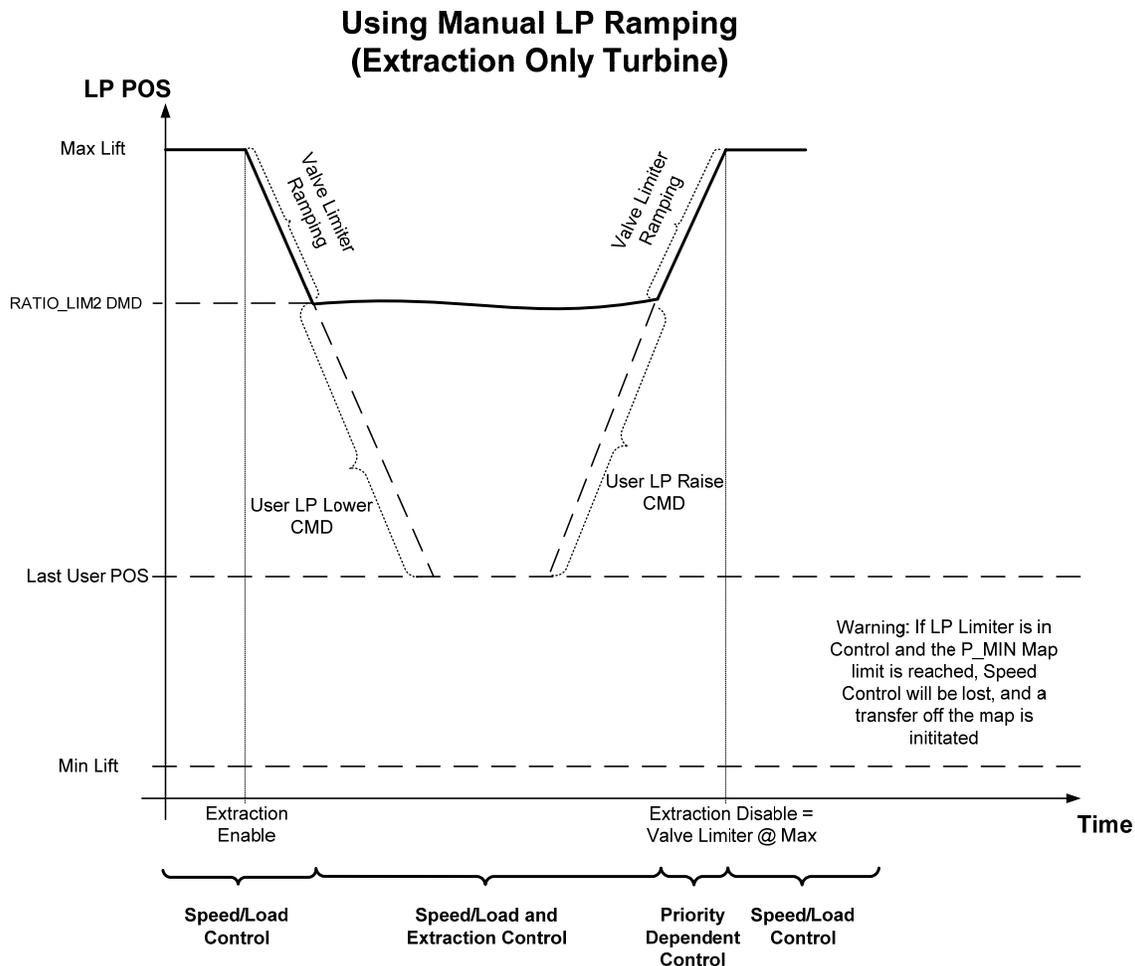


Figure 2-17. Transitions between Speed Only and Ratio Limiter Control – Manual

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

Table 2-11. Ext/Adm Controller 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, 5009XT 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

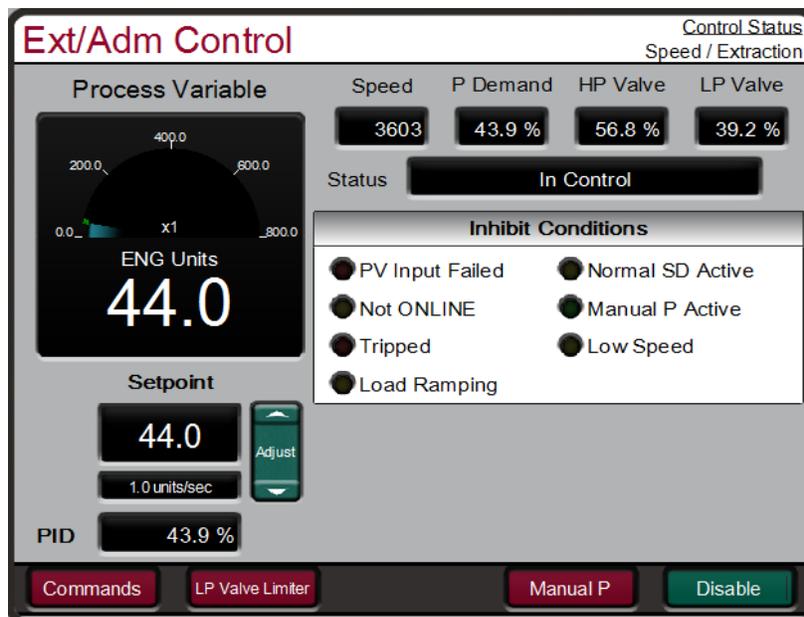


Figure 2-21. Extraction/Admission Control Panel

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 insuring 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:

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

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

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 5009XTGUI 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 5009XT 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 5009XT’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 5009XTGUI, 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 5009XT 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 5009XT 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 5009XT uses the values programmed to calculate the turbine's internal pressure ratios and limits. In order 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 5009XT as extraction/ admission data. This data is taken from the turbine's steam map or envelope. When entering extraction/admission data into the 5009XT, 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 5009XT 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 5009XT 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 4-4).

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 2-18.

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).

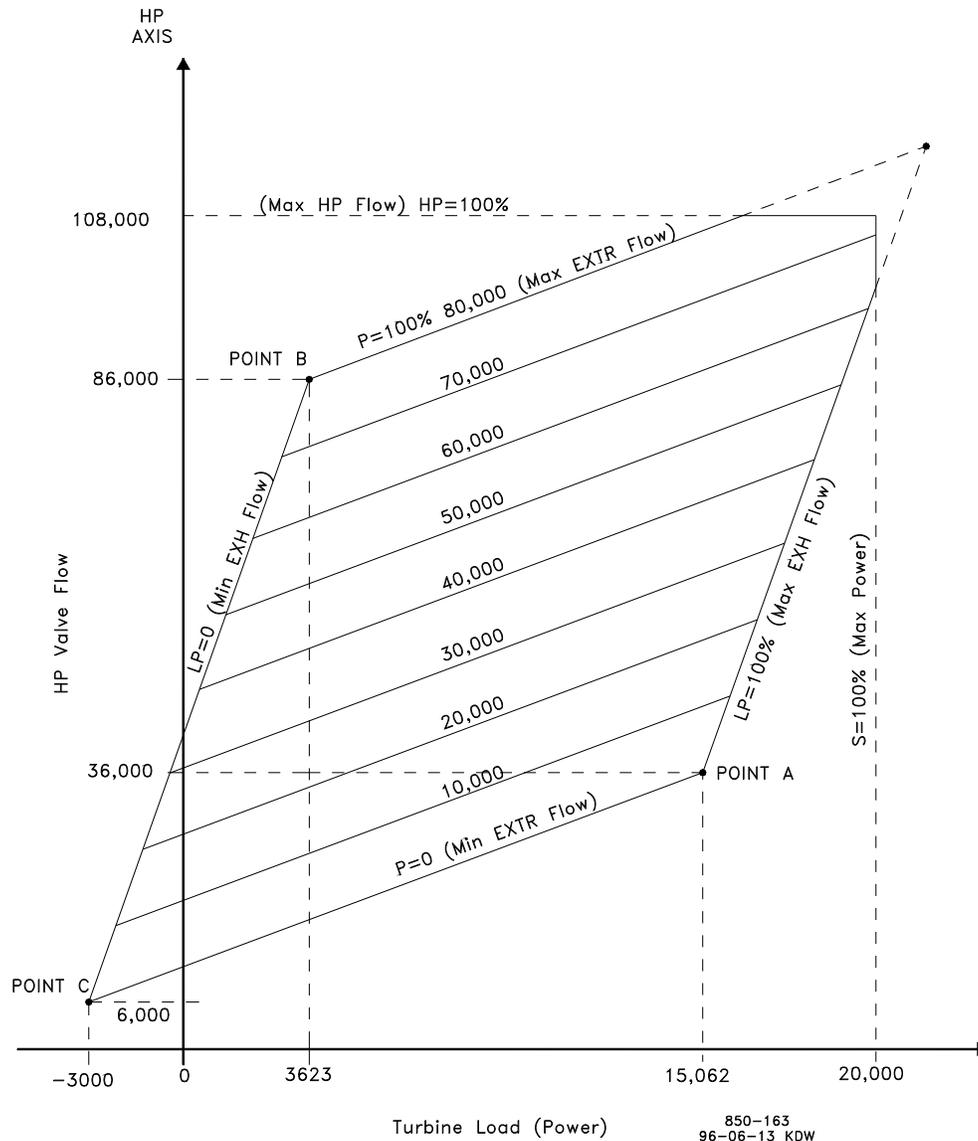


Figure 2-18. Typical Extraction Steam Map

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 2-18).

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 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 2-22) 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 2-18.
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 2-18.

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 $8000/105\ 000 = 7.6\%$

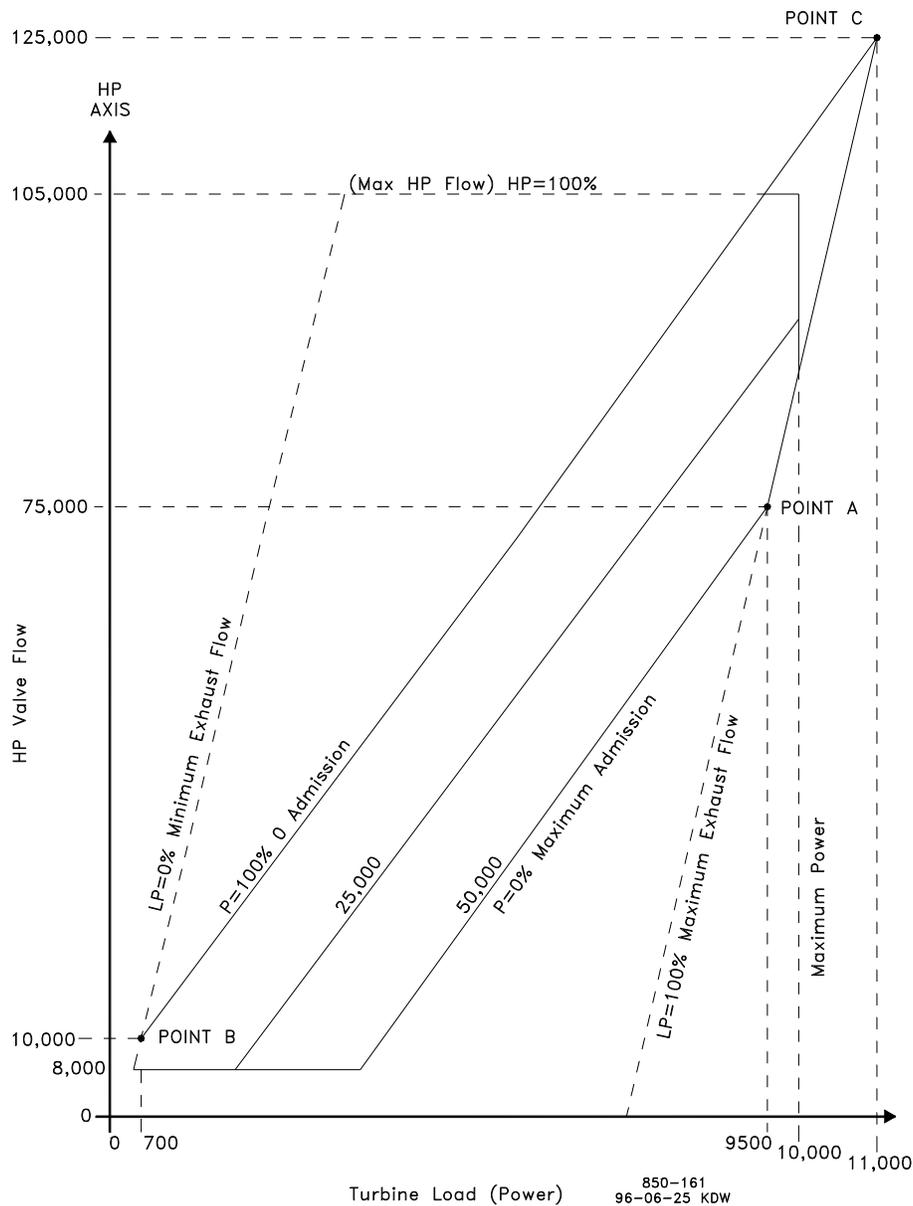


Figure 2-19. Typical Admission Steam Map

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 2-20).

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 2-20) the minimum required flow was 8000 lb/h (3629 kg/h).

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 5009XT will support several different modes of operation for Extraction/Admission turbine configurations. In simple terms the 5009XT has 2 control valves so therefore it can control 2 parameters as long as neither a parameter nor a valve has reached a limit. Prior to configuring the 5009XT control it is important to understand which parameters are planned to be controlled by the 5009XT 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 5009XT. 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 2-12. 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 a 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 5009XT supports multiple alternate modes – but any transition into an alternate mode must be initiated from the base mode (Speed/Extraction).

Ratio Limiter Functionality

The 5009XT 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

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

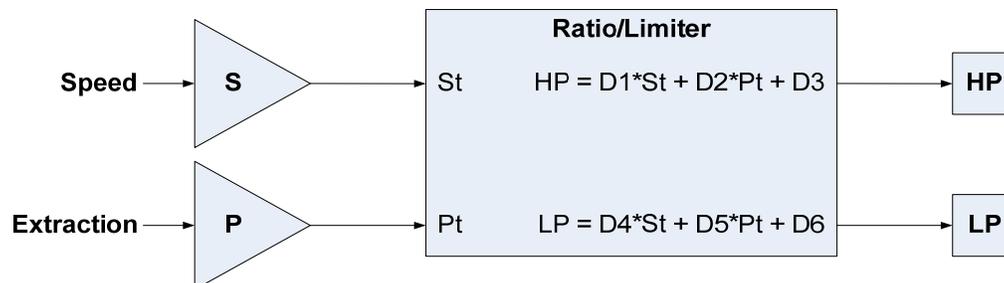
Transferring Modes

The 5009XT 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 through Mode 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 bumbles.

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



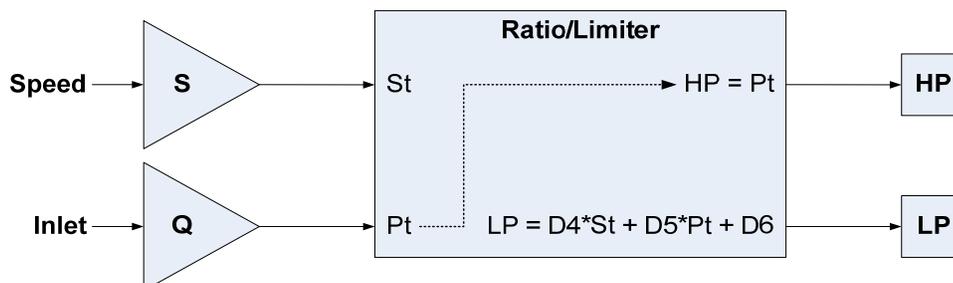
$$\begin{aligned} \text{HP} &= D1.St + D2.Pt + D3 \\ \text{LP} &= D4.St + D5.Pt + D6 \end{aligned}$$

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

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

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



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

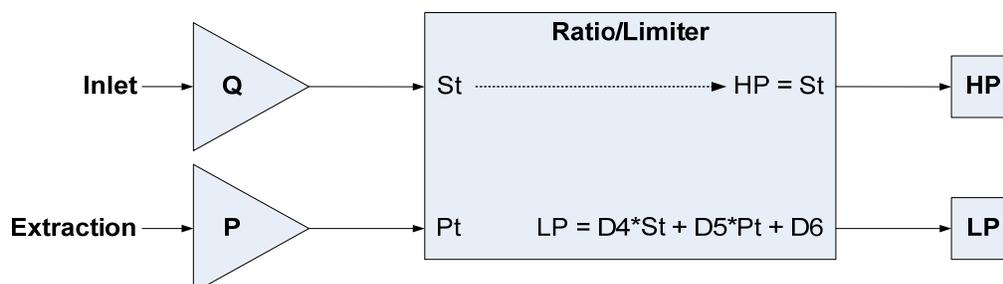
$$\begin{aligned} \text{St} &= \text{S} && \text{(speed)} \\ \text{Pt} &= \text{Q} && \text{(inlet)} \end{aligned}$$

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

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



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

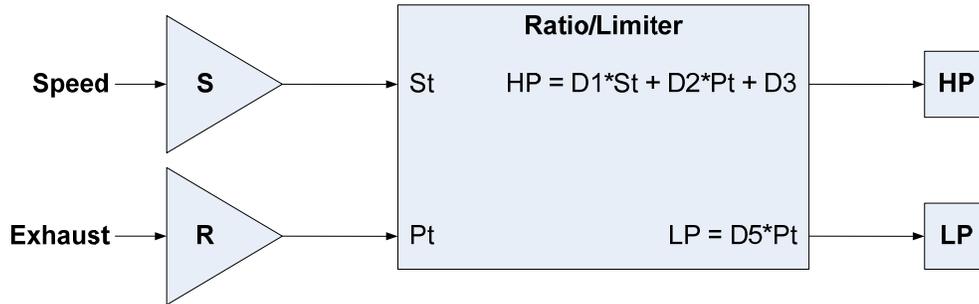
$$\begin{aligned} \text{St} &= \text{Q} && \text{(Inlet)} \\ \text{Pt} &= \text{P} && \text{(Extraction)} \end{aligned}$$

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

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



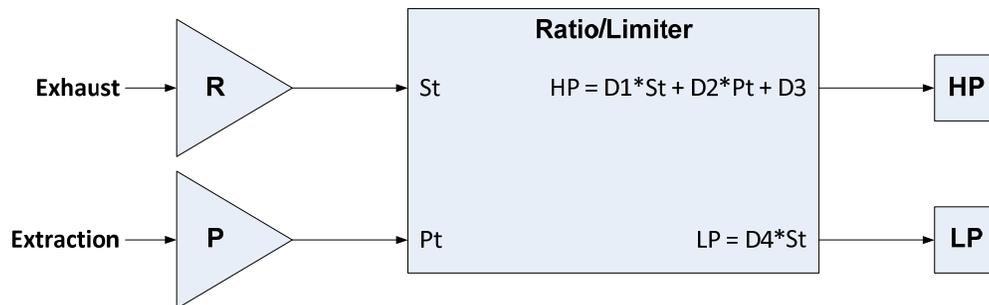
$$\begin{aligned} HP &= D1 \cdot St + D2 \cdot Pt + D3 & [1] \\ LP &= D4 \cdot St + D5 \cdot Pt + D6 & [2] \end{aligned}$$

$$\begin{aligned} St &= S && \text{(Speed)} \\ Pt &= R && \text{(Exhaust Pressure)} \end{aligned}$$

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

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

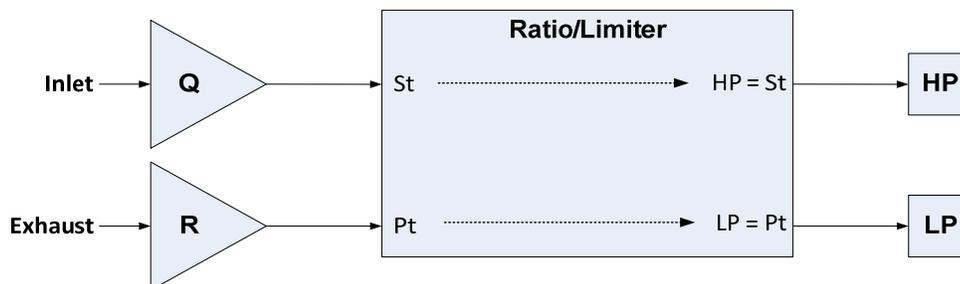


$$\begin{aligned} HP &= D1 \cdot St + D2 \cdot Pt + D3 & [1] \\ LP &= D4 \cdot St + D5 \cdot Pt + D6 & [2] \end{aligned}$$

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

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

Mode 5: Inlet and Exhaust (Decoupled)



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

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

$$St = Q \quad \text{(Inlet)}$$

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

$$D1 = 1$$

$$D2 = 0$$

$$D3 = 0$$

$$D4 = 0$$

$$D5 = 1$$

$$D6 = 0$$

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.

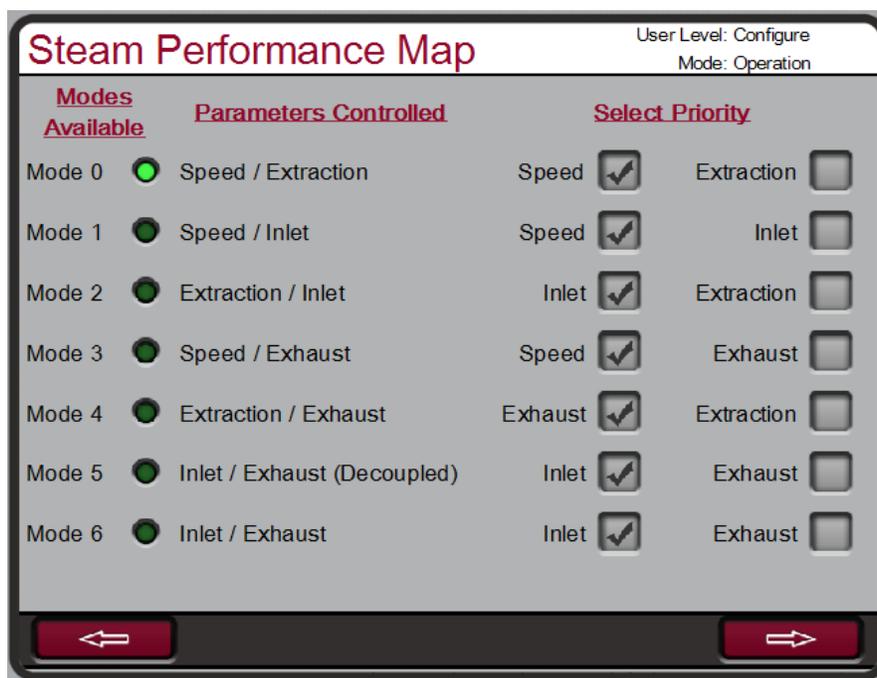


Figure 2-21. Ext/Adm Mode Control Priorities

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 2-22. 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 selection of the Process Variable 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 5009XT.

Inlet Pressure Control Functional Overview

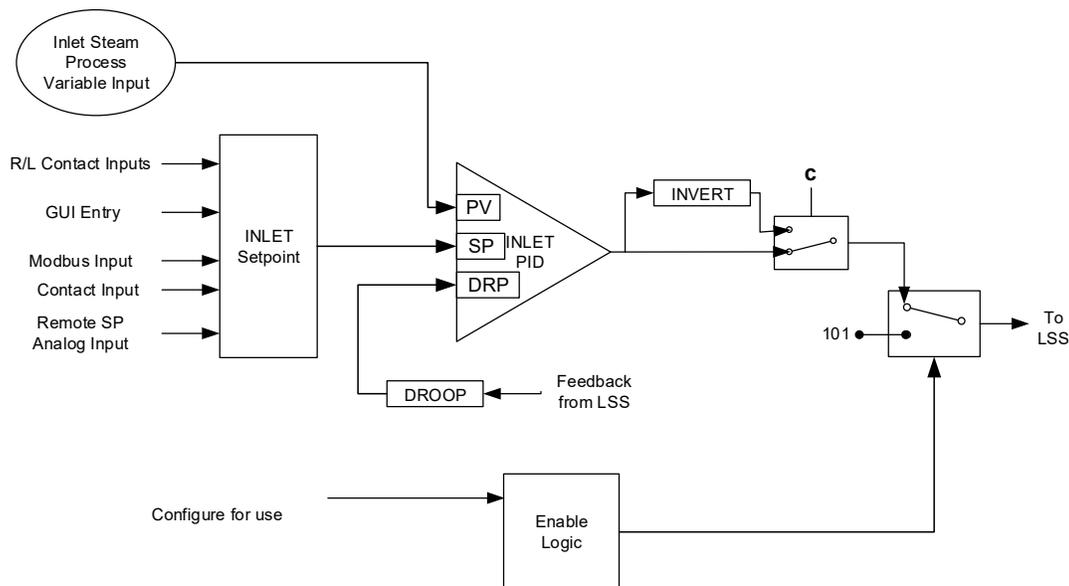


Figure 2-23. Inlet Steam Pressure Control Overview

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 selection of the Process Variable 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 5009XT.

Exhaust Pressure Control Functional Overview

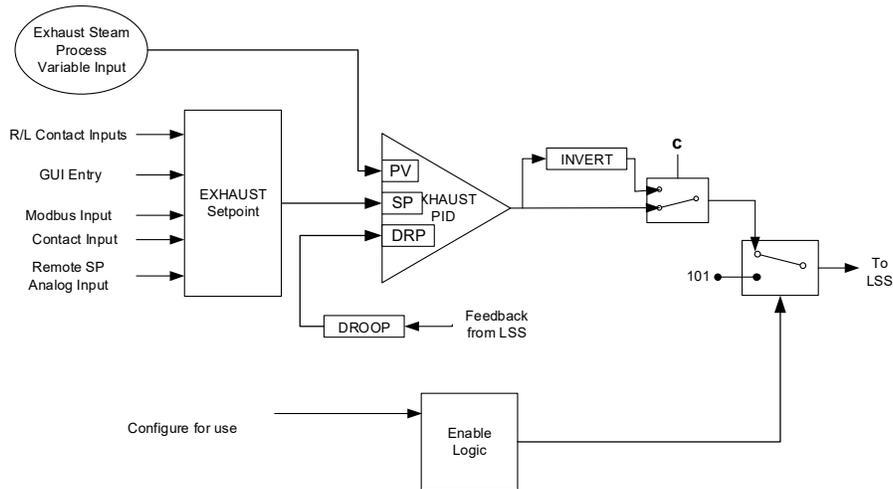


Figure 2-24. Exhaust Steam Pressure Control Overview

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 5009XT is the source of system instability, the valve limiter can be positioned to manually take control of the valve position. Care should be taken when using the valve limiter in this fashion, so as to not allow the system to reach a dangerous operating point.

The valve limiter level is adjusted through the 5009XTGUI, 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 5009XTGUI 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 5009XTGUI, 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 5009XT's screen will momentarily display a value out-of-range message.

To "enter" a specific set point from the 5009XT 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 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**Manual Valve Demand**

Use caution when adjusting manual demand as the 5009XT 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 5009XT 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.

	X	Y
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.

IMPORTANT

Pressure compensation will affect the accuracy of the droop calculation when the 5009XT 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 5009XT 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 a 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

The 5009XT has 2 options for setting the demand to the actuators when a TRIP condition occurs. These are found in the Configuration menus under Operating Parameters. The default is to drive the actuator output signals to zero milliamps, the alternate choice is to drive the actuators to zero demand (with some digital drivers the valve will close faster with this selection. In all cases of a Trip condition, the Shutdown relay de-energizes, and the shutdown cause (first shutdown condition sensed) is displayed on the 5009XT's GUI. See Chapter 5 for a detailed list of the possible shutdown (Trip) conditions.

In addition to the required Emergency Stop on discrete input #1, up to fifteen (15) external trip inputs (contact inputs) can be programmed to allow the 5009XT to indicate the cause of an emergency shutdown. By wiring trip conditions directly into the 5009XT, instead of a trip string, the 5009XT 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 5009XT'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 5009XT's GUI, and Modbus communications. 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.

Under the view screens for both Alarm and Trip events is a HISTORY button that will access a log file of all previous events in the control.

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 will allow any output relay that is configured as a "Trip Relay" to briefly clear, even if the summary trip latch remains tripped (True), to allow external trips coming into the 5009XT to clear. This setting has no effect on the programmable Summary Shutdown relays.

Controlled Shutdown

The STOP button on the GUI provides access to two commands that will shut down the turbine. The TRIP command will immediately step the valve demands to zero and trip the turbine. The Normal Stop option will perform a Controlled Shutdown function is used to stop the turbine in a controlled manner, as opposed to an Emergency Trip. When a Normal 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 two 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 5009XT'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 5009XT'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 5009XT GUI, 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 5009XT will display an "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 5009XT'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 5009XT'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 5009XT'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 5009XT 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.

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.

Relays

The 5009XT has eight relay outputs available. The first of these relays is dedicated for a system shutdown command from the 5009XT identified as the Trip Relay output. 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 Trip 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 5009XT's Service mode, to toggle on and off repeatedly when an 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 5009XT initiated trip by setting the 'Ext trips in Trip Relay' option to NO. Using this option, 5009XT trip annunciation will only occur if the 5009XT tripped the turbine and not annunciate when the other external devices shuts 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 5009XT Control Status OK relay is normally energized, and will only de-energize if unit inlet power is lost, the 5009XT's CPU fails, or the 5009XT is in the Configuration mode.

The Overspeed Test Enable relay will energize when an Overspeed Test is performed. This relay functions like the 5009XT 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 Control' 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 5009XT'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 5009XT 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.

Chapter 3

Configuration Procedures

Program Architecture

The 5009XT is easy to configure from the graphical user interface (GUI), using the RemoteView tool on a user PC. 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. Refer to the appropriate appendix in Volume 2 for installing and using RemoteView.

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 5009XT 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 GUI 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 3-1. Mode Access by 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 in order to calibrate signals and field devices. In this mode, the actuator, analog, and relay outputs can be manually controlled. To enter this mode the 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 5009XT

Before the 5009XT can be used to operate any turbine, it must be configured with a valid configuration. A 5009XT 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 file to and from the control.

Figure 3-1 illustrates the 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.

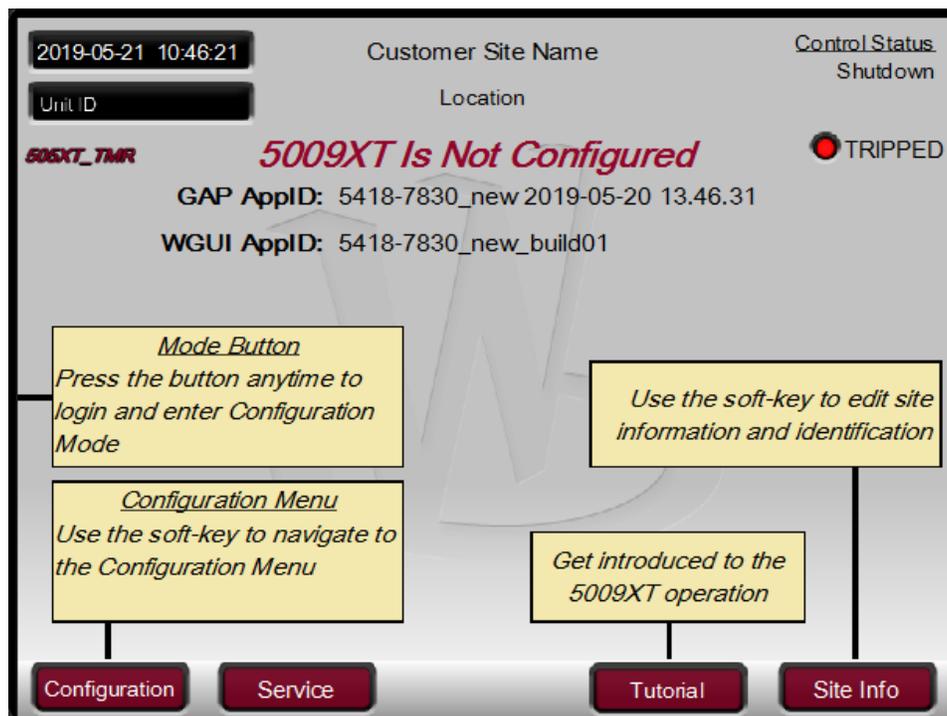


Figure 3-1. Initial HOME Screen (unit not configured)

Use the following procedure to begin configuring the 5009XT:

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 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 5009XT control. To ensure that values are saved, exit Configure mode or select 'Save Settings' from the MODE screen. If power is removed from the control 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, specific application information must be entered into the control. 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 5009XT.

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 3-2. Configuration Menu – Configuration Mode (Edit)

Table 3-2. 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, redundant operation, feed-forward and Trip relay functionality
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 the type of actuator driver outputs required for the steam control valves – user must configure this screen
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 5009XT 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.

NOTICEDriver Configuration
Screen

The Drivers page is a required configuration page that should be configured prior to assigning output demands to specific channels. The Drivers page determines what the logic should verify when performing configuration checks at the end of final configuration. It also is used to active the CAN real time communication networks if digital drivers are being used in the system.

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.

SEMI-AUTOMATIC START?**dflt= NO (Yes/No)**

Select this to configure a semiautomatic start mode. When configured, the 5009XT 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.

AUTOMATIC START?**dflt= NO (Yes/No)**

Select this to configure an automatic start mode. When configured for an automatic start mode, the 5009XT 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.

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.

HP 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 5009XT 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 and less than Maximum Governor)

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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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**dfilt= 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)**dfilt= 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 Setpoints 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 5009XT'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 5009XT 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.

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 5009XT 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 Menu

- 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.
- 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.
- 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 5009XT'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)** **dflt = 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 has to increase in order to trigger the Emergency Feed-Forward action.
- EMERGENCY MAX FORWARD RATE (%/s)** **dflt = 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** **dflt = 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)** **dflt = 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?** **dflt= 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 ?** **dflt= 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 5009XT will shut down the 5009XT control but will not de-energize the 5009XT's trip relay output.
- RESET CLEARS TRIP OUTPUT ?** **dflt= 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 5009XT—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 5009XT trip and will not energize until all trips have cleared and a 'Reset' command is given.
- TRIP = ZERO CURRENT TO ACTUATORS** **dflt= 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 PRESSURE COMPENSATION ?** **dflt= 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? **dflt= NO (Yes/No)**

Select YES to configure the auxiliary control function. Select NO if the auxiliary function is not used.

LOST INPUT SHUTDOWN? **dflt= 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. (<i>Must program a 'remote auxiliary 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)
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). (<i>Must be greater than the 'Min Cascade Setpt' Setting</i>)	
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. (<i>Must be less than or equal to the 'Max Cascade Setpt' Setting</i>)	
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. (<i>Must be greater than or equal to the 'Minimum Governor Speed Setpt' Setting</i>)	
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. (<i>Must be less than or equal to the 'Maximum Governor Speed Setpt' Setting</i>)	
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.
(Must program a 'remote inlet 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)**
- 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).
(Must be greater than the 'Min Ext/Adm Setpt' Setting)
- 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.
(Must be less than or equal to the 'Maximum 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 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.

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. (<i>Must be less than or equal to the 'Max Exhaust 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 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. (<i>Must program a 'remote exhaust 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)

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 in 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. (<i>Only used for Exhaust Control Modes</i>)	
MAX ADMISSION FLOW	dflt= 100.0 (-100000.0, 100000.0)
This is the maximum possible admission steam flow in engineering units. (<i>Only used for Admission only or Ext/Adm units</i>)	

USE AUTOMATIC ENABLE?	dflt= YES (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=100% 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. <i>(Power must be greater than Pt C)</i>	
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 <i>(Flow must be greater than Pt C)</i>	
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. <i>(Power must be greater than Pt C)</i>	
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 <i>(Flow must be greater than Pt C)</i>	
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. <i>(Power must be less than Pt A)</i>	
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 <i>(Flow must be less than Pt A)</i>	
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 5009XT). 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** **dflt= 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?** **dflt= 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

Isolated Control Menu

- USE ISOLATED PID** **dflt= NO (Yes/No)**
Select YES to configure the Isolated PID function. Select NO if the 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 5009XT 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** **dflt= 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** **dflt= 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?** **dflt= 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?** **dflt= 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 on a CPU are required to be configured for a unique subnet (domain). The factory default settings are listed below as an example). The IP's are set using the AppManager service tool.

Ethernet IP Addresses

Kernel A ENET 1 ADDRESS/SUBNET MASK	dflt= 172.16.100.11 (0, 255) dflt= 255.255.0.0 (0, 255)
Kernel A ENET 2 ADDRESS/ SUBNET MASK	dflt= 192.168.128.21 (0, 255) dflt= 255.255.255.0 (0, 255)
Kernel B ENET 1 ADDRESS/SUBNET MASK	dflt= 172.16.100.12 (0, 255) dflt= 255.255.0.0 (0, 255)
Kernel B ENET 2 ADDRESS/ SUBNET MASK	dflt= 192.168.128.22 (0, 255) dflt= 255.255.255.0 (0, 255)
Kernel C ENET 1 ADDRESS/SUBNET MASK	dflt= 172.16.100.13 (0, 255) dflt= 255.255.0.0 (0, 255)
Kernel C ENET 2 ADDRESS/ SUBNET MASK	dflt= 192.168.128.23 (0, 255) dflt= 255.255.255.0 (0, 255)

Note: the ENET 4 address is not, it is for links to expansion chassis

Modbus Configuration

USE MODBUS?	dflt= NO (Yes/No)
Set to YES to use the Modbus communications feature of the 5009XT. 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 LINK 1 (CPU A Ethernet)?	dflt= NO (Yes/No)
Set to YES to use an Ethernet Modbus port on Kernel A.	
NET ADDRESS	dflt= 1 (1, 247)
Enter the integer corresponding to the Modbus device number/address required.	
TYPE (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 1.	
ENABLE LINK 1 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.	
USE LINK 2 (CPU B Ethernet)?	dflt= NO (Yes/No)
Set to YES to use an Ethernet Modbus port on Kernel B.	
USE LINK 1 SETTINGS?	dflt= NO (Yes/No)
Set to YES to use the same settings as Link 1 (only the IP address will be unique)..	
NET ADDRESS	dflt= 2 (1, 247)
Enter the integer corresponding to the Modbus device number/address required.	
TYPE (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.	
ENABLE LINK 2 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.	
USE LINK 3 ?	dflt= NO (Yes/No)
Set to YES to use Link 3 from the Modbus block.	
NET ADDRESS	dflt= 2 (1, 247)
Enter the integer corresponding to the Modbus device number/address required.	
ENABLE LINK 3 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.	
TYPE	dflt= TCP (TCP, UDP port 5002, serial)
Select TCP, UDP or Serial communication for this Modbus link. Selecting UDP will use port 5002 for Link 3. Selecting serial will give options to use the port on either kernel A or kernel C	
PROTOCOL	dflt= ASCII (ASCII, RTU)
Select ASCII or RTU to determine the format of the Modbus communications.	
BAUD RATE	dflt= 38,400
Select the communications baud rate.	

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.	
USE LINK 4 ?	dflt= NO (Yes/No)
Set to YES to use Link 4 from the Modbus block.	
NET ADDRESS	dflt= 2 (1, 247)
Enter the integer corresponding to the Modbus device number/address required.	
ENABLE LINK 4 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.	
TYPE	dflt= TCP (TCP, UDP port 5002, serial)
Select TCP, UDP or Serial communication for this Modbus link. Selecting UDP will use port 5002 for Link 4. Selecting serial will give options to use the port on either kernel B or kernel C	
PROTOCOL	dflt= ASCII (ASCII, RTU)
Select ASCII or RTU to determine the format of the Modbus communications.	
BAUD RATE	dflt= 38,400
Select the communications baud rate.	
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.	

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. The function menu list does provide options for duplicate or triplicated inputs on critical signals. If only 1 is used, select the first signal. For example, Extraction/Admission Input #1

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)

mA Signal A/B/C **display only**
 This will show the actual current input from each of the 3 kernels.

DEVICE TAG**dflt= AI_xx**

This is a user entered field. It allows entry of a short description or tag name for this channel.

UNITS**dflt= EU**

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 5009XT slave modbus communication link

DECIMALS DISPLAYED**dflt= 1.0 (0, 1, 2, 3)**

This is the number of decimals to be displayed on the 5009XT screens for this parameter

Analog Inputs # 2 through # 8 are configured following the same rules as described for Analog Input # 1.

NOTICE	<p>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</p>
Entering Text	

Analog Outputs Menu

All four of 4–20 mA analog outputs may be configured. The function that the output 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. The first 15 options of the function menu are valve driver demands and are meant to drive the primary valve demands of HP, HP2, LP and LP2.

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.

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**dflt= AO_xx**

This is a user entered field. It allows entry of a short description or tag name for this channel.

UNITS**dflt= EU**

This is a user entered field. It allows entry of a unit label for this channel.

Driver Configuration Menu

Configure the type of actuator drive output signals required by the steam control valves. If the actuators require a signal other than a 4-20mA demand, then an optional kit must be added. Initially a 2 Chan Actuator kit will be offered (same as previous control 5009FT). When revision A of the application is released the support for using digital drivers will be enabled using the CAN Port 2 on the CPU's in Kernel B (KB) and Kernel C (KC). CAN will be used to send the 0-100% valve demand to SPC drivers which can support many various types interfaces to either proportional or integrating actuators with feedback.

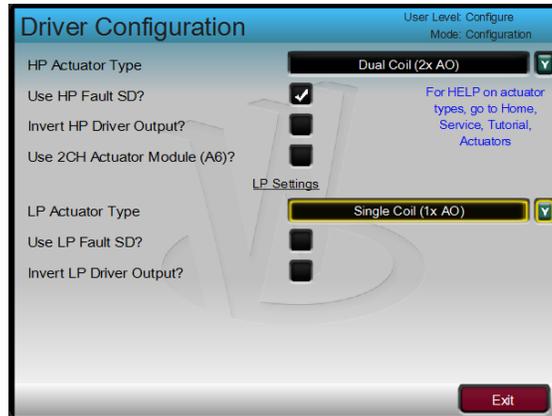


Figure 3-3. Driver Menu – Configuration Mode (Edit)

HP ACTUATOR TYPE

dflt= Not Used

Must scroll through the menu and select the type of actuator required by the system.

Single Coil

Dual Coil

Redundant Actuators

To KB SPC11 with AO as backup demand

To KB SPC11 (no AO backup)

To 2 SPC's (KB SPC11 and KC SPC21)

To 2 SPC's (KB SPC11 and KC SPC21) both with AO backup

USE HP ACTUATOR FAULT SHUTDOWN ?

dflt= YES (Yes/No)

Select YES to issue a trip whenever an actuator fault is detected. If YES, the control will issue a shutdown if the HP Actuator 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 HP 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.

LP ACTUATOR TYPE

dflt= Not Used

If the unit is an Ext/Adm unit, you must scroll through the menu and select the type of actuator required by the system.

Single Coil

Dual Coil

Redundant Actuators

To KB SPC12 with AO as backup demand

To KB SPC12 (no AO backup)

To 2 SPC's (KB SPC12 and KC SPC22)

To 2 SPC's (KB SPC12 and KC SPC22) both with AO backup

USE LP ACTUATOR FAULT SHUTDOWN ?**dflt= NO (Yes/No)**

Select YES to issue a trip whenever an actuator fault is detected. If YES, the control will issue a shutdown if the LP Actuator 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 LP 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.

USE 2CH ACTUATOR MODULE (A6) ?**dflt= NO (Yes/No)**

Set to YES to configure the 5009XT to use this optional module kit. When this has been selected, it will activate additional pages after this one that will allow the user to setup the 2 channels. In the application, the channels on each module are paired together for redundancy and cannot be driven individually. This is why there are only 2 channels and not 4 available to configure.

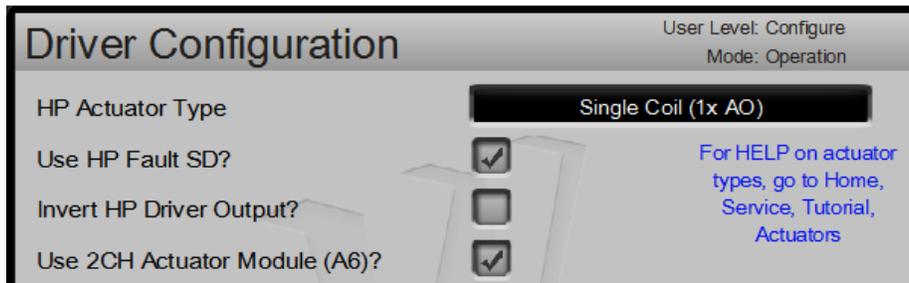


Figure 3-4. Driver Configuration – Optional module selection

If an HP2 or LP2 driver demand output is programmed on any output channel – the offset percentage settings will appear on this page.

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.

LP2 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.

USIE HP2 FAULT AS A SHUTDOWN?**dflt= NO (Yes/No)**

Set to YES to trigger a trip if any fault is detected on the HP2 actuator driver .

If the 2CH Actuator Modules option is selected – the Drivers page will make the Actuator channel configuration pages visible. Refer to the information in this manual about this option I/O module for more information about these specific selections.

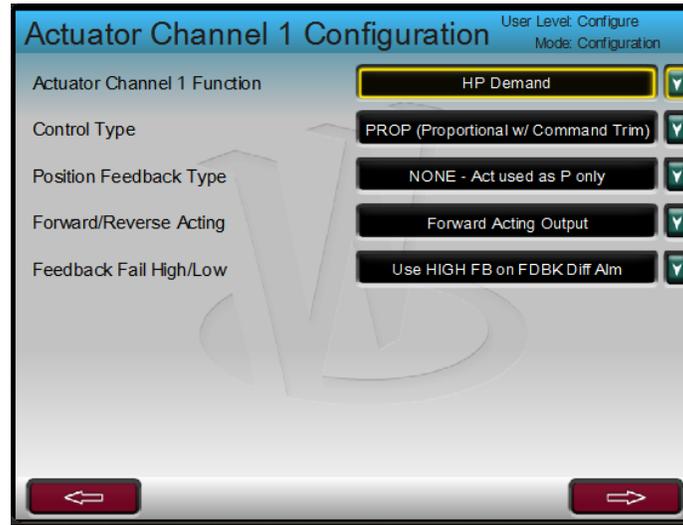


Figure 3-5. Actuator Channel Configuration Mode (Edit)

ACTUATOR CHANNEL 1 FUNCTION

dflt= Not Used

Select the desired function for this channel from the 4 options – HP, HP2 LP or LP2 demand

CONTROL TYPE

dflt= PROP (w/ Command Trim)

Select the type of actuator controller, there are 5 options. The default is for a proportional actuator (a linear demand from 0-100% from minimum to maximum current range). The other 4 options are all for integrating actuators that use a null current with position feedback. PI, P PI_LAG and PI_LEADLAG with the P or PI being the most commonly used

POSITION FEEDBACK TYPE

dflt= NONE

If feedback is used select the type of wiring that is coming back to the control for voltages. Three options are available, the device must be either an LVDT or RVDT.

FORWARD/REVERSE ACTING

dflt= Forward Acting Output

Select how the valve demand relates to increasing current. Forward acting means the valve opens as the current is increased (this applies to both proportional and integrating actuators).

FEEDBACK FAIL HIGH/LOW

dflt= Use High FB

If 2 feedback signals are used, select the correct (safest) one to follow if the 2 devices have a difference

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:

TEST RELAY?**dflt= NOT USED**

Select this option if you desire to use the automated latent fault detection logic for checking the function of each individual relay (of the 6) each 48 hours. (this value is not on the GUI – but can be adjusted using control assistant/winpanel with the following variable -> FTR_A_01.CCT_HRS.IN_1

CONFIGURATION**dflt= NOT USED**

If the latent fault test is used, set this to the correct configuration for where the field load is to be seen on the relay under test.

LEVEL ON (UNITS)

dfilt= 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)

dfilt= 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?

dfilt= 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 5009XT 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.

LINK TO DSLC-2 (TCP Modbus on Ethernet Port 3)**Use a DSLC-2 (Digital Synchronizer/Load Control)?**

dfilt= NO (Yes/No)

(Radio buttons select one)

Use Synchronization? _____

Use Sync/Load Share? _____

Use KW Signal Only? _____

Device Slave Address (1-255)

dfilt= 247 (1, 255)

Device IP Address

dfilt= 192.168.1.3 (0, 255)

Enter the integers corresponding to the network TCP/IP address.

5009XT ENET3 IP Address

dfilt= 192.168.129.20 (0, 255)

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 5009XT to save the configuration and exit IO Lock. If there are no errors in the configuration, the control 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 control 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 control will remain 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 5009XT 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 5009XT can operate the turbine. All errors must be corrected before in order to be able to reset the 5009XT 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.

Event ID	Description	Error Meaning
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".
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.

Event ID	Description	Error Meaning
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.
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 configured also. 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 an Cascade analog input was configured also. 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 an Cascade analog input was configured also. 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 an Cascade analog input was configured also. With this configuration, only the Exhaust Pressure analog input is used for the Cascade controller.

Event ID	Description	Error Meaning
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
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.
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.

Event ID	Description	Error Meaning
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 5009XT'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 5009XT'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.
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.

Event ID	Description	Error Meaning
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.
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

Event ID	Description	Error Meaning
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

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 insure that the 5009XT is correctly calibrated to the turbine control valve(s). When calibration is complete, 0 to 100% actuator position as displayed by the 5009XT 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.

With the turbine shutdown, enter the Calibration mode and follow the steps below. 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. To ensure proper control to actuator resolution do not calibrate the span of the actuator output to less than a range of 100 mA (20–160 mA output) or 12 mA (4–20 mA output). If necessary, the actuator to valve linkage may need to be adjusted to ensure proper 5009XT to valve resolution.

Calibrating Valves configured on the Analog Outputs

From the channel screen enter the Force Output screen. The screen shot below shows the 'Orange gradient banner' across the top to signal that the unit is in calibration mode. If a fault appears on the channel, verify the wiring is complete to the actuator and issue reset.

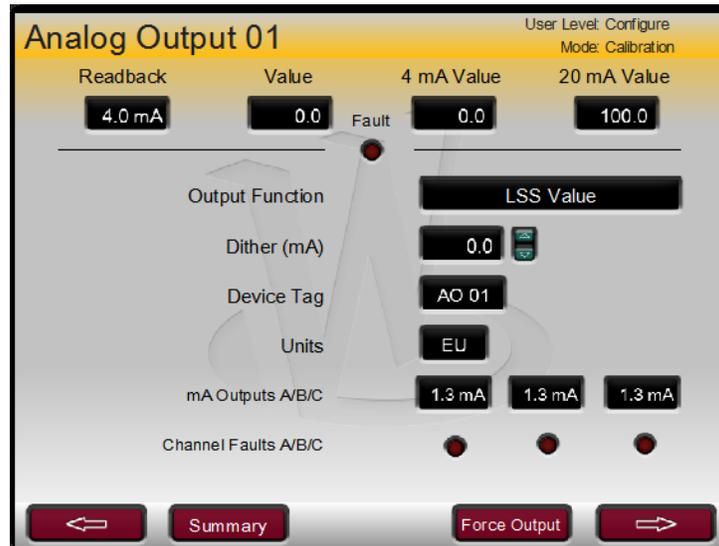


Figure 3-6. Analog Output Channel Calibration Mode

On the forcing pop-up screen, enable forcing and verify that the minimum current of 4 mA drives the valve to the minimum (0%) position, then adjust the value to maximum of 20 mA and verify the maximum position.

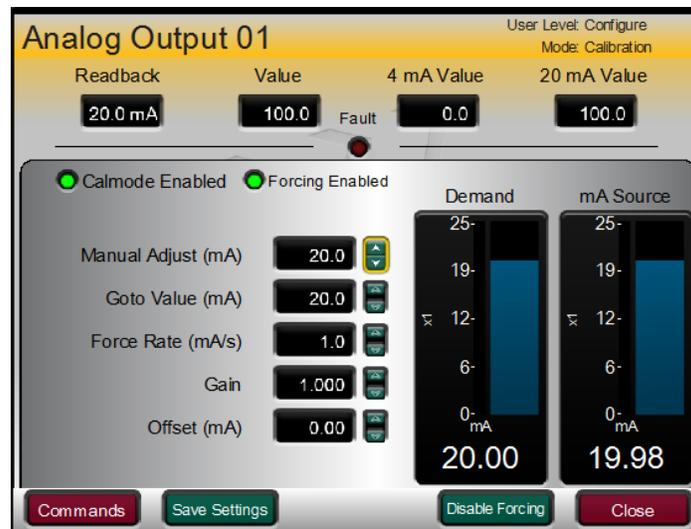


Figure 3-7. Analog Channel Forcing Mode

The stroking can be done in multiple ways, the Commands button will make visible buttons to Go to Min and Go to Max, as well as a Go button that will drive the output from the current position to the Goto value. If needed use the Gain and/or offset values to reach the 0-100% valve stroke. The force rate will adjust the rate at which the output strokes.

When finished save the settings and disable forcing. A step by step procedure for this is documented below.

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 5009XT 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 Analog Outputs Summary page from the HOME menu or Configure menu.
5. Select the desired Analog output channel.
6. On the Analog channel screen press the 'Force Output' button
7. Verify the green "Calmode Enabled" LED is ON to confirm that the unit is in Calibration Mode.
8. For analog output channels - Press the 'Enable Forcing' button and then confirm on the popup that channel 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, Goto 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 the 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 5009XT. 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.

Calibration of Valves on the 2 Channel Actuator module channels

If this option is enabled and the modules, cables and FTM's are installed with the actuator connected then these channels can be calibrated.

The Actuator circuits on these modules are paired together for redundancy. This is done so that any single fault can be tolerated while still providing the correct drive output to the actuator. When calibrating these 2 channels, there is a specific sequence of steps that must be followed. The GUI will provide clear guidance in this procedure. The calibration should be done once all wiring is completed for both channels. Calibration mode is enabled from the MODE button screen.

Go to the Actuator channel page – if you have entered Calibration mode, the top of the page will have a color gradient to indicate you are in this mode.

Calibration of an Integrating Valve Driver

The example below is from a configuration for an integrating valve.

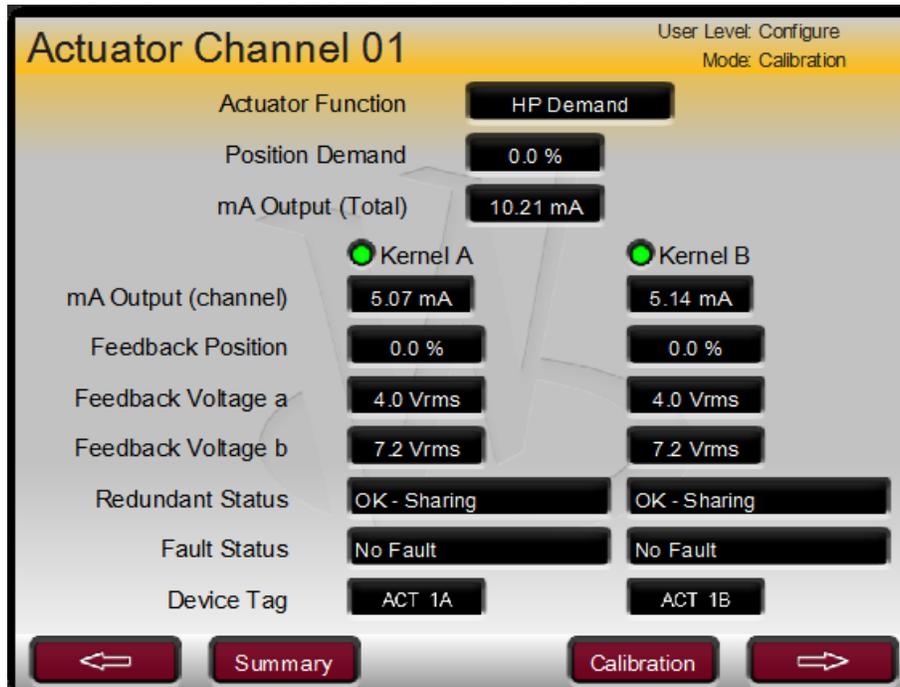


Figure 3-8. Actuator channel 1 – Integrating Driver

Clicking on the Calibration button will change the screen to look like this:

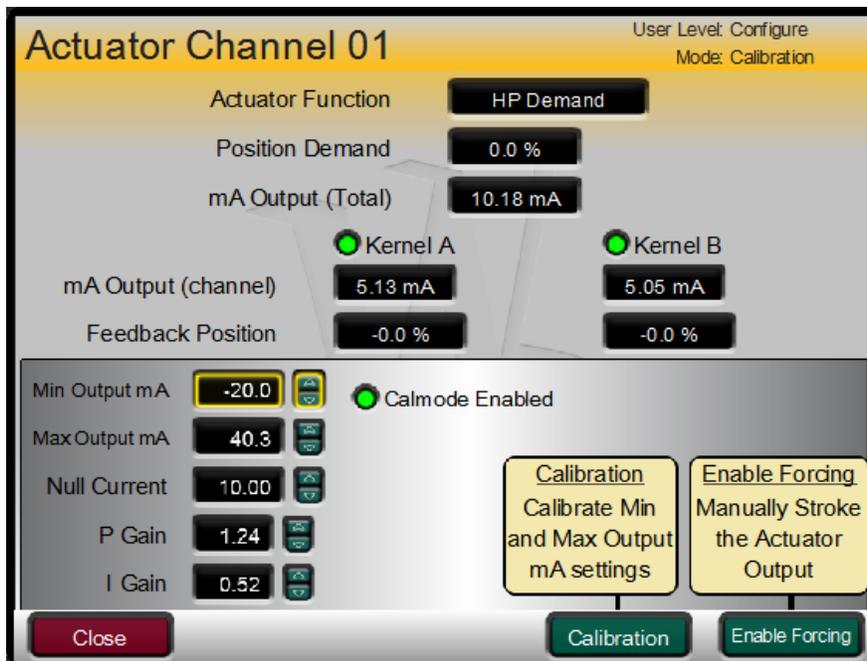


Figure 3-9. CALMODE access to Calibration and Forcing (Stroking)

If you click on the green Calibration button, the control will enter the automated calibration sequence routine to escort the user through all steps.

The first sequence step will shutdown the Kernel B channel (0 mA) and provide a -30 mA bias to the Kernel A channel to drive the valve to minimum position. The control sequence will wait until the user clicks the “Confirm Min” button to lock in these feedback voltages as equating to 0% valve position.

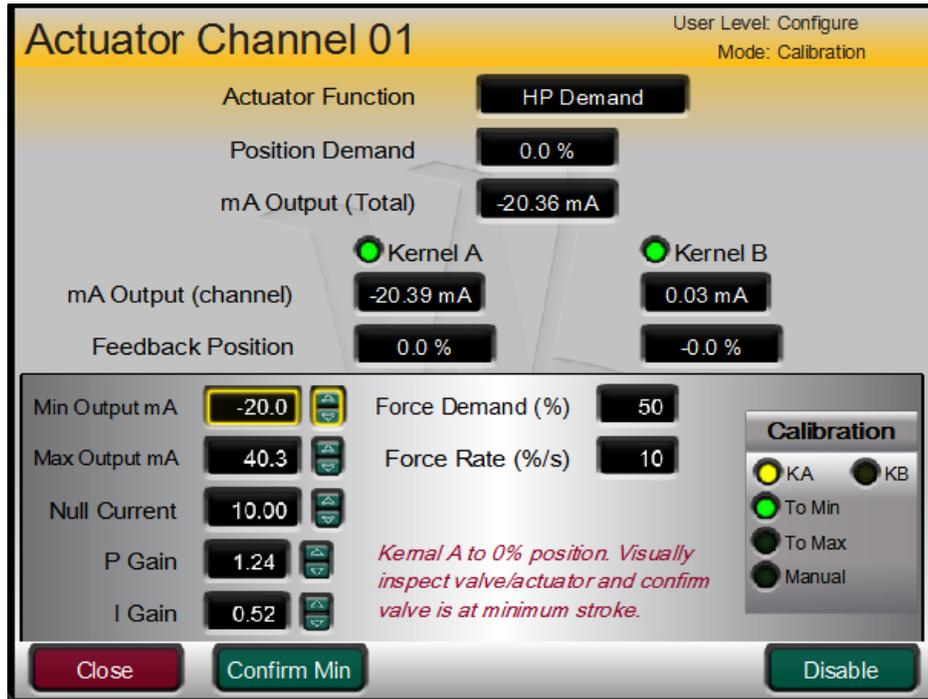


Figure 3-10. Waiting for Minimum position feedback

To proceed to the next step, press Continue and the control will now bias the current above the null current to drive the valve to the maximum position. Notice that even though the output drive current from kernel B is shut off, the feedback voltages and position readback are still active.



Figure 3-11. Waiting for Maximum position feedback

The control sequence will wait until the user clicks the “Confirm Max” button to lock in these feedback voltages as equating to 100% valve position. It will then ramp the demand back to 0%.

The next “Continue” command will manual forcing of the demand to the kernel A channel, while still in calibration mode. This may be helpful for initial tuning of the gain values on integrating valves.

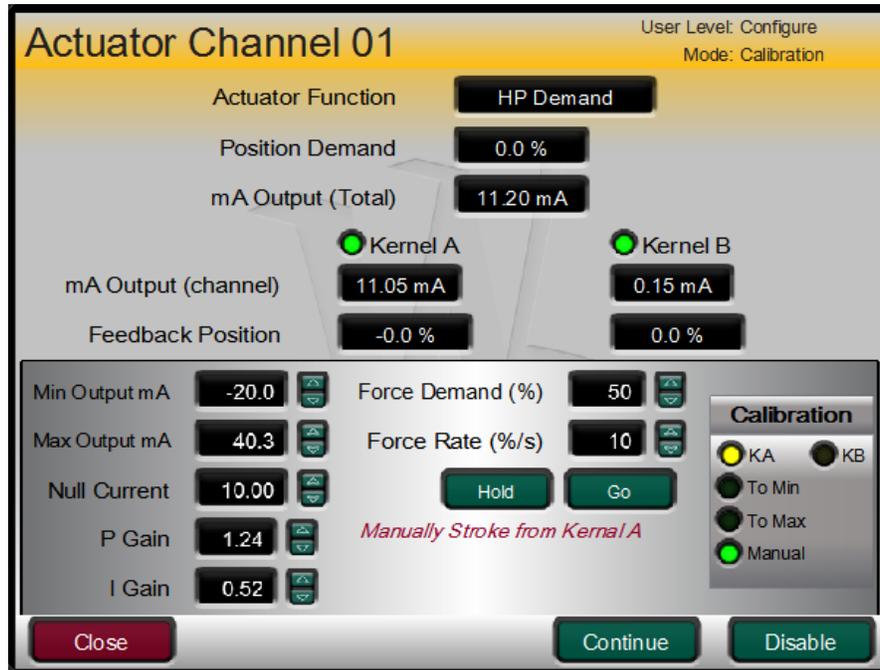


Figure 3-12. Kernel A channel complete – manual demand allowed

The next “Continue” command will proceed to setting up the kernel B channel. The control will shutdown the Kernel A channel (0 mA) and provide a -30 mA bias to the Kernel B channel to drive the valve to minimum position. The control sequence will wait until the user clicks the “Confirm Min” button to lock in these feedback voltages as equating to 0% valve position.

Proceed through the same steps for this channel and the final ‘Continue’ command will exit the Calibration routine.

Calibration of a Proportional Valve Driver

For Proportional only channels on these modules the same procedures as above apply, but the screens and the calibration routines are simpler.

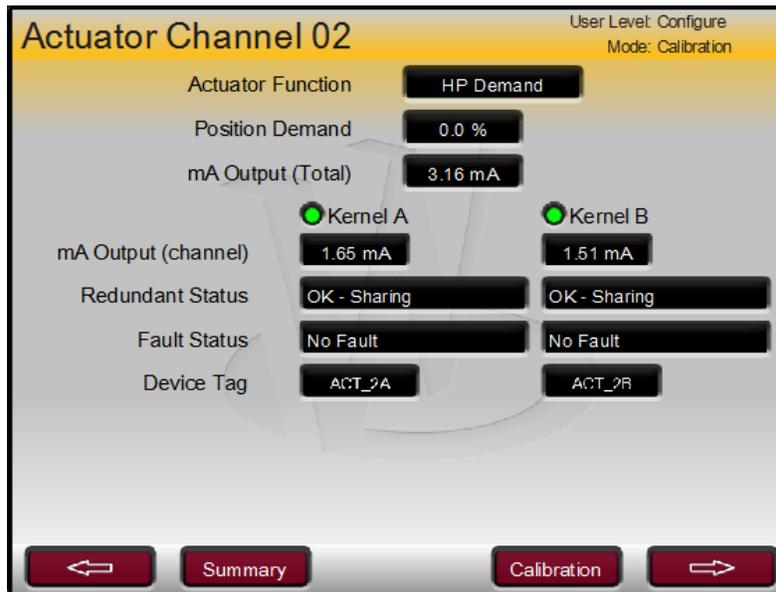


Figure 3-13. Actuator channel 2 – Proportional Driver

Entering Calibration will go to this screen where kernel B channel is shutdown, set the mA at 0% value to the correct current that drive the valve to just reach the minimum position. Click Confirm Min, then Continue to drive the current to the mA at 100% value.

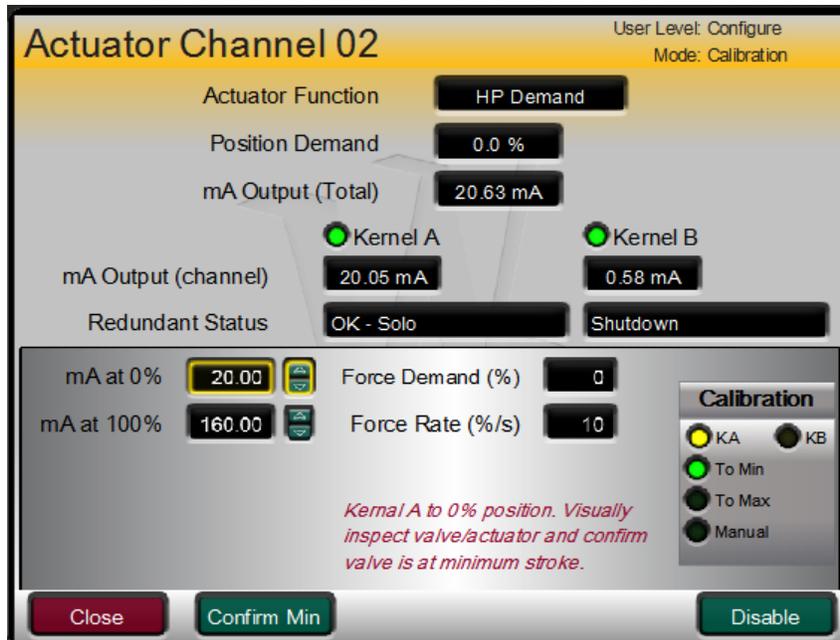


Figure 3-14. Waiting to confirm 0% position at minimum mA

If needed, adjust the mA at 100% current setting to the point where the valve just reaches the maximum position. Click Confirm Max, then Continue to be able to manually test this channel. When finished click on Continue to proceed to the same steps for the kernel B channel.

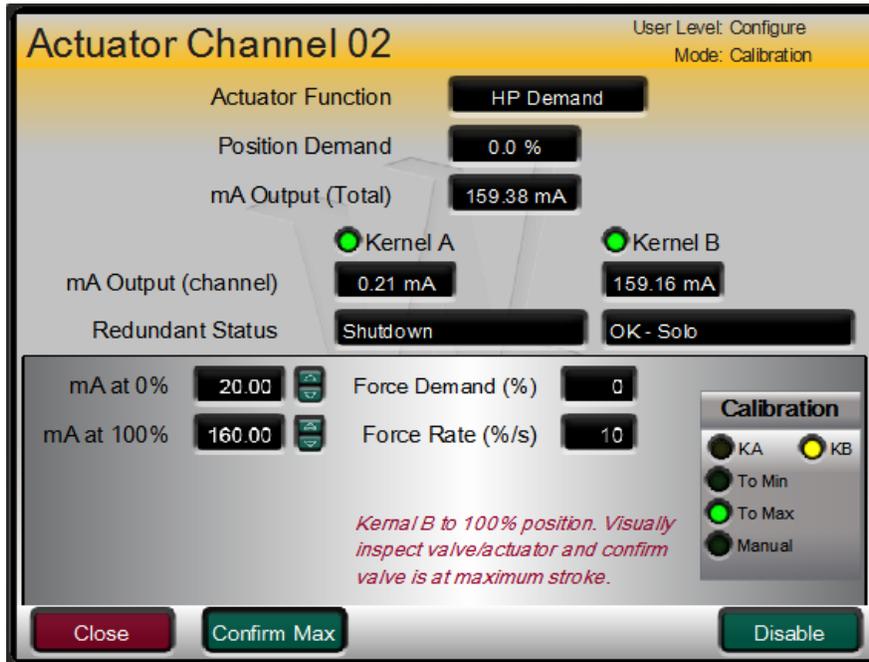


Figure 3-15. Waiting to confirm 100% position at maximum mA

Enable Forcing Routine -

After the valve has been calibrated, it is desirable to have a procedure to manually stroke the valve to insure they are functioning correctly. This is done by selecting the Enable Forcing button.

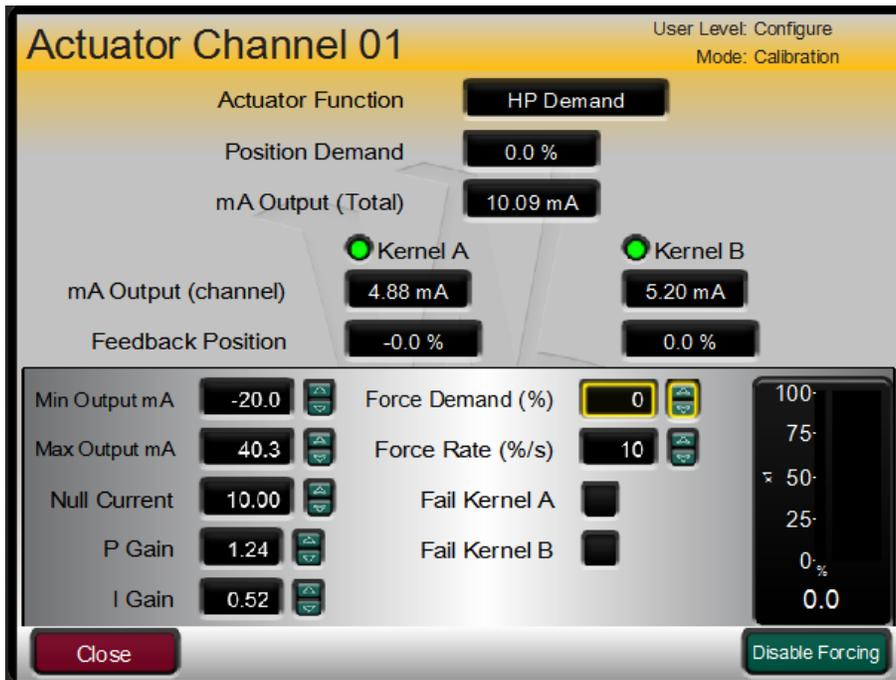


Figure 3-16. CALMODE – Forcing mode enabled for integrating valve

From this screen the user can enter a demand position, adjust the rate at which the control will move the demand from the current demand value to the entered demand value and choose to fault the individual channel on either kernel A or B to verify that a single channel can fully stroke the valve.

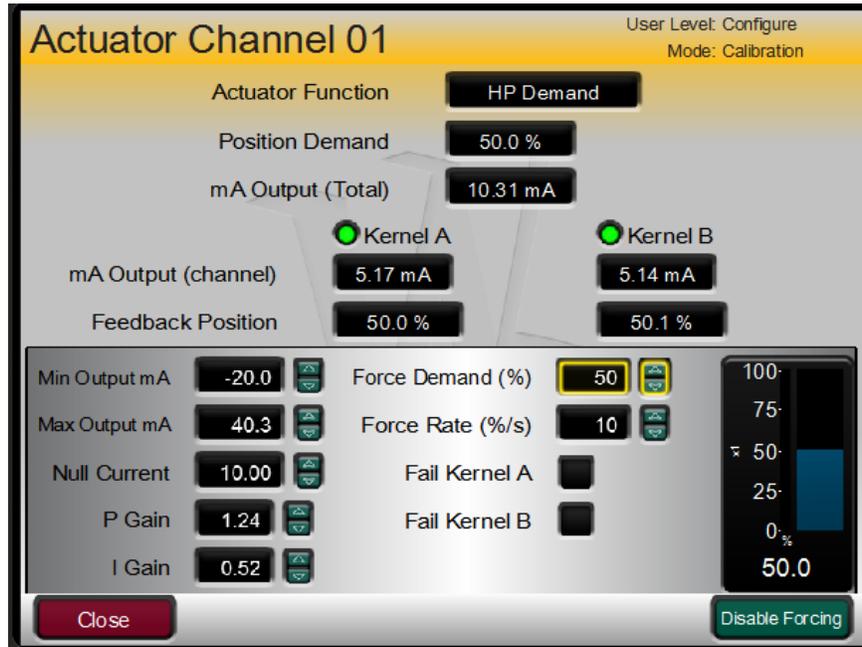


Figure 3-17. Forcing mode to manually stroke an integrating valve

For the proportional driver configuration the procedure for manual stroking is the same, but the pop-up window will appear slightly different.

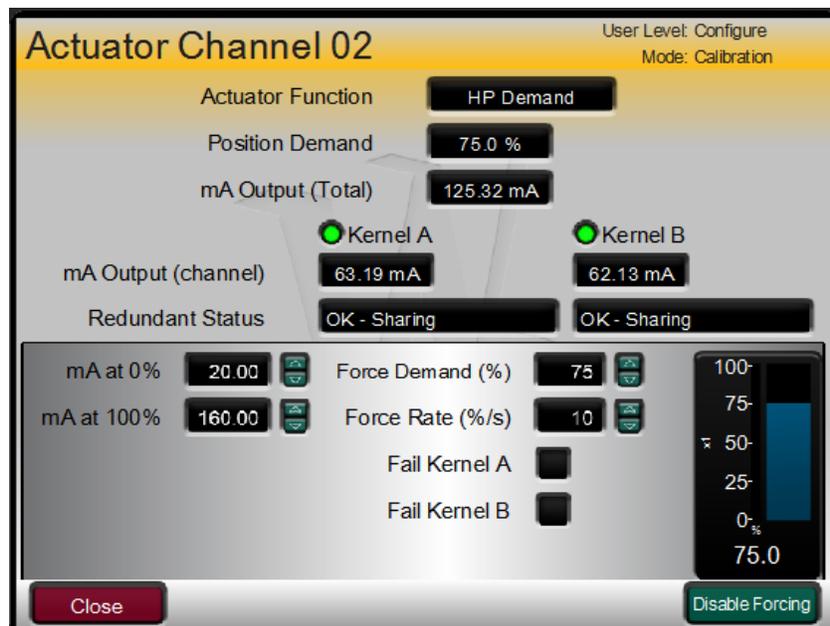


Figure 3-18. Forcing mode for a proportional driver

NOTICE

The Woodward MicroNet TMR has a unique way of retaining and validating actuator calibration data. Once the actuator modules and actuator/valve assembly are correctly calibrated, the calibration data is stored in both the CPU and the Actuator Controller module.

If an actuator module needs to be replaced, the spare (uncalibrated) module will utilize the calibration information from the CPU, thus allowing on-line replacement without needing to recalibrate. If a GAP application update is made to the system, and configuration tunable settings are loaded into the control, the CPU will retrieve the calibration information from the Actuator controller module, so that recalibration is not required due to an application software update.

Service Parameters for Actuator channels

Under the Service menus the Actuators screens will be available to adjust certain values depending on the type of actuator being driven.

The first example is for an integrating actuator, which shows multiple parameters related to settings and delays that produce alarms related to feedback signals and demand versus position errors.

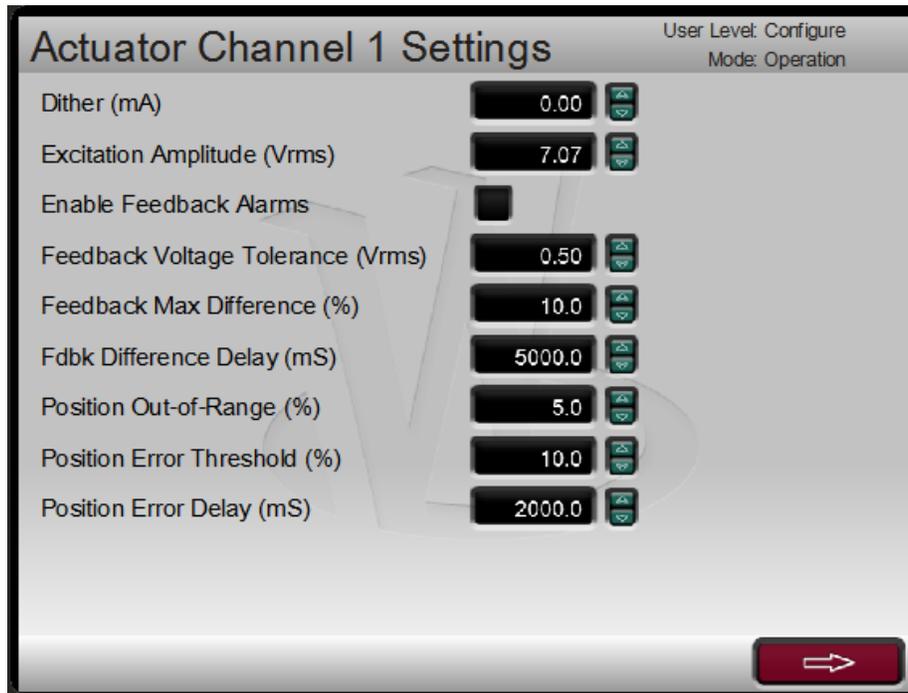


Figure 3-19. Service parameters for integrating driver

For proportional drivers there are only 2 parameters. Dither adds and subtracts a small amount of current to the drive signal at a very high frequency. It is used for some valve/actuators that may be prone to 'sticking'. The Command Trim selection has no affect if there is no feedback, if there is a feedback device this allows the user to enable or disable this feature.

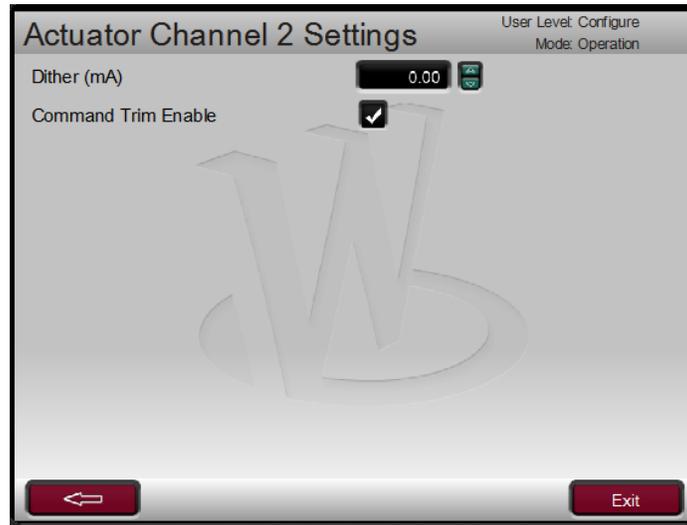


Figure 3-20. Service parameters for proportional driver

Chapter 4

5009XT Operation

Software Architecture

The 5009XT is a field configurable steam turbine control and graphical user interface (GUI) integrated into the MicroNet TMR platform. Both of these software application programs reside on the control CPU's. The GAP program controls the I/O and controls all turbine operation. The other program provided is the graphical user interface (GUI) program that provides all the visual and command interaction with the user. This program does not execute on the CPU, it is accessed and executed from a user PC.

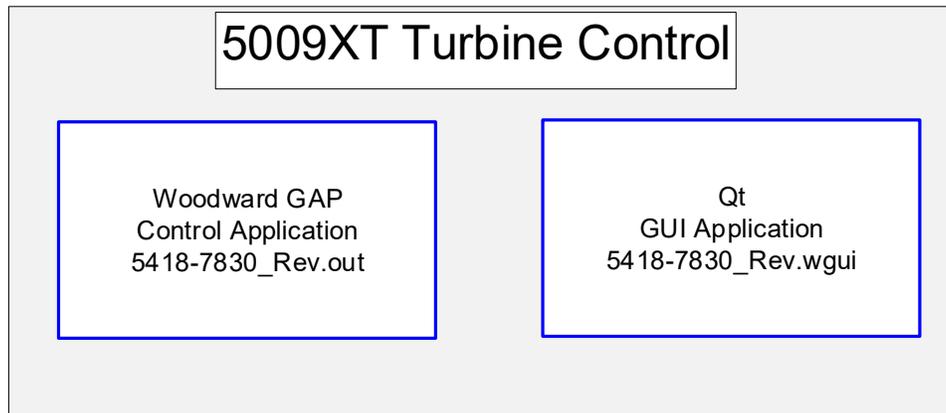


Figure 4-1. Software Architecture

All of the user interaction for configuration, service, operation and troubleshooting is done via the GUI application program that is accessed by Woodward's RemoteView tool running on a user supplied PC. Refer to the appendix in Volume 2 of this manual for information on installing the RemoteView software.

Using Remote View once the CPU's have been setup

Before using the Remote View tool, complete the follow steps to connect to the control. These steps are described in detail in the Remote View Configuration section.

- Enter the IP address of the control in the configuration window (for Kernel A CPU ENET port 1 – the default IP = 172.16.100.11 then click the + button
- Under Display Properties - Select Platform** = 5009XT and Panel Type = Simple and a Scale of 0.80
- Click on the GUI file in the Application list for the control and click on the Launch button
- Enter the desired user level (requires a login)

** The RemoteView tool has various Platform and Panel types to select from. These are actually just 'frames' or 'skins' that are applied around the individual screens. The screen resolution size was defined by the original 505XT platform template, so this is the reason for the native resolution of 800x600. The data on all the screens is exactly the same regardless of which platform or panel type is selected.

Return to these settings at any time using the gear icon in the upper right corner of RemoteView

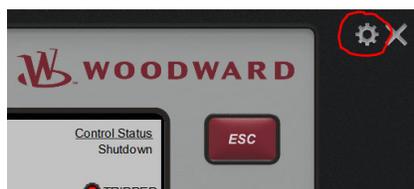


Figure 4-2. RemoteView configuration settings

The initial HOME screen seen below, reflects a RemoteView connection to a control with the factory default settings in the application. The message “Unit is Not Configured” is shown along with some initial help prompts about using the MODE button to login and direction to a tutorial on how to navigate and enter values using RemoteView. Once the user has started to configure the control, these prompts will no longer appear and the HOME screen will show the more typical page navigation button screen.

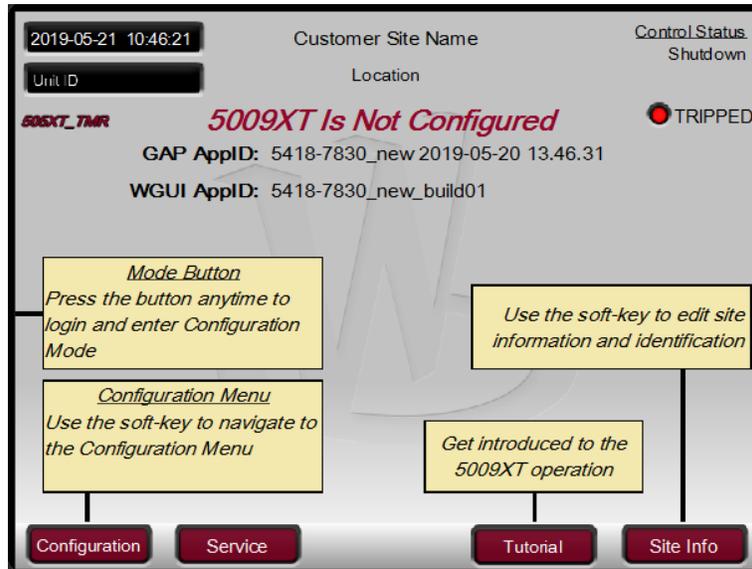


Figure 4-3. Initial screen with control at factory default settings

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 two will jump to the Speed Control screen, from that screen if you press seven it will jump to the Startup Curve screen. From any operational screen, pressing HOME will always return to this screen



Figure 4-4. Boot-up to HOME Screen

Control Mode Architecture

Basic control program architecture is illustrated in Figure 4-1. The 5009XT'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 control 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 control are disabled. This means that all Relays are de-energized and all Analog/Driver outputs are at zero current. Initially all 5009XT'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 control 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. If security is a concern, there is an option under the Service menu / Screen/Key options to configure the control to bootup in Monitor mode which will inhibit any commands (including a reset command) from the RemoteView program.

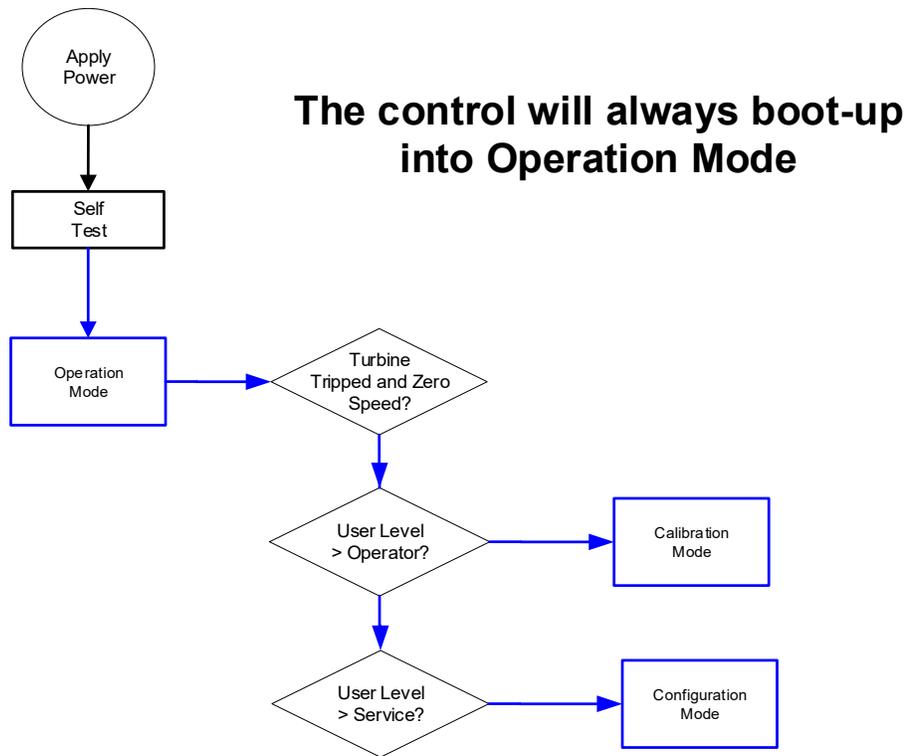


Figure 4-5. Control Mode Architecture

User Login Levels

Pressing the MODE key at any time will open the Login and Mode Screen

User Login and Mode Selection

Configuration Error

User Level	Description
<input type="radio"/> Monitor	View Only - commands inhibited
<input type="radio"/> Operator	Operational commands available
<input type="radio"/> Service	Additional commands, settings, and dynamic tuning available
<input checked="" type="radio"/> Configure	All commands and settings available

Mode	Description
<input checked="" type="radio"/> Operation	Turbine Operation
<input type="radio"/> Calibration	Turbine Shutdown - signal calibration, output forcing
<input type="radio"/> Configuration	Turbine Shutdown - IOLOCK, I/O and functional configuration

Calibration and Configuration Mode Permissives

Unit Shutdown
 No Speed Detected
 User Level

LOGIN

Save Settings

Calibration

Configuration

Figure 4-6. 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

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.

Navigation

In general, the maroon buttons provide navigation from page-to-page and throughout the components on a page. When using the RemoteView tool typically a mouse is used to point and click, however the arrows of a keyboard will also move the IN-Focus highlighter in the direction pressed.

1. Click on desired page or use arrow keys 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 4-7. 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.

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 features of the control. It is automatically updated to match the configuration of the control.

Configuration menus - The Configuration 'HOME' page contains navigation buttons to all features and options of the control. 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.

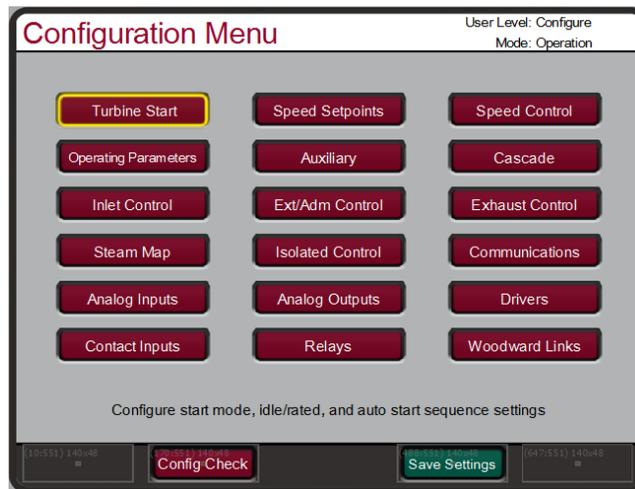


Figure 4-8. Configuration Menu – Operation Mode (View only)

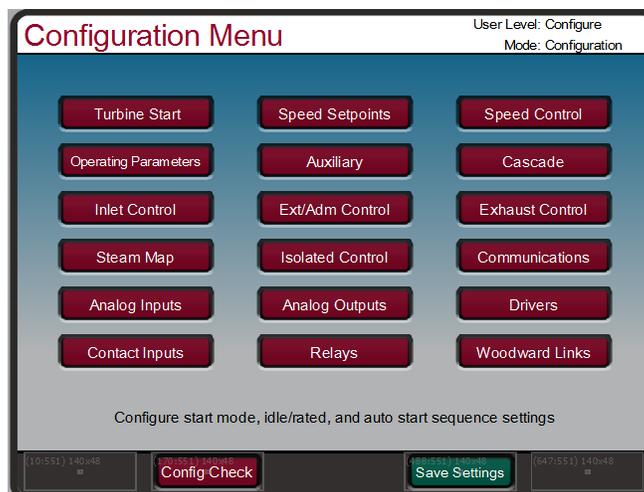


Figure 4-9. Configuration Menu – Configuration Mode (Edit)

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)

Overview Screen

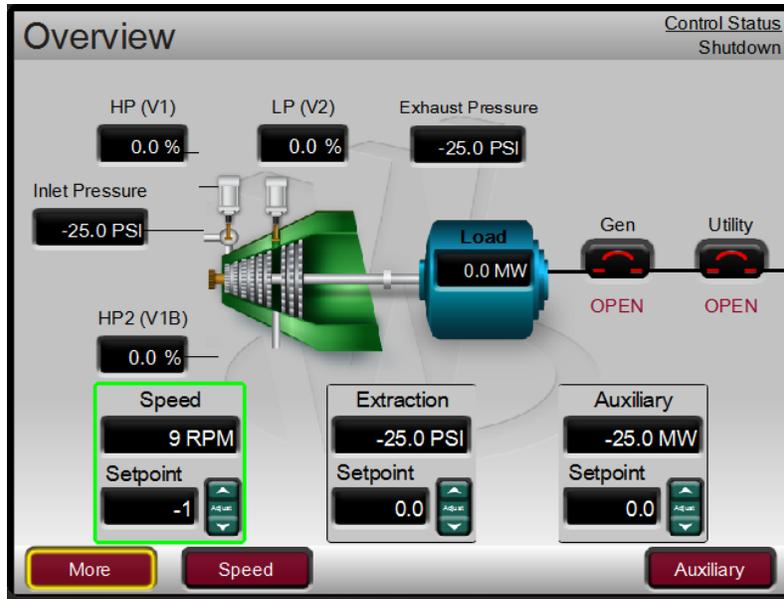


Figure 4-10. Overview Screen

The Overview screen will adapt to the configuration of the 5009XT 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

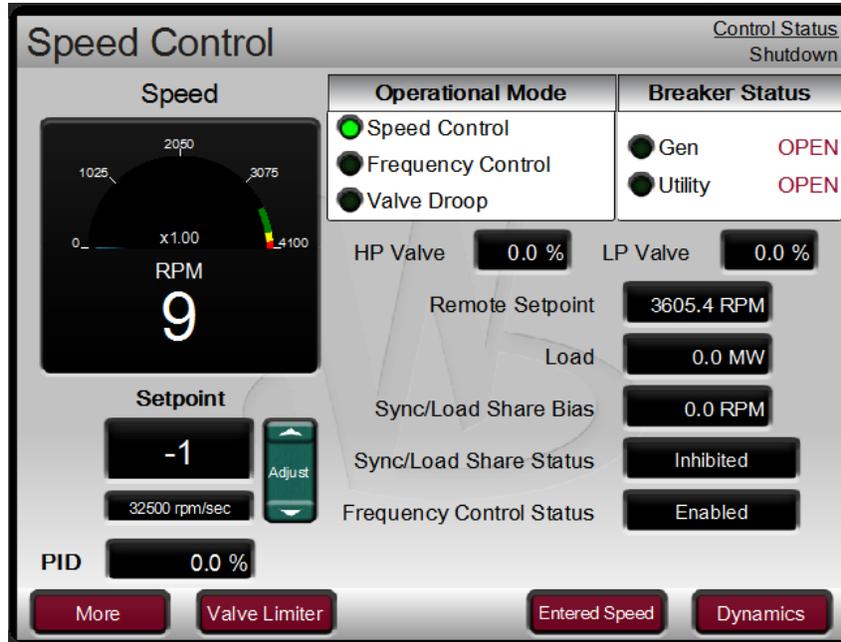


Figure 4-11. Speed Control Screen

The Speed Control screen will adapt to the configuration of the 5009XT 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

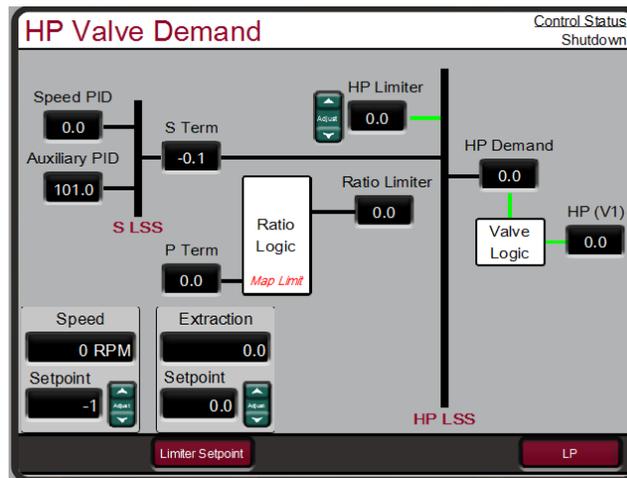


Figure 4-12. Valve Demand Screen

The Valve Demand screen will adapt to the configuration of the 5009XT 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

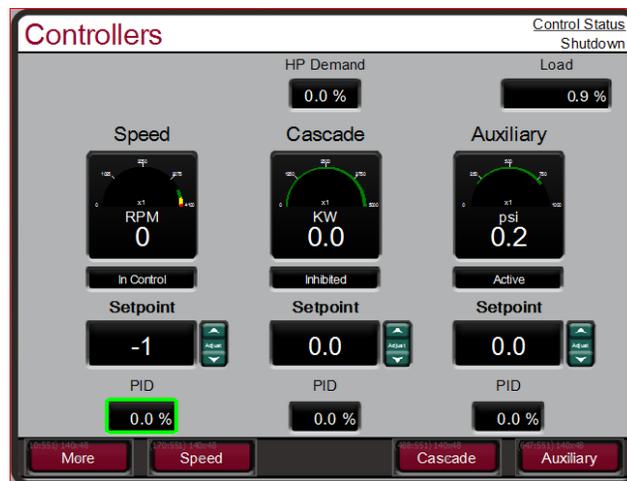


Figure 4-13. Controllers Screen

The Controllers screen will adapt to the configuration of the 5009XT 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 5009XT 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

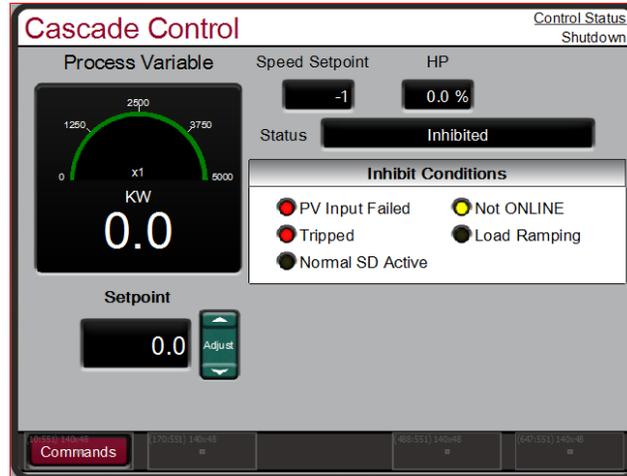


Figure 4-14. Cascade Control Screen

The Cascade Control screen will adapt to the configuration of the 5009XT. 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 control 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 4-15. Auxiliary Control Screen

The Auxiliary Control screen will adapt to the configuration of the 5009XT. 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

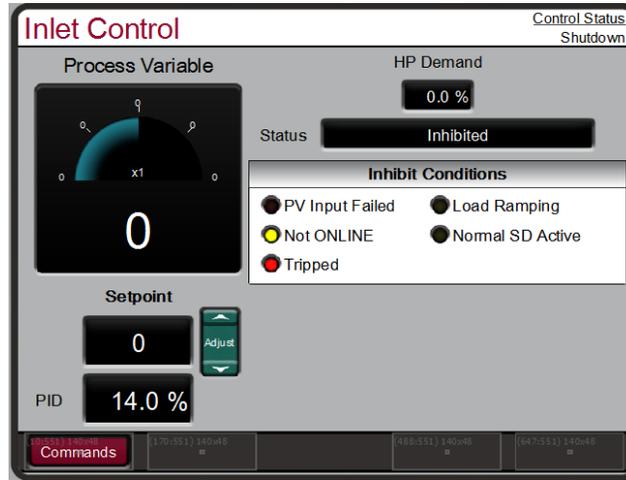


Figure 4-16. Inlet Steam Pressure Control Screen

The Inlet Pressure Control screen will adapt to the configuration of the 5009XT. 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

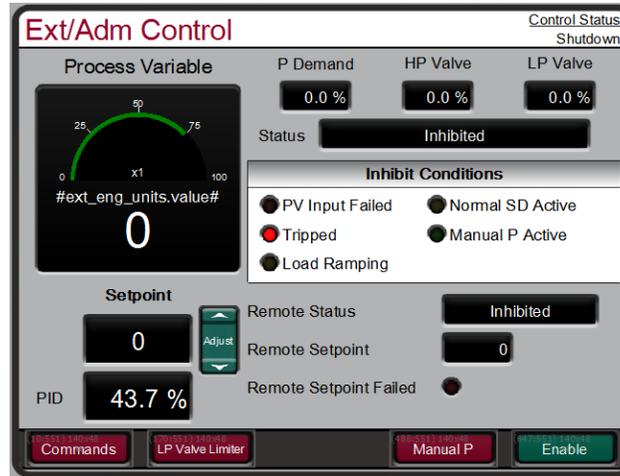


Figure 4-17. Ext/Adm Pressure Control Screen

The Extraction/Admission Control screen will adapt to the configuration of the 5009XT. 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

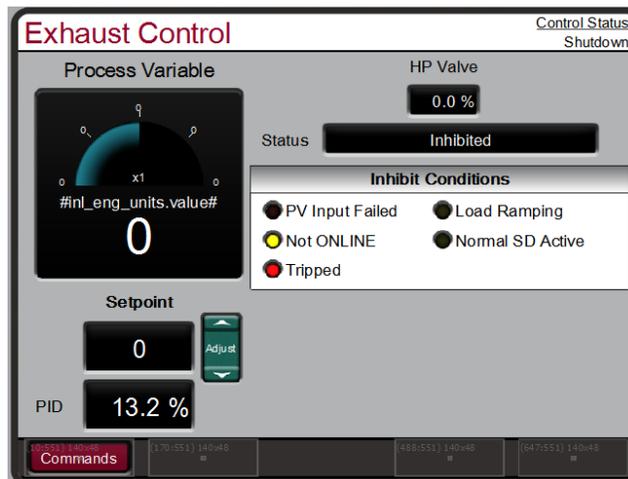


Figure 4-18. Exhaust Pressure Control Screen

The Exhaust Pressure Control screen will adapt to the configuration of the 5009XT. 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

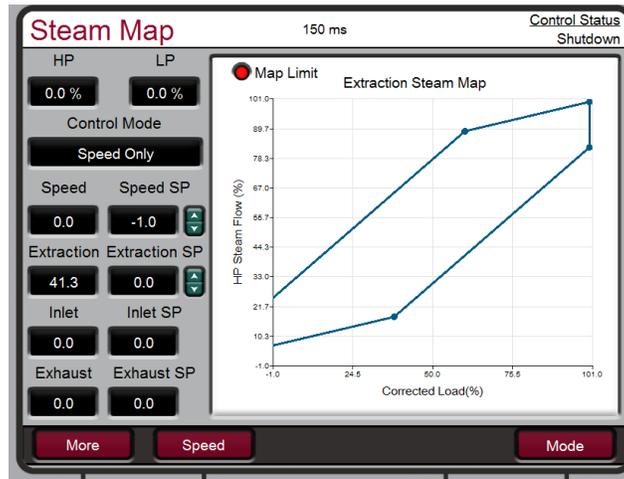


Figure 4-19. Steam Map Screen

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.

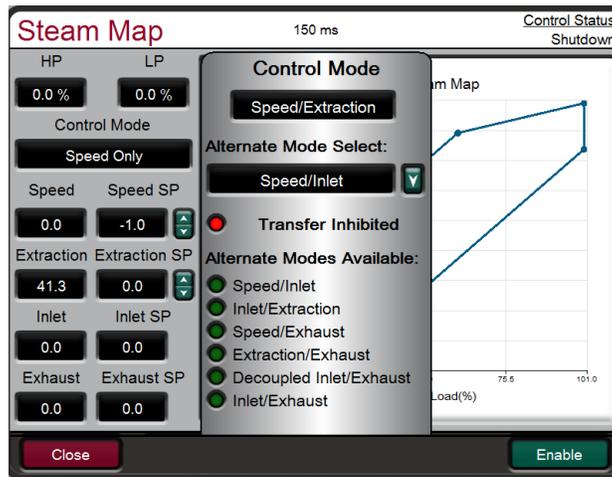


Figure 4-20. Steam Map – Mode Popup

Analog Input Summary Screen

Channel Page	Function	Tag	Validated Value	KA	KB	KC
AI_01	Remote Speed Setpoint #1	AI_01	-25.0 EU	4.00 mA	3.99 mA	4.00 mA
AI_02	Generator Load Input #1	AI_02	-25.0 EU	3.99 mA	3.99 mA	3.99 mA
AI_03	Cascade Input #1	AI_03	-25.0 EU	4.00 mA	4.00 mA	4.00 mA
AI_04	Auxiliary Input #1	AI_04	-25.0 MW	3.99 mA	3.99 mA	4.00 mA
AI_05	Inlet Pressure Input #1	AI_05	-25.0 PSI	3.91 mA	3.91 mA	3.91 mA
AI_06	Exhaust Pressure Input #1	AI_06	-25.0 PSI	0.01 mA	0.00 mA	0.00 mA

Control Status Shutdown

Back Speed Inputs A3 - Speed/AIO AI 7-12 Analog Outputs

Figure 4-21. Analog Input Summary Screen

The Analog Input Summary screen will display the status of all channels available on the 5009XT 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

Contact	Status	Function	Tag
Contact 01	●	Emergency Stop	BI01
Contact 02	●	Reset Command	BI02
Contact 03	●	Speed Raise Command	BI03
Contact 04	●	Speed Lower Command	BI04
Contact 05	●	Start Permissive 1	BI05
Contact 06	●	—Not Used—	BI06
Contact 07	●	—Not Used—	BI07
Contact 08	●	—Not Used—	BI08

User Level: Configure
Mode: Operation

● = Energized

Back Relays A4 - DIO Contacts 9-16 Contacts 17-24

Figure 4-22. Contact Input Summary Screen

The Contact Input Summary screen will display the status of channels available on the 5009XT 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. The center of the menu bar will show the module I/O type and the kernel slot location, if the module is part of the standard 5009XT product.

Analog Output Summary Screen

Channel Page	Function	Tag	Validated Value	Total Demand	KA Rdbk	KB Rdbk	KC Rdbk
AO_01	LP Valve Demand	AO 01	0.0 EU	0.00 mA	0.00 mA	0.00 mA	0.00 mA
AO_02	Actual Shaft Speed	AO 02	9.2 EU	5.47 mA	1.82 mA	1.83 mA	1.81 mA
AO_03	HP2 Valve Demand	AO 03	0.0 EU	0.00 mA	0.00 mA	0.00 mA	0.00 mA
AO_04	LP2 Valve Demand	AO 04	0.0 EU	0.00 mA	0.00 mA	0.00 mA	0.00 mA

Control Status Shutdown

Back Speed Inputs A3 - Speed/AIO Analog Inputs

Figure 4-23. Analog Output Summary Screen

The Analog Output Summary screen will display the status of all channels available on the 5009XT 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

Relay	Status	Function	Tag
Relay 01	●	Trip Relay	Relay 01
Relay 02	●	Summary Alarm	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

User Level: Configure
Mode: Operation

Back Relays 7-12 A4 - DIO Contact Inputs

Figure 4-24. Relay Output Summary Screen

The Relay Output Summary screen will display the status of all channels available on the 5009XT 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. The center of the menu bar will show the module I/O type and the kernel slot location, if the module is part of the standard 5009XT product.

Chassis Screen

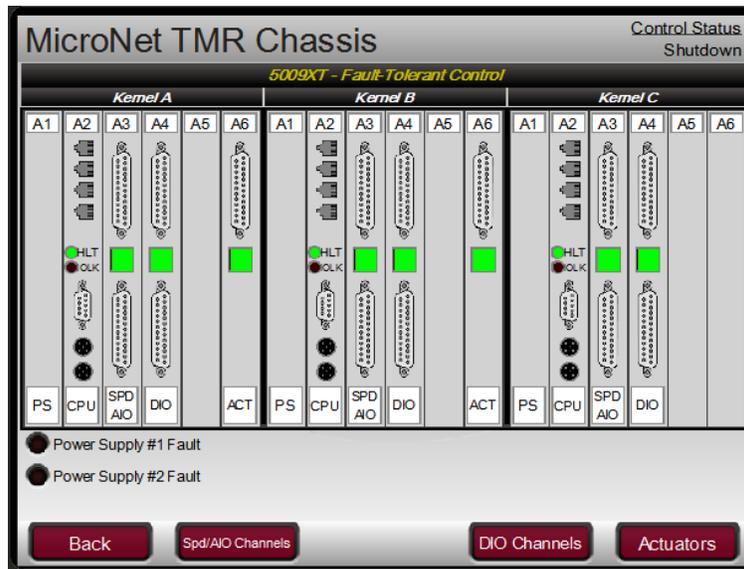


Figure 4-25. Chassis Layout/Status Screen

The Chassis screen will display the module layout in the TMR chassis, including any options that may be configured for use (such as this example screen shows the 2 Chan Actuator modules in slot 6 of the A and B kernels). The navigation buttons at the bottom allow the user to go directly to the summary screen for each module. The module LED's will be GREEN when healthy and turn RED if the module is faulted or removed. The LED's under the chassis will give the status of the power supplies and any communication links that are configured for use.

Actuators Screen



Figure 4-26. Actuator Outputs Screen

The Actuator screen will be visible if the control is configured to use this option. The function, position demand, total current and each kernel current output 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.

Starting Procedures (Start Curve Screen)

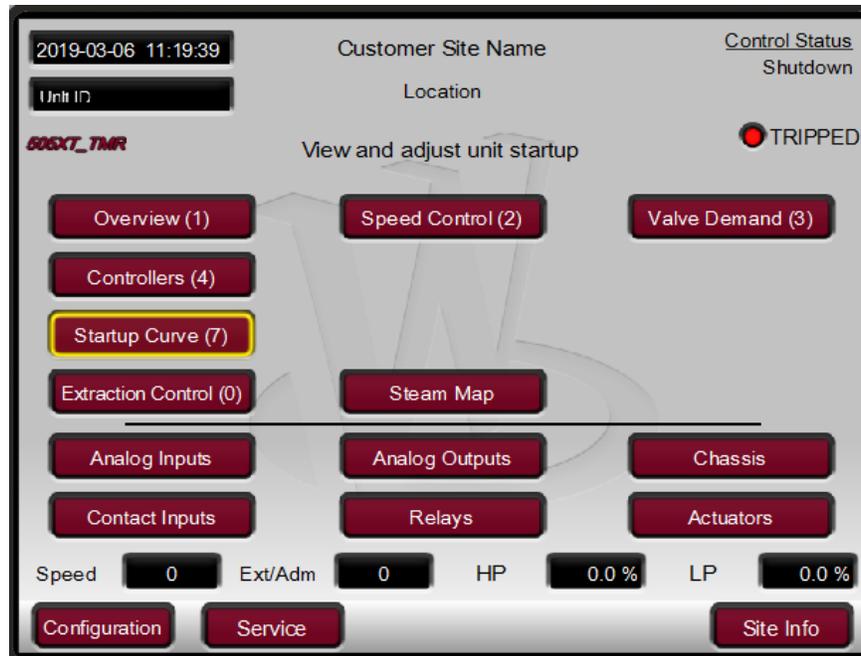


Figure 4-27. HOME Menu showing "Startup Curve" IN-Focus

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 5009XT's RESET CLEARS TRIP setting is programmed "YES", the 5009XT'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 5009XT'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 5009XT'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 5009XT's keypad, external switches or communication links.

Overspeed Test Function (Speed Control Screen)

The 5009XT'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 5009XT's internal overspeed trip logic and any external overspeed trip device's settings and logic. Figure 4-11 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)

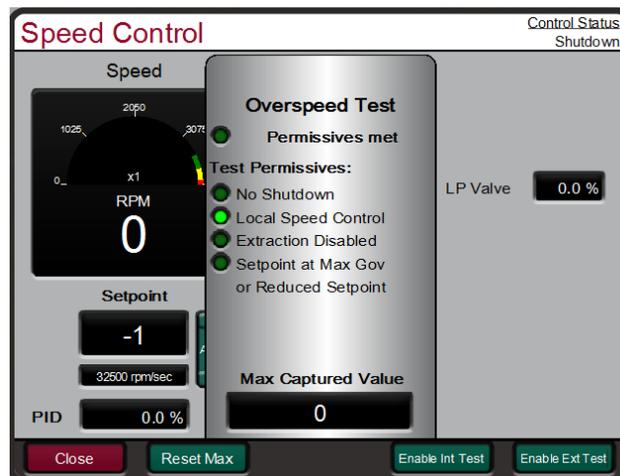


Figure 4-28. Overspeed Test Permissives

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

- 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 insure 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

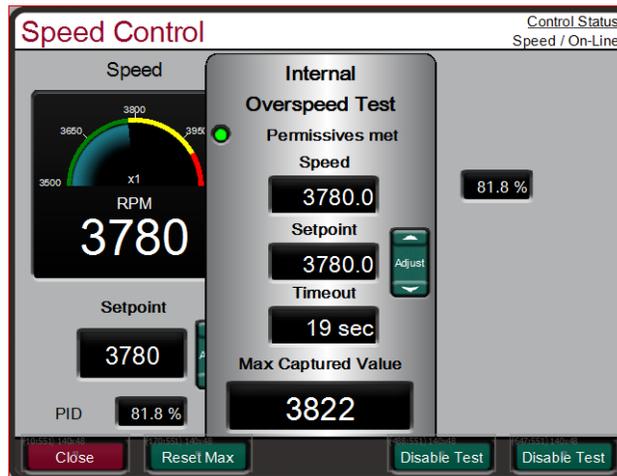


Figure 4-29. Internal (Control) Overspeed Test

- 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 5009XT's internal OVERSPEED TRIP (rpm) setting, the 5009XT will TRIP the turbine

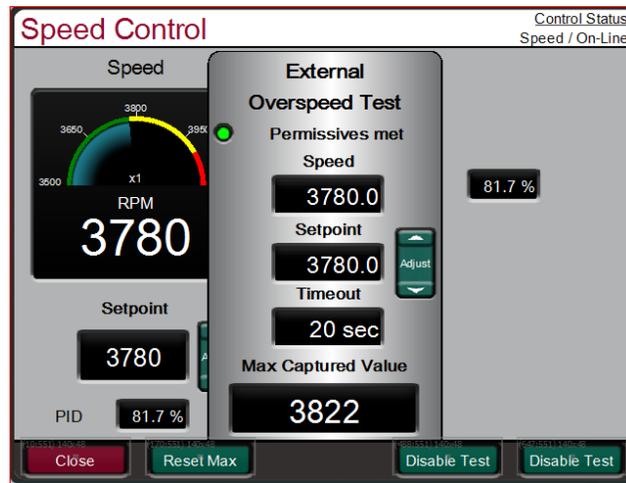


Figure 4-30. External Overspeed Test

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 5009XT internal overspeed trip will be changed to be just an alarm and the 5009XT will allow the speed to continue increasing up to the Overspeed Test Limit (rpm). If the 5009XT 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 5009XT's internal OVERSPEED TRIP (rpm) setting, the 5009XT 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 5009XT will Trip on Overspeed
- If the Speed or the Setpoint reach the Overspeed Test Limit the 5009XT 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.

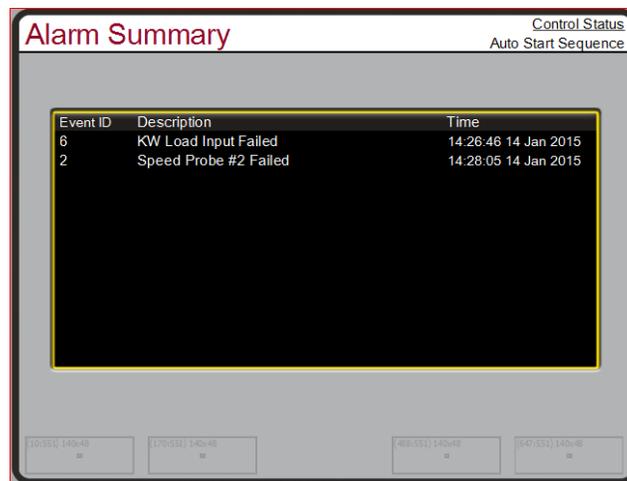
Stop Key

The STOP key opens a dialog box that give the user a choice to TRIP the unit or initiate a Normal Stop sequence routine. The TRIP command will act like an emergency trip on the unit, immediately closing the V1 (governor) valve. The Normal Stop 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 be 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 time-stamp will remain unchanged.



The screenshot shows the 'Alarm Summary' screen with a table of alarm events. The table has three columns: Event ID, Description, and Time. The events listed are:

Event ID	Description	Time
6	KW Load Input Failed	14:28:46 14 Jan 2015
2	Speed Probe #2 Failed	14:28:05 14 Jan 2015

At the bottom of the screen, there are four buttons labeled '00000 14648', '07000 14648', '40000 14648', and '04000 14648'.

Figure 4-31. 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 Common Alarm, in addition to the dedicated Alarm Relay output.

The complete table of all the potential alarm conditions and their Event ID is found in Appendix C.

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 time-stamp will remain unchanged.

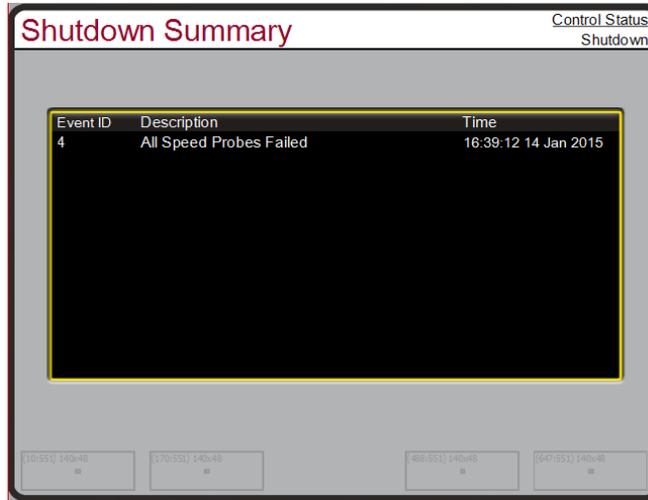


Figure 4-32. Shutdown Summary Screen

The complete table of all the potential shutdown conditions and their Event ID is found in Appendix C.

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 5009XT 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 PID Loop Controllers

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.

The following are the PID loops available for use that require initial dynamic tuning if they are used:

- Speed Control (Always used/required)**
- Cascade Control**
- Auxiliary Control**
- Extraction/Admission Control**
- Inlet Control**
- Exhaust Control**
- Isolated PID Control**

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.

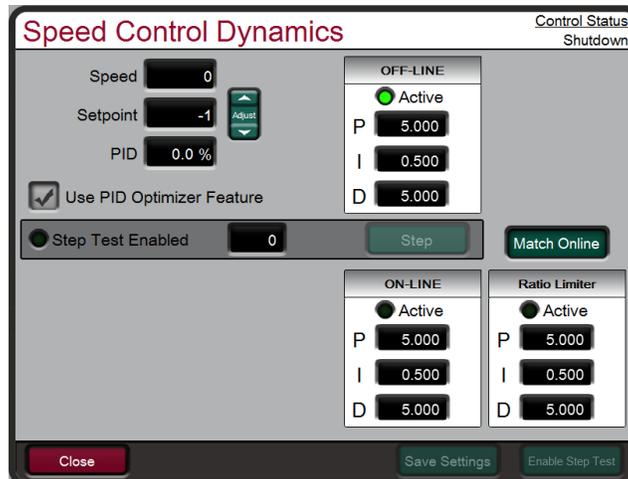


Figure 4-33. Speed Dynamics Adjustment Screen

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 5009XT 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 5009XT's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 5009XT'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 5009XT's output results in a large speed or load changes (high mechanical gain) it may not be possible to take the 5009XT'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% 5009XT 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 recommended 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 5009XT, 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 5009XT's PIDs to assist in determining the gain terms that provide optimum control loop response times (Ziegler Nichols, etc.).

Figure 4-33 shows the typical response to a load change when the dynamics are optimally adjusted.

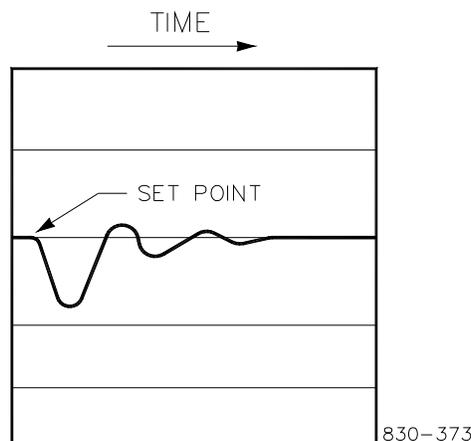


Figure 4-34. Typical Response to Load Change

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

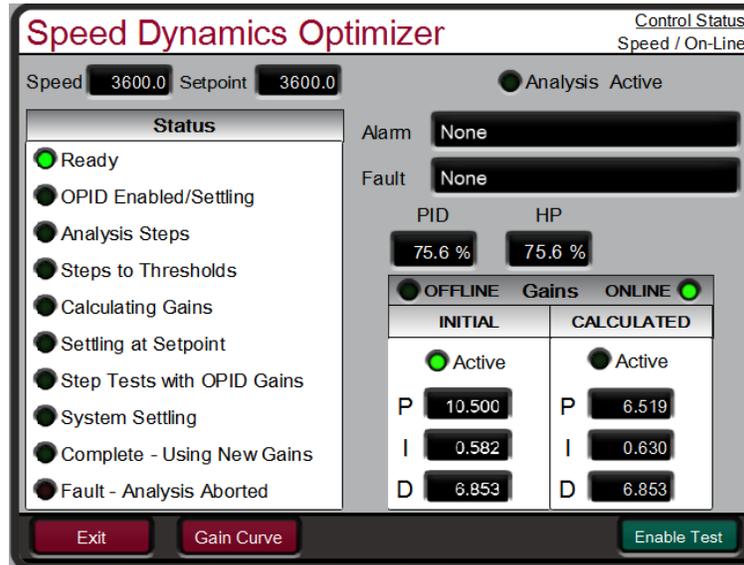


Figure 4-35. Overview of the Automated PID Optimizer Routine

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.

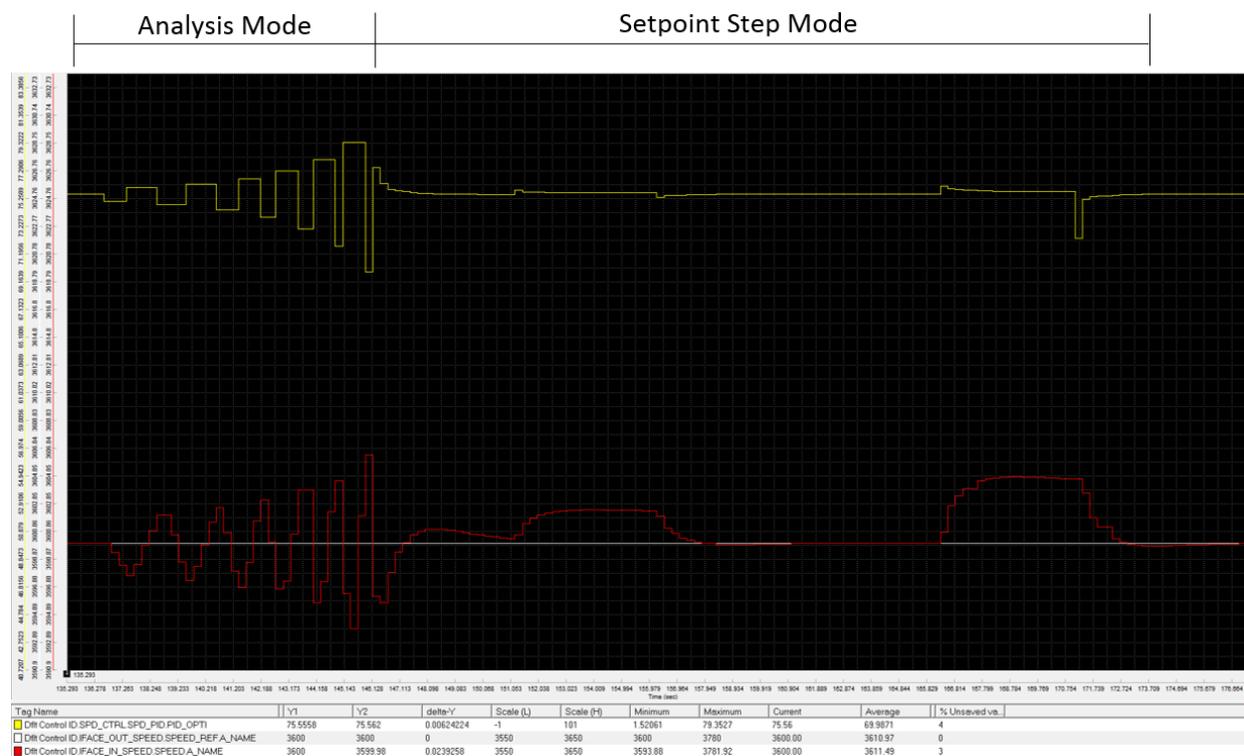


Figure 4-36. Optimization Routine Overview Trend

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.

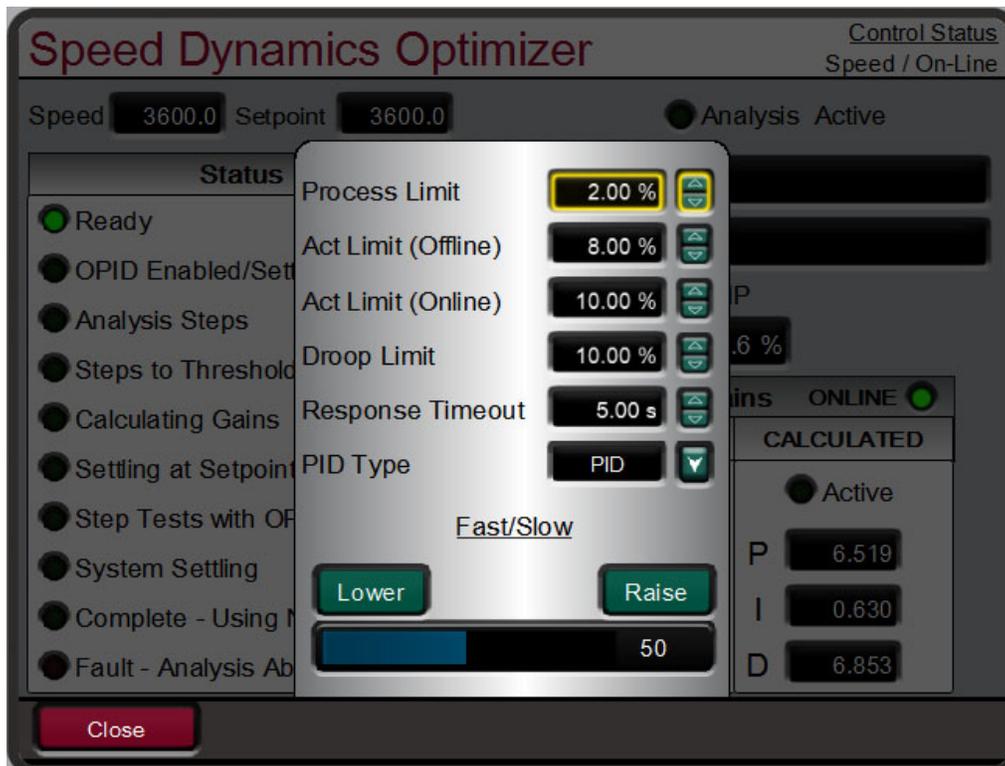


Figure 4-37. Configuration Parameters 'Configure' Pop-up

Process Limit (%) $dflit= 2.0 (0.0, 10.0)$

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 on 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 on 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 slew 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 exceeded 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

Chapter 5

Service Menu Screens

Once the 5009XT has been configured, the service menu screens will allow access to view or adjust other settings parameters in the control that may or may not need the turbine to be in operation. Caution should still be used as to not create an upset in turbine operation with some of these settings. The user must login as Service level or high to make these adjustments.

Once logged in with an appropriate user level, parameters within the Service menus will become available for adjustment. See Figure 5.1 for an example of how to see that a parameter is authorized, use the work sheet (provided at the end of this manual), to document any changes for future reference.



Figure 5-1. Authorized and Unauthorized Components

Each of the Service menu parameters are described in detail below.

Service Mode Parameters

Speed Control Settings

RATE TO MIN (RPM/S)

dflt= xxx (0.01, 2000)

Adjusts the rate the set point moves from zero to the minimum controlling speed when the unit is started. 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 startup features is used, the min speed will be the minimum governor speed set point. This value is set in the program mode.

SLOW RATE OFFLINE (RPM/S)

dflt= xxx (0.01, 500)

Normal speed set point rate of change while in the OFFLINE mode of operation. This value is set in the program mode.

SLOW RATE ONLINE (RPM/S)

dflt= xxx (0.01, 500)

Normal speed set point rate of change while in the ONLINE mode of operation. This value is set in the program mode.

FAST RATE DELAY (SEC)

dflt= 3.0 (0, 100)

Delay, in seconds, before the Setpt 'Fast Rate' ONLINE/OFFLINE is selected.

FAST RATE OFFLINE (RPM/S)

flt= xxx (0.0099, 500.0)

This rate is defaulted to three times (3x) the 'Slow Rate OFFLINE'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

FAST RATE ONLINE (RPM/S)

dflt= xxx (0.0099, 500.0)

This rate is defaulted to three times (3x) the 'Slow Rate ONLINE'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

ENTERED RATE OFFLINE (RPM/S)

dflt= xxx (0.0099, 500.0)

This is the rate that the Speed set point will move when set point is entered from the front panel of the control or from the communication links while in the OFFLINE mode of operation. This rate is defaulted to the Slow RATE OFFLINE. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

ENTERED RATE ONLINE (RPM/S)**dflt= xxx (0.0099, 500.0)**

This is the rate that the Speed set point will move when set point is entered from the front panel of the control or from the communication links while in the ONLINE mode of operation. This rate is defaulted to the S RATE ONLINE. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

UNDERSPEED SETTING (RPM)**dflt= xxx (0.0, 20000)**

Only used if an underspeed relay is programmed. Speed setting for the underspeed indication. This rate is defaulted to 100 rpm below the 'Minimum Governor Speed Setpt'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

ONLINE SPEED DEADBAND**dflt= 0.0 (0.0, 20.0)**

When configured as a mechanical drive unit (not a Generator Application), this is the value of a speed deadband that can be configured in RPM. For a generator application, see 'Frequency Deadband' in the "Breaker Logic" Service menu.

INSTANT MINIMUM LOAD RATE**dflt= 50.0 (2.0, 10000.0)**

When Emergency Minimum Load is triggered this is the rate, in RPM/s, that will be used to go to minimum load.

ONLINE SPEED DYNAMICS SPEED LEVEL**dflt= Min Gov (Low Idle, Max Gov)**

For Mechanical Drive only. When Speed increases above this value, the control switches to Online Dynamics. The value default is Minimum Governor.

DISPLAY GAUGE MULTIPLIER**dflt= 1.0 (0.01, 1000.0)**

This allows scaling of the number for display on the gauge on the 5009XT runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, use this setting to multiply by a factor of 10.

HOLD SPEED CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Set Point Fast Rate, the Entered Rate, and Underspeed settings. To permanently save these changes into the 5009XT, set to YES. On the main service page select save settings soft key in the bottom of the menu, or select the "Mode" button, then save settings soft key in the bottom of the menu.

OVERSPEED RATE (RPM/S)**dflt= xxx (0.0099, 500.0)**

This rate is defaulted to the 'Slow Rate OFFLINE'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

USE REDUCED OVERSPEED SETPOINT**dflt= NO (Yes/No)**

Set to YES to reduce the Overspeed Trip value within the operating range of the turbine. This can be used to test the Overspeed Trip functionality and systems without increasing speed above Maximum Governor.

REDUCED OVERSPEED SETPOINT (RPM)**dflt= 1000 (100.0, 20000.0)**

This value will be used as the Overspeed Trip value when 'USE REDUCED OVERSPEED SETPOINT' is YES. If the speed meets or exceeds this value, an Overspeed Trip will be initiated.

Remote Speed Settings (only displayed if configured)

Note: Available as the last page of the "Speed Control" Service menu.

NOT MATCHED RATE**dflt= xxx (0.0099, 200.0)**

Rate the set point moves when remote is enabled and the remote input doesn't match the actual set point. This rate is defaulted to the set point slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

SPEED SETPOINT MAXIMUM RATE**dflt= xxx (0.01, 500)**

Rate the setpoint moves once the remote input and actual set point are matched. This is a maximum rate. Normally the setpoint will follow the remote input setting. This value is set in the configure mode.

MINIMUM SPEED SETPOINT**dflt= xxx (0.0, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Speed Setpoint Minimum Governor Speed value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)

MAXIMUM SPEED SETPOINT dflt= xxx (0.0, 20000)

Maximum setting allowed by the remote input. This setting is defaulted to the Speed Setpoint Maximum Governor Speed value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings and greater than Minimum Speed Setting)

REMOTE DEADBAND VALUE**dflt= 0.0 (0.0, 100)**

Remote speed setting deadband in RPM.

REMOTE LAG-TAU VALUE**dflt= 0.0 (0.0, 10)**

Remote Set Point input lag setting.

USE MINIMUM LOAD?**dflt= YES (Yes/No)**

When set to YES, the speed set point cannot be lowered/decreased by the remote speed set point input below the rated/synchronous speed set point plus the 'Min Load Bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When NO, the remote speed set point can move the speed set point down to the higher of the minimum governor setting or the RSS 4 mA value.

HOLD REMOTE CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Speed Settings. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

GENERATOR BREAKER OPEN DISABLE?**dflt=No(Yes/No)**

Set to TRUE to have unit automatically disable remote speed setpoint when generator breaker opens.

UTILITY BREAKER OPEN DISABLE?**dflt=No(Yes/No)**

Set to TRUE to have unit automatically disable remote speed setpoint when utility tie breaker opens.

Valve Limiter Settings**HP LIMITER RATE (%/SEC)****dflt= xxx (0.1, 25)**

The rate at which the HP valve limiter will move when a raise or lower command is given from the contact inputs or the Modbus connections. This rate is set in the program mode.

HP ENTERED RATE (%/SEC)**dflt= xxx (0.1, 100)**

This is the rate the HP valve limiter will move at when a new position is entered from the front panel of the control. This rate is defaulted to the slow rate. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

HP LIMITER MAXIMUM LIMIT (%)**dflt= 100.0 (0, 101)**

HP Valve Limiter Maximum setting. Normally set to 100%, but this can be set lower to provide a maximum valve lift setting.

HP MAXIMUM VALUE AT STARTUP (%)**dflt= 100.0 (0, 101)**

During start up this would restrict the opening of the HP valve to the desired value.

SHUTDOWN AT MAXIMUM?**dflt= NO (Yes/No)**

When set to YES, the control will issue a shutdown whenever the HP ramp exceeds the HP maximum value at startup. When set to NO, this function is disabled.

HOLD HP LIMITER CHANGES?**dflt= NO (Yes/No)**

Set to YES to hold the changes made to the Entered Rate. To permanently save these changes into the 505, set to YES and select the 'Save Settings' key.

LP LIMITER RATE (%/SEC)**dflt= xxx (0.1, 25)**

The rate at which the LP valve limiter will move when a raise or lower command is given from the contact inputs or the Modbus connections. This rate is set in the program mode.

LP ENTERED RATE (%/SEC)**dflt= xxx (0.1, 100)**

This is the rate the LP valve limiter will move at when a new position is entered from the front panel of the control. This rate is defaulted to the slow rate. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

LP MAXIMUM LIMIT (%)**dflt= 100.0 (0, 100)**

LP Valve Maximum setting. Normally set to 100%, but this can be set lower to provide a maximum valve lift setting.

LP MINIMUM VALUE (%)	dflt= 0.0 (0, 100)
LP Valve Minimum Setting. Normally set to 0.0%, but this can be set higher to provide a minimum valve lift setting.	
SHUTDOWN AT MAXIMUM?	dflt= NO (Yes/No)
When set to YES, the control will issue a shutdown whenever the HP ramp exceeds the HP maximum value at startup. When set to NO, this function is disabled.	
HOLD LP LIMITER CHANGES?	dflt= NO (Yes/No)
Set to YES to hold the changes made to the Entered Rate. To permanently save these changes into the 505, set to YES and select the 'Save Settings' key.	

MPU Signals

USE MPU OVERRIDE TIMER?	dflt= NO (Yes/No)
When set to YES, the MPU override will go OFF when the MPU Override Time expires after a start is initiated. This provides a maximum time for speed to be sensed on startup before a loss of speed is detected.	
MPU OVERRIDE TIME (SEC)	dflt= 600.0 (0.0, 600)
Sets the maximum time after a start is initiated for speed to be sensed above the failure level. Only valid if 'Use MPU Override Timer?' is YES.	
MPU #1 OVERRIDE ON STATUS	(status indication only)
Indicates when the speed probe failure override is on.	
MPU #2 OVERRIDE ON STATUS	(status indication only)
Indicates when the speed probe failure override is on. This status message only appears if the application is using two speed probes.	

Idle/Rated Ramp (only displayed if configured)

HOURS SINCE TRIP (HRS)	(status indication only)
Indicates the number of hours the unit was tripped, as determined by the control.	
HOT RESET TIMER	dflt= 0 (0.0, 200)
Use this to adjust the "Hot Reset Timer" value set in Configuration. This is the time needed, when RST Timer level is reached, to transfer the start-up parameters from COLD to HOT.	
IDLE/RATED COLD RATE (RPM/S)	dflt= xxx (0.01, 2000)
Rate at which the speed set point will ramp from idle to rated speed when the turbine is considered COLD. This value is set in the program mode.	
IDLE/RATED WARM RATE (RPM/S)	dflt= xxx (0.01, 2000)
Rate at which the speed set point will ramp from idle to rated speed when the turbine is considered WARM. This value is set in the program mode.	
IDLE/RATED HOT RATE (RPM/S)	dflt= xxx (0.01, 2000)
Rate at which the speed set point will ramp from idle to rated speed when the turbine is considered HOT. This value is set in the program mode.	
USE RAMP TO IDLE?	dflt= YES (Yes/No)
Set to YES if want to return to idle speed with this function. If set to NO, the Idle/ Rated function acts as a 'Ramp to Rated' function and will not return to idle. When set to NO, closing the Idle/Rated contact accelerates the speed set point towards Rated and opening the contact stops the acceleration.	
IDLE PRIORITY?	dflt= NO (Yes/No)
If YES, the set point will move to idle whenever Idle is selected. If NO, the set point will move to Idle only if Remote Speed Set Point is not enabled, Cascade control is not enabled, Auxiliary 'controller' is not enabled, and the Generator Breaker is open.	
RATED PRIORITY?	dflt= YES (Yes/No)
If YES, the Rated command will be allows to move the setpoint to Rated before reaching Idle. If NO, the set point will move to Idle and then the Rated command should be given to move to Rated; the Rated command will not be accepted before reaching Idle.	
TEMPERATURE 1 INPUT	dflt= xxx (-20000, 20000)
Indication only. This is the current value of the Temperature 1 Analog Input	
OVERRIDE TEMPERATURE 1?	dflt= NO (Yes/No)
If YES, an Analog Input failure will be overridden and start permissives related to this temperature will be met, allowing for the startup of the turbine.	
TEMPERATURE 2 INPUT	dflt= xxx (-20000, 20000)
Indication only. This is the current value of the Temperature 1 Analog Input	

OVERRIDE TEMPERATURE 2?

dfit= NO (Yes/No)

If YES, an Analog Input failure will be overridden and start permissives related to this temperature will be met, allowing for the startup of the turbine.

Auto Start Sequence (only displayed if configured)

The following information is provided to display the information useful to the auto start sequence. It allows the operator to check all the times and rates that the 5009XT is using for the present start sequence.

HOURS SINCE TRIP (HRS)

(status indication only)

Indicates the number of hours the unit was tripped, as determined by the control.

HOT RESET TIMER

dfit= 0 (0.0, 200)

Use this to adjust the "Hot Reset Timer" value set in Configuration. This is the time needed, when RST Timer level is reached, to transfer the start-up parameters from COLD to HOT.

HOT RESET TIME REMAINING

(status indication only)

This shows the remaining time for the Hot Reset Timer. When the time is complete, all turbine start parameters will be using the HOT start values.

HOT TIME REMAINING

(status indication only)

This shows the time remaining, after the unit is shut down, until the HOT start values begin ramping to the COLD start values.

TIME UNTIL COLD START

(status indication only)

This shows the time remaining, after the unit is shut down, until the turbine will be considered cold and the COLD start values will be used.

RATE TO RATED (RPM/S)

(status indication only)

Indicates the acceleration rate, in rpm/s; used by the control from High Idle to Rated.

IDLE 1 DELAY (MIN)

(status indication only)

Indicates the hold time at Idle 1, in minutes.

RATE TO IDLE2 (RPM/S)

(status indication only)

Indicates the acceleration rate, in rpm/s; used by the control from Idle to Idle2.

IDLE2 DELAY (MIN)

(status indication only)

Indicates the hold time at Idle 2, in minutes.

RATE TO IDLE3 (RPM/S)

(status indication only)

Indicates the acceleration rate, in rpm/s; used by the control from Idle2 to Idle3.

IDLE3 DELAY (MIN)

(status indication only)

Indicates the hold time at Idle 3, in minutes.

TEMPERATURE 1 INPUT

dfit= xxx (-20000, 20000)

Indication only. This is the current value of the Temperature 1 Analog Input

OVERRIDE TEMPERATURE 1?

dfit= NO (Yes/No)

If YES, an Analog Input failure will be overridden and start permissives related to this temperature will be met, allowing for the startup of the turbine.

TEMPERATURE 2 INPUT

dfit= xxx (-20000, 20000)

Indication only. This is the current value of the Temperature 1 Analog Input

OVERRIDE TEMPERATURE 2?

dfit= NO (Yes/No)

If YES, an Analog Input failure will be overridden and start permissives related to this temperature will be met, allowing for the startup of the turbine.

Pressure Compensation (only displayed if configured)

The pressure compensation settings are used to bias the actuator 1 (V1) position based on inlet pressure.

Pressure 1

dfit= *0.0 (0.0, 10000.0)

Input point #1 of the pressure compensation curve, in engineering units.

(Must be less than the 'Pressure 2' value)

Gain 1

dfit= *1.0 (0.65, 1.54)

Output point #1 of the pressure compensation curve.

Pressure 2

dfit= *25.0 (0.0, 10000.0)

Input point #2 of the pressure compensation curve, in engineering units.

(Must be between the 'Pressure 1' value and the 'Pressure 3' value settings)

Gain 2

dfit= *1.0 (0.65, 1.54)

Output point #2 of the pressure compensation curve.

Pressure 3

dfit= *50.0 (0.0, 10000.0)

Input point #3 of the pressure compensation curve, in engineering units.

(Must be between the 'Pressure 2' value and the 'Pressure 4' value settings)

Gain 3	dflt= *1.0 (0.65, 1.54)
Output point #3 of the pressure compensation curve.	
Pressure 4	dflt= *75.0 (0.0, 10000.0)
Input point #4 of the pressure compensation curve, in engineering units. (Must be between the 'Pressure 3' value and the 'Pressure 5' value settings)	
Gain 4	dflt= *1.0 (0.65, 1.54)
Output point #4 of the pressure compensation curve.	
Pressure 5	dflt= *100.0 (0.0, 10000.0)
Input point #5 of the pressure compensation curve, in engineering units. (Must be greater than the 'Pressure 4' value)	
Gain 5	dflt= *1.0 (0.65, 1.54)
Output point #5 of the pressure compensation curve.	

Breaker Logic (only displayed if a generator)

FREQUENCY CONTROL ARMED

(status indication only)

Displays when Frequency Control is activated for isochronous control. If not, then the control will be in droop. See Frequency Control description in volume 1 of the manual for details.

SYNC WINDOW (RPM)

dflt= 10.0 (0.0, 200)

A set point window, in rpm, that the set point moves at a slower rate to accommodate synchronizing to the bus. This rate is only active while within this window and the generator breaker is open.

SYNC WINDOW RATE (RPM/S)

dflt= 2.0 (0.1, 100)

The rate the speed set point moves at when within the 'Sync Window' and the generator breaker is open. This is normally slower than the slow rate to accommodate synchronizing to the bus.

TIEBRKR OPEN RAMP?

dflt= YES (Yes/No)

If NO, the speed set point is instantly set to the last utility bus speed setting and holds. When set to YES, the speed set point is instantly set to the last utility bus speed setting and moves to the synchronous (rated) speed set point after the utility tie breaker opens and the generator breaker is still closed.

TIE OPEN RATE (RPM/S)

dflt= 1.0 (0.099, 20000.0)

Rate the set point moves to rated speed after the utility tie breaker opens (only used if 'Tiebrkr Open Sync Ramp' is YES).

GEN OPEN SETPOINT (RPM)

dflt= xxx (0.0, 20000)

This set point is defaulted to 50 rpm below the synchronous (rated) speed set point. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Governor' and 'Rated Speed Setpt' settings)

ZERO LOAD VALUE (HP Valve %)

dflt= xxx (0.0, 100)

This value is automatically sampled and held at the actuator/load demand value when the generator breaker is closed. When the steam conditions are not at rated conditions when the breaker is closed, this value can be adjusted to a more reasonable value (2–10%). Every time the generator breaker closes, this value is re-sampled.

USE MINIMUM LOAD?

dflt= YES (Yes/No)

When set to YES, the speed set point automatically increases to the rated/synchronous speed set point plus the 'Min Load Bias' setting when the generator breaker is closed and the unit is on-line (the utility tie breaker is closed). When NO, no automatic set point action occurs.

REVERSE POWER PROTECTION?

dflt= YES (Yes/No)

When set to YES, the Minimum Load Bias will be used for the lower limit of the Speed Setpoint range. This will prevent the unit from reducing load below the Minimum Load Bias. When set to NO, the lower limit of the Speed Setpoint is Minimum Governor, allowing the setpoint to move below Rated, causing the generator to reverse power. This protection also applies to the Controlled Shutdown sequence; when a Controlled Shutdown is initiated and this setting is YES, the controller will reduce load down to min load and wait for the generator breaker to open.

MINIMUM LOAD BIAS (RPM above Rated)

dflt= xxx (0.0, 500)

This value is the rpm bias above rated speed and the default is calculated as 3% of full load. This is the value the speed set point will increase to upon the generator breaker closure (when the utility tie is closed).

FREQ OFFSET (Hz)**dfit= 0.0 (-2.5, 2.5)**

This is the deviation, in Hz, from the configured rated speed of 50/60 Hz. It allows the center of the deadband to be adjusted for grid frequencies that are not exactly at 50 or 60 Hz. For example, if rated speed is 3600 rpm = 60 Hz, but the grid is actually running at 60.1 Hz, then this value can be tuned to 0.1 Hz so that the deadband in the 5009XT will be at 3606 rpm, the actual "speed" of the grid.

FREQ Deadband (Hz)**dfit= 0.0 (0.0, 3.0)**

This is the dead band in Hz used during the droop mode of operation to avoid HP valve oscillations. It will allow frequency to vary a certain amount, plus or minus the configured value, from the configured rated speed before the control reacts by moving the valve.

TIE OPEN LOAD REJECTION?**dfit= YES (YES/NO)**

Setting to YES will allow load rejection recovery logic to activate on a Tie Breaker open event.

HOLD BREAKER CHANGES?**dfit= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Gen Breaker Open Set Point and Min Load Bias. To permanently save these changes into the 505, set to YES and select the 'Save Settings' key.

FREQUENCY EXCURSION TEST VISIBLE?**dfit= NO (Yes/No)**

If YES, the pop-up menu for the Frequency Excursion Test will be available from the Speed Control run-time page. Allows for Standard NERC and ERCOT tests of logging the control response to utility grid frequency deviations.

Sync/Load Share Settings (only displayed if configured)**INPUT BIAS GAIN (%)****dfit= xxx (0.0, 100)**

Affects the rpm bias the Sync/Load Sharing input has on the speed setting. This setting is defaulted to the Droop (%) value or 3%, whichever is higher. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

Note that the Input Bias Gain affects both the Synchronizing and Load Sharing functions if configured. A feature has been added to make the Synchronizing input 5 times less sensitive than the load sharing input. Therefore, to avoid instability in load sharing mode, the Input Bias Gain should be tuned for the load sharing mode. If load sharing is not used, this note can be disregarded.

INPUT BIAS DEADBAND**dfit= 0.0 (0.0, 100)**

Load Share dead band in rpm.

LAG-TAU VALUE**dfit= 0.0 (0.0, 10)**

Load Sharing input lag setting.

HOLD CHANGES?**dfit= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Load Share Gain (%). To permanently save these changes into the 505, set to YES and select the 'Save Settings' key.

Speed Droop (only if generator unit)**ACTUAL DROOP (%)****(status indication only)**

Shows the actual Speed/load control droop being used by the controller.

MINIMUM DROOP (%)?**dfit= 0.0 (0.0, 4.0)**

When setting the droop from the keypad this defines the minimum droop value that can be set.

MAXIMUM DROOP (%)?**dfit= 12.0 (2.0, 15.0)**

When setting the droop from the keypad this defines the maximum droop value that can be set.

USE MW AS LOAD UNITS?**dfit= 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?**dfit= YES (Yes/No)**

When set to NO, the unit is forced to use speed demand/actuator position droop. This setting is used and relevant if Load Droop was programmed.

ENTERED DROOP SETPOINT (%)**dfit= 5.0 (min, max)**

When setting the droop from the keypad this sets the desired droop value for control.

Auxiliary Control Settings (only displayed if configured)**SLOW RATE (UNITS/S)****dfit= xxx (0.01, 1000)**

Normal set point rate of change. This value is set in the program mode.

FAST RATE DELAY (SEC)**dflt= 3.0 (0.0, 100)**

Delay, in seconds, before the 'Fast Rate' of change is selected.

FAST RATE (UNITS/S)**dflt= xxx (0.01, 5000)**

This rate is defaulted to three times (3x) the 'Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

SETPT ENTERED RATE (UNITS/S)**dflt= xxx (0.01, 1000)**

This is the rate that the Aux set point will move when set point is entered from the front panel of the control or from the communication links. This rate is defaulted to the Aux set point slow rate. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

DROOP (%)**dflt= xxx (0.0, 100)**

Aux control droop setting. This value is set in the program mode.

RATED AUXILIARY SETPOINT**dflt= xxx (-20000, 20000)**

Only used to determine the auxiliary control Droop. This set point is defaulted to the aux maximum set point limit. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Auxiliary Set Point' and the 'Maximum Auxiliary Set Point' settings)

PID THRESHOLD (LIMITER)**dflt= 10 (0.0, 110)**

Aux PID threshold setting when aux is used as a limiter. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID THRESHOLD (CONTROLLER)**dflt= 100 (0.0, 110)**

Aux PID threshold setting when aux is used as a controller. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID MINIMUM OUTPUT**dflt= 0.00 (0.0, 50)**

Auxiliary PID min output setting. The auxiliary PID cannot output a lower value to the LSS. This can be used to stop the aux PID from taking the LSS low enough to take the unit off-line or below min governor.

DISPLAY GAUGE MULTIPLIER**dflt= 1.0 (0.01, 1000.0)**

This allows scaling of the number for display on the gauge on the 505 runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, use this setting to multiply by a factor of 10.

HOLD AUXILIARY CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Set Point Fast Rate, Entered Rate, and Rated Aux Set Point. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

Remote Auxiliary Settings (only displayed if configured)

Note: Available as the last page of the "Auxiliary Control" Service menu.

REMOTE NOT MATCHED RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves when remote is enabled and the remote input doesn't match the actual set point. This rate is defaulted to the 'Aux Set Point Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

REMOTE AUXILIARY MAXIMUM RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves once the remote input and actual set point are matched. This is a maximum rate. Normally the set point will follow the remote input setting. This value is set in the program mode.

MINIMUM REMOTE AUXILIARY SETPOINT**dflt= xxx (-20000, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Aux Set Point Minimum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Auxiliary Set Point' and the 'Maximum Auxiliary Set Point' settings)

MAXIMUM REMOTE AUXILIARY SETPOINT**dflt= xxx (-20000, 20000)**

Maximum setting allowed by the remote input. This setting is defaulted to the Aux Set Point Maximum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Auxiliary Set Point' and the 'Maximum Auxiliary Set Point' settings)

REMOTE DEADBAND VALUE**dflt= 0.0 (0.0, 500)**

Remote aux setting input dead band in engineering units.

REMOTE LAG-TAU VALUE**dflt= 0.0 (0.0, 10)**

Remote Set Point input lag setting.

HOLD REMOTE AUXILIARY CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Aux Settings. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

Extraction/Admission Control Settings (only displayed if configured)**SLOW RATE (UNITS/S)****dflt= xxx (0.01, 1000)**

Normal set point rate of change. This value is set in the program mode.

FAST RATE DELAY (SEC)**dflt= 3.0 (0.0, 100)**

Delay, in seconds, before the 'Fast Rate' of change is selected.

FAST RATE (UNITS/S)**dflt= xxx (0.01, 5000)**

This rate is defaulted to three times (3x) the 'Set Point Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

SETPT ENTERED RATE (UNITS/S)**dflt= xxx (0.01, 1000)**

This is the rate that the Ext/Adm set point will move when set point is entered from the front panel of the control or from the communication links. This rate is defaulted to the Ext/Adm set point slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

USE DROOP?**dflt= NO (0.0, 100)**

If YES, the Droop setting will be used.

DROOP (%)**dflt= xxx (0.0, 100)**

Ext/Adm control droop setting. This value is set in the program mode.

ACTION ON PV FAILURE**dflt= Manual P Demand**

On an Ext/Adm input failure, the control can take one of the following actions

Manual P Demand: Manual Demand will hold the last PID value

LP Limiter to Max: LP Limiter ramps to the Max LP Value

LP Limiter to Min: LP Limiter ramps to the Min LP Value

RATED SETPOINT**dflt= xxx (-20000, 20000)**

Only used to determine the Ext/Adm control Droop. This set point is defaulted to the Ext/Adm maximum set point limit. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

PID THRESHOLD**dflt= 100 (0.0, 110)**

Ext/Adm PID threshold setting when Ext/Adm is used as a controller. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID MINIMUM OUTPUT**dflt= 0.00 (0.0, 50)**

Ext/Adm PID min output setting. The Ext/Adm PID cannot output a lower value to the LSS. This can be used to stop the Ext/Adm PID from taking the LSS low enough to take the unit off-line or below min governor.

STARTUP DEMAND SETTING (E/A or ADM)**dflt= 50.00 (0.0, 100)**

This value sets the initial Ext/Adm Demand for turbine startup. Used mainly for admission or extraction/admission control to balance the pressure across the admission stop valve prior to opening the valve. Using this setting, the default can be programmed to be close to the correct value to minimize adjustments required while starting up. The default value is the 5009XT's calculated zero extraction flow based on performance map entries. This value can also be accessed from the Startup and Ext/Adm run-time screens under the 'Adm Startup' pop-up.

SPEED ENABLE SETTING**dflt= 1000.00 (0.0, 20000)**

Value of speed as a permissive for enabling Extraction/Admission control. The speed must be greater than this setting before control will be active. This value must be greater than Minimum Governor Speed.

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.

DEADBAND**dflt= 0 (0.0, 50)**

Ext/Adm PID deadband setting in Engineering Units.

DISPLAY GAUGE MULTIPLIER**dflt= 1.0 (0.01, 1000.0)**

This allows scaling of the number for display on the gauge on the 5009XT runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, us this setting to multiply by a factor of 10.

MANUAL P DEMAND RATE (%/sec)**dflt= 0.5 (0.0099, 5.0)**

This value controls the rate, in percent per second, which the Manual P Demand ramp moves.

HOLD EXTRACTION/ADMISSION CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Set Point Fast Rate, Entered Rate, and Rated Aux Set Point. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

GO TO FULL DECOUPLED MODE?**dflt= NO (Yes/No)**

If YES and the 'Permissives to Enable/Disable' are met, the control will run in fully decoupled mode. 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.

PERMISSIVES TO ENABLE OR DISABLE FULL DECOUPLED**CONFIGURED TO ALLOW FULL DECOUPLING****(status indication only)**

If LED is ON, 'Allow the use of Full Decoupled Mode' has been selected from the Extraction/Admission Configuration Menu.

IN SPEED CONTROL ONLY MODE**(status indication only)**

If LED is ON, the control is in Speed Only mode, with the S PID in control of the HP valve, allowing for the Full Decoupled mode to be enabled.

EXT/ADM CONTROL DISABLED**(status indication only)**

If LED is ON, EXT/ADM control is currently disabled, allowing for Full Decoupled Mode to be enabled.

Remote Extraction/Admission Settings (only displayed if configured)

Note: Available as the last page of the "Ext/Adm Control" Service menu.

REMOTE NOT MATCHED RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves when remote is enabled and the remote input doesn't match the actual set point. This rate is defaulted to the 'Ext/Adm Set Point Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

REMOTE MAXIMUM RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves once the remote input and actual set point are matched. This is a maximum rate. Normally the set point will follow the remote input setting. This value is set in the program mode.

MINIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Ext/Adm Set Point Minimum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

MAXIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Maximum setting allowed by the remote input. This setting is defaulted to the Ext/Adm Set Point Maximum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

REMOTE DEADBAND VALUE	dfit= 0.0 (0.0, 500)
Remote Ext/Adm setting input dead band in engineering units.	
REMOTE LAG-TAU VALUE	dfit= 0.0 (0.0, 10)
Remote Set Point input lag setting.	
HOLD REMOTE EXT/ADM CHANGES?	dfit= NO (Yes/No)
Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Ext/Adm Settings. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.	
Cascade Control Settings (only displayed if configured)	
SLOW RATE (UNITS/S)	dfit= xxx (0.01, 1000)
Normal set point rate of change. This value is set in the program mode.	
FAST RATE DELAY (SEC)	dfit= 3.0 (0.0, 100)
Delay, in seconds, before the 'Setpt Fast Rate' is selected.	
SETPOINT FAST RATE (UNITS/S)	dfit= xxx (0.01, 5000)
This rate is defaulted to three times (3x) the set point 'Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
SETPOINT ENTERED RATE (UNITS/S)	dfit= xxx (0.01, 1000)
This is the rate that the Cascade set point will move when set point is entered from the front panel of the control or from the communication links. This rate is defaulted to the Cascade set point slow rate. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
DROOP (%)	dfit= xxx (0.0, 100)
Cascade control droop setting. This value is set in the program mode.	
RATED CASCADE SETPOINT	dfit= xxx (-20000, 20000)
This setting is only used to determine the cascade control droop. This set point is defaulted to the cascade maximum set point limit. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
<i>(Must be between the 'Minimum Cascade Set Point' and the 'Maximum Cascade Set Point' settings)</i>	
CASCADE NOT MATCHED RATE	dfit= xxx (0.01, 1000)
This rate is defaulted to the 'Speed Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
MAXIMUM SPEED SETPOINT RATE	dfit= xxx (0.1, 100)
The maximum rate at which the cascade control can vary the speed set point. This value is set in the program mode.	
MAXIMUM SPEED SETPOINT	dfit= xxx (0.0, 20000)
This setting is defaulted to the maximum speed set point value set in the program mode. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
<i>(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)</i>	
MINIMUM SPEED SETPOINT	dfit= xxx (0.0, 20000)
This setting is defaulted to the minimum speed set point value set in the program mode. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.	
<i>(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)</i>	
CASCADE DEADBAND	dfit= 0.1 (0.0, 50)
Cascade PID controller integrator deadband setting in percent.	
RAISE /LOWER CASCADE SETPOINT ONLY?	dfit= NO (Yes/No)
When set to NO, the cascade raise/lower commands will adjust the speed set point when cascade control is disabled and adjust the cascade set point when cascade control is enabled. When YES, the cascade raise/lower commands adjust the cascade set point only.	
USE MINIMUM LOAD?	dfit= YES (Yes/No)
When set to YES, the speed set point cannot be lowered/decreased by the cascade control PID below the rated/synchronous speed set point plus the 'min load bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When NO, the cascade control PID can move the speed set point down to the cascade minimum speed setting value.	

BREAKER ENABLES CONTROL**dfit= YES (Yes/No)**

Set to TRUE to have unit automatically disable cascade when either the utility or generator breaker opens. If FALSE, then the cascade input will need to be cycled to resume control after the breaker is closed.

DISPLAY GAUGE MULTIPLIER**dfit= 1.0 (0.01, 1000.0)**

This allows scaling of the number for display on the gauge on the 5009XT runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, us this setting to multiply by a factor of 10.

HOLD CASCADE CHANGES?**dfit= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Fast Rate, Entered Rate, Rated Setpt, Casc Not Matched Rate, Maximum Speed Setting and Minimum Speed Setting. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

Remote Cascade Settings (only displayed if configured)

Note: Available as the last page of the "Cascade Control" Service menu.

NOT MATCHED RATE**dfit= xxx (0.01, 1000)**

Rate the set point moves when remote is enabled and the remote input doesn't match the actual set point. This rate is defaulted to the 'Cascade Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

REMOTE CASCADE MAXIMUM RATE**dfit= xxx (0.01, 1000)**

Rate the set point moves once the remote input and actual set point are matched. This is a maximum rate. Normally the set point will follow the remote cascade input setting. This rate is set in the Program Mode.

MINIMUM REMOTE CASCADE SETPOINT**dfit= xxx (-20000, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Minimum Cascade Set Point Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Cascade Set Point' and the 'Maximum Cascade Set Point' settings)

MAXIMUM REMOTE CASCADE SETPOINT**dfit= xxx (-20000, 20000)**

Maximum setting allowed by the remote input. This setting is defaulted to the Maximum Cascade Set Point Value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Cascade Set Point' and the 'Maximum Cascade Set Point' settings)

REMOTE DEADBAND VALUE**dfit= 0.0 (0.0, 500)**

Remote cascade setting input deadband in engineering units.

REMOTE LAG-TAU VALUE**dfit= 0.0 (0.0, 10)**

Remote Set Point input lag setting.

HOLD REMOTE CASCADE CHANGES?**dfit= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Casc Settings. To permanently save these changes into the 5009XT, set to YES and select the 'Save Settings' key.

Communications

When this header appears in the display, press the down arrow key to view or change this block or press the left or right arrow key to select another block to change.

Modbus Settings**USE MODBUS TRIP?****dfit= YES (Yes/No)**

Use trip command through the Modbus link from the Modbus device.

USE 2-STEP TRIP?**dfit= NO (Yes/No)**

If using a Modbus Trip, is this a two-step trip. If YES, requires both the Trip command and the Trip Acknowledge command to go YES before a trip from the Modbus link will executed.

ENABLE LINK 1 (SERIAL) WRITES?**dfit= NO (Yes/No)**

If YES, the control will accept Boolean and Analog Writes made on this link.

ENABLE LINK 2 (ETHERNET) WRITES?**dfit= NO (Yes/No)**

If YES, the control will accept Boolean and Analog Writes made on this link.

ENABLE LINK 3 (ETHERNET) WRITES?

dflt= NO (Yes/No)

If YES, the control will accept Boolean and Analog Writes made on this link.

Modbus Link 1**LINK STATUS**

(status indication only)

Displays a green LED if the port is healthy. The `Time-out Delay` or port configuration may need to be adjusted.

EXCEPTION ERROR

(status indication only)

Displays a red LED if the port has an exception error.

TIMEOUT DELAY

dflt= 10.0 (0, 100)

Sets the port timeout. This is the delay, with no communication on the Modbus link, before the link is considered failed and an alarm is issued.

ERROR CODE

(status indication only)

Displays the error code related to the communication problem.

0 = No Errors 1 = Illegal Function

2 = Illegal Data Address 3 = Illegal Data Value

9 = Checksum Error 10= Garbled Message

Press RESET to clear the port error.

Modbus Link 2**LINK STATUS**

(status indication only)

Displays a green LED if the port is healthy. The `Time-out Delay` or port configuration may need to be adjusted.

EXCEPTION ERROR

(status indication only)

Displays a red LED if the port has an exception error.

TIMEOUT DELAY

dflt= 10.0 (0, 100)

Sets the port timeout. This is the delay, with no communication on the Modbus link, before the link is considered failed and an alarm is issued.

ERROR CODE

(status indication only)

Displays the error code related to the communication problem.

0 = No Errors 1 = Illegal Function

2 = Illegal Data Address 3 = Illegal Data Value

9 = Checksum Error 10= Garbled Message

Press RESET to clear the port error.

Modbus Link 3**LINK STATUS**

(status indication only)

Displays a green LED if the port is healthy. The `Time-out Delay` or port configuration may need to be adjusted.

EXCEPTION ERROR

(status indication only)

Displays a red LED if the port has an exception error.

TIMEOUT DELAY

dflt= 10.0 (0, 100)

Sets the port timeout. This is the delay, with no communication on the Modbus link, before the link is considered failed and an alarm is issued.

ERROR CODE

(status indication only)

Displays the error code related to the communication problem.

0 = No Errors 1 = Illegal Function

2 = Illegal Data Address 3 = Illegal Data Value

9 = Checksum Error 10= Garbled Message

Press RESET to clear the port error.

Modbus Link 4**LINK STATUS**

(status indication only)

Displays a green LED if the port is healthy. The `Time-out Delay` or port configuration may need to be adjusted.

EXCEPTION ERROR

(status indication only)

Displays a red LED if the port has an exception error.

TIMEOUT DELAY

dflt= 10.0 (0, 100)

Sets the port timeout. This is the delay, with no communication on the Modbus link, before the link is considered failed and an alarm is issued.

ERROR CODE**(status indication only)**

Displays the error code related to the communication problem.

0 = No Errors 1 = Illegal Function

2 = Illegal Data Address 3 = Illegal Data Value

9 = Checksum Error 10 = Garbled Message

Press RESET to clear the port error.

Servlink Socket 1 through 8**IP****(status indication only)**

Shows the Ethernet IP address that is connected to this socket.

STATUS**(status indication only)**

Displays a green LED if the port is healthy. The `Time-out Delay` or port configuration may need to be adjusted.

LEVEL**(status indication only)**

Displays the authority level of this socket connection. For example, the following are the most common levels a user will encounter are

- 0 = Monitor
- 1 = Operator
- 2 = Service
- 3 = Configure
- 11 = ServiceUser

CAN Communications**CAN PORT 2 on Kernel B CPU****PORT ENABLED****(status indication only)**

If LED is ON, this PORT has been configured for use.

LINK ERROR**(status indication only)**

If LED is ON, this PORT has a Link Error indicating no CAN activity for a timeout period.

RX ERROR**(status indication only)**

If LED is ON, this PORT has accumulated greater than 127 Receive Network errors.

CAN LOAD (%)**(status indication only)**

This value displays the current loading of CAN PORT 1 in %. It provides a "real time" monitor of the network load.

NMT STATUS**(status indication only)**

Table 12-1. Current CANOPEN NMT State Values Displayed

Status Meaning

0 Bootup

4 Stopped

5 Operational

127 Pre-Operational

STATE (status indication only)

Table 12-2. Current CANOPEN State Values Displayed

State Meaning

0 Preoperational

1 Initializing

2 Operational

3 Faulted

Alarms**IS TRIP AN ALARM?****dflt= YES (Yes/No)**

When set to YES, any trip condition will also be annunciated as an alarm. When NO, a trip condition will not necessarily mean an alarm will be issued.

BLINK ALARMS?**dflt= NO (Yes/No)**

Set to YES if want an indication if another alarm occurs when an alarm is already present. When set to YES, the alarm relay blinks when an alarm condition occurs until a reset command is issued. If the alarm still exists, the relay will stay energized, but will stop blinking until another alarm occurs. When NO, the alarm relay indicates an alarm continuously whenever an alarm condition exists.

SHUTDOWN ON POWER-UP?**dflt= YES (Yes/No)**

When set to YES, the control will initially power-up in a Shutdown state requiring an operator reset to start. When set to NO the unit will initialize into a ready to start mode if all shutdown conditions are clear. This option should always be set to YES when the control is configured for redundant operation.

TEST ALARM (TUNABLE) – EVENT ID 82**dflt= NO (Yes/No)**

Set to YES to trigger Alarm ID 82. This can be used to test communications to external devices. Set to NO and press RESET to clear the alarm.

CONFIGURABLE ALARM 1**ANALOG INPUT SIGNAL****dflt= Not Used (Analog Input Functions)**

This dropdown selects the signal to be used for triggering alarms. This dropdown list matches the available Analog Input function list such that any 4-20mA input can be used.

USE ALARM SETPOINT 1?**dflt= NO (Yes/No)**

Set to YES to enable Level 1 Setpoint. Once enabled, if the signal is greater than the Level 1 Setpoint, an Alarm will be generated.

USE ALARM SETPOINT 2?**dflt= NO (Yes/No)**

Set to YES to enable Level 2 Setpoint. Once enabled, if the signal is greater than the Level 2 Setpoint, an Alarm (or trip) will be generated.

LEVEL 1 SETPOINT?**dflt= 60.00 (-90000.0, 90000.0)**

Value for the Level 1 Setpoint Alarm in engineering Units.

INVERT ACTION ON LEVEL 1?**dflt= NO (Yes/No)**

Set to YES to change alarm to a falling level trigger. If the Signal falls below the Level 1 Setpoint, an Alarm will be generated.

LEVEL 2 SETPOINT?**dflt= 70.00 (-90000.0, 90000.0)**

Value for the Level 2 Setpoint Alarm/Trip in engineering Units.

INVERT ACTION ON LEVEL 2?**dflt= NO (Yes/No)**

Set to YES to change alarm to a falling level trigger. If the Signal falls below the Level 2 Setpoint, an Alarm/Trip will be generated.

USE LEVEL 2 AS A TRIP?**dflt= NO (Yes/No)**

Set to YES to enable the Level 2 Setpoint will generate a trip, shutting down the turbine.

SETPOINT HYSTERESIS?**dflt= -3.00 (-100.0, 100.0)**

The hysteresis value determines when the Alarm will be triggered and when it will be cleared again. For non-inverted action:

If hysteresis is zero, an alarm triggers when the Input Signal becomes greater than or equal to the Level Setpoint and the alarm condition is cleared when the input signal goes less than the Level Setpoint.

If hysteresis is positive, an alarm triggers when the Input Signal becomes greater than or equal to the Level Setpoint *plus* Hysteresis and the alarm condition clears when the input signal goes less than the Level Setpoint.

If hysteresis is negative, an alarm triggers when the Input Signal becomes greater than or equal to the Level Setpoint and the alarm condition is cleared when the input signal goes less than the Level Setpoint *minus* Hysteresis (absolute value).

For inverted action:

If hysteresis is zero, an alarm is triggered when the Input Signal becomes less than or equal to the Level Setpoint and the alarm condition is cleared when the input signal goes greater than the Level Setpoint.

If hysteresis is positive, an alarm is triggered when the Input Signal becomes less than or equal to the Level Setpoint *minus* Hysteresis and the alarm condition is cleared when the input signal goes greater than the Level Setpoint.

If hysteresis is negative, an alarm is triggered when the Input Signal becomes less than or equal to the Level Setpoint *plus* Hysteresis (absolute value) and the alarm condition is cleared when the input signal goes greater than the Level Setpoint.

DELAY FOR EVENT ACTION (sec)?**dflt= 2.00 (0, 300.0)**

This value sets the delay in seconds from the time an Alarm condition is met to the time an alarm is generated. The alarm condition must be present for at least this delay time for an alarm to be generated.

ENABLE SPEED SETPOINT (RPM)?**dflt= 100 (-1, 10000)**

This value is used as a permissive for the alarm condition. If turbine speed is below this value, an alarm is not generated even if the alarm condition is met.

ENABLE SPEED SETPOINT HYSTERESIS (RPM)? dflt= 10.00 (-100, 100)

The hysteresis value determines when the Alarm speed permissive will be met and when it will be cleared again.

If hysteresis is zero, the alarm speed permissive is met when the Speed Signal becomes greater than or equal to the Enable Speed Setpoint and the alarm speed permissive is not met when the speed signal goes less than the Enable Speed Setpoint.

If hysteresis is zero, the alarm speed permissive is met when the Speed Signal becomes greater than or equal to the Enable Speed Setpoint *plus* Hysteresis and the alarm speed permissive is not met when the speed signal goes less than the Enable Speed Setpoint.

If hysteresis is zero, the alarm speed permissive is met when the Speed Signal becomes greater than or equal to the Enable Speed Setpoint *plus* Hysteresis and the alarm speed permissive is not met when the speed signal goes less than the Enable Speed Setpoint *minus* Hysteresis (absolute value).

CONFIGURABLE ALARM 2 and 3

Please see the descriptions above for Configurable Alarm 1.

INLET AND EXHAUST PRESSURE ALARMS

Please see the descriptions above for Configurable Alarm 1.

VALVE POSITION FEEDBACK ALARM**ENABLE HP DIFFERENCE ALARM?**

dflt= NO (Yes/No)

Set to YES to enable the HP Difference Alarm. Once enabled, if the HP Demand differs from the Position Feedback for the Position Error Tolerance for the Position Error Delay time, an alarm will be generated.

POSITION ERROR TOLERANCE (%)

dflt= 5.00 (0.5, 100.0)

Amount of difference allowed between the Valve Demand and Position Feedback.

POSITION ERROR DURATION (sec)

dflt= 5.00 (1.0, 20.0)

Amount of time the difference between Valve Demand and Position Feedback can be greater than Position Error Tolerance before an alarm is generated.

ENABLE HP2 DIFFERENCE ALARM?

dflt= NO (Yes/No)

Set to YES to enable the HP2 Difference Alarm. This alarm uses the same Position Tolerance and Duration as above.

ENABLE LP DIFFERENCE ALARM?

dflt= NO (Yes/No)

Set to YES to enable the LP Difference Alarm. This alarm uses the same Position Tolerance and Duration as above.

Valve Linearization (can be configured as actuator output 1 or 2)**HP LinearizationX-1 VALUE**

dflt= 0.0 (-5,

110)

Input point #1 of the actuator linearization curve, in percentage.

(Must be less than the 'X-2 Value')

Y-1 VALUE

dflt= 0.0 (-5, 110)

Output point #1 of the actuator linearization curve, in percentage.

X-2 VALUE

dflt= 10.0 (-5, 110)

Input point #2 of the actuator linearization curve, in percentage.

(Must be between the 'X-1 Value' and the 'X-3 Value' settings)

Y-2 VALUE

dflt= 10.0 (-5, 110)

Output point #2 of the actuator linearization curve, in percentage.

X-3 VALUE

dflt= 20.0 (-5, 110)

Input point #3 of the actuator linearization curve, in percentage.

(Must be between the 'X-2 Value' and the 'X-4 Value' settings)

Y-3 VALUE

dflt= 20.0 (-5, 110)

Output point #3 of the actuator linearization curve, in percentage.

X-4 VALUE

dflt= 30.0 (-5, 110)

Input point #4 of the actuator linearization curve, in percentage.

(Must be between the 'X-3 Value' and the 'X-5 Value' settings)

Y-4 VALUE

dflt= 30.0 (-5, 110)

Output point #4 of the actuator linearization curve, in percentage.

X-5 VALUE

dflt= 40.0 (-5, 110)

Input point #5 of the actuator linearization curve, in percentage.

(Must be between the 'X-4 Value' and the 'X-6 Value' settings)

Y-5 VALUE	dflt= 40.0 (-5, 110)
Output point #5 of the actuator linearization curve, in percentage.	
X-6 VALUE	dflt= 50.0 (-5, 110)
Input point #6 of the actuator linearization curve, in percentage. (Must be between the 'X-5 Value' and the 'X-7 Value' settings)	
Y-6 VALUE	dflt= 50.0 (-5, 110)
Output point #6 of the actuator linearization curve, in percentage.	
X-7 VALUE	dflt= 60.0 (-5, 110)
Input point #7 of the actuator linearization curve, in percentage. (Must be between the 'X-6 Value' and the 'X-8 Value' settings)	
Y-7 VALUE	dflt= 60.0 (-5, 110)
Output point #7 of the actuator linearization curve, in percentage.	
X-8 VALUE	dflt= 70.0 (-5, 110)
Input point #8 of the actuator linearization curve, in percentage. (Must be between the 'X-7 Value' and the 'X-9 Value' settings)	
Y-8 VALUE	dflt= 70.0 (-5, 110)
Output point #8 of the actuator linearization curve, in percentage.	
X-9 VALUE	dflt= 80.0 (-5, 110)
Input point #9 of the actuator linearization curve, in percentage. (Must be between the 'X-8 Value' and the 'X-10 Value' settings)	
Y-9 VALUE	dflt= 80.0 (-5, 110)
Output point #9 of the actuator linearization curve, in percentage.	
X-10 VALUE	dflt= 90.0 (-5, 110)
Input point #10 of the actuator linearization curve, in percentage. (Must be between the 'X-9 Value' and the 'X-11 Value' settings)	
Y-10 VALUE	dflt= 90.0 (-5, 110)
Output point #10 of the actuator linearization curve, in percentage.	
X-11 VALUE	dflt= 100.0 (-5, 110)
Input point #11 of the actuator linearization curve, in percentage. (Must be greater than the 'X-10 Value')	
Y-11 VALUE	dflt= 100.0 (-5, 110)
Output point #11 of the actuator linearization curve, in percentage.	
HP DEMAND (%) =	(status indication only)
Displays the actuator demand (%) before the linearization curve.	
HP OUTPUT (%) =	(status indication only)
Displays the actuator demand (%) after the linearization curve.	
TRACK OFFSET (%) =	dflt= 0.0 (0.0, 5.0)
Displays the actuator demand (%) after the linearization curve.	
HP2 Linearization (only displayed if configured)	
HP2 can be used for dual inlet or split range valve applications.	
X-1 VALUE	dflt= 0.0 (-5, 110)
Input point #1 of the actuator linearization curve, in percentage. (Must be less than the 'X-2 Value')	
Y-1 VALUE	dflt= 0.0 (-5, 110)
Output point #1 of the actuator linearization curve, in percentage.	
X-2 VALUE	dflt= 10.0 (-5, 110)
Input point #2 of the actuator linearization curve, in percentage. (Must be between the 'X-1 Value' and the 'X-3 Value' settings)	
Y-2 VALUE	dflt= 10.0 (-5, 110)
Output point #2 of the actuator linearization curve, in percentage.	
X-3 VALUE	dflt= 20.0 (-5, 110)
Input point #3 of the actuator linearization curve, in percentage. (Must be between the 'X-2 Value' and the 'X-4 Value' settings)	
Y-3 VALUE	dflt= 20.0 (-5, 110)
Output point #3 of the actuator linearization curve, in percentage.	

X-4 VALUE	dflt= 30.0 (-5, 110)
Input point #4 of the actuator linearization curve, in percentage. (Must be between the 'X-3 Value' and the 'X-5 Value' settings)	
Y-4 VALUE	dflt= 30.0 (-5, 110)
Output point #4 of the actuator linearization curve, in percentage.	
X-5 VALUE	dflt= 40.0 (-5, 110)
Input point #5 of the actuator linearization curve, in percentage. (Must be between the 'X-4 Value' and the 'X-6 Value' settings)	
Y-5 VALUE	dflt= 40.0 (-5, 110)
Output point #5 of the actuator linearization curve, in percentage.	
X-6 VALUE	dflt= 50.0 (-5, 110)
Input point #6 of the actuator linearization curve, in percentage. (Must be between the 'X-5 Value' and the 'X-7 Value' settings)	
Y-6 VALUE	dflt= 50.0 (-5, 110)
Output point #6 of the actuator linearization curve, in percentage.	
X-7 VALUE	dflt= 60.0 (-5, 110)
Input point #7 of the actuator linearization curve, in percentage. (Must be between the 'X-6 Value' and the 'X-8 Value' settings)	
Y-7 VALUE	dflt= 60.0 (-5, 110)
Output point #7 of the actuator linearization curve, in percentage.	
X-8 VALUE	dflt= 70.0 (-5, 110)
Input point #8 of the actuator linearization curve, in percentage. (Must be between the 'X-7 Value' and the 'X-9 Value' settings)	
Y-8 VALUE	dflt= 70.0 (-5, 110)
Output point #8 of the actuator linearization curve, in percentage.	
X-9 VALUE	dflt= 80.0 (-5, 110)
Input point #9 of the actuator linearization curve, in percentage. (Must be between the 'X-8 Value' and the 'X-10 Value' settings)	
Y-9 VALUE	dflt= 80.0 (-5, 110)
Output point #9 of the actuator linearization curve, in percentage.	
X-10 VALUE	dflt= 90.0 (-5, 110)
Input point #10 of the actuator linearization curve, in percentage. (Must be between the 'X-9 Value' and the 'X-11 Value' settings)	
Y-10 VALUE	dflt= 90.0 (-5, 110)
Output point #10 of the actuator linearization curve, in percentage.	
X-11 VALUE	dflt= 100.0 (-5, 110)
Input point #11 of the actuator linearization curve, in percentage. (Must be greater than the 'X-10 Value')	
Y-11 VALUE	dflt= 100.0 (-5, 110)
Output point #11 of the actuator linearization curve, in percentage.	
HP2 DEMAND (%) =	(status indication only)
Displays the actuator demand (%) before the linearization curve.	
HP2 OUTPUT (%) =	(status indication only)
Displays the actuator demand (%) after the linearization curve.	
LP Linearization (only displayed if configured)	
X-1 VALUE	dflt= 0.0 (-5, 110)
Input point #1 of the actuator linearization curve, in percentage. (Must be less than the 'X-2 Value')	
Y-1 VALUE	dflt= 0.0 (-5, 110)
Output point #1 of the actuator linearization curve, in percentage.	
X-2 VALUE	dflt= 10.0 (-5, 110)
Input point #2 of the actuator linearization curve, in percentage. (Must be between the 'X-1 Value' and the 'X-3 Value' settings)	
Y-2 VALUE	dflt= 10.0 (-5, 110)
Output point #2 of the actuator linearization curve, in percentage.	
X-3 VALUE	dflt= 20.0 (-5, 110)
Input point #3 of the actuator linearization curve, in percentage. (Must be between the 'X-2 Value' and the 'X-4 Value' settings)	

Y-3 VALUE	dflt= 20.0 (-5, 110)
Output point #3 of the actuator linearization curve, in percentage.	
X-4 VALUE	dflt= 30.0 (-5, 110)
Input point #4 of the actuator linearization curve, in percentage. (Must be between the 'X-3 Value' and the 'X-5 Value' settings)	
Y-4 VALUE	dflt= 30.0 (-5, 110)
Output point #4 of the actuator linearization curve, in percentage.	
X-5 VALUE	dflt= 40.0 (-5, 110)
Input point #5 of the actuator linearization curve, in percentage. (Must be between the 'X-4 Value' and the 'X-6 Value' settings)	
Y-5 VALUE	dflt= 40.0 (-5, 110)
Output point #5 of the actuator linearization curve, in percentage.	
X-6 VALUE	dflt= 50.0 (-5, 110)
Input point #6 of the actuator linearization curve, in percentage. (Must be between the 'X-5 Value' and the 'X-7 Value' settings)	
Y-6 VALUE	dflt= 50.0 (-5, 110)
Output point #6 of the actuator linearization curve, in percentage.	
X-7 VALUE	dflt= 60.0 (-5, 110)
Input point #7 of the actuator linearization curve, in percentage. (Must be between the 'X-6 Value' and the 'X-8 Value' settings)	
Y-7 VALUE	dflt= 60.0 (-5, 110)
Output point #7 of the actuator linearization curve, in percentage.	
X-8 VALUE	dflt= 70.0 (-5, 110)
Input point #8 of the actuator linearization curve, in percentage. (Must be between the 'X-7 Value' and the 'X-9 Value' settings)	
Y-8 VALUE	dflt= 70.0 (-5, 110)
Output point #8 of the actuator linearization curve, in percentage.	
X-9 VALUE	dflt= 80.0 (-5, 110)
Input point #9 of the actuator linearization curve, in percentage. (Must be between the 'X-8 Value' and the 'X-10 Value' settings)	
Y-9 VALUE	dflt= 80.0 (-5, 110)
Output point #9 of the actuator linearization curve, in percentage.	
X-10 VALUE	dflt= 90.0 (-5, 110)
Input point #10 of the actuator linearization curve, in percentage. (Must be between the 'X-9 Value' and the 'X-11 Value' settings)	
Y-10 VALUE	dflt= 90.0 (-5, 110)
Output point #10 of the actuator linearization curve, in percentage.	
X-11 VALUE	dflt= 100.0 (-5, 110)
Input point #11 of the actuator linearization curve, in percentage. (Must be greater than the 'X-10 Value')	
Y-11 VALUE	dflt= 100.0 (-5, 110)
Output point #11 of the actuator linearization curve, in percentage.	
LP DEMAND (%) =	(status indication only)
Displays the actuator demand (%) before the linearization curve.	
LP OUTPUT (%) =	(status indication only)
Displays the actuator demand (%) after the linearization curve.	

Actuators (if configured to use Act modules)

If these modules are added to the system – the following service parameter settings will appear – this will exist for both channels.

DITHER (mA)	dflt= 0.00 (0.5, 100.0)
If desired a dither can be added to actuator – this is the mA amplitude of the dither signal	
Excitation Amplitude (Vrms)	dflt= 7.07 (2.0, 20.0)
Set this to the correct excitation voltage for the position feedback transducers	
COMMAND TRIP ENABLE?	dflt= NO (Yes/No)
Set to YES to enable command trim if feedback is used with proportional type actuators	
ENABLE FEEDBACK ALARMS?	dflt= NO (Yes/No)

Set to YES to enable any of the feedback alarms associated with this channel **Feedback Voltage Tolerance (Vrms)** **dflt= 0.50 (0.5, 10.0)**

Set the voltage tolerance for the feedback signals

Feedback Max Difference (%) **dflt= 10.0 (0.5, 100.0)**

Set the maximum difference allowed between two feedback signals, larger than this creates a feedback difference alarm

Feedback Difference Delay (ms) **dflt= 2000 (500, 10000)**

Set the amount of time a difference can exist before an alarm is triggered

Position Out of Range (%) **dflt= 5.0 (0.5, 100.0)**

Set the demand percentage that indicates the feedback is out of the 0-100% range

Position Error Threshold (%) **dflt= 10.0 (0.5, 100.0)**

Set the percentage error between demand and position that will trigger an alarm

Position Error Delay (ms) **dflt= 2000 (500, 10000)**

Set the amount of time a demand versus feedback position can exist before an alarm is triggered

Real Time Clock

USE SNTP SYNCHRONIZATION **dflt= NO (Yes/No)**

Select this option if using an SNTP Server for time synchronization with the 5009XT internal clock. This will affect alarm and event indication time stamping.

TIME ZONE **dflt= NO (-12, 13)**

This value will change the local time on the control. The hardware time will be set to GMT. Changing this input will have no effect on the actual hardware keeping track of time. Therefore, if the Time Zone is changed after the hardware time is setup; the Local time will change as it offsets a different Time Zone to the Local Time.

Table 12-3. Time Zones

-12= -11= -10=Hawaii

-9=Alaska -8=Pacific -7=Mountain

-6=Central -5=Eastern -4=Atlantic

-3= -2= -1=

0=GMT 1= 2=

3=Moscow 4= 5=

6= 7= 8=Hong Kong

9=Tokyo 10= 11=

12= 13=

YEAR **dflt= 15 (0, 99)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value.

MONTH **dflt= 15 (1, 12)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

DAY **dflt= 15 (1, 31)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

HOUR **dflt= 15 (0, 23)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

MINUTES **dflt= 15 (0, 59)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

SECONDS **dflt= 15 (0, 59)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

Data Log

DATA SAMPLE RATE **dflt= 1000.0 (10, 1000)**

Set the number of milliseconds between each data point in the data log. After changing this value, the Data Log must be stopped and started again for this sample rate to be used.

ENABLE CONTINUOUS/DISABLE CONTINUOUS**dflt= Disabled**

Enabling Continuous allows continuous datalogs to be collected via AppManager. When Enabled, the control will create 2 log files which get downloaded by AppManager automatically, once configured. This pulls the datalog files onto a PC which can be put together seamlessly via Control Assistant. The Continuous Mode will collect 10ms data for 8 hours before automatically disabling. This is intended to be used for commissioning or troubleshooting purposes. When disabled, the Trend Log will automatically re-enable.

Continuous Mode Active**(status only)**

When the LED is illuminated, Continuous Mode is active and files can be collected via AppManager.

Operation Log**NUMBER OF TURBINE STARTS****dflt= 0 (0, 999999)**

This is the number of times a Start command has been issued. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

NUMBER OF HOT TURBINE STARTS**dflt= 0 (0, 999999)**

This is the number of times a Start command has been issued while the turbine is considered HOT. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

TOTAL TRIPS**dflt= 0 (0, 999999)**

This is the number of times a Trip has occurred. The trip latch must be reset/cleared and then triggered again to increment this counter. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

TRIPS WITH LOAD > 25%**dflt= 0 (0, 999999)**

This is the number of times a Trip has occurred above 25% load. Load is determined by the LSS percentage if configured as a mechanical drive unit. As a generator drive unit the load level is determined by the calculated LSS load percentage or the load analog input if configured. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

TRIPS WITH LOAD > 75%**dflt= 0 (0, 999999)**

This is the number of times a Trip has occurred above 75% load. Load is determined by the LSS percentage if configured as a mechanical drive unit. As a generator drive unit the load level is determined by the calculated LSS load percentage or the load analog input if configured. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

OVERSPEED TRIPS**dflt= 0 (0, 999999)**

This is the number of overspeed trips. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

TOTAL RUN TIME HOURS**dflt= 0.0 (0.0, 1.0e+8)**

This is the total time the turbine has been running. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

RUN TIME HOURS WITH LOAD > 25%**dflt= 0.0 (0.0, 1.0e+8)**

This is the total time the turbine has been running with more than 25% load. Load is determined by the LSS percentage if configured as a mechanical drive unit. As a generator drive unit the load level is determined by the calculated LSS load percentage or the load analog input if configured. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

RUN TIME HOURS WITH LOAD > 75%**dflt= 0.0 (0.0, 1.0e+8)**

This is the total time the turbine has been running with more than 75% load. Load is determined by the LSS percentage if configured as a mechanical drive unit. As a generator drive unit the load level is determined by the calculated LSS load percentage or the load analog input if configured. This number can be reset by pressing the 'Reset Values' soft key to reset all Operation Values to the "Rewrite Value" specified in this menu.

TOTAL RUN TIME HOURS**(status indication only)**

This is the total time the turbine has been running. This is a repeat of the value on the previous page for ease of comparing the run time with the maintenance alarm time.

ENABLE MAINTENANCE ALARM**dflt= YES (Yes/No)**

Select this option to turn on the maintenance alarm, which is an alarm based on the number of turbine run hours and reminds the user that the control should be serviced periodically. Unselected this to disable the maintenance alarm.

MAINTENANCE INTERVAL**dflt= 15000 (10, 100000)**

This sets the number of turbine run hours that will trigger the maintenance alarm. After the turbine has been running for this many hours, the maintenance alarm will activate to remind the user to service the unit.

MAINTENANCE ALARM**(status indication only)**

This indicates the status of the maintenance alarm. A red LED indication is a reminder that the unit should be serviced. This alarm indication can be reset by pressing the "Reset Alarm" soft key at the bottom of the screen if the appropriate security level is logged in.

PEAK SPEED REACHED**(status indication only)**

This indicates the maximum turbine speed detected by the 5009XT.

MAXIMUM ACCELERATION REACHED**(status indication only)**

This indicates the maximum turbine acceleration detected by the 5009XT.

Isolated Control (only displayed if configured)**SETPOINT****(set by user)**

This is the setpoint in engineering units. It is the target control point for the Isolated Control PID.

PROCESS**(status indication only)**

This is the process value from the analog input in engineering units. It is the parameter to be controlled by the Isolated Control PID.

DEMAND**(set by user)**

This is the output of the Isolated Control PID in percent. This can be manually adjusted by a user with the appropriate security login level by enabling manual mode or in the event of an analog process input fault.

REMOTE SETPOINT ENABLED**(status indication only)**

This is a status indication that the remote setpoint analog input is driving the Isolated Control setpoint. A green LED indicates the Remote Setpoint is enabled.

REMOTE SETPOINT FAULT**(status indication only)**

This is a status indication that the remote setpoint analog input is failed. A red LED indicates the Remote Setpoint fault is present.

AUTO CONTROL**(status indication only)**

This is a status indication that the Isolated Control is controlling the process and attempting to maintain the setpoint automatically. A green LED indicates the PID is controlling.

PROCESS INPUT FAULT**(status indication only)**

This is a status indication that the process value analog input is failed. A red LED indicates the process analog input fault is present.

MANUAL DEMAND**(status indication only)**

This is a status indication that the Isolated Control is not controlling the process. The output of the Isolated Control PID is set manually by the operator. A yellow LED indicates the Isolated Control PID is in manual mode and the PID is not maintaining the setpoint.

Setpoint Limits**MAXIMUM****(status indication only)**

This is the maximum limit for the Isolated Control setpoint in engineering units.

MINIMUM**(status indication only)**

This is the minimum limit for the Isolated Control setpoint in engineering units.

INITIAL**(status indication only)**

This is the value in engineering units at which the Isolated Control setpoint ramp will initialize.

NORMAL RATE**dflt= 1.0 (0.0, 100000.0)**

This is the rate in engineering units per second at which the Isolated Control setpoint will move when a setpoint raise/lower command is issued.

FAST RATE**dflt= 3.0 (0.0, 100000.0)**

This is the rate in percent per second at which the Isolated Control setpoint will move after the setpoint raise/lower command has been active for 5 seconds.

Output Limits**MAXIMUM****dflt= 100.0 (-10.0, 110.0)**

This is the maximum limit for the Isolated Control PID demand in percent.

MINIMUM	dflt= 0.0 (-10.0, 110.0)
This is the minimum limit for the Isolated Control PID demand in percent.	
INITIAL	dflt= 0.0 (-10.0, 110.0)
This is the value in percent at which the Isolated Control setpoint ramp will initialize.	
NORMAL RATE	dflt= 1.0 (0.0, 1000.0)
This is the rate in percent per second at which the Isolated Control output will move when a manual demand raise/lower command is issued.	
FAST RATE	dflt= 3.0 (0.0, 1000.0)
This is the rate in percent per second at which the Isolated Control output will move after the manual demand raise/lower command has been active for 5 seconds.	
Commands	
Remote Setpoint	
REMOTE SETPOINT	(status indication only)
This is the remote setpoint for the Isolated Control setpoint in engineering units. When enabled, an analog input is used to drive the setpoint for the Isolated Control PID. The Remote Setpoint can be enabled using the soft key at the bottom of the screen.	
REMOTE RATE	dflt= 5.0 (0.1, 100000.0)
This is the maximum rate at which the remote setpoint can move the Isolated Control setpoint in engineering units per second.	
PID Dynamics	
P TERM	(set by user)
This is the Proportional gain setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.	
I TERM	(set by user)
This is the Integral gain setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.	
DR TERM	(set by user)
This is the Derivative Ratio setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.	
Screen/Key Options	
AUTO LOGIN AS OPERATOR	dflt= YES (Yes/No)
Select this option to determine which user level is active when the 5009XT initializes. With this option selected, the 5009XT will initialize like the older 2-line display models in operator mode with operator commands available. If not selected, the 5009XT will initialize in the Monitor user level with only screen navigation functionality. No operator commands can be issued from the Monitor user level. Note that this will also determine the user level that is logged in any time the user wakes up the display and turns off the screen saver.	
OPERATOR PASSWORD	dflt= wg1111
If "Auto Login as Operator" is selected, this sets the Operator password. If the user level and password have not been changed, the default input will allow the 505 to login the Operator user level as described above. If the Operator password has been changed, then it must be entered here to authorize the 505 to automatically login to the Operator user level.	
USE 'STOP' COMMAND?	dflt= YES (Yes/No)
When set to YES, allows the Controlled Stop command to be used. When NO, the Controlled Stop feature is disabled from front panel, Modbus, and contact commands.	
USE REMOTEVIEW TRIP?	dflt= YES (Yes/No)
When set to YES, allows the Controlled.	
CPU IDLE TIME (%)	(status indication only)
This indicates the amount of available CPU horsepower.	

Real Time Clock - (Real Time Clock)

SYSTEM DATE	Dflt= Display Only
Displays the current date in the controller.	
SYSTEM TIME (24HR)	dflt= Display Only
Displays the current time in the controller.	

USE SNTP SYNCHRONIZATION**dflt= NO (YES/NO)**

Select this option if using an SNTP Server for time synchronization with the Vertex internal clock. This will affect alarm and event indication time stamping.

TIME ZONE**dflt= 0 [-12, -11, -10, -9, -8,****-7, -6, -5, -4, -3, -2,****-1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]**

This value will change the local time on the control. The hardware time will be set to GMT. Changing this input will have no effect on the actual hardware keeping track of time. Therefore, if the Time Zone is changed after the hardware time is setup, the Local time will change as it offsets a different Time Zone to the Local Time.

-12= -11= -10=Hawaii

-9=Alaska -8=Pacific -7=Mountain

-6=Central -5=Eastern -4=Atlantic

-3= -2= -1=

0=GMT 1= 2=

3=Moscow 4= 5=

6= 7= 8=Hong Kong

9=Tokyo 10= 11=

12= 13=

YEAR**dflt= 15 (0, 99)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

MONTH**dflt= 1 (1, 12)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

DAY**dflt= 1 (1, 31)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

HOUR**dflt= 0 (0, 23)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

MINUTES**dflt= 0 (0, 59)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

SECONDS**dflt= 0 (0, 59)**

When 'SET CLOCK' is pressed (or the Clock SYNC Pulse Contact Input is closed), the hardware time will be set to this value

Custom Trend

Opening Custom Trend page begins the trend, exiting the page will continue to record data in the background. Trends can be paused using the soft-key. While paused, the data continues to record in the background. Once resumed, the trend snaps to real time.

Settings**TIME WINDOW****dflt= 60 (1, 600)**

Set the amount of time that is shown on the trend. This is the trend window time in seconds. Setting this to '60', for example, will show 60 seconds of data preceding the present time.

Parameter 1 (Red)**VARIABLE****(set by user)**

Select the parameter to be displayed by this trend line. The color that will appear for this parameter on the trend is indicated to the left of this selection.

Y MAX**dflt= 100 (-20000, 20000)**

Set the maximum value for the Y axis on the trend for this signal. This sets the maximum vertical limit of the trend display for the signal.

Y MIN**dflt= 0 (-20000, 20000)**

Set the minimum value for the Y axis on the trend for this signal. This sets the minimum vertical limit of the trend display for the signal.

WIDTH**dflt= 1 (1, 5)**

Set the width of the line shown on the trend for this signal. To increase thickness of the line, this number should be increased.

SHOW AXIS

dflt= YES (Yes/No)

Set the maximum value for the Y axis on the trend for this signal. This sets the maximum vertical limit of the trend display for the signal.

Parameter 2 (Green)

The configuration options are similar to that of Parameter 1. See Parameter 1 settings for a description of each option.

Parameter 3 (Blue)

The configuration options are similar to that of Parameter 1. See Parameter 1 settings for a description of each option.

Parameter 4 (Purple)

The configuration options are similar to that of Parameter 1. See Parameter 1 settings for a description of each option.

Parameter 5 (Orange)

The configuration options are similar to that of Parameter 1. See Parameter 1 settings for a description of each option.

Manual Demand**ENABLE THE USE OF MANUAL DEMAND**

dflt= NO (Yes/No)

Select this option to allow the use of the manual valve demand feature. This allows the operator to disable all controllers and hold the valve demand steady for a limited period of time for system troubleshooting purposes.

Warning - Using the Manual Valve Demand feature allows the operator to lock the valve demand. This means that closed loop control is not active. In other words, the Speed PID will not be in control of the turbine speed!

MANUAL DEMAND RATE (%/sec)

dflt= *0.5 (0.0099, 5.0)

Set the rate at which the valve demand can be moved when Manual Valve Demand is enabled. This is a value in percent per second.

TIMEOUT WHEN INACTIVE (sec)

dflt= 120.0 (10.0, 300.0)

Set the maximum length of time, in seconds, that Manual Valve Demand may be enabled. If Manual Valve Demand is enabled for this length of time then it will automatically be disabled and the control will return to Speed PID Control.

Acceleration Limiter**USE ACCELERATION LIMITER**

dflt= NO (Yes/No)

Set to YES to enable the Acceleration Limiter PID during startup.

PROPORTIONAL GAIN

(set by user)

This is the Proportional gain setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.

INTEGRAL GAIN

(set by user)

This is the Integral gain setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.

DERIVATIVE RATIO

(set by user)

This is the Derivative Ratio setting for the Isolated Control PID. It can be adjusted by a user with the appropriate user level. The PID algorithm is the same as the other control PID's. See the PID tuning section of the manual for details on the PID parameters.

Inlet Control Settings (only displayed if configured)**SLOW RATE (UNITS/S)**

dflt= xxx (0.01, 1000)

Normal set point rate of change. This value is set in the program mode.

FAST RATE DELAY (SEC)

dflt= 3.0 (0.0, 100)

Delay, in seconds, before the 'Fast Rate' of change is selected.

FAST RATE (UNITS/S)

dflt= xxx (0.01, 5000)

This rate is defaulted to three times (3x) the 'Set Point Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

SETPT ENTERED RATE (UNITS/S)**dflt= xxx (0.01, 1000)**

This is the rate that the set point will move when set point is entered from the front panel of the control or from the communication links. This rate is defaulted to the set point slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

DROOP (%)**dflt= xxx (0.0, 100)**

Control droop setting. This value is set in the program mode.

RATED SETPOINT**dflt= xxx (-20000, 20000)**

Only used to determine the control Droop. This set point is defaulted to the aux maximum set point limit. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

PID THRESHOLD (LIMITER)**dflt= 10 (0.0, 110)**

Aux PID threshold setting when Inlet is used as a limiter. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID THRESHOLD (CONTROLLER)**dflt= 100 (0.0, 110)**

Aux PID threshold setting when Inlet is used as a controller. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID MINIMUM OUTPUT**dflt= 0.00 (0.0, 50)**

PID minimum output setting. The PID cannot output a lower value to the LSS. This can be used to stop the PID from taking the LSS low enough to take the unit off-line or below min governor.

DISPLAY GAUGE MULTIPLIER**dflt= 1.0 (0.01, 1000.0)**

This allows scaling of the number for display on the gauge on the 5009XT runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, use this setting to multiply by a factor of 10.

HOLD INLET CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Set Point Fast Rate, Entered Rate, and Rated Set Point. To permanently save these changes into the control, set to YES and select the 'Save Settings' key.

Remote Inlet Settings (only displayed if configured)

Note: Available as the last page of the "Inlet Control" Service menu.

REMOTE NOT MATCHED RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves when remote is enabled and the remote input doesn't match the actual set point. This rate is defaulted to the 'Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

REMOTE MAXIMUM RATE**dflt= xxx (0.01, 1000)**

Rate the set point moves once the remote input and actual set point are matched. This is a maximum rate. Normally the set point will follow the remote input setting. This value is set in the program mode.

MINIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Set Point Minimum Value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

MAXIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Maximum setting allowed by the remote input. This setting is defaulted to the Set Point Maximum Value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

REMOTE DEADBAND VALUE**dflt= 0.0 (0.0, 500)**

Remote setting input dead band in engineering units.

REMOTE LAG-TAU VALUE**dflt= 0.0 (0.0, 10)**

Remote Set Point input lag setting.

HOLD REMOTE INLET CHANGES?

dflt= NO (Yes/No)

Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Settings. To permanently save these changes into the control, set to YES and select the 'Save Settings' key.

Exhaust Control Settings (only displayed if configured)**SLOW RATE (UNITS/S)**

dflt= xxx (0.01, 1000)

Normal set point rate of change. This value is set in the program mode.

FAST RATE DELAY (SEC)

dflt= 3.0 (0.0, 100)

Delay, in seconds, before the 'Fast Rate' of change is selected.

FAST RATE (UNITS/S)

dflt= xxx (0.01, 5000)

This rate is defaulted to three times (3x) the 'Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

SETPT ENTERED RATE (UNITS/S)

dflt= xxx (0.01, 1000)

This is the rate that the set point will move when set point is entered from the front panel of the control or from the communication links. This rate is defaulted to the set point slow rate. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

DROOP (%)

dflt= xxx (0.0, 100)

Control droop setting. This value is set in the program mode.

RATED SETPOINT

dflt= xxx (-20000, 20000)

Only used to determine the control Droop. This set point is defaulted to the aux maximum set point limit. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)

PID THRESHOLD (LIMITER)

dflt= 10 (0.0, 110)

Aux PID threshold setting when Exhaust is used as a limiter. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID THRESHOLD (CONTROLLER)

dflt= 100 (0.0, 110)

Aux PID threshold setting when Exhaust is used as a controller. The value of the Threshold input determines how much error (difference between actual and reference) will be permitted before this block's output goes to 101% (LSS) or -1% (HSS), when this block is not in control of the LSS or HSS bus into which it feeds. It is not advisable to set the Threshold to zero.

PID MINIMUM OUTPUT

dflt= 0.00 (0.0, 50)

PID minimum output setting. The PID cannot output a lower value to the LSS. This can be used to stop the PID from taking the LSS low enough to take the unit off-line or below min governor.

DISPLAY GAUGE MULTIPLIER

dflt= 1.0 (0.01, 1000.0)

This allows scaling of the number for display on the gauge on the runtime screen for this controller. If the number is too big or small to be displayed correctly or as desired, use this setting to multiply by a factor of 10.

HOLD EXHAUST CHANGES?

dflt= NO (Yes/No)

Set to YES to permanently hold the changes made to the Set Point Fast Rate, Entered Rate, and Rated Set Point. To permanently save these changes into the control, set to YES and select the 'Save Settings' key.

Remote Exhaust Settings (only displayed if configured)

Note: Available as the last page of the "Exhaust Control" Service menu.

REMOTE NOT MATCHED RATE

dflt= xxx (0.01, 1000)

Rate the set point moves when remote is enabled and the remote input does not match the actual set point. This rate is defaulted to the 'Set Point Slow Rate'. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

REMOTE MAXIMUM RATE

dflt= xxx (0.01, 1000)

Rate the set point moves once the remote input and actual set point are matched. This is a maximum rate. Normally the set point will follow the remote input setting. This value is set in the program mode.

MINIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Minimum setting allowed by the remote input. This setting is defaulted to the Set Point Minimum Value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization. *(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)*

MAXIMUM REMOTE SETPOINT**dflt= xxx (-20000, 20000)**

Maximum setting allowed by the remote input. This setting is defaulted to the Set Point Maximum Value. This value can be changed to a new value; however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization. *(Must be between the 'Minimum Set Point' and the 'Maximum Set Point' settings)*

REMOTE DEADBAND VALUE**dflt= 0.0 (0.0, 500)**

Remote setting input dead band in engineering units.

REMOTE LAG-TAU VALUE**dflt= 0.0 (0.0, 10)**

Remote Set Point input lag setting.

HOLD REMOTE EXHAUST CHANGES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Settings. To permanently save these changes into the control, set to YES and select the 'Save Settings' key.

Steam Map (only displayed if configured)

The below constants are calculated based on the turbine performance parameters entered in the program mode. These values can be changed to a new value; however, the Retain Service Values must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

K1 (dHP/dS) VALUE**dflt= 0.0 (0.001, 100.0)****K2 (dHP/dP) VALUE****dflt= 0.0 (0.001, 100.0)****K3 HP OFFSET VALUE****dflt= 0.0 (-100.0, 100.0)****K4 (dLP/dS) VALUE****dflt= 0.0 (0.001, 100.0)****K5 (dLP/dS) VALUE****dflt= 0.0 (-100.0, 100.0)****K6 LP OFFSET VALUE****dflt= 0.0 (-100.0, 100.0)****S0 Value****dflt = xxxxx (-1e38, 1e38)**

This value is used to adjust the Steam Map such that 0% Speed PID demand results in zero HP demand. The value is subtracted from the power component of points A, B, C, and Max Load. The effect is to move the map to the right. This value is initially calculated from the Steam Map such that K3 will be equal to Zero, allowing the HP to fully close. Because turbine efficiency can change once the unit is warmed up, this value is available to be adjusted in Service Mode. To make an update to the Steam Map, the unit must be operating in Speed Only control (Ext/Adm disabled). Press the 'Update Map' button to apply changes.

RETAIN SERVICE VALUES?**dflt= NO (Yes/No)**

Set to YES to permanently hold the changes made to the K Value Constants. To permanently save these changes into the control, set to YES and select the 'Save Settings' key.

STEAM MAP PRIORITY SELECTIONS

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 1 parameter can be controlled the user, depending on the configuration, can select which parameter is maintained.

MODE 0**dflt= Speed (Speed/Extraction)****MODE 1****dflt= Speed (Speed/Inlet)****MODE 2****dflt= Inlet (Extraction/Inlet)****MODE 3****dflt= Speed (Speed/Exhaust)****MODE 4****dflt= Exhaust (Extraction/Exhaust)****MODE 5****dflt= Inlet (Inlet/Exhaust)****MODE 6****dflt= Inlet (Inlet/Exhaust)**

Chapter 6

Communications

Modbus Communications

The 5009XT 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 on each of the 3 CPU's. There are 2 Ethernet ports available for either Modbus UDP or TCP/IP protocol which can be utilized from Ethernet port 1 or 2 on each CPU. 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 5009XT Modbus link to monitor and/or operate, check the "Use Modbus" checkbox under the Configurations menu / Communications page and then configure the desired links (ports) to be used. Ethernet is available on all 4 links and are assigned to a specific kernel CPU. Once assigned they are available on either Ethernet port, that is defined by the Modbus Master end by assignment of the remote IP address. Serial port connections are only supported on Links 3 and 4.

Redundant links should be assigned to different kernel CPU's to insure continuous monitoring during any fault conditions.

Monitor Only

The four Modbus communication links, are defaulted as read-only. As read-only links, the 5009XT can be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, and to the 5009XT's defaulted protocol settings (parity, stop bits, etc.), this device can be used to monitor all the 5009XT'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 link is configured within the 5009XT's Configuration mode, the 5009XT will accept RUN mode commands from an external network master device (DCS, etc.). This allows a Modbus compatible device to monitor and perform all 5009XT 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 link is independent of the other, and can be used simultaneously. Each link must have its own slave device address and each has its own enable write checkbox. The last command given from any of the links has priority or is the mode or function selected.

Modbus Communication

The 5009XT 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 6-1. ASCII vs RTU Modbus

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

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 5-1 below).

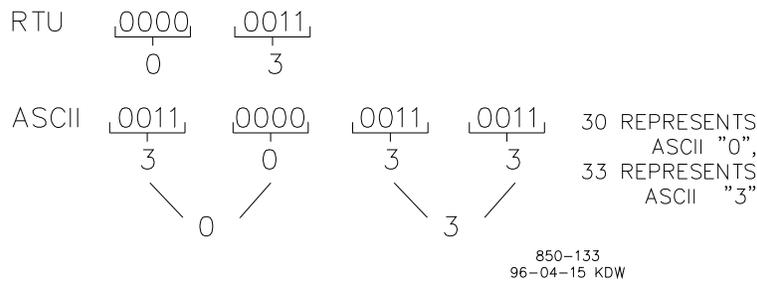


Figure 6-1. ASCII/RTU Representation of 3

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

The 5009XT control is programmed to function as a slave unit only. As a slave unit, the 5009XT will only respond to a transaction request by a master device. The 5009XT can directly communicate with a DCS or other Modbus supporting device on a single communications link, or through a multi-dropped network. If multi-dropping is used, up to 246 devices (5009XTs or other customer devices) can be connected to one Master device on a single network. The control address is programmed under the 5009XT's communications block and can be changed in the service mode, if needed.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information. See Table 6-2.

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
1	Read Digital Outputs (Raise/Lower and Enable/Disable Commands)	0XXXX
2	Read Digital Inputs (Status Indications/Alarms and Trips)	1XXXX
3	Read Analog Outputs	4XXXX
4	Read Analog Inputs (Speed, Setpoint, etc.)	3XXXX
5	Write Single Discrete Output (Raise/Lower and Enable/Disable Commands)	0XXXX
6	Write Single Register (Enter Setpoint Directly)	4XXXX
8	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	Code Sent	Description
	Message	To Master	
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 5009XT 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

5009XT Control Modbus Addresses

The Modbus communication ports in the 5009XT 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 5009XT 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 5009XT. 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

A complete list of all Modbus addresses is found in Appendix D.

Boolean Writes (Holding Coils)

Holding coils are logical signals that are both readable from and writable to the 5009XT 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 5009XT 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 D-1.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writable to, the 5009XT 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 5009XT control supports Modbus function code 2, which involves reading selected input coils. The input coils available are listed in Table D-2.

Analog Reads (Input Registers)

Input registers are analog values that are readable from, but not writable to, the 5009XT 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 5009XT Service mode for defaulted communication constants and ranges. The 5009XT control supports Modbus function code 4, which involves reading selected input registers. The input registers available are listed in Table D-3.

Analog Writes (Holding Registers)

Holding registers are analog values that are writable to the 5009XT 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 5009XT 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 D-4.

Last Turbine Trip Cause

The cause of the last turbine trip (address 3:0089) is an integer that represents the Event ID found in Appendix C.

5009XT Controlling Parameters

The controlling status parameter messages that appear on the display of the 5009XT 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 5009XT to support 'legacy' messaging so that customers replacing old 5009XT'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 5009XT, it is a subset of the information available on the new addresses.

Table 6-7. 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)	
5009XT Control Parameter		(3:0001)
5009XTE Control Parameter 1		(3:0070)
5009XTE Control Parameter 2		(3:0071)

The controlling parameter status of the 5009XT 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 6-8. Analog Read Register (3:0143) 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 6-9. Analog Read Register (3:0144) 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	Extraction	23	Remote Inlet / Exhaust
4	Remote Speed / Extraction	24	Inlet / Exhaust
5	Speed / Remote Extraction	25	Remote Inlet / Remote Exhaust
6	Speed / Extraction	26	Inlet / Remote Exhaust
7	Remote Speed / Remote Inlet	27	Remote Inlet / Exhaust
8	Remote Speed / Inlet	28	Inlet / Exhaust
9	Speed / Remote Inlet	29	Remote Speed Only
10	Speed / Inlet	30	Speed Only
11	Remote Extraction / Remote Inlet	31	Remote Extraction Only
12	Extraction / Remote Inlet	32	Extraction Only
13	Remote Extraction / Inlet	33	Remote Inlet Only
14	Extraction / Inlet	34	Inlet Only
15	Remote Speed / Remote Exhaust	35	Remote Exhaust Only
16	Remote Speed / Exhaust	36	Exhaust Only
17	Speed / Remote Exhaust		
18	Speed / Exhaust		
19	Remote Extraction / Remote Exhaust		
20	Exhaust		
	Extraction / Remote Exhaust		
	Remote Extraction / Exhaust		

Table 6-10. Analog Read register (3:0145) 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 6-11. 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 HP Valve Limiter and LP Valve	9	Auto Start Sequence
27	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 3:0207—0218 give the configuration value of the analog inputs in order. The configuration for the analog inputs are defined by the Table B-1 found in Appendix B.

Analog Read addresses 3:0219—0222 give the configuration value of the analog outputs in order. The configuration for the analog outputs are defined by the Table B-2 found in Appendix B.

Analog Read addresses 3:0223—0234 give the configuration value of the relays in order. The configuration for the relays are defined by the Table B-4 found in Appendix B.

Analog Read addresses 3:0235—0257 give the configuration value of the contact inputs 2 thru 24 in order. The configuration for the contact inputs are defined by the Table B-3 found in Appendix B.

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 5009XT 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 5009XT 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 **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

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

Product Service Options

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

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

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in "like-new" condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- Return authorization number
- Name and location where the control is installed
- Name and phone number of contact person
- Complete Woodward part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

Packing a Control

Use the following materials when returning a complete control:

- Protective caps on any connectors
- Antistatic protective bags on all electronic modules
- Packing materials that will not damage the surface of the unit
- At least 100 mm (4 inches) of tightly packed, industry-approved packing material
- A packing carton with double walls
- A strong tape around the outside of the carton for increased strength

NOTICE

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

Replacement Parts

When ordering replacement parts for controls, include the following information:

- The part number(s) (XXXX-XXXX) that is on the enclosure nameplate
- The unit serial number, which is also on the nameplate

Engineering Services

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

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: www.woodward.com.

Contacting Woodward's Support Organization

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

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

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

Products Used in Engine Systems

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

Products Used in Industrial Turbomachinery Systems

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

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name

Site Location

Phone Number

Fax Number

Prime Mover Information

Manufacturer

Turbine Model Number

Type of Fuel (gas, steam, etc.)

Power Output Rating

Application (power generation, marine,
etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Symptoms

Description

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Revision History

Revision A—

- Replaced CAN Digital Drivers section in Chapter 1
- Added Table 1-3a. revised Table 1-3b
- Replaced Figure 1-17a and added Figure 1-17b
- Replaced LED Table 1-4 and paragraph immediately below in Chapter 1

We appreciate your comments about the content of our publications.

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Please reference publication **35135V1**.



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