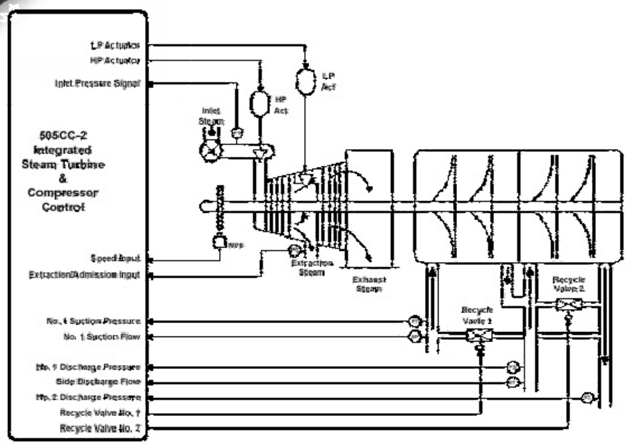
WOODWARD

Product Manual 26542V2
(Revision D, 10/2014)
Original Instructions



505CC-2 Atlas-II™
Steam Turbine and Compressor Control

Steam Turbine Control Manual
Part Number 8301-1258

Volume 2

General Precautions	**Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.** **Practice all plant and safety instructions and precautions.** **Failure to follow instructions can cause personal injury and/or property damage.**

Revisions	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:** www.woodward.com/publications **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

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

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 Out-of-date translations are marked with ⚠.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

Contents

Contents

Contents

Contents

Contents

Illustrations and Tables

Illustrations and Tables

Warnings and Notices

Important Definitions

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

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

WARNING

Overspeed / Overtemperature / Overpressure

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

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

WARNING

Personal Protective Equipment

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

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

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

WARNING

Start-up

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

WARNING

Automotive Applications

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

NOTICE

Battery Charging Device

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

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Chapter 1.
General Information

> **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 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.**

1.2 Introduction

The 505CC-2 is a steam and compressor control designed for use on a single- or two-valve steam turbine driving a one- or two-loop dynamic compressor. This is volume 2 of the 26542 Woodward 505CC-2 Atlas-II™ manual. The manual encompasses three separate volumes:

- **Volume 1—**Provides information on the Commissioning Configuration software Tools (CCT), hardware interface, such as a description of the Atlas-II platform, modules, I/O interfaces used, installation, maintenance, and troubleshooting.
- **Volume 2—**Provides information on steam turbine control, configuration, service, and run mode configuration and settings.
- **Volume 3—**Provides information on compressor control, configuration, service, and run mode configuration and settings.

This volume is dedicated to the compressor control describing compressor control functionality, configuration, service, and run mode settings.

The 505CC-2 manual does not contain instruction for the operation of the complete turbine and compressor systems. For turbine, compressor, or plant operating instructions, contact the plant-equipment manufacturer.

1.1 Quick Start Guide

The following links provide shortcuts to pertinent information within this manual required of a typical installation. However, they are not intended to replace comprehensive understanding of the 505CC-2 and its functionality, it is still recommended to read and understand the manual fully.

Topic	Location (manual 26542)
Physical Installation / Wiring	Volume 1, Chapter 2
Software / System Configuration	Volume 1, Chapter 8
Modbus® *	Volume 1, Chapter 7
Security / Login Passwords	Volume 1, Chapter 8
Turbine Configuration Mode	Volume 2, Chapter 4
Turbine Service Mode	Volume 2, Chapter 5
Turbine Run Mode	Volume 2, Chapter 6
Compressor Configuration Mode	Volume 3, Chapter 4
Compressor Service Mode	Volume 3, Chapter 5
Compressor Run Mode	Volume 3, Chapter 6

*—Modbus is a trademark of Schneider Automation Inc.

Chapter 2.
Turbine Control Description

2.1 Introduction

The 505CC-2 is designed to control single-valve, as well as extraction, extraction/admission, or admission steam turbines. 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 difference between the single-valve turbine and the latter two-valve 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 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 and will have a stop valve or Trip & Throttle Valve in the low-pressure line to prevent steam from entering the turbine when the unit is tripped.

An extraction/admission turbine will allow low-pressure header steam to enter or exit the turbine depending on system pressures.

The 505CC-2 controls turbine speed via a PID (Proportional-Integral-Derivative) controller. Likewise, a second PID controller is provided for extraction and/or admission steam pressure control for two-valve turbines.

If a turbine decoupling mode is selected, more PID controllers are provided for inlet and exhaust steam pressure control. The outputs of these controllers are sent to a ratio limiter, where the HP and LP Valve demands are calculated according to the configured steam map and decoupling option.

In addition, another controller, in a cascade control scheme, can manipulate the speed setpoint, providing external process control through turbine speed. The cascade process variable may be an internal value from the compressor control, e.g. discharge pressure, suction pressure, flow, or from an external source, 4–20 mA input.

All PID setpoints may alternatively be received from a remote device through a configurable 4–20 mA analog input.

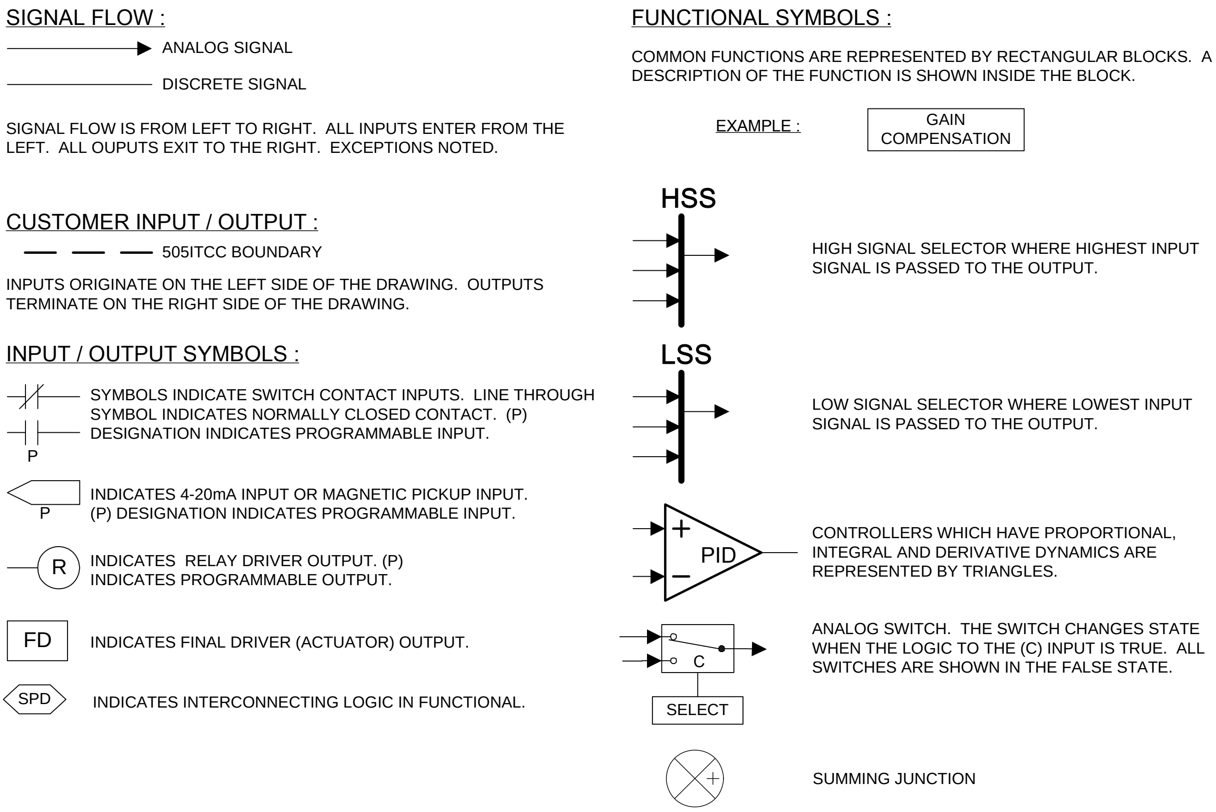


Figure 2-1. Overview of 505CC-2 Control Functionality Notes

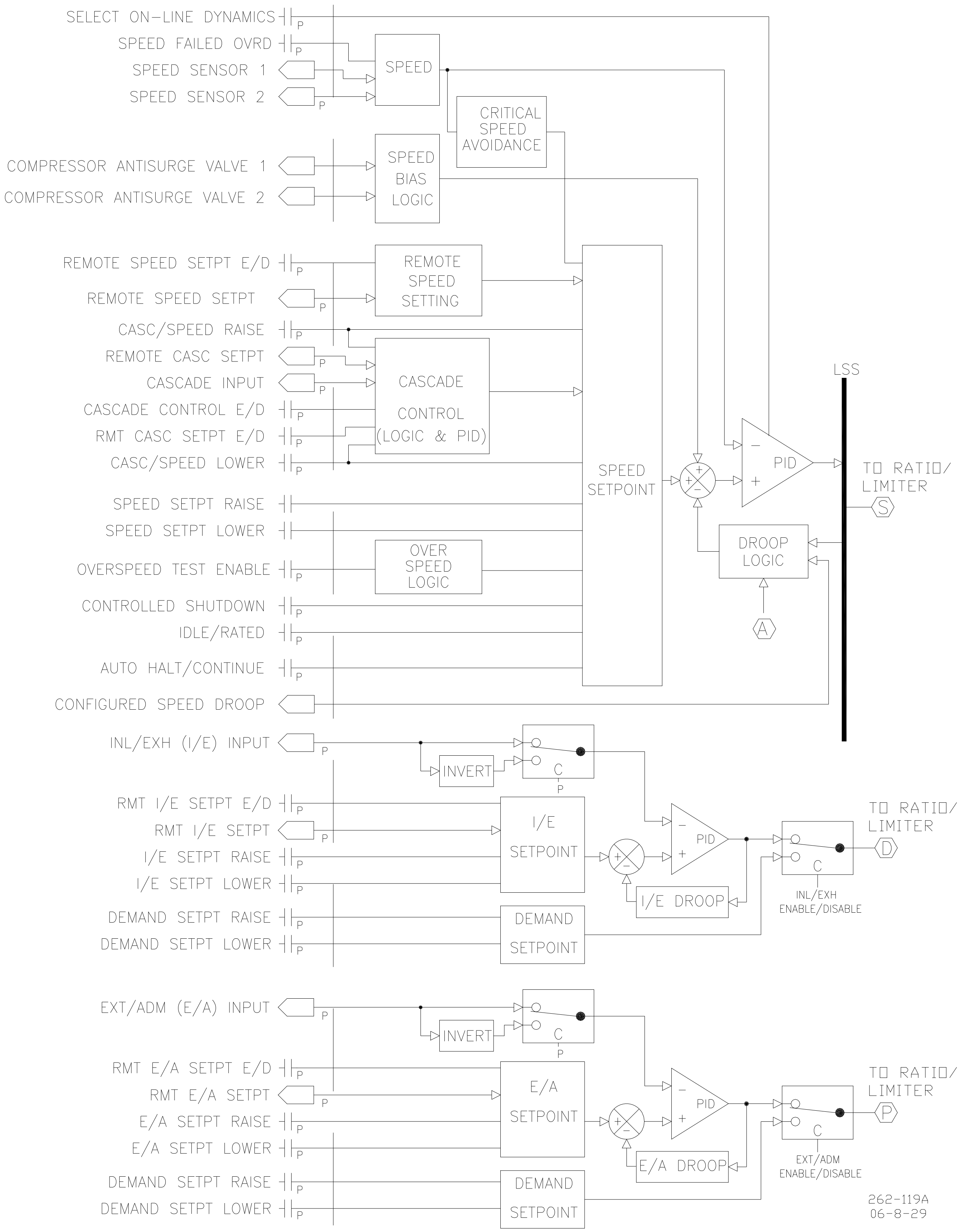


Figure 2-2. Overview of 505CC-2 Turbine Control Functionality

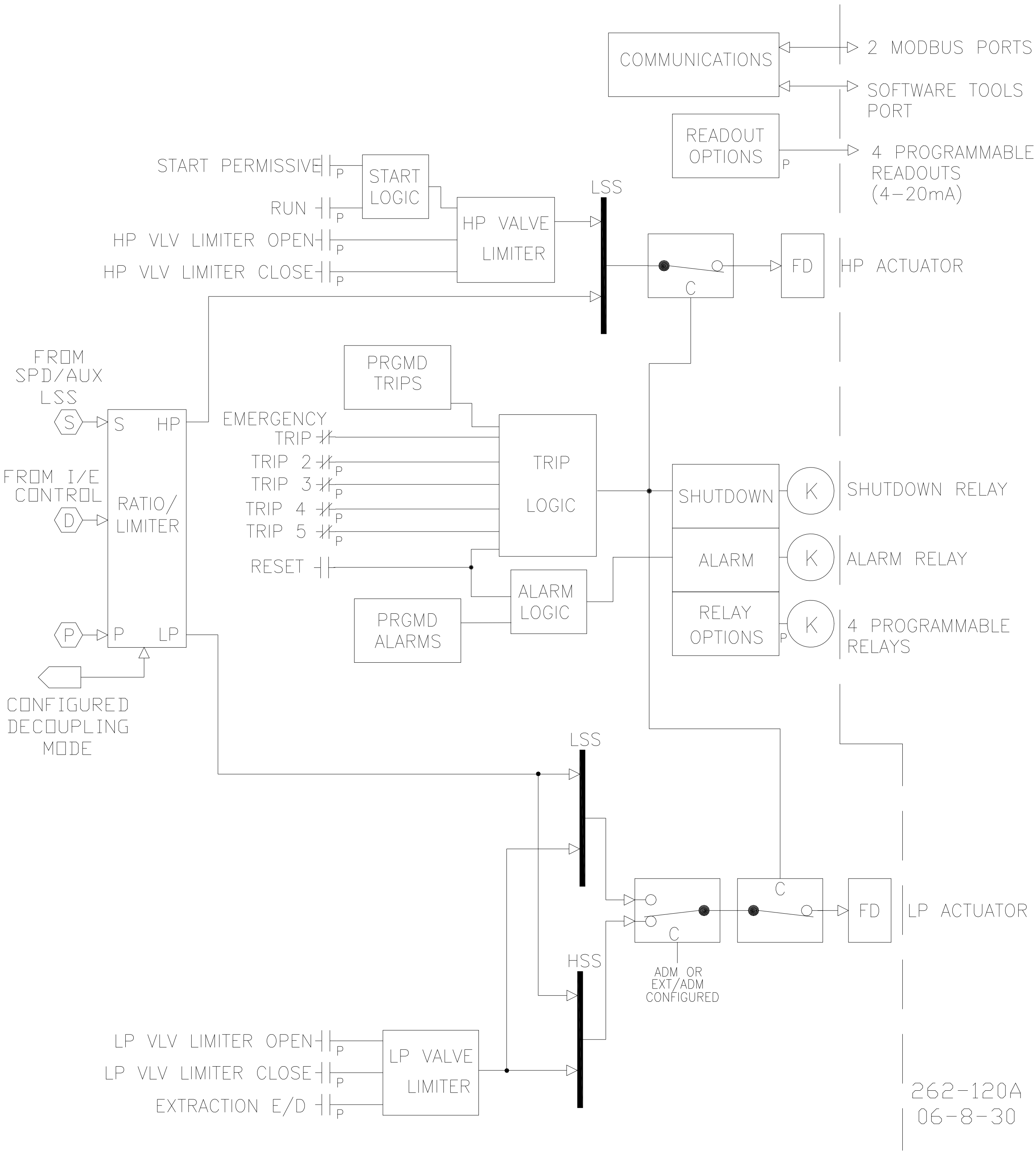


Figure 2-3. Overview of 505CC-2 Turbine Control Functionality

2.2 Extraction Turbines

The 505CC-2 can be configured to operate single automatic extraction turbines by controlling the interaction of the governor (HP or high pressure) valve and the extraction (LP or low pressure) valve. (The 505CC-2 can also operate the governor valve and the first extraction valve of multiple extraction turbines).

Single automatic extraction turbines have a high-pressure stage and a low-pressure stage, each controlled by a valve. Steam enters the turbine through the HP Valve (see Figure 2-1). At the downstream end of the HP turbine stage and before the LP Valve, steam can be extracted. The LP Valve controls the entry of steam into the LP turbine stage, and the diverting of steam through the extraction line. As the LP Valve is opened, more steam enters the LP stage and less is extracted.

In most cases, the operator of an extraction turbine needs to maintain both turbine speed/load and extraction pressure/flow at constant levels. Changing the position of either the HP Valve or the LP Valve affects both turbine speed/load and extraction. If either the load on the turbine or the extraction demand changes, both the HP Valve position and the LP Valve position must be changed to maintain speed/load and extraction. The movement of both valves is automatically calculated by the 505CC-2’s ratioing logic, based on the turbine performance parameters, to minimize valve/process interaction.

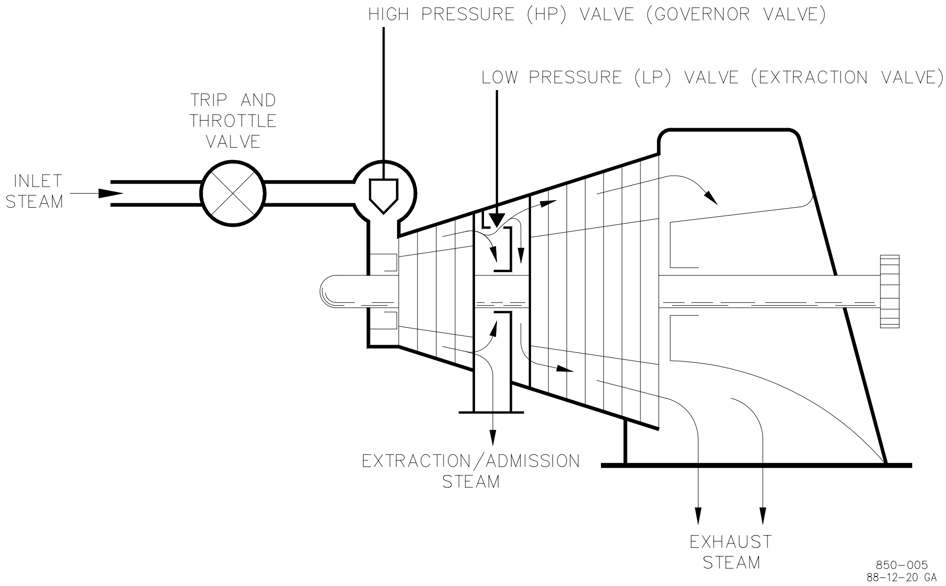


Figure 2-4. Typical Extraction or Extraction/Admission Steam Turbine

2.3 Admission Turbines

The 505CC-2 can be configured to operate single automatic admission turbines by controlling the interaction of the governor (HP or high pressure) valve and the admission (LP or low pressure) valve.

Single automatic admission turbines have a high-pressure stage and a low-pressure stage, each controlled by a valve. Steam enters the turbine through the HP Valve (see Figure 2-4) and, at the downstream end of the HP turbine stage, through the LP Valve. The LP Valve controls the entry of steam into the LP turbine stage and through the admission line. As the LP Valve is opened, more steam enters the LP stage.

In most cases, the operator of an admission turbine needs to maintain both turbine speed/load and admission pressure/flow at constant levels. Changing the position of either the HP Valve or the LP Valve affects both turbine speed/load and admission. If either the load on the turbine or the admission demand changes, both the HP Valve position and the LP Valve position must be changed to maintain speed/load and admission.

The movement of both valves is automatically calculated by the 505CC-2's ratioing logic, based on the turbine performance parameters, to minimize valve/process interaction.

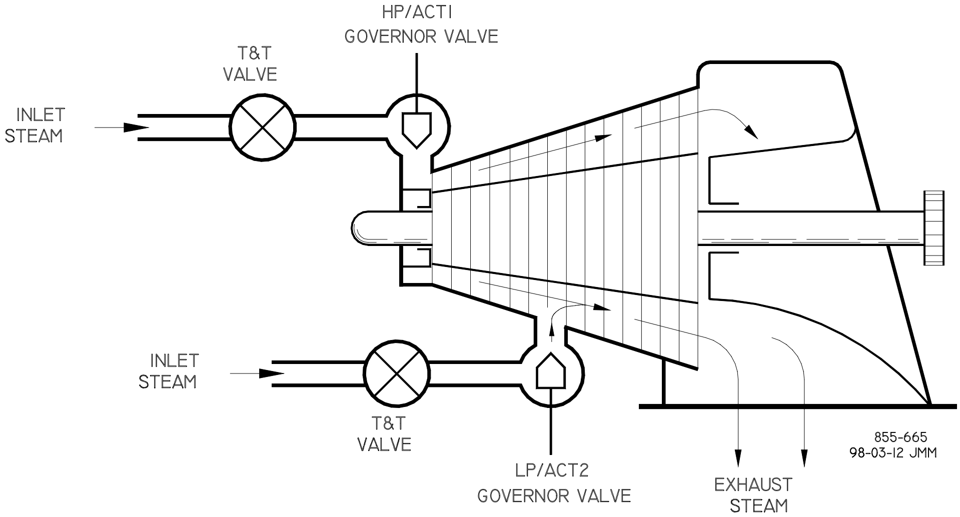


Figure 2-5. Typical Admission Steam Turbine

2.4 Extraction and Admission Turbines

The 505CC-2 can be configured to operate single automatic extraction and admission turbines by controlling the interaction of the governor (HP or high pressure) valve and the extraction (LP or low pressure) valve.

Single automatic extraction/admission turbines have a high-pressure stage and a low-pressure stage, each controlled by a valve. Steam enters the turbine through the HP Valve (see Figure 2-5). At the downstream end of the HP turbine stage and before the LP Valve, steam can either be extracted or admitted (inducted) into the LP turbine stage. The LP Valve controls the entry of steam into the LP turbine stage. As the LP Valve is opened, more steam enters the LP stage and less is extracted.

In most cases, the operator of an extraction/admission turbine needs to maintain both turbine speed/load and extraction/admission pressure/flow at constant levels. Changing the position of either the HP Valve or the LP Valve affects both turbine speed/load and extraction/admission. If either the load on the turbine or the extraction/admission demand changes, both the HP Valve position and the LP Valve position must be changed to maintain speed/load and extraction/admission. The movement of both valves is automatically calculated by the 505CC-2's ratioing logic, based on the turbine performance parameters, to minimize valve/process interaction.

2.5 Speed Control

The speed control receives a turbine speed signal from one or two magnetic pickups (MPUs) or proximity probes. The frequency input is converted to speed by the following equation:

$$\text{Speed (rpm)} = \frac{\text{Frequency Input (Hz)}}{\text{Number of Teeth} * \text{Gear Ratio} * 0.016667}$$

Number of Teeth and Gear Ratio are configured into the control during commissioning. The maximum frequency sensed by the 505CC-2's speed inputs is 25,000 Hz. And, the maximum speed, an internal limit used by the control, is calculated as 105% of the configured Overspeed Test Limit. Therefore, the following rule applies to the Gear Ratio and Number of Teeth:

$$\frac{\text{Max Speed (rpm)} * \text{Gear Ratio} * \text{Number of Teeth}}{60} < 25000\ \text{(Hz)}$$

$$\frac{\text{Overspeed Test Limit (rpm)} * 1.05 * \text{Gear Ratio} * \text{Number of Teeth}}{60} < 25000\ \text{(Hz)}$$

$$\text{Gear Ratio} * \text{Number of Teeth} < \frac{25000\ \text{(Hz)} * 60}{\text{Overspeed Test Limit (rpm)} * 1.05}$$

If this condition is not met, the largest measured speed will be:

$$\text{Speed (rpm)} = \frac{25{,}000}{\text{Number of Teeth} * \text{Gear Ratio} * 0.016667}$$

IMPORTANT

If both speed inputs are utilized (two separate probes), they must be mounted on the same gear--The Teeth Seen by MPU and Gear Ratio settings, used to calculate actual turbine speed, are common for both inputs.

The Speed PID then compares this signal to the speed setpoint to generate an output signal to the Ratio-Limiter. The 505CC-2 Speed PID operates in a Speed control mode at all times, which means that the Speed PID will control the turbine at the same speed regardless of the load it is supplying (up to the unit's load capability).

Supplemental Speed PID features include a configurable droop mode, based upon Speed PID demand feedback, which may be needed to prevent process instabilities (extraction pressure) when using the Inlet/Speed Decoupling mode.

In addition, two bias signals from the compressor control (one for each compressor) may be configured to interact with the speed controller. These bias signals, proportional to movement in the compressor's anti-surge valves, may be used to decrease any adverse interaction between the compressor control and the steam turbine control.

2.5.1 Speed Setpoint (Speed Reference)

The speed control's setpoint is adjustable with raise or lower commands from the CCT, remote contact inputs, or Modbus. The setpoint can also be directly entered from the CCT or through Modbus. In addition, a 4–20 mA analog input may be configured for Remote Speed Setpoint, allowing an external device, e.g. DCS, PLC, to remotely set the speed setpoint. As discussed later in this chapter, the Cascade PID, if configured, will also directly affect the speed setpoint.

The speed setpoint's normal range is defined by the turbine's normal operating range between Minimum Governor and Maximum Governor, both of which are configurable on the turbine speed control configuration screen. The speed setpoint cannot be raised above Maximum Governor unless an Overspeed Test is performed. Once the speed setpoint is above Minimum Governor, it cannot go below it again unless Idle is commanded or a Controlled Stop is initiated.

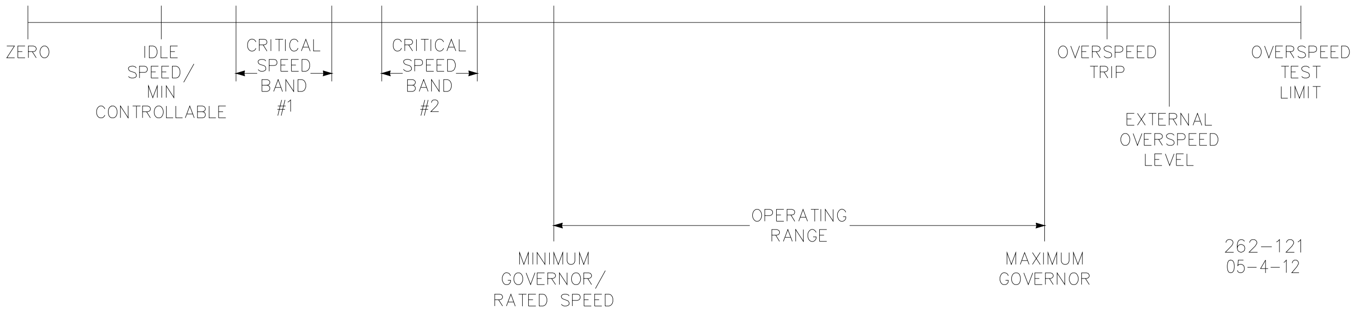


Figure 2-6. Speed Setpoint Relationships

Above Minimum Governor, the speed setpoint may be adjusted through discrete raise and lower commands. When a Raise/Lower command is issued, the setpoint moves at the configured Default Rate. If a Raise/Lower command is held for the configured Fast Rate Delay time, the setpoint will begin to ramp at the configured Fast Rate. Whether from the CCT, remote contact inputs, or Modbus, the Raise/Lower commands are received as toggles. That is to say, the setpoint will ramp as long as the command is active.

⚠WARNING **The user should consider some appropriate engineering solution if there is any failure mode for the contact inputs or Modbus commands that might keep them active unintentionally.**

The speed setpoint may be specified directly by entering the desired value through the CCT. This value must be below Maximum Governor and above Idle (or Minimum Controllable) and not within a critical speed band. Once the speed reference is above Minimum Governor, the entered setpoint cannot be set below Minimum Governor. Likewise, a value can be entered directly via Modbus. However, the allowable range is between Minimum and Maximum Governor. In either case, the reference will ramp to the entered value if it is within these prescribed limits. If the entered value is outside of these limits, it will not be accepted.

If Remote Speed Setpoint is enabled, the reference will ramp at the configured Remote Rate. CCT and Modbus entered setpoints will ramp at the configured Default Rate.

These four setpoint sources are prioritized in descending order as Remote 4–20 mA, CCT, Modbus 1, and Modbus 2, i.e. the Remote 4–20 mA signal has the highest priority. If Remote Speed Setpoint is enabled, all other speed setpoint commands, Raise/Lower, CCT or Modbus entered setpoint, are inhibited.

The compressor control maintains compressor operation to the right of its surge control line, but compressor flow is proportional to speed. Therefore, when operating on the control line, any decrease in speed could inadvertently drive the compressor into surge by reducing flow. Direct setpoint speed reference entry lower commands and remote speed setpoint are inhibited when compressor operation is on or near its control line. Boolean speed lower commands from the CCT, discrete input, or Modbus are still permitted for operational flexibility.

All pertinent speed control parameters are available through Modbus. See Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.5.2 Remote Speed Setpoint

One of the configurable 4–20 mA analog inputs can be assigned to remotely position the speed reference. Typically, some process control external to the 505CC-2, e.g. PLC, DCS may interface with this input to regulate the turbine's speed or load to control a related process.

The Remote Speed Setpoint function may be enabled and disabled from the CCT, remote contact input, or Modbus. The last command given from any of these three sources dictates the enabled/disabled state. If the contact input is used, Remote Speed Setpoint is disabled when the contact is open and enabled when closed. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to enable Remote Speed Setpoint. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled. The Remote Rate dictates the rate at which the analog input will position the speed reference.

The minimum (4 mA) and maximum (20 mA) engineering unit values for this analog input should normally be configured as (or within) Minimum and Maximum Governor. The analog signal is limited accordingly, regardless of the upper and lower range values of the input. If the milliamp signal to the Remote Speed Setpoint input is out of range, defaulted to 2–22 mA, an alarm is generated and Remote Speed Setpoint is disabled and inhibited until the input signal is corrected. Remote Speed must be re-enabled after the input is re-established.

Since Cascade Control also acts on the speed setpoint, it and Remote Speed Setpoint cannot be active at the same time. If Cascade is configured and active, it will be disabled as soon as Remote Speed Setpoint is enabled. Likewise, Remote Speed will automatically be disabled if Cascade is enabled. If Remote Speed Setpoint is enabled, all other speed setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited. And, as described above, remote speed setpoint is inhibited if it is decreasing while the compressor is operating on or near its control line.

2.5.3 Remote Speed Setpoint Status Messages

The Remote Speed Setpoint function may be in one of the following states as displayed on the CCT:

- Disabled;
  - The Remote Speed Setpoint function is not enabled and will have no effect on the speed reference.
- Enabled;
  - Remote Speed Setpoint has been enabled.
- Active;
  - The remote setpoint is in control of the speed reference, but the Speed PID is not in control of the actuator output.
- In Control;
  - The remote setpoint is in control of the speed reference, and the Speed PID is in control of the actuator output.
- Inhibited;
  - Remote Speed Setpoint cannot be enabled. The input signal has failed, a controlled stop is selected, a shutdown is active, or Remote Speed Setpoint is not configured.

All pertinent Remote Speed Setpoint parameters are available through Modbus. Refer to Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.5.4 Speed Control Dynamics (PID Tuning)

The 505CC-2 offers two sets of configurable dynamics for the speed PID, the second of which is available at one of three configurable switch points. The two sets of tuning parameters are termed offline and online, the latter available after reaching Minimum Governor, with Decoupling enabled, or at the switch of a configurable contact input. These dynamic variables allow the speed PID to be tuned for optimal response under varying process conditions.

If above Minimum Governor is configured as the Dual Dynamics switch point, the Speed PID's offline dynamics, or set 1, are used when turbine speed is below Minimum Governor. Conversely, the online dynamics, or set 2, are selected when turbine speed is above Minimum Governor.

Similarly, a configurable contact input may be assigned to perform this switching; the online tuning parameters are selected when the contact is closed or the online dynamics can be selected when decoupling is enabled.

A relay output can be configured to indicate when the online dynamics are selected and used by the Speed PID.

.

2.6 Cascade Control

Cascade can be configured to control any system process, related to or affected by turbine speed or load. Typically, this controller is used to regulate turbine inlet or exhaust pressure or compressor suction or discharge pressure. When Total Decoupling (No Ratioing) is configured for an extraction/admission turbine, the cascade controller is typically configured for inlet steam pressure.

The Cascade controller is a PID controller that compares a 4–20 mA process signal or internally available process variable with a setpoint. The Cascade PID adjusts the speed controller setpoint until the process variable and setpoint match. By cascading two PIDs in this fashion, a bumpless transfer between the two controlling parameters can be performed.

Cascade control may be enabled and disabled from the CCT, remote contact input, or Modbus. The last command given from any of these three sources dictates the Cascade PID's control state. If the contact input is used, Cascade is disabled when the contact is open and enabled when closed. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to enable Cascade. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

Since Cascade is a secondary speed setting function, the Speed PID must be in control in order for Cascade to take control. And, turbine speed must be greater than Minimum Governor, or Cascade Min Speed, if configured, before Cascade can be enabled. Cascade Control is inhibited if the compressor is tripped (commanded to full recycle) via the "Stage Trip" button on the compressor operating screen.

Since the speed reference is also affected by Remote Speed Setpoint, it and Cascade Control cannot be active at the same time. If Remote Speed Setpoint is configured and active, it will be disabled as soon as Cascade is enabled. Likewise, Cascade will automatically be disabled if Remote Speed is enabled.

When online, the compressor software controls compressor operation on or to the right of its control line. Compressor flow is proportional to speed. Therefore, when operating on the control line, any decrease in speed could inadvertently drive the compressor into surge by reducing flow. To prevent this undesirable effect, some speed reference lower commands, including those from the Cascade controller, are inhibited when compressor operation is on or near its control line.

2.6.1 Cascade Control Status Messages

Cascade Control may be in one of the following states as displayed on the CCT:

- Cascade Disabled;
  - Cascade control is not enabled and will have no effect on the speed reference.
- Cascade Enabled;
  - Cascade has been enabled but is not active or in control.
- Cascade Active / Not in Speed Control;
  - Cascade has been enabled but the Speed PID is not in control of the LSS bus (Valve Limiter is in control).
- Cascade In Control;
  - Cascade is in control of the LSS bus (via the Speed PID).
- Cascade Active with Remote Setpoint;
  - Cascade has been enabled and the Remote Cascade Setpoint is in control of the setpoint but the Speed PID is not in control of the LSS bus.
- Cascade in Control with Remote Setpoint;
  - Cascade is in control of the LSS bus (via the Speed PID) and the Remote Cascade Setpoint is positioning the Cascade setpoint.
- Cascade is Inhibited;
  - Cascade cannot be enabled because the Cascade input signal has failed, a controlled stop is selected, a shutdown is active, or Cascade Control is not configured.

All pertinent Cascade Control parameters are available through Modbus. Refer to Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.6.2 Cascade Setpoint (Cascade Reference)

The Cascade Control's setpoint is adjustable with raise or lower commands from the CCT, remote contact inputs, or Modbus. The setpoint can also be directly entered from the CCT or through Modbus. In addition, a 4–20 mA analog input may be configured for Remote Cascade Setpoint, allowing an external device (e.g. DCS, PLC) to remotely position the Cascade setpoint. When the 505CC-2 is powered-up, the setpoint is reset to the configured Setpoint Initial Value.

The Cascade setpoint range must be defined by Min Cascade Setpoint and Max Cascade Setpoint in the Turbine Cascade Control Configuration screen. While these parameters can be somewhat arbitrary, and are used primarily to normalize the PID to 0-100%, it is advisable that they correspond roughly to the turbine's normal operating speed range, i.e. the Cascade process variable when the turbine is at Minimum Governor (or Cascade Min Speed) and Maximum Governor under normal operating conditions. For example, if the range is set too narrow and Cascade is enabled when the process variable is well outside the setpoint range, the Cascade PID may drive its demand to 0% or 100%. And following, the speed reference may be driven to its limits.

When a Raise/Lower Cascade Setpoint command is issued, the reference moves at the configured Cascade Default Rate. If the command is held for the configured Fast Rate Delay time, the reference will begin to ramp at the configured Fast Rate. Whether from the CCT, remote contact inputs, or Modbus, the Raise/Lower commands are received as toggles. That is to say, the setpoint will ramp as long as the command is active.

⚠WARNING

The user should consider some appropriate engineering solution if there is any failure mode for the contact inputs or Modbus commands that might keep them active unintentionally.

The Cascade setpoint may be specified directly by entering the desired value through the CCT or Modbus. These entered setpoints are limited by the configured Min and Max Cascade Setpoint and will ramp at the configured Default Rate. Likewise, a configurable 4–20 mA analog input may be assigned to remotely position the Cascade setpoint. This setting will be limited by the configured Remote Min and Max Settings and will ramp at the configured Remote Rate.

These four setpoint sources are prioritized in descending order as Remote 4–20 mA, CCT, Modbus 1, and Modbus 2 (the Remote 4–20 mA signal has the highest priority). If Remote Cascade Setpoint is enabled, all other Cascade setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

2.6.3 Cascade **Setpoint Tracking**

To allow a bumpless transfer from turbine Speed/Load control to Cascade control, the Cascade PID can be configured to track its controlling process input when disabled.

When this tracking feature is programmed, the Cascade PID will be satisfied when enabled, providing a bumpless transfer to Cascade control. After enabling, the reference will ramp to the active commanded setpoint, if any, or respond to Raise/Lower commands as normal.

If Setpoint Tracking is not enabled, the reference will remain at its last setting (running or shutdown). With this configuration, when Cascade control is enabled, and the sensed process signal does not match setpoint, the Cascade PID will instantly take control and begin to move the Speed Reference. If Cascade is the controlling parameter and one of the permissives is lost or Cascade is disabled, the speed setpoint will remain at the last setting until otherwise adjusted.

2.6.4 Cascade Droop

When sharing control of a parameter with another external controller, the Cascade PID can also be configured with a droop feedback signal for control loop stability, helping prevent multiple control loops from fighting. This feedback signal is a percentage of the Cascade PID's output. If Cascade droop is used, the Cascade input signal will not match the Cascade setpoint when in control. The difference will depend on the amount (%) of droop configured and the output of the Cascade PID.

The droop value is subtracted from the normalized Cascade process variable input and is calculated as a percentage of the speed reference. In other words, after the Cascade input and setpoint are normalized as a percentage of Cascade setpoint range (Max Cascade Setpoint–Min Cascade Setpoint), droop is subtracted, itself a percentage of the current speed reference.

2.6.5 Invert Cascade Input

Depending on the control action required, the Cascade input signal can be inverted. If a decrease in speed is required to increase the Cascade process signal, such as for turbine inlet steam pressure or compressor suction pressure, Invert Cascade Input should be configured.

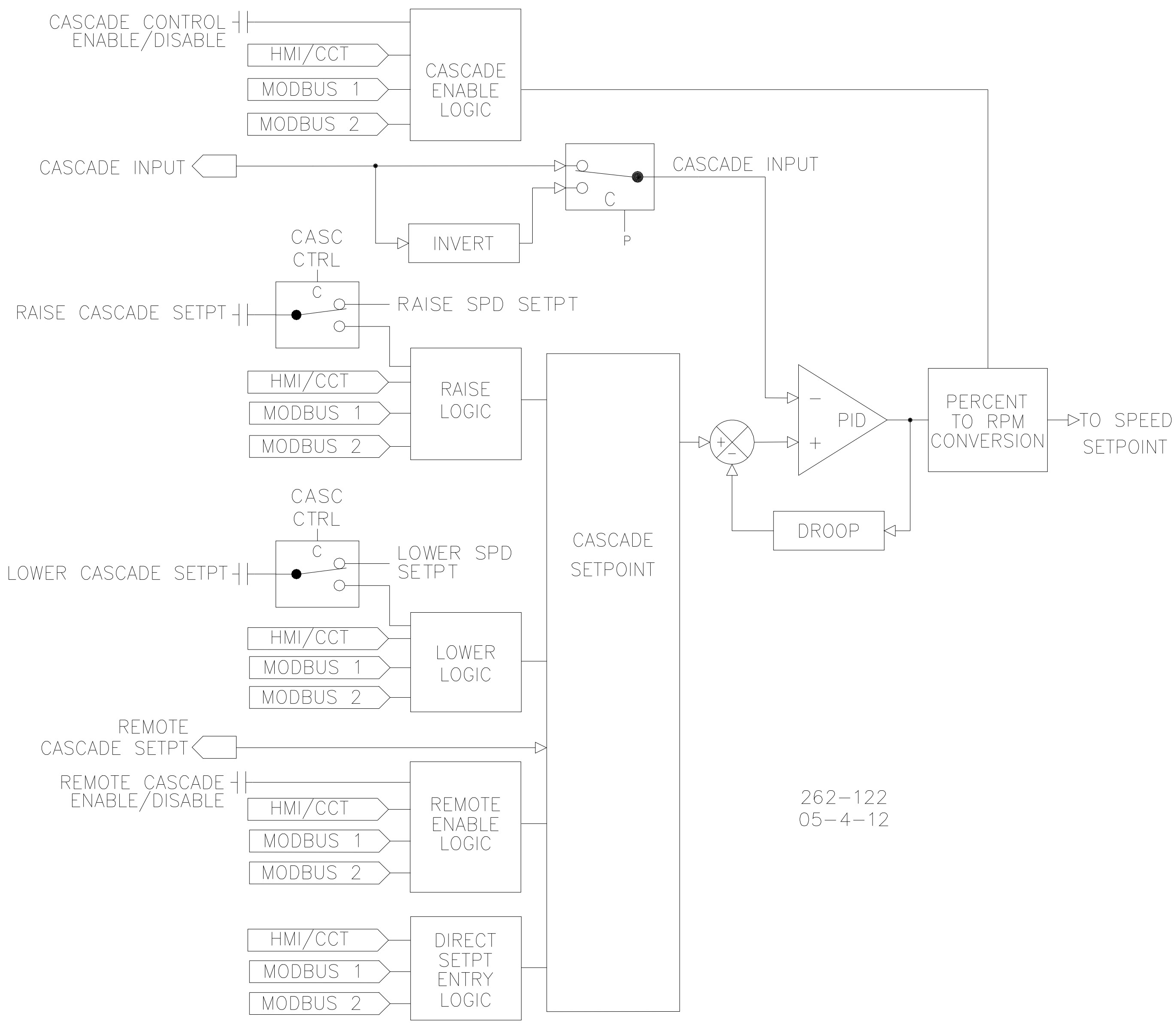


Figure 2-7. Cascade Control Functional Diagram

2.6.6 Remote Cascade Setpoint

One of the configurable 4–20 mA analog inputs can be assigned to remotely position the Cascade reference. Typically, some process control external to the 505CC-2 (e.g. PLC, DCS) may interface with this input to regulate the turbine's speed or load to control a related process in a Cascade Control scheme.

The Remote Cascade Setpoint function may be enabled and disabled from the CCT, remote contact input, or Modbus. The last command given from any of these three sources dictates the enabled/disabled state. If the contact input is used, Remote Cascade Setpoint is disabled when the contact is open and enabled when closed. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to enable Remote Cascade Setpoint. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled. The Remote Rate dictates the rate at which the analog input will position the Cascade reference.

The minimum (4 mA) and maximum (20 mA) engineering unit values for this analog input should normally be configured as (or within) the configured Cascade Remote Min Setting and Remote Max Setting. The analog signal is limited accordingly, regardless of the upper and lower range values of the input. If the milliamp signal to the Remote Cascade Setpoint input is out of range (defaulted to 2–22 mA) an alarm is generated and Remote Cascade Setpoint is disabled and inhibited until the input signal is corrected. Remote Cascade must be re-enabled after the input is re-established.

Since Cascade Control also acts on the speed setpoint, it and Remote Speed Setpoint cannot be active at the same time. If Cascade is configured and active, it will be disabled as soon as Remote Speed Setpoint is enabled. Likewise, Remote Speed will automatically be disabled if Cascade is enabled. If Remote Cascade Setpoint is enabled, all other Cascade setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

2.6.7 Remote Cascade Setpoint Status Messages

Remote Cascade Setpoint may be in one of the following states as displayed on the CCT:

- Disabled
  - The Remote Cascade Setpoint function is not enabled and will have no effect on the Cascade setpoint.
- Enabled
  - Remote Cascade Setpoint has been enabled but Cascade Control is not active. Speed is less than Minimum Governor or Cascade has not taken control.
- Active
  - The remote setpoint has been enabled but Cascade is not in control. Cascade has been enabled, and the Remote Cascade Setpoint is in control of the reference, but the Speed PID is not in control (Valve Limiter is in control).
- In Control
  - Cascade is in control (via the Speed PID) and the Remote Cascade Setpoint is positioning the Cascade reference.
- Inhibited
  - Remote Cascade Setpoint cannot be enabled because the remote setpoint input signal is failed, the Cascade process variable input signal is failed, a controlled stop is selected, a shutdown is active, or Remote Cascade Setpoint is not configured.

2.6.8 Cascade Control Dynamics (PID Tuning)

The Cascade PID control uses its own set of tuning parameters. These values are configurable and may be tuned at any time.

2.7 Extraction and/or Admission Control

The Extraction/Admission controller receives an Extraction/Admission pressure or flow signal from a field transmitter via 4–20 mA Analog Input. The Extraction/Admission PID then compares this signal to the setpoint, generating an output to the Ratio-Limiter. The ratio logic ratios this input with a similar speed demand input and, based on the turbine performance parameters, produces two output signals. One output to control the HP Valve and one to control the LP Valve. The limiter logic restricts the valve demands within the boundaries of the turbine steam map.

Extraction/Admission control may be enabled and disabled from the CCT, remote contact input, or Modbus. The last command given from any of these three sources dictates the Extraction/Admission PID's control state. If the contact input is used, Extraction/Admission is disabled when the contact is open and enabled when closed. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to enable Extraction/Admission. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

2.7.1 Extraction/Admission Control Status Messages

Extraction/Admission Control may be in one of the following states as displayed on the CCT:

- Disabled;
  - Extraction/Admission control is not enabled and will have no effect.
- Enabled;
  - Extraction/Admission has been enabled but is not active or in control.
- Active / Not in Control;
  - Extraction/Admission has been enabled but the turbine is on an operating limit with speed priority or the LP Valve Limiter is limiting Extraction/Admission PID output.
- In Control;
  - Extraction/Admission PID is in control of its process.
- Active with Remote Setpoint;
  - Extraction/Admission has been enabled and the Remote Extraction/Admission setpoint is in control of the setpoint, but the turbine is on a operating limit with speed priority or the LP Valve Limiter is limiting Extraction/Admission PID output.
- In Control with Remote Setpoint;
  - Extraction/Admission is in control and the Remote Extraction/Admission setpoint is positioning the Extraction/Admission reference.
- Inhibited;
  - Extraction/Admission cannot be enabled because the Extraction/Admission input signal has failed, the Inlet/Exhaust pressure input has failed in Total Decoupled mode (if configured), speed is below Minimum Governor, a controlled stop is selected, or a shutdown is active.

2.7.2 Extraction/Admission Setpoint (Extraction/Admission Reference)

The Extraction/Admission setpoint is adjustable with raise or lower commands from the CCT, remote contact inputs, or Modbus. The setpoint can also be directly entered from the CCT or Modbus. In addition, a 4–20 mA analog input may be configured for Remote Extraction/Admission Setpoint, allowing an external device (e.g. DCS, PLC) to remotely set the Extraction/Admission setpoint. When the 505CC-2 is powered-up, the setpoint is reset to the configured Setpoint Initial Value.

The Extraction/Admission setpoint range must be defined by Min Extraction/Admission Setpoint and Max Extraction/Admission Setpoint in the Turbine Extraction/Admission Control Configuration screen. While these parameters can be somewhat arbitrary, and are used primarily to normalize the PID to 0-100%, it is advisable that they correspond roughly to the turbine's normal operating speed range—that is, the Extraction/Admission process variable when the turbine is at Minimum Governor and Maximum Governor under normal operating conditions.

When a Raise/Lower Extraction/Admission Setpoint command is issued, the reference moves at the configured Extraction/Admission Default Rate. If the command is held for the configured Fast Rate Delay time, the reference will begin to ramp at the configured Fast Rate. Whether from the CCT, remote contact inputs, or Modbus, the Raise/Lower commands are received as toggles. That is to say, the setpoint will ramp as long as the command is active.

WARNING — **The user should consider some appropriate engineering solution if there is any failure mode for the contact inputs or Modbus commands that might keep them active unintentionally.**

The Extraction/Admission setpoint may be specified directly by entering the desired value through the CCT or Modbus. These entered setpoints are limited by the configured Min and Max Extraction/Admission Setpoint and will ramp at the configured Default Rate. Likewise, a configurable 4–20 mA analog input may be assigned to remotely position the Extraction/Admission setpoint. This setting will be limited by the configured Remote Min and Max Settings and will ramp at the configured Remote Rate.

These four setpoint sources are prioritized in descending order as Remote 4–20 mA, CCT, Modbus 1, and Modbus 2 (the Remote 4–20 mA signal has the highest priority). If Remote Extraction/Admission Setpoint is enabled, all other Extraction/Admission setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

2.7.3 Extraction/Admission Setpoint Tracking

To reduce the number of steps required to enable Extraction/Admission control bumpless, the Extraction/Admission setpoint can be programmed to track the Extraction/Admission process input when disabled. With Extraction/Admission Setpoint Tracking configured, the Extraction/Admission PID will be satisfied when enabled, thus there is no immediate or radical process correction required. After enabling, the reference will ramp to the active commanded setpoint, if any, or respond to Raise/Lower commands as normal.

If Setpoint Tracking is not configured, the reference will remain at its last setting (running or shutdown). When Extraction/Admission control is enabled, and the sensed process signal does not match setpoint, the Extraction/Admission PID will instantly take control and begin to move the pressure demand signal. If one of the permissives is lost or Extraction/Admission is disabled, the Extraction/Admission reference will remain at the last setting until otherwise adjusted.

All pertinent Extraction/Admission control parameters are available through Modbus. See Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

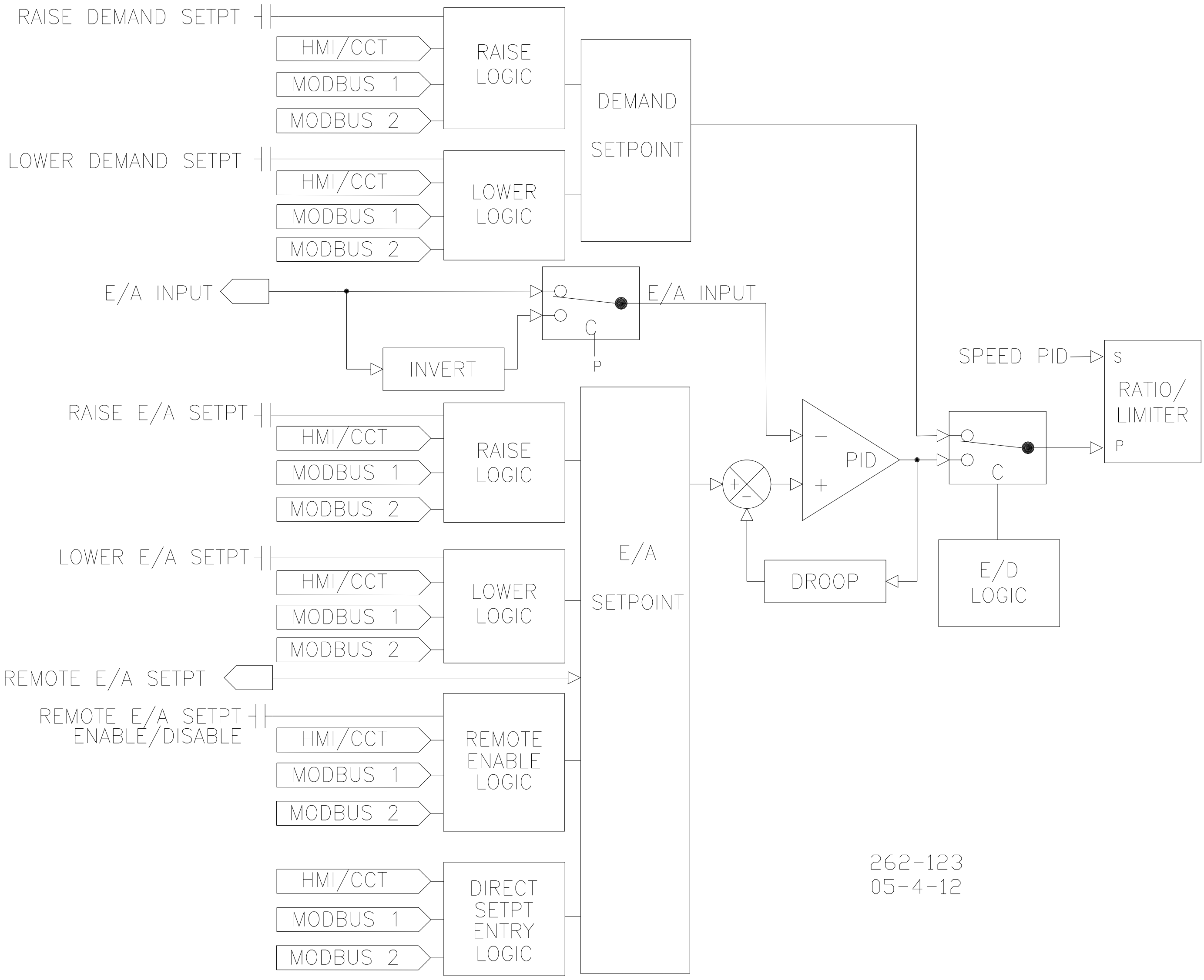


Figure 2-8. Extraction/Admission Control Functional Diagram

2.7.4 Extraction/Admission Droop

When sharing control of a parameter with another external controller, the Extraction/Admission PID can also be configured with a droop feedback signal for control loop stability, helping prevent multiple control loops from *fighting*. This feedback signal is a percentage of the Extraction/Admission PID's output. If Extraction/Admission droop is used, the Extraction/Admission input signal will not match the Extraction/Admission setpoint when in control. The difference will depend on the amount (%) of droop configured and the output of the Extraction/Admission PID.

The droop value is subtracted from the normalized Extraction/Admission process variable input and is calculated as a percentage of the Ratio-Limiter pressure demand (P-demand). In other words, after the Extraction/Admission input and setpoint are normalized as a percentage of Extraction/Admission setpoint range (Max Extraction/Admission Setpoint–Min Extraction/Admission Setpoint), droop is subtracted, itself a percentage of the current P-demand.

2.7.5 Invert Extraction/Admission Input

Depending on the control action required, the Extraction/Admission input signal can be inverted. If a decrease in valve position is required to increase the Extraction/Admission process signal, such as for typical admission turbines, Invert Extraction/Admission Input should be configured.

If the Extraction/Admission input signal fails (defaulted to 2–22 mA) during operation, the 505CC-2 can be configured to trip, continue running and ramp the LP Valve to its open limit, continue running and ramp the LP Valve to its closed limit, or switch directly to Manual Pressure (Flow) Demand control.

2.7.6 Remote Extraction/Admission Setpoint

One of the configurable 4–20 mA analog inputs can be assigned to remotely position the Extraction/Admission reference. Typically, some process control external to the 505CC-2 (e.g. PLC, DCS) may interface with this input to regulate the turbine's Extraction/Admission pressure.

The Remote Extraction/Admission Setpoint function may be enabled and disabled from the CCT, remote contact input, or Modbus. The last command given from any of these three sources dictates the enabled/disabled state. If the contact input is used, Remote Extraction/Admission Setpoint is disabled when the contact is open and enabled when closed. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to enable Remote Extraction/Admission Setpoint. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled. The Remote Rate dictates the rate at which the analog input will position the Extraction/Admission reference.

The minimum (4 mA) and maximum (20 mA) engineering unit values for this analog input should normally be configured as (or within) the configured Remote Minimum Extraction/Admission Setting and Maximum Extraction/Admission Setting. The analog signal is limited accordingly, regardless of the upper and lower range values of the input. If the milliamp signal to the Remote Extraction/Admission Setpoint input is out of range (defaulted to 2–22 mA) an alarm is generated and Remote Extraction/Admission Setpoint is disabled and inhibited until the input signal is corrected. Remote Extraction/Admission must be re-enabled after the input is re-established.

If Remote Extraction/Admission Setpoint is enabled, all other Extraction/Admission setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

2.7.7 Remote Extraction/Admission Setpoint Messages

Remote Extraction/Admission Setpoint may be in one of the following states as displayed on the CCT:

- Disabled
    - Remote Extraction/Admission Setpoint is disabled and will have no effect on the Extraction/Admission setpoint.
- Enabled
    - Remote Extraction/Admission Setpoint has been enabled, but permissives are not met.
- Active
    - Remote Extraction/Admission Setpoint has been enabled, and permissives are met, but the Extraction/Admission PID is not in control.

- In Control
  - o Remote Extraction/Admission Setpoint is in control of the Extraction/Admission setpoint, and the Extraction/Admission PID is in control.
- Inhibited
  - o Remote Extraction/Admission Setpoint cannot be enabled because the remote setpoint input signal is failed, a controlled stop is selected, a shutdown is active, or Remote Extraction/Admission Setpoint is not configured.

2.7.8 Extraction/Admission Control Dynamics (PID Tuning)

The Extraction/Admission PID uses its own set of tuning parameters. These values are configurable and may be tuned at any time.

2.7.9 Extraction/Admission Manual Pressure (Flow) Demand

In some instances, it is not necessary the control the Extraction/Admission pressure (flow) on an Extraction/Admission turbine, such as when using only Inlet Pressure/Exhaust Pressure control (see Decoupling). In this case, by configuring Extraction By-Pass, the Extraction/Admission pressure (flow) demand can be controlled in manual mode. This Manual Pressure (Flow) Demand control mode is also available if the Extraction/Admission pressure (flow) sensor fails while online.

The Manual Pressure (Flow) demand is adjustable with raise or lower commands from the CCT, remote contact inputs, or Modbus. The setpoint can also be directly entered from the CCT or Modbus. In addition, a 4–20 mA analog input may be configured for Remote Manual Pressure (Flow) Demand, allowing an external device (e.g. DCS, PLC) to remotely set the demand. When the 505CC-2 is powered-up, the setpoint is reset to the configured Setpoint Initial Value.

The Manual Pressure (Flow) Demand range must be defined by Min Flow Setpoint and Max Flow Setpoint (typically 0 and 100%) in the Turbine Manual Flow Control Configuration screen.

When a Raise/Lower Manual Pressure (Flow) Demand command is issued, the reference moves at the configured Default Rate. If the command is held for the configured Fast Rate Delay time, the demand will begin to ramp at the configured Fast Rate. Whether from the CCT, remote contact inputs, or Modbus, the Raise/Lower commands are received as toggles. That is to say, the setpoint will ramp as long as the command is active.

WARNING **The user should consider some appropriate engineering solution if there is any failure mode for the contact inputs or Modbus commands that might keep them active unintentionally.**

The Manual Pressure (Flow) Demand may be specified directly by entering the desired value through the CCT or Modbus. These entered setpoints are limited by the configured Min and Max Flow Setpoint and will ramp at the configured Default Rate. Likewise, a configurable 4–20 mA analog input may be assigned to remotely position the demand. This setting will be limited by the configured Remote Min and Max Flow Settings and will ramp at the configured Remote Rate.

These four setpoint sources are prioritized in descending order as Remote 4–20 mA, CCT, Modbus 1, and Modbus 2 (the Remote 4–20 mA signal has the highest priority). If Remote Manual Pressure (Flow) Demand is enabled, all other Manual Demand commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

The Manual Pressure (Flow) Demand is actually P-demand, or Extraction Pressure Demand, not manual valve position. Raising Manual (Pressure) Flow Demand on an Admission or Extraction/Admission turbine will decrease admission flow. However, if operating in Total Decoupled Mode (see the Ratio-Limiter section later in this chapter), the Raise/Lower Manual Pressure (Flow) Demand will act directly on valve position.

2.7.10 Remote Extraction/Admission Manual Pressure (Flow) Demand

One of the configurable 4–20 mA analog inputs can be assigned to remotely adjust the Extraction/Admission Pressure (Flow) Demand. The maximum rate at which the remote input signal can change the Extraction/Admission Pressure (Flow) Demand is configurable as the Remote Rate.

The Remote Manual Demand function may be enabled and disabled from the CCT or Modbus. The last command given from any of these sources dictates the enabled/disabled state. The control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled. The Remote Rate dictates the rate at which the analog input will position the Extraction/Admission Manual Pressure (Flow) demand.

The minimum (4 mA) and maximum (20 mA) engineering unit values for this analog input should normally be configured as (or within) the configured Remote Minimum Pressure (Flow) Setting and Maximum Pressure (Flow) Setting. The analog signal is limited accordingly, regardless of the upper and lower range values of the input. If the milliamp signal to the Remote Manual Demand input is out of range (defaulted to 2–22 mA) an alarm is generated and Remote Manual Demand is disabled and inhibited until the input signal is corrected. Remote Manual Demand must be re-enabled after the input is re-established.

If Remote Manual Demand is enabled, all other Pressure (Flow) Demand setpoint commands (Raise/Lower, CCT or Modbus entered setpoint) are inhibited.

2.8 Extraction-Only Control

Extraction Control enabling may be automatic or manual and performed after one of the 505CC-2's three Start Modes has been completed and related permissives met. Typically a turbine is controlling speed/load at or above Minimum Governor and at some minimum process load before Extraction Control is enabled. After startup, the HP and LP Valve Limiters should normally both be fully open. If the HP Valve Limiter is not fully open, it will act as a speed/load limiter and will interfere with automatic governor operation.

When configured for Extraction Control the 505CC-2's LP Valve Limiter is high signal selected with the output of the Ratio-Limiter. Because the LP Valve Limiter is automatically ramped to 100% during startup, the LP Valve cannot be controlled below its 100% open position. All related Extraction enable permissives must be met before the 505CC-2 will allow the Extraction/Admission PID to take control of the Extraction steam process.

There are two ways of enabling/disabling Extraction Control: manually or automatically. The manual enable/disable routine uses the LP Valve Limiter's Raise/Lower commands. The automatic routine uses an Enable/Disable command from the CCT, remote contact input, or Modbus. Automatic enabling/disabling can only be performed if Use Automatic Enable is selected on the Extraction/Admission Map Configuration Screen. Even with automatic enabling configured, an operator can still enable and disable Extraction Control manually, if desired.

2.8.1 Manual Enable/Disable

To manually enable Extraction Control, slowly lower the LP Valve Limiter until the Extraction/Admission PID takes control of its process. Then, continue lowering the LP Valve Limiter to its minimum (closed) position. If the LP Valve Limiter is not fully closed, it will act as an Extraction limiter and will interfere with automatic governor operation. All related Extraction permissives must be met before the 505CC-2 will allow the LP Valve Limiter to be lowered and Extraction/Admission Control enabled.

To disable Extraction Control, slowly raise the LP Valve Limiter until the Extraction/Admission PID relinquishes control of its respective process. Then, continue raising the LP Valve Limiter to its maximum (open) position.

2.8.2 Automatic Enable/Disable

After receiving an enable command, the 505CC-2 will automatically lower the LP Valve Limiter at the configured LP Valve Limiter Rate. After the Extraction/Admission demand is inside the steam map or the PID takes control of its process, the LP Valve Limiter will continue lowering to its minimum (closed) position at five times the configured rate. The LP Valve Limiter may be stopped at any time during the automatic enabling routine by momentarily issuing an LP Limiter Raise or Lower command.

Stopping the automatic enabling routine halts the LP Valve Limiter. The Extraction/Admission PID's output will still 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 reissue an enable command.

The 505CC-2 accepts an Extraction enable command only if all related permissives are met. An enable/disable command may be given from the CCT, a remote contact input, or Modbus. The last command given from any of these three sources dictates the state of the Extraction Control. When a contact input is programmed to function as an enable/disable command, a closed state represents an enable command and an open state represents a disable command. This contact can either be open or closed when a trip condition is cleared. If the contact is closed, it must be opened and re-closed to issue an enable command. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

Upon receiving a disable command, the 505CC-2 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 configured LP Valve Limiter Rate. At some point, depending on system conditions, the Extraction/Admission PID will relinquish control of its process.

The LP Valve Limiter may be stopped at any time during the automatic disabling routine by momentarily issuing an LP Limiter Raise or Lower command. An operator can continue the disabling routine manually, as desired, or reissue a disable command. After reissuing a disable command, the disable routine will continue raising the LP Valve Limiter to its maximum (open) position.

2.9 Admission or Extraction/Admission Control

The procedure for enabling the Extraction/Admission PID with Admission or Extraction/Admission applications is the same as described above for Extraction-Only turbines. In all cases, it is assumed that an external trip valve or a Trip & Throttle Valve is used to completely stop any admission steam from entering the turbine when a system shutdown exists.

⚠WARNING

An external Admission or Extraction/Admission Trip & Throttle valve is required to prevent any admission steam from entering the turbine when shut down.
Otherwise, there exists a possibility of turbine runaway, possibly resulting in serious equipment damage, personnel injury, or loss of life. Configure a closed limit switch on the T&T Valve as a start permissive for additional protection.

Admission or Extraction/Admission Control can be enabled after one of the three Starts Modes has been completed. 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.

When configured for any Admission turbine, the 505CC-2's LP Valve Limiter is low signal selected with the output of the Ratio/Limiter. Because the LP Valve Limiter is automatically ramped to 100% during startup, the LP Valve will take its demand from the Ratio-Limiter. During startup, this demand will likely be at or close to 0%. If it is necessary to have the LP Valve fully open during startup of an Admission or Extraction/Admission turbine, to provide cooling to the LP turbine section for example, configure Use HSS for LP on the Turbine Extraction/Admission Control Configuration screen. This will configure the 505CC-2 to utilize the high signal selection of Ratio-Limiter and LP Valve Limiter demands, similar to that described previously for Extraction turbines. In this case, the Limiter will be fully open on startup only—When Extraction Control is disabled, the Limiter will not ramp open.

All related Extraction/Admission enable permissives must be met before the 505CC-2 will allow the Extraction/Admission PID to take control of the Extraction/Admission steam process.

To perform a bumpless transfer into Admission or Extraction/Admission control, the pressures on each side of the Admission trip valve or T&T Valve should be matched. The following procedure facilitates a bumpless transfer into Admission or Extraction/Admission control:

1. Verify that all Extraction/Admission enable permissives are met.
2. Match the Extraction/Admission setpoint to that of the pressure on the plant side of the Extraction/Admission T&T Valve. Skip this step if Setpoint Tracking is used.
3. Vary the Manual Pressure (Flow) Demand to match the turbine's internal Extraction/Admission pressure to that of the pressure on the plant side of the Extraction/Admission T&T valve.
4. Open the Extraction/Admission T&T valve.
5. Enable Admission or Extraction/Admission control.

All the functions required for bumpless enable/disable of Admission or Extraction/Admission control can be performed through the CCT, remote contact inputs, or Modbus.

The 505CC-2 accepts an enable command only if all related permissives are met. An enable/disable command may be given from the CCT, a remote contact input, or Modbus. The last command given from any of these three sources dictates the state of the Extraction/Admission control. When a contact input is programmed to function as an enable/disable command, a closed state represents an enable command and an open state represents a disable command. This contact can either be open or closed when a trip condition is cleared. If the contact is closed, it must be opened and re-closed to issue an enable command. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

The following procedure allows Admission or Extraction/Admission control to be disabled in a controlled manner:

1. Disable Admission or Extraction/Admission control.
    a. At this point the Manual Pressure (Flow) Demand will step to the Extraction/Admission PID's last position, take control of the process from the PID, then ramp back to the setting that was used to enable Extraction/Admission Control. This setting should be at or close to zero.
2. If necessary, manually adjust the Manual Pressure (Flow) Demand to reach zero Extraction/Admission flow.
3. Close the Extraction/Admission T&T Valve.

2.10 Ratio-Limiters

The Ratio-Limiter receives input signals from the Speed and Extraction/Admission Control PIDs (or Inlet/Exhaust PIDs if decoupled, see below). The ratio logic uses these signals and, based on the turbine performance parameters, produces two output signals; one to control the HP actuator and one to control the LP actuator. The limiter logic restricts the actuator outputs within the boundaries of the turbine steam map.

The ratio logic controls the interaction of both HP and LP valves to maintain desired turbine speed/load and extraction/admission pressure/flow levels. By controlling valve interaction, the ratio logic minimizes the effects of one controlled process on the other controlled process.

When speed/load or extraction/admission demands cause the turbine to reach an operating limit, the limiter logic restricts the HP or LP Valves to maintain speed/load in compressor drive applications.

2.10.1 HP & LP Coupled Mode (Speed/Extraction)

In most cases, an extraction/admission turbine needs to maintain both turbine speed/load and extraction/admission pressure/flow at constant levels. Changing the position of either the HP Valve or the LP Valve affects both turbine speed/load and extraction/admission pressure/flow. If either the load on the turbine or the extraction/admission demand changes, both the HP Valve position and the LP Valve position must be changed to maintain speed/load and extraction/admission pressure/flow.

In this operating mode, the turbine's HP and LP Valves are coupled (ratioed) together to control both processes without interacting with each other—Turbine load and extraction/admission pressure are controlled by moving both valves simultaneously. Responding to a change in either process, both valves are repositioned so as not to affect the other process.

HP & LP Coupled Mode is configured by selecting Speed/Extraction for the Decoupling Type on the Turbine General Configuration screen.

2.10.2 Decoupling

There are cases when the ratioing described above is not desired, requiring decoupling of one or both valve outputs. There are three decoupling options available in the 505CC-2 that have been designed to continuously control speed (necessary for compressor drive applications) and a third parameter, instead of extraction/admission pressure (flow).

These decoupling modes are:

- Decoupled HP (or inlet) & speed
- Decoupled LP (or exhaust) & speed
- Decoupled HP and LP (speed PID acts only on HP, without ratioing)

In any of these modes, the speed setpoint can still be manipulated by the Cascade PID or Remote Speed Setpoint to maintain another process variable.

Selecting Inlet or Exhaust Decoupling permits further configuration of that control's reference, rate, and dynamics settings, as described previously for Extraction/Admission control. Refer to the earlier Extraction and/or Admission Control section for details on specific settings

2.10.3 HP Decoupled Mode (Inlet/Speed)

This mode is typically used when the two controlled parameters during normal operation are turbine inlet pressure (or flow) and speed/load. The turbine's HP and LP Valve actions are decoupled to allow control of a turbine's inlet pressure without interaction from speed/load changes. Turbine speed/load is controlled by only moving the LP Valve. Although turbine extraction/admission pressure is not controlled, it is still limited within the turbine's configured operating limits.

The HP and LP Valve actions are, however, still coupled to control turbine speed/load without interaction from turbine inlet pressure or flow changes. Turbine inlet pressure is controlled by moving both the HP and LP valves simultaneously, based on the Decoupled Ratio algorithm, to avoid any disturbance in speed control. Responding to a change in either process, both valves are repositioned so as not to affect the other process. Turbine inlet pressure is controlled through the 505CC-2's Inlet PID. Speed/load can be controlled through either the Speed or Cascade PIDs.

If desired, the Inlet PID can be put into manual mode at any time, such as when process instabilities are negatively affecting turbine operation or a pressure reducing station is in operation. The HP Valve demand is then frozen but can be manually adjusted open or closed by the operator via Raise/Lower commands from the HMI/CCT or Modbus.

It is not necessary to configure an Extraction/Admission pressure input when this decoupling mode is configured, in which case Bypass Extraction should be configured on the Extraction/Admission Control Configuration screen. However, Extraction/Admission Control, even if no input is used, must be enabled manually or automatically first, to make sure that the transfer between decoupled and coupled is bumpless. Inlet Decoupled mode cannot be activated if Extraction/Admission is disabled. To enable Inlet Decoupled mode, the LP Valve position must be within the steam map limits, and not limited by the LP Valve Limiter.

HP Decoupled Mode is configured by selecting Inlet/Speed for the Decoupling Type on the Turbine General Configuration screen.

2.10.4 LP Decoupled Mode (Exhaust/Speed)

This mode is typically used when the two controlled parameters during normal operation are turbine speed/load and exhaust pressure (or flow). The turbine's HP and LP Valve actions are decoupled to allow control of a turbine's exhaust pressure without interaction from speed/load changes. Turbine speed/load is controlled by only moving the HP Valve. Although turbine Extraction/Admission pressure is not controlled, it is still limited within the turbine's configured operating limits.

The HP and LP Valve actions are, however, still coupled to control turbine speed/load without interaction from turbine exhaust pressure or flow changes. Turbine exhaust pressure is controlled by moving both the HP and LP Valves simultaneously, based on the Decoupled Ratio algorithm, to avoid any disturbance in speed control. Responding to a change in either process, both valves are repositioned so as not to affect the other process. Turbine exhaust pressure can be controlled through the 505CC-2's Exhaust PID. Speed/load can be controlled through either the Speed or Cascade PIDs.

If desired, the Exhaust PID can be put into manual mode at any time, such as when process instabilities are negatively affecting turbine operation or a pressure reducing station is in operation. The LP Valve demand is then frozen but can be manually adjusted open or closed by the operator via Raise/Lower commands from the CCT or Modbus.

It is not necessary to configure an Extraction/Admission pressure input when this decoupling mode is configured, in which case Bypass Extraction should be configured on the Extraction/Admission Control Configuration screen. However, Extraction/Admission Control, even if no input is used, must be enabled manually or automatically first, to make sure that the transfer between decoupled and coupled is bumpless. Exhaust Decoupled mode cannot be activated if Extraction/Admission is disabled. To enable Exhaust Decoupled mode, the LP Valve position must be within the steam map limits, and not limited by the LP Valve Limiter.

LP Decoupled Mode is configured by selecting Exhaust/Speed for the Decoupling Type on the Turbine General Configuration screen.

2.10.5 HP & LP Total Decoupled (No Ratio)

This mode is typically used when the two controlled parameters during normal operation are turbine inlet pressure (or flow) and exhaust pressure (or flow). The turbine's HP and LP Valve actions are fully decoupled, bypassing the Ratio-Limiter.

⚠WARNING	**No Steam Map limiting is available in Total Decoupled Mode. It is the turbine operator's responsibility to ensure that the HP and LP Valves are controlled in a safe operating range.**

The HP Valve can be positioned by the Speed or Cascade PIDs, and the LP Valve is positioned by the Extraction/Admission PID. The decoupled configuration allows control of a turbine's inlet pressure without interaction from exhaust flow changes. Turbine inlet pressure is controlled by moving the HP Valve only, and exhaust pressure is controlled by moving the LP Valve only.

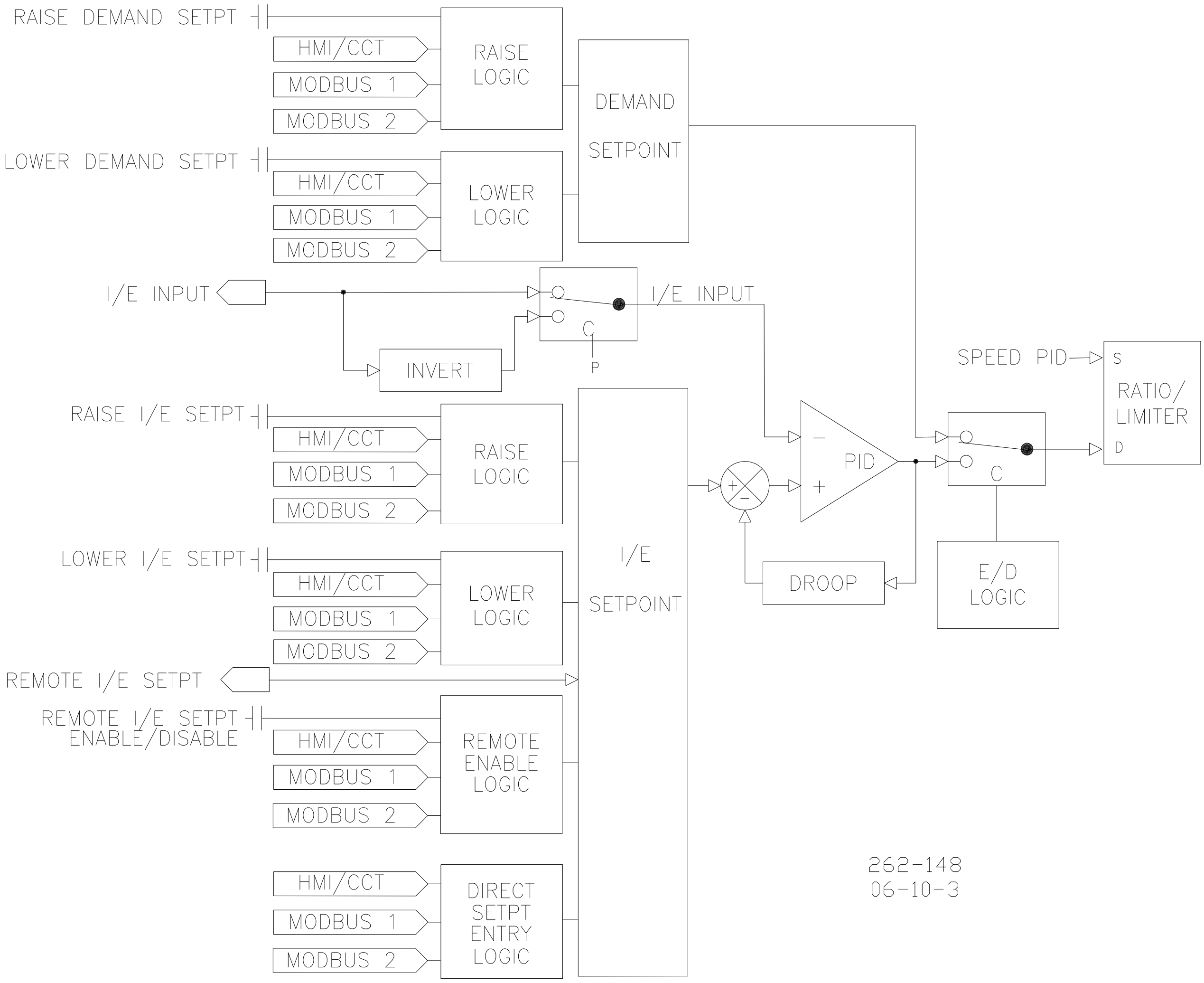


Figure 2-9. Inlet/Exhaust Decoupling Control Functional Diagram

The turbine's HP and LP Valve actions are also decoupled to control turbine exhaust pressure/flow without interaction from turbine inlet pressure/flow changes. Turbine inlet pressure is controlled by only moving the HP Valve, thus no change in exhaust pressure/flow is created. For a change in either process the respective valves are repositioned for a net effect of no pressure or flow change on the other process. With this mode of operation, turbine inlet pressure is controlled through the Cascade PID and turbine exhaust pressure is controlled through the Extraction/Admission PID. Therefore, connect the inlet steam pressure transmitter to a turbine configurable analog input as the Cascade controller's process variable and configure the controller on the Cascade Configuration screen. Similarly, connect the exhaust pressure transmitter to the Extraction/Admission pressure input (analog input #6) and configure Extraction/Admission control.

2.10.6 Block Diagram Description

The block diagrams displayed below provide a detailed view of each Ratio-Limiter configuration and the relationship between the Ratio-Limiter's input and output signals.

The S input signal originates from the Speed Control and represents the Speed or Cascade PID demand. The P input signal originates from the Extraction/Admission PID or the Extraction/Admission Manual Pressure (Flow) Demand, depending on selected modes, and represents Extraction/Admission Pressure (Flow) Demand. The D input signal originates from the Inlet/Exhaust PID when either decoupling mode is selected. The DC input signal is a discrete signal that originates from the control's decoupling map logic and goes to a true state when Ratio-Limiter decoupling is selected.

The P signal must pass through map limiters before it used in the ratioing equations. The P signal is limited because speed priority is defaulted for compressor applications.

These limiters allow the valves to be correctly positioned on each turbine operating limit. To simplify the limiter logic, the Min (HSS bus) and Max (LSS bus) limiters are displayed as one limiter bus. Each turbine operating limit is labeled and displayed graphically. All Limiters are based on the entered steam map values and actual HP and LP Valve positions (as derived from the control's actuator driver signals).

Downstream of the limiter, the signals are referred to as S' (S-prime) and P' (P-prime). When the turbine is not operating on a limit, the S' value equals the S input signal and the P' value equals the P input signal.

If configured for decoupled operation, digital ramps are used to transfer between Ratio-Limiters. During normal enabling and disabling of the decoupled mode, these ramps take 50 seconds to completely ramp from one Ratio-Limiter to the next. The control starts by using the Coupled Ratio-Limiter, then switches to the Decoupled Ratio-Limiter when the Cascade PID is enabled. The control switches back to the Coupled Ratio-Limiter when the Cascade PID is disabled.

The HP output signal represents HP Valve demand and is connected to the control's HP LSS bus. The LP output signal represents LP Valve demand and is connected to the control's LP LSS and HSS busses (depending upon turbine type and configuration).

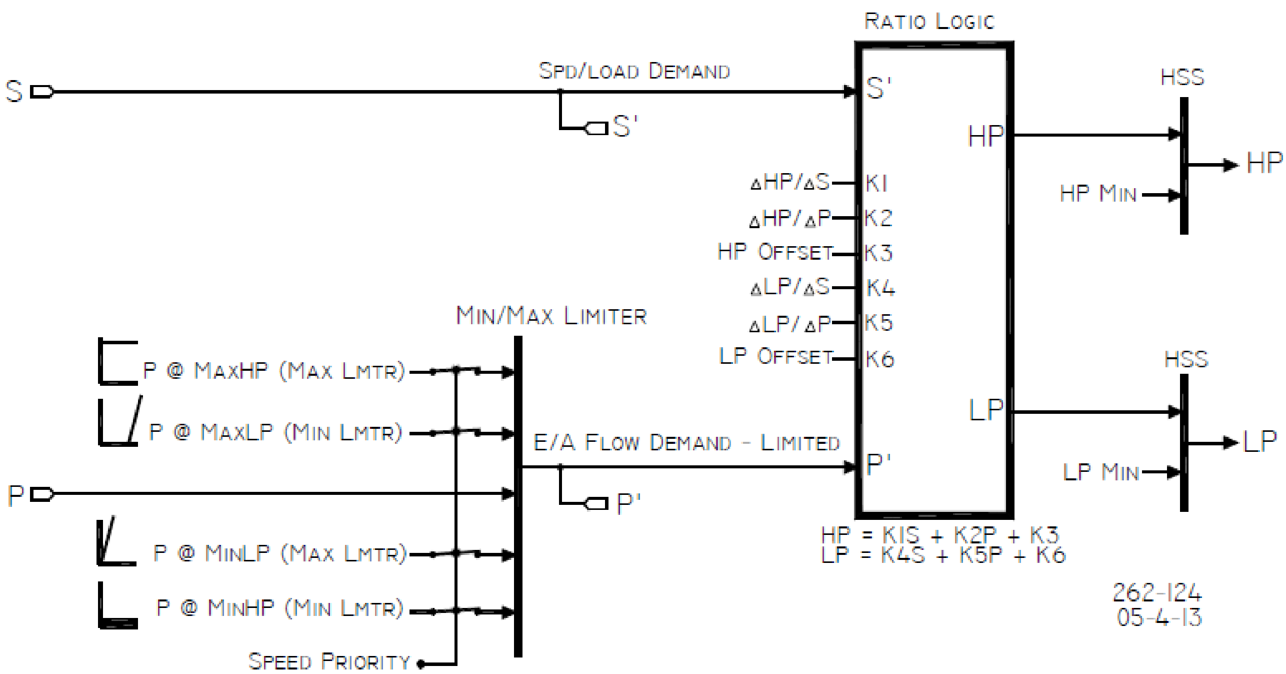


Figure 2-10. Coupled HP & LP Mode

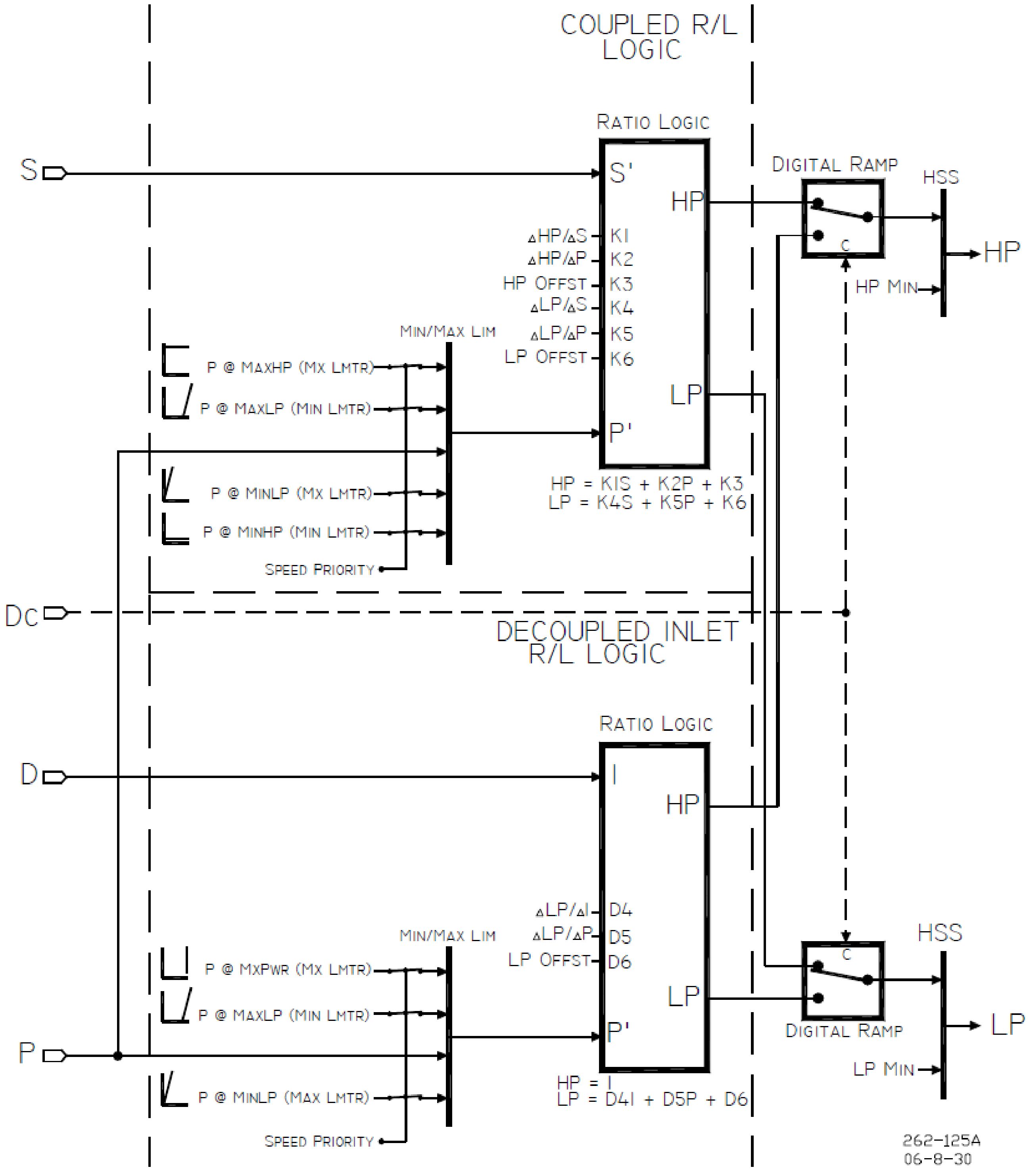


Figure 2-11. Decoupled Inlet (HP) Mode

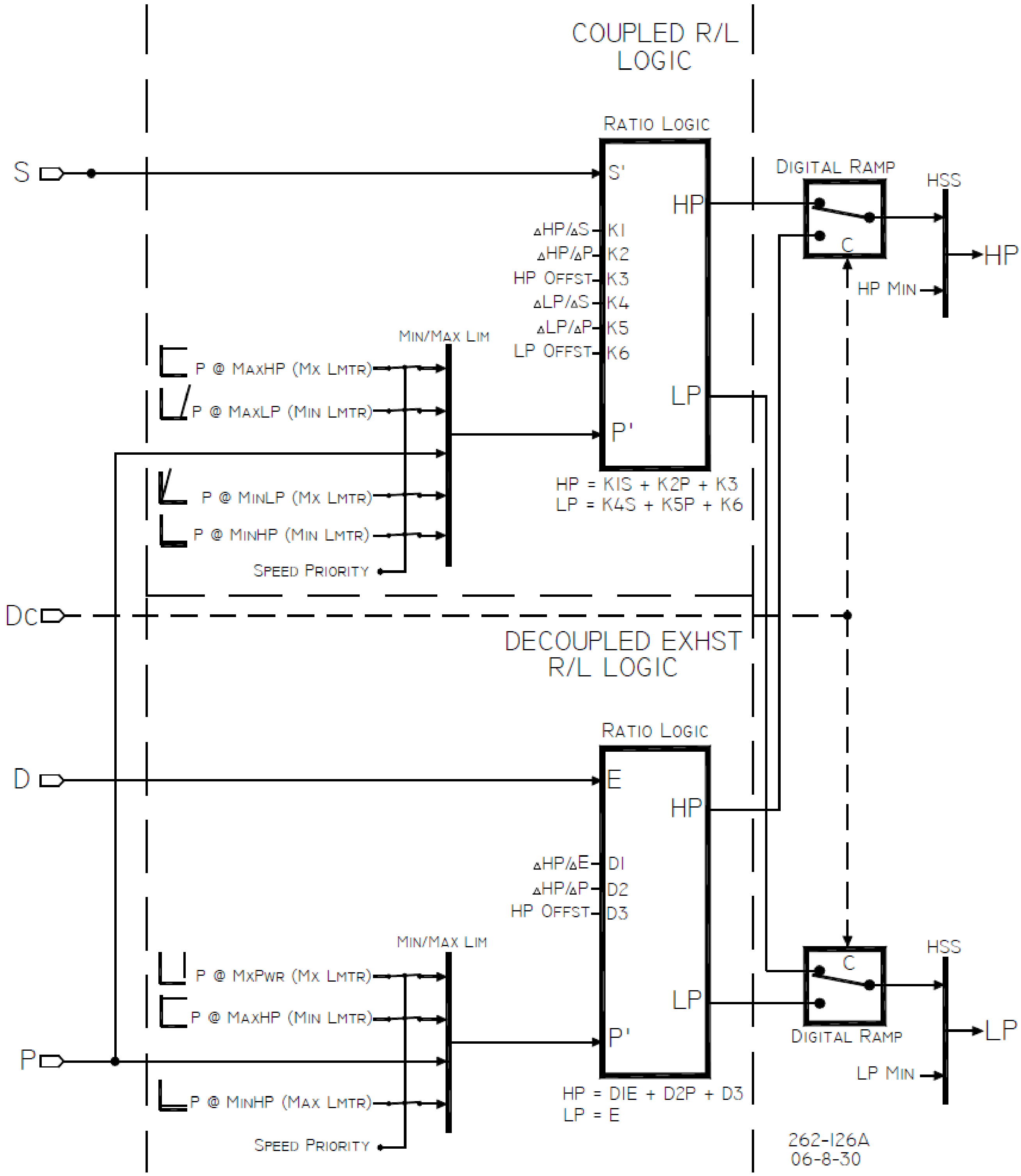


Figure 2-12. Decoupled Exhaust (LP) Mode

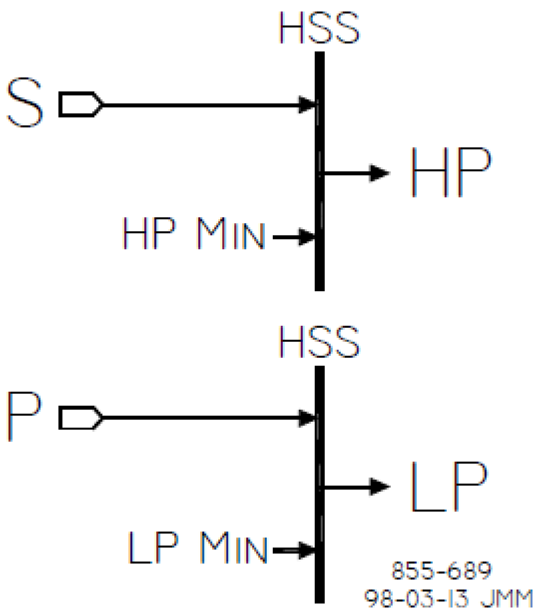


Figure 2-13. Decoupled HP & LP Mode

2.11 Valve Limiters

The HP and LP Valve Limiters limit the HP and LP Valve demands to aid in starting and shutting down the turbine. The limiters are adjustable with raise or lower commands from the CCT, remote contact inputs, or Modbus. When raise or lower commands are received, the limiters move up or down, respectively, at the configured rate. In all cases, a limiter's range is defaulted to 0-100%. However, these limits are configurable on the Valve Limiter Settings Configuration screen.

The output of the HP Valve Limiter is low signal selected with the output of the Ratio-Limiter--The lower signal will control the HP Valve position. Thus, the HP Valve Limiter limits the maximum HP Valve position.

The output of the LP Valve Limiter is high signal selected with the output of the Ratio-Limiter for extraction steam turbines, and low signal selected for admission or extraction/admission steam turbines. Thus, the LP Valve Limiter limits the minimum or maximum LP Valve position, depending on the type of turbine configured.

The valve limiters also can be used to troubleshoot system dynamic problems. If it is believed that the 505CC-2 is the source of system instability, the valve limiters can be positioned to manually take over control of the valve positions. Care should be taken when using the valve limiters in this fashion, so as to prevent the system from reaching a dangerous operating point.

2.11.1 Min HP and LP Lift

The Min HP Lift limiter is used only with Admission or Extraction/Admission applications to limit the HP Valve's minimum position above 0% to insure HP section cooling steam. This limiter is prevents the Ratio/Limiter from taking the HP valve fully closed. Unless specified by the turbine manufacture, this setting should be zero. The Min HP Lift limiter is only active if the following conditions are true:

- Admission or Extraction/Admission is configured
- Extraction/Admission control is enabled
- HP Valve demand is above the Min HP Lift limiter

The Min LP Lift limiter is used to limit the LP Valve's minimum position. This limiter is active at all times (except shutdowns) and prevents the Ratio/Limiter from taking the LP Valve fully closed. However, during shutdown conditions the LP Valve is taken fully closed. Unless specified by the turbine manufacture, this setting should be zero.

Min Lift values can be derived from the turbine's steam map. See the Extraction/Admission Steam Map Configuration section 4.8 Steam Map for examples. All pertinent valve limiter parameters are available through Modbus. See Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.12 Turbine Starting Features

The 505CC-2 provides three different starting modes: automatic, semi-automatic, and manual. One of these modes must be programmed to get the turbine from a shutdown state to speed control at minimum speed. Once a Start/Run command is issued, the speed setpoint and HP Valve Limiter are manipulated automatically by the control, or manually by the operator, depending on which start mode is configured. After a turbine start is completed, speed will be controlled at a minimum controlling speed (Idle speed if Idle/Rated or Auto Start Sequence are configured--Minimum Governor otherwise).

A Start/Run command may be issued from the CCT, remote contact input, or Modbus. If a contact input is configured for Start/Run, the 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 Start/Run command. Likewise for Modbus commands, the Start is pulsed from a positive edge trigger.

If turbine speed is sensed when a Start/Run command is issued, the control will instantly match the speed setpoint 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 setpoint will match this sensed speed, the Speed PID will control at this point, and the control will wait for further action by the operator (unless Auto Start Sequence is configured). If the turbine speed is first sensed within a critical speed avoidance band, the speed reference will match the actual speed, increase to the upper-end of the critical avoidance band, and wait for action by the operator.

The Start Mode and Minimum Governor controlling speed configured will depend on normal plant operating procedures and turbine manufacturer's recommendations.

2.12.1 Start Permissive

A remote contact input may be used as a turbine Start Permissive. When configured as such, the contact input must be closed in order for a Start/Run command to be executed. Should the contact be open when a Start/Run is attempted, an alarm will be issued indicating that the start permissive was not met. The alarm does not need to be cleared, but the contact must be closed before the control will accept a Start/Run command. After a start, the Start Permissive contact will have no effect on operation. This input is typically from a Trip & Throttle (T&T) Valve's closed limit switch to verify that the T&T is in the closed position before startup.

2.12.2 Zero Speed Signal Override

The 505CC-2 issues a shutdown if no speed signal is detected (e.g. magnetic pickup voltage less than the typical detectable threshold ~1 V_{rms}), or speed is less than the configured 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 manual or automatic speed override. For added protection, a timed limit on the override is available.

2.12.3 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 or until the Override Timer expires (if configured). 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 configured Failed Speed Level.

The Override Timer, up to ten minutes in length, is provided as an extra level of protection, in the event the contact input is unintentionally left closed. The timer begins when a Start/Run command is initiated. When it expires, loss-of-speed detection is re-armed--The 505CC-2 will execute a system shutdown if turbine speed is not above the configured Failed Speed Level when the timer expires.

2.12.4 Automatic Speed Override

If Manual Speed Override is not utilized (contact input not configured for Override MPU Fault), the Automatic Speed Override logic is used by the 505CC-2 to override the loss-of-speed detection logic during a startup. In this case, the loss-of-speed detection circuit is armed when the turbine trips and remains armed until the sensed turbine speed exceeds the configured Failed Speed Level (+25 rpm) on the subsequent start. Once re-armed, the control will execute a system shutdown if sensed speed drops below the Failed Speed Level setting.

The Override Timer, up to ten minutes in length, is provided as an extra level of protection, in the event the turbine is unable to accelerate or if the speed inputs are indeed failed. The timer begins when a Start/Run command is initiated. When it expires, loss-of-speed detection is re-armed--The 505CC-2 will execute a system shutdown if turbine speed is not above the configured Failed Speed Level when the timer expires.

2.12.5 Critical Speed Avoidance

In many applications, 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 505CC-2 configuration, two critical speed avoidance bands may be selected. These bands may be any speed ranges that are between idle speed and minimum governor speed. Within a critical speed range, the 505CC-2 moves the speed setpoint at the configured critical speed rate and does not allow the speed setpoint to stop within the critical speed avoidance band.

If a Raise/Lower Speed Setpoint command is issued while in a critical band, the speed setpoint will ramp up or down (depending on the command received) to the extent of the critical range. Since the Lower command has priority over a Raise command, issuing a Lower command while increasing through the band will reverse the setpoint direction and return it to the lower limit of the band. This might be the necessary action if excessive vibration is observed while accelerating through the critical band. If a Lower 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 setpoint value cannot be directly entered within the configured critical speed bands. If this is attempted, an alarm is generated and the setpoint value is rejected.

During startup, if the Speed PID cannot accelerate the unit through a critical band within a calculated length of time, a Stuck in Critical alarm will be issued and the unit tripped. This calculated length of time is double the length of time it should normally take to accelerate through the band (based on the Critical Speed Rate) and must be at least 15 seconds.

Critical speed bands are defined in the Turbine Speed Control Configuration Screen. All critical speed band settings must be between the Idle Speed (or Minimum Controllable Speed) and Minimum Governor settings. A configuration error will occur if an Idle setpoint is programmed within a critical speed band. The rate at which the speed setpoint moves through a critical speed band is configured as the Critical Speed Rate. It should normally be set at, but no higher than, the turbine's rated maximum acceleration rate.

2.13 Turbine Start Modes

2.13.1 Manual Start Mode

The following startup procedure is employed when the Manual Start mode is configured:

1. Issue a Reset command (to reset all alarms and shutdowns).
2. Verify that the Trip & Throttle Valve is closed and issue a Start/Run command.
   a. The 505CC-2 will ramp open the LP Valve Limiter to its maximum position at the configured LP Valve Limiter Rate. (For Extraction-only Turbines, the LP Valve position will ramp to the maximum limit until extraction is enabled. For any Admission Turbine, the LP Valve position will vary to maintain zero extraction/admission flow or open fully, depending upon the configuration.)
   b. The 505CC-2 will ramp open the HP Valve to its maximum position at the configured HP Valve Limiter Rate.
   c. The speed setpoint will ramp from zero to the minimum controlling speed setting at the configured Rate to Min.
3. Open the HP Trip & Throttle Valve at a controlled rate.
   a. When turbine speed increases to the minimum controlling speed, the Speed PID will take control of turbine speed by throttling the HP Valve.
4. Open the HP Trip & Throttle Valve to 100%.
   a. Speed remains at the minimum controlling setpoint until action is taken by the operator, or until the Auto Start Sequence, if configured, begins controlling.
   b. Extraction/Admission Control may be enabled using the procedures described earlier in this chapter.

⚠WARNING	**The HP Trip & Throttle Valve must be closed before initiating a Start/Run command in Manual Start mode.** **If a Start/Run command is given while the Trip & Throttle Valve is open, there exists a possibility of turbine runaway, possibly resulting in serious equipment damage, personnel injury, or loss of life.**

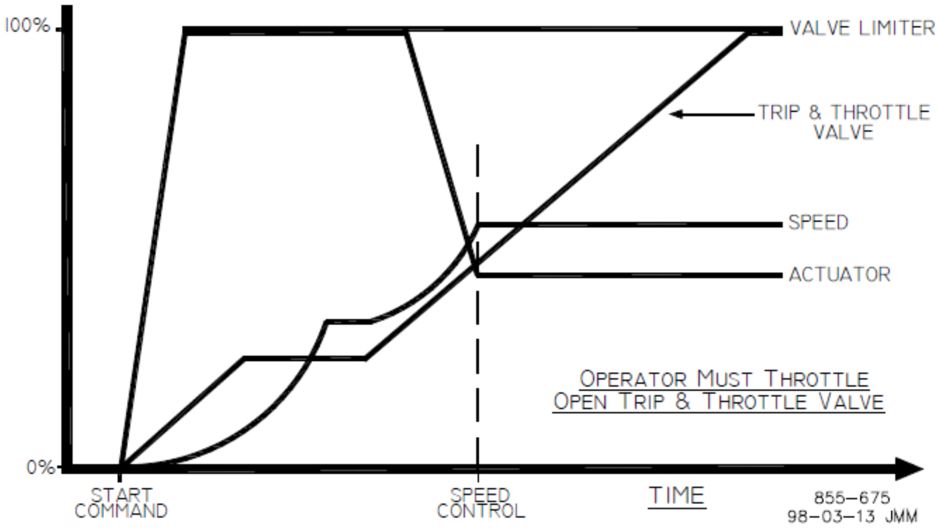


Figure 2-14. Manual Start Mode Example

2.13.2 Semiautomatic Start Mode

The following startup procedure is employed when the Semiautomatic Start mode is configured:

1. Issue a Reset command (to reset all alarms and shutdowns).
2. Open the HP Trip & Throttle Valve and verify that the turbine does not accelerate.
3. Issue a Start/Run command.
   a. The 505CC-2 will ramp open the LP Valve Limiter to its maximum position at the configured LP Valve Limiter Rate. (For Extraction-only Turbines, the LP Valve position will ramp to the maximum limit until extraction is enabled. For any Admission Turbine, the LP Valve position will vary to maintain zero extraction/admission flow or open fully, depending upon the configuration.)
   b. The speed setpoint will ramp to the minimum controlling speed setting at the configured Rate to Min.
4. Raise the HP Valve Limiter at a controlled rate.
   a. When turbine speed increases to the minimum controlling speed, the Speed PID will take control of turbine speed by throttling the HP Valve.
5. Raise the HP Valve Limiter to 100%.
   a. Speed remains at the minimum controlling setpoint until action is taken by the operator, or until the Auto Start Sequence, if configured, begins controlling.
   b. Extraction/Admission Control may be enabled using the procedures described earlier in this chapter.

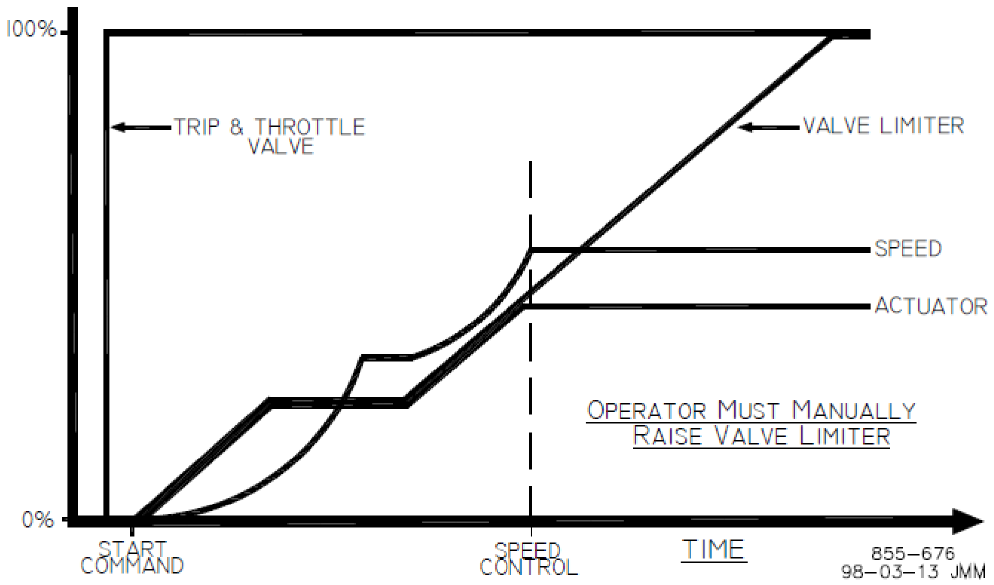


Figure 2-15. Semiautomatic Start Mode Example

2.13.3 Automatic Start Mode

The following startup procedure is employed when the Automatic Start mode is configured:

1. Issue a Reset command (to reset all alarms and shutdowns).
2. Open the HP Trip & Throttle Valve and verify that the turbine does not accelerate.
3. Issue a Start/Run command.
   a. The 505CC-2 will ramp open the LP Valve Limiter to its maximum position at the configured LP Valve Limiter Rate. (For Extraction-only Turbines, the LP Valve position will ramp to the maximum limit until extraction is enabled. For any Admission Turbine, the LP Valve position will vary to maintain zero extraction/admission flow or open fully, depending upon the configuration.)
   b. The HP Valve Limiter will ramp to its maximum position at the configured HP Valve Limiter Rate.
   c. The speed setpoint will ramp to the minimum controlling speed setting at the configured Rate to Min.
   d. When turbine speed increases to match the ramping setpoint, the Speed PID will take control by throttling the HP Valve.
   e. Speed remains at the minimum controlling setpoint until action is taken by the operator, or until the Auto Start Sequence, if configured, begins controlling.
   f. Extraction/Admission Control may be enabled using the procedures described earlier in this chapter.

The Automatic Start routine may be aborted at any time by issuing HP Valve Limiter Raise or Lower commands or an Emergency Shutdown.

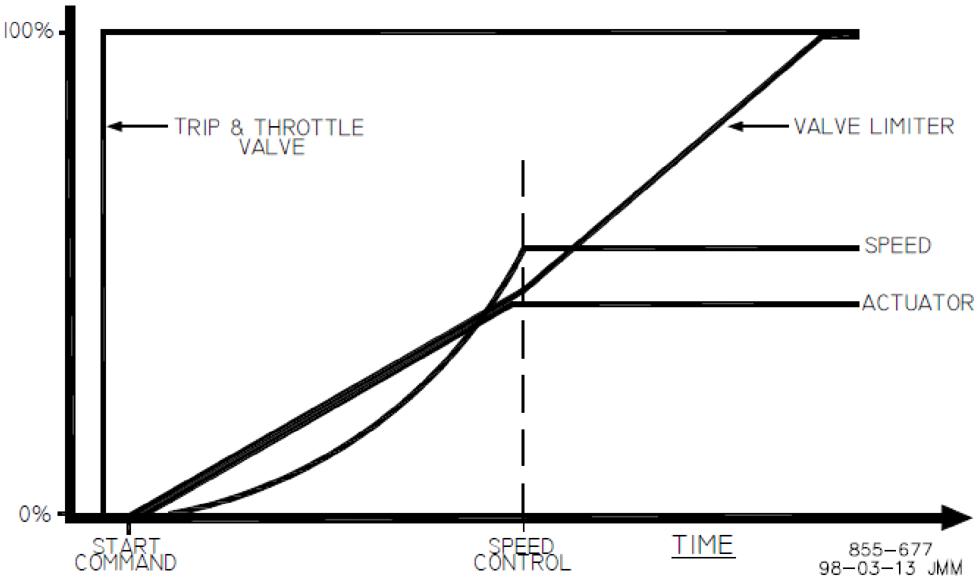


Figure 2-16. Automatic Start Mode Example

2.14 Turbine Start Speeds

2.14.1 Minimum Governor

Selecting a Minimum Governor start will ramp the speed setpoint from zero to the Minimum Governor setpoint at the configured Rate to Min.

2.14.2 Idle/Rated (Single Idle)

The Idle/Rated function gives the operator the ability to move between a configured Idle speed and Rated speed (Minimum Governor) at a configured rate. The selection of Idle or Rated speed setpoint positions can be made through the HMI/CCT, remote contact inputs, or Modbus. When deselected, the turbine speed ramps down to Idle.

The Idle/Rated function can be used with any 505CC-2 start mode (Manual, Semiautomatic, and Automatic). When a Start/Run is initiated, the speed setpoint will ramp from zero up to, and hold at, the configured Idle Speed. The speed setpoint ramps to Minimum Governor at the configured Rate to Min when the Rated command is issued. While ramping to Minimum Governor, the setpoint can be stopped by a Raise or Lower speed command or a valid, entered speed setpoint.

If Idle is selected while in a critical speed band, the speed setpoint will return to Idle, continuing to move at the critical avoidance rate while within the band. The speed setpoint cannot be stopped within a critical speed avoidance band. Attempting to stop the ramp to Minimum Governor while in a critical band will continue the speed setpoint to the upper or lower limit of the band, depending upon the command issued (Raise or Lower).

2.14.2.1 Ramp to Rated Feature

The Idle/Rated function can be configured as a Ramp to Rated. In this configuration, the speed setpoint holds at the Idle speed setting until the Rated command is given. Upon command the speed setpoint will accelerate to Minimum Governor. However, it will not ramp back to Idle. When Rated is de-selected, the speed setpoint stops, as opposed to returning to Idle.

If Rated is de-selected while in a critical speed band, the speed setpoint 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 setpoint command, the setpoint will continue to the upper or lower limit of the band, depending upon the command issued.

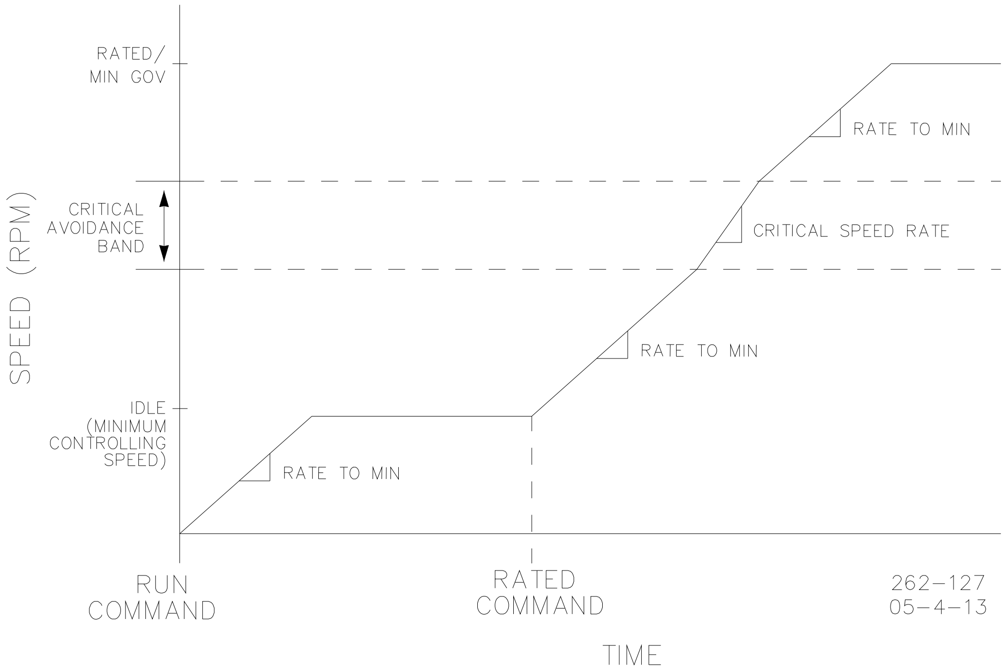


Figure 2-17. Idle/Rated Start

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

If a contact input is configured for Idle/Rated, Idle is selected when the contact is open, and Rated is selected when it is closed. The Idle/Rated contact may be either open or closed when a trip condition is cleared. If the contact is closed at that time, it must be opened and re-closed to initiate a Ramp to Rated. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

All pertinent Idle/Rated parameters are available through Modbus. Refer to Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.14.3 Auto Start Sequence

IMPORTANT	**Auto Start Sequence is not the same as Automatic Start Mode. Auto Start Sequence can be used with any of the three start modes.**

The Auto Start Sequence logic allows the 505CC-2 to perform a completely automatic, controlled system startup from zero speed to Minimum Governor, and may be used with any Start Mode (Manual, Semiautomatic, and Automatic). The unit first ramps to a configured Low Idle speed, holding there until the configured Low Idle Delay (warm-up) time has expired. The control ramps, at a configurable rate to a configured High Idle speed. Then again holding until the configured High Idle Delay (warm-up) time has expired. Finally, the control will ramp to Minimum Governor.

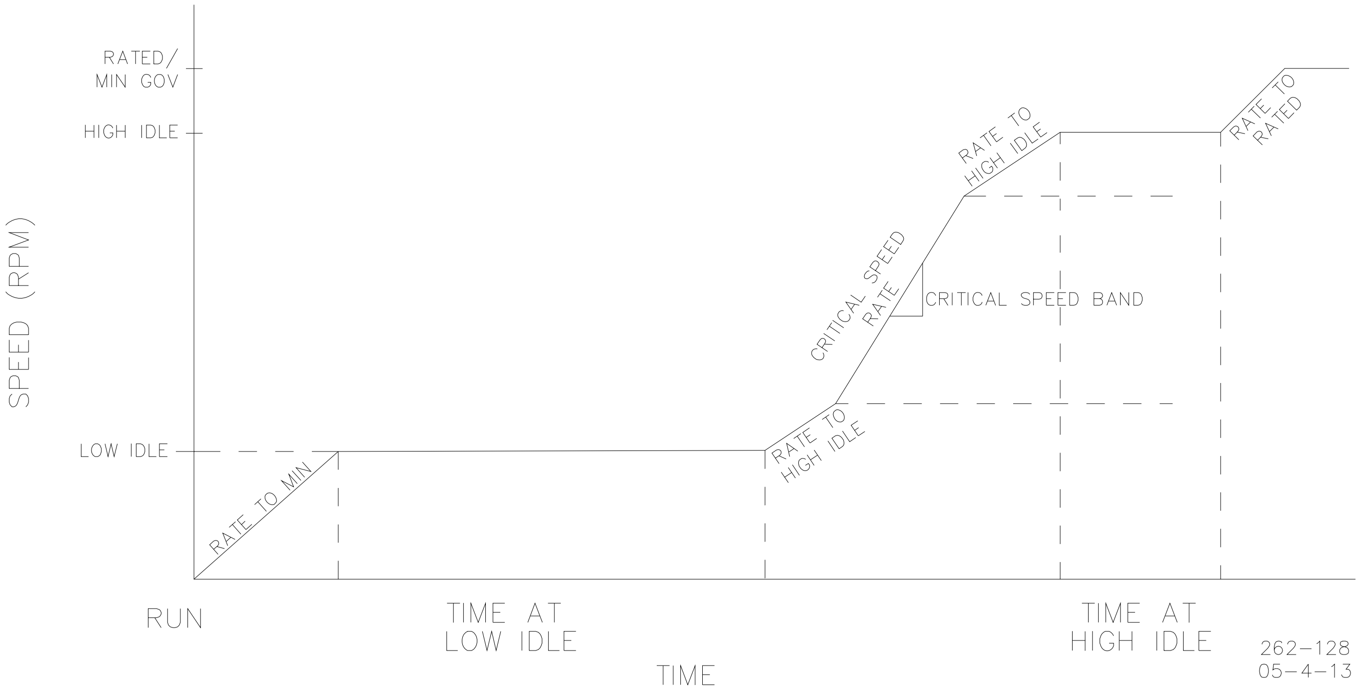


Figure 2-18. Automatic Start Sequence

The hold times and ramp rates will vary with configured *hot* and *cold* parameters according to how long the turbine has been shut down. A timer starts when a shutdown occurs and the turbine rolls below Idle (or Minimum Controllable) speed. If the shutdown is reset while the unit coasts down, the timer stops but will not reset (unless speed is above Minimum Governor). If the unit is not restarted, the timer will continue until a subsequent start and run above Minimum Governor. When a Start/Run is initiated, this timer value is compared to the configured hot and cold time values to generate the appropriate idle times and ramp rates. If the timer value exceeds the configured Cold Start Hours, the cold parameters are used. Conversely, the hot parameters are used if the timer value is less than the configured Hot Start Hours. If the timer is between hot and cold values, the control interpolates between the hot and cold data points to determine the appropriate ramp rates and hold times.

IMPORTANT

The hot hours value should be configured less than the cold hours value. Otherwise, the control cannot interpolate between settings.

In this case, the higher hot hours value is ignored, and the control will use either the hot or cold idle delays and ramp rates, depending upon the current timer value relative to the configured cold hours value.

For example, consider the following 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 MIN
LOW IDLE DELAY (HOT) = 10 MIN
HI IDLE SETPT = 2000 RPM
RATE TO HI IDLE (COLD) = 5 RPM/SEC
RATE TO HI IDLE (HOT) = 15 RPM/SEC
HI IDLE DELAY TIME (COLD) = 15 MIN
HI IDLE DELAY TIME (HOT) = 5 MIN
RATE TO RATED (COLD) = 10 RPM/SEC
RATE TO RATED (HOT) = 20 RPM/SEC
MINIMUM GOVERNOR SETPOINT = 3400 RPM

If, at the next start, the unit's Hours since Trip timer was at 12 hours, the 505CC-2 would interpolate between the Hot and Cold parameters and use the following rates and delays:

LOW IDLE DELAY = 20 MIN
RATE TO HI IDLE = 10 RPM/SEC
HI IDLE DELAY = 10 MIN
RATE TO RATED = 15 RPM/SEC

Based on this example, the speed setpoint would ramp to 1000 rpm at the configured Rate to Min and hold for 20 minutes; then move to 2000 rpm at 10 rpm/sec and hold there for 10 minutes; and lastly, move to 3400 rpm at 15 rpm/sec. At 3400 rpm, the sequence would be completed.

IMPORTANT

The 505CC-2 will automatically set the Hours Since Trip timer to 1000 hours to insure that a cold start is selected after a control system power-up.

This timer will reset only after a Start is initiated and speed increases past idle (or minimum controllable).

The Auto Start Sequence can be stopped and restarted, if desired, by issuing Halt/Continue commands, which can be made through the CCT, remote contact inputs, or Modbus. Any Speed Raise/Lower or Speed Setpoint entry via the CCT or Modbus will also halt the sequence. Alternatively, the Auto Start Sequence can be configured to automatically halt at each idle setpoint.

When the sequence is halted, the delay timers do not stop if they have already started counting. 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 issuing a Continue command, the sequence would remain at the idle speed for the remainder of the Idle Delay Time, which in this example would be 5 minutes. And, if a Speed Raise/Lower or Speed Setpoint entry cause the speed to exceed the idle setpoint while the sequence is halted, that idle delay is considered complete regardless of the timer; the sequence will continue on the next ramp.

If a contact input is programmed to function as a Halt/Continue command, the sequence is halted when the contact is closed, and continued when the contact is opened. If the contact is closed when a Reset and Start are initiated, it must be opened and re-closed to halt. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled. And, a relay output can be assigned to indicate when the Auto Start Sequence is halted.

An option is available to automatically halt the Auto Start Sequence at the Low and High Idle setpoints. If the unit is started and the speed is above the Low Idle setpoint, the sequence will initialize as halted. The Halt/Continue contact input, if configured, must transition open to continue the sequence, as described previously. The hold timers are still active with this option. If Continue is commanded, and the hold timer has not expired, the sequence will remain in a timed wait until the hold timer has expired and then continue.

2.15 Emergency Shutdown

When an Emergency Shutdown occurs, both valve output signals are stepped to their minimum current levels, the Shutdown relay output de-energizes, and the shutdown cause (first-out indication) is displayed on the CCT.

Up to ten External Shutdown inputs, remote contact inputs, can be configured to initiate a 505CC-2 Emergency Shutdown. This in addition to the mandatory Main Shutdown command input. By wiring trip initiators directly into the control instead of a hard-wired trip string, the 505CC-2 can pass a trip signal directly to its output relay, to trip the T&T valve, and indicate the first trip condition sensed. All trip conditions are indicated through the CCT and Modbus.

The last trip indication is latched and can be viewed until the shutdown conditions are reset. Once, the shutdowns are cleared, the first-out indication is also cleared, awaiting another start.

In addition to the dedicated Shutdown relay at Relay Output #1, any turbine configurable relay output may be assigned to indicate a Shutdown condition or as a Trip Relay. The main Shutdown Relay Output #1 and configurable Trip Relay outputs are de-energized on shutdown. However, the configurable Shutdown Condition output can be configured de-energized, energizing on a trip condition to indicate the shutdown on a remote panel or to a plant DCS.

The 505CC-2 shutdown initiators can be found in Volume 1, Appendix G. The numerical reference can be used as an index to determine the cause of a trip via the first-out number in the Datalog or passed to Modbus.

2.16 Controlled Shutdown

The 505CC-2's Controlled Shutdown function is used to stop the turbine in a controlled manner, as opposed to an Emergency Trip. When a Stop command (controlled shutdown) is issued the following sequence is performed:

1. All control functions and PIDs, except Speed and Extraction/Admission, are disabled.
2. Extraction/Admission control is disabled (the LP limiter is raised for Extraction applications).
3. The Speed Setpoint is ramped toward Minimum Governor at the configured Controlled Shutdown Rate to Min Gov.
4. The Speed Setpoint continues ramping toward Idle at the configured Controlled Shutdown Rate to Idle.
5. At Idle, the turbine will wait for a configured Controlled Shutdown "Cooldown Time" (not applicable if Start Speed is Minimum Governor).
6. After the cooldown, the Controlled Stop is complete and a Shutdown is initiated.

As noted in step 5 above, the cooldown feature applies only if the Start Speed is configured as Single Idle (Idle/Rated) or Auto Sequence. The Minimum Governor start has no configured Idle speed, therefore no cooldown.

A Controlled Shutdown can be initiated or aborted from the CCT, remote contact input, or Modbus. If the contact input is used, the Stop is initiated when the contact is closed and aborted when opened. The contact can be either open or closed when a trip condition is cleared. If the contact is closed it must be opened and re-closed to initiate a Stop. Similarly, the control responds to Modbus commands on the positive edge transition, regardless of whether they are pulsed or toggled.

The Controlled Shutdown sequence can be aborted at any time. By issuing a Controlled Shutdown Abort command, the control will interrupt the turbine's stop ramp. If above Minimum Governor, the 505CC-2 will be in the online state and await further action by the operator. If below Minimum Governor and above Idle, the unit will be in the Start Sequence Hold state and await further action. At this point the shutdown sequence can be re-initiated when desired, or the unit can be brought back to a fully operational state.

2.17 Overspeed Test Function

The 505CC-2's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test the electrical overspeed protection logic and/or the turbine's mechanical overspeed device. This includes the 505CC-2's internal overspeed trip logic and any external overspeed trip device's settings and logic. An Overspeed Test will allow the control's speed setpoint to be increased above the normal Maximum Governor limit. This test can be performed from the CCT or with remote contact inputs. This test is not permissible through Modbus.

An overspeed test is allowed only under the following conditions:

- The Speed PID must be in control.
- The Cascade, Extraction/Admission, and Remote Speed Setpoint functions must be disabled.
- The Speed Setpoint must be at Maximum Governor.

If the Overspeed Test Enable command is issued (CCT or contact input) and the above conditions are not met, the CCT will display an "Overspeed Test / Not Permissible" message. Once the test is enabled, the speed reference can be raised above Maximum Governor up to the configured Overspeed Test Limit.

There are two configurable relay output options available to indicate overspeed status. One indicates an Overspeed Trip condition. The second provides indication that an Overspeed Test is enabled and/or being performed.

All pertinent overspeed test parameters are available through Modbus. See Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.18 Local/Remote

The Local/Remote functionality allows an operator at the turbine skid or through the CCT to disable any remote command, e.g. from a remote control room that may put the system in an unsafe condition. This function is typically used during a system startup or shutdown to allow only one operator to manipulate the 505CC-2 control modes and settings.

The Local/Remote function must be configured on the Binary Inputs configuration screen before an operator can select the Local or Local/Remote Modes. If it is not configured, all contact inputs and Modbus commands (if Modbus is configured) are active at all times. If the Local/Remote function is configured, Local and Local/Remote Modes can be selected through the remote contact input or Modbus.

When Local Mode is selected, the 505CC-2 is controlled only through its CCT. This mode disables all contact inputs and Modbus commands, with the exceptions noted below:

- External Trip Contact In (active at all times)
- External Trip 2 Contact In (active at all times, if configured)
- External Trip 3 Contact In (active at all times, if configured)
- External Trip 4 Contact In (active at all times, if configured)
- External Trip 5 Contact In (active at all times, if configured)
- Override MPU Fault Contact In (active at all times, if configured)
- Start Permissive Contact In (active at all times, if configured)
- Select On-line Dynamics Contact In (active at all times, if configured)
- Local/Remote Contact In (active at all times, if configured)
- Local/Remote Modbus Command (active at all times, if Modbus configured)
- Trip Command Modbus Command (active at all times, if Modbus configured)

IMPORTANT

The optional touchscreen HMI, or a similar HMI/CCT computer provided by the user, may be installed anywhere, even some distance from the 505CC-2 and/or the turbine/compressor unit. With regard to the Local/Remote functionality, the HMI/CCT is always considered Local, no matter where it is installed.

When Local/Remote Mode is selected, the 505CC-2 can be controlled through its HMI/CCT, remote contact inputs, and/or all Modbus commands.

When using a contact input to select Local or Local/Remote Modes, a closed contact input selects the Local/Remote Mode, and an open contact input selects the Local Mode.

Optionally, a configurable relay output can be assigned to indicate when Local Mode is selected. There is also indication of the Local/Remote Mode selection through Modbus.

The 505CC-2 is defaulted to only allow control operation though its HMI/CCT when the Local Mode is selected. If desired, this can be modified to enable all contacts inputs and Modbus commands when in Local Mode.

All pertinent Local/Remote control parameters are available through Modbus. See Volume 1, Appendix E for the complete Modbus list of the 505CC-2.

2.19 Alarms

See Volume 1, Appendix F for the complete alarm list of the 505CC-2.

The numerical reference can be used as an index to determine the first alarm received via the first-alarm number in the Datalog or Modbus.

2.20 High-Speed Datalog

The control is defaulted to continually log specific variables into a memory file once a Turbine Start/Run command is issued. Upon a Trip the control will create a file of this data on the CPU hard-drive. This data is logged at 10 ms intervals and will retain about 4 minutes worth of run-time, thus it is intended for high resolution views of specific events (such as a breaker trip, load transient, or PID tuning). It is not intended to be a historical trend of parameters.

Chapter 3.
General Description

3.1 Introduction

The 505CC-2 has incorporated Woodward Global Steam Turbine CORE (GSTC) software logic which contains steam turbine control algorithms jointly developed by a global Woodward application engineering team. The CORE software is under engineering control by its own GAP part number and can be enhanced by Woodward without affecting site configurations.

3.2 Additional Features

The 505CC-2 also provides the following turbine control features:

- First-Out Trip Indication (5 total trip inputs from external devices)
- Critical Speed Avoidance (2 configurable speed bands and ramp rate)
- Configurable Start Routines (Rated, Idle/Rated, Auto Start Sequence)
- Dual Speed/Load Dynamics
- Zero Speed Override
- Peak Speed Indication for Overspeed Trip

3.3 505CC-2 Inputs and Outputs

3.3.1 Control Inputs

3.3.1.1 Analog Inputs

Two speed inputs (MPU or proximity probe) and six configurable 4–20 mA analog inputs are available. The numbers may be used as an index to the configuration value available in the Modbus list.

1. --- Not Used ---
2. Remote Speed Reference Setpoint
   a. If configured, this input may be used to provide a speed setpoint from an external device.
3. Cascade Input
   a. If configured, this input may provide a process variable for Cascade control on turbine speed.
4. Remote Cascade Setpoint
   a. If configured, this input may be used to provide a Cascade setpoint from an external device.
5. Auxiliary Input
   a. If configured, this input may provide a process variable for auxiliary control..
6. Remote Auxiliary Setpoint
   a. If configured, this input may be used to provide a setpoint from an external device.
7. Extraction/Admission Input
   a. If configured, this input may provide a process variable for extraction/admission control.
8. Remote Extraction/Admission Setpoint
   a. If configured, this input may be used to provide a setpoint from an external device.
9. Remote Manual Extraction/Admission (P) Dmd

10. Inlet/Exhaust Press/Flow
    a. If configured for Inlet or Exhaust Decoupling with a two-valve turbine, this input provides the Inlet or Exhaust Pressure/Flow measurement.
11. Remote Inlet/Exhaust Setpoint
    a. If configured for Inlet or Exhaust Decoupling with a two-valve turbine, this input may be used to provide a setpoint from an external device.
12. Remote Manual Inlet/Exhaust Demand
13. Feed Forward Input
14. Process Value for Hot/Cold Start Curves
15. Customer Defined Monitor Input #1
16. Customer Defined Monitor Input #2
17. Customer Defined Monitor Input #3
18. Customer Defined Monitor Input #4

3.3.1.2 Contact Inputs

Twenty-four contact inputs are available. The first contact input is fixed as emergency shutdown input. The others are configurable. The numbers may be used as an index to the configuration value available in the Modbus list.

1. Not Used by Turbine
2. Reset Command
3. Start Command
4. Halt/Continue-Idle/Rated
5. Raise Speed
6. Lower Speed
7. E/D Remote Speed
8. Normal SD Request
9. Overspeed Test
10. Select Hot/Next Curve
11. Raise HP Ramp
12. Lower HP Ramp
13. Raise LP Ramp
14. Lower LP Ramp
15. E/D Cascade
16. Raise Cascade SP
17. Lower Cascade SP
18. Ldsh Request (spare)
19. Swing Request (spare)
20. Normal Request (spare)
21. E/D Remote Cascade
22. E/D Auxiliary
23. Raise Auxiliary SP
24. Lower Auxiliary SP
25. Raise Auxiliary Demand
26. Lower Auxiliary Demand
27. E/D Remote Auxiliary
28. Auxiliary Manual Request
29. Enable/Disable Extr/Adm
30. Extr/Adm Manual Mode Request
31. Extr/Adm Automatic Mode Request
32. Raise Extr/Adm Setpoint
33. Lower Extr/Adm Setpoint
34. Raise Extr/Adm Demand
35. Lower Extr/adm Demand
36. E/D Rem Extr/adm Setpoint
37. Enable Remote Manual Extraction
38. E/D Inlet/Exhaust Control
39. Inlet/Exhaust Manual Control
40. Inlet/Exhaust Automatic Control
41. Raise Inlet/Exhaust Setpoint

42. Lower Inlet/Exhaust Setpoint
43. E/D Remote Inlet/Exhaust Setpoint
44. Enable Rem Manual Inlet/Exhaust
45. E/D Feedforward Loop
46. External Shutdown #1
47. External Shutdown #2
48. External Shutdown #3
49. External Shutdown #4
50. External Shutdown #5
51. External Shutdown #6
52. External Shutdown #7
53. External Shutdown #8
54. External Shutdown #9
55. External Shutdown #10
56. External Alarm #1
57. External Alarm #2
58. External Alarm #3
59. External Alarm #4
60. External Alarm #5
61. External Alarm #6
62. External Alarm #7
63. External Alarm #8
64. External Alarm #9
65. External Alarm #10
66. Override MPU Fault
67. Select On-line PID
68. Local/Remote
69. RTC Clock Synchronize
70. Emergency to Min Governor

3.3.2 Control Outputs

3.3.2.1 Analog Outputs

Two actuator outputs are provided for the HP and LP valves, configurable for either 4–20 mA or 20-160 mA, nominal. Two analog outputs are reserverd for the compressor control anti-surge valves. Four additional configurable analog outputs are provided for readouts of any of the following parameters. The numbers may be used as an index to the configuration value available in the Modbus list.

1. Used for Compressor
2. --- Not Used ---
3. Actual Shaft Speed
4. Speed Reference Setpoint
5. Remote Speed Reference Setpoint
6. Extraction/Admission Signal
7. Extraction/Admission Setpoint
8. Remote Extract/Admission Setpoint
9. Cascade Signal
10. Cascade Setpoint
11. Remote Cascade Setpoint
12. Auxiliary Signal
13. Auxiliary Setpoint
14. Remote Auxiliary Setpoint
15. S Demand (Speed)
16. P Demand (Extraction)
17. ACT 1 (HP) Valve Limiter Setpoint
18. ACT 2 (LP) Valve Limiter Setpoint
19. ACT 1 (HP) Valve Demand
20. ACT 2 (LP) Valve Demand
21. ACT1 Demand after Linearization

22. ACT2 Demand after Linearization
23. Monitor #1
24. Monitor #2
25. Monitor #3
26. Monitor #4
27. Monitor #5
28. Monitor #6
29. Monitor #7
30. Monitor #8

3.3.2.2 Relay Outputs

Twelve relay outputs are available. Two of the outputs are fixed for Shutdown and Alarm indications. The four remaining outputs are configurable for the following discrete statuses or level switches. The numbers may be used as an index to the configuration value available in the Modbus list.

Status Indication

1. Shutdown Active
2. Trip Relay
3. Alarm Active
4. Start Inhibit Active
5. Ready to Start
6. Atlas II Control Status OK
7. Acceleration Protection Activated
8. Overspeed Trip
9. Overspeed Test Enabled
10. Speed PID in Control
11. Rated Selected
12. Auto Start Sequence Halted
13. Online PID Selected
14. Local Mode Selected
15. Remote Speed Setpoint Enabled
16. Remote Speed Setpoint Active
17. Cascade Control Enabled
18. Cascade Control Active
19. Remote Cascade Enabled
20. Remote Cascade Active
21. Auxiliary Limiter Active
22. Auxiliary Control Enabled
23. Auxiliary Control Active
24. Extraction/Admission Enabled
25. Extraction/Admission Active
26. Extraction/Admission Control in Auto
27. Extraction Admission in Remote Auto
28. Extraction Admission in Manual
29. Extraction Admission in Remote Manual
30. Inlet/Exhaust Ctrl Mode Selected
31. Inlet/Exhaust Ctrl in Automatic Mode
32. Inlet/Exhaust Ctrl in Remote Auto Mode
33. Inlet/Exhaust Ctrl in Manual Mode
34. Inlet/Exhaust Ctrl in Remote Manual Mode
35. Any Steam Map Limit Reached
36. Feed-forward enabled
37. Feed-forward Active
38. Modbus#1 Command Enabled
39. Modbus#2 Command Enabled
40. Internal Level Switch 1 On
41. Internal Level Switch 2 On
42. Internal Level Switch 3 On
43. Internal Level Switch 4 On
44. Internal Level Switch 5 On

45. Internal Level Switch 6 On
46. Internal Level Switch 7 On
47. Internal Level Switch 8 On
48. Spare
49. Spare
50. Reset Pulse (1 second)

Level Switch, i.e. the ON and OFF levels for switching can be defined

1. Speed
2. Speed Setpoint
3. Extracxtion Input
4. Extraction Setpoint
5. Cascade Input
6. Cascade Setpoint
7. Auxiliary Input
8. Auxiliary Setpoint
9. S Demand Value
10. P Demand Value
11. HP Valve Limit Value
12. LP Valve Limit Value
13. Actuator #1 Demand
14. Actuator #2 Demand
15. Monitor #1
16. Monitor #2
17. Monitor #3
18. Monitor #4
19. Monitor #5
20. Monitor #6
21. Monitor #7
22. Monitor #8

Chapter 4.
Configuration Mode

4.1 Introduction

The 505CC-2 may be configured using the Commissioning Configuration Tool (CCT) software running on a connected computer. See Volume 1 for a description of the software tools and Volume 3 for the compressor configuration mode. This chapter will provide detailed information concerning the steam turbine configuration mode only.

The Configuration Mode of the ToolKit Tool Application, 54183682CF, is a step by step procedure to program the 505CC-2 compressor control. A series of pages are used to escort the user through every option the 505CC-2 compressor control contains. The following screens will step a user through all of the configurable features of the control system.

4.2 Home Page

The home page is displayed up after starting the ToolKit Tool Application, 54183682CF.wtool. It can display full or limited configuration access. The full configuration mode is used to configure the control to the application, and is only accessible when the turbine is shutdown with full configuration authorization. The limited configuration mode allows the user to view these same page screens, change some selections, but disables the selection of configuration settings that should not be changed with the turbine running.

Figure 4-1. 54183682CF.wtool Home Page

It displays the following:

- Turbine Full or Limited Configuration
  - o This will be explained in this Chapter.
- Compressor Full or Limited Configuration
  - o Will show up after Enable Compressor Config on Full Configuration mode
  - o See Volume 3 for more information on Compressor Configuration Screens.

- External Programs; see Volume 1 for a more detailed description of these programs.
  - AppManager enables functionality such as application loading and datalog retrieval.
  - Control Assistant can be tunable extraction, and datalog viewing.
  - On-Screen Keyboard enables usage of a mouse operated keyboard.
- System Info
  - Displays the GAP application P/N and revision, and coder version used.
- Authorization Level
  - Shows the authorization level for the miscellaneous functionality.

The screen shown in Figure 4-1 shows the initial screen with factory default tunables. The error no turbine and/or compressor configured might appear when the user has not successfully completed the configuration mode steps.

NOTICE

Entering full configuration mode will issue a CPU I/O lock to the hardware interface modules and all outputs from the control will be disabled.

Ensure the turbine and/or compressor is in a shutdown condition and that devices are properly locked out or that a safety issue is not created.

Perform the following steps to enter the full configuration mode from a limited configuration mode condition:

1. Ensure the turbine and/or compressor is shutdown and steam block valves closed.
2. Press the button Enter Full Configuration Mode.
3. Press the Confirm Action button that will appear. If not pressed with a few seconds will result in returning to the Enter Full Configuration Mode button.
4. The CPU will now issue an I/O lock to the hardware interface modules and all outputs from the control will be disabled.
5. The Turbine Full Configuration button is available now

Click on Turbine Full Configuration to proceed with the turbine configuration, see 4.3 General Overview.

4.3 General Overview

This is the initial screen for configuration of a particular turbine application in which the turbine configuration and site specific information can be set.

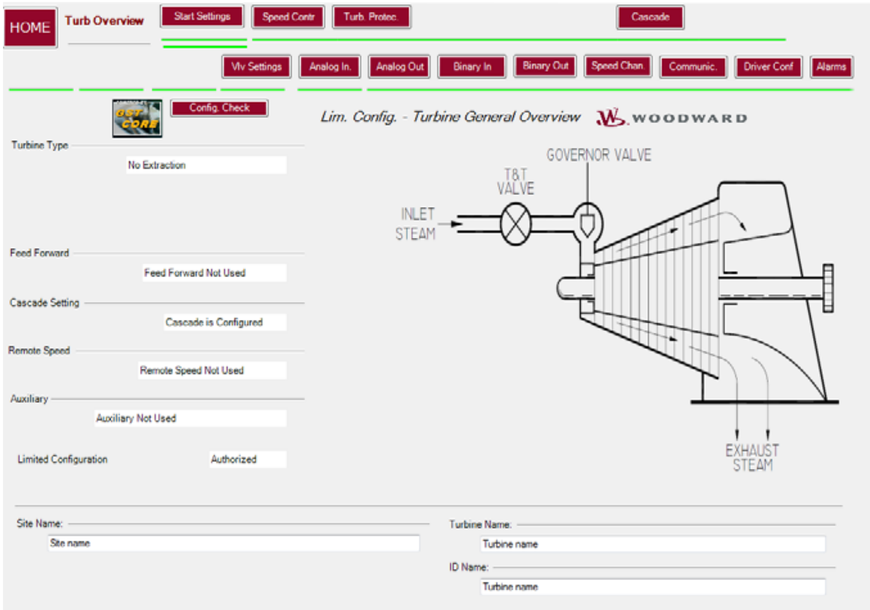


Figure 4-2. General Overview

4.3.1 Turbine Configuration

Type

The following turbine type selections are available:

- No Extraction;
  - Select this option if the turbine being controlled is a basic steam turbine with only one steam valve.
- Extraction Only;
  - Select this option if the turbine being controlled is a single controlled extraction turbine (has two modulating control valves; one inlet control valve and one extraction control valve).
- Admission Only
  - Select this option if the turbine being controlled is a single controlled admission (induction) turbine (has two modulating control valves; one inlet control valve and one admission control valve).
- Admission Only with Direct Feed
  - Select this option if the turbine being controlled is a single controlled admission (induction (has two modulating control valves; one inlet control valve and one admission control valve) feeding directly the LP body)
- Extraction and Admission;
  - Select this option if the turbine being controlled is a single controlled extraction/admission turbine (has two modulating control valves; one inlet control valve and one extraction/admission control valve). With this type of application, the turbine can extract or admit steam, depending on system requirements.

Decoupling Mode (Ratio/Limiter)

Decoupling selections become visible when extraction and/or admission turbine type is selected. The ratio/limiter logic controls the interaction of HP and LP valves to control the desired turbine related parameters, i.e. speed, extraction pressure/flow, inlet pressure/flow, exhaust pressure/flow and minimize the effects of one controlled process on the other controlled process.

When correcting for a system demand change in one process it may be desirable to have the control move both turbine valves at the same time in order to reduce or stop the interaction of one process on the other. For this reason the 505CC-2 Ratio/ Limiter can be configured in the following operational modes depending on the parameters being controlled and the turbine's function within the system, reference 2.10 Ratio-Limiters. The following selections are available:

- Coupled Mode (HP and LP);
  - This mode is typically used when the two controlled parameters during normal operation are turbine speed/load and extraction pressure (or flow).
- Inlet & Speed Decoupling (Decoupled Inlet HP);
  - This mode is typically used when the two controlled parameters during normal operation are turbine inlet pressure (or flow) and speed.
- Exhaust & Speed Decoupling;
  - This mode is typically used when the two controlled parameters during normal operation are turbine exhaust pressure (or flow) and speed.
- Total Decoupling & No Map;
  - This mode is typically used when the two controlled parameters during normal operation are turbine inlet pressure (or flow) and exhaust pressure (or flow).

Depending on the selection of Decoupling a button for another screen will appear in the CCT to configure the Decoupling parameters, see 4.11 Decoupling.

Feed Forward Control

The Feed Forward Control is a feature which normally is not required. Still in some cases it could be necessary to decouple the speed control and some other devices such as the anti-surge controller. The following selections are available:

- Feed Forward Not Used
- Feed Forward is Configured

Depending on the selection of Feed Forward Control a button for another screen will appear in the CCT to configure the Feed Forward Control parameters.
.

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, compressor suction/discharge pressure controller.

Cascade Control is a PID controller that is cascaded with the Speed PID. By cascading these two PID a bumpless transfer between the two controlling parameters can be performed, reference 2.6 Cascade Control. The following selections are available:

- Cascade Not Used
- Cascade is Configured

Depending on the selection of Cascade Control a button for another screen will appear in the CCT to configure the Cascade Control parameters.
.

Remote Speed Setpoint

Use this to configure the control to utilize a remote speed setpoint signal (4-20 mA input) from some other system device. If this is configured the Configuration Check will expect to find at least one analog input configured for this function. Otherwise an error will be annunciated, reference 2.5 Speed Control. The following selections are available:

- Remote Speed Not Used
- Remote Speed is Configured

Auxiliary Type

Select the Auxiliary PID functionality by configuring it as a Limiter or a Process Controller. The Auxiliary PID can be used to limit turbine inlet pressure, turbine exhaust pressure, pump/compressor discharge pressure, or any other auxiliary parameters directly related to turbine speed/load. This limiter will act on an LSS bus just after the Extraction PID demand.

The following selections are available:

- Auxiliary Not Used;
  - o Select this option when auxiliary functionality is not required.
- Auxiliary as Process Limiter;
  - o This limiter can be used to limit any process value, such as the inlet pressure, exhaust pressure, exhaust temperature etc.
  - o This limiter will act on an LSS bus just after the Extraction PID demand.

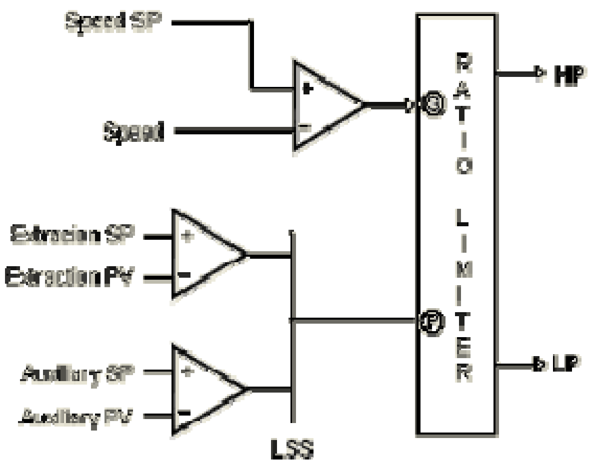


Figure 4-3. Auxiliary as Process Limiter

- Auxiliary as Second Process Controller;
  - o Auxiliary used as control. For example, exhaust pressure as second control when decoupling is selected for inlet pressure as the first control.
  - o Via the E/D switch the operator can decide to totally by-pass the extraction PID controller and to transfer the P demand control to auxiliary controller. Once enabled the extraction PID controller is automatically put in tracking mode.
  - o Can only be used in case of an extraction and/or admission turbine.

- o Extraction control mode requires to be enabled for this selection.
- o Decoupling related to the second process controller should not be enabled.

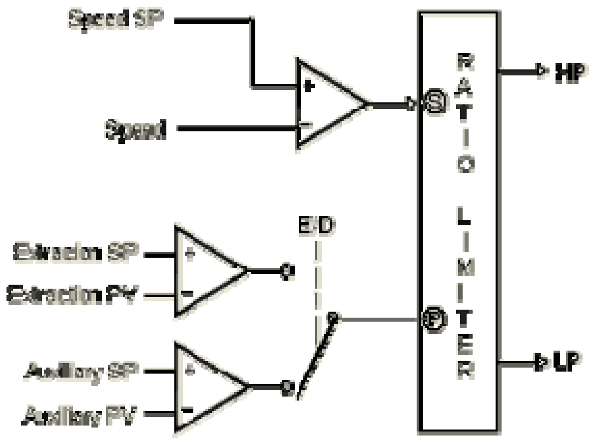


Figure 4-4. Auxiliary as Second Process Controller

- Auxiliary as Load Limiter on Speed Reference;
  - o Example, compressor discharge pressure override is requested; see Volume 3, while cascade controls the suction pressure.
  - o Example, it can also be used to limit the load if inlet pressure collapses
  - o This limiter is faster than the limiter on cascade since it direct acts on the speed setpoint for the speed PID, but could result in instabilities on the cascade process value at recovery.
  - o Can be used for all turbine types.

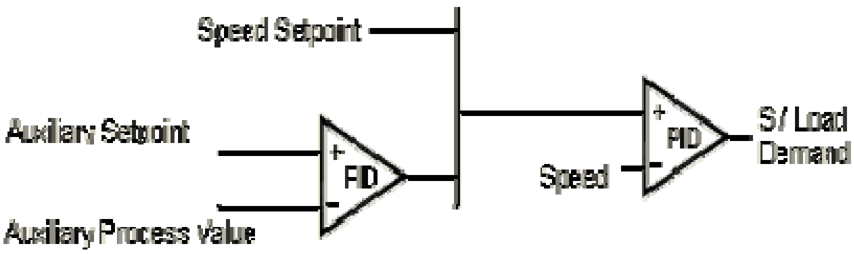


Figure 4-5. Auxiliary as Load Limiter on Speed Reference

- Auxiliary as Load Limiter on Cascade
  - o The same examples apply as for the Auxiliary as Load Limiter on Speed Reference.
  - o Cascade control applies limitations to the usage of Auxiliary as Load Limiter.
  - o This limiter is not available when Cascade is not configured.
  - o Can be used for all turbine types.

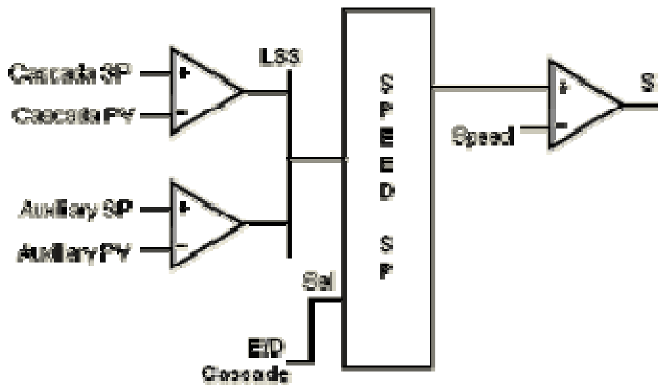


Figure 4-6. Auxiliary as Load Limiter on Cascade

Depending on the selection of the Auxiliary Type a button for another screen will appear in the CCT to configure the Auxiliary parameters, see 4.13 Auxiliary.

4.3.2 Identification Tags

Site, Turbine, and ID Tag fields may be used to distinguish between applications and turbines. This information can help identify a turbine when downloading a program to a turbine or retrieving a program from a turbine.

This information is saved in the control and is also saved in the configuration file when the control configuration is saved to a file.

When a file is retrieved, this information can identify which turbine is associated with this file.

4.4 Start Settings

This screen is used to configure the turbine start mode, start-up sequence, speed setpoints and the hot/cold loading curve information.

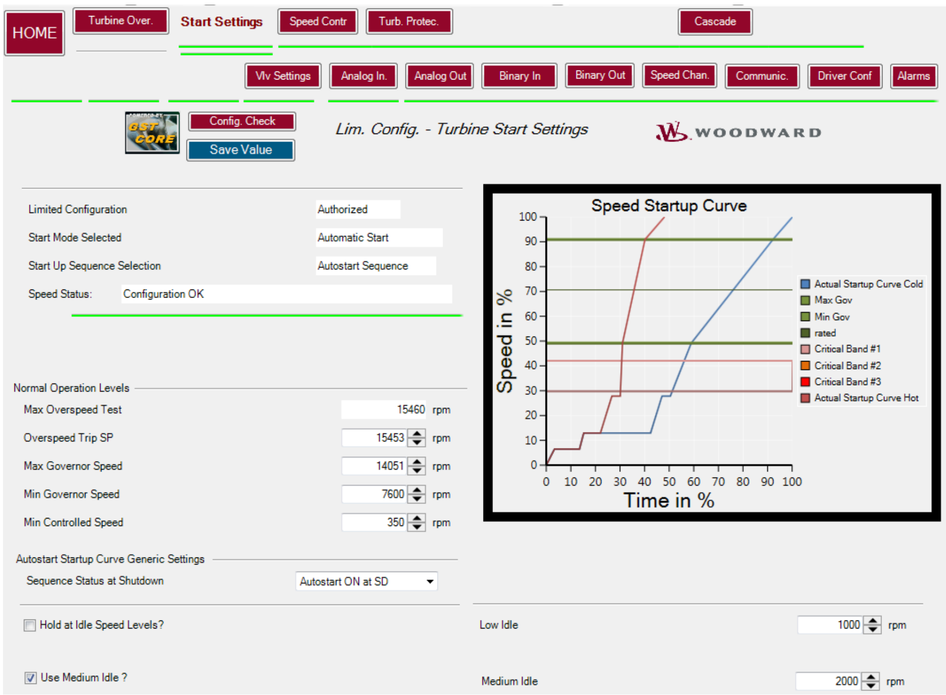


Figure 4-7. Start Settings

4.4.1 Start Mode Configuration

Start Mode Selection

The following are the basic type of start mode procedures; see for details 2.13 Turbine Start Modes:

- Automatic Start;
  - When configured for an automatic start mode, the 505CC-2 controls the turbine speed from zero up to the minimum control speed. The Automatic Start Sequence would be:
  - Operator opens the trip-throttle valve.
  - Issue a start command.
  - The HP valve limiter opens automatically until the governor takes control.
- Semi-Automatic Start;
  - When configured, the 505CC-2s HP 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 trip-throttle valve.
  - Issue a Start Command.
  - The 505CC-2 control’s valve limiter must then be raised by the operator until governor takes control.

- Manual Start;
    - 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:
    - Issue a Start command.
    - The actuators automatically move to HP max position at start-up.
    - The operator slowly opens the trip-throttle valve until the governor takes control.

4.4.2 Start Up Sequence Selection

- Idle/Rated
    - Select this routine to have the control begin controlling speed at an Idle speed setting, then allow an operator to manually raise the speed setpoint or issue a Ramp to Rated command.
    - The control will ramp from the Idle speed setting to the Rated Speed setting when a Ramp to Rated command is given (via the CCT, Modbus or an external contact input).
    - Critical avoidance bands can be used with this routine.
- Auto Start Sequence
    - Select this routine to have the turbine speed control from zero up to rated speed using hot and cold start routines based on how long the turbine was shutdown.
    - This routine ramps the speed setpoint to a low idle speed setting once a start command is given, holds for a set delay time, ramps the speed setpoint to a high idle speed setting, holds for a set delay time, and then ramps the speed setpoint to a rated speed setting.
    - This routine can be halted and continued at any point through the CCT, Modbus or external contact input commands.
    - Even though configured for an automatic start, an operator can at any time choose to raise or lower the speed setpoint manually to complete a system start-up.
- No Idle
    - Select this routine to have the control begin controlling turbine speed at the Minimum Controlled Speed.
    - The control speed setpoint can be manually adjusted between the Minimum and Maximum Governor Speed.
    - Critical avoidance bands are not used or allowed with this routine.
- Multi Curve Start
    - This is a special feature that allows the user to select from a variety of load curves using an analog input signal. The speed setpoint can be only manipulated in manual start mode when the engine speed is below low idle. In any other type of configuration, speed and speed reference must be at low idle to authorize raise setpoint commands.

Miscellaneous other configuration options might appear depending on the selected start up sequence.

4.4.2.1 Normal Operation Levels

Max Overspeed Test **Initial=4450 (100, 25000)**

Set this value to the maximum desired speed reference needed to test external overspeed trips. Recommend is to set the test level not more than 2% above the external overspeed setpoint. The 505CC-2 will trip if the speed reaches the set level without having the external overspeed activating.

Overspeed Trip SP **Initial=4400 (100, 25000)**

Set this value to the desired overspeed trip point for the 505CC-2 control. This value must be below the Max Overspeed Test setpoint.

Max Governor Speed **Initial=3937 (100, 25000)**

Set this value to the upper control limit of the speed reference.

Min Governor Speed **Initial=2625 (100, 25000)**

Normal operation of the turbine should be from min to max governor. Set this value to the lower control limit of the speed reference.

Min Controlled Speed **Initial=100 (1, 10000)**

Set this value to the lowest speed at which the 505CC-2 could begin controlling speed. Lowest Idle setpoint must be above this speed

4.4.3 Idle/Rated

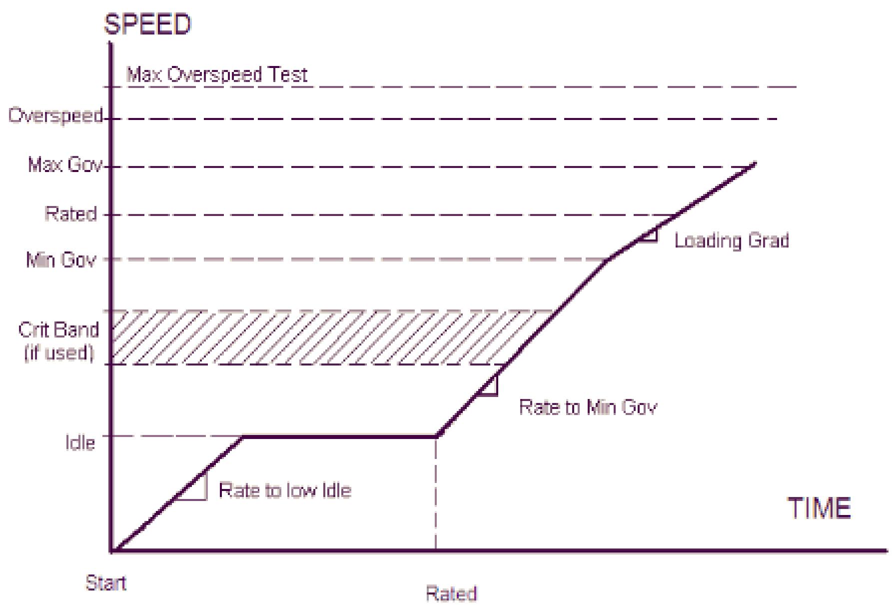


Figure 4-8. Idle/Rated

Idle Priority?

Enabling this option replaces the Hold functionality with Idle functionality.

Clicking or selecting the Hold button is used to issue a halt command to the 505CC-2 control. This is used to hold the start procedure at any moment and to keep the turbine at that place in the start procedure.

With Idle Priority enabled during start-up and the Idle command is issued will result in the turbine ramping back to idle speed instead of Hold.

Rate to Low Idle **Initial=100.0 (0.01, 1000)**

Enter the ramp rate in rpm/sec for going to Idle Speed.

Rate to Min Governor **Initial=100.0 (0.01, 1000)**

Enter the ramp rate in rpm/sec for going to Minimum Governor Speed.

Loading Gradient **Initial=100.0 (0.01, 1000)**

Enter the ramp rate in rpm/sec for going to between Minimum Governor and Maximum Governor Speed.

Idle Speed **Initial=500 (100, 25000)**

Enter the Idle Speed setpoint.

Rated Speed **Initial=3750 (100, 25000)**

Enter the Rated Speed setpoint. This is the speed that the turbine is running in normal operating conditions between minimum and maximum governor speed.

4.4.4 Auto Start-up Sequence

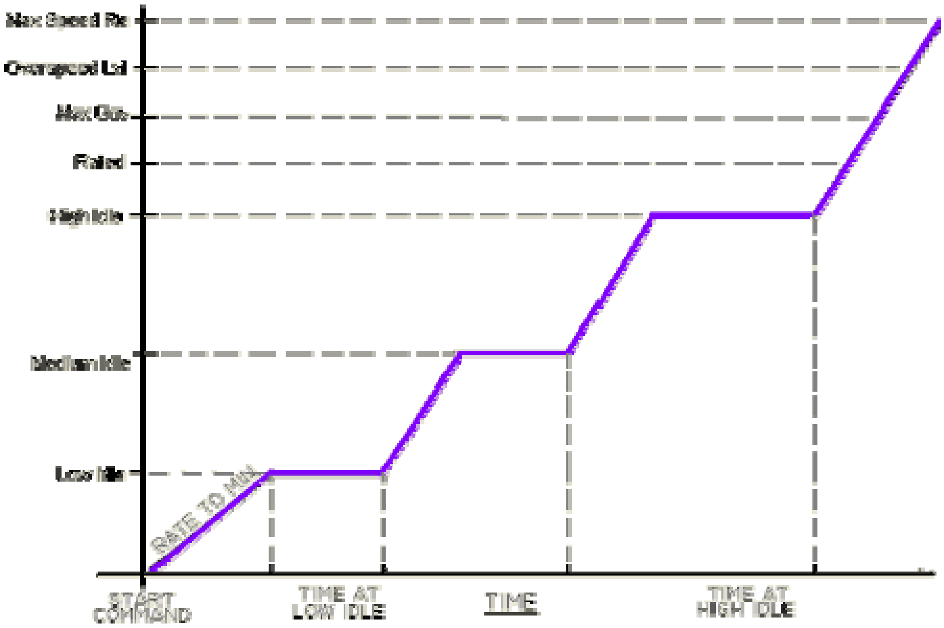


Figure 4-9. Auto Start Sequence

4.4.4.1 Auto Startup Curve Generic Settings

Sequence Status at Shutdown

The following selections are available:

- Auto-start On at SD;
    - At SD the auto-start sequence will remain enabled regardless of the contact input E/D auto-start sequence, Modbus or CCT commands.
- Auto-start Remains at SD;
    - At SD the auto-start sequence will remain disabled regardless of the contact input E/D auto-start sequence, Modbus or CCT commands.
- Auto-start Off at SD;
    - At SD the auto-start sequence can be disabled/enabled via the contact input E/D auto-start sequence, Modbus or CCT commands.

Hold at Idle Speed Levels?

Select this option if it is desired to stop the automatic start sequence each time speed setpoint reaches an Idle speed. The operator will have to issue an auto-start sequence again to continue.

Low Idle **Initial=500 (100, 25000)**

Enter the Low Idle Speed Setting. This is the first hold speed. The speed setpoint will remain at this setting until the low idle delay/hold time has expired. If the Hold at Idle Speed box is checked it will hold at Idle until operator action continues the sequence.

Use Medium Idle?

Select this option when minimum two idle speeds are needed during startup.

Medium Idle **Initial=900 (100, 25000)**

If the use box is checked it will use this setpoint in the sequence and allow the option of having a third point, High Idle.

If selected, the auto start sequence will ramp the speed from Low idle to Medium Idle after the hot/cold delay has passed.

When speed is between Low idle and Medium Idle, in manual mode, and continue sequence is selected, the auto start sequence will ramp the reference to Medium Idle, regardless of the delays.

If not selected, the auto start sequence will ramp the speed from Low idle to rated speed after the hot/cold delay has passed.

When the speed reference is between Low Idle and Min Governor, in manual mode, and continue sequence is selected, it will ramp to Rated Speed regardless of the delays.

Use High Idle?

Select this option when minimum three idle speeds are needed during startup.

High Idle **Initial=1100 (100, 25000)**

If the use box is checked it will use this setpoint in the sequence.

Enter the High Idle Speed Setpoint. This is the third speed setting when using the automatic start sequence and must be greater than the Medium Idle Setpoint.

Rated Speed **Initial=3750 (100, 25000)**

Enter the Rated Speed Setpoint. This is the final speed setting when using the automatic start sequence. Once this speed setpoint is reached, the start sequence is completed.

4.4.4.2 Hot/Cold Start-up Curves

Curve Mode Select

Enter the desired start-up curves to be used for the turbine. The following selections are available:

- Internal Curves Calculation Used;
  - These are calculated from the data entered below.
- Hot/Cold Binary Contact Used;
  - Control will switch between Hot/Cold curves based on a discrete contact. An open contact, i.e. false, will select the Cold curve.

- Hot/Cold Process Value Used;
  - Select this option if, instead of the internal Hot/Cold timer, an external 4-20 mA signal is used to determine if the engine is hot or cold. An analog input needs to be configured.

4.4.4.3 Internal Curves Calculation

Cold Start Time **Initial=20 (1E-05, 500)**

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 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 Time **Initial=4 (1E-05, 500)**

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.

This value must be less than or equal to the cold start hours.

Min Speed to Detect Warm Condition **Initial=3000 (1E-05, 25000)**

Enter the minimum speed to start to switch from cold curve to hot curves

Time Switch to Hot **Initial=0.01 (0.01, 500)**

Enter the time to transfer from fully cold to fully hot parameters when minimum speed to detect warm condition is reached.

4.4.4.4 Hot/Cold Process Value Used

Units

Select the units for the external Hot/Cold Process Value used.

PV at 4 mA

Set the sensor range of the remote Hot/Cold signal for 4 mA.

PV at 20 mA

Set the sensor range of the remote Hot/Cold signal for 20 mA.

Value to detect Cold

Set the value in the set units for the turbine to be determined to be cold.

Value to detect Hot

Set the value in the set units for the turbine to be determined to be hot.

Tag

Enter a customized tag for the external Hot/Cold Process Value.

4.4.4.5 Start-Up Curve Cold

Cold Rate to Low Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from zero to low-idle speed when turbine is cold.

Cold Delay at Low Idle **Initial=0.1 (0.0, 20000)**

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.

Cold Rate to Medium Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from low-idle to medium idle speed when turbine is cold.

Cold Delay at Medium Idle **Initial=0 (0, 20000)**

Enter the cold start hold time desired at medium idle. This is the programmable time, in minutes, that the turbine will wait/hold at the medium idle speed when a cold start is determined.

Cold Rate to High Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from medium idle to high idle speed when turbine is cold.

Cold Delay at High Idle **Initial=0 (0, 20000)**

Enter the cold start hold time desired at high idle. This is the programmable time, in minutes, that the turbine will wait/hold at the high idle speed when a cold start is determined.

Cold Rate to Min Governor **Initial=100 (0.01, 1000)**

Set the acceleration value from high idle to min governor speed when turbine is cold.

Cold Loading Gradient **Initial=100 (0.01, 1000)**

Set the acceleration value when unit is above minimum governor speed when the turbine is cold. This is the programmable rate, in rpm per second that the speed setpoint will accelerate when moving from min governor to max governor when a cold start is determined.

Even when cascade or remote speed setpoint are taking the control of the speed reference, this will remain the maximum rate to move the speed reference, in order to protect the turbine against overloading/rotor stress.

4.4.4.6 Start-Up Curve Hot

Hot Rate to Low Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from zero to low-idle speed when turbine is hot.

Hot Delay Time at Low Idle **Initial=0 (0, 20000)**

Enter the hot start hold time at low idle. This is the programmable time, in minutes, 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.

Hot Rate to Medium Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from low-idle to medium speed when turbine is hot.

Hot Delay Time at Medium Idle **Initial=0 (0, 20000)**

Enter the hot start hold time at medium idle. This is the programmable time, in minutes, that the turbine will wait/hold at the medium 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 medium idle hold time.

Hot Rate to High Idle **Initial=100 (0.01, 1000)**

Set the acceleration value from medium idle to high idle speed when turbine is hot.

Hot Delay at High Idle **Initial=0 (0, 20000)**

Enter the hot start hold time at high idle. This is the programmable time, in minutes, that the turbine will wait/hold at the high 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 high idle hold time.

Hot Rate to Min Governor **Initial=100 (0.01, 1000)**

Set the acceleration value from high idle to min governor speed when turbine is hot.

Hot Loading Gradient **Initial=100 (0.0, 1000)**

Set the acceleration value when unit is above min governor speed when the turbine is hot. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving from min governor to max governor when a hot start is determined.

If cascade or remote speed setpoint are taking the control of the speed reference, this will remain the maximum rate to move the speed reference, in order to protect the turbine against overloading/rotor stress.

4.4.5 No Idle

Select this routine to have the control begin controlling turbine speed at the Minimum Controlled Speed. The control speed setpoint can be manually adjusted between the Minimum and Maximum Governor Speed. Critical avoidance bands are not used or allowed with this routine.

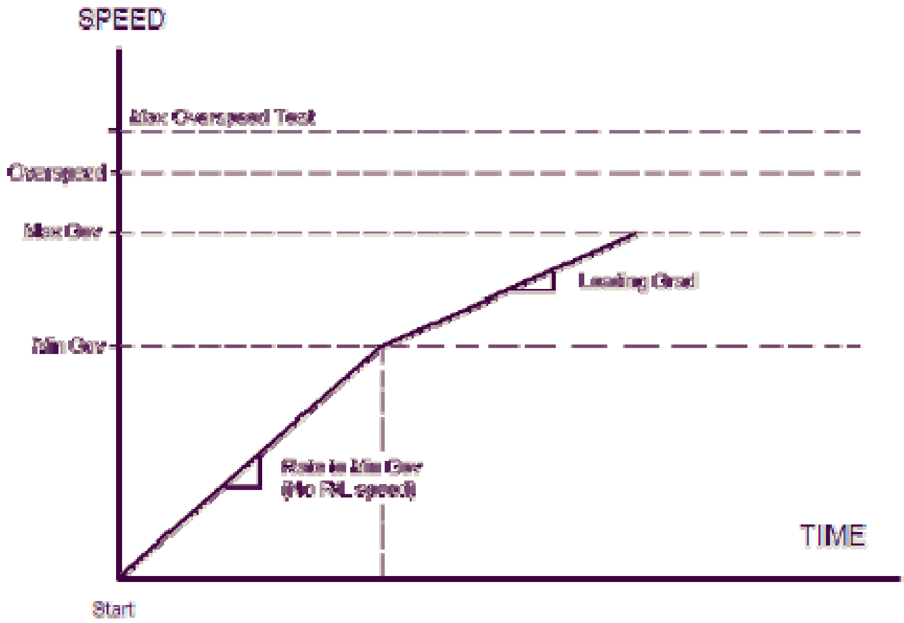


Figure 4-10. No Idle

Rate to Min Governor **Initial=100 (0.01, 1000)**

Set the acceleration value from minimum controlled speed to minimum governor speed.

Loading Gradient **Initial=100 (0.01, 1000)**

Set the loading gradient from minimum governor speed to maximum governor speed.

4.4.6 Multi Curve Start

The 505CC-2 has the ability to allow the user to define an elaborate hot/cold start curve that can have up to 6 curves (slopes) each with tunable rates and delay times. This feature would be used with an external binary for curve selection or analog signal that would provide a remote hot/cold temperature measurement that correlates to the turbine manufacturer warm-up profile.
Auto Startup Curve Generic Settings

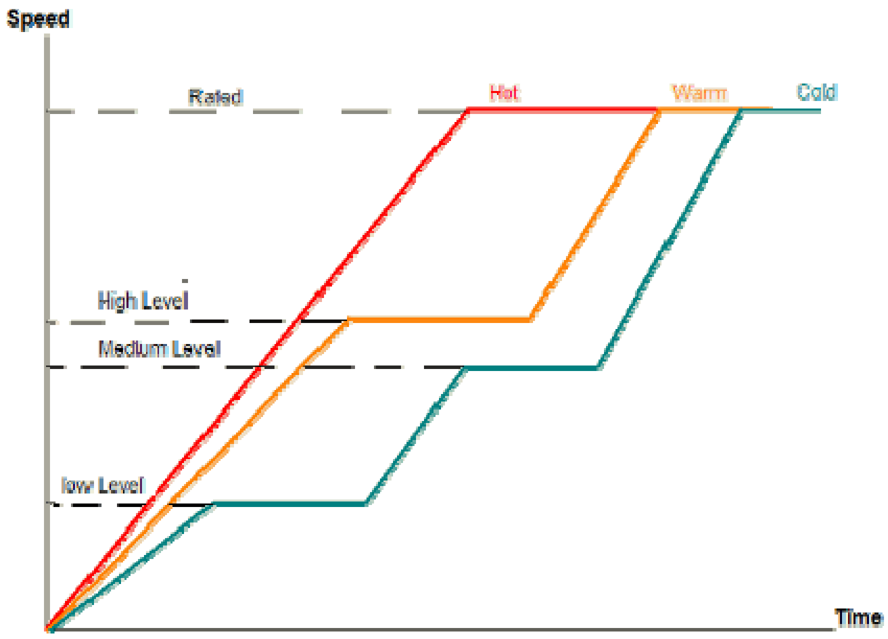


Figure 4-11. Multi Curve Start

4.4.6.1 Auto Startup Curve Generic Settings

Some settings are similar as for the Auto-Start Sequence selection. Reference paragraph 4.4.4 for a description of the following functionality:

- Sequence Status at Shutdown
- Hold at Idle Speed Levels?
- Low Idle
- Use Medium Idle?
- Medium Idle
- Use High Idle?
- High Idle
- Rated Speed
- Curve Mode Select
- Units
- PV at 4 mA
- PV at 20 mA
- Tag

Number of Curves Used

Up to six curves can be selected.

4.4.6.2 Curve Settings

The following descriptions apply for every curve selected.

Ramp to Low Idle Curve **Initial=25.0 (5.0, 1000)**

Set the acceleration value from zero to low-idle speed for the applicable curve.

Ramp to Medium Idle Curve **Initial=50.0 (5.0, 1000)**

Set the acceleration value from low-to medium idle speed for the applicable curve.

Ramp to High Idle Curve **Initial=50.0 (5.0, 1000)**

Set the acceleration value from medium to high-idle speed for the applicable curve.

Ramp to Min Gov Curve **Initial=12.5 (5.0, 1000)**

Set the acceleration value from high-idle to minimum governor speed for the applicable curve.

Loading Gradient Curve **Initial=12.5 (0.01, 1000)**

Set the acceleration value when unit is above min governor speed for the applicable curve.

Delay at Low Idle Curve **Initial=0.2 (0.0, 1000)**

Set the hold time at low idle.

Delay at Medium Idle Curve **Initial=0.5 (0.0, 1000)**

Set the hold time at medium idle.

Delay at High Idle Curve **Initial=0.0 (0.0, 1000)**

Set the hold time at high idle.

4.4.6.3 Transition

The following descriptions apply for every curve selected when the selected curve mode is Hot/Cold Process Value Used.

Level to Select Curve to Curve **Initial=90.0 (5.0, 1000.0)**

Set the level for the external measurement on which the 505CC-2 determines its transition to the next curve.

Hysteresis **Initial=0.0 (-500.0, 0.0)**

Set the deficiency for the transition level from curve to curve. This prevents a continuous swapping between curves when the external measurement is at the transition level.

For example:

The transition level to go from curve 1 to 2 is at 90 degree C. The Hysteresis is set to -10 degree C. The result is that the transition back from curve 2 to 1 will be at 80 degree C.

4.5 Speed Control

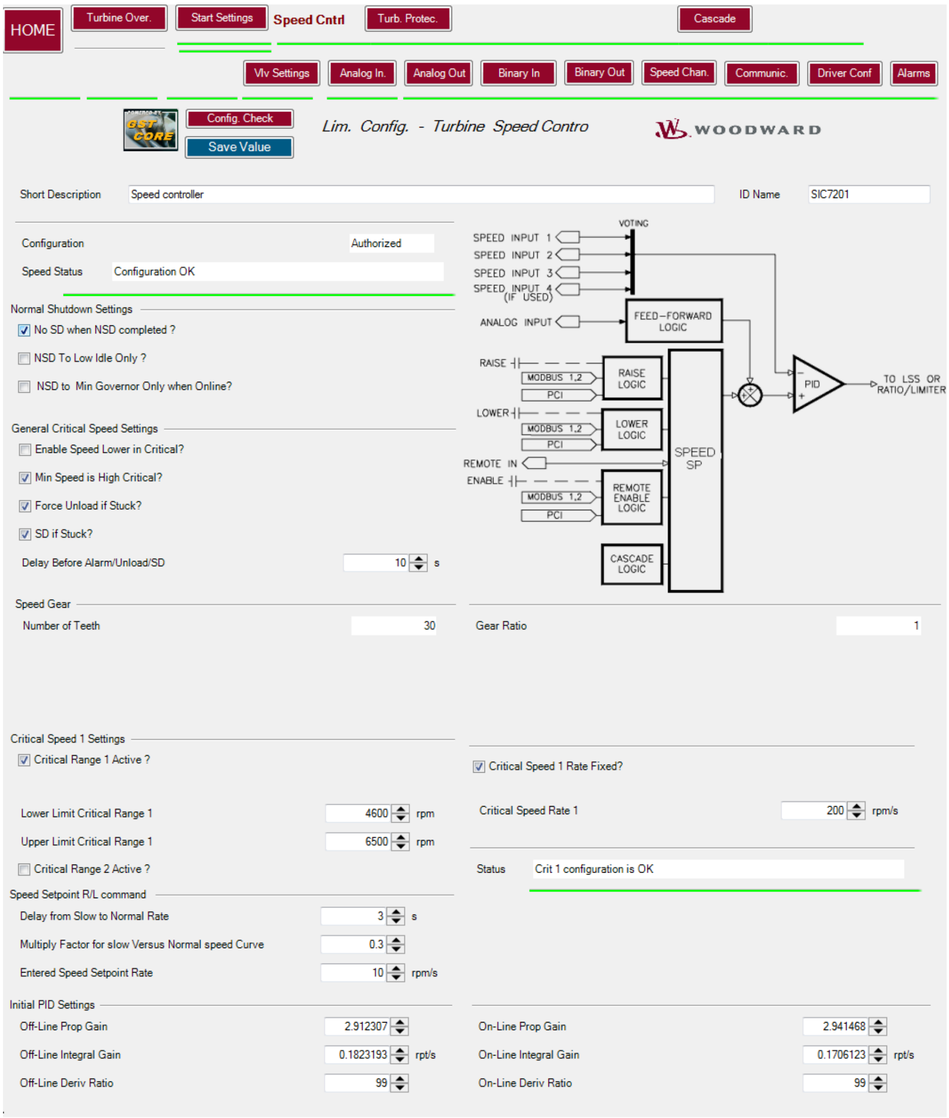


Figure 4-12. Speed Control Screen

4.5.1 Normal Shutdown Settings –

No SD when NSD completed?

Check this to disable the 505CC-2 issuing a trip output when a normal shutdown sequence has been completed.

NSD to Low Level Only?

Enabling this will take the unit down to the Low Idle Speed setpoint and remain there until manually tripped by the operator.

NSD to Min Governor Only when Online?

Enabling this will take the unit down to Minimum Governor Speed setpoint and remain there until manually tripped by the operator. The other options for a NSD apply when the unit has not reached Minimum Governor.

4.5.2 Speed Gear

Number of Teeth **Initial=60 (1, 300)**

Enter the number of teeth on the gear that the speed probe is mounted on.

Gear Ratio **Initial=1.0 (0.1, 20.0)**

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. If speed sensor gear is mounted on the turbine shaft, the ratio is 1.

4.5.3 Critical Speed Settings (for each curve)

Up to three critical speeds can be configured. The enabled critical speed ranges will be avoided and ramped through at the rates configured. The turbine is considered started, and the critical speeds have been avoided, once the turbine speed is at or above the Minimum Governor Speed.

Critical Range Active?

Select to enable the critical speed range. Additional critical speed configurations are shown when the previous is enabled. For example, Critical Speed 2 Settings is shown after Critical Speed 1 Settings has been enabled. In addition General Critical Speed Settings are shown for configuration, see 4.5.4.

Lower Limit Critical Range **Initial=2100 (100, 25000)**

Set the lower limit in rpm of the critical speed avoidance band. This must be lower than the upper limited. The shown initial level is for the first critical range. Subsequent critical range lower limit have an initial value of 2300 rpm.

Upper Limit Critical Range **Initial=2200 (100, 25000)**

Set the upper limit in rpm of the critical speed avoidance band. This must be lower than the Minimum Governor Speed. The shown initial level is for the first critical range. Subsequent critical range upper limit have an initial value of 2400 rpm.

Critical Speed Rate Fixed?

Normally the speed reference acceleration will depends on the auto start sequence parameters. This will allow the defined hot/cold acceleration while speed reference is inside critical band.

When selected, the speed reference will accelerate at a fixed rate when it is necessary to have the rate higher than the rate used for auto start sequence.

Critical Speed Rate **Initial=10 (1, 5000)**

This will be shown when Critical Speed Rate Fixed is enabled. Set the required acceleration for the applicable critical speed range.

4.5.4 General Critical Speed Settings

Enable Speed Lower in Critical?

When selected, a lower speed command will be accepted even if the speed is inside the critical band. If not selected, it is not possible to lower the speed until the speed is not anymore inside the critical band.

Min Speed is High Critical?

When selected, if the critical band is passed, using raise/lower speed commands; it is not possible to lower the speed below the maximum critical band.

Force Unload if Stuck?

When the speed do not accelerate more than 0.2 times the supposed rate during 2 seconds, then an alarm, “Stuck in Critical” will be generated. The speed will be lowered automatically below the minimum critical speed when this option is selected.

SD if Stuck?

When the speed do not accelerate more than 0.2 times the supposed rate during 2 seconds, then an alarm, “Stuck in Critical” will be generated and a shutdown will be initiated.

4.5.5 Speed Setpoint R/L command

Delay from Slow to Normal Rate **Initial=3 (0, 25)**

The momentary raise/lower commands to adjust the setpoint will move at the slow rate for any command less than the delay time set here. The rate will switch to the normal rate defined in the startup curve, including Loading Gradient, when the command is longer than the delay time set

Multiply Factor of Normal Rate for Slow Rate **Initial=0.3 (0.3, 1)**

Define the Slow Rate as a multiplication of the normal rate.

4.5.6 Initial PID Settings

Off-Line Proportional Gain **Initial=4.0 (0.001, 50.0)**

Enter the Off-Line PID proportional gain percentage. This value is used to set speed/load control response when the turbine speed is below minimum governor speed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 1%.

Off-Line Integral Gain **Initial=1.0 (0.0001, 50)**

Enter the Off-Line PID integral gain in repeats-per-second (rps). This value is used to set speed/load control response when the turbine speed is below minimum governor speed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5 rps.

Off-Line Derivative Ratio **Initial=100.0 (0.01, 100)**

Enter the Off-Line PID derivative ratio. This value is used to set speed/load control response when the turbine speed is below minimum governor speed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 100%, i.e. disabled.

On-Line Proportional Gain **Initial=4.0 (0.001, 50)**

Enter the On-Line PID proportional gain percentage. This value is used to set speed/load control response when the turbine speed is above minimum governor speed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 1%.

On-Line Integral Gain **Initial=1.0 (0.0001, 50)**

Enter the On-Line PID integral gain, in repeats-per-second (rps). This value is used to set speed/load control response when the turbine speed is above minimum governor. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5 rps.

On-Line Derivative Ratio Gain **Initial=100.0 (0.01, 100)**

Enter the On-Line PID derivative ratio. This value is used to set speed/load control response when the turbine speed is above minimum governor speed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 100%, i.e. disabled.

If a contact input has been configured to select On-line PID settings, its position will define the usage of Off-Line/On-line PID regardless of the speed setpoint.

4.5.7 Remote Speed Setpoint

Remote Speed Setpoint Value at 4 mA **Initial=1000 (0, 25000)**

Speed setpoint range level for 4 mA. This can also be set in the analog input configuration.

Remote Speed Setpoint Value at 20 mA **Initial=3000 (0, 25000)**

Speed setpoint range level for 20 mA. This can also be set in the analog input configuration.

Min Cascade & Remote Speed Demand **Initial=2625 (0, 25000)**

This is the minimum speed reference possible for using the remote speed setpoint. It must be inside sensor range, above or equal to min governor and below or equal to maximum governor)

Max Cascade & Remote Speed Demand **Initial=4200 (50, 25000)**

This is the maximum speed reference possible for using the remote speed setpoint. It must be inside sensor range, above the min value and below or equal to maximum governor. For example, if the Remote Setpoint is ranged from 0 to 4000 RPM by an external device, but the user wishes the speed to be limited to 3500—3700 RPM, than this option will allow for it.

Max Remote Speed Setpoint Rate **Initial=100 (0, 1000)**

This value determines the rate the setpoint moves when remote is enabled and the remote input doesn’t match the actual speed setpoint.

Max Remote Speed Setpoint Deviation Level **Initial=100 (0, 1000)**

This value determines the maximum deviation authorized for the remote speed setpoint. When the deviation is above this value, the Not Matched Rate will be used.

Not Matched Rate **Initial=100 (0, 1000)**

This value determines the rate the setpoint moves when remote is enabled and the remote input doesn’t match the actual speed setpoint exceeding the set deviation level.

4.6 Protection

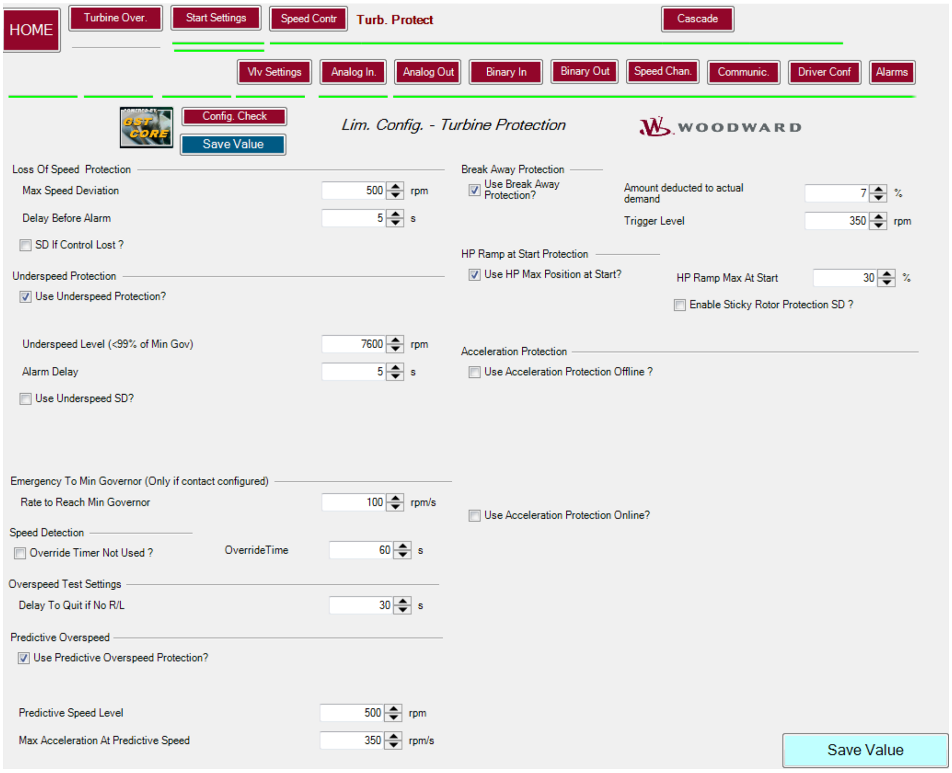


Figure 4-13. Protection Screen

4.6.1 Loss of Speed Protection

This protection is used to prevent any loss of speed control by the 505CC-2. If the 505CC-2 is used for mechanical drive, it must be in control of the speed.

Max Speed Deviation **Initial=400 (0, 5000)**

Define the maximum acceptable absolute deviation of speed in rpm.

Delay Before Alarm **Initial=10 (0, 60)**

An alarm will be generated if the deviation is greater than the configured deviation level, during more than the set delay time in seconds.

SD if Control Lost?

If selected, instead of an alarm, a trip will be generated if the deviation is greater than the acceptable level for more than the delay time.

4.6.2 Underspeed Protection

This protection is used to annunciate or trip the unit if the speed falls significantly under the Minimum Governor speed.

Use Underspeed Protection?

If checked, underspeed protection will be active

Underspeed Level **Initial=2000 (500, 20000)**

Define the minimum acceptable speed setpoint in rpm. This should be set smaller than 99 % of the Minimum Governor Level.

Alarm Delay **Initial=10 (0, 60)**

After a completed start-up and the speed drops below the configured underspeed level for more than this set time delay, an alarm will be generated

Use Underspeed SD?

If checked, a trip will be initiated if the underspeed condition lasts more than the Underspeed SD Delay

Underspeed SD Delay **Initial=10 (0, 200)**

After a completed start-up and the speed drops below the configured underspeed level for more than this set time delay, a trip will be generated

4.6.3 Emergency to Min Governor

Emergency to Minimum Governor is only applicable when the output contact for this functionality is configured. The speed setpoint will ramp to minimum governor when this contact is closed

Rate to Reach Min Governor **Initial=100 (1, 100000)**

This is the deceleration of the speed setpoint to go to Minimum Governor.

4.6.4 Speed Detection

Override Timer Not Used?

If checked, the control will look for a discrete input to override the speed sensor faults when the unit is not running

Override Timer

If the above box is not checked the control will automatically override the speed sensor faults until this time has elapsed after a start turbine command is issued.

4.6.5 Overspeed Settings

Delay to Quit if No R/L **Initial=60 (10, 300)**

If no raise or lower speed commands are received for this amount of time during an Overspeed Test, then the control will exit the test mode and reduce the speed setpoint to max governor.

Use Predictive Overspeed Protection?

If checked, the control will use above a high speed level a max acceleration calculation around that speed to preemptively trip the unit on anticipation of an overspeed event. This should only be used on units that experience overspeed trips and are looking to reduce the maximum speed reached during an overspeed event.

Predictive Speed Level **Initial=2000 (500, 20000)**

Set the Speed Level to activate the predictive overspeed protection.

Max Acceleration at Predictive Speed **Initial=500 (10, 20000)**

The predictive overspeed logic will generate a trip if this acceleration rate is reached when the unit is at or above the predictive speed level.

4.6.6 Break Away Protection

Use Break Away Protection?

If checked, the control will boost down the valve demand by a fixed percentage once the speed has reached the Trigger level.

This protection is used when at start a speed jump up occurs while the valve demand is already high, e.g. due to internal friction.

Amount deducted to actual demand **Initial=5 (5, 75)**

Percentage deducted to actual valve demand when Break Away Protection is enabled.

Trigger Level **Initial=100 (20, 2000)**

Speed level at which the protection is activated. This level is in any case limited by the Low Idle level minus 100 rpm.

4.6.7 HP Ramp at Start Protection

Use HP Max Position at start?

Select this option if it is desired to limit the HP valve position as long as speed did not reach the Low Idle level.

HP Ramp Max at start **Initial=100 (0, 100)**

Maximum HP linear valve position percentage during startup set as long as speed is not at least at Idle minus 100 rpm.

Enable Sticky Rotor Protection SD?

A shutdown command will be issued if selected, when turbine is started, HP demand reaches the maximum limit, and speed is not at low Idle.

4.6.8 Acceleration Protection

Use Acceleration Protection Offline?

Select to enable acceleration protection. Then the control, when speed is below Minimum Governor, will constantly monitor the turbine acceleration. It will immediately take control of the valve when the acceleration level is too high, regardless of the speed setpoint, and limit the acceleration.

This option is highly recommended for Manual Start mode, when the T&T valve might be opened too fast. This protection can be used only if the speed PID settings have been preliminary tuned correctly.

Min Deviation before Acting **Initial=50 (20, 1000)**

The minimum speed deviation between setpoint and process value, SP-PV, to have this protection activated

Offline Max Acceleration **Initial=100 (1, 5000)**

This is the maximum turbine acceleration value. The Offline Acceleration protection will limit the speed up to the speed setpoint according this rate.

Use Acceleration Protection Online?

Select to enable acceleration protection. The 505CC-2, when speed is above Maximum Governor, will constantly monitor the turbine acceleration. It will immediately take control of the valve when the acceleration level is too high, regardless of the speed setpoint, and limit the acceleration.

This protection can be used only if the speed PID settings have been preliminary tuned correctly.

Online Max Acceleration **Initial=200 (1, 5000)**

This is the maximum turbine acceleration value. The Online Acceleration protection will limit the speed up to the speed setpoint according this rate.

Use Acceleration Protection Boost Control?

Enabling this will boost the valve demand down for short spike, few milliseconds, when the speed is above maximum governor and acceleration above the maximum online acceleration.

Boost Speed Trigger level **Initial=3000 (100, 25000)**

Minimum speed level to get the boost protection activated which should always be set above the maximum governor speed for the 505CC-2.

Boost Valve Demand **Initial=0 (0, 100)**

Maximum valve position change requested when the boost is activated. Another protection limiter will always verify that this demand is lower than actual Demand.

4.7 Extraction and/or Admission Control

The 505CC-2 can be configured for extraction, admission, or extraction and admission types of steam turbines. The following sections show extraction as the example due to the similarities in the extraction, admission, and extraction/admission configuration pages. Therefore your pages may appear slightly different, but all possible selections will be shown in the text descriptions.

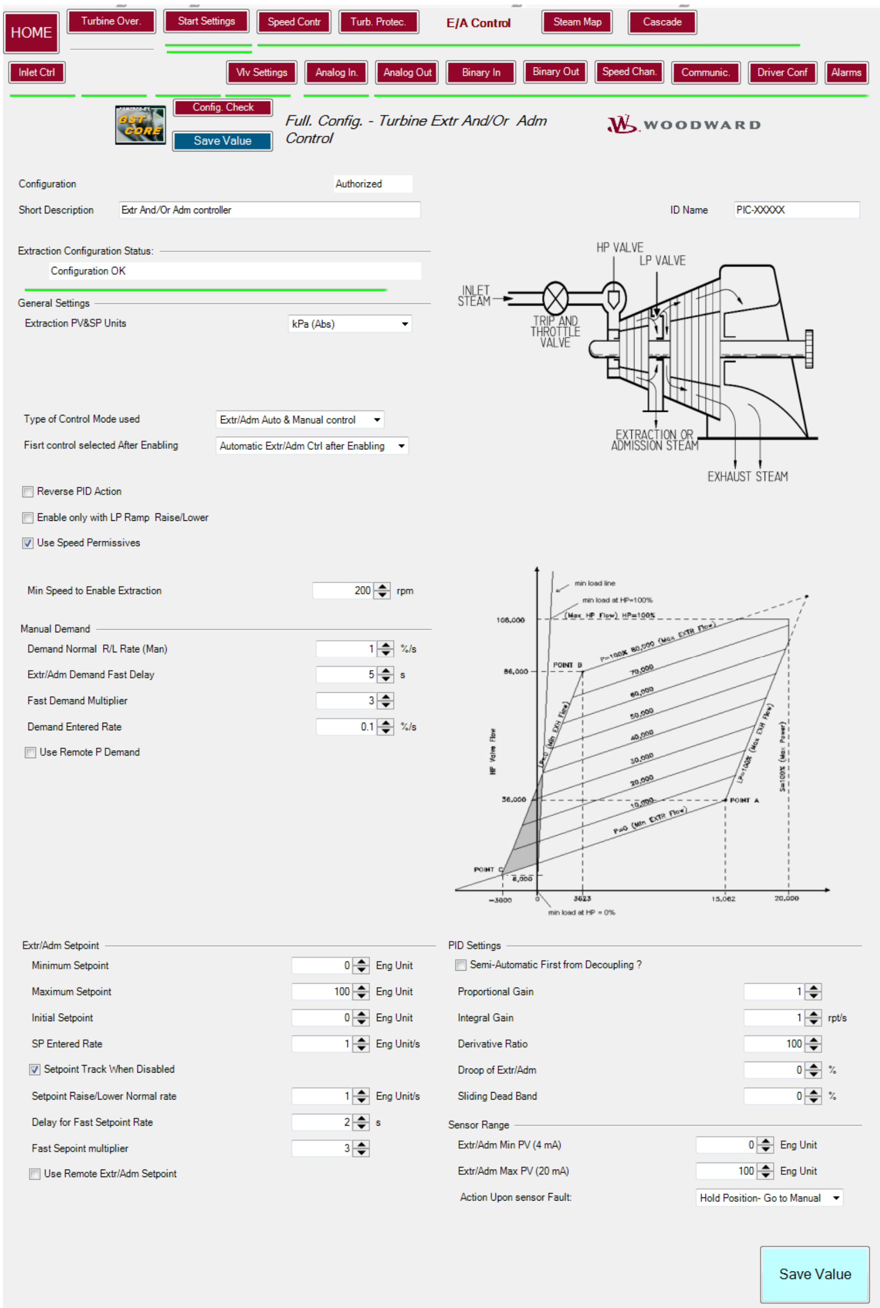


Figure 4-14. Extraction and/or Admission Control

4.7.1 General Settings

Extraction PV&SP Units

This selection will define the engineering units of the extraction pressure signals and other user settings. The following options are available:

Metric	Imperial/Miscellaneous
kPa (abs)	psia
MPa (abs)	ft of H2O (abs)
barA	atm (abs)
kg/cm² (abs)	torr (abs)
mmH2O (abs)	tons-force/ft² (abs)
kPag	inches of Hg (abs)
MPag	psig
barg	ft of H2O (gauge)
mmH2O (gauge)	atm (gauge)
Kg/cm2 (gauge)	torr (gauge)
t/h	tons-force/ft2 (gauge)
°C	In of Hg (Gauge)
mm	k#/hr
	k#/s
	_#/hr
	_%
	°F
	other customer-defined

Type of Control Mode

This option will select the operation mode for extraction/admission. The following selections are available:

- Extr/Adm Auto & Manual Control;
  - During normal operation it is possible to toggle from close loop (Auto) to open loop P(demand) control
- Extr/Adm Automatic Control Only;
  - Only close loop is possible during normal operation. Exception will only be when the sensor fails.
- Extr/Adm Manual Control Only;
  - Only open loop is possible during normal operation. Operator will manipulate P demand by using raise/lower P demand, or via a 4-20 mA remote demand signal when used.
- Extr/Adm Never used;
  - This option is selected when it is desired to never control the Extr/Adm pressure/flow demand. This option can only be selected if Inlet/Exhaust decoupling has been configured.

First control selected after enabling

These options are used to select the PID in control just after enabling extraction/admission. The options available depend on the previous “Type of Control Mode used” selection. The configuration check will verify and indicate any discrepancies when occurring.

Be aware that this option will also affect the selections possible for “Type of Control Mode used” that will be made on the “Inlet/Exhaust” screen. The following selections are available:

- Automatic Extr/Adm Ctrl After Enabling;
  - Extraction/Admission will be active and in close loop as soon as the Steam Map is in control.
- Manual Extr/Adm Ctrl After Enabling;
  - Extraction/Admission will be active and in open loop as soon as the Steam Map is control.
- Automatic Inlet/Exhaust Ctrl After Enabling;
  - Inlet/Exhaust control will be active and in close loop as soon as the Steam Map is in control.
- Manual Extr/Adm Ctrl After Enabling;
  - Inlet/Exhaust control will be active and in open loop as soon as the Steam Map is in control.

Reverse PID Action

Check this box to reverse the action of the PID in relation to an error between the PV and the SP. Default action is, when an increase in extraction pressure is desired, that the valve demand moves down from 100%, i.e. forcing more extraction flow.

Enable only with LP Ramp Raise/Lower?

Select this function if it is not desired to ramp the LP valve limiter automatically (zero for extraction or admission with external valve) when extraction/admission is requested.

Use Speed Permissive?

Select this function if it is not desired to inhibit the activation of the control with the LP valve based on a speed setpoint level. The Extr/Adm functionality can be enabled prior, but activation will wait for this speed trigger to activate the Extr/Adm control.

When selected the following parameter will appear:

Min Speed to Enable Extraction (Admission) Initial=200 (0, 25000)

Adjust this level to desired when after which control using the LP can be activated

4.7.2 Manual Demand

Demand Normal R/L Rate (Manual) Initial=1 (0, 100)

Rate, in %/sec, that the Manual Raise and Lower commands move the valve.

Extraction Demand Fast Delay Initial=5 (1, 20)

Time (sec) it will use normal rate before the rate will change to fast rate.

Fast Demand Multiplier Initial=3 (1, 10)

Fast rate equals the normal rate times this number.

Demand Entered Rate Initial=0.1 (0.001, 10)

Rate in %/sec that the “Go To” commands move the valve.

Use Remote P Demand

Check this box to use a remote P Demand signal. Further configuration settings for this will appear.

Remote Demand Max Deviation Level **Initial=0.1 (0.001, 10)**

This is the maximum P deviation level in % when Remote P is requested. When the 4-20 mA signal deviation is higher than this value, the P term will move forward the remote demand according the Demand Entered Rate.

This protection is only used at E/D. Once the deviation is less than Max Remote Demand Rate will be used.

Max Remote Demand Rate **Initial=1 (0.0001, 100)**

In normal operation, the P term will move forward the remote demand according this rate.

4.7.3 Extraction Setpoint

Minimum Setpoint **Initial=0.0 (-200000, 200000)**

Set the minimum extraction/admission setpoint. This value is the minimum setpoint value to which the extraction/admission setpoint can be decreased, i.e. lower limit of extraction/admission setpoint.

Maximum Setpoint **Initial=100.0 (--200000, 200000)**

Set the maximum extraction/admission setpoint. This value is the maximum setpoint value to which the extraction/admission setpoint can be increased, i.e. upper limit of extraction/admission setpoint. This must be greater than the Minimum Setpoint setting.

Initial Setpoint **Initial=0.0 (-200000, 200000)**

Enter the initialization value for the extraction/admission setpoint. This is the value that the setpoint initializes to upon power-up or after exiting the configuration mode. This must be less than or equal to the Maximum Setpoint setting.

Setpoint Entered Rate **Initial=1.0 (0.01, 1000.0)**

This is the rate in percent per second that the “Go To” command moves the valve.

Setpoint Track When Disabled

The setpoint will track the process value when extraction/admission are disabled or in manual mode when enabled.

Setpoint Raise / Lower Normal Rate **Initial=1.0 (0.0, 1000.0)**

Enter the extraction/admission setpoint slow rate (in units per second) at which extraction/admission setpoint moves when adjusted for less than the delay. After the delay, the rate will increase to the multiplier of this rate. The delay and multiplier can be adjusted, see below.

Delay for Fast Setpoint rate **Initial=2.0 (1.0, 10.0)**

The time in seconds that it will use the normal rate before the rate will change to the fast rate.

Fast Setpoint Multiplier **Initial=3.0 (0,100)**

The fast rate equals the normal rate times this number.

Use Remote Extraction/Admission Setpoint

Check this box to use a remote extraction setpoint signal.

Maximum Remote Setpoint Rate **Initial=100.0 (0.0, 100)**

This is the maximum percent per second that the remote setpoint will be limited to.

Remote SP Max Deviation Level **Initial=1.0 (0.01, 1000)**

The setpoint will move forward the remote setpoint according the Setpoint Entered Rate when the 4-20 mA signal deviation is higher than this value.

This protection is only used at E/D. Once the deviation is less than Maximum Remote SP Rate will be used.

4.7.4 PID Settings

Semi-Automatic First from Decoupling?

When not selected, when a request is send to quit inlet/exhaust control and go back to coupled mode, the open loop (manual) will be the first mode activated.

The setting “Type of Control Mode used” has priority versus this setting, therefore, this setting won’t have any effect, if no open loop has been authorized.

The close loop will be the first mode activated when selected, when a request is send to quit inlet/exhaust control and go back to “coupled mode”,

Proportional Gain **Initial=1.0 (0.0, 50)**

Enter the Extraction/admission PID proportional gain value. This value is used to set extraction/admission control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.

Integral Gain **Initial=1.0 (0.001, 25)**

Enter the Extraction/admission PID integral gain value, in repeats-per- second (rps). This value is used to set extraction/admission 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 rps.

Derivative Ratio **Initial=100.0 (0.0, 100)**

Enter the Extraction/Admission PID derivative ratio. This value is used to set extraction/admission control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 99.99%.

Droop of Extr/Adm **Initial=0.0 (0.0, 10)**

Enter the droop percentage. If required, typically set between 0-2% and not more than 10%. This will result in the demand biasing the setpoint for usage when multiple PID’s are conflicting, trying to control the same process value.

Sliding Dead-band **Initial=0.0 (0.0, 10)**

If required, enter the deadband in percent of sensor range. Typically set it between 0 – 2 % and not more than 10 %. Process value changes within this band will not result in PID control action.

4.7.5 Sensor Range

Extr/Adm Min PV (4 mA) **Initial=0.0 (0.0, 100000)**

Enter the Extraction/Admission process value for the 4 mA analog input. This can also be set also in the Analog Input Configuration Mode screen.

Extr/Adm Max PV (20 mA) **Initial=100.0 (0.0, 100000)**

Enter the Extraction/Admission process value level for the 20 mA analog input. This can also be set also in the Analog Input Configuration Mode screen.

Action Upon Sensor Fault

This defines the control action when an Extr/Adm input signal fault occurs:

- Hold Position, Go to Manual;
  - The operator can manipulate the Pressure/flow demand in open loop until the sensor is repaired.
- Disable Extr/Adm
  - Control with LP valve is disabled, and valve will ramp up/down, depending on the type of turbine selected.
- P term to Max if Fault
  - The control will ramp P up to 100%, i.e. minimum position of LP according steam map load.
- P term to Min if Fault
  - The control will ramp P to zero, i.e. maximum LP position according steam map load.
- Shutdown if Fault
  - The turbine will trip as soon as the sensor fault is detected.

4.8 Steam Map

4.8.1 Introduction

Please read the steam map description below before configuring the extraction/admission and steam maps. This section describes steam maps and how to convert your steam map information into a format usable by the 505CC-2 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 505CC-2 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:

1. The map must be linear, i.e. all lines must be straight.
2. The lines for extraction/admission flow at 0%, and the lines for extraction/admission flow at 100% must be parallel. Also the lines for the LP valve at 0%, the lines for the LP valve at 100% must be parallel.

Redraw the envelope, use graph paper, when your envelope lines are not all straight and parallel as described above. 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. 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 505CC-2 as extraction/admission data. This data is taken from the turbine's steam map or envelope. It does not matter which units you use when entering extraction/admission data into the 505CC-2, as long as you use the same units throughout for power, and the same units throughout for HP and extraction/admission flow.

The 505CC-2 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 Figure 4-15. 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 described in this manual. 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 the examples provided 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.

4.8.2 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 4-15.

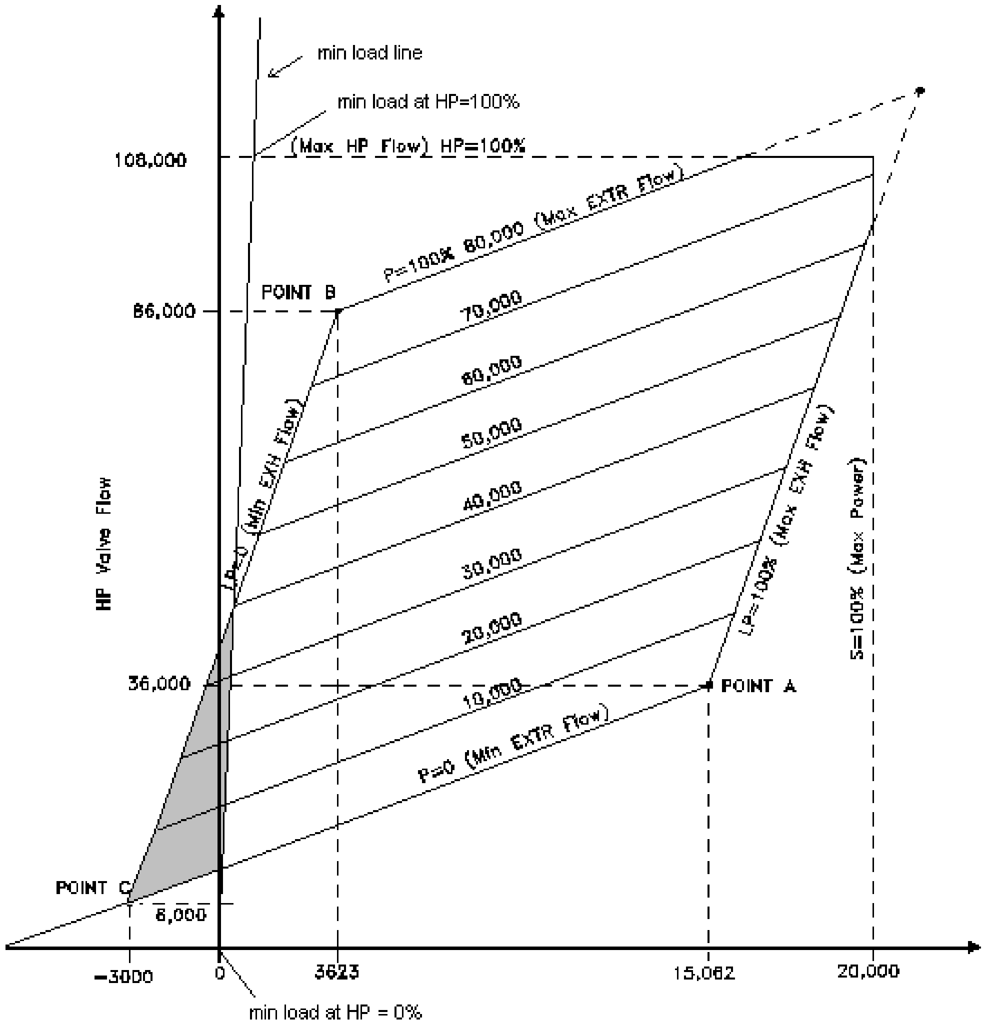


Figure 4-15. Typical Extraction Steam Map

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 above steam map in Figure 4-15:

- The Max Power value is the load where the S=100 line crosses the horizontal S-axis, about 20,000 KW in our example.
- The Max HP Flow value is the flow where the HP=100 line crosses the vertical HP-axis, about 108,000 lbs/hr.
- 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 lbs/hr.
- Point B is where the LP=0 and P=100 lines intersect;
    - Min Power @ Max Extraction = about 3,623 KW.
    - HP Flow @ Max Extraction = about 86,000 lbs/hr.
- Point C is where the LP=0 and P=0 lines intersect;
    - Min Power @ Min Extraction = about -3,000 KW.
    - Min HP Flow @ Min Extraction = about 6,000 lbs/hr.

The ratio of one value to another is what is important. It does not matter if values are entered in engineering units, percentages, or values. As long as all values are entered in the same units, then map will ratio correctly.

The 505CC-2 will convert all the point in percentage, and send the result through Modbus for monitoring purposes on for example a HMI or DCS.

Different screens to enter steam map information will be available depending if the 505CC-2 is configured for extraction, admission, or extraction/admission.

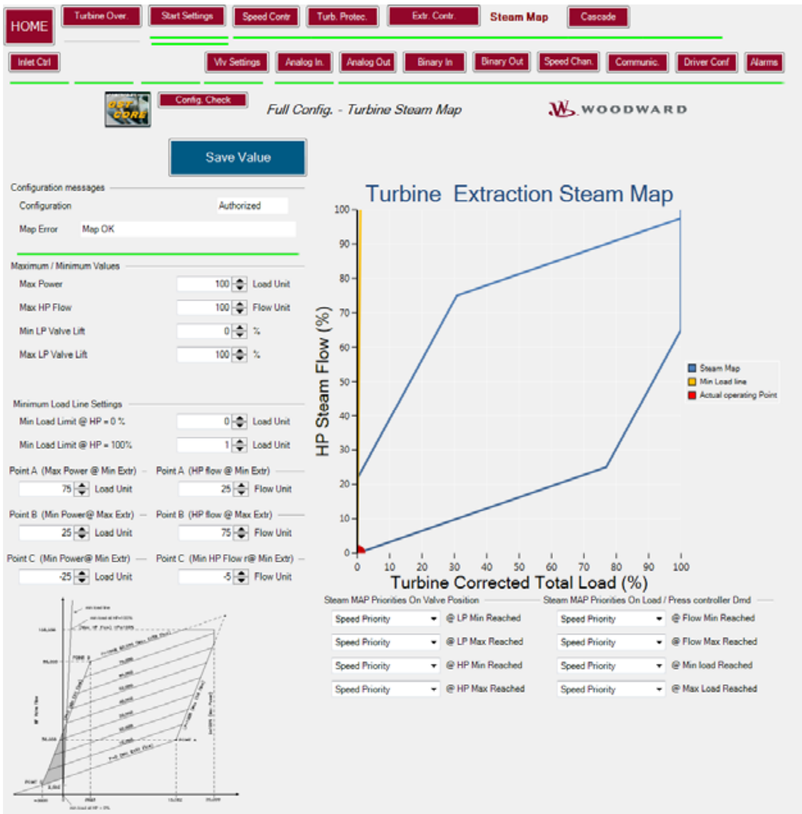


Figure 4-16. Steam Map Extraction Only Screen

4.8.2.1 Maximum/Minimum Values

Maximum Power **Initial=100.0 (0.0, 100000)**

Enter the Maximum Rated Turbine Power.

Maximum HP Flow **Initial=100.0 (0.0, 100000)**

Enter the Maximum Rated HP Valve Flow.

Minimum LP lift **Initial=0.0 (0.0, 100)**

Recopy of the parameter set in extraction folder (can be tuned from here also).

Maximum LP lift **Initial=0.0 (0.0, 100)**

Recopy of the parameter set in extraction folder (can be tuned from here also).

4.8.2.2 Minimum Load Line Settings

The Minimum Load Line Settings define the minimum load limits when extraction is in control. The following needs to be considered:

- It represents the intersection of the steam map and the Y-axis.
- This line can be shifted, right/left, and its inclination can be changed
- This line cannot be vertical for control reasons. A minimum of 1% load change for HP-0% and HP=100% is required.

Min Load Limit at HP=0% **Initial=0.0 (-10000.0, 1000000)**

Set the intersection point of the minimum load line when HP=0%.

Min Load Limit at HP=100% **Initial=1.0 (-10000.0, 1000000)**

Set the intersection point of the minimum load line when HP=100%.

4.8.2.3 Point A Values

Maximum Power at Minimum Extraction **Initial=75.0 (0.0, 100000)**

Enter the maximum power attainable at zero extraction flow.

Maximum HP Flow at Minimum Extraction **Initial=25.0 (0.0, 1000000)**

Enter the maximum HP valve flow attainable at maximum extraction flow.

4.8.2.4 Point B Values

Minimum Power at Maximum Extraction **Initial=25.0 (0.0, 100000)**

Enter the minimum power attainable at 100% or maximum extraction flow.

Minimum HP Flow at Maximum Extraction **Initial=75.0 (0.0, 1000000)**

Enter the minimum HP valve flow attainable at 100% or maximum extraction flow.

4.8.2.5 Point C Values

Minimum Power at Minimum Extraction **Initial=-25.0 (-100000.0, 100000)**

Enter the minimum power attainable at zero extraction flow.

Minimum HP Flow at Minimum Extraction **Initial=-5.0 (-100000.0, 1000000)**

Enter the minimum HP valve flow attainable at zero extraction flow.

4.8.2.6 Steam Map Priorities

The following descriptions, due to the similarities in control functionality, apply to both extraction only, admission only, and extraction/admission turbine applications.

The control can control two parameters at a time with two unlimited valves, i.e. HP and LP valve. However, when the turbine reaches an operating limit then only one parameter can be controlled. Examples of operating limits are the maximum power or one of the valves reaching a mechanical limit.

The fields to be configured determine which controlling parameter will be controlled when the turbine reaches an operating limit. Speed/Load is the default priority during a start-up, and when extraction is disabled.

IMPORTANT **Speed should have the highest priority because the 505CC-2 controls only mechanical features. In case of any doubt, speed priority should be selected, even when it is possible to change the priorities.**

The priorities are divided in the following operating limits:

- Priorities on valve position;
    - LP minimum reached.
    - LP maximum reached.
    - HP minimum reached.
    - HP maximum reached.

- Priorities on load / pressure controller demand;
  - Flow minimum reached.
  - Flow maximum reached.
  - Minimum load reached.
  - Maximum load reached.

Subsequent the choice can be made to select the following priorities for these operating limits:

- Speed priority
- Flow/Pressure priority

Below the considerations are described when selecting the flow/pressure priority for each operation limit:

Flow/Pressure Priority on LP Minimum reached

Check this box to have the control switch to extraction/admission priority whenever the LP valve is on its minimum limit. The actual speed will be higher than the reference when this limit is reached.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

This protection is to make sure that there is enough flow through the HP stage.

Flow/Pressure Priority on LP Maximum Reached

Check this box to have the control switch to extraction/admission priority whenever the LP valve is on its maximum limit. When this limit is reached, the actual speed will be lower than the reference.

In this case, if the limit is reached, speed raise command is inhibited.

This protection prevents over pressure after the HP stage.

Flow/Pressure Priority on HP Minimum Reached

Check this box to have the control switch to extraction/admission priority whenever the HP valve is on its minimum limit. When this limit is reached, the actual speed will be higher than the reference.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

This protection may be used only when inlet/exhaust control is configured and is declared more important than speed control.

Flow/Pressure Priority on HP Maximum Reached

Check this box to have the control switch to extraction/admission priority whenever the HP valve is on its maximum limit. When this limit is reached, the actual speed may be lower than the reference.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

This protection may be used only when inlet/exhaust control is configured and is declared more important than speed control.

Flow/Pressure Priority on Flow Minimum Reached

Check this box to have the control switch to extraction/admission priority whenever the P term valve is on its minimum limit. When this limit is reached, the actual speed may be lower than the reference.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

Flow/Pressure Priority on Flow Maximum Reached

Check this box to have the control switch to extraction/admission priority whenever the P term valve is on its maximum limit. When this limit is reached, the actual speed may be lower than the reference.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

Flow/Pressure Priority on Minimum Load Reached

Check this box to have the control switch to extraction/admission priority whenever the minimum load is reached, while extraction is in control. When this limit is reached, the actual speed will be higher than the reference.

In this case, if the limit is reached, speed Lower command is inhibited.

Care should be taken that the loss of control settings configure in the speed settings won't be triggered, e.g. deviation between reference and actual speed.

This limit prevents an overheating at the exhaust of the HP stage, due to insufficient flow.

Flow/Pressure Priority on Maximum Load Reached

Check this box to have the control switch to extraction/admission priority whenever the maximum load is reached, while extraction is in control.

This limit will limit the HP vale opening, but should not affect the speed.

4.8.3 Admission Only Steam Map

Before a turbine admission steam map can be programmed into the control, it must have the intersection points A, B, and C, refer to Figure 4-19.

Points C can be determined when points A and B are known. To do this extend the LP=100 line and the P=100 line until they cross or intersect, the intersection is point C.

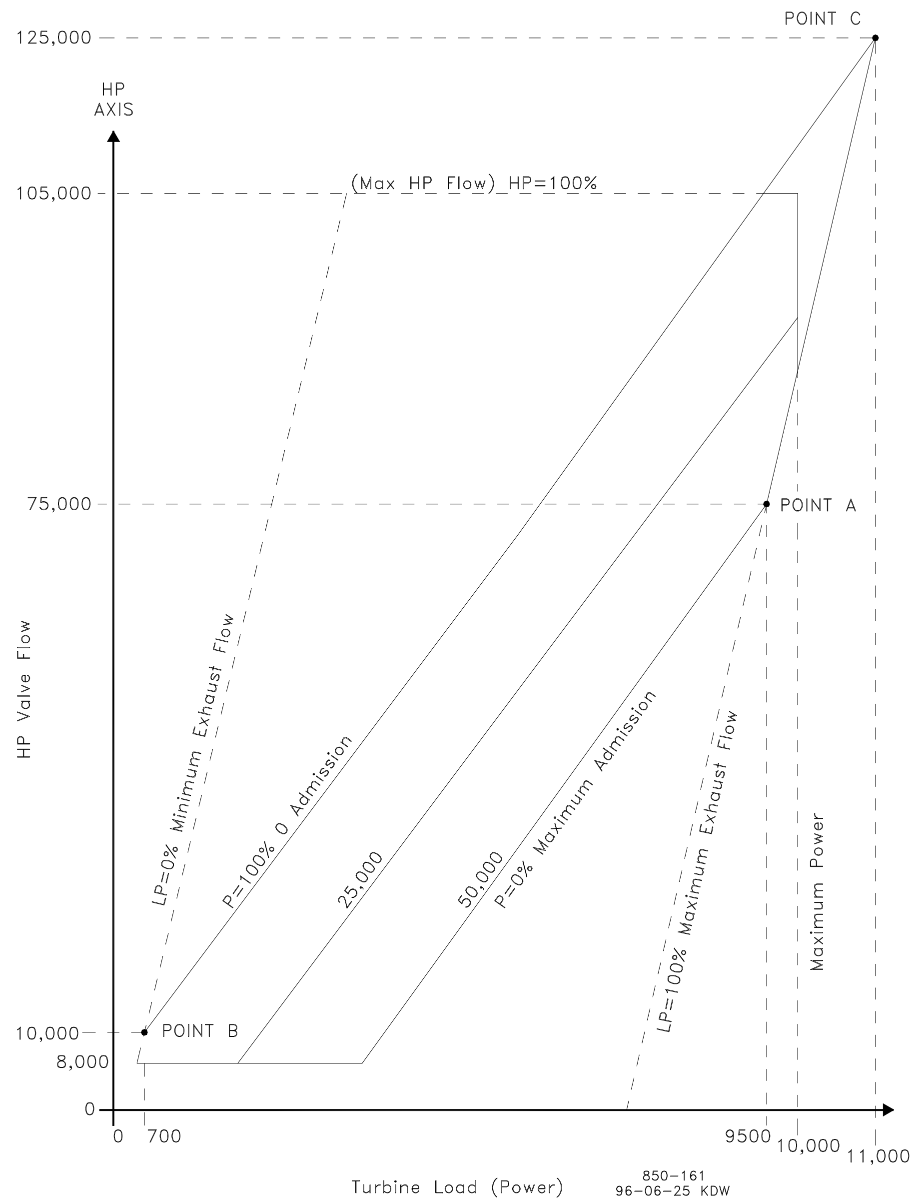


Figure 4-17. Typical Admission Steam Map

Your map will have to be modified to include points B & C if only point A exists. 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, see Figure 4-19, the minimum required flow was 10,000 lbs/hr.

1. Extend the zero admission (or induction) line (p=100%). Refer to Figure 4-19.
2. Find your turbine's minimum back-end steam flow. This will be point B, HP flow crossing the extended line.
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.
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. 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 4-19.

- 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 lbs/hr.
- Point A is where the P=0 and LP=100 lines intersect;
  - Max Power @ Max Admission = about 9,500 KW.
  - HP Flow @ Max Admission = about 75,000 lbs/hr.
  - Admission Flow @ Max Admission = about 50,000 lbs/hr.
- 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 lbs/hr, this point was used because 10,000 lbs/hr is the minimum back-end cooling steam flow required by the turbine.
- 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 lbs/hr.
- An additional parameter, Min HP Lift (%), would also be set to 8000/105,000 = 7.6%.

The ratio of one value to another is what is important. It does not matter if values are entered in engineering units, percentages, or values. As long as all values are entered in the same units, the map will ratio correctly.

The 505CC-2 will convert all the point in percentage, and send the result through Modbus for monitoring purposes on for example a HMI or DCS.

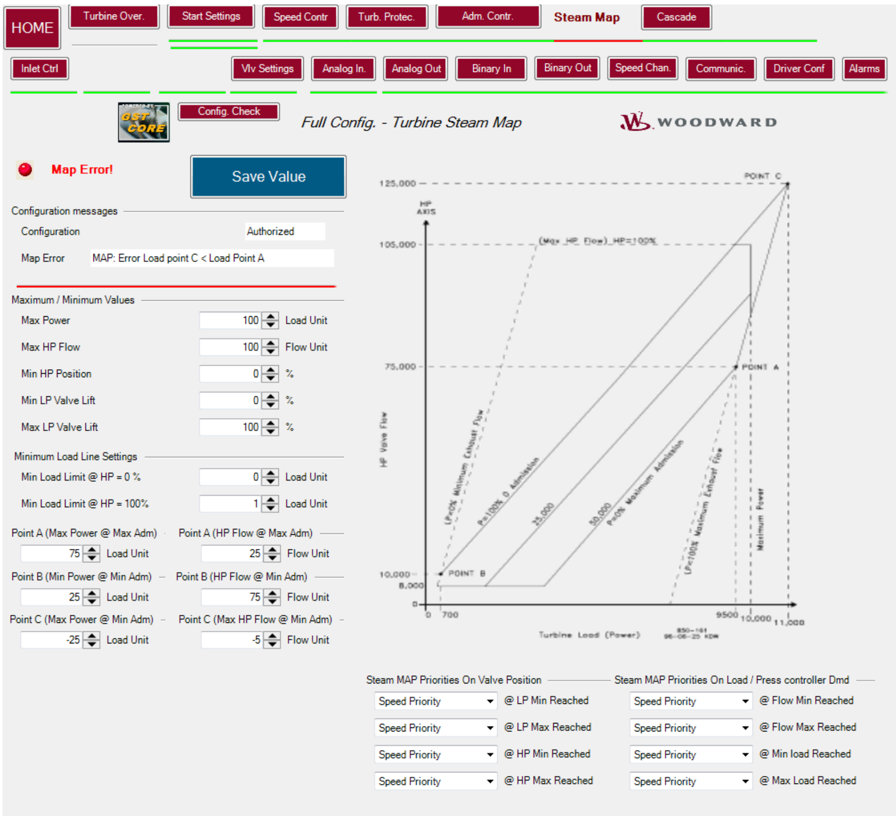


Figure 4-18. Steam Map Admission Only Screen

For Maximum/Minimum Values and Minimum Load Line Settings refer to 4.8.2.1 and 4.8.2.2.

4.8.3.1 Point A Values

Maximum Power at Maximum Admission **Initial=75.0 (0.0, 100000)**

Enter the maximum power attainable at 100% or maximum admission flow.

Maximum HP Flow at Maximum Admission **Initial=25.0 (0.0, 1000000)**

Enter the maximum HP valve flow attainable at 100% or maximum admission flow.

4.8.3.2 Point B Values

Minimum Power at Minimum Admission **Initial=25.0 (0.0, 100000)**

Enter the minimum power attainable at zero admission flow.

Minimum HP Flow at Minimum Admission **Initial=75.0 (0.0, 1000000)**

Enter the minimum HP valve flow at zero admission flow.

4.8.3.3 Point C Values

Maximum Power at Minimum Admission Initial=-25.0 (-100000.0, 100000)

Enter the maximum power attainable at zero admission flow.

Maximum HP Flow at Minimum Admission Initial=-5.0 (-100000.0, 1000000)

Enter the maximum HP valve flow at zero admission flow.

For Steam Map Priorities refer to 4.8.2.6.

4.8.4 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, and C, refer to Figure 4-19.

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 if points A and B already exist. This results in point C.

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.

Your map will have to be modified to include points B and C if they do not exist. 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 4-19, the minimum required flow is 8,000 lbs/hr.

1. Extend the maximum extraction line. Refer to Figure 4-19.
2. Extend the zero extraction and admission line.
3. Find your turbine's minimum back-end steam flow. This will be point C, HP flow.
4. Mark the intersection of the zero extraction and admission flow line and the turbine's minimum back-end steam flow. This mark will be point C.
5. Draw a line parallel to the LP=100 line, through the mark created in step 4. This will be your LP=0 line or LP valve closed line.
6. Mark the intersection of the maximum extraction line and the created LP=0 line. This will be point B.

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

An additional parameter, Min HP Lift (%), would also be set to 4000/54,000 = 7.4%.

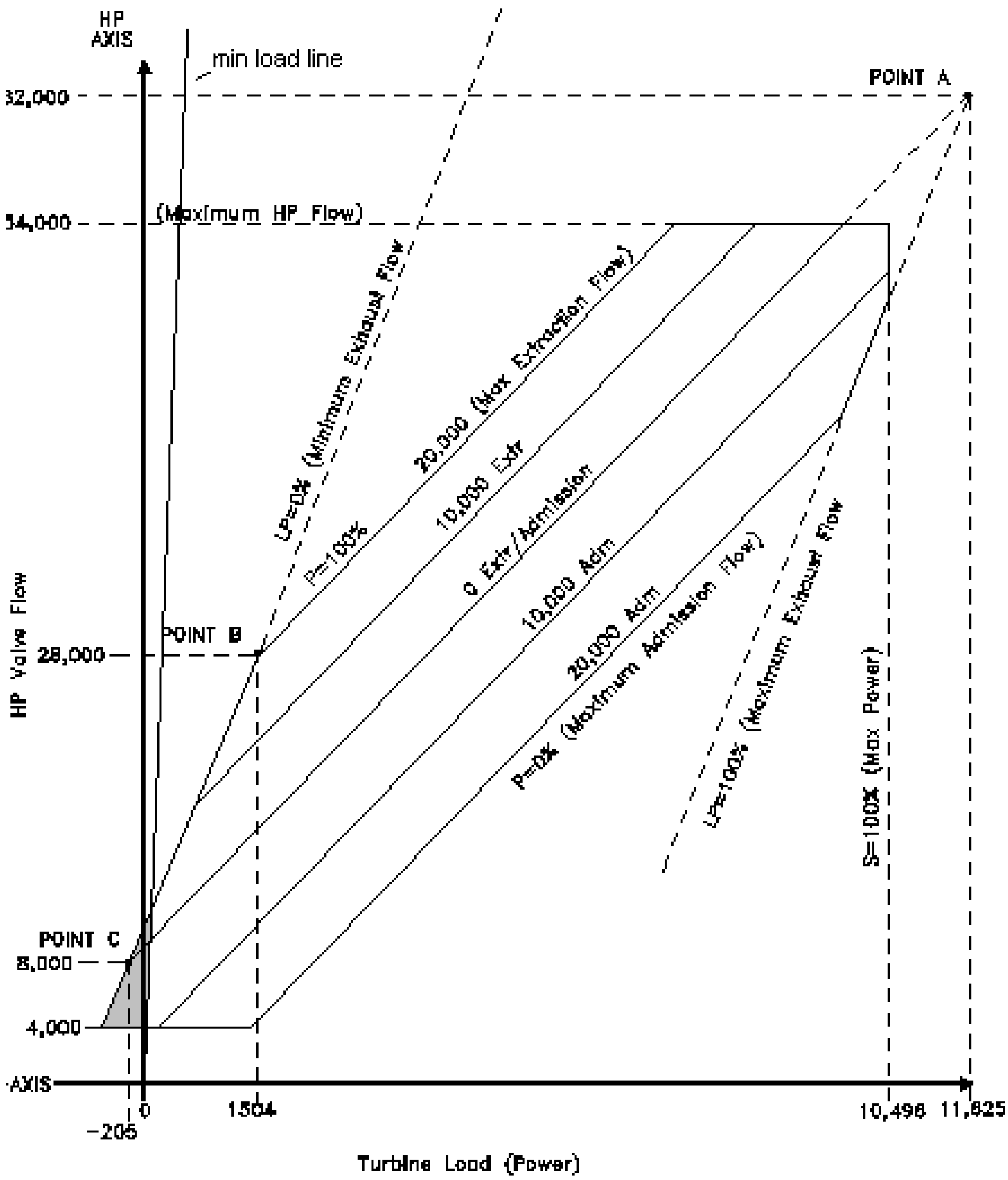


Figure 4-19. Typical Extraction & Admission Steam Map

The ten values needed can be taken from the converted steam map. An example has been provided below, using the steam map in Figure 4-19:

- The Max Power value is the load where the S=100 line crosses the S-axis, about 10,496 kW in our example.
- The Max HP Flow value is the flow where the HP=100 line crosses the HP-axis, about 54,000 lbs/hr.
- 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 lbs/hr.
- Max Admission = about 20,000 lbs/hr.

- Point B is where the LP=0 and P=100 lines intersect;
  - o Min Power @ Max Extraction = about 1504 kW.
  - o Min HP Flow @ Max Extraction = about 28,000 lbs/hr.
- Point C is where the LP=0 and zero extraction & admission flow lines intersect;
  - o Min Power @ Zero Extr/Adm = about—205 kW.
  - o Min HP Flow @ Zero Extr/Adm = about 8,000 lbs/hr.
- An additional parameter, Maximum Admission Flow (%), would also be set to 4000/54000 = 7.4%.

The ratio of one value to another is what is important. It does not matter if values are entered in engineering units, percentages, or values. As long as all values are entered in the same units, the map will ratio correctly.

The 505CC-2 will convert all the point in percentage, and send the result through Modbus for monitoring purposes on for example a HMI or DCS.

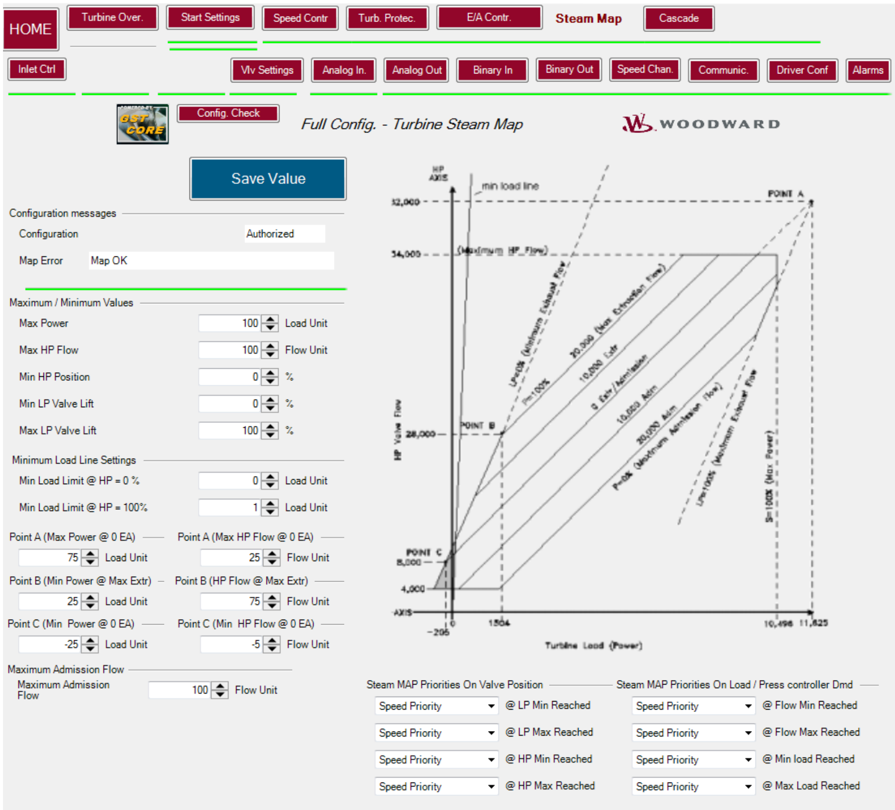


Figure 4-20. Steam Map Extraction/Admission Screen

For Maximum/Minimum Values and Minimum Load Line Settings refer to 4.8.2.1 and 4.8.2.2.

4.8.4.1 Point A Values

Maximum Power at zero E/A **Initial=75.0 (0.0, 100000)**

Enter the maximum power attainable at zero extraction/admission flow.

Maximum HP Flow at zero E/A **Initial=25.0 (0.0, 1000000)**

Enter the maximum HP valve flow attainable zero extraction/admission flow.

4.8.4.2 Point B Values

Minimum Power at Maximum Extraction **Initial=25.0 (0.0, 100000)**

Enter the minimum power attainable at maximum extraction flow.

Minimum HP Flow at Maximum Extraction **Initial=75.0 (0.0, 1000000)**

Enter the minimum HP valve flow at maximum extraction flow.

4.8.4.3 Point C Values

Minimum Power at zero E/A **Initial=-25.0 (-100000.0, 100000)**

Enter the minimum power attainable at zero extraction/admission flow.

Minimum HP Flow at zero E/A **Initial=-5.0 (-100000.0, 1000000)**

Enter the minimum HP valve flow at zero extraction/admission flow.

Maximum Admission Flow **Initial=100.0 (0.0, 1000000)**

Enter the maximum rated LP valve flow, admission, for the turbine.

For Steam Map Priorities refer to 4.8.2.6.

4.9 Cascade Control

The following configuration screen will be available if the 505CC-2 is configured to use Cascade Control, reference 4.3.1 Turbine Configuration.

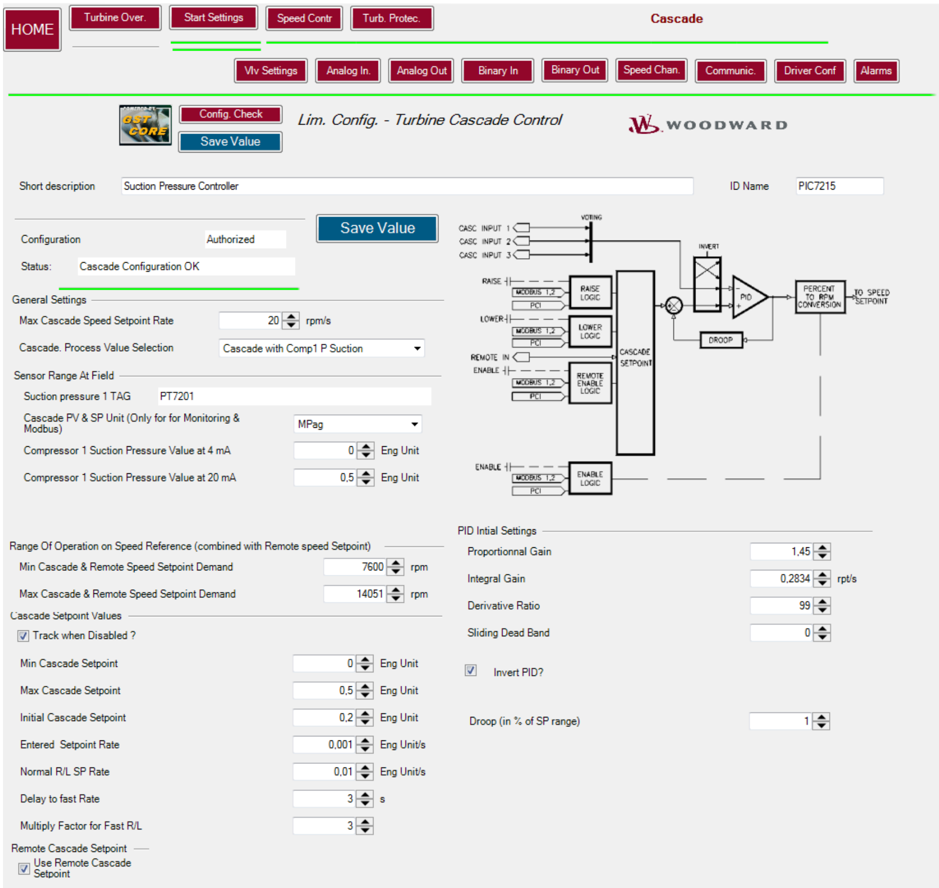


Figure 4-21. Cascade Control Screen

4.9.1 Cascade General Settings

Max Cascade Speed Setpoint Rate **Initial=100 (0, 1000)**

Maximum speed rate that cascade will move the speed reference. This is in any case limited by the speed setting, i.e. Loading Gradient.

Cascade Process Value Selection

Since the 505CC-2 can be configured for anti-surge control, the process value needed might already exist, without the need to configure a dedicated cascade PV. The following selections are available:

- Cascade with Cascade PV;
  - An analog input called cascade is used.
- Cascade with Comp1 P Suction;
  - Compressor #1 suction pressure PV will be used for cascade.
- Cascade with Comp1 Altern P1 override;
  - Compressor #1 alternative suction pressure override sensor will be used for cascade.
- Cascade with Comp1 P discharge;
  - Compressor #1 discharge pressure PV will be used for cascade.
- Cascade with Comp1 Altern P2 override;
  - Compressor #1 alternative discharge pressure override sensor will be used for cascade.
- Cascade with Comp1 Pressure Ratio

- Cascade with Comp1 Actual Flow
- Cascade with Comp1 Mass Flow
- Cascade with Comp2 P Suction;
    - Compressor #2 suction pressure PV will be used for cascade.
- Cascade with Comp2 Altern P1 override;
    - Compressor #2 alternative suction pressure override sensor will be used for cascade.
- Cascade with Comp2 P discharge;
    - Compressor #2 discharge pressure PV will be used for cascade.
- Cascade with Comp2 Altern P2 override;
    - Compressor #2 alternative discharge pressure override sensor will be used for cascade.
- Cascade with Comp2 Pressure Ratio
- Cascade with Comp2 Actual Flow
- Cascade with Comp2 Mass Flow
- Cascade with exported flow
    - Flowmeter at the downstream of compressor will be used for cascade.

4.9.2 Sensor

Cascade Tag

Enter a customized tag for the cascade sensor in case of Cascade with Cascade PV selection or else the preconfigured compressor tag will be shown.

Cascade PV & SP Units

Select the unit applicable for the cascade process value and setpoint. The following options are available:

Metric	Imperial/Miscellaneous
kPa (abs)	psia
MPa (abs)	ft of H2O (abs)
barA	atm (abs)
kg/cm² (abs)	torr (abs)
mmH2O (abs)	tons-force/ft² (abs)
kPag	inches of Hg (abs)
MPag	psig
barg	ft of H2O (gauge)
mmH2O (gauge)	atm (gauge)
Kg/cm² (gauge)	torr (gauge)
t/h	tons-force/ft² (gauge)
°C	inches of Hg (gauge)
mm	k#/hr
	k#/s
	_#/hr
	_%
	°F
	other customer defined

This option appears only for the Cascade with Cascade PV selection. The units are defined under compressor settings for the other selection although units for monitoring through Modbus can be defined.

Cascade PV at 4 mA **Initial=0.0 (-1000.0, 1000)**

This option appears only for the Cascade with Cascade PV selection. For other cases, the correct PV settings will be displayed. This value can also be configured in the Analog Input configuration screen (see 4.15, Analog Inputs).

Cascade PV at 20 mA **Initial=100.0 (-1000.0, 1000)**

This option appears only for the Cascade with Cascade PV selection. For other cases, the correct PV settings will be displayed. This value can also be configured in the Analog Input configuration screen (see 4.15, Analog Inputs).

4.9.3 Range of Operation on Speed Reference

Minimum Cascade & Remote Speed Demand **Initial=2625 (0, 25000)**

Enter the minimum speed setpoint that the cascade controller can lower the speed setpoint. Must be greater than or equal to the Minimum Control Speed Setpoint setting.

Maximum Cascade & Remote Speed Demand **Initial=4200 (50, 25000)**

Enter the maximum speed setpoint that the cascade controller can raise the speed setpoint. This value is used to limit the cascade PID from over-powering the unit. Must be less than or equal to the Maximum Control Speed Setpoint setting.

4.9.4 Cascade Setpoint Values

Track when Disabled?
If checked the setpoint will track the process value when cascade mode is disabled. The tracking/not tracking command can later be changed via Modbus/CCT only. If tracking is not selected, then the operator can change the setpoint at any time.

Min Cascade Setpoint **Initial=0 (0, 100)**

Set the minimum cascade setpoint. This value is the minimum setpoint value that the cascade setpoint can be decreased to (lower limit of cascade control).

Max Cascade Setpoint **Initial=0.6 (0, 1000)**

Set the maximum cascade setpoint. This value is the maximum setpoint value that the cascade setpoint can be increased to (upper limit of cascade control).

It must be greater than the Min Cascade Setpoint setting.

Initial Cascade Setpoint **Initial=0.75 (0, 1000)**

Enter the setpoint initialization value for the cascade setpoint. This is the value that the setpoint initializes to upon power-up or exiting configuration mode.

This must be less than or equal to the Max Cascade Setpoint setting.

Entered Setpoint rate **Initial=1(-0.001, 1000)**

This is the rate of change for an entered setpoint in engineering units/sec.

Normal R/L SP Rate **Initial=0.03 (0.001, 500)**

Enter the cascade setpoint slow rate, in units per second, at which cascade setpoint moves when adjusted for less than 2 seconds. After 2 seconds, the rate will increase to the multiplied factor rate.

Delay to Fast Rate **Initial=3 (0, 20)**

This is the time to wait when R/L command is send to use the fast rate settings.

Multiply Factor for Fast R/L **Initial=3 (1, 10)**

Set this multiply factor used for the setpoint rate when fast rate is selected

4.9.4.1 Remote Cascade Setpoint

Use Remote Cascade Setpoint

If checked, an external 4–20 mA signal can be used, to be configured in the Analog Input screen, to change the cascade setpoint. The cascade control setpoint will move to this input signal whenever the Remote Cascade Setpoint is enabled.

Max Remote Cascade Setpoint Rate **Initial=1 (-10000, 100000)**

Enter the maximum desired rate that the cascade setpoint will change for a large step change in the Remote Cascade Setpoint signal.

Remote Max Deviation Level **Initial=0.1 (0.001, 1000)**

When the 4-20 mA signal deviation is higher than this value, the setpoint will move forward the Remote Setpoint according the Entered Setpoint Rate.

This protection is only used during enabling Remote Cascade Setpoint. The Max Remote Cascade Setpoint Rate will be used once the deviation is less again.

4.9.4.2 PID Initial Settings

Proportional Gain **Initial=1.0 (0.01, 20)**

Enter the cascade PID proportional gain value. 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 1%.

Integral Gain **Initial=1 (0.001, 20)**

Enter the cascade PID integral gain value, in repeats-per-second (rps). 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 0.3 rps.

Derivative Ratio **Initial=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%.

Sliding Dead-band (% of sensor range) **Initial=0.0 (0.0, 10)**

If required, enter the deadband. Typically, set between 1% and not more than 10%. Process value changes within this band will not result in PID control action.

Invert PID?

Check this box when the cascade control action required is reverse acting. If selected, this option will result in the HP valve (S-term) decreasing to increase the cascade input parameter.

An example when the input would be inverted is when cascade PID is being used for turbine inlet pressure control.

Droop (in % of SP range) **Initial=4.0 (0.0, 10)**

Enter the droop percentage, if required, typically set between 4-6% and not more than 100%. This will result in the demand biasing the setpoint for usage when multiple PID’s are conflicting, trying to control the same process value.

4.10 Cascade Load Sharing

Cascade Load Sharing is currently not available in the 505CC-2.

This section is reserved for a possible release and description of this functionality.

4.11 Decoupling

The following configuration screen will be available when the 505CC-2 is configured to use Decoupling, reference 4.3.1 Turbine Configuration:

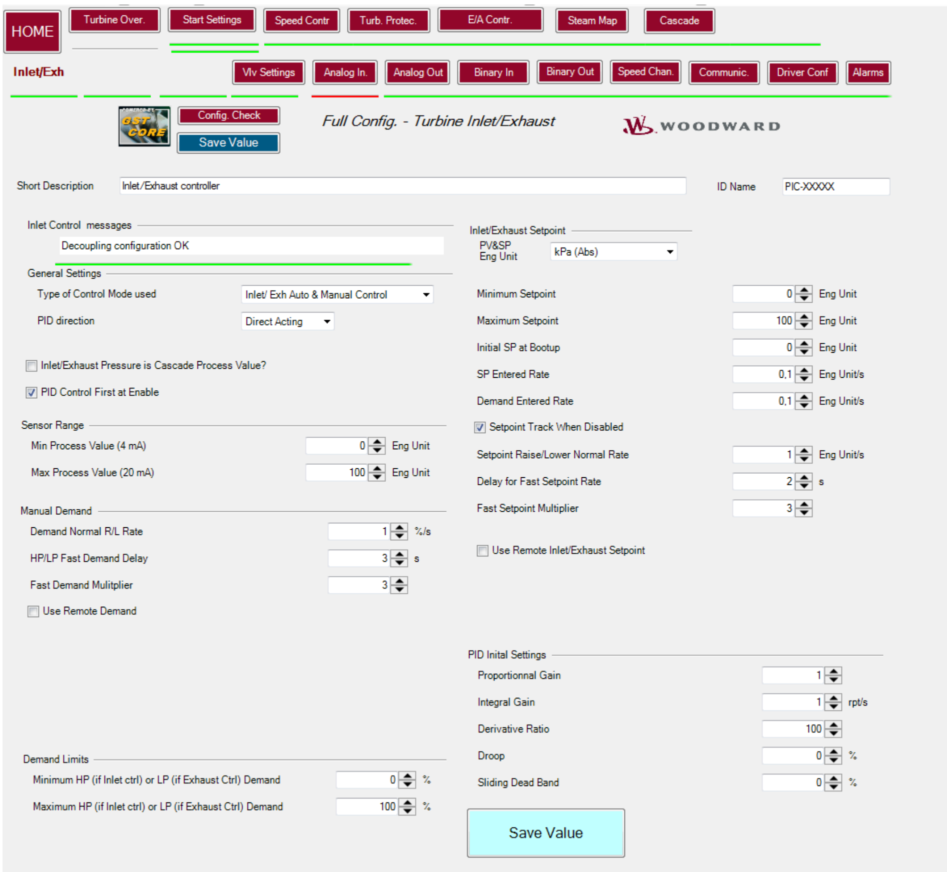


Figure 4-22. Decoupling (Inlet/Exhaust) Control

4.11.1 General settings

Type of Control Mode used

This option will select the operation mode for Inlet/Exhaust Control. The following selections are available:

- Inlet/Exhaust Auto & Manual control;
  - During normal operation it is possible to toggle from close loop (Automatic) to open loop, HP (Inlet)/LP(Exhaust) demand control.
- Inlet/Exhaust Automatic Control Only;
  - During normal operation, only close loop is possible. An Exception to this will only be when the sensor fails.

- Inlet/Exhaust Manual Control Only;
  - During normal operation, only open loop is possible. The operator will manipulate HP/LP demand by using raise/lower demand, or, if remote demand used, via a 4-20 mA signal.

This option may interfere with the setting put for first control selected in the Extraction and/or Admission configuration screen.

PID Direction

Selection of the PID Direction depends on the type of decoupling selected. The following options are available:

- Direct Acting
- Reverse Acting

For example in case of HP/inlet pressure decoupling selected:

- Pressure Control, Reverse Acting: HP close on SP increase
- Flow Control, Direct Acting: HP open on SP increase

Or in case of LP/exhaust decoupling:

- Direct Acting: LP open on SP increase
- Reverse Acting: LP close on SP increase

Inlet/Exhaust Pressure is Cascade Process Value?

Check this box when the Cascade PV is also used for Inlet/Exhaust control. This results in:

- That there is no need to configure an analog input for Inlet/Exhaust.
- Cascade must have been configured.
- SP rates are defined in the Cascade configuration.
- The units selected are just for display, and should be copy of the cascade units.
- It is protected to have Cascade and Decoupling active at the same time.
- The remote Inlet/Exhaust setpoint is the remote Cascade setpoint.

PID Control First at Enable

Check this box when Inlet/Exhaust control is requested. First Close loop mode have to be selected.

The selection Type of Control Mode used has priority in any case.

4.11.1.1 Sensor Range

The external sensor range needs to be defined in case the Decoupling is not the Cascade process value.

Min Process Value (4 mA) **Initial=0.0 (-10000.0, 10000)**

Define the 4 mA range value in engineering units. This value can also be configured in the Analog Input configuration screen (see 4.15, Analog Inputs).

Max Process Value (20 mA) **Initial=100.0 (-1000.0, 1000)**

Define the 20 mA range value in engineering units. This value can also be configured in the Analog Input configuration screen (see 4.15, Analog Inputs).

4.11.1.2 Manual Demand

Demand Normal R/L Rate **Initial=1.0 (0, 10)**

This is the rate in %/sec that the manual Raise and Lower commands move the valve.

HP/LP Fast Demand Delay **Initial=3.0 (0, 10)**

Time in second that it will use Normal Rate before the rate will change to Fast Rate.

Fast Demand Multiplier **Initial=3.0 (1, 10)**

Fast Rate equals the Normal Rate times this number.

Use Remote Demand

Check this box to use a remote 4-20 mA signal to control HP/LP valve Position Demand signal, Additional configuration below will be required.

Remote Demand Max Deviation Rate **Initial=0.1 (0.001, 10)**

This is the maximum P deviation level in percentage when Remote Demand is requested.

The P term will move forward the Remote Demand according the Not Match Rate setting when the 4-20 mA signal deviation is higher than this value.

This protection is only used during enabling Remote Demand. The Max Remote Demand Rate will be used once the deviation is less again.

Not Match Rate **Initial=0.1 (0.001, 10.0)**

When demand deviates too much, the HP/LP valve position demand will move forward the remote demand according this rate.

Max Remote Demand Rate **Initial=1.0 (0.001, 100)**

In normal operation, the P term will move forward the remote demand according this rate.

4.11.1.3 Demand Limits

Minimum HP or LP Demand **Initial=0.0 (-1, 50)**

This limit defines the minimum valve demand authorized for the decoupling controllers.

Maximum HP or LP Demand **Initial=100 (50, 101)**

This limit defines the maximum valve demand authorized for the decoupling controllers.

4.11.1.4 Inlet/Exhaust Setpoint

PV & SP Eng Unit

Select the engineering unit for the Inlet/Exhaust setpoint. The selections shown below are available:

Metric	Imperial/Miscellaneous
kPa (Abs)	Psia
MPa (Abs)	Ft of H2O (Abs)
BarA	Atm (Abs)
kg/cm2 (Abs)	Torr (Abs)
mmH2O (Abs)	Tons-force/ft2 (Abs)
kPag	In of Hg (Abs)
MPag	Psig
Barg	Ft of H2O (Gauge)
mmH2O (Gauge)	Atm (Gauge)
Kg/cm2 (Gauge)	Torr (Gauge)
t/h	Tons-force/ft2 (Gauge)
Deg C	In of Hg (Gauge)
mm	k#/hr
	k#/s
	_#/hr
	_%
	Deg F
	Other Customer Defined

Minimum Setpoint **Initial=0.0 (-200000, 200000)**

Set the minimum decoupling setpoint. This value is the minimum setpoint value that the decoupling setpoint can be decreased, i.e. lower limit of decoupling control.

Maximum Setpoint **Initial=100.0 (-200000, 200000)**

Set the maximum decoupling setpoint. This value is the maximum setpoint value that the decoupling setpoint can be increased, upper limit of decoupling control.

This must be greater than the Minimum Setpoint setting.

Initial SP at Boot-up **Initial=0.0 (-200000, 200000)**

Enter the initialization value for the decoupling setpoint. This is the value that the setpoint initializes to upon power-up or exiting configuration mode.

This must be less than or equal to the Maximum Setpoint setting.

SP Entered Rate **Initial=0.1 (0.01, 1000)**

Enter the desired rate at which the decoupling setpoint will move when a user entered target is given.

Demand Entered Rate **Initial=0.1 (0.001, 10)**

Enter the desired rate at which the decoupling demand (output) will move when a user entered demand value is given.

Setpoint Track when Disabled

If checked the setpoint will track the process value when decoupling mode is disabled or in manual mode. The tracking/not tracking command can later be changed via Modbus/CCT only. If tracking is not selected, then the operator can change the setpoint at any time.

Setpoint Raise / Lower Normal Rate **Initial=1.0 (0, 1000)**

Enter the Inlet/Exhaust setpoint slow rate at which setpoint moves when adjusted for less than the delay rate. After the delay, the rate will increase to the multiplication of this rate. The slow rate, fast rate time delay, and multiplier are all adjustable, see below.

Delay for Fast Setpoint rate **Initial=2.0 (1, 10)**

The time in seconds that it will use the normal rate before the rate will change to the fast rate.

Fast Demand Multiplier **Initial=3.0 (1, 10)**

The fast rate equals the normal rate times this number.

Use Remote Inlet/Exhaust Setpoint

Check this box to use a Remote Inlet/Exhaust Setpoint signal.

Max Remote SP Rate **Initial=100.0 (0.0, 1000)**

Enter the maximum %/sec that as a limiter for the remote setpoint.

Remote SP Max Deviation Level **Initial=0.1 (0.001, 1000)**

When the 4-20 mA signal deviation is higher than this value, the setpoint will move forward the Remote Setpoint according the SP Entered Rate.

This protection is only used during enabling Remote SP. The Max Remote SP Rate will be used once the deviation is less again.

4.11.1.5 PID Initial Settings

Proportional Gain **Initial=1.0 (0.0, 10)**

Enter the DCPL PID proportional gain value. This value is used to set decoupling control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 1%.

Integral Gain **Initial=1 (0.001, 10)**

Enter the DCPL PID integral gain value, in repeats-per-second (rps). This value is used to set decoupling control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 0.3 rps.

Derivative Ratio **Initial=100 (0, 100)**

Enter the Decoupling PID derivative ratio. This value is used to set decoupling control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%.

Droop **Initial=0.0 (0.0, 10)**

Enter the droop percentage. If required, typically set between 0-5% and not more than 10%. This will result in the demand biasing the setpoint for usage when multiple PID are conflicting, trying to control the same process value.

Sliding Dead Band **Initial=0 (0.0, 10)**

If required, enter the deadband. Typically, set between 1% and not more than 10%. Process value changes within this band will not result in PID control action.

4.12 Feed-Forward

The following configuration screen will be available when the 505CC-2 is configured to use Feed-Forward control mode, reference 4.3.1 Turbine Configuration. This is a performance enhancement feature that can be used on mechanical drive / compressor control applications.

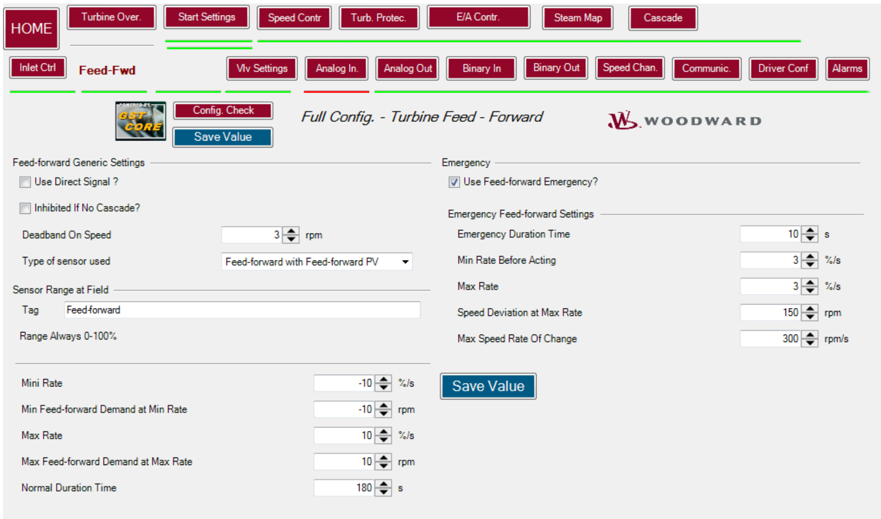


Figure 4-23. Feed Forward Performance Control

4.12.1.1 Feed-Forward Generic Settings

Use Direct Signal?

The speed bias will be directly proportional to the incoming signal when this option is selected. Else, if not selected, the speed bias will be a temporary action based on the Lag times configured. Do not select this option when the incoming signal is the anti-surge valve position.

The units are expressed in RPM when the Feed-Forward loop will be a direct signal, i.e. bias directly the speed.

The units are expressed in percentage when the Feed-Forward loop is not a direct signal, i.e. anti-surge valve position send.

Inhibited if No Cascade

Select this option if no speed Feed-Forward is desired when cascade is disabled.

Deadband on Speed **Initial=3 (2, 100)**

This creates a sliding deadband in rpm. It can be used to avoid unnecessary small speed corrections.

Type of sensor used

Define the signal used for this function. The following selections are available:

- Feed-forward with Feed-forward PV;
    - An analog signal must be configured.
- Feed-forward with AS1 Valve Demand
- Feed-forward with AS2 Valve Demand

Min Rate **Initial=-10.0 (-100, -1)**

This setting is the minimum gradient of the Feed-forward PV (anti-surge valve) possible in normal operation. Without hysteresis noticed, the absolute value should be equal to Max FW gradient.

Min Feed-forward Demand at Min Rate **Initial=-10 (-300, 0)**

This is the speed bias requested when Feed-forward demand (valve position minus lagged valve position) reaches the min FW gradient.

In between, Min FFW gradient and zero, speed bias will be proportional.

Without hysteresis noticed, the absolute value should be equal to speed bias at max gradient.

Max Rate **Initial=10.0 (1.0, 300)**

This setting is the maximum gradient of the Feed-forward PV (anti-surge valve) possible in normal operation.

Max FFW Demand at Max Rate **Initial=10.0 (0.0, 300)**

This is the speed bias requested when Feed-forward demand (valve position minus lagged valve position) reaches the max FW gradient.

In between, Max FFW gradient and zero, speed bias will be proportional.

Without hysteresis noticed, the absolute value should be equal to speed bias at max gradient.

Normal Duration time **Initial=180.0 (0.0, 1000)**

This time should be at least equal to five times the surge time loop.

When FW signal moves Up/Downs and stays at its position, the speed bias will ramp back to zero in more than 180 sec (valve position minus lagged valve position with time constant at 180 s).

This time should be long enough for the cascade PID to control perfectly its PV (example suction/discharge pressure of a compressor).

4.12.1.2 Emergency

The emergency loop will be added to the actual speed setpoint. Its action is always positive. It should be activated only in case of a sudden FW Process Value increase.

This loop should be activated and tuned only after proper tuning of the normal one.

Use Feed-Forward Emergency?

When the speed bias will be a temporary action based on the emergency lag times configured. The speed bias will act only in case of sudden valve change, opening, due to surge detection. During normal stroke of the valve, this mode should not act on the speed bias.

Care should be taken during calibration of this loop that the emergency bias acts only when necessary.

Emergency Duration Time **Initial=*10.0 (0.0, 100)**

This time should be equal to the surge time loop.

When FW signal moves up and stays at its position, the speed bias will ramp back to zero in more than 10 s, i.e. valve position minus lagged valve position with time constant at 10 s.

This time should be long enough to dump speed oscillation due to surge, but not too long to avoid new instability.

Min Rate Before Acting **Initial=3.0 (2.0, 100)**

This setting is the minimum gradient of the feed-forward PV (anti-surge valve) possible in normal operation.

This setting is used to trigger the emergency loop. It should be high enough to avoid accidental activation. During normal anti-surge stroke, emergency loop should not be activated.

Max Rate **Initial=3.0 (0, 100)**

This setting is the max deviation/demand of the valve position minus lagged valve position.

Speed Deviation at Max Rate **Initial=150.0 (0.0, 300)**

This is the speed bias requested when feed-forward demand (valve position minus lagged valve position) reaches the max FW gradient.

In between, zero and Max FW gradient, speed bias will be proportional.

Max Speed Rate of Change **Initial=300.0 (0.0, 300)**

This setting limits the rate of the speed bias when emergency loop is active.

4.13 Auxiliary

If the 505CC-2 is configured to use Auxiliary Controller Modes the following configuration page will be available. The Auxiliary controller can be a process controller or a limiter.

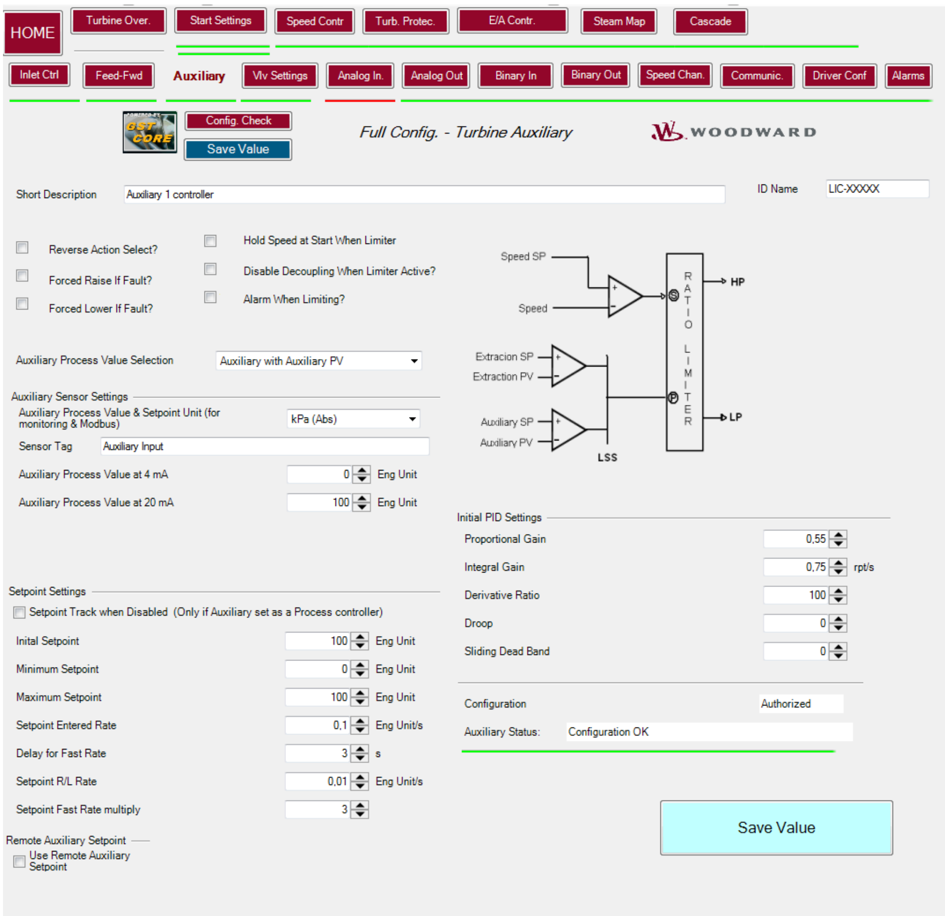


Figure 4-24. Auxiliary Control

4.13.1 Main Settings

Reverse Action Select?

Check this box if the control action required is to be reverse acting. Normal Action is when the SP>PV then the demand must increase. Reverse Action is when SP>PV then the demand must decrease.

Forced Raise If Fault?

Select this option when the setpoint should be forced high in case of sensor failure.

Forced Lower If Fault?

Select this option when the setpoint should be forced low in case of sensor failure.

Hold Speed at Start When Limiter

The following functionality will apply when selected:

- Start will be inhibited if Auxiliary is already trying to control.
- Automatic start will be stopped if Auxiliary tries to control.

Disable Decoupling When Limiter Active?

This limiter can be configured to disable Decoupling when Decoupling is active. It will automatically disable Decoupling mode and limit its process value if selected.

If not selected, then it won't operate as long as Decoupling mode is active.

Alarm When Limiting?

An alarm is generated when this option is selected when auxiliary acts as a limiter.

Auxiliary Process Value Selection

The process value needed might already exist, without the need to configure a dedicated Auxiliary PV since the 505CC-2 can be configured for anti-surge control. The following selections are available:

- Auxiliary with Auxiliary PV;
    - An analog input called Auxiliary is used.
- Auxiliary with Comp1 P Suction;
    - Compressor #1 suction pressure PV will be used for Auxiliary.
- Auxiliary with Comp1 Altern P1 override;
    - Compressor #1 alternative suction pressure override sensor will be used for Auxiliary.
- Auxiliary with Comp1 P discharge;
    - Compressor #1 discharge pressure PV will be used for Auxiliary.
- Auxiliary with Comp1 Altern P2 override;
    - Compressor #1 alternative discharge pressure override sensor will be used for Auxiliary.
- Auxiliary with Comp1 Pressure Ratio
- Auxiliary with Comp1 Actual Flow
- Auxiliary with Comp1 Mass Flow
- Auxiliary with Comp2 P Suction;
    - Compressor #2 suction pressure PV will be used for Auxiliary.
- Auxiliary with Comp2 Altern P1 override;
    - Compressor #2 alternative suction pressure override sensor will be used for Auxiliary.

- Auxiliary with Comp2 P discharge;
  - o Compressor #2 discharge pressure PV will be used for Auxiliary.
- Auxiliary with Comp2 Altern P2 override;
  - o Compressor #2 alternative discharge pressure override sensor will be used for Auxiliary.
- Auxiliary with Comp2 Pressure Ratio
- Auxiliary with Comp2 Actual Flow
- Auxiliary with Comp2 Mass Flow

4.13.1.1 Auxiliary Sensor Settings

Auxiliary Process Value & Setpoint Unit

Select the desired unit. The following selections are available.

Metric	Imperial/Miscellaneous
kPa (Abs)	Psia
MPa (Abs)	Ft of H2O (Abs)
BarA	Atm (Abs)
kg/cm2 (Abs)	Torr (Abs)
mmH2O (Abs)	Tons-force/ft2 (Abs)
kPag	In of Hg (Abs)
MPag	Psig
Barg	Ft of H2O (Gauge)
mmH2O (Gauge)	Atm (Gauge)
Kg/cm2 (Gauge)	Torr (Gauge)
t/h	Tons-force/ft2 (Gauge)
Deg C	In of Hg (Gauge)
mm	k#/hr
	k#/s
	_#/hr
	_%
	Deg F
	Other Customer Defined

Min Process Value (4 mA) **Initial=0.0 (-10000.0, 100000)**

Define the 4 mA range value in engineering units. This value can also be configured in the Analog Input configuration screen, see 0.

Max Process Value (20 mA) **Initial=100.0 (-10000.0, 100000)**

Define the 20 mA range value in engineering units. This value can also be configured in the Analog Input configuration screen, see 0.

This option appears only for Auxiliary with Cascade PV. For other cases, the correct PV settings will be displayed

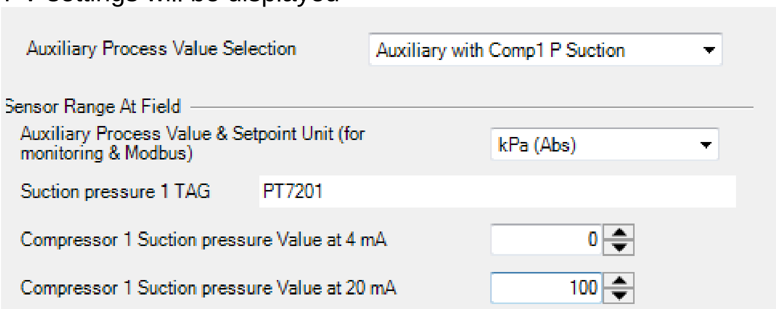


Figure 4-25. Auxiliary Control with Compressor #1 Suction Pressure

4.13.1.2 Setpoint Settings

Setpoint Track when Disable and Controller

The setpoint will be tracked when auxiliary control is disabled when this option is selected.

Initial Setpoint **Initial=100 (-100000, 100000)**

Enter the initial setpoint for auxiliary control.

Minimum Setpoint **Initial=0 (-100000, 100000)**

Enter the minimum auxiliary control setpoint value desired.

Maximum Setpoint **Initial=100 (-100000, 100000)**

Enter the maximum auxiliary control setpoint value desired.

Setpoint Entered Rate **Initial=0.1 (0, 1000)**

Here the maximum rate in units per second is entered that the setpoint is allowed to raise or lower.

Delay for Fast Rate **Initial=3.0 (0, 10)**

Here the duration is entered in seconds before the fast rate will be applied when a raise or lower command is issued.

Setpoint R/L Rate **Initial=0.01 (0, 100000)**

Here the rate is entered in units per second that is used when a raise or lower command is given for the setpoint.

Setpoint Fast Rate Multiply **Initial=3.0 (1, 10)**

This value determines the multiplication factor used that acts on the normal rate.

Use Remote Auxiliary

Select this option if external remote control is desired.

Remote Auxiliary Max Rate **Initial=100 (0, 1000)**

Enter the maximum remote setpoint rate that the remote setpoint is allowed to change.

Remote SP Max Deviation Level **Initial=100 (0, 1000)**

Enter the maximum deviation level for remote setpoint that is allowed.

The entered rate will be used first when remote SP is enabled and Auxiliary Remote SP is above this level.

4.13.1.3 Initial PID Settings

Proportional Gain **Initial=0.55 (0.0, 100)**

Enter the Auxiliary PID proportional gain value. This value is used to set the control response. This value can be changed in the Service Mode while the turbine is operating.

Integral Gain **Initial=0.75 (0.0, 50)**

Enter the Auxiliary PID integral gain value, in repeats-per- second (rps). This value is used to set auxiliary control response. This value can be changed in the Service Mode while the turbine is operating.

Derivative Ratio **Initial=100.0 (0.01, 100)**

Enter the Auxiliary 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.

Droop **Initial=0.0 (0.0, 25)**

If required, enter the deadband, typically, set between 0-6% and not more than 10%. This deadband is used if the output of the PID needs to remain the same, e.g. if the signal is noisy.

Sliding Dead-band **Initial=0.0 (0.0, 5)**

If required, enter the deadband, typically, set between 0-6% and not more than 10%. This deadband is used if the output of the PID needs to remain the same, e.g. if the signal is noisy.

4.14 Valve Settings

This screen is used to configure the 505CC-2 for the correct type of steam control valve arrangements present in the system.

It will adjust its display according the type of turbine configured

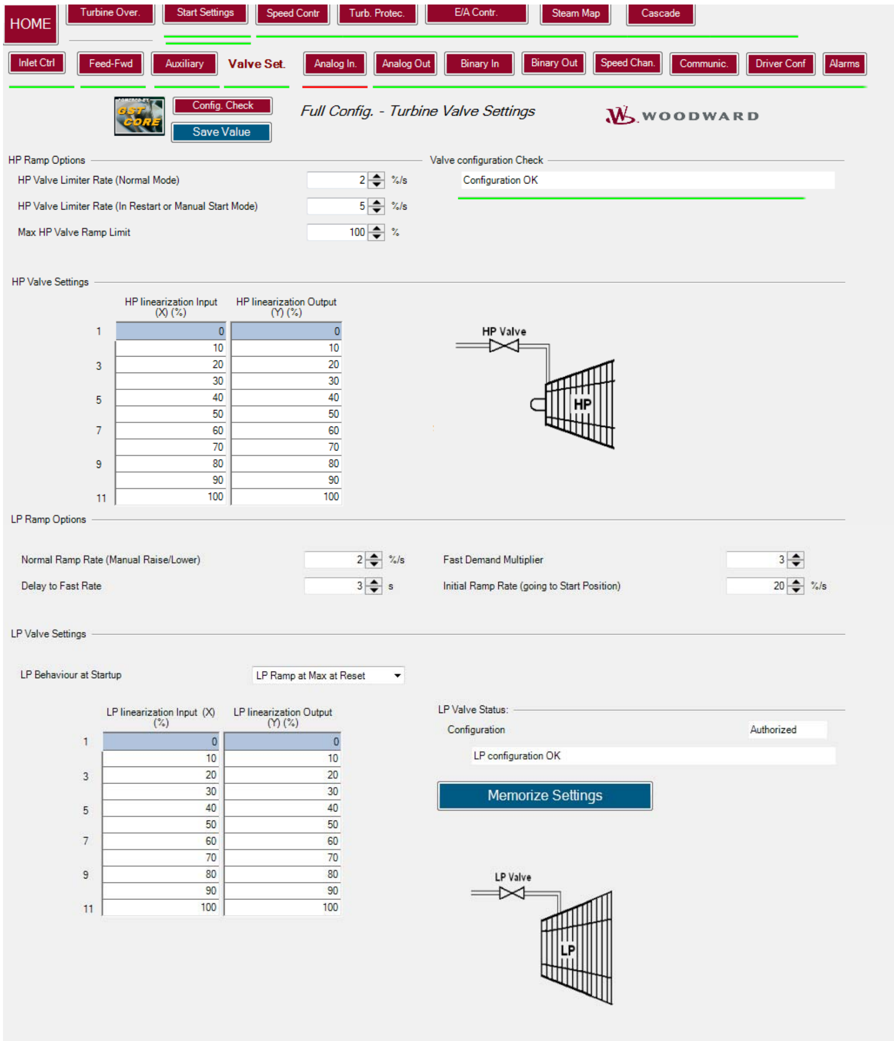


Figure 4-26. Valve Settings

4.14.1.1 HP Ramp Options

HP Valve Limiter Rate (Normal Modes) Initial=2.0 (0.0, 100)

Enter the HP Valve Limiter Rate, in percent per second. This is the rate at which the HP valve limiter moves when a RUN command is given or when the limiter setting is changed through Raise/Lower commands. When using a semiautomatic or automatic start, this setting should be very slow—- typically less than 2%/sec.

HP Valve Limiter Rate (in Restart or Manual) Initial=5.0 (0.0, 100)

Enter the HP Valve Limiter Rate, in percent per second. This is the rate at which the HP valve limiter moves when a RESTART command is given or when the unit is in a Manual Start Routine. When using a manual start, this setting is less critical and can be left at the default of 5% / sec.

Max HP Valve Ramp Limit Initial=100% (0, 100)

Enter the maximum limit that the HP valve should be driven to (usually 100%). This value can be used if conditions exist that warrant limiting the full stroke of the HP valve to something less than 100%.

HP Valve Used

This selection is only available for a single stage turbine configuration, i.e. no extraction type turbine

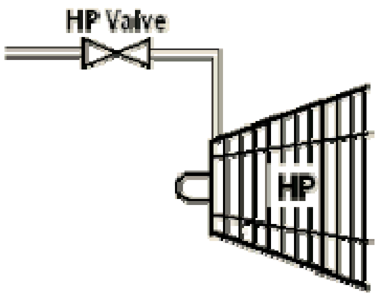
Available types include:

- One HP Valve;
    - This is the most common type.
- Two HP Valves Split range;
    - Two valves with a percentage offset between them.
- HP with HP2 Startup Valve.
- HP with HP2 Boost Valve

The split range allows two inlets valves to operate off of the same HP demand signal from the control with an offset percentage between them.

4.14.1.2 Valve Configuration

One HP Valve



Linearization Table

It is necessary to adjust the settings below if it is needed to have linearity between the linear HP demand and the flow through the turbine.

	HP linearization Input (X) (%)	HP linearization Output (Y) (%)
1	0	0
	10	10
3	20	20
	30	30
5	40	40
	50	50
7	60	60
	70	70
9	80	80
	90	90
11	100	100

Figure 4-27. Linearization Table, One Valve

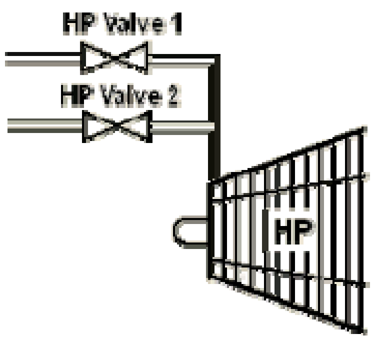
⚠WARNING

The First point of this curve should not be modified and remain as displayed above.
Input = 0%
Output =0%

The 505CC-2 won't accept any value requesting a valve opening >0% at Shutdown/ Ready to start Position

Any modification of this first value while turbine is running and in operation may result in a Turbine Overspeed.

Two HP Valves Split Range



Offset for Split Valve **Initial=0 (0, 100)**

Enter the amount of offset between the two valves in a split valve arrangement. HP2 Valve will start to open when the valve demand reaches this value.

Linearization Table

It is necessary to adjust the settings below if it is needed to have linearity between the linear HP, HP2 demand and the flow through the turbine.

Offset for Split Valve 0 %

	HP linearization Input (X) (%)	HP linearization Output (Y) (%)		HP2 linearization Input (X) (%)	HP2 linearization Output (Y) (%)
1	0	0	1	0	0
	10	10		10	10
3	20	20	3	20	20
	30	30		30	30
5	40	40	5	40	40
	50	50		50	50
7	60	60	7	60	60
	70	70		70	70
9	80	80	9	80	80
	90	90		90	90
11	100	100	11	100	100

Figure 4-28. Linearization Table, Split Range

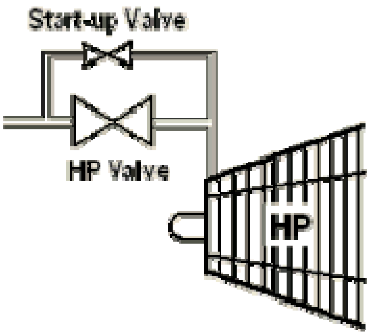
⚠WARNING

The First point of this curve should not be modified and remain as displayed above.
Input = 0%
Output =0%

The 505CC-2 won't accept any value requesting a valve opening >0% at Shutdown/ Ready to start Position

Any modification of this first value while turbine is running and in operation may result in a Turbine Overspeed.

HP with HP2 Startup Valve



The Startup Valve configuration allows a small startup valve to be used in tandem with a very large inlet HP valve. The small valve operates below one speed setpoint, or valve demand %, and the large valve operates above a second speed setpoint, or valve demand %. In between the two setpoints, both valves are active and the openings are interpolated.

Transfer Time at Disable **Initial=0.01 (0.01, 100)**

Set the time to disable the usage of HP2 valve in case of failure. A small value is recommended

Minimum Transfer time **Initial=10.0(1.0, 100)**

Set the minimum time to transfer the usage of HP2 valve to HP valve. In case of failure, after reset, this is the time to go back to normal situation.

Use Valve Demand for Xfer?

Transfer will be based on speed setpoint when not selected:

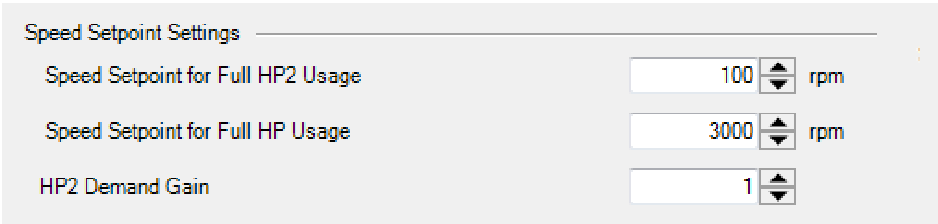


Figure 4-29. Transfer Based on Speed Setpoint

Else when selected transfer will be based on valve demand:

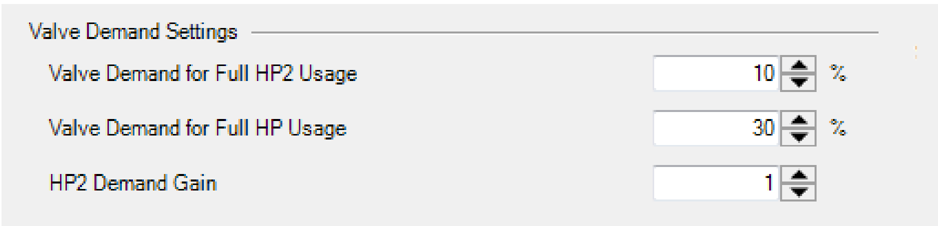


Figure 4-30. Transfer Based on Valve Demand

HP2 Demand Gain **Initial=1 (0.05, 100)**

The curve setup and PID gains must be carefully setup to insure stable startup operation. Typically a secondary gain equal to the Max flow on HP divided by Max flow on HP2 is used

Linearization Table

If needed, to have linearity between the HP and HP2 demand (linear) and the flow through the turbine, it is necessary to adjust the settings below.

	HP linearization Input (X) (%)	HP linearization Output (Y) (%)		HP2 linearization Input (X) (%)	HP2 linearization Output (Y) (%)
1	0	0	1	0	0
	10	10		10	10
3	20	20	3	20	20
	30	30		30	30
5	40	40	5	40	40
	50	50		50	50
7	60	60	7	60	60
	70	70		70	70
9	80	80	9	80	80
	90	90		90	90
11	100	100	11	100	100

Figure 4-31. Linearization Table, HP with HP2 Startup Valve

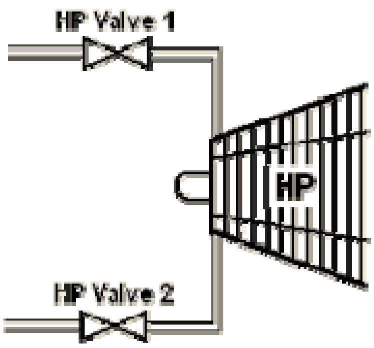
⚠WARNING

The First point of this curve should not be modified and remain as displayed above.
Input = 0%
Output =0%

The 505CC-2 won't accept any value requesting a valve opening >0% at Shutdown/ Ready to start Position

Any modification of this first value while turbine is running and in operation may result in a Turbine Overspeed.

HP with HP2 Boost Valve



The boost valve configuration allows an admission valve to be used as a starter assisting valve.

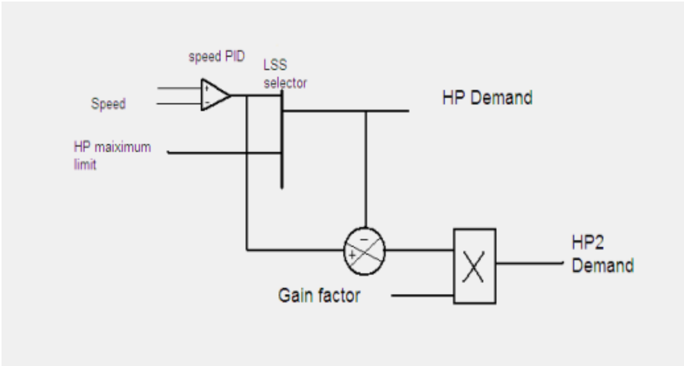


Figure 4-32. HP with HP2 Control

HP2 Gain **Initial=1.0 (0.05, 100)**

The curve setup and PID gains must be carefully setup to insure stable startup operation. Typically a secondary gain equal to the max flow on HP divided by the maximum flow on HP2 is used.

Minimum Transfer time **Initial=10.0(1, 100)**

Set the minimum time to transfer the usage of HP2 valve to HP valve. In case of failure, after reset, this is the time to go back to normal situation.

Transfer Time at Disable **Initial=0.01(0.01, 10)**

Set the time to disable the usage of HP2 valve in case of failure. A small value is recommended.

Linearization Table

If needed, to have linearity between the HP and HP2 demand (linear) and the Flow through the turbine, it is necessary to adjust the settings bellow

	HP linearization Input (X) (%)	HP linearization Output (Y) (%)		HP2 linearization Input (X) (%)	HP2 linearization Output (Y) (%)
1	0	0	1	0	0
	10	10		10	10
3	20	20	3	20	20
	30	30		30	30
5	40	40	5	40	40
	50	50		50	50
7	60	60	7	60	60
	70	70		70	70
9	80	80	9	80	80
	90	90		90	90
11	100	100	11	100	100

Figure 4-33. Linearization Table, HP with HP2 Boost Valve

⚠WARNING

The First point of this curve should not be modified and remain as displayed above.
Input = 0%
Output =0%

The 505CC-2 won't accept any value requesting a valve opening >0% at Shutdown/ Ready to start Position

Any modification of this first value while turbine is running and in operation may result in a Turbine Overspeed.

4.14.1.3 LP Ramp Options

This configuration is available in case of an Extraction and Admission turbine type.

Normal Ramp Rate (Manual Raise/Lower) Initial=2.0 (0.1, 20)

Set the rate in %/sec that valve limiter moves.

Delay to Fast Rate Initial=3.0 (1.0, 10)

Set the time it will use normal rate before the rate will change to fast rate.

Fast Demand Multiplier Initial=3.0 (1.0, 10)

Fast rate equals the normal rate times this number.

Initial Ramp Rate (going to Start Position) Initial=20.0 (1.0, 50)

Enter the ramp rate for the valve to go to the start position.

4.14.1.4 LP Valve Settings

LP Behavior at Startup

The following selections are available:

- LP Ramp at Max at Reset;
  - LP to Max when unit is ready to Start.
- LP Ramp to Max at Start;
  - LP to Max when Start initiated.
- Map in control during Startup;
  - LP is already modulating in startup for zero Extr/Adm demand.

An extra option will appear when the last option is selected, Map in control during Startup:

LP Min Position at Start Initial=*100 (0, 100)

Set the minimum LP ramp limiter position during startup.

4.15 Analog Inputs

The Analog Inputs screen is used to assign the analog inputs. The configuration check status message will support this by indicating the missing assignments.

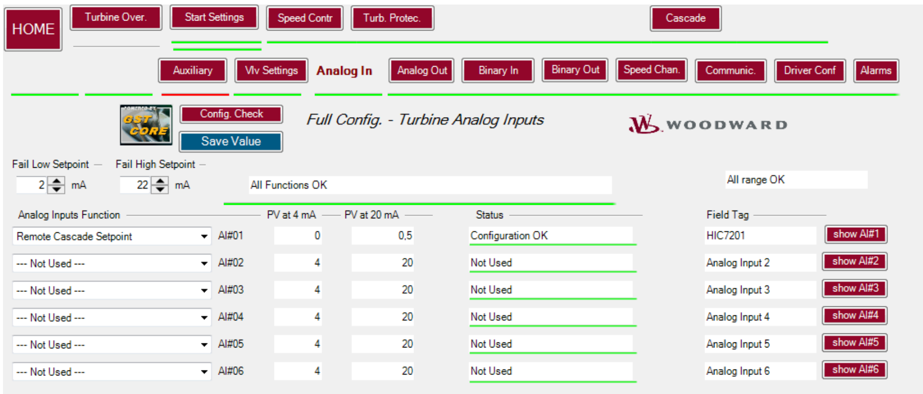


Figure 4-34. Analog Inputs Screen

The default settings for detecting analog input failures are a fail setpoint of low 2 mA and high 22 mA. These can be adjusted if required:

Fail Low Setpoint **Initial=2.0 (0.0, 4.0)**

Set the level low to detect analog Input failure.

Fail High Setpoint **Initial=22.0 (20.0, 24.0)**

Set the level high to detect analog Input failure.

4.15.1.1 Analog Inputs Range and Function

The following analog input turbine control configurations are possible:

- Remote Speed Reference Setpoint
- Cascade Input
- Remote Cascade Setpoint
- Auxiliary Input
- Remote Auxiliary Setpoint
- Extraction/Admission Input
- Remote Extract/Admiss Setpoint
- Rem Manual Extract/Admiss (P) Dmd
- Inlet/Exhaust Press/Flow
- Remote Inlet/Exhaust Setpoint
- Remote Manual Inlet/Exhaust Demand
- Feed Forward Input
- Process Val for Hot/Cold Start Curves

The above are pre-defined analog inputs. An extra four customer defined monitor inputs are available for configuration:

- Customer Defined Monitor Input #1
- Customer Defined Monitor Input #2
- Customer Defined Monitor Input #3
- Customer Defined Monitor Input #4

Further configuration of the range is possible by pressing the button Show for the assigned analog inputs. In addition the Modbus multiplier and a field tag can be set, see Figure 4-35.

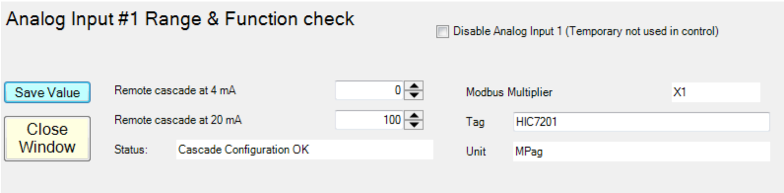


Figure 4-35. Further Configuration Analog Inputs

A specific window will appear depending on the type of signal selected. Be aware that some ranges may have been already set previously during configuration. In addition modifying the range may interfere with the configuration check, i.e. consistency between setpoints and ranges. For that reason configuration check messages might appear for some signals.

Tag

A customized tag name can be assigned to the signals. The alarm page will display the tag name set here in case of signal failure.

For example:

PT-31000 Extraction flow Fault

Instead of:

Extraction/Admission PV Fault

Will be displayed on the alarm page

Sensor Range

Enter the field process values for 4 mA.

Enter the field process values for 20 mA.

Modbus Multiplier

The Modbus protocol does not send decimal values. To resolve this it is necessary to select a multiply factor. This value will be a multiply factor on the process value, in engineering units, and associated setpoints prior to be send via Modbus.

In addition the Modbus protocol does not support a higher integer value than 32768. Therefore, the multiply factor must be selected in order that this is not exceeded by verifying the 20 mA sensor range times the multiplier is not exceeding 32768.

The Modbus multiplier is always 100 in all cases for values expressed in percentage.

Disable Analog Input

Selecting this temporary inhibits the usage of the sensor in the control logic.

This option may be selected when it is desired to calibrate safely the sensor in the field.

The check mark must be un-selected and a reset issue to re-use the signal in the controller.

This option is available and more relevant in service mode.

Some additional notes on Analog Input configuration:

- The configuration check routine will attempt to correlate these choices with other settings made by the user such as turbine type, control functions used, etc.;
    - For example, if the use of Remote Speed Setpoint is configured, then the control will generate a configuration Error if none of the Analog Inputs are configured for this function.
- Customized device tag names are optional and can be entered in any mode.

4.16 Analog Outputs

The Analog Outputs screen is used to assign the analog outputs. In addition the 4 mA and 20 mA ranges can be defined, and a tag name entered.

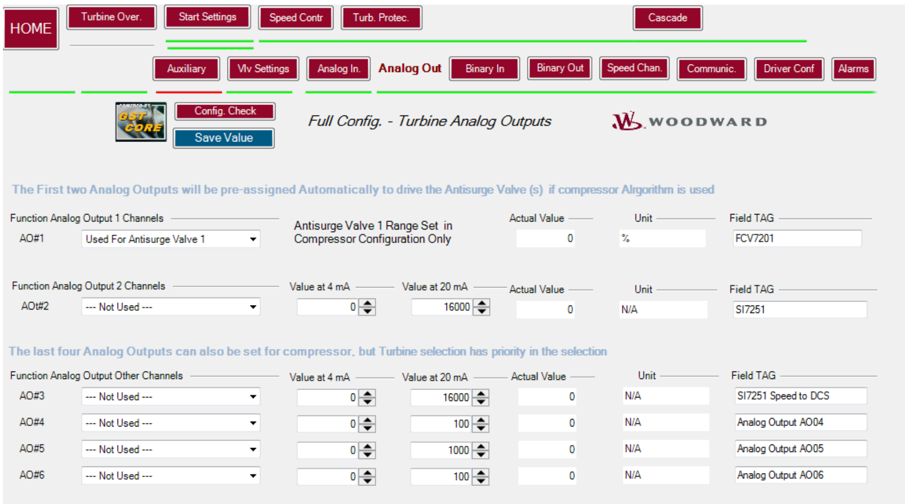


Figure 4-36. Analog Outputs Screen

The first two analog outputs are dedicated for Anti-Surge valve 1 and 2 when these compressor loops have been configured. The following analog output turbine control configurations are possible:

- Actual Shaft Speed
- Speed Reference Setpoint
- Remote Speed Reference Setpoint
- Extraction/Admission Signal
- Extraction/Admission Setpoint
- Remote Extract/Admiss Setpoint
- Cascade Signal
- Cascade Setpoint
- Remote Cascade Setpoint
- Auxiliary Signal
- Auxiliary Setpoint
- Remote Auxiliary Setpoint
- S Demand (Speed)
- P Demand (Extraction)
- ACT 1 (HP) Valve Limiter Setpoint
- ACT 2 (LP) Valve Limiter Setpoint
- ACT 1 (HP) Valve Demand
- ACT 2 (LP) Valve Demand
- ACT1 Demand after linearization
- ACT2 Demand after linearization
- Monitor#1
- Monitor#2

- Monitor#3
- Monitor#4
- Monitor#5
- Monitor#6
- Monitor#7
- Monitor#8

Value at 4 mA

Set the selected signal value for 4 mA in engineering units.

Value at 20 mA

Set the selected signal value for 20 mA in engineering units.

Tag

A customized tag name can be assigned to the signals. The alarm page will display the tag name set here in case of signal failure.

IMPORTANT

The message Used for Compressor is shown when an analog output is already assigned by the compressor configuration, but the turbine selection has priority versus compressor selection. Therefore it is possible to re-assign the channel for another function and the previous assignment done in compressor configuration will be erased.

4.17 Binary Inputs

The Binary Inputs screen is used to assign the binary inputs. In addition a tag name can be entered here.

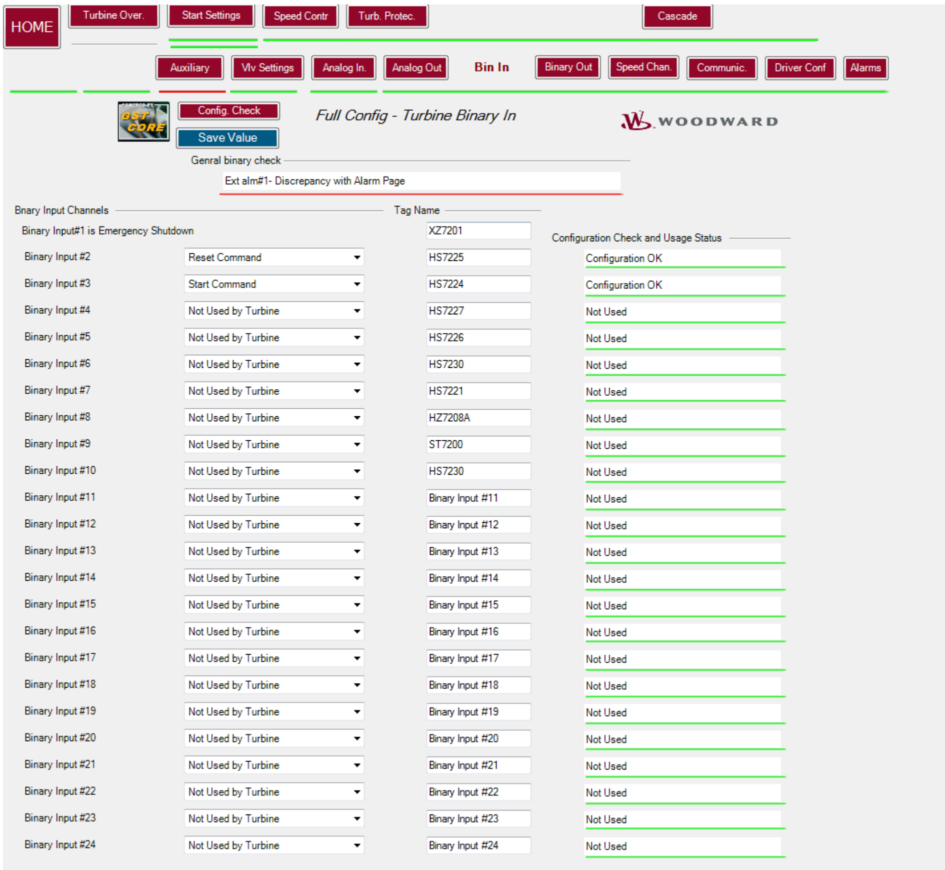


Figure 4-37. Binary Inputs Screen

The first discrete input is reserved for emergency shutdown functionality into the 505CC-2. All other channels are configurable, however the next five configurable binary inputs are defaulted to common signals expected to exist in the system.

- Reset Command
- Start Command
- Halt/Continue-Idle/Rated
- Raise Speed
- Lower Speed
- E/D Remote Speed
- Normal SD request
- Overspeed Test
- Select Hot / Next Curve
- Raise HP ramp
- Lower HP ramp
- Raise LP ramp
- Lower LP ramp
- E/D Cascade
- Raise Cascade SP
- Lower Cascade SP
- Ldsh Request (spare)
- Swing request (spare)
- Normal Request (spare)
- Enable/Disable Remote Cascade
- Enable/Disable Auxiliary

- Raise Auxiliary SP
- Lower Auxiliary SP
- Raise Auxiliary Demand
- Lower Auxiliary Demand
- Enable/Disable Remote Auxiliary
- Auxiliary Manual Request
- Enable/Disable Extraction/Admission
- Extraction/Admission Manual Mode Request
- Extraction/Admission Automatic Mode request
- Raise Extraction/Admission Setpoint
- Lower Extraction/Admission Setpoint
- Raise Extraction/Admission Demand
- Lower Extraction/Admission Demand
- Enable/Disable Remote Extraction Setpoint
- Enable Remote Manual Extraction
- Enable/Disable Inlet/Exhaust Control
- Inlet/Exhaust Manual Control
- Inlet/Exhaust Automatic Control
- Raise Inlet/Exhaust Setpoint
- Lower Inlet/Exhaust Setpoint
- Enable/Disable Remote Inlet/Exhaust Setpoint
- Enable Rem Manual Inlet/Exhaust
- Enable/Disable Feed-Forward Loop
- External Shutdown #1
- External Shutdown #2
- External Shutdown #3
- External Shutdown #4
- External Shutdown #5
- External Shutdown #6
- External Shutdown #7
- External Shutdown #8
- External Shutdown #9
- External Shutdown #10
- External Alarm #1
- External Alarm #2
- External Alarm #3
- External Alarm #4
- External Alarm #5
- External Alarm #6
- External Alarm #7
- External Alarm #8
- External Alarm #9
- External Alarm #10
- Override MPU Fault
- Select On-line PID
- Local/Remote
- RTC Clock Synchronize
- Emergency to Min Governor

The configuration check will display an error in case of a duplicated binary input. Signal already assigned to the compressor control will be indicated.

Also the configuration check will indicate a discrepancy error when for example an External Shutdown input is selected. The message indicates that under the alarms configuration screen the external alarm/shutdown must also be configured. The message will be cleared when the binary input selection and alarms configuration match.

IMPORTANT

The message Used for Compressor is shown when a binary input is already assigned by the compressor configuration, but the turbine selection has priority versus compressor selection. Therefore it is possible to re-assign the channel for another function and the previous assignment done in compressor configuration will be erased.

4.18 Binary Outputs

The Binary Outputs screen is used to assign the binary outputs. A LED will show the status of the configured relays, i.e. energized or not. In addition a customized identification tag can be entered for each channel.

Reset Clears Trip Output

Use this option to break a shutdown loop, e.g. an external device trips the 505CC-2 which subsequently sends a trip command to external device. This is the loop that has to be broken for the shutdown to be cleared. The way it works is that when selected, as soon as a trip occurs, the trip relay is de-energized, inversion is not possible. When reset is pressed, the trip relay will be re-energized, even if a trip condition still exists. However, the control will remain internally in trip condition, and will maintain the speed reference to its minimum value.

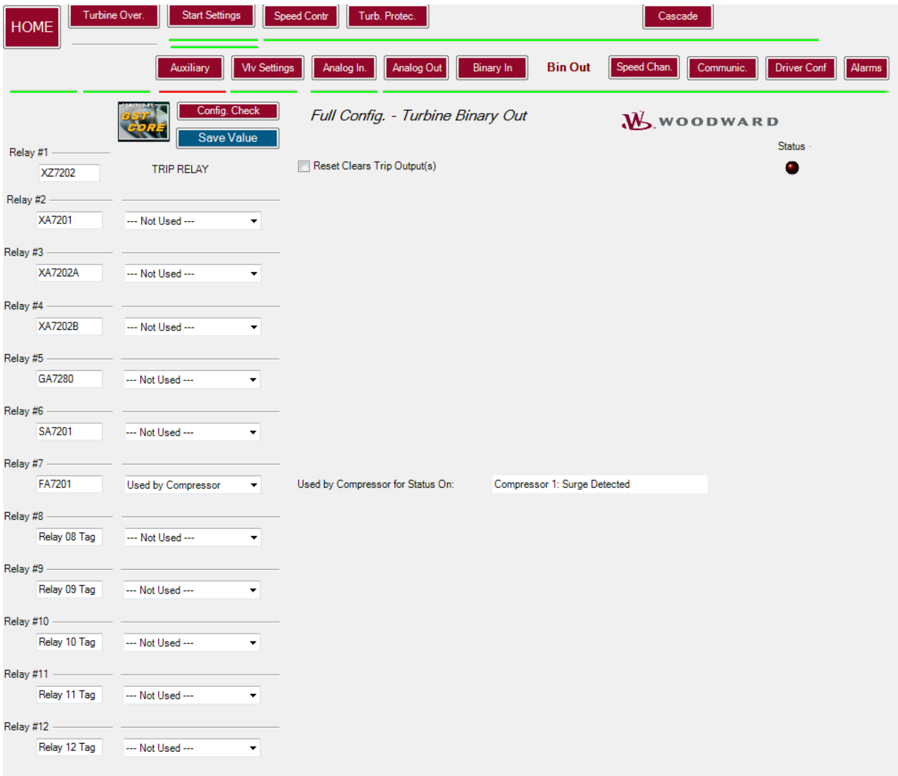


Figure 4-38. Binary Outputs Screen

The relay outputs can be configured using the pull-down menus. The first discrete output is reserved for the summary trip relay functionality from the 505CC-2. All other channels are configurable; however the second channel is defaulted as a summary alarm output.

A distinction can be made in the configurable discrete outputs between status indication and level switch. The following discrete output turbine control configurations are possible:

Relays configured as status indication require the functionality to be assigned. The following functionality is available:

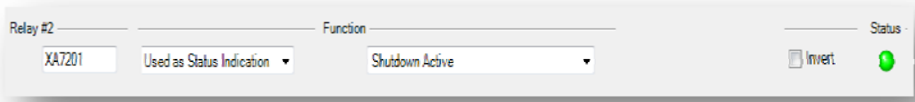


Figure 4-39. Relay Status Indication

- Shutdown Active
- Trip Relay
- Alarm Active
- Start Inhibit Active
- Ready to Start
- Atlas-II Control Status OK
- Acceleration Protection Activated
- Overspeed Trip
- Overspeed Test Enabled
- Speed PID In Control
- Rated Selected
- Auto Start Sequence Halted
- Online PID Selected
- Local Mode Selected

- Remote Speed Setpoint Enabled
- Remote Speed Setpoint Active
- Cascade Control Enabled
- Cascade Control Active
- Remote Cascade Enabled
- Remote Cascade Active
- Auxiliary Limiter Active
- Auxiliary Control Enabled
- Auxiliary Control Active
- Extraction/Admission Enabled
- Extraction/Admission Active
- Extraction/Admission Control in Auto
- Extraction/Admission In Remote Auto
- Extraction/Admission In Manual
- Extraction/Admission in Remote Manual
- Inlet/Exhaust Ctrl mode selected
- Inlet/Exhaust Ctrl In Automatic mode
- Inlet/Exhaust Ctr in Remote Auto mode
- Inlet/Exhaust Ctrl Mode in Manual mode
- Inlet/Exhaust Ctrl in Rem Manual mode
- Any steam Map limit Reached
- Feed-forward Enabled
- Feed-forward Active
- Modbus#1 Command Enabled
- Modbus#2 Command Enabled
- Internal Level Switch1 ON
- Internal Level Switch2 ON
- Internal Level Switch3 ON
- Internal Level Switch4 ON
- Internal Level Switch5 ON
- Internal Level Switch6 ON
- Internal Level Switch7 ON
- Internal Level Switch8 ON
- Spare1
- Spare2
- Reset Pulse (1 second)

Relays configured as level switch require the functionality to be assigned, and an on/off level defined.

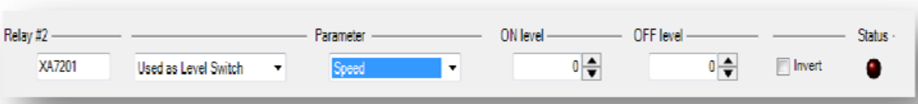


Figure 4-40. Relays Level Switch

The on and off level for energizing the relay output can be configured based on the following values:

- Speed
- Speed Setpoint
- Extraction Input
- Extraction Setpoint
- Cascade Input
- Cascade Setpoint
- Auxiliary Input
- Auxiliary Setpoint
- S Demand Value

- P Demand Value
- HP Valve Limit Value
- LP Valve Limit Value
- Actuator #1 Demand
- Actuator #2 Demand
- Monitor#1
- Monitor#2
- Monitor#3
- Monitor#4
- Monitor#5
- Monitor#6
- Monitor#7
- Monitor#8

Invert

It is possible to invert the signal.

ON Level

Level based on the parameter selected set to activate the relay.

OFF Level

Level based on the parameter selected set to de-activate the relay.

IMPORTANT	**The relay will behave as a high select switch, energized at ON and de-energized at OFF, when the ON level > the OFF level.** **The relay will behave as a low select switch, energized at ON and de-energized at OFF, when the ON level < the OFF level.** **Therefore it might not be needed to use the Invert functionality.**

IMPORTANT	**The message Used for Compressor is shown when a binary output is already assigned by the compressor configuration, but the turbine selection has priority versus compressor selection. Therefore it is possible to re-assign the channel for another function and the previous assignment done in compressor configuration will be erased.**

4.19 Speed Channel

Configuration is possible for a single speed input or redundant. In addition the tag can be set for each configured speed channel. The possible types for speed input are:

- MPU
- Proximity Probe

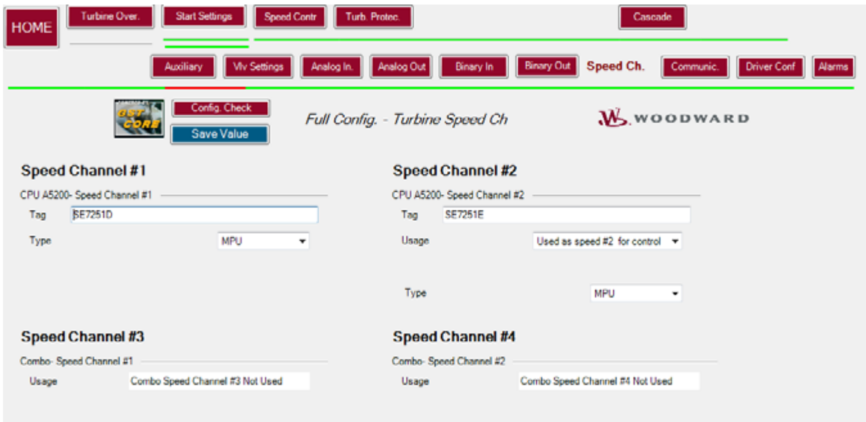


Figure 4-41. Speed Channel Screen

Following are setting required to be set for each channel:

- Minimum speed
  - This setting is the setpoint for detecting loss of speed. A limitation is that the value at which it is set cannot be lower than 1/50 of the range.
- Max Speed readable
  - This is automatically set based on the minimum speed setting based on the range limitations. Ensure the minimum speed is set sufficient for the maximum speed to cover the speed range of the application.
- Gear teeth
  - This setting should be the number of teeth on the gear the speed sensing device is mounted to. This value is used to determine the conversion from hertz to rpm.
- Gear ratio
  - Enter here the relationship of the speed of the gear on which the speed sensing device is mounted to the driven equipment shaft speed. This value is used to determine the hertz to rpm relationship. The hertz to rpm is calculated as:

$$\text{Gear teeth} \times \text{Gear ratio} \times 0.016667$$

-
  - For example, if the number of gear teeth is 30 and the gear ratio is 1.0 (1:1), the hertz to rpm relationship could be 0.5, i.e. 2.0 rpm for every hertz input.

4.20 Communication

See also volume 1 of the manual, 26542V1, for the available Modbus list.

Modbus is the software protocol for how data is packet, how commands are interpreted, and how errors are checked. The 505CC-2 can communicate through Modbus slave with external monitoring interfaces such as a DCS. Modbus slave defines a device that will only respond when requested to by a master, i.e. Modbus master. A Modbus slave will never generate a request for data. Two ports are available with the following usage configurations possible:

- Modbus over Serial Port
- Modbus over Ethernet TCP
- Modbus over Ethernet UDP
- Modbus backup over Ethernet TCP
- Modbus backup over Ethernet UDP

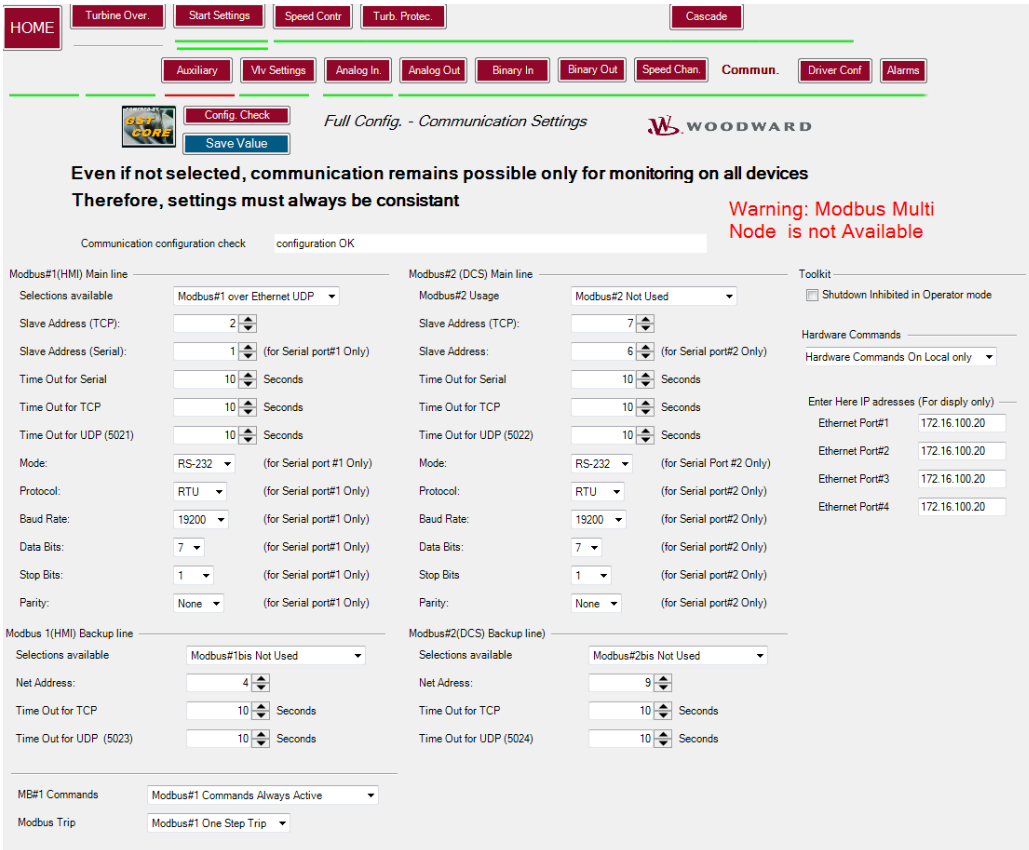


Figure 4-42. Communication Screen

IMPORTANT **Four IP address of Atlas-II shown on the page is only for display. To configure the IP address, follow procedure in manual 26542V1.**

Writes or in other words commands can also be issued to the 505CC-2 through Modbus. The functionality for this can be configured after selecting the usage:

- Commands always active
- Commands active when remote selected
- Commands always disabled
- Commands for trip only

The hardware command can be configured to be always active or only in local selected mode on the bottom of the communication page.

Enabling shutdown inhibited in operator mode disable the trip functionality from the Toolkit Tool run pages.

The command for trip can be further configured underneath Modbus Trip:

- Modbus trip not used
  - o Disables the Modbus trip command.
- Modbus one step trip
  - o A trip issued directly results in a trip condition.
- Modbus two step trip
  - o An acknowledgment need to be issued in addition to the trip command for the trip condition to activate.

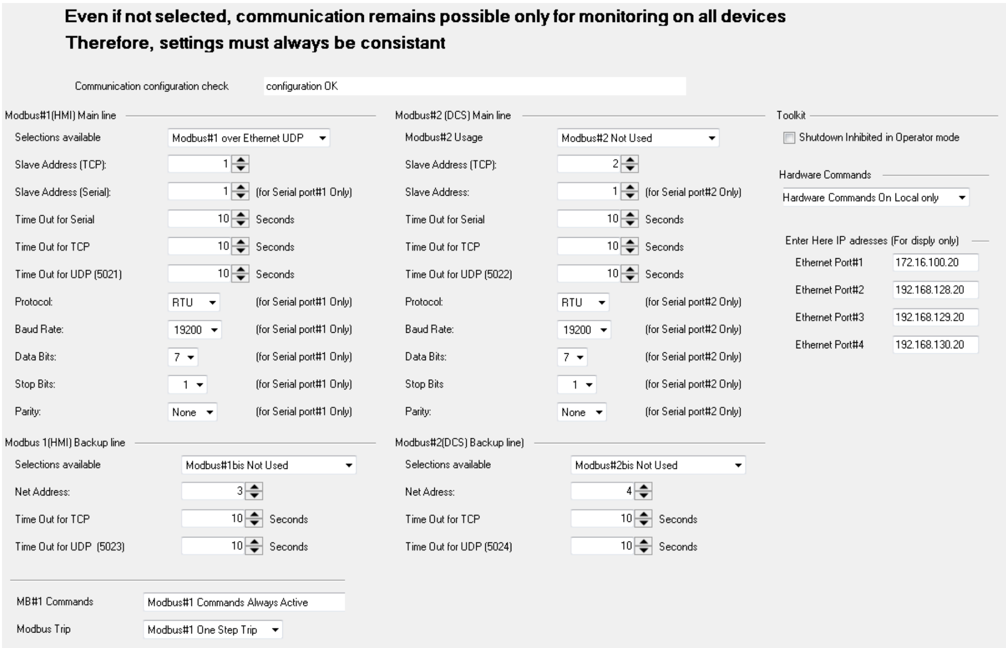


Figure 4-43. Modbus Serial and Ethernet Configuration

4.20.1.1 Modbus over serial port

The protocol is the set of rules governing the format, timing, sequencing and error control of exchanged messages. ASCII and RTU are two modes of data representations associated with Modbus.

- ASCII;
  - o hex coding / 7 bits per character (4 transmitted) / any parity / 1 or 2 stop bits
- RTU;
  - o 8 bit binary coding/ 8 bits per char (8 transmitted) / any parity / 1 or 2 stop bits

RTU sends data in 8-bit binary characters. ASCII firsts divides each RTU character into two 4-bit parts (high order and low order) and then represents them by their hexadecimal equivalent. The ASCII characters representing the hexadecimal characters are used to construct the message thus using twice as many characters as RTU mode. Additionally, RTU message characters are transmitted in a continuous stream, whereas ASCII can have breaks of up to one second between characters.

The driver is the definition for electrical connection between devices. The options in the 505CC-2 are the following:

- RS-232;
    - An ANSI (American National Standards Institute) standard definition of electrical, functional and mechanical connections for communications between DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) such as connection of a computer to a modem. It has gained wide usage in very short haul applications (15 meter / 50 feet).
- RS-422;
    - Also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers it can communicate over long distances (1200 meter / 4000 feet) at high baud rates. The standard RS-422 features a multidrop function is implemented as well. This allows more than one device to be connected to a common bus (up to 32 devices) with a single master requesting data. It requires two twisted pairs and ground to operate.
- RS-485;
    - Also an ANSI standard definition of electrical connections for communications between devices. This protocol is implemented identically to RS-422 at Woodward with the exception that only one twisted pair is required. Both transmitted and received data use the same pair of wires. It will generally only be used to communicate with external devices which are on a 485 network.

Slave address **Initial=1 (1, 246)**

The slave address input defines the network address on the Modbus network. The address may depend on the Modbus master allowable addresses. The address must be unique when using Modbus in a network, such as with TCP Modbus.

Baud rate determines the rate of bit transmission in a serial communication scheme in bits per second. The selections that the 505CC-2 supports are:

- 9600 bps
- 19200 bps
- 38400 bps
- 57600 bps

Data bits define then number of bits in the data packages. The number selected equals the number of data bits:

- 7 bits
- 8 bits

Stop bits define the number of stop bits for the communications protocol. Stop bits specify the time that elapses between transmitted characters:

- 1 stop bits
- 2 stop bits
- 1.5 stop bits

Parity input defines protocol for the parity. If you selected 8 data bits then select none else select the following:

- None
- Odd
- Even

Time out **Initial=10.0 (1.0, 100.0)**

Time out defines the Modbus link dead time allowed before a link communication alarm occurs.

4.20.1.2 Modbus over Ethernet TCP

Ethernet is a high speed (10 Mbit/sec) communication protocol. The 505CC-2 has the facility for TCP/IP and UDP packets via Ethernet. The software protocol is Modbus.

The protocol is the set of rules governing the format, timing, sequencing and error control of exchanged messages. ASCII and RTU are two modes of data representations associated with Modbus.

- ASCII;
  - hex coding / 7 bits per character (4 transmitted) / any parity / 1 or 2 stop bits
- RTU;
  - 8 bit binary coding/ 8 bits per char (8 transmitted) / any parity / 1 or 2 stop bits

RTU sends data in 8-bit binary characters. ASCII firsts divides each RTU character into two 4-bit parts (high order and low order) and then represents them by their hexadecimal equivalent. The ASCII characters representing the hexadecimal characters are used to construct the message thus using twice as many characters as RTU mode. Additionally, RTU message characters are transmitted in a continuous stream, whereas ASCII can have breaks of up to one second between characters.

The slave address input defines the network address on the Modbus network. The address may depend on the Modbus master allowable addresses. The address must be unique when using Modbus in a network, such as with TCP Modbus.

Time out **Initial=10.0 (1.0, 100.0)**

Time out defines the Modbus link dead time allowed before a link communication alarm occurs.

4.20.1.3 Modbus over Ethernet UDP

Ethernet is a high speed (10 Mbit/sec) communication protocol. The 505CC-2 has the facility for TCP/IP and UDP packets via Ethernet. The software protocol is Modbus.

The port number through which UDP is communicating are:
- Port 5021: Modbus#1 main line over UDP
- Port 5022: Modbus#2 main line over UDP
- Port 5023: Modbus#1 backup line over UDP
- Port 5024: Modbus#2 backup line over UDP

The protocol is the set of rules governing the format, timing, sequencing and error control of exchanged messages. ASCII and RTU are two modes of data representations associated with Modbus.

- ASCII;
  - hex coding / 7 bits per character (4 transmitted) / any parity / 1 or 2 stop bits
- RTU;
  - 8 bit binary coding/ 8 bits per char (8 transmitted) / any parity / 1 or 2 stop bits

RTU sends data in 8-bit binary characters. ASCII firsts divides each RTU character into two 4-bit parts (high order and low order) and then represents them by their hexadecimal equivalent. The ASCII characters representing the hexadecimal characters are used to construct the message thus using twice as many characters as RTU mode. Additionally, RTU message characters are transmitted in a continuous stream, whereas ASCII can have breaks of up to one second between characters.

The slave address input defines the network address on the Modbus network. The address may depend on the Modbus master allowable addresses. The address must be unique when using Modbus in a network, such as with TCP Modbus.

Time out **Initial=10.0 (1.0, 100.0)**

Time out defines the Modbus link dead time allowed before a link communication alarm occurs.

4.21 Driver Configuration

The Driver Configuration screen is used to define the specific settings for the HP and LP valve driver.

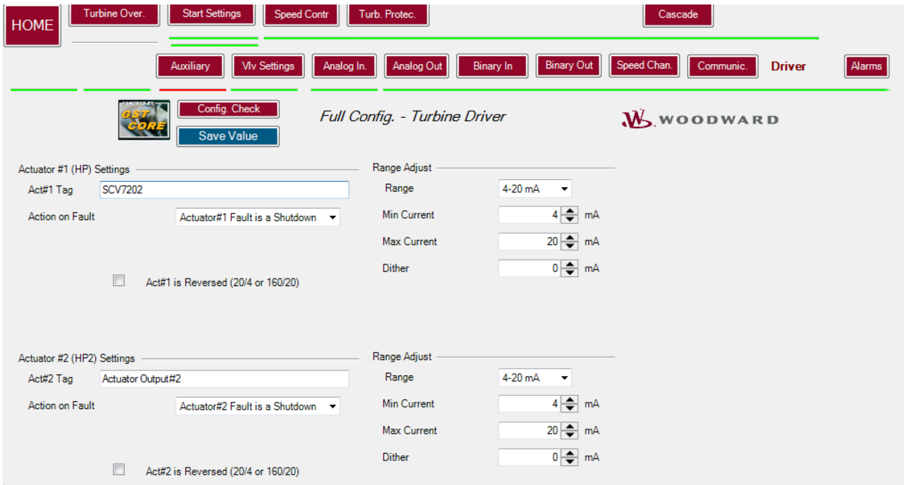


Figure 4-44. Driver Configuration Screen

4.21.1.1 Actuator Settings

The following settings are available for each valve.

Action on Fault

On fault detected it can be decided to shutdown or issue an alarm. Following are the selections:

- Actuator#1/2 Fault is a Shutdown
- Actuator#1/2 Fault is Alarm only

Act1/2 is Reversed

If checked, the current is reversed, meaning:

- 0% valve demand is 20 mA or 160 mA.
- 100% valve demand is 4 mA or 20 mA.
- In case of shutdown, the driver will send 20 mA.

4.21.1.2 Range Adjustments

Range

The actuator output can be selected to be:

- 4-20 mA output
- 20-160 mA output

Min Current **Initial=4.0 (0.0, 11)**

Initial=20.0 (0.0, 75)

Set the current demand for a 0 % valve demand. This is limited 0-11 mA for a 4-20 mA driver, and 0-75 mA for a 20-160 mA driver.

Max Current **Initial=20.0 (12.0, 22)**

Initial=160.0 (80.0, 200)

Set the current demand for 100 % valve demand. This is limited 12-22 mA for 4-20 mA driver, 80-200 mA for 20-160 mA driver.

Dither **Initial=0.0 (0.0, 2)**

Set the amplitude of the high frequency signal added to the normal demand. This can be used when the valve actuator is sticky.

4.22 Alarms

See also volume 1 of the manual, 26542V1, for the alarm and shutdown list.

4.22.1.1 External Alarm Settings

Specific settings can be set in this page when a binary input has been configured for External Alarm. The functionality that has been defined is:

- Alarm Only;
    - The binary input is used just generate an alarm.
- Start Inhibit Only;
    - The binary input is used to prevent the turbine to start and not for alarm.
- Alarm and Start Inhibit
    - The binary input is used to generate an alarm and to prevent the turbine from starting.

Invert

Each individual external alarm can be reversed. An open contact will give an alarm and/or start inhibit command when reversed.

Use non Latching Alarm

Alarms will be non-latching when selected. This option is not applicable for shutdown commands.

A customized tag can be entered, which will also be shown on the alarm message display.

4.22.1.2 External Shutdown Settings

It must be confirmed in this page by selecting Used when a binary input has been configured for External Shutdown.

Invert

Each individual external shutdown can be reversed. An open contact will give a shutdown command when reversed.

A customized tag can be entered, which will also be shown on the alarm message display.

4.22.1.3 Internal Level Switches

The 505CC-2 has the option to configure eight internal level switches to generate additional alarms, start inhibits and/or shutdowns. See also 4.18 Binary Outputs explaining that the internal level switches can be configured to energize relays.

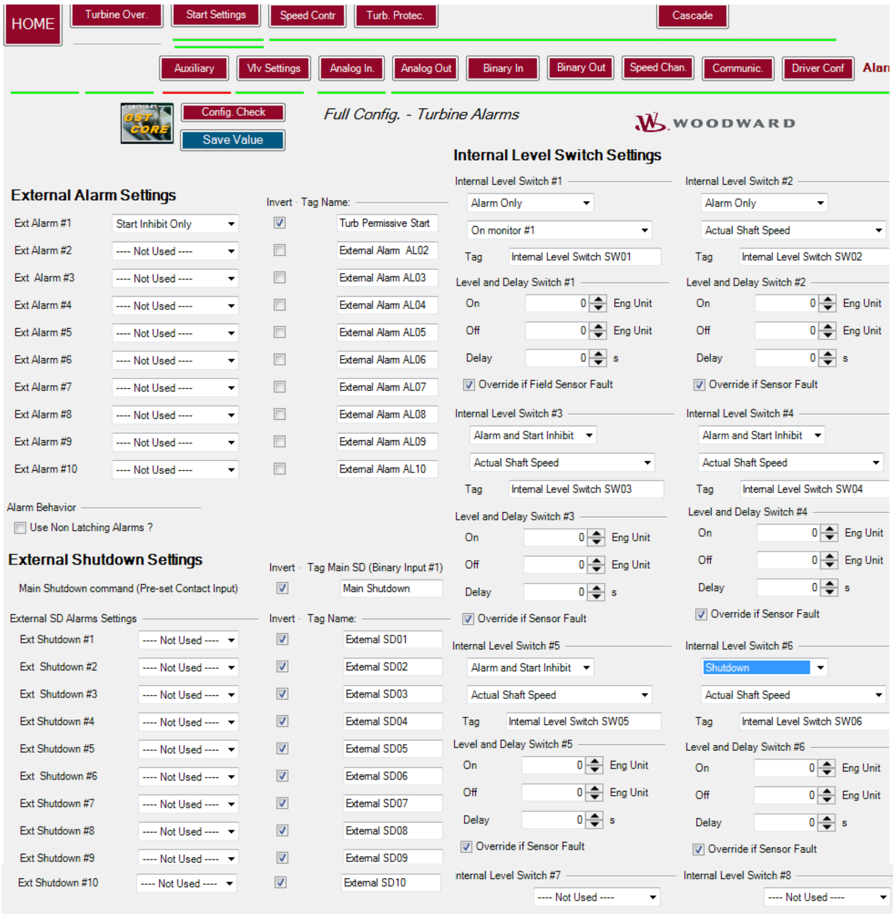


Figure 4-45. Alarms Screen

The internal level switch options for turbine control are:

- Actual Shaft Speed
- Speed Reference Setpoint
- Remote Speed Reference Setpoint
- Extraction/Admission Signal
- Extraction/Admission Setpoint
- Remote Extract/Admiss Setpoint
- Inlet/Exhaust Signal
- Inlet/Exhaust Setpoint
- Remote Inlet/Exhaust Setpoint
- Cascade Signal
- Cascade Setpoint
- Remote Cascade Setpoint
- Auxiliary Signal
- Auxiliary Setpoint
- Remote Auxiliary Setpoint
- S Demand (Speed)
- P Demand (Extraction)
- ACT 1 (HP) Valve Limiter Setpoint
- ACT 2 (LP) Valve Limiter Setpoint
- ACT 1 (HP) Valve Demand

- ACT 2 (LP) Valve Demand
- ACT1 Demand after linearization
- ACT2 Demand after linearization
- On monitor #1
- On monitor #2
- On monitor #3
- On monitor #4
- On monitor #5
- On monitor #6
- On monitor #7
- On monitor #8
- On stage 1 P1
  - Compressor 1 Suction pressure
- On stage 1 T1
  - Compressor 1 Suction temperature
- On stage 1 P2
  - Compressor 1 Discharge pressure
- On stage 1 T2
  - Compressor 1 Discharge temperature
- On stage 1 Actual Flow
  - Compressor 1 Actual Flow
- On stage 1 WSPV
  - Compressor 1 WSPV
- On stage 2 P1
  - Compressor 2 Suction pressure
- On stage 2 T1
  - Compressor 2 Suction temperature
- On stage 2 P2
  - Compressor 2 Discharge pressure
- On stage 2 T2
  - Compressor 2 Discharge temperature
- On stage 2 Actual Flow
  - Compressor 2 Actual Flow
- On stage 2 WSPV
  - Compressor 2 WSPV

The on monitor level switches are customer-defined. A typical usage would be for example the oil pressure, send via a customer defined analog input. In that case a Low Pressure could initial an alarm, start inhibit or shutdown command. Oil temperature, exhaust pressure and exhaust temperature are other typical signals which can be connected to the 505CC-2.

The on-stage level switches are based on compressor control process values; see Volume 3 of this manual for more information.

A customized tag can be entered, which will also be shown on the alarm message display. Configuration of the on, off level, and delay time completes the internal level switch settings. The possibility to override the internal level witch on sensor fault can be enabled, i.e. analog input exceeding defined values for fault, such as 2 and 22 mA.

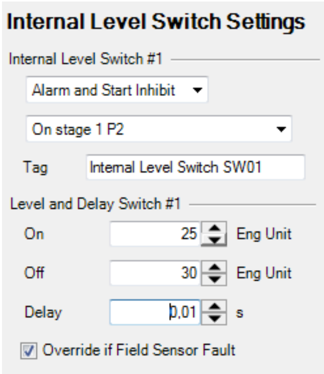


Figure 4-46. Internal Level Switch

On Level **Initial=0.0 (-100000.0, 100000)**

Level based on the parameter selected set to activate the switch.

Off Level **Initial=0.0 (-100000.0, 100000)**

Level based on the parameter selected set to de-activate the switch.

Delay **Initial=0.0 (0.0, 1000)**

Delay in seconds that the level needs to maintain at the on level to activate the switch.

Override if sensor Fault

It might be desired not to generate an alarm or shutdown in case of sensor failure. In that case this option must be selected.

IMPORTANT

The internal level switch will behave as a high select switch, energized at ON and de-energized at OFF, when the ON level > the OFF level.

The internal level switch will behave as a low select switch, energized at ON and de-energized at OFF, when the ON level < the OFF level.

Therefore it might not be needed to use the Invert functionality.

IMPORTANT

The configuration check will not verify for settings to be based on existing signals.

Selecting a non-existing signal won't be detected by the 505CC-2.

4.23 Configuration Check

Selecting the button configuration check will show errors detected. Another button enables to go to the configuration screen related to the displayed error.

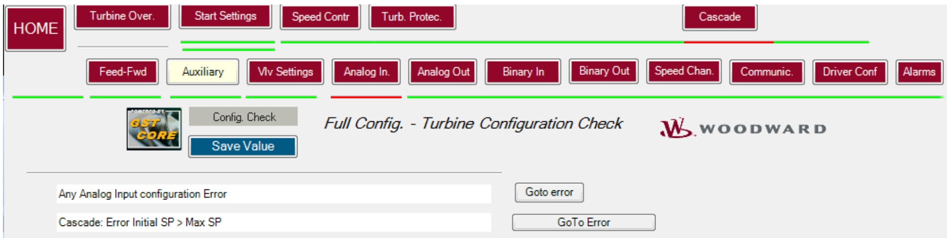


Figure 4-47. Configuration Check

The configuration check error that the unit never has been configured can be cleared by checking the configured once selection. This check mark will disappear after this acknowledgement.

The user will not be allowed to exit the full configuration mode until all configuration errors are corrected.

It is recommended to fill in the configuration worksheet attached to this manual to record an overview of the configuration applied (see Appendix A, Configuration Worksheet).

4.24 Save / Exit Configuration Mode

Once all the program settings have been configured, they can be saved to the control.

The values are saved in the control by clicking on the Save Value button.

To leave configuration mode return to the home page by using the displayed button.

You will not be able to exit configuration mode if any configuration errors have been detected. You can click on the Quit Configuration mode button when no errors are present. Then the CCT program performs a final configuration error check before any values are saved. A pop-up box appears and displays a message to wait while the control re-initializes and releases the I/O lock.

Chapter 5.
Service Mode

5.1 Introduction

Operational requirements of steam turbines are as varied as the processes in which they operate. This chapter is intended to provide an overview of steam turbine operation with respect to the 505CC-2's functionality only. For more complete, process-specific steam turbine or plant operating instructions, contact the plant-equipment manufacturer.

The service mode screens give the user access to pages specially designed for tuning and signal forcing once the unit has been initially configured.

Some parameters set in configuration may be available in these pages for fine adjustment. To use this mode, the 505CC-2 control hardware should not be in I/O LOCK, meaning that in service mode the output signals from the control are active.

The service mode is for qualified personnel to adjust and tune control parameters that may need to be tuned with the control & turbine in operation, such as dynamic tuning of PID controllers. The service mode can be used to change control settings, test control hardware, and calibrate control inputs/outputs while the unit is on-line, i.e. operating at any load. The parameters that are tuned in the service mode may affect system performance. Caution is advised when tuning any parameter with the turbine running. The service mode can be used to operate the turbine in combination with run mode functions when tuning is needed, but should not be used for normal operation.

IMPORTANT **Not all page parameters are referred to or explained in this chapter. This chapter provides descriptions for parameters which only exist in the Service Mode. Refer to the configuration mode chapter for all other page parameter descriptions.**

5.2 Home Page

The home page for run and service mode is displayed up after starting the ToolKit Tool Application, 54183682RS.wtool.

This chapter explains the service mode screen so select the Turbine Service button to proceed to the general configuration screen.

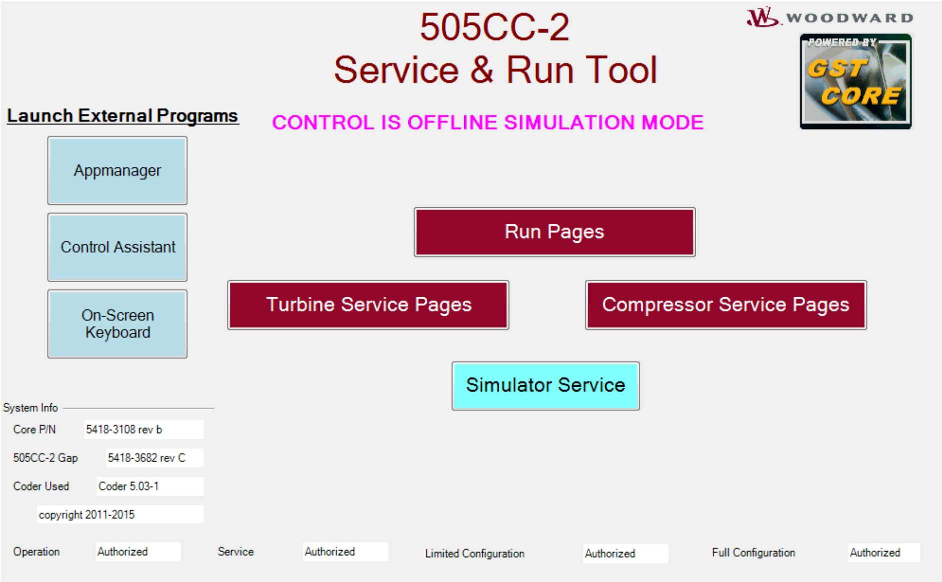


Figure 5-1. 54183682RS.wtool Home Page

5.3 General Overview

This page shows the summary of the main functional configuration of the control that was setup in the configuration mode, reference 4.3 General Overview.

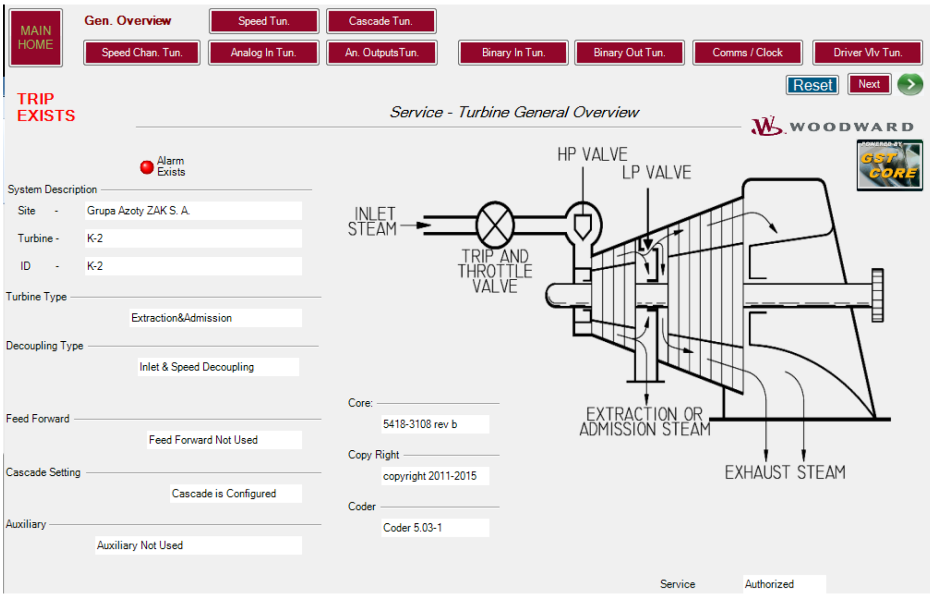


Figure 5-2. General Overview Screen

5.4 Dynamics Adjustments

The Speed, Cascade, Extraction/Admission, and Auxiliary controls are PID controllers. The response of each control loop can be adjusted by configuring its proportional gain, integral gain (stability), and SDR (speed derivative ratio) at the turbine tuning screen. These 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 505CC-2 as follows:

- P = Proportional Gain (% output per unit error)
- I = Integral Gain (repeats per second)
- D = Derivative Ratio

Refer to the sections below for general tuning theory and procedures. See the other paragraphs for specific features of the 505CC-2's turbine control tuning screens.

5.4.1 Tuning P & I Gains

Proportional gain must be tuned to best respond to a system transient or step change. 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 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 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, and then come into control.

A PID control loop's gain is a combination of all the gains in the loop. The loop's total gain includes actuator gain, valve gain, valve linkage gain, transducer gain, and the 505CC-2's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 505CC-2's adjustable gains must be very low to result in a system gain that affords stability.

In cases where a small change in the 505CC-2's output results in a large load changes (high mechanical gain) it may not be possible to take the 505CC-2'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 such that 0-100% 505CC-2 output corresponds to 0-100% valve travel.

5.4.2 Tuning Derivative

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

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

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

The change from one of these configurations to the other may have no effect during normal operation. However, it can cause great differences in response when coming into control, e.g. at startup, during a 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, and can therefore prevent overshoot of the setpoint better than a feedback dominant controller. Although this response is desirable during a startup or load rejections, it can cause excessive control motions in some systems where a smooth transition response is desired and where noise is present.

A controller configured as feedback dominant is more sensitive to the change-of-rate of its feedback (the HSS bus). A feedback dominant controller has the ability to limit the rate of change of the HSS bus when a controller is near its set-point but is not yet in control. This limiting of the HSS bus allows a feedback dominant controller to make smoother control transitions than an input dominant controller. However, the feedback dominant controller is slightly slower to respond to the initial input disturbance. Because it is more forgiving (easier to tune) and less sensitive to signal noise, most PIDs will be configured as feedback dominant (1<DR<100).

5.4.3 Tuning Example

If the system is unstable, first verify whether or not the control is the cause. Place the control in Manual if available, or use the respective Valve Limiter to gain control of the valve. If the system continues to oscillate when the 505CC-2 output is clamped, the system instability is caused by an external device/function. If the controller is causing the oscillation, time the oscillation cycle. Generally, if the system's oscillation cycle time is less than 1 second, reduce the proportional gain term. Conversely, if the system's oscillation cycle time is greater than 1 second, reduce the integral gain term (proportional gain may need to be increased as well).

On an initial startup with the 505CC-2, 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 505CC-2's PIDs to assist in determining the gain terms that provide optimum control loop response times (Ziegler Nichols, etc.). The following method is a simplified version of other tuning methods, and can be used to achieve PID gain values that are close to optimum:

1. Place the control in Automatic.
2. Increase the Derivative Ratio (DR) to 100.00 (This is the default setting).
3. Reduce integral gain to minimum.
4. Increase the proportional gain until the system just starts to oscillate.
5. Record the system gain (G) as the current proportional gain value and time the oscillation period (T) in seconds.
6. Set the dynamics as follows:

- For PID control set the proportional gain=0.60*G; integral gain=20/T; SDR=5
- For PI control set the proportional gain=0.45*G; integral gain=12/T; SDR=100

This method of tuning will result in acceptable gain settings. They can be fine-tuned from this point. Figure 5-3 shows the typical response to a load change when the dynamics are optimally adjusted.

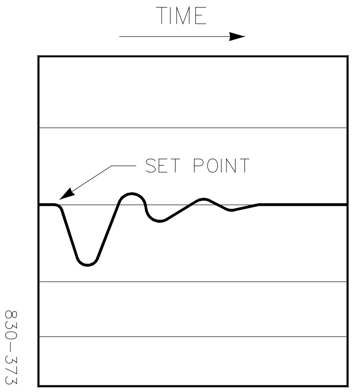


Figure 5-3. Typical Response to Load Change

5.5 Speed Tuning

This page is used to tune the dynamics of the speed control loop.

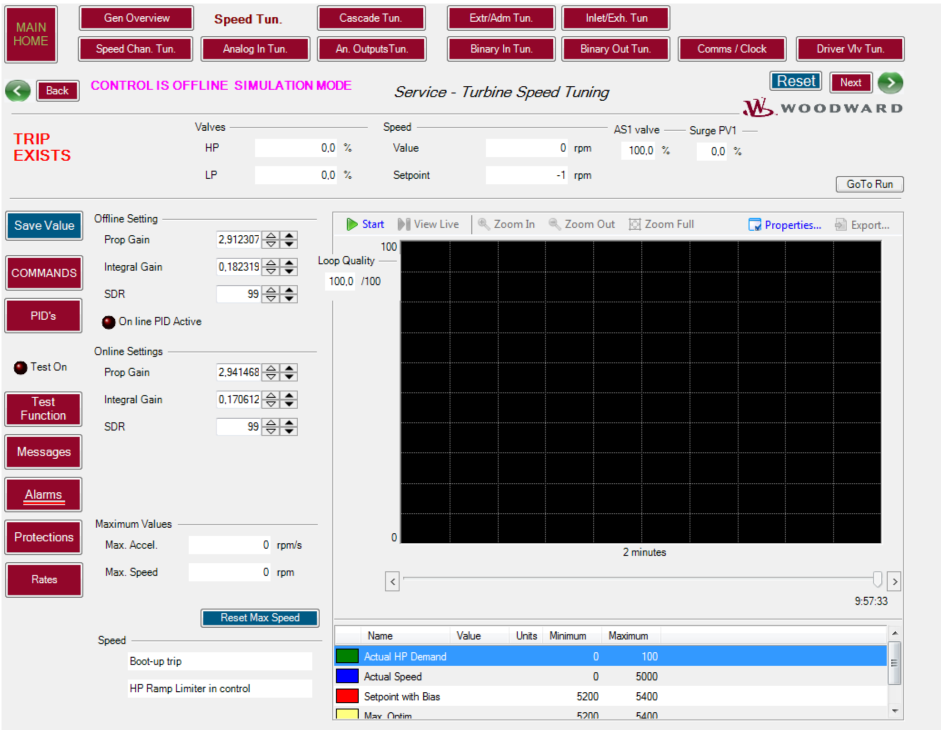


Figure 5-4. Speed Tuning Screen

The speed tuning screen allows the user to change the 505CC-2 control speed settings. The speed input is displayed in the speed display box at all times. The 505CC-2 control will attempt to control the turbine such that the speed input matches the speed setpoint.

The speed control function is active at all times. Another control function, such as decoupling Limiter can take control of the valves; however, the speed control function is still active and will control the speed.

During commissioning/tuning it is desired to constantly monitor the speed behavior and access immediately any parameter/command without losing track. Therefore, the service screens have been designed to provide ergonomically navigation for this purpose.

Interactive Trend Graph

The trend graph provides a view of the speed control parameters with zoom features, stop/start graph and freeze view capability. Using the properties icon the user can adjust the range of any parameter to allow the graph to be more useful for specific tuning, for example around a smaller speed window range. The export icon will export the data from the trend to an html document.

IMPORTANT **Export trend graph data will export all data in the buffer from the initial start command of the trend script, so the file may be come large and may take a while to create if the trend has been open and running for a long time.**

5.5.1 Commands

The button commands enables access to a panel with basic functionality for turbine control. The selections available will depend on the start-up sequence configuration, reference 4.4.2 Start Up Sequence Selection.

- Start turbine
- Continue;
  - This button is shown in case of the multi-curve start-up sequence selection.
- Continue sequence;
  - This button is shown in case of the auto-start start-up sequence selection.
- Idle;
  - This button is shown in case of the idle/rated start-up sequence selection.
- Rated;
  - This button is shown in case of the idle/rated start-up sequence selection.
- Lower speed
- Raise speed
- Speed target window
- Open HP ramp
- Close HP ramp

The speed reference can be changed by using the raise and lower speed button or using the speed target window to enter a speed setpoint. To use speed target windows press the related button, enter the speed setpoint target, and press send speed. The speed status window will indicate that the speed target is active.

5.5.2 PID Settings

The button PID’s enables the speed control PID settings to be monitored and changed. The speed control P, I, and D terms can be adjusted with the arrow buttons to the right of each term.

Two sets of PID terms are used:

- Offline settings
  - During start-up without handling a load.
- Online settings
  - During a defined point that the turbine is handling a load.

Both sets of PID terms can be adjusted independent whether or not the control is on line. This allows two separate sets of dynamics for the two basic modes of speed control, i.e. dual-dynamics. Care needs to be taken that the terms changed are the correct terms for the case needed. Adjusting the PID terms for the on-Line selection while the turbine is running off-Line will not affect the turbine operation until the turbine is placed on-Line.

The PID terms can be adjusted before the online speed control is in effect. This allows the user, during initial start-up, to adjust dynamic settings before they take effect to ensure stable operation. The control can then be fined tuned, once the turbine is up to speed/on-line. The same can be for the off-line adjustments, i.e. tune them while on-line to take effect when going off-line.

A LED will indicate that on-line dynamics are active, when the LED is off then the off-Line dynamics are in use.

Proportional Gain **Initial=4.0 (0.001, 50)**

Enter the PID proportional gain percentage. This value is used to set the speed control response. This value can be changed while the turbine is operating.

Integral Gain **Initial=1.0 (0.0001, 50)**

Enter the PID integral gain in repeats-per-second (rps). This value is used to set speed control response. This value can be changed while the turbine is operating.

SDR - Derivative Ratio **Initial=100 (0.01, 100)**

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

Max Values

Maximum speed and acceleration are also available in this panel. A dedicated reset is available to re-initialize the maximum values.

5.5.3 Test Function

A special feature called loop response rest is available for all PID used in the 505CC-2. The loop response test allows the following types of testing:

- Step response test
- Ramp response test
- One shot response test
- Oscillation test

The following figures show the behavior during of the loop response test available:

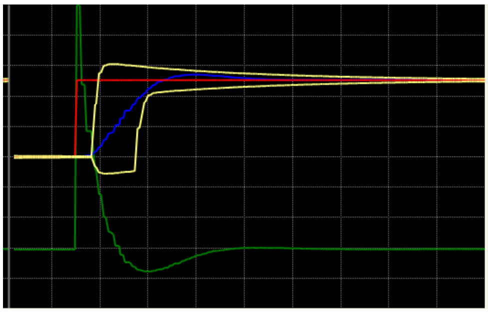


Figure 5-5. Step Response Test

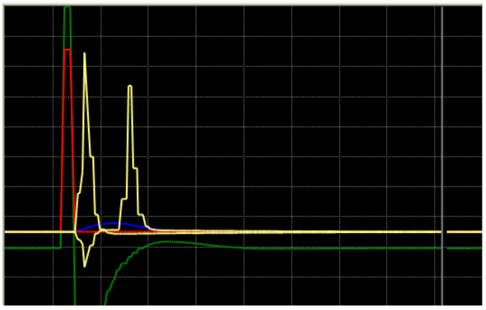


Figure 5-6. One Shot Test

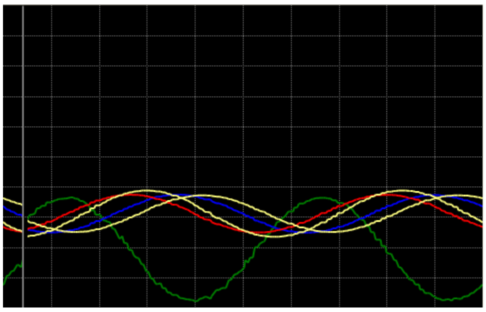


Figure 5-7. Oscillation Test

Freq **Initial=0.004882 Hz**

This setting is used only when the oscillation test is selected and concerns the oscillation frequency of the signal added to the reference. The frequency must be selected with care according the expected response time desired for the control.

Level **Initial=10.0 (1.0, 300.0)**

This is the amplitude of the signal added to the setpoint used for all types of loop response testing. Setting this to 1 – 3 % of rated speed should be considered a sufficient setting. Higher levels are not recommended, but can be considered in case of a one shot test if the pulse delay is short.

Ramp **Initial=10.0 (0.1, 500.0)**

This is used for the triangle oscillation test only.

Pls dly **Initial=1.0 (0.01, 20.0)**

This is used for the one shot test only.

Press the test request button to accept using the loop response test function. Subsequent press the toggle to start the selected test.

5.5.4 Overspeed Test

It is possible to perform an overspeed test when the speed reference is equal to the maximum governor speed and service security mode has been authorized.

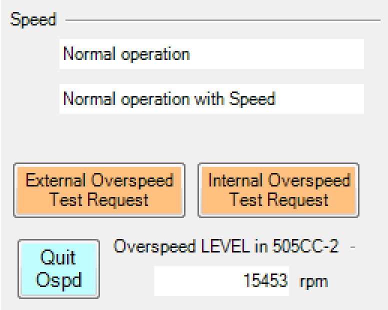


Figure 5-8. Select Overspeed Test Request

The following tests are possible:

- External overspeed test
- Internal overspeed test

Performing the external overspeed test will override the internal 505CC-2 overspeed level. An external device, such as the Woodward Pro Tech 203, is supposed to trip the turbine before the speed setpoint reaches the maximum overspeed test limit.

Performing the internal test will keep the internal level active. The unit will trip at this level, unless the external overspeed device level is set lower.

A message will be indicated that the test is active after the test has been selected.

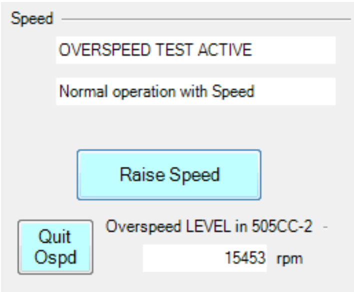


Figure 5-9. Overspeed Test Active

Subsequent the speed can be raised beyond maximum governor speed until the unit trips at the internal or external overspeed level.

The overspeed test can be aborted at any time pressing the Quit Ospd button. In addition the test will be aborted when no raise command has been given for more than setting the in configuration mode, protection screen, Delay to Quit if no R/L, reference 4.6 Protection.

5.5.5 Messages

The button messages enable visualization of the status of other controllers configured in 505CC-2:

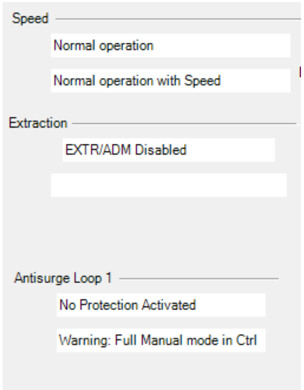


Figure 5-10. Messages

5.5.6 Alarms

The button alarm enables a panel to show the active alarms. The alarms to be displayed are limited to ten. The bar on the button will display red when an alarm is active, or green when in-active.

5.5.7 Protections

Selecting the button protections makes it possible to enable, disable, and tune safety functions, such as acceleration protection and break away protection. See the configuration mode for more details.

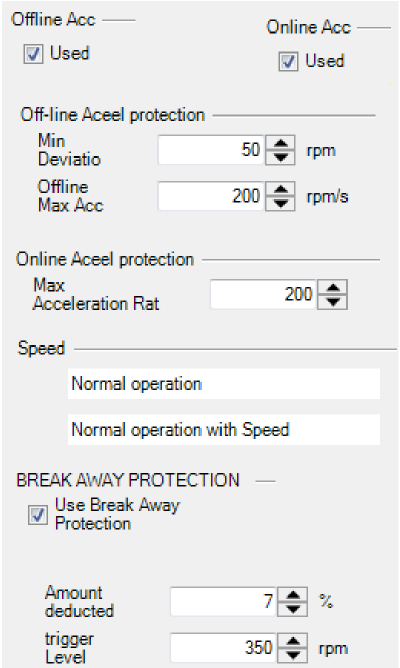


Figure 5-11. Protections

5.5.8 Rates

Selecting the rates button enables adjustments to the rate that the setpoint moves in conjunction with the raise and lower buttons. In addition the loading rate can be adjusted.

Loading Rate **Initial=100.0 (0.01, 100)**

Slow to Normal Dly **Initial=3.0 (0.0, 25)**

Multiplier **Initial=0.3 (0.3, 1)**

This is the delay in seconds and the multiplier that is used in conjunction with the loading rate to determine the rate at which the setpoint moves with the raise and lower momentary buttons.

For example, a loading gradient of 20 rpm/sec will move the reference at 6.66 rpm/sec for 3 seconds and then move at 20 rpm/sec for the rest of the time the momentary button is pushed. Any duration less than the delay will always move the setpoint at the slower rate.

Entered Speed Rate **Initial=10.0 (0.0, 300)**

Rate used from speed target send when remote speed is used, used as not matching rate.

5.6 Cascade Tuning

This page is used to tune the dynamics of the cascade control loop.

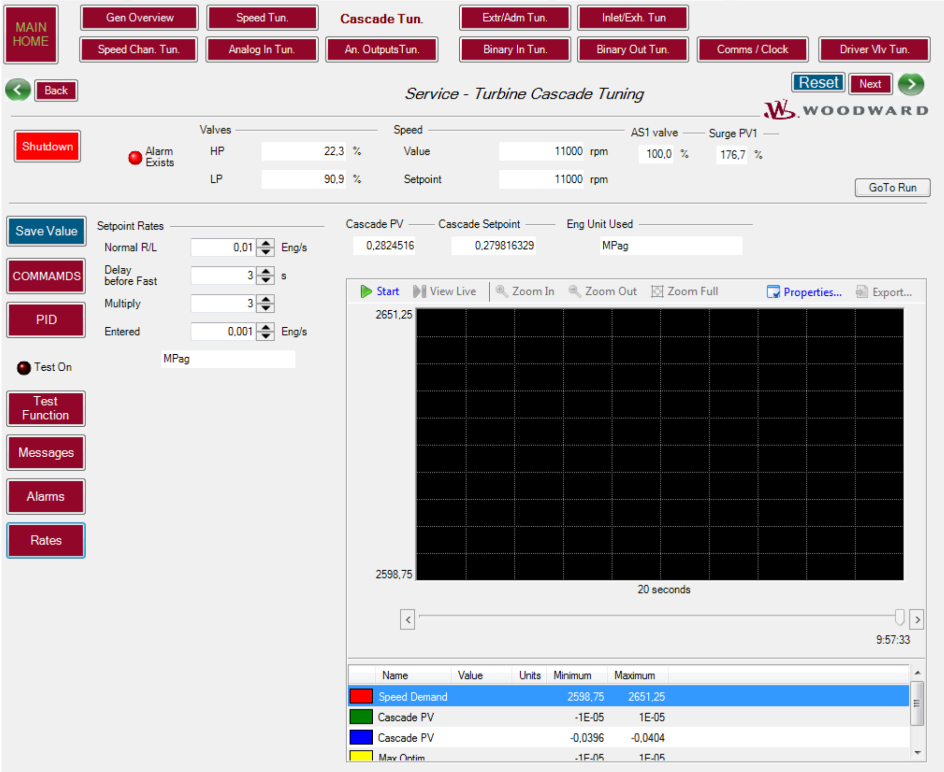


Figure 5-12. Cascade Tuning Screen

If no cascade control is used then this page will not be available. The cascade control PID settings can be monitored and changed on this page. The cascade Control P, I, and D terms can be adjusted with the arrow buttons to the right of each term.

The layout of this page is similar to the speed tuning page so reference 5.5 Speed Tuning for more information. Further specifics are described in the following paragraphs.

Cascade Setpoint

This displays the cascade process setpoint in engineering units.

Cascade Process Value

The actual process value of the cascade parameter in engineering units is displayed.

Interactive Trend Graph

The trend graph provides a view of the cascade control parameters with zoom features, stop/start graph and freeze view capability. Using the properties icon the user can adjust the range of any parameter to allow the graph to be more useful for specific tuning, for example around a smaller speed window range. The export icon will export the data from the trend to an html document.

IMPORTANT	**Export trend graph data will export all data in the buffer from the initial start command of the trend script, so the file may be come large and may take a while to create if the trend has been open and running for a long time.**

5.6.1 Commands

Enable Cascade

A button to enable or disable cascade functionality.

Raise/Lower Cascade SP

Buttons selections to raise and lower the cascade setpoint at the normal setpoint rate.

5.6.2 PID

Prop Gain **Initial=1.0 (0.01, 20)**

Enter the PID proportional gain percentage. This value is used to set the cascade control response. This value can be changed while the turbine is operating. A recommended starting value is 1.

Intl Gain **Initial=1.0 (0.001, 20)**

Enter the PID integral gain in repeats-per-second (rps). This value is used to set cascade control response. This value can be changed while the turbine is operating. A recommended starting value is 1.0 rps.

SDR **Initial=100.0 (0.01, 100)**

Enter the PID derivative ratio. This value is used to set cascade control response. A recommended starting value is 100 %, i.e. disabled.

Sliding DB **Initial=0.0 (0.0, 10)**

If desired, enter a deadband range. The control will stop actively adjusting the output demand when the process value is within +/- of this value from the setpoint. A recommended starting value is 0 %, i.e. disabled.

Droop **Initial=4.0 (0.0, 10)**

Enter the droop percentage. This is typically not required, but it will allow an offset between setpoint and process.

Droop may be suitable when another controller tries at the same time to control the cascade process value.

5.6.3 Rates

Normal R/L **Initial=0.03 (0.001, 500)**

The user can set the normal rate at which the raise/lower buttons will move after the slow rate delay time has expired.

Delay before Fast **Initial=3.0 (0.0, 20)**

The momentary raise/lower commands to adjust the setpoint will move at the slow rate, normal rate x multiply factor, for any command less than this time period in seconds. The rate will switch to the normal rate when the command is held true for longer than this time.

Multiply **Initial=3.0 (1.0, 10)**

The slow rate will equal the normal rate times this factor in rpm/sec.

Entered **Initial=1.0 (0.0, 1000)**

This is the rate used when cascade target is send and when remote cascade setpoint is used, used as not matching rate.

5.7 Extraction/Admission Tuning

This page allows for setup and control loop tuning of the extraction control (P) loop in an extraction and or admission turbine.

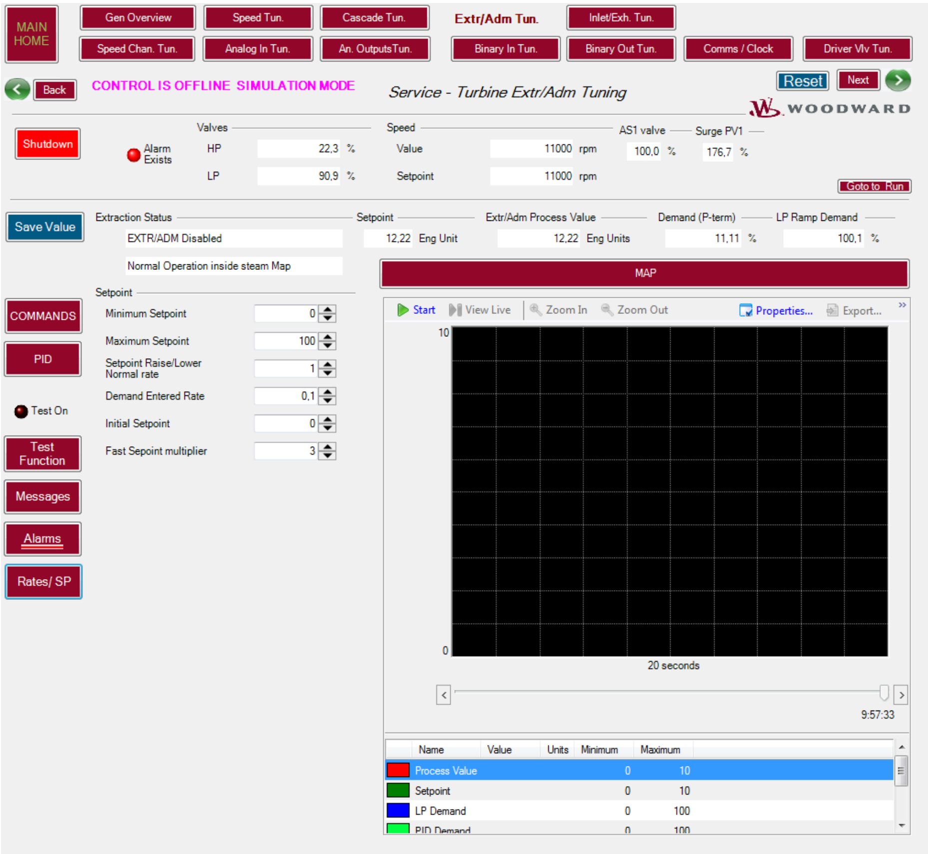


Figure 5-13. Extraction/Admission Tuning Screen

The extraction status display at the top of the page will inform the user when the Extraction/Admission PID is in control. The Extraction/Admission Control P, I, and D terms can be adjusted with the arrow buttons to the right of each term.

The layout of this page is similar to the speed tuning page so reference 5.5 Speed Tuning for more information. Further specifics are described in the following paragraphs.

The Extraction/Admission PID uses the settings displayed to determine PID response. Any change to these settings will immediately affect PID response when the Extraction/Admission PID is in control. These values are stored in the control EEPROM memory. The button save settings can be selected to immediately upload the new values to the control EEPROM memory. This insures that when power to the control is lost the PID values will be saved. If the save settings button is not selected, the control will automatically save these values within 15 minutes.

Setpoint

Extraction/admission pressure setpoint in engineering units.

Extr/Adm Process Value

Extraction/admission pressure in engineering units.

Demand (P-term)

PID output demand in %.

LP Ramp Demand

Displaying the LP ramp demand.

Interactive Trend Graph

The trend graph provides a view of the cascade control parameters with zoom features, stop/start graph and freeze view capability. Using the properties icon the user can adjust the range of any parameter to allow the graph to be more useful for specific tuning, for example around a smaller speed window range.

The export icon will export the data from the trend to an html document.

IMPORTANT **Export trend graph data will export all data in the buffer from the initial start command of the trend script, so the file may be come large and may take a while to create if the trend has been open and running for a long time.**

5.7.1 Command

It may be helpful while tuning the extraction loop to limit the actual LP valve demand output using command buttons.

Enable Control with LP

Select this button to enable control with LP.

Automatic / Manual

These buttons can be used to switch the control between manual mode, i.e. user uses the raise/lower LP valve demand buttons to position the LP valve to the desired position and automatic mode, i.e. control extraction PID along with the ratio limiter control determines the LP valve output position.

Raise/Lower Demand

This enables to raise/lower the actual LP valve demand output once the unit is placed in manual mode else these button might be hidden. The extraction pressure will be affected when the valve output demand is changed. These buttons have no effect or might be hidden when the control is in auto mode.

Open/Close LP Ramp

Open or close the LP ramp with these buttons.

Lower/Raise Speed

These buttons are used to raise/lower the speed reference setpoint.

Open/Close HP Ramp

Open or close the HP ramp with these buttons.

5.7.2 PID

Proportional Gain **Initial=1.0 (0.0, 50)**

Enter the extraction/admission PID proportional gain value. This value is used to set extraction/admission control response. This value can be changed while the turbine is operating. If unknown, a recommended starting value is 1%.

Integral Gain **Initial=1.0 (0.001, 25)**

Enter the extraction/admission PID integral gain value, in repeats-per-second (rps). This value is used to set extraction/admission control response. This value can be changed while the turbine is operating. If unknown, a recommended starting value is 0.3 rps.

Derivative Ratio **Initial=0.0 (0.0, 100)**

Enter the extraction/admission PID derivative ratio. This value is used to set extraction/admission control response. This value can be changed in the while the turbine is operating. If unknown, a recommended starting value is 99.99%.

Droop of Extraction **Initial=0.0 (0.0, 10)**

Enter the droop percentage. Typically this not required, it will allow an offset between setpoint and process.

Sliding Dead-band **Initial=0.0 (0.0, 10)**

If required, enter the deadband percentage. Typically, set between 1-5% and not more than 10%.

5.7.3 Rates

Minimum Setpoint **Initial=0.0 (-200000, 200000)**

Enter the minimum extraction/admission setpoint that should be allowed by the system.

Maximum Setpoint **Initial=100.0 (-200000.0, 200000)**

Enter the maximum extraction/admission setpoint that should be allowed by the system.

Setpoint Raise/Lower Normal Rate **Initial=1.0 (0.0, 1000)**

The user can set the normal rate at which the raise/lower buttons will move up until the delay time has been reached.

Delay before Fast Rate **Initial=3.0 (0.1, 25)**

The momentary raise/lower commands to adjust the setpoint will move at the normal rate for any command less than this time period (seconds). When the command is held true for longer than this time the rate will switch to the fast rate.

Initial Setpoint Value **Initial=0.0 (-20000-, 200000)**

Enter the setpoint initialization value for the extraction/admission setpoint. This is the value that the setpoint initializes to upon power-up or exiting the program mode. This must be less than or equal to the Max Admission Setpt Setting put in configuration mode.

Fast Setpoint Multiplier **Initial=3.0 (0.0, 100)**

The fast rate will equal the normal rate times this factor.

5.7.4 Decoupling Tuning

The decoupling screen is only visible when a decoupling control is configured into the 505CC-2 control.

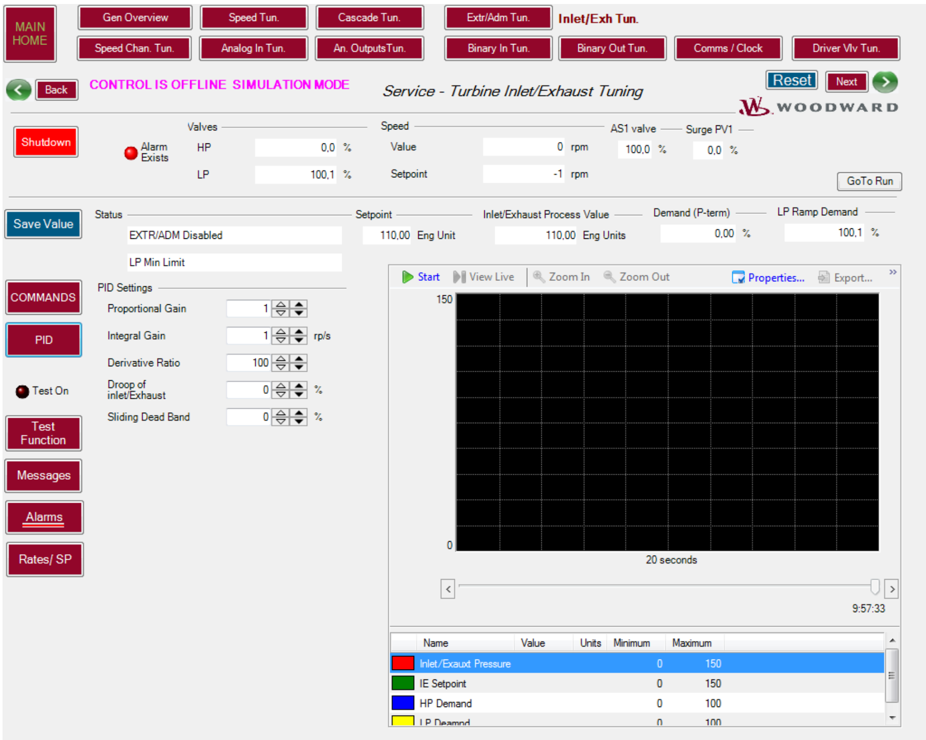


Figure 5-14. Decoupling Tuning

The decoupling controller will take control of HP or LP valves any time it is enabled and in control. To enable, the extraction/admission control must first be enabled and in control of the LP.

When configured for Inlet & Speed, the decoupling PID will control directly the HP valve and, in conjunction with the speed PID, the LP valve.

When configured for Exhaust & Speed, the decoupling PID will control directly the LP valve, and in conjunction with the speed, the HP valve.

The decoupling input is constantly displayed in the decoupling input display box. Once decoupling control is enabled, the 505CC-2 will be attempting to match the input to the set point.

The decoupling control function can be enabled and disabled by manually selecting the enable/disable buttons in the Commands box. The status on top will display what mode the decoupling control function is in at all times. As linked to the extraction status, extraction status is also indicated

The decoupling setpoint can be manually changed by pressing the arrow keys next to the setpoint value. The status of the decoupling controller does not affect whether the setpoint can be adjusted or not. The rate at which the setpoint can change is set in the Rates/SP panel.

When the decoupling controller is disabled, the setpoint will remain at the last valid setpoint and will control at that setpoint when the Decoupling controller is again enabled. If the Setpoint Tracking feature is active the setpoint will track the input whenever the decoupling controller is disabled.

Like the extraction PID, the decoupling PID can be put in manual mode. This will allow an easy transfer from letdown station control to decoupling control. In case of strong process instabilities, manual mode may also be needed.

The decoupling setpoint can also be varied by a 4–20 mA remote decoupling setpoint signal. The 4–20 mA remote decoupling setpoint information is only visible if the function is configured in configuration mode. The enable/disable will appear in the Commands panel when configured.

Remote Setpoint Status display gauge are used to enable and disable the remote setpoint function. If configured, the status of the 4–20 mA Remote Decoupling function is continually displayed in the Remote Status display gauge.

5.7.4.1 Decoupling Control Dynamics

The decoupling control PID settings can be monitored and changed by selecting the dynamics button in the PID panel. When the run mode security is locked, the PID settings can only be monitored. If the run mode security is unlocked, the PID settings can be monitored and changed. Reference the Security Button section of this chapter for instructions on locking and unlocking the Run Mode's Security logic.

Selecting the "Dynamics button on the Decoupling Control folder will allow access to the Dynamics display box. This Decoupling Control Dynamics display box displays the Decoupling PID dynamic settings. The Controlling Parameter display at the bottom of the folder will inform the user when the Decoupling PID is in control. The Decoupling Control's P, I, and D terms can be adjusted with the arrow buttons to the right of each term.

5.8 Auxiliary Tuning

This page is available if auxiliary control has been configured, to tune the dynamic response of the auxiliary controller.

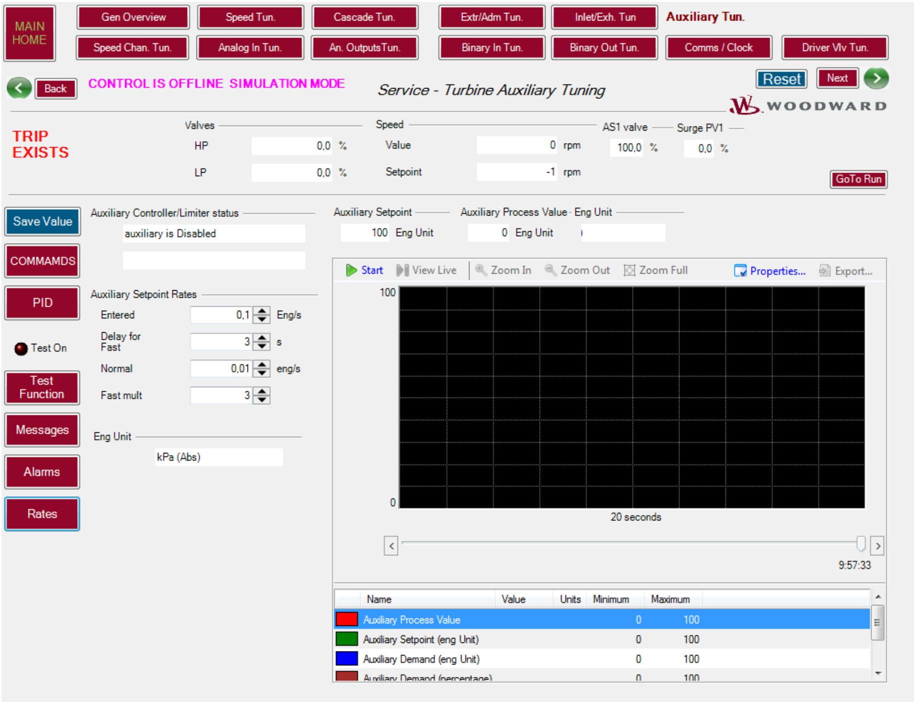


Figure 5-15. Auxiliary Tuning

The auxiliary controller can only be used as a limiter on the speed reference setpoint for any type of turbine. Auxiliary can be a limiter on cascade (LSS demand) when cascade has been configured. When the application is a two valve turbine (HP & LP) then the auxiliary limiter can be configured as a reference limiter or a process controller. For each condition a switchable panel will display either the text or enable/disable buttons.

The following will be displayed depending the configuration for auxiliary.

Auxiliary Setpoint

This displays the auxiliary process setpoint in engineering units.

Auxiliary Process Value

The actual process value of the auxiliary parameter in engineering units is displayed.

Auxiliary Demand

The PID output demand Value of Auxiliary controller is shown.

Limited P Demand

The auxiliary PID output limited by steam map or ratio limiter.

Interactive Trend Graph

The trend graph provides a view of the auxiliary control parameters with zoom features, stop/start graph and freeze view capability. Using the properties icon the user can adjust the range of any parameter to allow the graph to be more useful for specific tuning, for example around a smaller speed window range. The export icon will export the data from the trend to an html document.

> **IMPORTANT**
> **Export trend graph data will export all data in the buffer from the initial start command of the trend script, so the file may be come large and may take a while to create if the trend has been open and running for a long time.**

5.8.1 Commands

Auto Request

In case of auxiliary process controller the user can request when to enable/disable this controller.

Manual Request

In case of auxiliary process controller the user can request to switch to manual mode to control the LP valve position via raise/lower.

5.8.2 PID Settings

Proportional Gain **Initial=0.55 (0.0, 99.99)**

Enter the Auxiliary 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 0.5%.

Integral Gain **Initial=0.75 (0.0, 50)**

Enter the Auxiliary PID integral gain value, in repeats-per- second (rps). 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 0.75 rps.

Derivative Ratio **Initial=100 (0.01, 100)**

Enter the Auxiliary 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%.

Droop **Initial=0.0 (0.0, 25)**

If required, enter a droop percentage. If needed it is typically, set between 1-5% and not more than 10%.

Sliding Dead-band **Initial=0.0 (0.0, 5)**

If required, enter the deadband percentage. Typically, set between 1-5% and not more than 10%.

5.8.3 Rates Settings

The following settings can be entered concerning auxiliary setpoint rates.

Entered **Initial=0.1 (0.0, 1000)**

User can enter a rate at which to move to the target setpoint.

Delay before Fast **Initial=3.0 (0.0, 10)**

The setpoint will move at the normal rate for any command less than this time period in seconds. When the command is held active for longer than this time the rate will switch to the fast rate, i.e. multiplied x factor below).

Normal **Initial=0.01 (0.0, 100000)**

The user can set the normal rate at which the raise/lower buttons will move up until the delay time has been reached.

Fast Multiplier **Initial=3.0 (1.0, 10)**

The fast rate will equal the normal rate times this factor in rpm/sec.

5.8.4 Process Controller

Auto Request

User can request, when auxiliary is configured as a process controller, to enable/disable this controller

Manual Request

User can request, when auxiliary is configured as a process controller, to switch to manual mode to control the LP valve position via raise/Lower buttons.

5.9 Feed-Forward Tuning

⚠WARNING

Care should be taken while tuning the Feed-forward controller. Tuned correctly, it will reduce process instabilities noticed.

If tuned incorrectly, it may result in the opposite and amplify process instabilities.

Only qualified people should tune this loop.

The same data entry is available in the service mode feed-forward tuning as is in configuration mode (see 4.12, Feed Forward).

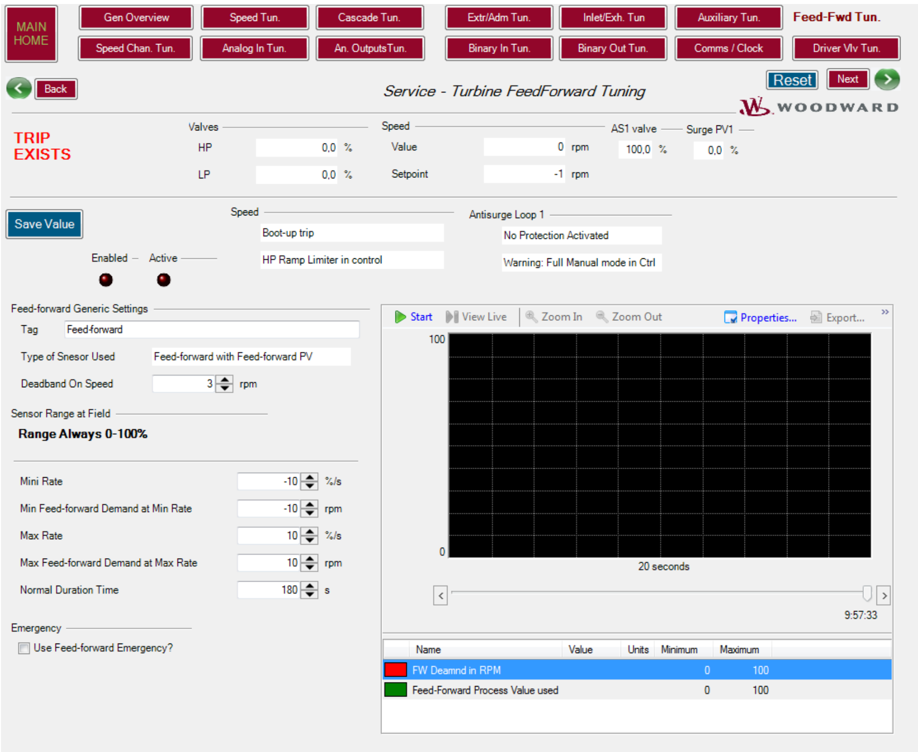


Figure 5-16. Feed Forward Tuning

5.9.1 Speed Channels

This page is mainly used to monitor the speed channels. For safety reasons, only one parameter can be changed while the turbine is in service, i.e. not in I/O lock/configuration mode.

Max speed Deviation Authorized **Initial=10.0 (0.1, 100)**

Max Deviation authorized between two speed probes before an alarm is generated.

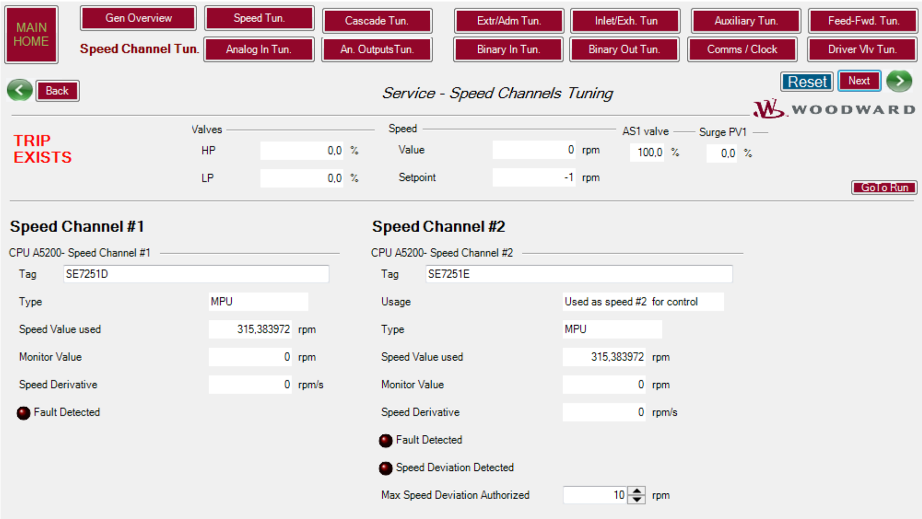


Figure 5-17. Speed Channels

5.9.2 Analog Inputs

This page provides a summary status of the validated analog Input channels, 1 through 6.

It shows the configured usage, the process value, the engineering units, the fault status, the override status and validated current input, in mA, of each channel.

Fail high Setpoint (mA) **dflt 22 (20-24)**

Max signal in mA to detect failure.

Fail Low Setpoint (ma) **dflt 2(0,4)**

Min signal in mA to detect failure.

For each analog input more detail is available by pressing the show AI navigation button. From this menu it is possible to disable, temporarily, the usage of the signal. It is also possible to change the Modbus multiplier, the units used and the tag Name. Sensor range can also be changed while turbine running

⚠WARNING

Take care while changing the range of a sensor while the turbine is running.

We recommend first disabling the function associated to this sensor, when possible.

Since the 505CC-2 is performing a configuration check to verify the consistency between the sensor range and the setpoints, any error will result in either:

- **Shutdown when turbine startup not completed**

or

- **Alarm when turbine startup completed**

The associated function linked to the sensor will be immediately disabled and remain disabled as long as the error is detected.

When cascade is configured and the sensor range change does not match anymore the setpoint range, cascade will be disabled.

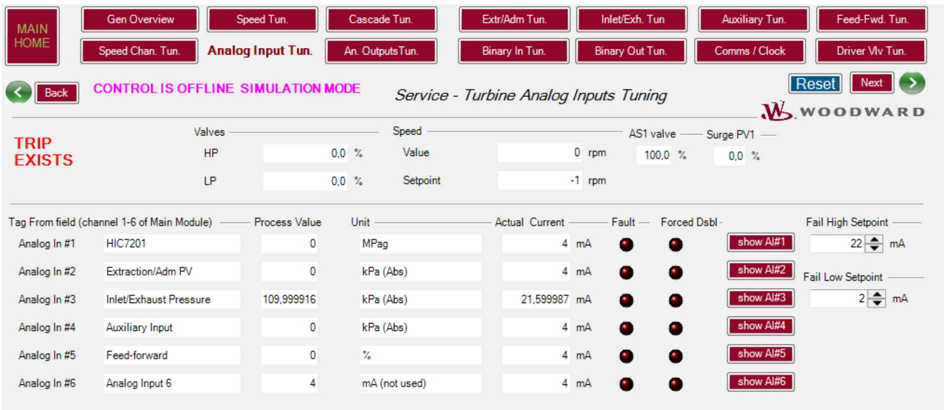


Figure 5-18. Analog Inputs

5.9.3 Analog Outputs

This page provides a summary status of the validated analog output channels 1 through 4.

Analog Output are readouts of internal signals, with the exception of the anti-surge valve demands.

This page shows the configured usage, the current send, the current readback for the first four analog outputs, the actual value of the parameter linked, the units of their linked parameter, the tag name (set in configuration), the fault status for the first four analog outputs, and the indication if the channel is forced.

A navigation button to take the user to details of each channel is available on this page.

On the details page, each channel can be calibrated to set the min/max currents equal to the desired engineering units range for the selected signal.

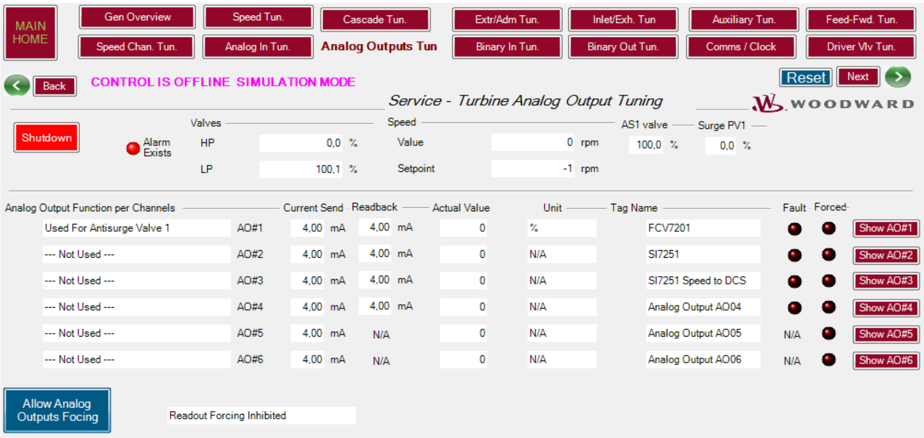


Figure 5-19. Analog Outputs

It is possible to calibrate any analog output while the turbine is running with the exception of:

- Analog output #1; used as for anti-surge #1 demand: Unit must be Tripped
- Analog output #2; used for anti-surge valve #2 demand: Unit must be tripped

To calibrate the analog output channels:

1. Allow the control into calibration mode by pressing the related button, Allow Analog Outputs Forcing.
2. Then click on the button force readout to place the AO channel in calibrate mode.

The panel will be updated as shown below:

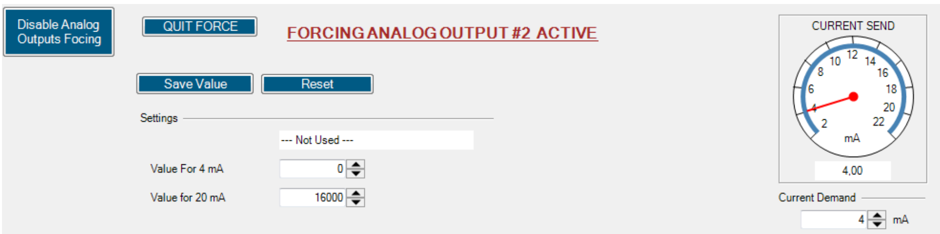


Figure 5-20. Analog Output Forcing

The output current demand will match the current send prior to enabling forcing the channel, i.e. bumpless transfer.

An alarm will immediately be sent to inform that an analog output is in force mode.

3. Set the desired output using the current demand.
4. If needed the range, value for 4 mA and 20 mA can be adjusted

When the calibration is completed, press quit force or disable analog outputs forcing, and issue a reset to remove the alarm indication.

5.9.4 Binary Inputs

This page provides a summary status of the validated binary input channels, 1 through 8. It shows the configured usage and input status of each channel.

A tunable string is available for each input to enter a device name label or tag.

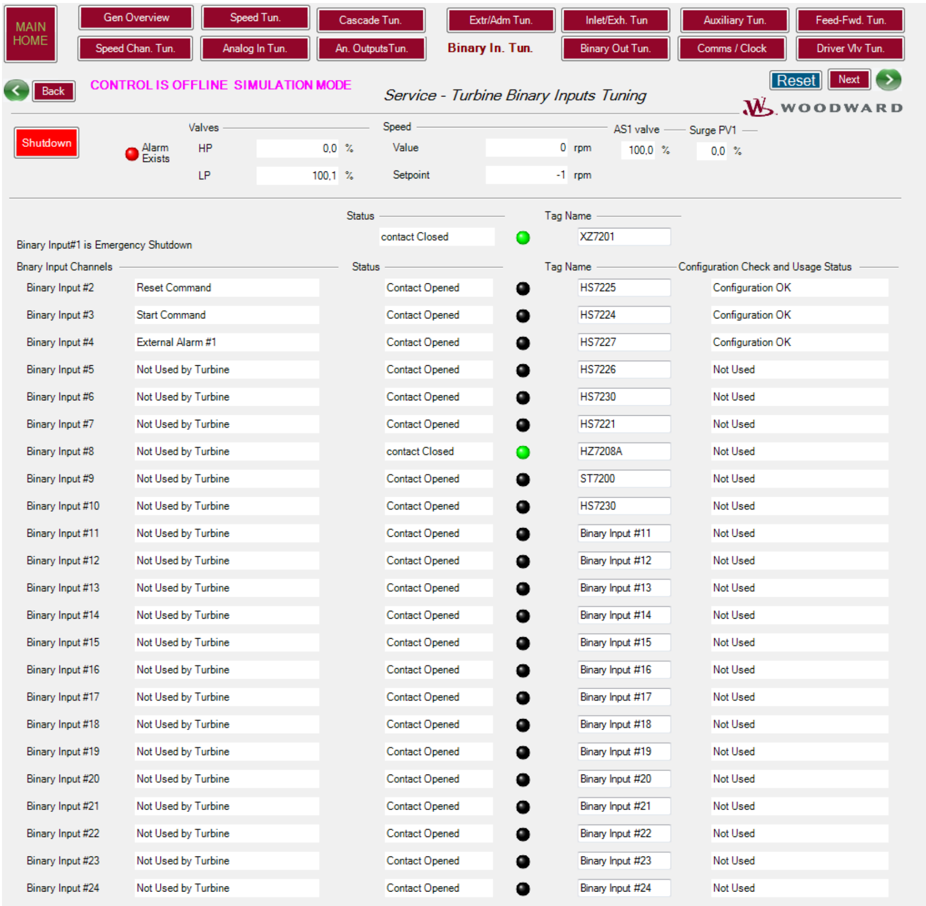


Figure 5-21. Binary Inputs

5.9.5 Binary Outputs

This page provides a summary status of the 12 relay output channels.

It shows the configured usage and validated output status of each relay channel. A tunable string is available for each input for the user to enter a device name label.

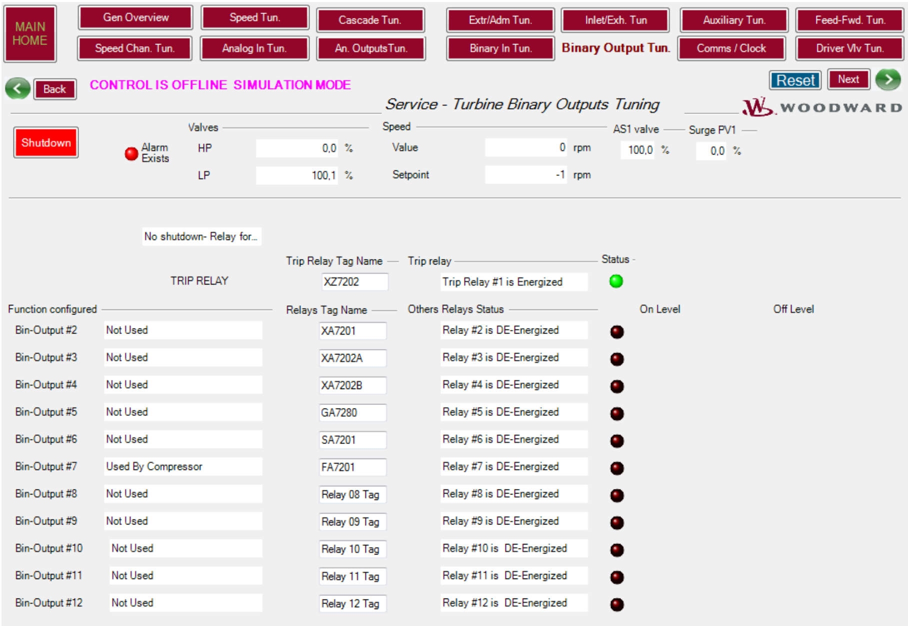


Figure 5-22. Binary Outputs

It is also possible to force the relay from this page when the turbine is tripped. When the turbine is tripped, a push button will appear to allow relay forcing. Press this push button to force the relays. Subsequent each relay can be individually forced by pressing force beside the relay to be forced. The transfer is to forcing is bumpless, i.e. the relay will remain in the position it was prior to force. A message will indicate which relay is in forced and an alarm will be triggered to indicate that any relay is in force mode. It is not possible to start the turbine as long as a relay is in force mode.

To change the state of a forced relay press energize or de-energize to set the output.

When forcing is completed, press inhibit force mode, and issue reset to clear the alarm.

5.9.6 Communication / Clock

This page shows the configuration of the Modbus blocks that are available to communicate system data to other devices.

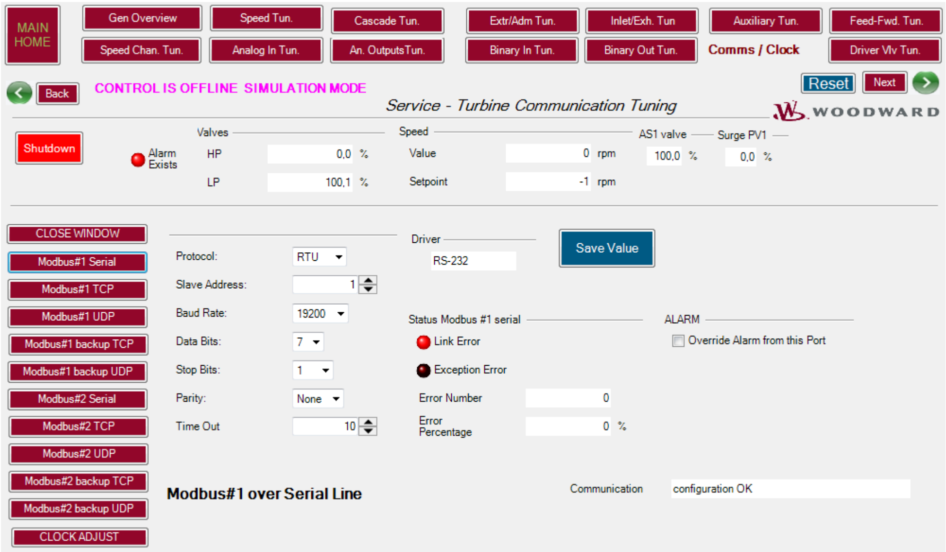


Figure 5-23. Communication / Clock

The checkbox options and the slave address numbers can be changed from this service mode page, however the type of connection assignment should only be changed in configure mode, depending on the master device end, the control may or may not communicate if these changes are made in service mode.

5.9.6.1 Adjust clock

The first time the 505CC-2 is used, it may be need to adjust the date and time which can be done on the bottom of the Communication / Clock page.

Press the button adjust clock, and set the date and/or time to the required values. Subsequent press the set data or time, and close the setting window.

IMPORTANT	**The clock will be re-synchronized to the default values each time an input is received when a time synchronization binary input has been configured.** **Therefore, set the default values to the expected periodic time of the synch request.** **A default time at 0:00:00 is not recommended, due to a possible date error that will occur, instead set it to 3:00:00.**

5.9.7 Driver Valve

This page provides service access to the actuator outputs available in the system. Navigation to the valve linearization curves for the high pressure (HP) and low pressure (LP) valves are only available through this screen.

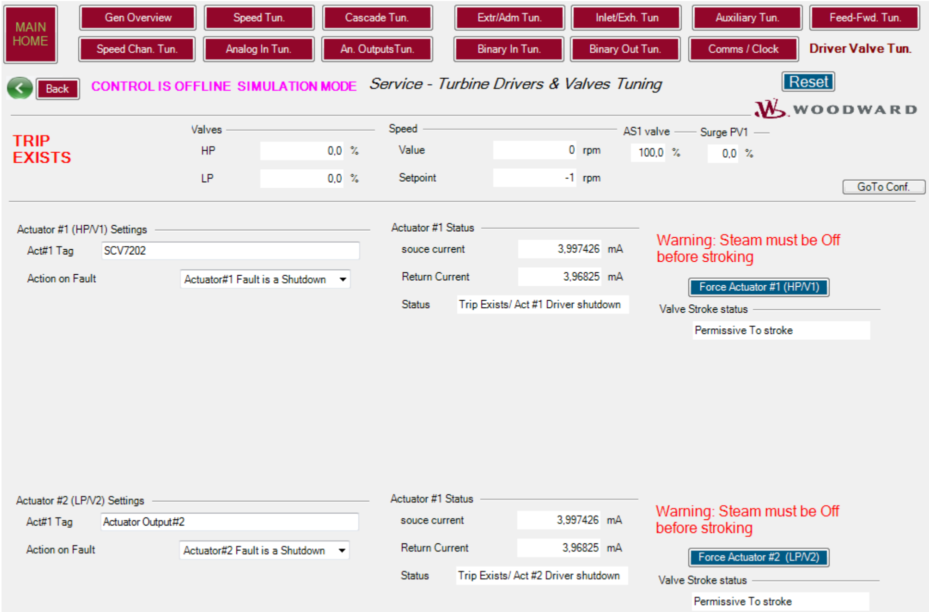


Figure 5-24. Driver & Valves Tuning

5.9.8 Calibration of Drivers

This option is only available when the turbine is tripped and not rotating. The calibration procedure will be immediately aborted when speed is detected.

Before initial operation or after a turbine overhaul where any actuator or valve travel may have been affected, the control must be calibrated or re-calibrated to the turbine valves.

> **⚠WARNING**
>
> **The control minimum and maximum currents relative to the closed (0%) and full open (100%) valve demand position are used to determine turbine operating conditions and limits.**
> **The turbine may not function correctly if the control is not correctly calibrated to the turbine valves.**

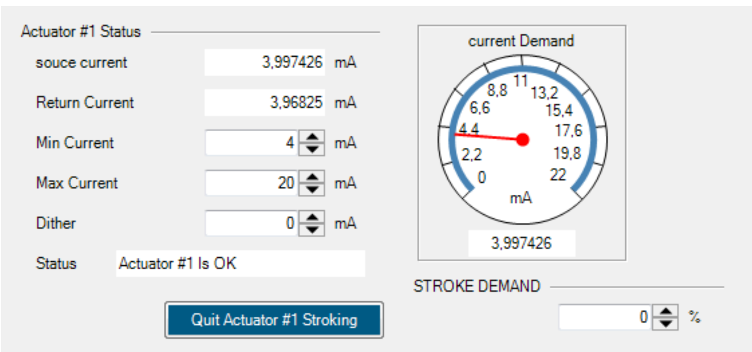


Figure 5-25. Stroking Proportional Actuator

Use the stroke demand to adjust the valve position. When calibration completed press Quit Actuator Stroking.

Chapter 6.
Run Mode

6.1 Introduction

Operational requirements of steam turbines are as varied as the processes in which they operate. This chapter is intended to provide an overview of steam turbine operation with respect to the 505CC-2's functionality only. For more complete, process-specific steam turbine or plant operating instructions, contact the plant-equipment manufacturer.

Once configured, the 505CC-2 provides fully automatic control of the steam turbine valves. During normal operation, there is generally little or no intervention required by an operator. The steam turbine run screens, available from the main screen provides access to all pertinent data used to control the steam turbine. The following paragraphs describe the available screens and data to interpret steam turbine operation and intervene as required. In addition start-up, online operation, and shutdown scenarios are described.

6.2 Home Page

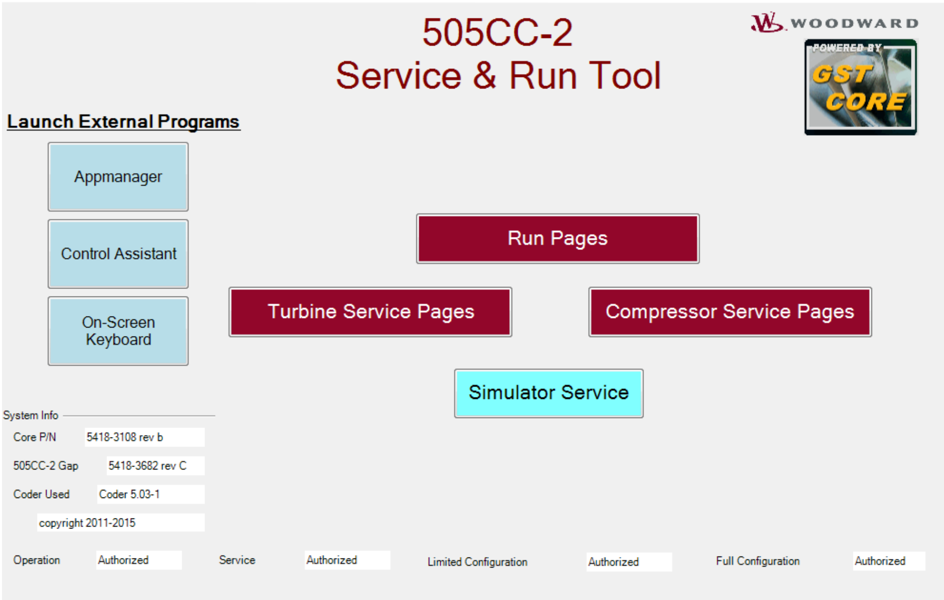


Figure 6-1. Run and Service Pages

6.2.1 Run Page

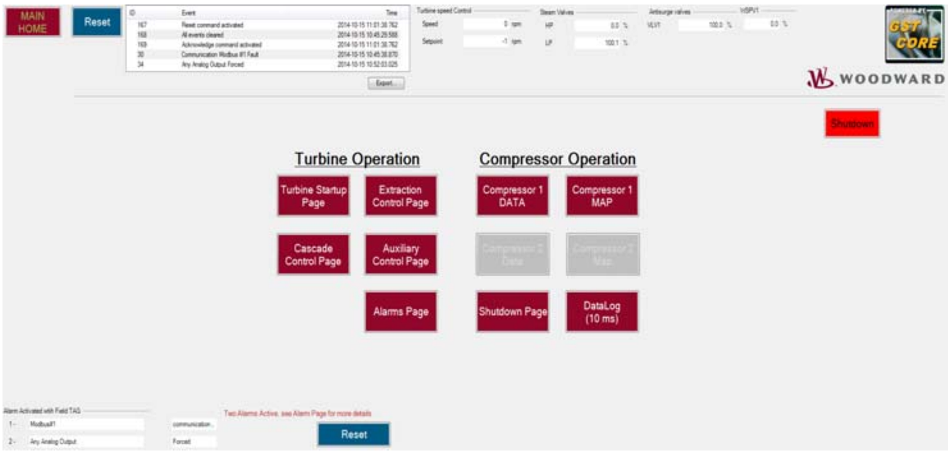


Figure 6-2. Turbine Run Pages

6.2.2 Alarm

See also volume 1 of the manual, 26542V1, for the alarm and shutdown overview of the steam turbine control. The numerical reference can be used as an index to determine the first alarm received via the first-alarm number in the Datalog or Modbus.

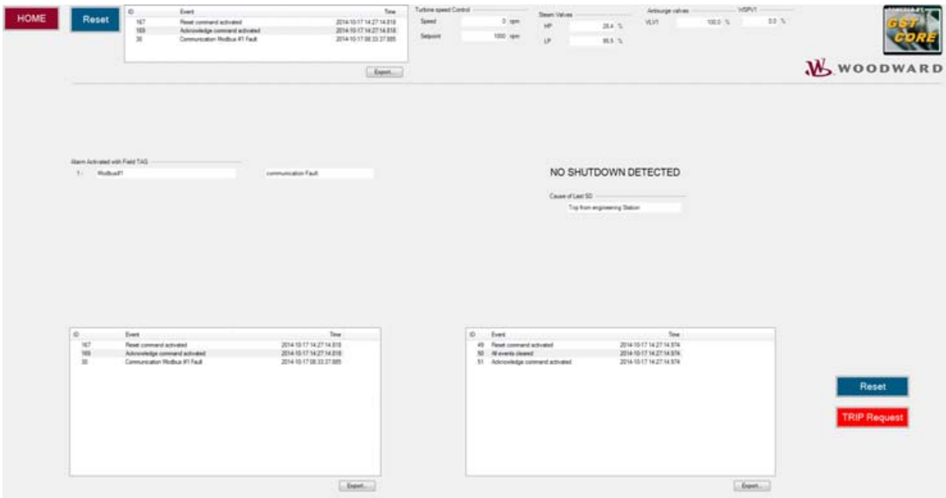


Figure 6-3. Alarms Screen

6.2.3 Shutdown

See also volume 1 of the manual, 26542V1, for the alarm and shutdown overview of the compressor control. The numerical reference can be used as an index to determine the first alarm received via the first-alarm number in the Datalog or Modbus.

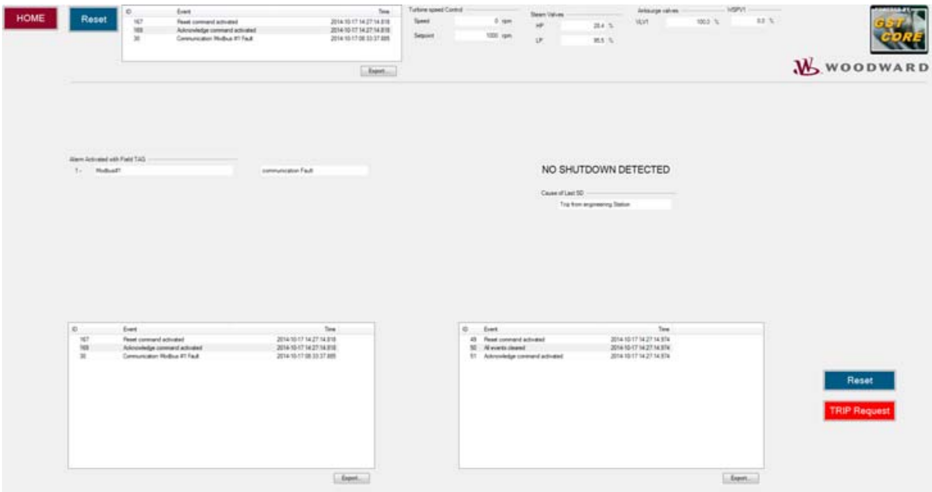


Figure 6-4. Shutdown Screen

6.2.4 Datalog (10 ms)

The 505CC-2 includes a high-speed datalogging facility that can assist in troubleshooting a unit shutdown or other event. It records all typical data for the turbine at a 10-millisecond sample rate. The data that are recorded are fixed. The sample rate can be changed but only with special software tools.

The datalog is a circular buffer that is stored in CPU memory. As shown in Table 6-1, it records 44 discrete values and 32 analog values for the turbine. This amount of data sampled every 10 ms results in a 68-second datalog. After the buffer is full, the datalog begins overwriting the oldest data. Recording automatically begins when the turbine is started and automatically stops 10 seconds after a compressor surge or unit shutdown. Using special software tools, starting and stopping the datalog can also be done manually to record specific transient events, process swings, etc. Two turbine datalogs can be stored on the CPU at any given time. If two completed datalog files already exist, the older of the two will be overwritten by the next datalog file.

AppManager and Control Assistant software, included on the Application CD, can be used to retrieve and view the datalogs. (These may also be downloaded from the software page at www.woodward.com) See AppManager's online help menu for details on retrieving files, including datalogs, from the control. The AppManager Datalog Retrieval Tool, available with an extra, purchased license, can also be configured to automatically archive datalogs from the control to a connected network computer. See Control Assistant's online help menu for details on viewing the .log datalog files. The file is a comma delimited text file, so it can also be imported into most trending or spreadsheet software for viewing and data manipulation.

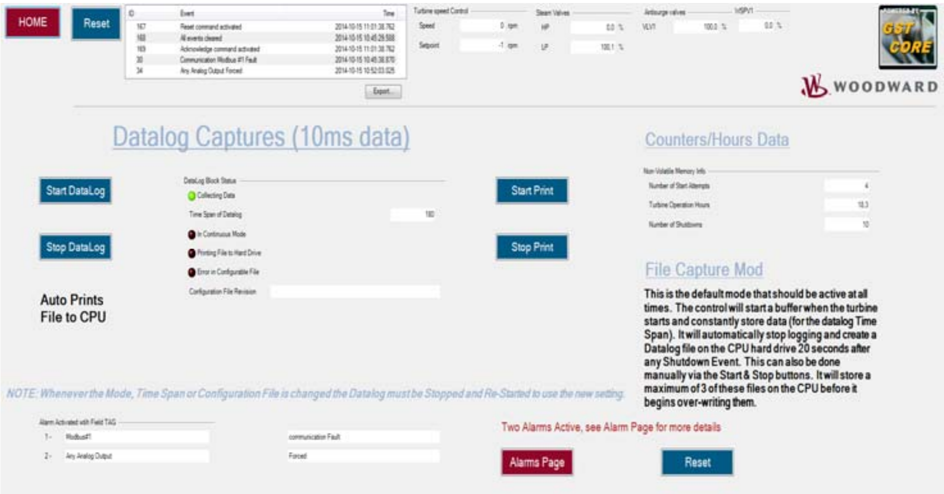


Figure 6-5. Datalog Screen

Discrete Values (TRUE/FALSE = 1/0)	Analog Values
Started	Cause of last SD
Shutdown exists	Cause of first SD
Alarm_exists	Cause of last alarm
Turbine configuration Error	Cause of first alarm
Actuator #1 Fault	Speedsig1
Actuator #2 Fault	Speedsig2
Analog Output #1 Fault	Speed_actual
Analog Output #2 Fault	Max Speed
Analog Output #3 Fault	Speed Setpoint
Analog Output #4 Fault	S demand
	P Demand
	HP Demand
	HP Ramp demand
	LP Demand
	LP Ramp demand
	Remote Speed val
	Cascade_val
	Remote Cascade
	extr_Adm_press
	Inlt_Exhaust_press
	Rem Inlt_Exhaust_press
	feedforward
	aux1 val
	Customer def1
	Customer def2
	Customer def3
	Customer def4
	Customer def5
	Customer def6
	Customer def7
	Customer def8
	speed Derivative
	Max Speed Derivative

Table 6-1. Steam Turbine Datalog

6.2.5 Start-up

This page is intended to be the primary operator interface screen for turbine operation. Once the unit has been configured, tuned and is ready for plant operation, this screen will provide a good overview of turbine operation. The view of this page changes based upon configuration options and where the turbine is in the start-up sequence. The Start Turbine screen is primarily used to bring the turbine up to rated speed. The Speed input, Speed setpoint and HP/LP Valve position demands are always displayed in the top banner of each Run page. At the bottom of each RUN page are Status messages, and a Shutdown button and a navigation buttons.

6.2.5.1 Shutdown Conditions

Clicking on, or selecting, the Reset button issues a reset command to the 505CC-2 control. This command will reset both alarms and trips and the control will proceed to check the start permissives.

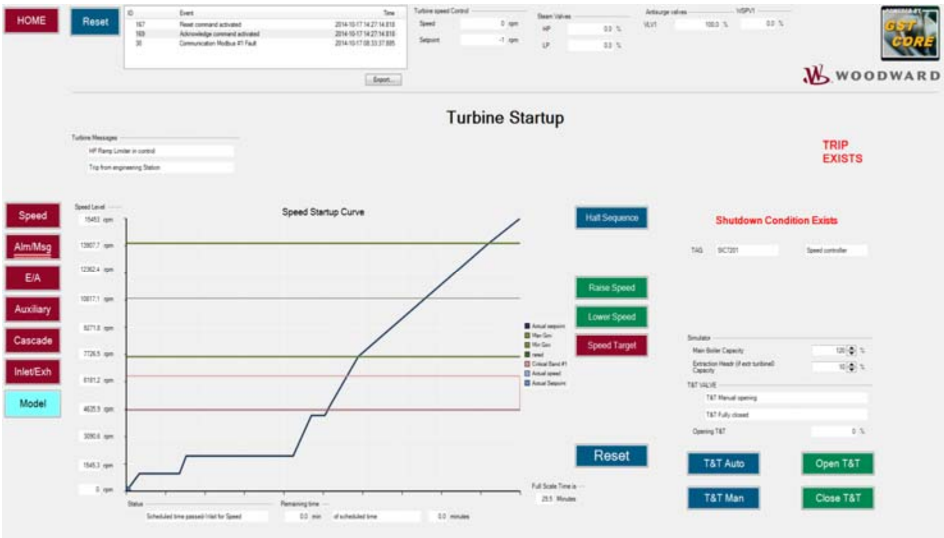


Figure 6-6. Shutdown Conditions Screen

6.2.5.2 Start Permissives

If any start permissives are configured, the control will wait until all permissives are met. This screen shows the conditions which need to be cleared. If all start permissives are met, the turbine is ready for the configured start procedure.

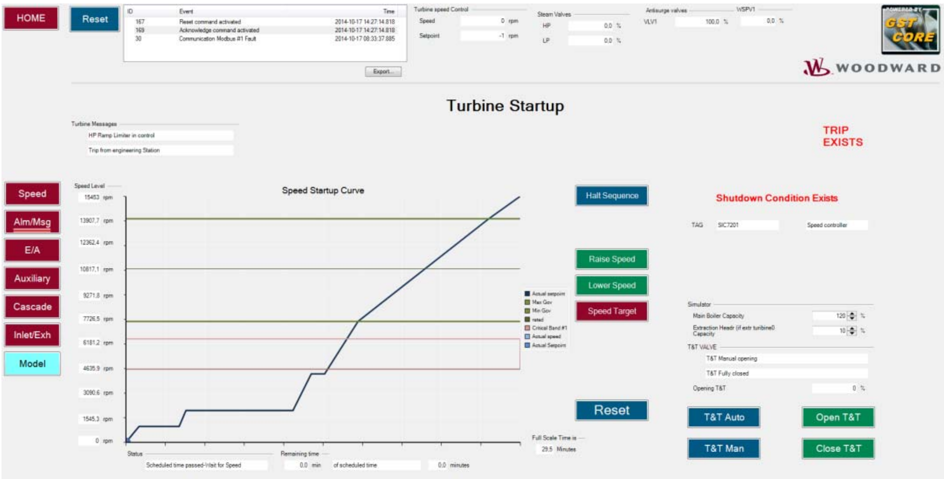


Figure 6-7. Start Permissive Screen

6.2.5.3 Start Command

Hot/Cold Start Buttons

If the Autostart Sequence is configured to use a Hot/Cold binary contact Input, it is possible to select the Hot or Cold curve in the startup screen.

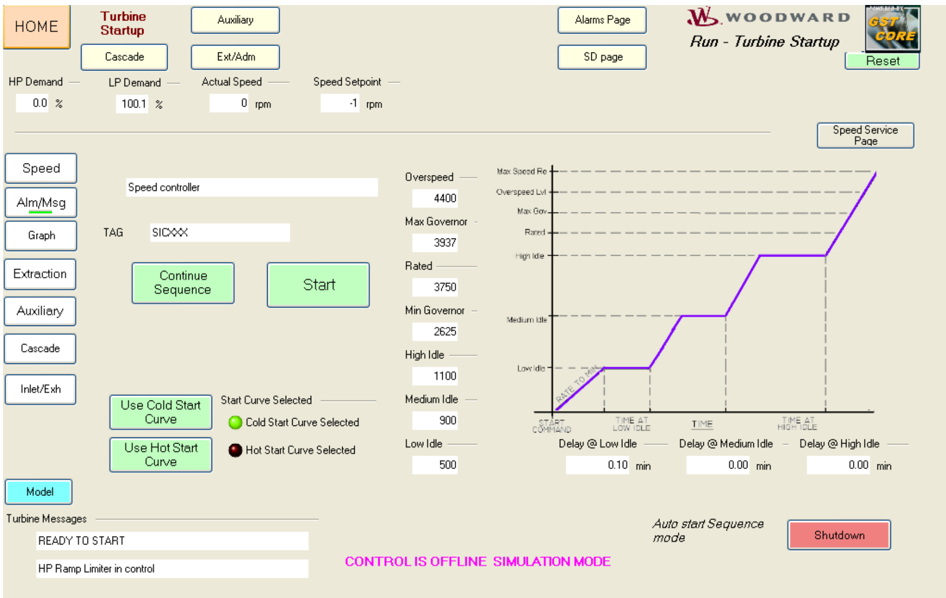


Figure 6-8. Hot/Cold Start

Next Multi Curve Button

If Multi Curves is configured to use a Hot/Cold contact input, it is also possible to select to desired curve by pressing the button “Next Multi Curve”. If four curves are configured, pressing “Next Multi Curve” when curve 4 is selected will bring back the selection to curve 1.

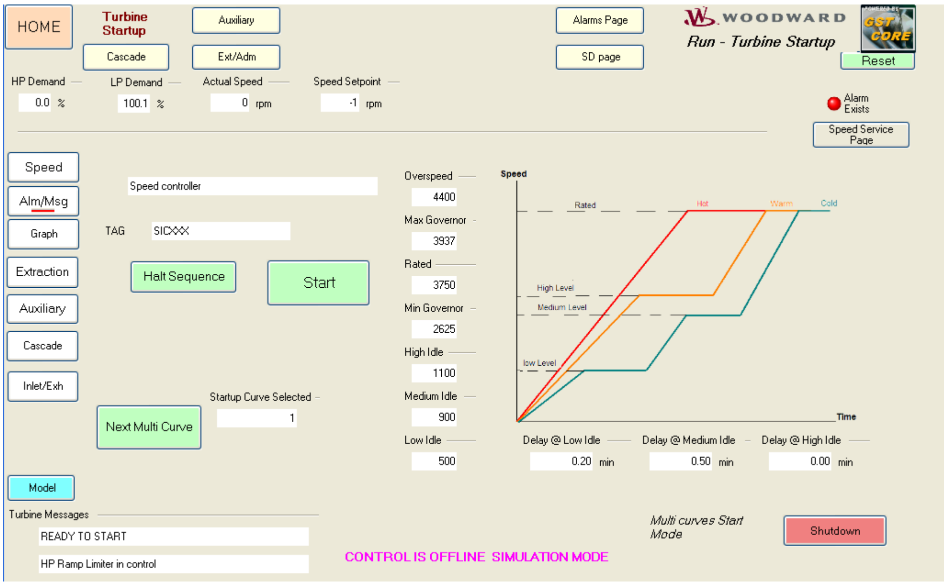


Figure 6-9. Multi Curve Start Sequence Screen

Start Button

Clicking or selecting the Start button is used to issue a start command to the 505CC-2 control. This command is identical to the Contact input or the Modbus RUN commands. This command will initiate the configured start procedure. All start permissives must be met before the start command is accepted.

Continue/Halt Sequence Buttons

Clicking or selecting the Halt button is used to issue a halt command to the 505CC-2 control. This command is identical to the Contact input or Modbus Continue/Halt commands. This is used to stop the auto start procedure at any moment and to keep the turbine at that place in the start procedure. The Continue button is used in the same way, to reinitiate the auto start procedure from the place it was stopped. The status of the Start Sequence is continually displayed in the Messages display box in this folder. Once startup is completed, these buttons disappear.

Raise/Lower HP Valve Limit Buttons

The Raise/Lower Limiter buttons are used to open the HP Limiter at the HP Valve Limiter in semi-automatic mode, or to limit the HP valve opening.

Shutdown Button

The Shutdown button allows a user to stop or trip the turbine. The controlled Normal Shutdown can be selected by pressing the red Shutdown button first and then press NSD. To trip the turbine, press the Trip button. The 505CC-2 control can be configured to ramp all controlling parameters down to a controlled turbine stop.

There is no confirmation request included from the Modbus or discrete input commands that also initiate a normal shutdown. If at any time during the controlled shutdown, the operator wishes to discontinue the shutdown, the Quit Normal Shutdown button will return the turbine to a run mode.

Depending on the configuration, the normal SD when completed, will trip the turbine. Let the turbine reset (ready to start) or bring the setpoint at low idle, and switch the control to manual commands.

6.2.5.4 Speed Control

When the startup sequence is completed the Speed Control screen will be shown. In this screen it is possible to write directly a speed set point to the control by pressing the button Speed Target. To be accepted, this target must not be inside a critical band. The speed set point can be raised or lowered as well by pressing the Raise Speed or Lower Speed button.

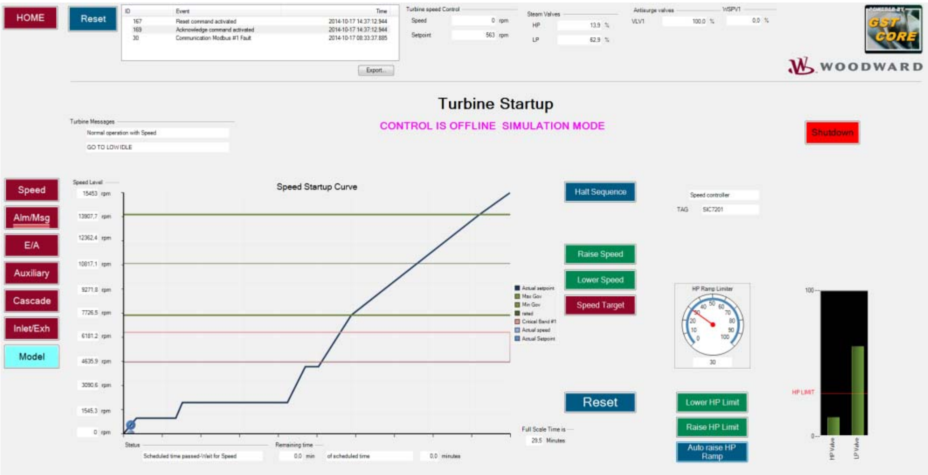


Figure 6-10. Speed Control Screen

6.2.6 Cascade Control

If cascade is configured for use, this page is designed to give a more detailed view of the controller and all operational options available. Cascade control can be enabled or disabled in this screen and the setpoint can be raised or lowered.

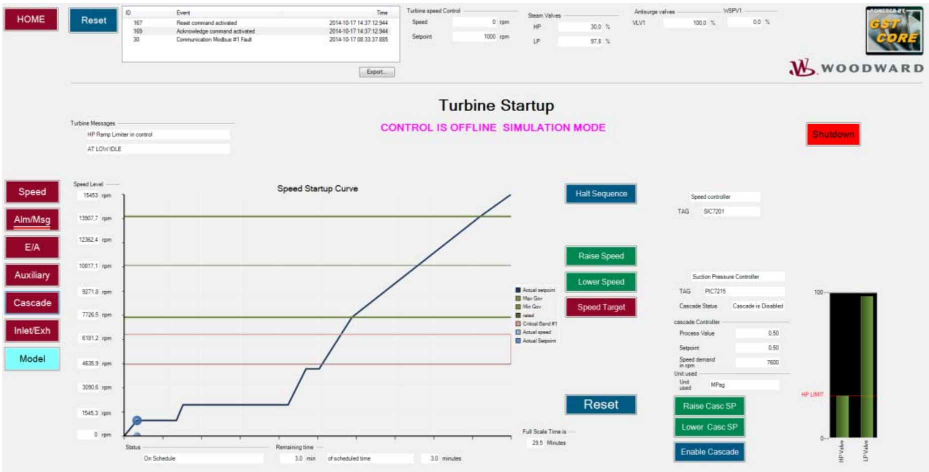


Figure 6-11. Cascade Control Screen

6.2.7 Extraction/Admission Control

This page is designed to give a more detailed view of the Extraction and Admission control. It allows enabling/disabling of extraction, raise/lowering of the setpoint, LP or HP demands when in decoupling mode or LP valve limiter ramp. Manual mode will allow the user to manually raise and lower the LP valve position.

Views of your page may differ slightly from what is shown below due to options and configuration items used.

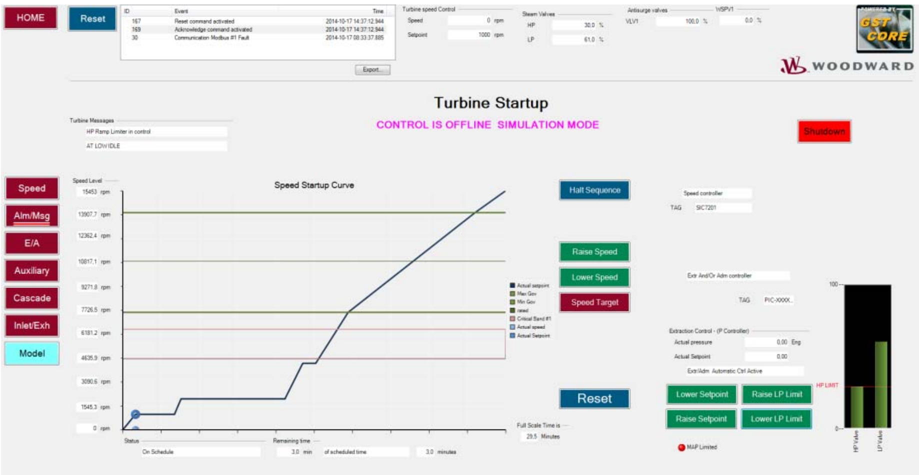


Figure 6-12. Extraction/Admission Control Screen

6.2.8 Auxiliary Control

If auxiliary is configured for use, this page is designed to give a more detailed view of the controller and all operational options available. Auxiliary control can be enabled or disabled if configured as secondary flow/pressure controller. The setpoint can be raised or lowered in this screen as well.

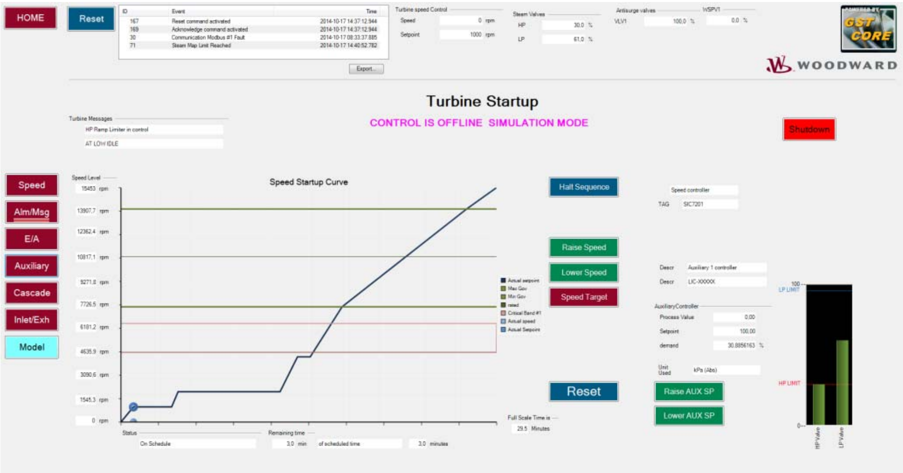


Figure 6-13. Auxiliary Control Screen

Appendix A
Configuration Worksheet

Turbine Configuration Sheet	Setting	Unit
Turbine General Overview		
Turbine Configuration		
Type		
Feed-Forward		
Cascade ctrl		
Remote Speed		
Auxiliary type		
Site name		
Turbine Name		
ID name		
Turbine Start Settings		
Start Mode Selection		
Start Up Sequence Selection		
Normal Operation Levels		
Max Overspeed test [rpm]		
Overspeed Trip SP [rpm]		
Max Governor Speed [rpm]		
Min Governor Speed [rpm]		
Min Controlled Speed [rpm]		
Idle/Rated Mode (if configured)		
Idle Priority?		
Rate to Low Idle [rpm/s]		
Rate to Min Governor [rpm/s]		
Loading Gradient [rpm/s]		
Idle Speed [rpm]		
Rated Speed [rpm]		
Autostart Sequence (if configured)		

Sequence Status at SD		
Hold at Idle Speed Levels?		
Low Idle [rpm]		
Use Medium Idle?		
Medium Idle [rpm] (if used)		
Use High Idle?		
High Idle [rpm] (if used)		
Rated Speed [rpm]		
Curve Mode Select		
Internal Curves Calculation Used (if configured)		
Cold Start Time (< xx HRS)		
Hot Start Time (> xx HRS)		
Min Speed to Detect Warm Condition [rpm]		
Time Switch to Hot [min]		
Hot/Cold Process Value Used (if configured)		
PV @ 4 mA		
PV @ 20 mA		
Value to detect Cold		
Value to detect Hot		
Units		
Tag		
Start-Up Curve Cold		
Cold Rate to Low Idle [rpm/s]		
Cold Delay at Low Idle [min]		
Cold Rate to Medium Idle [rpm/s]		
Cold Delay at Medium Idle [min]		
Cold Rate to High Idle [rpm/s]		
Cold Delay at High Idle [min]		
Cold Rate to Min Gov [rpm/s]		
Cold Loading Gradient [rpm/s]		
Start-Up Curve Hot		
Hot Rate to Low Idle [rpm/s]		
Hot Delay at Low Idle [min]		
Hot Rate to Medium Idle [rpm/s]		

Hot Delay at Medium Idle [min]		
Hot Rate to High Idle [rpm/s]		
Hot Delay at High Idle [min]		
Hot Rate to Min Gov [rpm/s]		
Hot Loading Gradient [rpm/s]		
No Idle Mode (if configured)		
Rate to Min Governor [rpm/s]		
Loading Gradient [rpm/s]		
Multi Curves Start Mode (if configured)		
Sequence Status at SD		
Number of Curves used(3-6)		
Low Idle [rpm]		
Use Medium Idle?		
Medium Idle [rpm]		
Use High Idle?		
High Idle [rpm]		
Rated Speed [rpm]		
Curve Mode Select		
Hot/cold binary contact used (if configured)		
Use Analog Selections?		
Remote Hot/cold used (if configured)		
Range High remote Hot/Cold PV		
Range Low remote Hot/Cold PV		
Curve 1 Settings		
Ramp to Low Idle Curve 1 [rpm/s]		
Delay at Low Idle Curve 1 [min]		
Ramp to Medium Idle Curve 1 [rpm/s] (if used)		
Delay at Medium Idle Curve 1 [min] (if used)		
Ramp to High Idle Curve 1 [rpm/s] (if used)		
Delay at High Idle Curve 1 [min] (if used)		
Ramp to Min Gov Curve 1 [rpm/s]		
Loading Gradient Curve 1 [rpm/s]		

Transition 1--> 2 (if used)		
Level to Select Curve 1 to Curve 2		
Hysteresis		
Curve 2 Settings		
Ramp to Low Idle Curve 2 [rpm/s]		
Delay at Low Idle Curve 2 [min]		
Ramp to Medium Idle Curve 2 [rpm/s] (if used)		
Delay at Medium Idle Curve 2 [min] (if used)		
Ramp to High Idle Curve 2 [rpm/s] (if used)		
Delay at High Idle Curve 2 [min] (if used)		
Ramp to Min Gov Curve 2 [rpm/s]		
Loading Gradient Curve 2 [rpm/s]		
Transition 2--> 3 (if used)		
Level to Select Curve 2 to Curve 2		
Hysteresis		
Curve 3 Settings		
Ramp to Low Idle Curve 3 [rpm/s]		
Delay at Low Idle Curve 3 [min]		
Ramp to Medium Idle Curve 3 [rpm/s] (if used)		
Delay at Medium Idle Curve 3 [min] (if used)		
Ramp to High Idle Curve 3 [rpm/s] (if used)		
Delay at High Idle Curve 3 [min] (if used)		
Ramp to Min Gov Curve 3 [rpm/s]		
Loading Gradient Curve 3 [rpm/s]		
Transition 3--> 4 (if used)		
Level to Select Curve 3 to Curve 3		
Hysteresis		
Curve 4 Settings (if used)		
Ramp to Low Idle Curve 4 [rpm/s]		

Delay at Low Idle Curve 4 [min]		
Ramp to Medium Idle Curve 4 [rpm/s] (if used)		
Delay at Medium Idle Curve 4 [min] (if used)		
Ramp to High Idle Curve 4 [rpm/s] (if used)		
Delay at High Idle Curve 4 [min] (if used)		
Ramp to Min Gov Curve 4 [rpm/s]		
Loading Gradient Curve 4 [rpm/s]		
Transition 4--> 5 (if used)		
Level to Select Curve 4 to Curve 4		
Hysteresis		
Curve 5 Settings (if used)		
Ramp to Low Idle Curve 5 [rpm/s]		
Delay at Low Idle Curve 5 [min]		
Ramp to Medium Idle Curve 5 [rpm/s] (if used)		
Delay at Medium Idle Curve 5 [min] (if used)		
Ramp to High Idle Curve 5 [rpm/s] (if used)		
Delay at High Idle Curve 5 [min] (if used)		
Ramp to Min Gov Curve 5 [rpm/s]		
Loading Gradient Curve 5 [rpm/s]		
Transition 5--> 6 (if used)		
Level to Select Curve 5 to Curve 5		
Hysteresis		
Curve 6 Settings (if used)		
Ramp to Low Idle Curve 6 [rpm/s]		
Delay at Low Idle Curve 6 [min]		
Ramp to Medium Idle Curve 6 [rpm/s] (if used)		
Delay at Medium Idle Curve 6 [min] (if used)		
Ramp to High Idle Curve 6 [rpm/s] (if used)		
Delay at High Idle Curve 6 [min] (if used)		

Ramp to Min Gov Curve 6 [rpm/s]		
Loading Gradient Curve 6 [rpm/s]		
Turbine Speed Control		
Short Description		
ID Name		
Normal Shutdown Settings		
No SD when NSD completed?		
NSD To Low Idle Only?		
Use NSD Permissive < Min Gov?		
Speed Gear		
Number of Teeth		
Gear Ratio		
General Critical Speed Settings (if used)		
Enable Speed Lower in Critical?		
Min Speed is High Critical?		
Force Unload if Stuck?		
SD if Stuck?		
Delay Before Alarm/Unload/SD [sec]		
Critical Speed 1 Settings		
Critical Range 1 Active?		
Critical Speed 1 Rate Fixed?		
Lower Limit Critical range 1 [rpm]		
Upper Limit Critical range 1 [rpm]		
Critical Speed 2 Settings (if used)		
Critical Range 2 Active?		
Critical Speed 2 Rate Fixed?		
Lower Limit Critical range 2 [rpm]		
Upper Limit Critical range 2 [rpm]		
Critical Speed 3 Settings (if used)		
Critical Range 3 Active?		

Critical Speed 3 Rate Fixed?		
Lower Limit Critical range 3 [rpm]		
Upper Limit Critical range 3 [rpm]		
Speed Setpoint R/L command		
Delay from Slow to Normal Rate [s]		
Multiply fact of Normal Rate for Slow		
Entered Speed Setpoint Rate [rpm/s]		
Initial PID Settings		
Off-line Prop Gain		
Off-line Integral Gain [rpt/s]		
Off-line Deriv Ratio		
On-line Prop Gain		
On-line Integral Gain [rpt/s]		
On-line Deriv Ratio		
Remote Speed Setpoint (If Configured)		
Remote Speed Setpoint at 4 mA [rpm]		
Remote Speed Setpoint at 20 mA [rpm]		
Min Cascade & Remote Speed Setpoint Demand [rpm]		
Max Cascade & Remote Speed Setpoint Demand [rpm]		
Max remote Speed Setpoint Rate [rpm/s]		
Max remote Speed Setpoint Deviation Level [rpm]		
Not Matched Rate [rpm/s]		
Turbine Protection		
Loss of Speed Protection		
Max Speed Deviation [rpm]		
Delay Before Alarm [s]		
SD if Control Lost?		
Underspeed Protection (if configured)		
Use Underspeed Protection?		
Underspeed Level [rpm]		
Alarm Delay [s]		

Use Underspeed SD?		
Underspeed SD Delay [s] (if used)		
Speed Detection		
Override Timer Not Used?		
Override Time [s] (if used)		
Overspeed Test Settings		
Delay to Quit if no R/L [s]		
Predictive Overspeed (if configured)		
Use Predictive Overspeed Protection?		
Predictive Speed Level [rpm] (if used)		
Max Acceleration at Predictive Speed [rpm/s] (if used)		
Break Away Protection		
Use Break Away Protection?		
Amount deducted to actual demand [%] (if used)		
Trigger Level [rpm] (if used)		
HP Ramp at Start Protection		
Use HP Max Position at Start?		
HP Ramp Max at Start [%] (if used)		
Enable Stocky Rotor Protection SD?		
Acceleration Protection Offline (if configured)		
Use Acceleration Protection Offline?		
Min Deviation Before Acting [rpm]		
Offline Max Acceleration [rpm/s]		
Acceleration Protection Online (if configured)		
Use Acceleration Protection Online?		
Max Acceleration Rate Online [rpm/s]		
Use Boost Protection?		
Boost Speed Trigger Level [rpm]		
Boost Valve demand [%]		
Emergency to Min Governor (if configured)		

Emergency Min Gov Rate [rpm/s]		
Turbine Extraction Control (if configured)		
Short Description		
ID Name		
General Settings		
Extraction PV&SP Units		
Type of Control Mode used		
First Control Selected After Enabling		
Reverse PID Action		
Enable only with LP Ramp Raise/Lower		
Use Speed Permissives		
Min Speed to Enable Extraction (if used) [rpm]		
Manual Demand (if applicable)		
Demand Normal R/L Rate (Man) [%/s]		
Extr/Adm Demand Fast Delay [s]		
Fast Demand Multiplier		
Demand Entered Rate [%/s]		
Use Remote P Demand (if available)		
Remote Demand Max Deviation Level (if used) [%]		
Max Remote P Demand Rate (if used) [%/s]		
HP Rate at disable (if available)		
Flow rate (HP Rate) at disable [%/s]		
Extr/Adm Setpoint (if used)		
Minimum Setpoint [Eng Unit]		
Maximum Setpoint [Eng Unit]		
Initial Setpoint [Eng Unit]		
SP Entered Rate [Eng Unit/s]		
Setpoint Track when Disabled?		
Setpoint Raise/Lower Normal rate [Eng Unit/s]		
Delay for fast Setpoint Rate [s]		
Fast Setpoint multiplier		

Use Remote Extr/Adm Setpoint		
Maximum Remote SP Rate [%/s] (if used)		
Remote SP Max Deviation Level [%] (if used)		
PID Settings (if used)		
Semi-Automatic from Decoupling?		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop of Extr/Adm [%]		
Sliding Dead Band [%]		
Sensor Range (if used)		
Extr/Adm Min PV (4 mA) [Eng Unit]		
Extr/Adm Max PV (20 mA) [Eng Unit]		
Action Upon Sensor Fault		
Turbine Admission Control (if configured)		
Short Description		
ID Name		
General Settings		
Admission PV&SP Units		
Type of Control Mode used		
First Control Selected After Enabling		
Reverse PID Action		
Enable only with LP Ramp Raise/Lower		
Use Speed Permissives		
Min Speed to Enable Admission (if used) [rpm]		
Manual Demand (if applicable)		
Demand Normal R/L Rate (Man) [%/s]		
Extr/Adm Demand Fast Delay [s]		
Fast Demand Multiplier		
Demand Entered Rate [%/s]		
Use Remote P Demand (if available)		

Remote Demand Max Deviation Level (if used) [%]		
Max Remote P Demand Rate (if used) [%/s]		
HP Rate at disable (if available)		
Flow rate (HP Rate) at disable [%/s]		
Extr/Adm Setpoint (if used)		
Minimum Setpoint [Eng Unit]		
Maximum Setpoint [Eng Unit]		
Initial Setpoint [Eng Unit]		
SP Entered Rate [Eng Unit/s]		
Setpoint Track when Disabled?		
Setpoint Raise/Lower Normal rate [Eng Unit/s]		
Delay for fast Setpoint Rate [s]		
Fast Setpoint multiplier		
Use Remote Extr/Adm Setpoint		
Maximum Remote SP Rate [%/s] (if used)		
Remote SP Max Deviation Level [%] (if used)		
PID Settings (if used)		
Semi-Automatic from Decoupling?		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop of Extr/Adm [%]		
Sliding Dead Band [%]		
Sensor Range (if used)		
Extr/Adm Min PV (4 mA) [Eng Unit]		
Extr/Adm Max PV (20 mA) [Eng Unit]		
Action Upon Sensor Fault		
Turbine Admission with direct Feed Control (if configured)		
Short Description		
ID Name		

General Settings		
Admission PV&SP Units		
Type of Control Mode used		
First Control Selected After Enabling		
Reverse PID Action		
Enable only with LP Ramp Raise/Lower		
Use Speed Permissives		
Min Speed to Enable Admission (if used) [rpm]		
Manual Demand (if applicable)		
Demand Normal R/L Rate (Man) [%/s]		
Extr/Adm Demand Fast Delay [s]		
Fast Demand Multiplier		
Demand Entered Rate [%/s]		
Use Remote P Demand (if available)		
Remote Demand Max Deviation Level (if used) [%]		
Max Remote P Demand Rate (if used) [%/s]		
HP Rate at disable (if available)		
Flow rate (HP Rate) at disable [%/s]		
Extr/Adm Setpoint (if used)		
Minimum Setpoint [Eng Unit]		
Maximum Setpoint [Eng Unit]		
Initial Setpoint [Eng Unit]		
SP Entered Rate [Eng Unit/s]		
Setpoint Track when Disabled?		
Setpoint Raise/Lower Normal rate [Eng Unit/s]		
Delay for fast Setpoint Rate [s]		
Fast Setpoint multiplier		
Use Remote Extr/Adm Setpoint		
Maximum Remote SP Rate [%/s] (if used)		
Remote SP Max Deviation Level [%] (if used)		
PID Settings (if used)		
Semi-Automatic from Decoupling?		

Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop of Extr/Adm [%]		
Sliding Dead Band [%]		
Sensor Range (if used)		
Extr/Adm Min PV (4 mA) [Eng Unit]		
Extr/Adm Max PV (20 mA) [Eng Unit]		
Action Upon Sensor Fault		
Turbine Ext/Adm Control (if configured)		
Short Description		
ID Name		
General Settings		
Ext/Adm PV&SP Units		
Type of Control Mode used		
First Control Selected After Enabling		
Reverse PID Action		
Enable only with LP Ramp Raise/Lower		
Use Speed Permissives		
Min Speed to Enable E/A (if used) [rpm]		
Manual Demand (if applicable)		
Demand Normal R/L Rate (Man) [%/s]		
Extr/Adm Demand Fast Delay [s]		
Fast Demand Multiplier		
Demand Entered Rate [%/s]		
Use Remote P Demand (if available)		
Remote Demand Max Deviation Level (if used) [%]		
Max Remote P Demand Rate (if used) [%/s]		
HP Rate at disable (if available)		
Flow rate (HP Rate) at disable [%/s]		
Extr/Adm Setpoint (if used)		

Minimum Setpoint [Eng Unit]		
Maximum Setpoint [Eng Unit]		
Initial Setpoint [Eng Unit]		
SP Entered Rate [Eng Unit/s]		
Setpoint Track when Disabled?		
Setpoint Raise/Lower Normal rate [Eng Unit/s]		
Delay for fast Setpoint Rate [s]		
Fast Setpoint multiplier		
Use Remote Extr/Adm Setpoint		
Maximum Remote SP Rate [%/s] (if used)		
Remote SP Max Deviation Level [%] (if used)		
PID Settings (if used)		
Semi-Automatic from Decoupling?		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop of Extr/Adm [%]		
Sliding Dead Band [%]		
Sensor Range (if used)		
Extr/Adm Min PV (4 mA) [Eng Unit]		
Extr/Adm Max PV (20 mA) [Eng Unit]		
Action Upon Sensor Fault		
Turbine Steam Map - Extraction Only (if used)		
Maximum / Minimum Values		
Max Power [Load Unit]		
Max HP Flow [Flow Unit]		
Min LP Valve Lift [%]		
Max LP Valve Lift [%]		
Minimum Load Line Settings		
Min Load Limit @ HP=0% [Load unit]		
Min Load Limit @ HP=100% [Load unit]		
Point A		
Max Power @ Min Extr [Load Unit]		

HP Flow @ Min Extr [Flow Unit]		
Point B		
Min Power @ Max Extr [Load Unit]		
HP Flow @ Max Extr [Flow Unit]		
Point C		
Min Power @ Min Extr [Load Unit]		
HP Flow @ Min Extr [Flow Unit]		
Steam Map Priorities On Valve Position		
LP Min reached		
LP Max reached		
HP Min reached		
HP Max reached		
Steam Map Priorities On Load / Press Controller Dmd		
Flow Min reached		
Flow Max reached		
Min Load reached		
Max Load reached		
Turbine Steam Map - Admission Only (if used)		
Maximum / Minimum Values		
Max Power [Load Unit]		
Max HP Flow [Flow Unit]		
Min HP Position [%]		
Min LP Valve Lift [%]		
Max LP Valve Lift [%]		
Minimum Load Line Settings		
Min Load Limit @ HP=0% [Load unit]		
Min Load Limit @ HP=100% [Load unit]		
Point A		
Max Power @ Max Adm [Load Unit]		
HP Flow @ Max Adm [Flow Unit]		
Point B		
Min Power @ Min Adm [Load Unit]		
HP Flow @ Min Adm [Flow Unit]		
Point C		

Max Power @ Min Adm [Load Unit]		
Max HP Flow @ Min Adm [Flow Unit]		
Steam Map Priorities On Valve Position		
LP Min reached		
LP Max reached		
HP Min reached		
HP Max reached		
Steam Map Priorities On Load / Press Controller Dmd		
Flow Min reached		
Flow Max reached		
Min Load reached		
Max Load reached		
Turbine Steam Map - Ext/Adm (if used)		
Maximum / Minimum Values		
Max Power [Load Unit]		
Max HP Flow [Flow Unit]		
Min HP Position [%]		
Min LP Valve Lift [%]		
Max LP Valve Lift [%]		
Minimum Load Line Settings		
Min Load Limit @ HP=0% [Load unit]		
Min Load Limit @ HP=100% [Load unit]		
Point A		
Max Power @ 0 EA [Load Unit]		
HP Flow @ 0 EA [Flow Unit]		
Point B		
Min Power @ Max Extr [Load Unit]		
HP Flow @ Max Extr [Flow Unit]		
Point C		
Min Power @ 0 EA [Load Unit]		
Min HP Flow @ 0 EA [Flow Unit]		
Steam Map Priorities On Valve Position		

LP Min reached		
LP Max reached		
HP Min reached		
HP Max reached		
Steam Map Priorities On Load / Press Controller Dmd		
Flow Min reached		
Flow Max reached		
Min Load reached		
Max Load reached		
Maximum Admission Flow		
Maximum Admission Flow [Flow Unit]		
Turbine Cascade Control (if used)		
Short Description		
ID Name		
General Settings		
Max Cascade Speed Setpoint Rate [rpm/s]		
Cascade Process Value Selection		
Sensor		
Cascade TAG (if available)		
Cascade PV and SP Units (if available)		
Cascade Process Value at 4 mA [Eng unit]		
Cascade Process Value at 20 mA [Eng unit]		
Range of Operation on Speed Reference		
Min Cascade & Remote Speed Setpoint Demand [rpm]		
Max Cascade & Remote Speed Setpoint Demand [rpm]		
Cascade Setpoint Values		
Track when Disabled?		
Min Cascade Setpoint [Eng Unit]		

Max Cascade Setpoint [Eng Unit]		
Initial Cascade Setpoint [Eng Unit]		
Entered Setpoint Rate [Eng Unit/s]		
Normal R/L SP Rate [Eng Unit/s]		
Delay for Fast Setpoint Rate [s]		
Multiply Factor for Fast rate		
Remote Cascade Setpoint		
Use Remote Cascade Setpoint		
Max Remote Cascade Setpoint Rate [Eng Unit/s]		
Remote Setpoint Max Deviation Level [Eng Unit]		
PID initial Settings		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Sliding Dead Band [%]		
Invert PID?		
Droop (in % of SP Range) [%]		
Turbine Inlet/Exhaust (if used)		
Short Description		
ID Name		
General Settings		
Type of Control Mode used		
Reverse PID		
Inlet/Exhaust Pressure is Cascade Process Value?		
PID Control First at Enable		
Demand Limits		
Minimum HP (if Inlet Ctrl) or LP (if Exhaust Ctrl) Demand [%]		
Maximum HP (if Inlet Ctrl) or LP (if Exhaust Ctrl) Demand [%]		
Sensor Range (if used)		
Process Value @ 4 mA [Eng Unit]		

Process Value @ 20 mA [Eng Unit]		
Manual Demand		
Demand R/L Normal Rate [%/s]		
Delay for Fast Demand Rate [s]		
Fast Demand Multiplier		
Use Remote Demand		
Remote Demand Max Deviation Level [%/s] (if used)		
Not Matched Rate [%/s] (if used)		
Max Remote Demand rate [%/s] (if used)		
Inlet/Exhaust Setpoint		
Inlet/Exhaust PV@SP Unit		
Minimum Setpoint [Eng Unit]		
Minimum Setpoint [Eng Unit]		
Initial SP at Bootup [Eng Unit]		
SP Entered Rate [Eng Unit/s]		
Demand Entered Rate [Eng Unit/s]		
Setpoint Track when disabled?		
Setpoint Raise/Lower Normal Rate [Eng Unit]		
Delay for Fast Setpoint Rate		
Fast Setpoint Multiplier		
Use Remote Inlet/Exhaust Setpoint		
Max Remote SP Rate [Eng Unit/s] (if used)		
Remote SP Max Deviation Level [Eng Unit] (if used)		
PID initial Settings (if used)		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop of Extr/Adm [%]		
Sliding Dead Band [%]		
Turbine Feed Forward (if used)		

Feed Forward Generic Settings		
Use Direct Signal?		
Inhibited if No Cascade?		
Deadband on Speed [rpm]		
Type of Sensor used		
Tag		
Min Rate [%/s]		
Min Feed-forward Demand at Min Rate [rpm]		
Max Rate [%/s]		
Max Feed-forward Demand at Max Rate [rpm]		
Normal Duration Time [s]		
Emergency Feed Forward Settings (if used)		
Use Feed-forward Emergency?		
Emergency Duration Time [s]		
Min Rate Before Acting [%/s]		
Max Rate [%/s]		
Speed Deviation at Max Rate [rpm]		
Max Speed Rate of Change [rpm/s]		
Turbine Auxiliary Control (if used)		
Short Description		
ID Name		
Auxiliary Main Settings		
Reverse Action Select?		
Forced Raise If Fault?		
Forced Lower If Fault?		
Hold Speed at Start when Limiter?		
Disable Decoupling when Limiter Active?		
Alarm when Limiting?		
Auxiliary Process Value Selection		
Auxiliary Sensor Settings		
Auxiliary Tag (if available)		
Auxiliary PV and SP Units (if available)		

Auxiliary Process Value at 4 mA [Eng unit]		
Auxiliary Process Value at 20 mA [Eng unit]		
Setpoint Settings		
Setpoint Track when Disabled		
Initial Setpoint [Eng Unit]		
Minimum Setpoint [Eng Unit]		
Maximum Setpoint [Eng Unit]		
Setpoint Entered Rate [Eng Unit/s]		
Delay for Fast Setpoint [s]		
Setpoint R/L Rate [Eng Unit/s]		
Multiply Factor for Fast rate		
Remote Cascade Setpoint		
Use Remote Auxiliary Setpoint		
Max Remote Auxiliary Setpoint Rate [Eng Unit/s]		
Remote SP Max Deviation Level [Eng Unit]		
PID Initial Settings		
Proportional Gain		
Integral Gain [rpt/s]		
Derivative Ratio		
Droop [%]		
Sliding Dead Band [%]		
Turbine Valve Settings - No Extraction (if used)		
HP Ramp Options		
HP Ramp Rate [%/s]		
HP Ramp Rate at Restart or Manual [%/s]		
Max HP Ramp [%]		
Valve Setup		
HP Settings - Split Range (if used)		
Offset for Split Range		

HP Settings - Two HP with HP2 as Startup Valve (if used)		
Transfer Time at Disable [s]		
Minimum Transfer Time [s]		
Use Valve Demand for Xfer?		
Startup Valve - Speed Setpoint Settings (if used)		
Speed Setpoint for Full HP2 Usage [rpm]		
Speed Setpoint for Full HP Usage [rpm]		
HP2 Demand Gain		
Startup Valve - Valve Demand Settings (if used)		
Valve Demand for Full HP2 Usage [%]		
Valve Demand for Full HP Usage[%]		
HP2 Demand Gain		
HP Settings - Two HP with HP2 Boost Valve (if used)		
HP2 Demand Gain		
Minimum Transfer Time [s]		
Transfer Time at Disable [s]		
HP Curve		
X1 [%], Y1 [%]		
X2 [%], Y2 [%]		
X3 [%], Y3 [%]		
X4 [%], Y4 [%]		
X5 [%], Y5 [%]		
X6 [%], Y6 [%]		
X7 [%], Y7 [%]		
X8 [%], Y8 [%]		
X9 [%], Y9 [%]		
X10 [%], Y10 [%]		
X11 [%], Y11 [%]		
HP2 Curve (If Used)		
X1 [%], Y1 [%]		
X2 [%], Y2 [%]		
X3 [%], Y3 [%]		

X4 [%], Y4 [%]		
X5 [%], Y5 [%]		
X6 [%], Y6 [%]		
X7 [%], Y7 [%]		
X8 [%], Y8 [%]		
X9 [%], Y9 [%]		
X10 [%], Y10 [%]		
X11 [%], Y11 [%]		
Turbine Valve Settings - Extr and/or Adm (if used)		
HP Ramp Options		
Enable Rotor Stuck Detection SD?		
Use HP Initial Position at Start?		
HP Ramp Max at Start [%] (if used)		
HP Ramp Rate [%/s]		
HP Ramp Rate at Restart or Manual [%/s]		
Max HP Ramp [%]		
HP Valve Settings		
HP Curve		
X1 [%], Y1 [%]		
X2 [%], Y2 [%]		
X3 [%], Y3 [%]		
X4 [%], Y4 [%]		
X5 [%], Y5 [%]		
X6 [%], Y6 [%]		
X7 [%], Y7 [%]		
X8 [%], Y8 [%]		
X9 [%], Y9 [%]		
X10 [%], Y10 [%]		
X11 [%], Y11 [%]		
LP Ramp Options		
R/L Delay to Fast [s]		
R/L Rate [%/s]		
R/L Rate Fast Multiplier		
Initial Ramp Rate [%/s]		
LP Valve Settings		

LP Behavior at Startup		
LP Min Position at Start [%] (if used)		
LP Curve		
X1 [%], Y1 [%]		
X2 [%], Y2 [%]		
X3 [%], Y3 [%]		
X4 [%], Y4 [%]		
X5 [%], Y5 [%]		
X6 [%], Y6 [%]		
X7 [%], Y7 [%]		
X8 [%], Y8 [%]		
X9 [%], Y9 [%]		
X10 [%], Y10 [%]		
X11 [%], Y11 [%]		
Turbine Analog Inputs		
Fail Low Setpoint [mA]		
Fail High Setpoint [mA]		
Analog Inputs		
AI#1 Function		
AI#1 Value at 4 mA		
AI#1 Value at 20 mA		
AI#1 Modbus Multiplier		
AI#1 Units		
AI#1 Tag Name		
AI#2 Function		
AI#2 Value at 4 mA		
AI#2 Value at 20 mA		
AI#2 Modbus Multiplier		
AI#2 Units		
AI#2 Tag Name		
AI#3 Function		
AI#3 Value at 4 mA		
AI#3 Value at 20 mA		
AI#3 Modbus Multiplier		
AI#3 Units		

AI#3 Tag Name		
AI#4 Function		
AI#4 Value at 4 mA		
AI#4 Value at 20 mA		
AI#4 Modbus Multiplier		
AI#4 Units		
AI#4 Tag Name		
AI#5 Function		
AI#5 Value at 4 mA		
AI#5 Value at 20 mA		
AI#5 Modbus Multiplier		
AI#5 Units		
AI#5 Tag Name		
AI#6 Function		
AI#6 Value at 4 mA		
AI#6 Value at 20 mA		
AI#6 Modbus Multiplier		
AI#6 Units		
AI#6 Tag Name		
Turbine Analog Outputs		
Analog Output Channels		
AO#1 Function		
AO#1 Value at 4 mA		
AO#1 Value at 20 mA		
AO#1 Tag Name		
AO#2 Function		
AO#2 Value at 4 mA		
AO#2 Value at 20 mA		
AO#2 Tag Name		
AO#3 Function		
AO#3 Value at 4 mA		
AO#3 Value at 20 mA		
AO#3 Tag Name		

AO#4 Function		
AO#4 Value at 4 mA		
AO#4 Value at 20 mA		
AO#4 Tag Name		
AO#5 Function		
AO#5 Value at 4 mA		
AO#5 Value at 20 mA		
AO#5 Tag Name		
AO#6 Function		
AO#6 Value at 4 mA		
AO#6 Value at 20 mA		
AO#6 Tag Name		
Turbine Binary Inputs		
BI#1 Function		
BI#1 Tag Name		
BI#2 Function		
BI#2 Tag Name		
BI#3 Function		
BI#3 Tag Name		
BI#4 Function		
BI#4 Tag Name		
BI#5 Function		
BI#5 Tag Name		
BI#6 Function		
BI#6 Tag Name		
BI#7 Function		
BI#7 Tag Name		
BI#8 Function		
BI#8 Tag Name		

BI#9 Function		
BI#9 Tag Name		
BI#10 Function		
BI#10 Tag Name		
BI#11 Function		
BI#11 Tag Name		
BI#12 Function		
BI#12 Tag Name		
BI#13 Function		
BI#13 Tag Name		
BI#14 Function		
BI#14 Tag Name		
BI#15 Function		
BI#15 Tag Name		
BI#16 Function		
BI#16 Tag Name		
BI#17 Function		
BI#17 Tag Name		
BI#18 Function		
BI#18 Tag Name		
BI#19 Function		
BI#19 Tag Name		
BI#20 Function		
BI#20 Tag Name		
BI#21 Function		
BI#21 Tag Name		

BI#22 Function		
BI#22 Tag Name		
BI#23 Function		
BI#23 Tag Name		
BI#24 Function		
BI#24 Tag Name		
Turbine Binary Outputs		
Relay #1 Function		
Relay #1 Tag Name		
Reset Clear Trip Output		
Relay #2 Function		
Relay #2 Tag Name		
Relay #2 Status indication (if used)		
Function		
Invert		
Relay #2 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #3 Function		
Relay #3 Tag Name		
Relay #3 Status indication (if used)		
Function		
Invert		
Relay #3 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #4 Function		
Relay #4 Tag Name		
Relay #4 Status indication (if used)		

Function		
Invert		
Relay #4 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #5 Function		
Relay #5 Tag Name		
Relay #5 Status indication (if used)		
Function		
Invert		
Relay #5 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #6 Function		
Relay #6 Tag Name		
Relay #6 Status indication (if used)		
Function		
Invert		
Relay #6 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #7 Function		
Relay #7 Tag Name		
Relay #7 Status indication (if used)		
Function		
Invert		
Relay #7 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		

Relay #8 Function		
Relay #8 Tag Name		
Relay #8 Status indication (if used)		
Function		
Invert		
Relay #8 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #9 Function		
Relay #9 Tag Name		
Relay #9 Status indication (if used)		
Function		
Invert		
Relay #9 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #10 Function		
Relay #10 Tag Name		
Relay #10 Status indication (if used)		
Function		
Invert		
Relay #10 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Relay #11 Function		
Relay #11 Tag Name		
Relay #11 Status indication (if used)		
Function		
Invert		
Relay #11 Level Switch (if used)		

Parameter		
ON Level		
OFF Level		
Invert		
Relay #12 Function		
Relay #12 Tag Name		
Relay #12 Status indication (if used)		
Function		
Invert		
Relay #12 Level Switch (if used)		
Parameter		
ON Level		
OFF Level		
Invert		
Turbine Speed Channels		
Speed Channel #1		
Tag name		
Type		
Speed Channel #1		
Usage		
Tag name		
Type		
Communication Settings		
Modbus#1		
Modbus#1 Usage		
MB#1 Commands		
Modbus Trip		
Modbus#1 over Serial Line (If used)		
Protocol		
Driver		
Slave Address		
Baud Rate		
Data Bits		
Stop Bits		

Parity		
Time Out [s]		
Modbus#1 over TCP (If used)		
Protocol		
Slave Address		
Time Out [s]		
Modbus#1 over UDP (If used)		
Protocol		
Slave Address		
Time Out [s]		
Modbus#2		
Modbus#2 Usage		
MB#2 Commands		
Modbus Trip		
Modbus#2 over Serial Line (If used)		
Protocol		
Driver		
Slave Address		
Baud Rate		
Data Bits		
Stop Bits		
Parity		
Time Out [s]		
Modbus#2 over TCP (If used)		
Protocol		
Slave Address		
Time Out [s]		
Modbus#2 over UDP (If used)		
Protocol		
Slave Address		
Time Out [s]		
Turbine Driver		
Actuator #1 (HP) Settings		

Act#1 Tag		
Action on Fault		
Act#1 is Reversed (20/4 or 160/20)		
Range		
Min Current [mA]		
Max Current [mA]		
Dither [mA]		
Actuator #2 (LP/HP2) Settings		
Act#2 Tag		
Action on Fault		
Act#2 is Reversed (20/4 or 160/20)		
Range		
Min Current [mA]		
Max Current [mA]		
Dither [mA]		
Turbine Alarms		
External Alarm Settings		
Ext Alarm #1 Type		
Ext Alarm #1 Invert		
Ext Alarm #1 Tag Name		
Ext Alarm #2 Type		
Ext Alarm #2 Invert		
Ext Alarm #2 Tag Name		
Ext Alarm #3 Type		
Ext Alarm #3 Invert		
Ext Alarm #3 Tag Name		
Ext Alarm #4 Type		
Ext Alarm #4 Invert		
Ext Alarm #4 Tag Name		
Ext Alarm #5 Type		
Ext Alarm #5 Invert		
Ext Alarm #5 Tag Name		
Ext Alarm #6 Type		

Ext Alarm #6 Invert		
Ext Alarm #6 Tag Name		
Ext Alarm #7 Type		
Ext Alarm #7 Invert		
Ext Alarm #7 Tag Name		
Ext Alarm #8 Type		
Ext Alarm #8 Invert		
Ext Alarm #8 Tag Name		
Ext Alarm #9 Type		
Ext Alarm #9 Invert		
Ext Alarm #9 Tag Name		
Ext Alarm #10 Type		
Ext Alarm #10 Invert		
Ext Alarm #10 Tag Name		
Alarm Behavior		
Use Non Latching Alarms		
External Shutdown Settings		
Main Shutdown Command - Invert		
Main Shutdown Command - Tag name		
Ext Shutdown #1 Usage		
Ext Shutdown #1 Invert		
Ext Shutdown #1 Tag Name		
Ext Shutdown #2 Usage		
Ext Shutdown #2 Invert		
Ext Shutdown #2 Tag Name		
Ext Shutdown #3 Usage		
Ext Shutdown #3 Invert		
Ext Shutdown #3 Tag Name		
Ext Shutdown #4 Usage		
Ext Shutdown #4 Invert		
Ext Shutdown #4 Tag Name		

Ext Shutdown #5 Usage		
Ext Shutdown #5 Invert		
Ext Shutdown #5 Tag Name		
Ext Shutdown #6 Usage		
Ext Shutdown #6 Invert		
Ext Shutdown #6 Tag Name		
Ext Shutdown #7 Usage		
Ext Shutdown #7 Invert		
Ext Shutdown #7 Tag Name		
Ext Shutdown #8 Usage		
Ext Shutdown #8 Invert		
Ext Shutdown #8 Tag Name		
Ext Shutdown #9 Usage		
Ext Shutdown #9 Invert		
Ext Shutdown #9 Tag Name		
Ext Shutdown #10 Usage		
Ext Shutdown #10 Invert		
Ext Shutdown #10 Tag Name		
Internal Level Switch Settings		
Internal Level Switch#1 Usage		
Internal Level Switch#1 Parameter		
Internal Level Switch#1 Tag		
Internal Level Switch#1 On Level [Eng Unit]		
Internal Level Switch#1 Off Level [Eng Unit]		
Internal Level Switch#1 Off Delay [s]		
Internal Level Switch#1 Override if Field Sensor Fault		
Internal Level Switch#2 Usage		
Internal Level Switch#2 Parameter		
Internal Level Switch#2 Tag		
Internal Level Switch#2 On Level [Eng Unit]		

Internal Level Switch#2 Off Level [Eng Unit]		
Internal Level Switch#2 Off Delay [s]		
Internal Level Switch#2 Override if Field Sensor Fault		
Internal Level Switch#3 Usage		
Internal Level Switch#3 Parameter		
Internal Level Switch#3 Tag		
Internal Level Switch#3 On Level [Eng Unit]		
Internal Level Switch#3 Off Level [Eng Unit]		
Internal Level Switch#3 Off Delay [s]		
Internal Level Switch#3 Override if Field Sensor Fault		
Internal Level Switch#4 Usage		
Internal Level Switch#4 Parameter		
Internal Level Switch#4 Tag		
Internal Level Switch#4 On Level [Eng Unit]		
Internal Level Switch#4 Off Level [Eng Unit]		
Internal Level Switch#4 Off Delay [s]		
Internal Level Switch#4 Override if Field Sensor Fault		
Internal Level Switch#5 Usage		
Internal Level Switch#5 Parameter		
Internal Level Switch#5 Tag		
Internal Level Switch#5 On Level [Eng Unit]		
Internal Level Switch#5 Off Level [Eng Unit]		
Internal Level Switch#5 Off Delay [s]		
Internal Level Switch#5 Override if Field Sensor Fault		
Internal Level Switch#6 Usage		
Internal Level Switch#6 Parameter		
Internal Level Switch#6 Tag		
Internal Level Switch#6 On Level [Eng Unit]		

Internal Level Switch#6 Off Level [Eng Unit]		
Internal Level Switch#6 Off Delay [s]		
Internal Level Switch#6 Override if Field Sensor Fault		
Internal Level Switch#7 Usage		
Internal Level Switch#7 Parameter		
Internal Level Switch#7 Tag		
Internal Level Switch#7 On Level [Eng Unit]		
Internal Level Switch#7 Off Level [Eng Unit]		
Internal Level Switch#7 Off Delay [s]		
Internal Level Switch#7 Override if Field Sensor Fault		
Internal Level Switch#8 Usage		
Internal Level Switch#8 Parameter		
Internal Level Switch#8 Tag		
Internal Level Switch#8 On Level [Eng Unit]		
Internal Level Switch#8 Off Level [Eng Unit]		
Internal Level Switch#8 Off Delay [s]		
Internal Level Switch#8 Override if Field Sensor Fault		

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26542V2D.

PO Box 1519, Fort Collins CO 80522-1519, USA
1000 East Drake Road, Fort Collins CO 80525, USA
Phone +1 (970) 482-5811 • Fax +1 (970) 498-3058

Email and Website—www.woodward.com

**Woodward has company-owned plants, subsidiaries, and branches,
as well as authorized distributors and other authorized service and sales facilities throughout the world.**

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