

## Product Manual 26361V1 (Revision H, 4/2013) Original Instructions





# 505DE Digital Governor for Steam Turbines

Part numbers: 8262-1023, -1024, -1040, -1041

Manual 26361 consists of 2 volumes (26361V1 & 26361V2).

**Volume 1—Configuration and Operation** 



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

Practice all plant and safety instructions and precautions.

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



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**Proper Use** 

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



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# **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.

# **MARNING**

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.

# **MARNING**

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.



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.



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.

- 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.

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# **Regulatory Compliance**

#### **European Compliance for CE Marking**

These listings are limited only to those units bearing the CE Marking:

**EMC Directive:** Declared to 2004/108/EC COUNCIL DIRECTIVE of 15

December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

Low Voltage Declared to 2006/95/EC COUNCIL DIRECTIVE of 12

**Directive:** December 2006 on the harmonization of the laws of the

Member States relating to electrical equipment designed

for use within certain voltage limits.

ATEX – Potentially Declared to 94/9/EC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member

Atmospheres
Directive: States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

Zone 2, Category 3, Group II G, Ex nA [nL] IIC T3 X

#### Other European and International Compliance

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

**GOST R:** Certified for use in ordinary locations within the Russian

Federation per GOST R certificate POCC

US.МЛ03.В01257.

#### **North American Compliance**

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

**CSA:** CSA Listed for Class I, Division 2, Groups A, B, C, & D,

T3A at 55 °C surrounding air temperature. For use in

Canada and the United States.

5441-694 DIO FTM Relay Driver rated for temperatures

up to 75 °C, Temperature Code T3A.

CSA Listing per Certificate of Compliance 2314167.

Marine

American Bureau ABS SVR Rules 2012 1-14/7.7, 1-1-A3, 4-2-1/7.3, 4-2-

**of Shipping:** 1/7.5.1, 4-9-3/17, 4-9-7/13, 4-9-2/11.7 & 4-9-4/23.

The MicroNet Digital Control System is to be installed in an enclosed, environmentally conditioned space (0 to

+55 °C)

**Det Norske Veritas:** Standard for Certification No. 2.4, 2006: Temperature

Class A, Humidity Class B, Vibration Class B, and EMC

Class A

Enclosure protection required according to the Rules to

be provided upon installation on board.

Lloyd's Register LR Type Approval Test Specification No. 1,

of Shipping: 2002 for Environmental Categories ENV1, ENV2

#### **Special Conditions for Safe Use**



The 16-Channel Relay Interface Modules are suitable for ordinary or non-hazardous locations only.

This equipment is suitable for use in European Zone 2, Group IIC environments when installed in an IP54 minimum rated enclosure per self-declaration to EN60079-15.

Wiring must be in accordance with North American Class I, Division 2, or European Zone 2, Category 3 wiring methods as applicable, and in accordance with the authority having jurisdiction.

A fixed wiring installation is required.

The power supply mains should be properly fused according to the National Electrical Code. The recommended fuse is a European Type T fuse.

Ground leakage current exceeds 3.5 mA.

Grounding is required by the input PE terminal.

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

An emergency switch shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator and that is clearly marked as the emergency disconnecting device for the equipment.

Field wiring must be suitable for at least 80 °C for operating ambient temperatures expected to exceed 55 °C.

For ATEX compliance, this equipment must be installed in an area providing adequate protection against the entry of dust or water. A minimum ingress protection rating of IP54 is required for the enclosure per EN60529. The interior of the enclosure shall not be accessible in normal operation without the use of a tool and must meet the construction requirements of IEC 60079-0.

For ATEX compliance, this equipment must be protected externally against transient disturbances. Provisions shall be made to prevent the power input from being exceeded by transient disturbances of more than 40% of the rated voltage.

Personnel must discharge their electrostatic build up to the cabinet ground point or use an ESD strap prior to touching the MicroNet or modules if the engine/turbine is operational.

CPU modules contain internal energy limited circuits. These circuits have no external connections and are not affected by module loading.

CPU modules contain single cell primary batteries. These batteries are not to be charged and are not customer replaceable.

For environmental specifications, please refer to the appropriate appendix in Volume 2 of this manual.

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



EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.

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

Do not remove or install power supply while circuit is live unless area is known to be non-hazardous.

Do not remove or install modules while circuit is energized unless area is known to be non-hazardous.

# **AVERTISSEMENT**

RISQUE D'EXPLOSION—Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.

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

Ne pas enlever ni installer l'alimentation électrique pendant que le circuit est sous tension avant de s'assurer que la zone est non dangereuse.

Ne pas enlever ni installer les cartes pendant que le circuit est sous tension à moins de se trouver dans un emplacement non dangereux.

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# Chapter 1. General Information

#### Introduction

This manual describes the Woodward 505DE Digital Governor for process steam turbines. The 505DE is so named because it is based on the 505 and 505E control software, with the addition of Double Extraction turbine capabilities. The 505DE can be configured to control single, double or triple valve turbines. This includes straight through turbines and turbines with single or double controlled extraction and/or admission pressure control. The 505DE utilizes Woodward's MicroNet™ Plus hardware platform. It consists of a VME chassis into which CPU, analog and digital I/O modules are inserted as well as Field Termination modules and interconnect cables. Redundancy can also be introduced to the system in the form of redundant CPU's, selectable redundant I/O, redundant communications, and redundant actuator control. The long chassis Configurations have space for redundant on-board integrating actuator control. The option charts below show the differences between the part numbers. Volume 1 of this manual describes the control, and explains the configuration (programming) and operating procedures. Volume 2 describes the hardware, lists hardware specifications, and provides installation steps.

This manual does not contain instructions for the operation of the complete turbine system. For turbine or plant operating instructions, contact the plant-equipment manufacturer.

Manuals 85017 and 85018 describe the 505 and 505E Digital Governors.

#### **Part Number Options**

Part Number	Power
8262-1023	Configuration # 1 – Short Chassis with AC/DC Power Supply
8262-1024	Configuration # 2 – Short Chassis with HVAC Power Supply
8262-1040	Configuration # 3 – Short Chassis Redundant CPU, I/O & P/S
8262-1041	Configuration # 4 – Short Chassis Redundant CPU, I/O & P/S

Please see Appendix B at the rear of this manual for kit bill of materials.



Remove power from the power supply board before removing it from the chassis. A false alarm will be displayed if a power supply board is powered when it is inserted into the chassis.

## **General Description**

#### General

The 505DE is a 32-bit microprocessor-based control designed to control single valve, single extraction, single extraction/admission, single admission, or double extraction steam turbines. The 505DE is field programmable, which allows a single design to be used in many different control applications and reduces both cost and delivery time. It uses menu driven software to instruct site engineers on programming the control to a specific generator or mechanical drive application. The 505DE can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

#### **Operator Control Panel**

The 505DE is field configurable and operable via its Personal Computer Interface program. This can be run on any laptop meeting performance requirements, or is available in a plug and play touch screen version. It provides an interface for programming the 505DE and performing Engineering tasks as well as an HMI for operating the unit. The 505DE PCI can also be set up to be an operator or viewing interface only. It communicates with the 505DE hardware over an Ethernet connection and uses the Modbus® \* TCP protocol.

\*—Modbus is a trademark of Schneider Automation Inc.

#### **Turbine Control Parameters**

The 505DE interfaces with one, two or three control valves to control one, two or three parameters and limit additional parameters if desired. The controlled parameters are typically speed (or load) and first and/or second extraction/admission pressure (or flow). However, the 505DE can be utilized to control or limit: turbine inlet pressure or flow, exhaust (back) pressure or flow, first stage pressure, generator power output, plant import and/or export levels, compressor inlet or discharge pressure or flow, unit/plant frequency, process temperature, or any other turbine related process parameter. Refer to Volume 2 for details on applications.

#### Communications

The 505DE can communicate directly with plant Distributed Control Systems and/or CRT based operator control panels, through multiple Modbus communication ports. One serial and one Ethernet port is available for each CPU used (one or two CPU's). Serial connections support RS-232, RS-422, or RS-485 communications using ASCII or RTU MODBUS transmission protocols. Ethernet connections can be made to Modbus TCP network addresses or to Modbus UDP network ports. Communications between the 505DE and a plant DCS can also be performed through hardwired connections. Since all 505DE PID setpoints can be controlled through analog input signals, interface resolution and control is not sacrificed.

OPC support is available through Woodward's external OPC server program, Servlink OPC Server.

#### **Additional Features**

The 505DE also provides the following features: First-Out Trip Indication (10 total trip inputs), 1-10 millisecond time stamping, Critical Speed Avoidance (3 speed bands), Auto Start Sequence (hot & cold starts), Dual Speed/Load Dynamics, Zero Speed Detection, Peak Speed Indication for Overspeed trip, and Isochronous Load Sharing between units.

#### Using the 505DE

The 505DE control has three normal operating modes, the Program Mode, the Service mode and the Run Mode. The Program Mode is used to select the options needed to configure the control to your specific turbine application. For safety, items contained in program mode can only be accessed while the turbine is shutdown (turbine shutdown is active in the 505DE software). Once the control has been configured, the Program Mode is typically never again used, unless turbine options or operation changes. Once configured, the Run Mode is used to operate the turbine from start-up through shutdown. In Addition to the Program and Run modes, the Service Mode can be used to adjust additional parameters and enhance system operation while the unit is running.

## 505DE Inputs and Outputs

#### **Control Inputs**

Four speed inputs that are jumper configurable for MPU (magnetic pickup units) inputs or proximity probes are available. Input one is always active.

There are 24 analog inputs are available. All are configurable.

There are 96 contact inputs available. Four are dedicated for shutdown, reset, raise speed setpoint, and lower speed setpoint. Another two contact inputs must be dedicated for generator breaker and utility tie breaker if the control is used in a generator application. Additional contact inputs can be configured as needed.

All configurable functions exist twice in the selection menu to allow for redundancy. To make an input redundant, select the first occurrence on one channel and the second, "redundant" occurrence on another. When an input is redundant, it is always assumed that availability is the highest priority, thus high signal select logic is used for control, while an alarm will notify the user that a redundant input has a mis-match.

#### **Control Outputs**

The 505DE offers six proportional actuator outputs (0-200 mA) (three in redundant configurations).

Twelve 4–20 mA outputs are available, for meters or other readouts.

The 505DE has 48 Form-C relay contact outputs and all but are configurable. The dedicated relay outputs are for shutdown and alarm indication.

#### **Control Communications**

Serial Modbus ports, to be used as control interfaces. The protocol can be either ASCII or RTU and the communications can be RS-232, RS-422, or RS-485.

Ethernet Modbus ports, to be used as control interfaces. The protocol can be either TCP or UDP. External (PC required) OPC server support is available.

#### **Control Overview**

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

The 505DE has three independent "S-term" control channels available, the speed/load and two auxiliary controllers. The outputs of these two controllers are low-signal-selected (LSS) to provide to speed/load demand signal to the ratio/limiter. In addition to these channels, the speed/ load controller can be manipulated by another controller, the cascade controller. The cascade controller is 'cascaded' into the speed controller, whereby the speed controller setpoint is changed directly by the cascade controller output. The auxiliary controllers can act as either control channels or as limiting channels, or one of each. All four of these PID controllers have the option of utilizing an analog input signal to remotely position their setpoints. Additional features of the 505DE include frequency control, isochronous load sharing, critical speed avoidance, idle/rated control, and an automatic start sequence. There serial and Ethernet communications ports which can be used to monitor and control the turbine using Modbus protocol.

#### **About Valve Nomenclature**

When configuring the 505DE, valves are referred to as V1, V2, and V3 since the 505DE can be configured to control one, two or three valves. In the context of single extraction turbines, this manual may refer to V1 and V2 as HP and LP valves when appropriate to the concept being described. Likewise, in the context of double extraction turbines, V1, V2 and V3 may be referred to as HP, IP and LP, when appropriate. For single valve turbines V1 is always the HP or inlet valve. For split range turbines, the second valve controlled by the HP or V1 demand, but offset by a configurable curve, is referred to as V1B. It is possible to configure a split range inlet configuration for any turbine type.

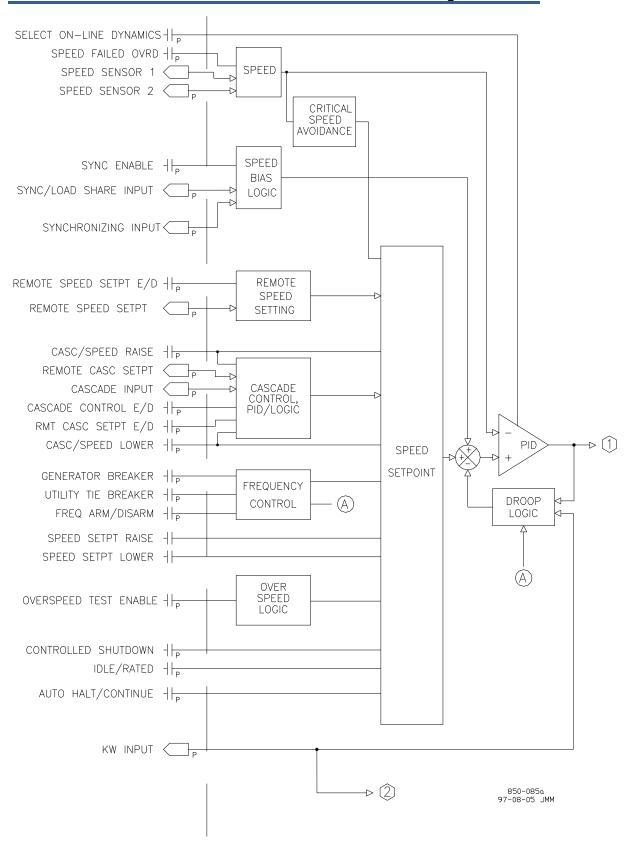


Figure 1-1. Overview of 505DE Single Valve Turbine Functionality

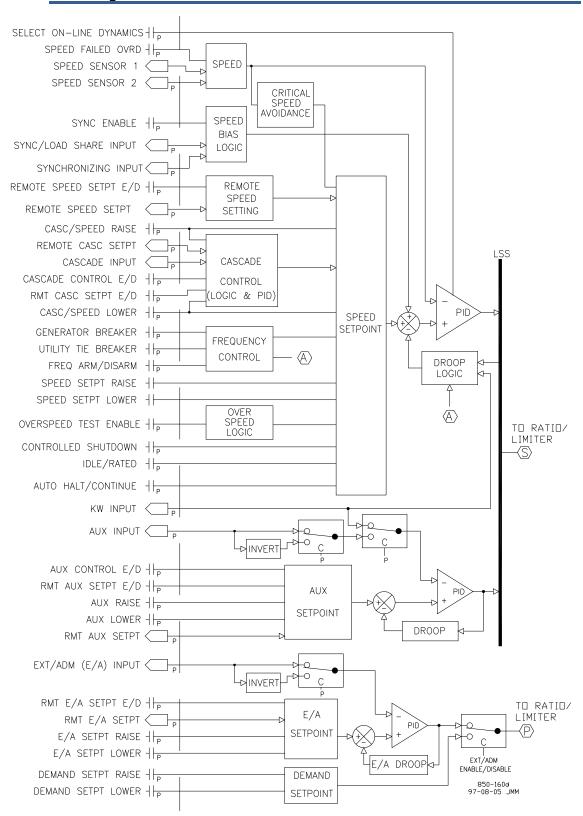


Figure 1-2. Overview of 505DE Single Extraction/Admission Functionality

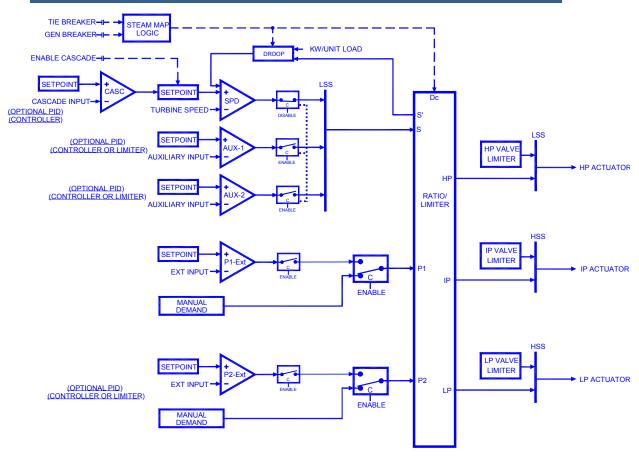


Figure 1-3. Overview of 505DE Double Extraction Functionality

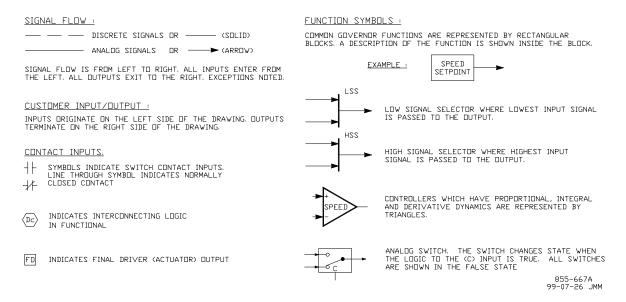


Figure 1-4. Overview of 505DE Functionality (Notes)

"Automatic" extraction, admission, extraction/admission or double extraction refers to the fact that the valve is controlled to some parameter. A "non-automatic" case would be where there is no valve changing flow between turbine sections, and extraction or admission occurs as the backpressure of the turbine exceeds or lags the header pressure. The 505DE is designed to control automatic turbines, although may be applicable for some non-automatic cases.

For the extraction and/or admission cases described here, the extraction and/or admission control valves are all shown in the steam path after the extraction and/or admission port. For cases where the valves precede the port, reverse the valve output.

#### **Single Valve Turbines**

The 505DE is defaulted to control single valve turbines. Single valve turbines generate a single valve demand to control inlet steam to the turbine. Split range turbines control a second valve utilizing the same inlet valve demand, but offset by a configurable curve. Because only one demand is used, split range turbines are still classified as single valve turbines, as opposed to extraction/admission or multiple extraction turbines.

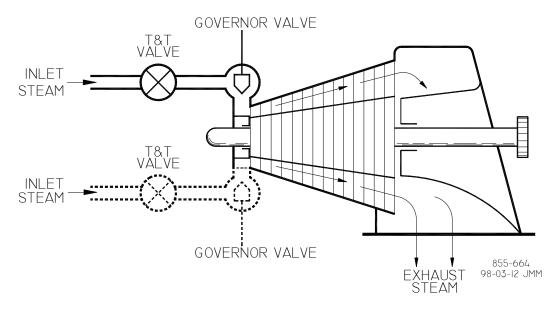


Figure 1-5. Typical Single or Dual Inlet Steam Turbine

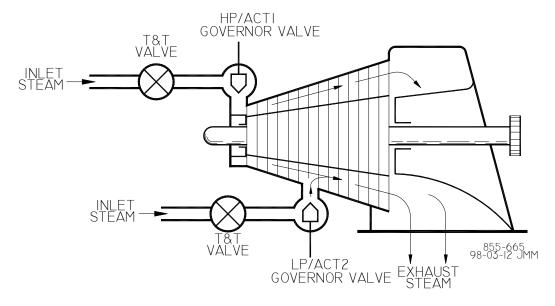


Figure 1-6. Split Range or Admission Type of Turbine Configuration

#### **Single Extraction Turbines**

The 505DE control 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.

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 1-7). 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 505DE's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.

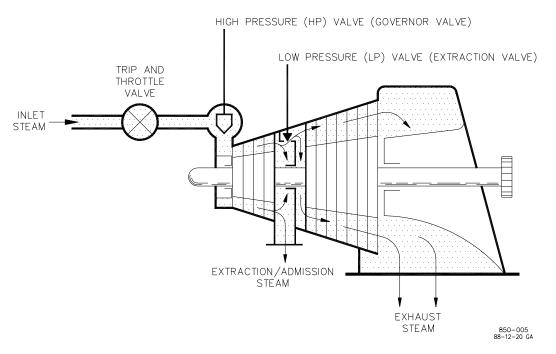


Figure 1-7. Typical Extraction and/or Admission Steam Turbine

#### **Single Admission Turbines**

The 505DE control can be configured to operate single automatic admission turbines by controlling the interaction of the governor (HP or high pressure) valve and the extraction (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 1-8) and at the downstream end of the HP turbine stage, before 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 505DE's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.

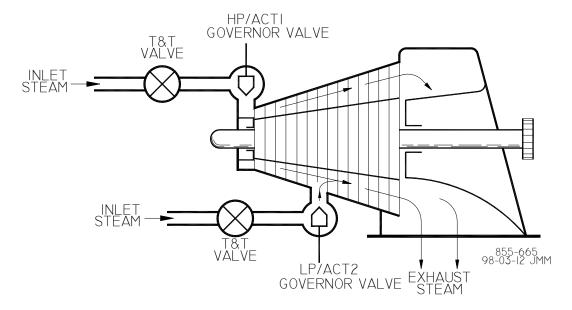


Figure 1-8. Typical Admission Steam Turbine

#### Single Extraction and Admission Turbines

The 505DE control 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 and 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. 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 turbine needs to maintain both turbine speed/ load and extraction or 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 or 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 505DE's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.

#### **Double Extraction Turbines**

The 505DE control can be configured to operate double automatic extraction turbines by controlling the interaction of the governor (HP or high pressure) valve and two extraction (IP or Intermediate pressure and LP or low pressure) valves.

Double automatic extraction turbines have a high pressure stage, an intermediate pressure stage, and a low pressure stage, each controlled by a valve. Steam enters the turbine through the HP valve (see Figure 1-9). At the downstream end of the HP turbine stage and before the IP valve, steam can be extracted. Also, at the downstream end of the IP stage and before the LP valve, steam can be extracted. The IP and LP valves control the entry of steam into the IP and LP turbine stages, and the diverting of steam through the extraction lines. As the IP and LP valves are opened, more steam enters the IP and LP stages and less is extracted.

In most cases, the operator of a double extraction turbine needs to maintain both turbine speed/ load and IP and LP extraction pressure/flow at constant levels. Changing the position of the HP, IP or LP valves affects turbine speed/load and both extractions. If either the load on the turbine or the extraction demands change, HP, IP, and LP valve positions must be changed to maintain speed/load and extraction. The movement of all valves is automatically calculated by the 505DE's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.

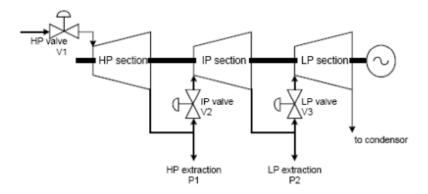


Figure 1-9. Double Extraction Turbine

The following functions apply to all turbine types.

## **Speed Control**

The speed control receives a turbine speed signal from up to four magnetic pickups or proximity probes. The speed PID (proportional, integral, derivative) control amplifier then compares this signal to the speed setpoint to generate an output signal to the ratio/ limiter (through a low signal select bus).

The speed control amplifier can also receive a programmable (optional) droop feedback signal to increase the stability of the turbine/governor system. This droop signal can be proportional to the controller's output signal or to the system's generator load (kW) signal.

The speed control's setpoint is adjustable with raise or lower commands through the 505DE HMI, contact inputs or Modbus. The speed setpoint can also be entered directly from the 505DE HMI or Modbus communications. In addition, a remote speed setpoint analog input can be programmed to position the speed setpoint.

#### **Remote Speed Setpoint**

One of the 4–20 mA inputs can be configured to adjust the speed setpoint. Typically, a process control external to the 505DE interfaces with this input to regulate the turbine's speed or load to control a related process.

The remote speed setpoint input directly affects the 505DE's speed setpoint. The maximum rate at which the remote input signal can change the speed setpoint is programmable. When the remote setpoint is enabled, the speed setpoint will move at a much slower rate until the two settings are matched, at which time the speed setpoint will be allowed to move at the maximum rate. The remote speed function can be enabled and disabled as required from the 505DE HMI, remote contact inputs or Modbus.

## **Auxiliary Control**

The 505DE offers two auxiliary control channels that function identically and are both low signal selected with the speed PID output. The Auxiliary control channels can be used to either control a parameter or limit a parameter. The Auxiliary PID controllers can be used to control or limit unit load/power, plant import/export levels, inlet pressure, exhaust pressure, temperature or any other process directly related to turbine load.

The Auxiliary inputs are 4–20 mA current signals. The Auxiliary PID control amplifiers compare their respective input signals with a their respective setpoints to produce control outputs to the digital LSS (low-signal select) bus. The LSS bus sends the lowest signal to the ratio/limiter logic that determines valve position(s). The Auxiliary control amplifiers also have programmable (optional) droop settings to increase system stability.

The Auxiliary setpoints are adjustable with raise or lower commands through the 505DE HMI, through remote contact inputs or through Modbus. Also, the setpoints can be entered directly through the 505DE HMI or Modbus. In addition, analog inputs can be programmed to remotely position the Auxiliary setpoints.

#### **Remote Aux Setpoint**

4–20 mA inputs can be configured to remotely adjust each Auxiliary setpoint. The remote aux setpoint input directly affects the auxiliary setpoint. The maximum rate at which the remote input signal can change the auxiliary setpoint is programmable. When the remote setpoint is enabled, the auxiliary setpoint will move at a much slower rate until the two settings are matched at which time the setpoint will be allowed to move at the maximum rate. The remote aux function can be enabled and disabled as required from the 505DE HMI, the remote contact inputs, or Modbus.

## **Load Sharing and Synchronizing Inputs**

The 505DE is capable of using an analog input to accept a 4-20 mA load sharing and/or synchronizing signal from one of Woodward's Synchronizing and/or load sharing products such as the Digital Synchronizer and Load Control (DSLC™) or the SPM-D. This input in conjunction with the synchronizer and/or load sharing controller allows the control to isochronously load share with any other compatible system. The 505DE's internal summing junction adds this signal with the speed/load PID's reference. In addition to load sharing, the input to the 505DE can be used to synchronize the unit to either the plant bus or to the utility.

#### **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 used as a turbine inlet or exhaust pressure controller.

The Cascade control is a PID controller that compares a 4–20 mA process signal with the Cascade setpoint. The PID controller sets the speed controller setpoint until the process signal and the setpoint match. The Cascade control can also receive a programmable (optional) droop feedback signal to increase control loop stability. This is a direct feedback using a portion of the cascade control amplifier's output.

The Cascade setpoint is adjustable with raise or lower commands through the 505DE HMI, remote contact inputs, or Modbus. Also, the setpoint can be entered directly from the 505DE HMI or through Modbus. In addition, a remote cascade setpoint analog input can be programmed to remotely position the cascade setpoint.

#### **Remote Cascade Setpoint**

One of the 4–20 mA inputs can be configured to remotely adjust the Cascade setpoint. The remote cascade setpoint input directly affects the 505DE's Cascade setpoint. The maximum rate at which the remote input signal can change the Cascade setpoint is programmable and can be changed in the Run mode. When the remote setpoint is enabled, the Cascade setpoint will move at a much slower rate until the two settings are matched at which the setpoint will be allowed to move at the maximum rate. The remote cascade function can be enabled and disabled as required from the 505DE HMI, the remote contact inputs or Modbus.

## **Starting Features**

The 505DE provides options for three different starting modes: automatic, semiautomatic, and manual. One of these modes must be programmed to get the turbine from a shutdown state to speed control at minimum speed. The start mode configured and minimum governor controlling speed will depend on normal plant starting procedures and turbine manufacturer's recommendations.

If an idle speed is programmed (either idle/rated or auto start sequence), the 50D5E can provide automatic speed control and critical speed avoidance. A 'Run' command can be given through the 505DE keypad, a remote contact input, or Modbus communications. In addition, an optional 'Start Permissive' contact input can be programmed to prevent a start if, for example, the trip-throttle or stop valve is not closed.

#### Valve Limiters

The 505DE valve limiters limit V1, V2 and V3 (as programmed) valves to aid in starting and shutting down the turbine. The limiters are adjusted through the 505DE HMI, external contact closures, or Modbus commands. When raise or lower commands are received the limiters move up or down, respectively, at the programmed rate.

The output of the V1 (HP) valve limiter is low-signal selected with the output of the ratio/ limiter. The lowest signal will control the V1 valve position, thus the V1 valve limiter limits the maximum V1 valve position.

The outputs of the V2 and V3 valve limiters are high-signal selected with the output of the ratio/ limiter when configured for single or double extraction steam turbines, and low-signal selected when configured for admission or extraction/admission steam turbines, thus the V2 and V3 valve limiters limit the minimum or maximum valve positions depending on the configuration selected.

See the Starting Procedures in Chapter 4 of this manual (Operation) for information on using the valve limiters during start-up. The valve limiters also can be used to troubleshoot system dynamic problems. If it is believed that the 505DE 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 to not allow the system to reach a dangerous operating point.

#### Idle/Rated

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

#### **Auto Start Sequence**

The auto start sequence function gives the operator the ability to start from a programmed idle speed, hold there until the programmed warm-up time has expired, then go to the next programmed idle speed or the programmed rated speed setpoint. From one to three idles can be configured. If one is configured, then the speed setpoint will go to that idle, and when speed reaches the idle, will hold for the required time, then proceed to rated speed. If two are programmed, then the setpoint will go to the first, hold, go to the second, hold, and then proceed to rated speed. If three idle setpoints are programmed, then the setpoint will go to and hold at all three before proceeding to rated speed.

The hold times and the acceleration rates are dependent on whether the turbine is considered 'hot' or 'cold' based on the time the turbine has been shut down. When the turbine is between hot and cold conditions, the control interpolates between the hot and cold data points to determine the appropriate startup rates and hold times.

The auto start sequence can be stopped and started, if desired, by using the auto start sequence halt/continue commands. The selection of halt or continue can be made through the 505DE HMI, remote contact inputs (if configured), or Modbus communications. In addition, the auto start sequence can be programmed to automatically halt at each idle setpoint.

#### **Critical Speed Avoidance**

In many turbines, it is desirable to avoid certain speeds or speed ranges (or pass through them as quickly as possible) due to excessive turbine vibration or other factors. During 505DE programming, from one to three critical speed avoidance bands may be selected. These bands may be any speed ranges that are between idle speed and minimum governor speed. Either the Idle/Rated or the Auto Start Sequence functions must be programmed to perform critical speed avoidance. Within a critical speed range, the 505DE moves the speed setpoint at the critical speed rate programmed and does not allow the speed setpoint to stop within the critical speed avoidance band. If the turbine is accelerating through a critical avoidance band and excessively high vibrations are experienced, selecting the speed setpoint lower command will bring the unit back to the lower limit of the band.

# Extraction/Admission and Double Extraction Controllers

The 505DE has two identical Extraction/Admission Controllers. For a single extraction, extraction/admission or extraction turbine, only one is used. For a double extraction turbine both are used. They are referred to as P1 and P2 for clarity.

Each Extraction/Admission (Extr/Adm) control receives an extraction/admission (4–20 mA) signal from a pressure or flow transducer. Each Extr/Adm PID controller then compares this signal to the setpoint to generate an output signal to the Ratio/Limiter.

Each Extr/Adm control also has a programmable (optional) droop setting to increase the stability of the extraction control loop.

Extr/Adm setpoints are adjustable with raise or lower commands through the 505DE HMI, the remote contact inputs, or Modbus. Also, the setpoints can be entered directly from the 505DE HMI or through Modbus. In addition, remote Extr/Adm setpoint analog inputs can be programmed to remotely position the Extr/Adm setpoint.

#### **Remote Extraction/Admission Setpoint**

4–20 mA inputs can be configured to remotely adjust each Extr/Adm setpoint. The remote setpoint inputs directly affect the 505DE's Extr/Adm setpoints. The maximum rate at which the remote input signal can change a setpoint is programmable and can be changed in the Run mode. When the remote setpoint is enabled, the Extr/Adm setpoint will move at a much slower rate until the two settings are matched, at which point the setpoint will be allowed to move at the maximum rate. The remote setpoint function can be enabled and disabled as required from the 505DE HMI, the remote contact inputs or Modbus.

## Single Extraction/Admission Ratio/Limiter

The Ratio/Limiter receives input signals from the speed (or aux) and Extr/Adm control PIDs. 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 keeps 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 limits the HP or LP valves to maintain speed/load or extraction/ admission demands depending on the priority selected.

#### **Double Extraction/Admission Ratio/Limiter**

The Ratio/Limiter receives input signals from the speed (or aux) and two Extraction control PIDs. The 'ratio' logic uses these signals and, based on the turbine performance parameters, produces three output signals, one to control the HP (or V1) actuator, one to control IP (or V2) actuator and one to control the LP (or V3) actuator. The 'limiter' logic keeps the actuator outputs within the boundaries of the turbine steam map.

The ratio logic controls the interaction of all HP, IP and LP valves to maintain desired turbine speed/load and extractions 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 demands cause the turbine to reach an operating limit, the limiter logic limits the one of HP, IP or LP valves to maintain speed/load or extractions demands depending on the priority selected. While the controller is limiting one parameter, the operating point might hit the other limitation so the controller should limit one other parameter.

The priority defined in the configuration determines which parameter(s) to be sacrifixed. First the lowest priority parameter will be sacrified then the second priority. As there are three parameters there are 6 options for defining the priorities as:

- S-P1-P2
- S-P2-P1
- P1-S-P2
- P1-P2-S
- P2-S-P1
- P2-P1-S

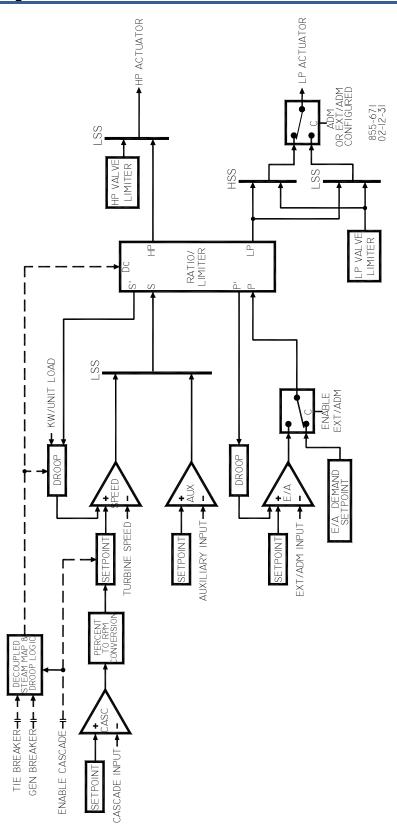


Figure 1-10. Overview with Auxiliary Configured as a Limiter for Single Extraction

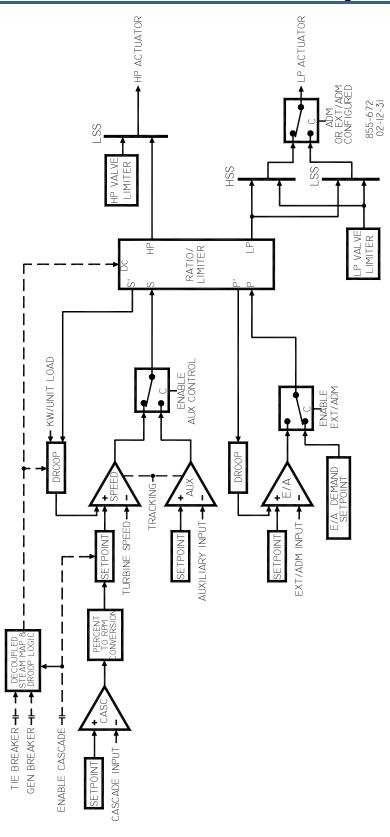


Figure 1-11. Overview with Auxiliary Configured as a Controller for Single Extraction

# **Chapter 2. 505DE Control Description**

The 505DE may be programmed to operate single valve, single extraction, single admission, single extraction/admission, or double extraction turbines.

## **Single Valve Configurations**

For a single valve turbine type, the 505DE uses a simple Low Signal Select Bus (in software) to allow the lowest of three signals to position the turbine's governor valve. This logic is used on all turbine types, but is the primary function of the single valve turbine controller. On EA turbines, the output of this LSS logic feeds the S-term of single or double EA ratio limiters.

The four signals available to control governor valve position are the Speed PID output, two programmable Auxiliary PID outputs, and a valve limiter output. The output of the LSS directly sets the actuator output current (V1 limited by the V1 valve limiter). In the case of a split range turbine, a second actuator (V1B) can be driven by the output of the LSS bus, but offset by a configurable curve.

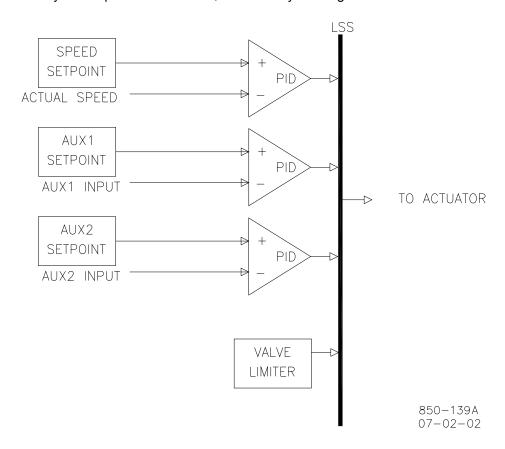


Figure 2-1. Basic Control Overview for Single Valve Turbine

## Single EA Ratio/Limiter Configurations

For single extraction, single admission, and single extraction/admission turbine applications, the 505DE's Single Ratio/Limiting functions may be configured to have the turbine's HP and LP valves (V1 and V2) interact differently depending on the turbine's function within a system.

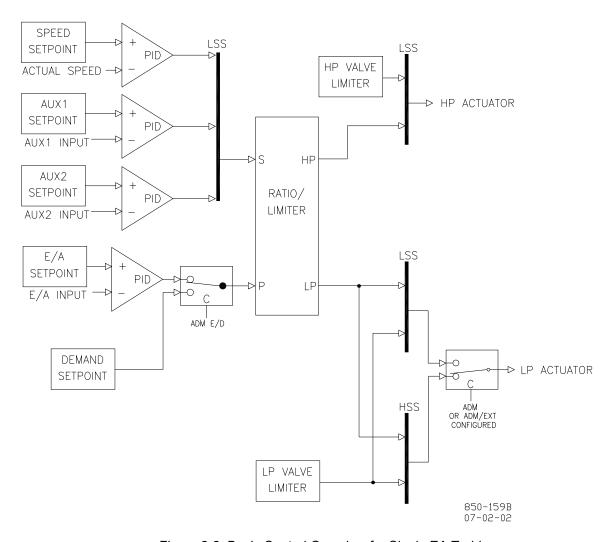


Figure 2-2. Basic Control Overview for Single EA Turbine

The 505DE Single EA Ratio/Limiter receives two input signals. One input signal is from the Speed and Auxiliary PIDs' LSS bus. The second input signal is from a software switch that selects between a Demand setpoint (used for Adm or Extr/Adm applications only) and the Extr/Adm PID. The ratio logic uses these two input signals to produce two output signals, one to control the HP actuator and one to control the LP actuator. The limiter logic keeps the turbine control valves' outputs within the boundaries of the turbine steam map.

The ratio logic controls the interaction of both HP and LP valves to maintain desired turbine speed/load (or Auxiliary or Cascade PID processes) 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 system conditions cause a turbine to reach an operating limit, the limiter logic limits the HP or LP valves to maintain speed/load or extraction/admission levels depending on the priority selected.

Because a single extraction and/or admission turbine has only two control valves, only two parameters at a time can be controlled. Due to a turbine's design, the positioning of either valve (HP or LP) has an effect on both parameters being controlled. This interaction between valves (controlled parameters), can cause undesirable fluctuations in a process not requiring a change.

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 505DE's Ratio/Limiter can be configured in the following operational modes depending on the parameters being controlled and the turbine's function within the system.

#### Ratio/Limiter Configurations:

Coupled HP & LP

#### Single Extraction and/or Admission Coupled HP & LP

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

In this operating mode, the turbine's HP and LP valve actions are coupled (ratioed) together to control both processes without the two processes interacting with each other. For a change in either process both valves are repositioned to create a net effect of no change (pressure, flow, or power) on the other process.

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

#### **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/auxiliary LSS buss and represents Speed, Load, Aux PID, or Casc PID demand. The 'P' input signal originates from the Extr/Adm PID or the E/A demand setpoint, depending on selected modes, and represents Extr/Adm flow demand. 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 'S' and 'P' signals must pass through map limiters, depending on the priority selected, before they are used in the ratioing equations. Only one parameter (S or P) at a time can be limited, thus if speed priority is enabled, only the P signal is limited. If Extr/Adm priority is selected, only the S signal is limited.

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 possible turbine operating limit is labeled and displayed graphically. All Limiters are based on the entered steam map values and actual HP & LP valve positions (as derived from the control's actuator driver signals).

Once the 'S' and 'P' signals pass through their respective limiters, they 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.

The 'HP' output signal represents HP valve demand and is connected to the control's HP LSS bus (refer to Figures 1-1 through 1-5 for signal interconnections). The 'LP' output signal represents LP valve demand and is connected to the control's LP LSS bus (refer to Figures 1-1 through 1-5 for signal interconnections).

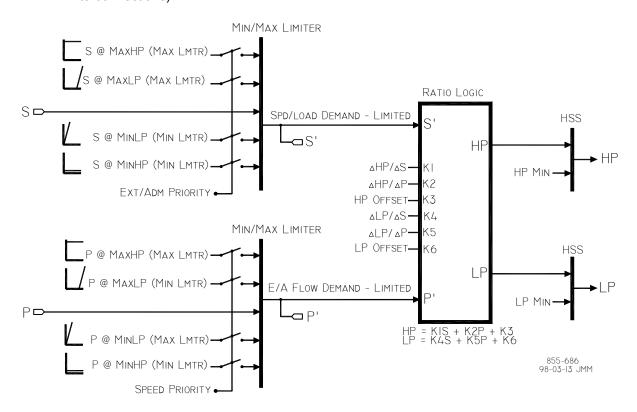


Figure 2-3. Coupled HP & LP Mode for Single EA

## Speed vs. Extr/Adm Priority

Because an extraction and/or admission turbine has two control valves, it can only control two parameters at a time. If the turbine reaches an operating limit, (i.e. a valve fully open or closed) the result is only one free moving valve to control with, thus the 505DE can only control one parameter. It is at these turbine limits that the 505DE can be programmed to select which one parameter will remain in control, or has priority over the other parameter.

If 'Speed priority' is programmed, the 505DE will only control turbine speed/load (Cascade PID process if used, or the Auxiliary PID process if used) when the turbine reaches an operating limit. When programmed for speed priority, the 505DE will maintain speed/load (or Casc or Aux, if programmed) and sacrifice extraction/admission control. With this configuration the Extr/Adm PID is forced to lose control of its process until system conditions change to allow the turbine to move off of an operating limit.

If Extr/Adm priority is programmed, the 505DE will only control the Extr/Adm PID's process when the turbine reaches an operating limit. With this configuration the Speed/ load PID (Cascade PID if used, or Auxiliary PID if used) is forced to lose control of its process until system conditions change to allow the turbine to move off of an operating limit.

If the 505DE is programmed for 'Speed priority only' it will be in Speed priority at all times. If the 505DE is programmed for 'Speed priority with Extr/Adm priority on the LP Max limiter', Speed Priority will be selected at all times except when the LP valve is at its maximum (open) position.

## **Auto Priority Enabling**

If the 505DE is programmed for Extr/Adm priority, Speed priority is initially selected and Extr/Adm priority can be programmed for automatic or manual selection. When 'Auto SW E/A priority' is true, the unit is programmed for automatic selection of Extr/Adm priority and will automatically switch priorities when the following conditions are met:

- Generator and Utility Tie Breaker are closed (if programmed as a gen set)
- Extr/Adm Control is enabled (programmed for Adm or Extr/Adm control)
- Extr/Adm PID is In-Control
- Unit is not on a limiter

Speed priority is again automatically selected if Extr/Adm control is disabled, the generator breaker opens, or the utility tie breaker opens.

#### **Manual Priority Enabling**

The 505DE only accepts an Extr/Adm priority select command if all related permissives are met (see enable permissive list above). An Extr/Adm priority enable (select) command may be given from the 505DE HMI, a contact input, or through Modbus. The last command given from any of these three sources dictates the priority selected.

When a contact input is programmed to function as an Extr/Adm priority select command a closed state represents Extr/Adm priority and an open state represents Speed priority. This contact can either be open or closed when a 505DE 'RUN' command is given. If the contact is open it must be closed to select Extr/Adm priority. If the contact is closed when a trip condition is cleared, it must be opened and re-closed to select Extr/Adm priority. The priority selected can be viewed on the HMI. Optionally a relay can be programmed to externally indicate the priority selected.

To select and de-select Extr/Adm priority from the 505DE, press the "Priority" key to view the Priority Status Screen. With all priority permissives met (listed above) press the "Enable/Disable Alternate Priority" to switch between the normal configured priority or the alternate priority. If a related permissive is not met when an Extr/Adm priority select/deselect command is given the priority will not be transferred and an "Unable to transfer priority" message will be momentarily displayed.

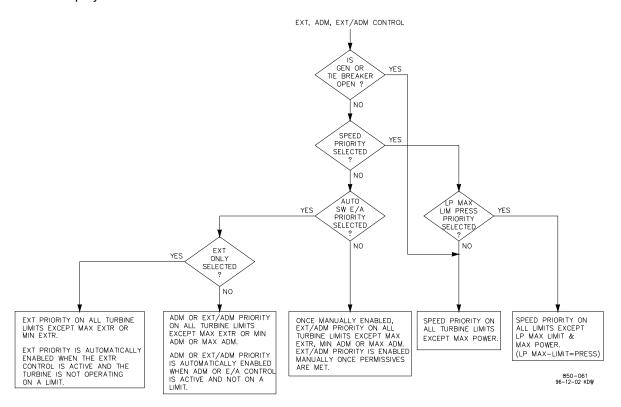


Figure 2-4. Priority Flow Diagram for Single EA Turbines

# **Double Extraction Ratio/Limitter Configurations**

The idea of the double extraction ratio/limiter is similar to single extraction except it uses three inputs and outputs instead of two. The ratio limiter accepts three parameters S, P1 and P2 and produces HP, IP and LP demands. One additional PID controller will be enabled in case when double extraction is configured and is used for controlling the second stage extraction. This PID controller is the same as the one which is used for the extraction/admission application.

Figure 2-5 illustrates the functional block diagram of the double .extraction controller.

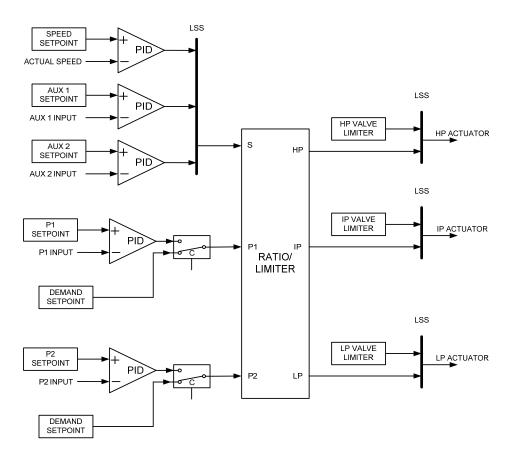


Figure 2-5. Basic Control Overview for Double EA Turbine

## **Turbine Start**

The 505DE has three turbine start modes (manual, semi-automatic or automatic) from which to choose from. One of these start modes must be programmed to perform a system startup. Once a start command is issued, the speed setpoint and HP valve limiter are manipulated automatically by the 505DE or manually by the operator, depending on which start mode is selected. After a turbine start has been completed, turbine speed will be controlled at a minimum controlling speed. The minimum controlling speed may be idle if idle/rated is being used, low idle if the auto start sequence is used, or minimum governor if neither idle/rated nor auto start sequence is used.

A start command may be issued from the 505DE HMI, an external contact, or through Modbus communications. If an 'External Run' contact is programmed, a start 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 command.

If turbine speed is sensed when a start 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 to be taken by the operator, unless auto start sequence is configured. If auto start sequence is configured, the control will pick up the auto start sequence at the appropriate point. If the turbine speed is first sensed within a critical speed avoidance band when start is selected, the speed setpoint will match the actual speed and increase to the upper-end of the critical avoidance band and wait for action to be taken by the operator.

#### **Start Permissive**

An external contact may be used as a turbine startup permissive. When programmed for this functionality, the contact input must be closed in order for a start command to be executed. Should the contact be open when a start command is given, an alarm will be issued and the 505DE HMI (and Modbus alarm) will indicate that the start permissive was not met (Start Perm Not Met). The alarm does not need to be cleared but the contact must be closed before the 505DE will accept a start command. After a start command has been accepted, the start permissive contact will have no effect on operation. If used, this input is typically connected to a Trip & Throttle valve's closed limit switch to verify that it is in the closed position before a turbine startup is performed.

## **Zero Speed Signal Override**

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

#### **Manual Speed Override**

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

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

## **Automatic Speed Override**

If the Manual Speed Override is not programmed, the Automatic Speed Override logic is used by the 505DE to override the loss-of-speed signal shutdown during a turbine startup. With the Automatic Override logic, the loss-of-speed signal shutdown is disarmed when the turbine trips and remains disarmed until the sensed turbine speed exceeds the programmed ('Failed Speed Level' setting + 250 rpm). Once turbine speed exceeds this level, the loss of speed detection circuit is armed and the control will execute a system shutdown if sensed speed drops below the 'Failed Speed Level' setting.

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

#### **Turbine Start Modes**

#### 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)
  - At this point the 505DE will ramp open the V2 and V3 valve limiters to their maximum positions.
  - If programmed as extraction only, the V2 and V3 valve positions will ramp to the maximum limit until extraction is enabled.
  - If programmed for any single admission, the V2 valve position will vary to maintain zero extraction/admission flow.
- 2. Issue a START command (verify T&T valve is closed before issuing)
  - At this point the 505DE will ramp open the V1 valve to its maximum position at the 'V1 Valve Limiter Rate'.
  - The speed setpoint will ramp from zero to the minimum controlling speed setting at the 'Rate to Min' rate.
- 3. Open HP Trip & Throttle valve at a controlled rate
  - When turbine speed increases to the minimum controlling speed, the 505DE's Speed PID will take control of turbine speed by controlling turbine inlet (V1) valve position.
- 4. Open HP Trip & Throttle valve to 100%
  - Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'Auto Start Sequence', if programmed, begins controlling.

At this point extraction, admission, or Extr/Adm may be enabled using the procedures stated later in this chapter.

The V1 Valve Max and Min Limit, V2 and V3 Valve Max and Min Limit, V1, V2 and V3 Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.



The HP trip-and-throttle valve must be closed before selecting START in Manual Start mode. If a START command is given while the trip-and-throttle valve is open, there exists a possibility of turbine runaway with resultant serious injury or loss of life.

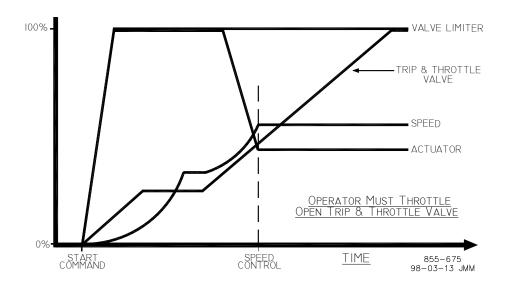


Figure 2-6. Manual Start Mode Example

#### **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)
  - At this point the 505DE will ramp open the V2 and V3 valve limiters to their maximum positions.
  - If programmed as extraction only, the V2 and V3 valve positions will ramp to the maximum limit until extraction is enabled.
  - If programmed for any single admission, the V2 valve position will vary to maintain zero extraction/admission flow.
- 2. Open the HP Trip & Throttle valve (verify that the turbine does not accelerate)
- 3. Issue a START command
  - At this point the speed setpoint will ramp to the minimum controlling speed setting at the 'Rate to Min' rate.
- 4. Raise the 505DE's V1 Valve Limiter at a controlled rate.
  - When turbine speed increases to the minimum controlling speed, the 505DE's Speed PID will take control of turbine speed by controlling turbine inlet (HP) valve position.
- 5. Raise the 505DE's V1 Valve Limiter to 100%.
  - Speed remains controlled at the minimum controlling point until the operator takes action or the 'Auto Start Sequence', if programmed, begins controlling.

At this point extraction, admission, or Extr/Adm may be enabled using the procedures stated later in this chapter.

The V1 valve limiter will open at the 'V1 Valve Limiter Rate' and may be moved using the 505DE HMI, external contacts, or Modbus communications. The V1 Valve Max and Min Limit, V2 and V3 Valve Max and Min Limits, V1, V2 and V3 Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.

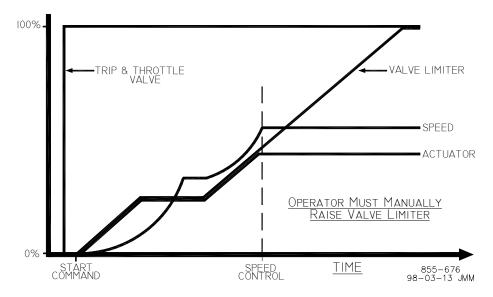


Figure 2-7. Semiautomatic Start Mode Example

#### **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)
  - At this point the 505DE will ramp open the V2 and V3 valve limiters to their maximum positions.
  - If programmed as extraction only, the V2 and V3 valve positions will ramp to the maximum limit until extraction is enabled.
  - If programmed for any single admission, the V2 valve position will vary to maintain zero extraction/admission flow.
- 2. Open the HP Trip & Throttle valve (verify that the turbine does not accelerate)
- 3. Issue a START command
  - At this point the 505DE will ramp open the V1 valve to its maximum position at the 'V1 valve Limiter Rate' setting.
  - The speed setpoint will ramp to the minimum controlling speed setting at the 'Rate to Min' rate.
  - When turbine speed increases and matches the ramping speed setpoint, the 505DE's Speed PID will take control of turbine speed by controlling turbine inlet valve (V1) position.
  - Speed remains controlled at the minimum controlling setpoint until the operator takes action or the 'Auto Start Sequence', if programmed, begins controlling.

 At this point extraction, admission, or Extr/Adm may be enabled using the procedures stated later in this chapter.

The automatic start routine may be aborted at any time by issuing V1 valve limiter raise or lower commands, or an emergency shutdown. The V1 Valve Max and Min Limit, V2 and V3 Valve Max and Min Limit, V1, V2 and V3 Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.

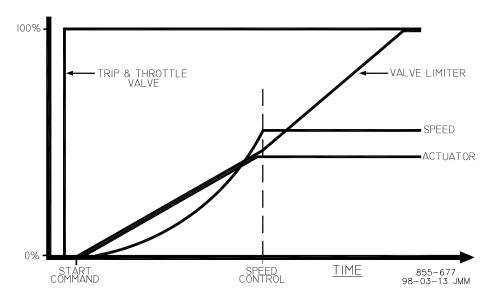


Figure 2-8. Automatic Start Mode

# **Critical Speed Avoidance**

In many turbines, it is desirable to avoid certain speeds or speed ranges (or pass through them as quickly as possible) due to excessive turbine vibration or other factors. During programming, from one to three critical speed ranges may be configured. The Idle/Rated or Auto Start Sequence function must be programmed to perform critical speed avoidance.

The speed setpoint cannot be stopped in a critical band. If a Raise/Lower Speed Setpoint command is issued while in a critical band, the speed setpoint will ramp up or down (up on a raise command and down on a lower command) to the extent of the critical range. Since the lower speed setpoint has priority over a raise setpoint, issuing a lower command while increasing through the band will reverse the setpoint direction and return it to the lower limit of the band. If a lower speed setpoint 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 (via 505DE HMI or Modbus) within the programmed critical speed band settings. In the event this is attempted, an alarm will be annunciated.

During a startup routine if the Speed PID cannot accelerate the unit through a programmed band within a calculated length of time, a "Stuck in Critical" alarm will be issued. The "calculated length of time" is a value of 2.5 times the length of time it should normally take to accelerate through the band (based on the "Critical Speed Rate" and the length of the critical band). If the "Stuck in Critical" alarm occurs on a regular basis, it may be indicating that the "Critical Speed Rate" is set too fast for the turbine to respond to. At 5 times the length of time, the 505DE will trip the turbine.

If another controlling parameter, besides the Speed PID, drives the turbine's speed into a critical band for longer than 2.5 times the length of time it should normally take to accelerate through the band then an alarm will occur (Stuck in Critical). If this occurs for 5 times the time it should take, then the unit will trip.

Critical speed bands are defined in the Program as shown in the Configuration Chapter of this manual. All critical speed band settings must be set between the "Idle Speed" and the "Min Governor Speed Setpoint" settings. A configure error will occur if an idle setpoint is programmed within a critical speed band. The 'Critical Speed Rate' setting sets the rate that the speed setpoint moves through a critical speed band. The 'Critical Speed Rate' setting should be set at but no higher than the turbine's rated maximum acceleration rate.

#### Idle/Rated

The 505DE is equipped with an Idle/Rated function that allows it to automatically ramp turbine speed to the application's Rated speed setting. When deselected, the turbine speed ramps down to the idle speed setting (see Idle Priority and Ramp To Idle in the start configuration section).

The Idle/Rated function can be used with any 505DE start mode (manual, semiautomatic, automatic). When a START command is issued, the speed setpoint will ramp from zero RPM up to and hold at the 'Idle Setpoint'. When a ramp-to-rated command is given, the speed setpoint ramps to the 'Rated Setpoint' at the 'Idle/Rated Rate'. While ramping to a Rated speed, the setpoint can be stopped by a raise or lower speed command or a valid entered speed setpoint.

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

#### Ramp to Rated Feature

The Idle/Rated function can be changed to a ramp to rated function (program 'no' for the Ramp To Idle function in the start configuration). With this configuration, the speed setpoint holds at the idle speed setting until a Ramp-to-Rated command is given. Upon command the speed setpoint will accelerate to the Rated speed setpoint, however, it will not ramp back to the idle speed setting. When Rated is de-selected, the speed setpoint stops as opposed to returning to Idle. When this configuration is used, there is no Ramp-to-Idle option; it is not used.

If Rated is de-selected while in a critical speed avoidance band (using Ramp to Rated only feature), the speed 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 limit of the band if a Raise command was used or will reverse direction to the lower limit of the band if a Lower command was used.

If Idle is selected while in a critical speed avoidance band (not using Ramp to Rated only feature), the speed setpoint will return to the idle setpoint, 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 rated while in a critical band will continue the speed setpoint to the upper limit of the band if a Raise command was used or will reverse direction to the lower limit of the band if a Lower command was used.

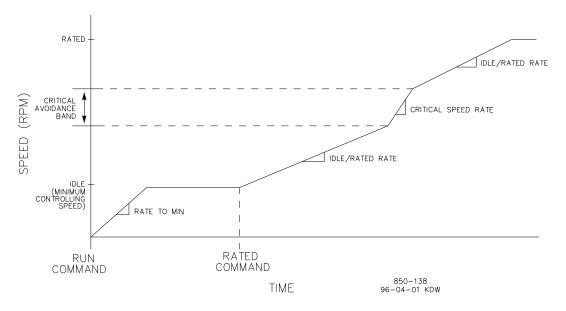


Figure 2-9. Idle / Rated Start

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

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

When the turbine is used for mechanical drive applications, rated speed may be set at or above the minimum governor speed setting. When the turbine is used to drive a generator, "rated speed" setpoint may be set at minimum governor speed, at synchronous speed, or at any intermediate speed setting.

All pertinent Idle/Rated parameters are available through Modbus. See Volume 2, Chapter 7 for a complete listing.

# **Automatic Start Sequence**



This function is not the same as the 'AUTOMATIC START MODE'. The Automatic Start Sequence can be used with any one of the three start modes. After the selected start mode (manual, semi-auto, auto) brings speed to the first configured auto start sequence Idle setpoint at the rate to min, the auto start sequence takes over to bring speed to subsequent idle setpoint and finally to rated speed.

The 505DE can be configured to utilize an Automatic Start Sequence to start the turbine. This sequencing logic allows the 505DE to perform a complete controlled system startup from zero speed to rated speed. With this function, the turbine's starting ramp rates and idle speed hold times depend on the length of time the unit was shut down. This sequence logic may be used with any of the three start modes (manual, semiautomatic, automatic).

Using the Auto Start Sequence function, when a START command is given, the chosen start mode (manual, semi-auto, auto) ramps the speed setpoint towards Min Governor at the rate to min, as in any start. However, all Auto Start Sequence idle points must be below min governor, so the speed setpoint will encounter the first configured Auto Start Sequence idle setpoint while ramping up under control of the selected start mode. At the first configured Auto Start Sequence idle point, the Auto Start Sequence will take control, and hold the speed setpoint at this setting for the configured duration. When the hold time expires, the Auto Start Sequence ramps the speed setpoint to the next configured idle setpoint or rated speed, holding for the configured duration at each configured idle point, always finishing at rated speed. Up to three idle points and hold times may be configured. All ramp rates and hold times are programmable for both hot start and cold start conditions. The control differentiates between hot and cold starts by using a hours-since-trip timer. This timer starts when a shutdown has been executed and turbine speed has decreased below the low idle speed setting.

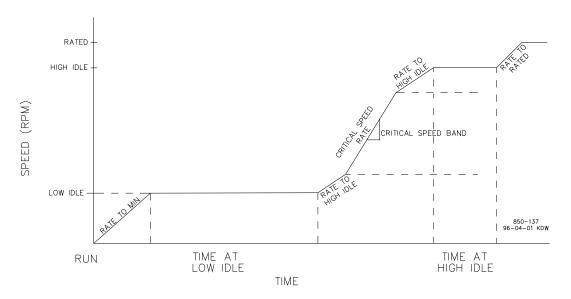


Figure 2-10. Automatic Start Sequence with two idle points configured

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

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

For example, if the unit had 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 = 10 MIN LOW IDLE DELAY (HOT) = 2000 RPM HI IDLE SETPT RATE TO HI IDLE (COLD) = 5 RPM/SEC RATE TO HI IDLE (HOT) = 15 RPM/SEC HI IDLE DELAY TIME (COLD) = 20 MIN HI IDLE DELAY TIME (HOT) = 30 MIN RATE TO RATED (COLD) = 10 RPM/SEC RATE TO RATED (HOT) = 20 RPM/SEC RATED SETPT = 3400 RPM

If the unit was tripped for 12 hours, the 505DE would interpolate between the Hot and Cold parameters and use the following rates and delays (viewed in the Service Mode):

LOW IDLE DELAY = 20 MIN
RATE TO HI IDLE = 10 RPM/SEC
HI IDLE DELAY = 10 MIN
RATE TO RATED = 15 RPM/SEC
HOURS SINCE TRIP (HRS) = 12 hrs

Based on the example's configuration and trip time, the speed setpoint would ramp to 1000 rpm at the 'Rate to Min' setting and hold for 20 minutes, 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.

If the unit was tripped for 2 hours or less and restarted, the 505DE would use the Hot Start parameters. If the unit was tripped for 22 hours or longer and restarted, the 505DE would use the Cold Start parameters. The 'Hours since Trip' timer starts counting when the unit shuts down and the speed has coasted down below the low idle speed setting.



The 505DE will automatically set the hours-since-trip timer to its maximum setting of 200 hours to ensure a cold start is selected after a power up or upon exiting the Program mode. The hours-since-trip timer will reset only when the turbine speed has increased above the minimum governor speed setting.

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

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

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

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

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

# No Idle Programmed (No Auto Start Type)

If neither the Idle/Rated nor Auto Start Sequence functions are programmed, the speed setpoint will ramp from zero to the minimum governor setpoint at the 'Rate To Min' setting rate. Critical speed bands cannot be programmed with this configuration.

# Speed Control Overview

Turbine speed is sensed through one to four MPUs or proximity probes. The 'MPU Gear Ratio' and the 'Teeth Seen By MPU' settings are configured to allow the 505DE to calculate actual turbine speed. MPUs and proximity probes can be used at the same time, however, they must be mounted on the same gear since the 'gear ratio' and 'teeth seen by the MPU' must be the same for all inputs. The 505DE's Speed PID (proportional, integral, derivative control amplifier) then compares this speed signal to a setpoint to generate an speed/load demand signal to the ratio/limiter (through a low signal select bus).

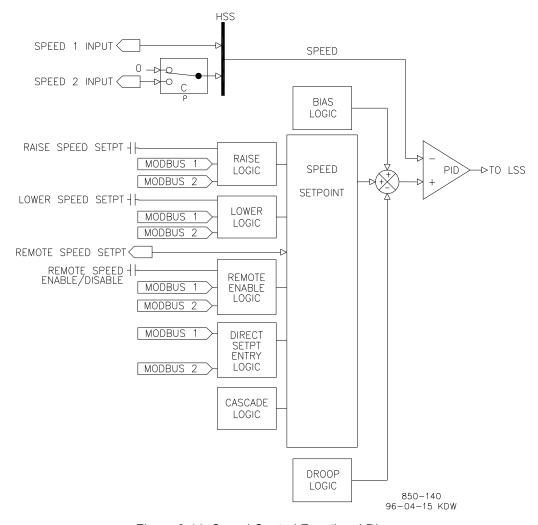


Figure 2-11. Speed Control Functional Diagram



A passive MPU or active proximity probe can be used on any speed input with a slight wiring difference at the 505DE Field Termination Module. See the hardware manual for wiring diagrams.



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

 $(T \times M \times R) / 60 \text{ must be} < 20000 \text{ Hz}$ 

T = Gear Teeth

M = Overspeed Test Limit Setting

R = Gear Ratio

# **Speed PID Operational Modes**

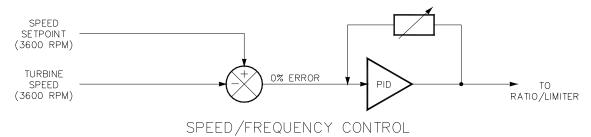
The Speed PID operates in one of the following modes, depending on configuration and system conditions:

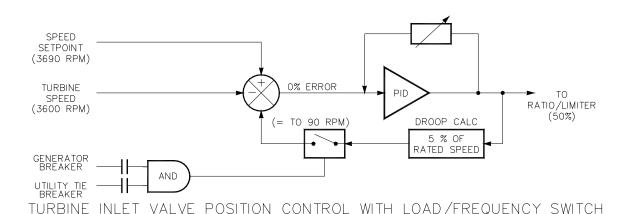
- 1. Speed Control
- 2. Frequency Control
- 3. Unit Load Control (droop)
  - Turbine HP and LP valve position control
  - Generator Load control

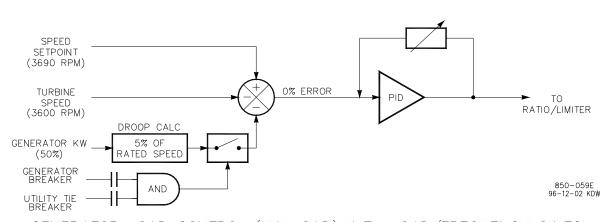
## **Speed Control**

When not programmed for generator applications, the 505DE Speed PID operates in a Speed control mode at all times. When programmed for generator applications, the state of the generator and utility breakers determine the operational mode of the Speed PID. If the Generator breaker contact is open, the Speed PID operates in a Speed control mode. If the generator breaker is closed and the utility breaker is open, then Frequency control mode is selected. When both the generator and utility breakers are closed, a Unit Load control mode is selected.

While in the Speed Control mode, the Speed PID will control a turbine at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). In speed control mode, the Speed PID does not use droop or a second controlling parameter for stability. Refer to Figure 2-12.







GENERATOR LOAD CONTROL (KW LOAD) WITH LOAD/FREQUENCY SWITCH

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Figure 2-12. Speed PID Control Modes

All pertinent speed control parameters are available through Modbus communications. See Volume 2, Chapter 7 for a list of all Modbus parameters.

## **Frequency Control**

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

The Speed PID operates in a Frequency control mode when the generator breaker is closed and the utility breaker is open. In this mode the unit will operate at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability).

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

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

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

#### **Unit Load Control**

The 505DE's Speed PID can control two independent parameters when the generator breaker is closed; frequency when the generator is isolated (utility breaker open), and unit load when the generator is paralleled with an infinite bus. When the 505DE's generator and utility breaker inputs are both closed, the Speed PID operates in a Unit Load mode. In this mode the speed / frequency of the turbine is locked to that of the infinite bus, so movement of the Speed PID output changes unit load. This method of allowing a PID to control a second parameter (in this case when the first is fixed by an external control) is referred to as droop.

In load control (droop) mode, since the infinite bus fixes speed, a change in the Speed PID controls unit load. However, the Speed PID can also move unit load in response to a change in the frequency of the infinite bus, acting as a stabilizing influence to counteract any change in bus frequency. When bus frequency decreases or increases, unit load increases and decreases respectively, based on the unit's droop setting. In combination with other drooped generators on the bus responding in the same fashion, the net effect is a more stable bus. See Figure 2-13 for a frequency and load relationship diagram. A configurable deadband allows the 505DE to ignore small changes in bus speed/frequency, but react to more significant ones. The deadband is especially necessary in regions with unstable utility bus frequencies.

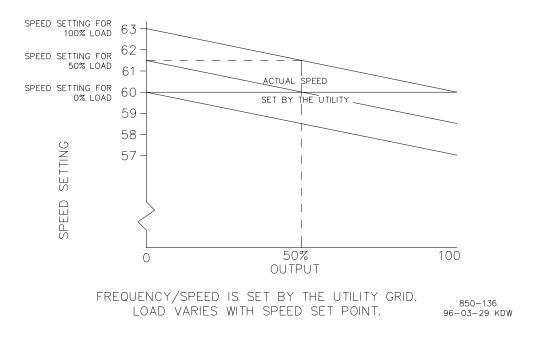


Figure 2-13. Frequency and Unit Load Relationship

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

DROOP % x (gen load or valve positions-%) x Rated Speed = Setpoint change in RPM

Example: 5% x 100% x 3600 rpm = 180 rpm

For this example when paralleled to a utility bus, the speed setpoint can be adjusted from 3600 rpm to 3780 rpm to vary unit load from 0 to 100%. The 'Maximum Governor Speed' setting should be programmed as 3780 rpm.

Droop feedback allows the Speed PID to control unit load (generator power or HP & LP valve positions) once it is paralleled with a utility bus or other generating system that does not have droop or load sharing capability. When a turbine generator set is paralleled with a utility bus, the utility determines the unit frequency/speed, thus the 505DE must control another parameter.

The 505DE senses unit load through the turbine HP and LP valve positions or an analog input from a watt transducer sensing generator load. HP and LP valve positions are sensed by their respective 0-100% actuator drive currents. Thus the calibration of drive current to actual valve position is very critical, and should be adjusted as close as possible, including linearization of the valves to represent 0-100% load over the full range of valve travel.

It is recommended that a Woodward Real Power Sensor, Woodward UMT or equivalent watt transducer be used to sense generator load and feed it back to the 505DE's kW input for kW droop control. However, if kW droop is not used or programmed, the 505DE uses a calculated load value based off of turbine's HP and LP valve positions when paralleled with an infinite bus. If the kW input signal fails while controlling generator load the 505DE will issue an alarm and revert to its internal calculated load value.

To configure the 505DE for generator load control when paralleled to a infinite bus, program the 'kW DROOP' setting to 'YES', and program the 505DE to accept an analog input from a Watt transducer sensing generator load. To configure the 505DE for turbine valve position control when paralleled to an infinite bus, program the KW DROOP setting to 'NO'. The Speed PID's droop percentage, (generator load or turbine valve positions) cannot be set greater that 10%, and is typically set at 5%.

If the 505DE is programmed to control unit load using turbine valve positions, the 505DE calculates load based on the valve positions at the time the generator breaker is closed. The valve positions at this point are considered to be zero load. In a typical application, where inlet and exhaust pressures are at rated levels when the generator breaker is closed, this zero load calculation allows unit load to be accurately sensed and controlled.

To obtain a more accurate calculated load when using valve position control (no KW DROOP), load the turbine throughout its range, adjusting the valve curves to match the Speed demand to load percentage as measured from an external source.

## **Speed Setpoint**

The Speed PID's setpoint may be adjusted from the 505DE HMI, external contacts, Modbus commands, or through a 4–20 mA analog input. A specific setpoint can also be directly entered through the 505DE HMI or Modbus communications. The Cascade PID directly controls the speed setpoint when Cascade is active.

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

When configuring the speed setpoints, note that they are for the most part limited by the value above them. Start with Overspeed Test Limit and work downward.

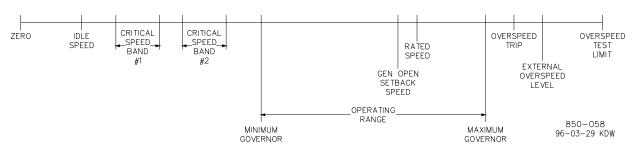


Figure 2-14. Speed Relationships

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

The shortest length of time a setpoint will move for an accepted raise or lower command via contact input is 120 milliseconds (240 milliseconds for a 505DE HMI or Modbus command). If the speed setpoint rate is programmed for 10 rpm/sec, the smallest increment it will move is 1.2 rpm (2.4 rpm for 505DE HMI and Modbus).

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

After a valid setpoint value is entered and accepted, the setpoint will ramp at the speed setpoint slow rate to the newly entered setpoint value. The rate that the setpoint ramps at when a specific value is entered may be changed from its defaulted value by changing the 'Entered' rate setting in the Speed Settings configuration section.

When entering a setpoint from the 505DE HMI, the 505DE checks the validity of the new entered setpoint. The speed setpoint must be below the maximum governor setting and above the idle setting and not within a critical speed avoidance band. Once the speed setpoint is above the minimum governor setting, the setpoint cannot be set below minimum governor. Also, if the unit is driving a generator and the unit is on-line, the speed setpoint cannot be set below the minimum load setting. The minimum load setting is defaulted to a 3% load setting (changeable in the Service Mode).

The speed setpoint can also be directly entered through Modbus; however, the allowed range is between the minimum governor and the maximum governor speed settings. With generator applications, the allowed setpoint range is limited to between the minimum load and the maximum governor settings if the unit is on-line.

When the 505DE is configured for a generator application, a special speed setpoint rate (Sync Window Rate) is used to increase setpoint resolution around synchronous speed. This allows for tighter setpoint control to accommodate synchronizing manually or by an automatic synchronizer interfacing to the 505DE via contact inputs. This Sync Window Rate is defaulted to two rpm/sec and is only used when the generator breaker is open and the speed setpoint is within 10 rpm of rated speed. Both the synchronizing rate and the synchronizing window are tunable in the Service mode.

When configured for generator applications a Minimum Load setpoint is used by the 505DE to reduce the chance of reverse powering a unit upon closing the generator breaker. With the utility breaker closed, when a generator breaker closed indication is received, the Speed setpoint is stepped to the Minimum Load setting. The Minimum Load setting is defaulted to 3% (changeable in the Service Mode). To disable the use of the Minimum Load Setpoint, configure the 'Use Min Load' setting to 'No'.

See Volume 2, Chapter 7 for a list of all speed-setpoint-related Modbus parameters.

## Frequency Arm/Disarm

The Frequency Arm/Disarm feature may be used when multiple generator sets are on a common isolated bus and no load sharing is used. With this feature, one unit on a multiple unit isolated bus controls frequency and the other units operate in a unit-load mode. The unit controlling frequency is referred to as the "Swing Machine" because its load will swing (vary) depending on the load of the plant while it controls frequency. Caution should be taken with this configuration to not allow the Swing Machine to be overloaded or reverse powered.

This feature, when programmed, allows an operator to select one unit out of all the units on an isolated bus to function as the swing machine, and to change the operating swing machine while in operation. The other units on the bus then operate in a drooped or base-loaded mode. Frequency control can be armed or disarmed while connected to an isolated or infinite bus. When armed, a unit will go to Frequency control if the utility breaker opens. When disarmed, a unit will stay in a unit-load control mode when the plant-to-utility breaker opens.

To use this feature, the program's 'Use Freq Arm/Disarm' setting must be set to 'Yes' and the Sync/Load Sharing mode cannot be programmed. The Frequency Arm/Disarm mode can be selected from a programmed contact input, 505DE HMI, or Modbus command. When the programmed contact input is closed the unit's Frequency control mode is armed. When the programmed contact input is open the unit's Frequency control mode is disarmed.



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

If the program's 'Use Freq Arm/Disarm' setting is set to 'No', Frequency control is always armed and the unit will go into Frequency control when the utility tie contact is open. If the program's 'Use Freq Arm/Disarm' setting is set to 'Yes' then Frequency control must first be armed before the unit will switch into Frequency control when the utility tie contact is open and the generator breaker is closed.

## **Speed Control Dual Dynamics**

The Speed PID has two sets of dynamics: off-line and on-line. When a system has variable response times, due to changing system conditions, these dynamic variables allow the Speed PID to be tuned for optimal response.

When the 505DE is configured for a generator application, the utility and generator breakers determine which set of dynamics the Speed PID will use. The speed PID's off- line dynamics are selected when either the utility or generator breakers are open. The Speed PID's on-line dynamics are selected if both breakers are closed (see Table 2-1).

When not configured for a generator application, the 505DE uses the programmed 'Min Governor Speed Setpoint' setting to determine which set of dynamic values are used by the Speed PID. The Speed PID's off-line dynamics are selected when turbine speed is below the 'Min Governor Speed Setpoint' setting. The Speed PID's on-line dynamics are selected when turbine speed is above the 'Min Governor Speed Setpoint'. (see Table 2-1).

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

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

Dynamic values are defined in the program mode and tunable at any time. Refer to the Dynamic Adjustments section in this manual.

Configuration	On-Line Dynamics Selected	Off-Line Dynamics Selected	
Gen Set	Both Brkrs Closed	Either Brkr Open	
Not A Gen Set	Spd > Min Gov Setting	Spd < Min Gov Setting	
*Contact Input	Closed	Open	

<sup>\*</sup>The contact input option has priority, when programmed.

Table 2-1. On-Line / Off-Line Dynamics Selection

#### **Remote Speed Setpoint**

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

The Remote Speed Setpoint (RSS) range is determined by the programmed Analog input's 4 mA and 20 mA settings. The Remote Speed Setpoint range is tunable in the Service mode but cannot control outside of the min governor and max governor speed setpoint values.

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

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

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

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

## **Remote Speed Setpoint Status Messages**

The Remote Speed Setpoint may be in one of the following states (505DE HMI or Modbus Status Messages):

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

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

All pertinent remote speed setpoint parameters are available through Modbus. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Synchronization**

Automatic generator synchronization can be performed through a Woodward Digital Synchronizer & Load Control (DSLC), or other Woodward synchronizer. The DSLC connects to a 505DE analog input to bias the 505DE's speed setpoint directly to vary generator speed, frequency and phase. Optionally the DSLC can interface with the unit voltage regulator to match system voltage across a generator breaker.

When the 505DE is configured for a Generator application, a special speed setpoint rate (Sync Window Rate) is used to increase setpoint resolution around synchronous speed. This allows for tighter setpoint control to accommodate synchronizing manually or by an automatic synchronizer interfacing to the 505DE via contact inputs. This Sync rate is defaulted to two RPM/SEC and is adjustable in the 505DE's Service mode. This rate is only used when the generator breaker is open the speed setpoint is within 10 RPM of rated speed (also tunable through the Service mode).

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

To configure the 505DE to utilize a DSLC for generator synchronization only, program the 'Synchronizing input' . The 'Synchronizing input' function has preset range and gain settings that are tunable in the Service mode. Thus the 4 mA and 20 mA Program Mode settings for the Synchronizing input are irrelevant and are not used by the function's operation.

A 505DE relay output can also be programmed to select a DSLC's synchronizing mode. A 'ready to synch' relay output is also available to indicate when startup has been completed and the 505DE is ready to accept synchronizing commands.

## Synchronization Status Messages

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

## Synchronizing / Load Sharing

A Woodward Digital Synchronizer & Load Control (DSLC) is used with a 505DE to allow automatic generator synchronization to a bus and the sharing of load with other units (using DSLCs on the same bus). The Woodward DSLC is a microprocessor based generator load control designed for use on three-phase AC generators with Woodward speed controls and automatic voltage regulators.

A DSLC with VAR/Power Factor control, allows all units with DSLCs to reactive load share as well as real power load share. The DSLC senses unit load through generator PTs and CTs and system load through the DSLC LON network (a combination of all units on the network). The DSLC uses a digital Echelon Network (LON) to communicate with other DSLCs on the same bus.

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

After synchronization, unit load can be controlled by the DSLC through the Sync/Load Share input or by the 505DE's internal speed/load setpoint. The Utility Breaker Contact is used to select unit load control through the DSLC or through the 505DE's internal load setpoint. When the 505DE's internal load control is selected (utility tie contact closed), the Speed PID setpoint is used to control unit load. Optionally the Cascade or Auxiliary control modes may be used to set unit load based on another system parameter.

The DSLC interfaces to the 505DE via its Speed Bias signal. The 'Sync/Ld Share input' function has preset range and gain settings that are tunable only in the Service mode (See Volume 2). Thus the 4 mA and 20 mA Program Mode settings for the Synchronizing input are irrelevant and are not used by the function's operation.

A combination of the Utility Breaker contact, Generator Breaker contact, and Sync/Ld Share Enable contact define the state of the 505DE's synchronizing and load sharing operating modes (See Table 2-2).

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

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

When using the 'Sync/Ld Share Enable' contact input, it only enables or disables the 505DE's synchronizing mode (analog input) before the generator breaker is closed. After the generator breaker is closed, this contact is ignored until the generator breaker is again open and the contact has been toggled open and closed again. Typically a double-pole- single-throw (DPST) switch is used in conjunction with this input to enable the 505DE's synchronizing mode and the DSLC's synchronizing mode at the same time (while providing device isolation). Refer to Volume 2, Figure 1-5 of this manual. Optionally the 505DE's synchronizing mode can be enabled from the 505DE HMI.

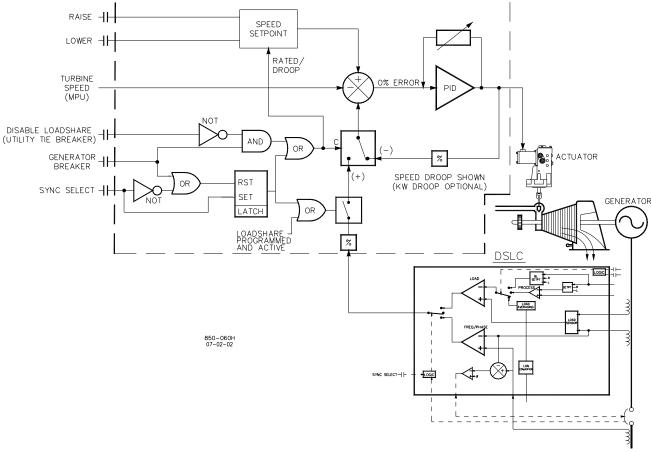


Figure 2-15. Load Sharing Logic

Tie Breaker Contact Status	Gen Breaker Contact Status	Sync/Ld Share Enable Contact	Speed Control Mode	Casc or Aux Modes If Used
Closed	Open	Open	Speed, Off-Line Dynamics	Not Active
Closed	Closed	XXXX	Unit Load Control, On-Line Dynamics	Active
Open	Open	Open	Speed, Off-Line Dynamics	Not Active
Open	Open	Closed	Synchronizing, Off-Line Dynamics	Not Active
Open	Closed	XXXX	Load Sharing, Off-Line Dynamics	Not Active

XXXX = open or closed

Table 2-2. Load Sharing Logic

When the 505DE is programmed to use the DSLC for Synchronization and Load Sharing, the 505DE HMI can be used to access and enable the Sync/Load Share function and monitor all function mode messages. See Chapter 4 for information on how to operate this function. The following Sync/Load Share mode messages can be viewed:

#### Sync/Load Share Status Messages

- Disabled—The Sync/Load Share Input is disabled and will have no effect on the Speed setpoint.
- Enabled—The Sync/Load Share Input has been enabled.
- In Control—The Sync/Load Share Input is biasing the Speed setpoint.
- Inhibited—The Sync/Load Share Input cannot be enabled; the input signal is failed, the turbine is shut down, a controlled shutdown is being performed, or the sync/load share feature is not programmed.

All pertinent synchronizing and load sharing parameters are available through Modbus. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

## **Extraction / Admission Controllers**

This Section describes the P1 Extraction and/or Admission controller. There are two identical Extraction and/or Admission controllers in the 505DE. For clarity they are referred to as P1 and P2, since P1 will control the LP valve in a single EA turbine, and the IP valve on a double extraction turbine. The P2 controller is identical to the P1 controller but is available for extraction only - when the 505DE is configured for a double extraction turbine. The P2 controller will always control the LP valve on a double extraction turbine and is not used for a single EA turbine or single valve turbine. The P1 controller is not used for a single valve turbine.

The P1 PID accepts a 4 to 20 mA current signal from a configured analog input as its controlling parameter. The PID control amplifier compares this input signal to a setpoint to produce an output signal to the control's Ratio/Limiter. A single extraction and/or admission Ratio/Limiter is used for that case, and a double extraction Ratio/Limiter is used when the 505DE is configured for a double extraction turbine. The Ratio/Limiter receives input signals from the Speed LSS and P1 control PIDs when configured for a single EA turbine. When configured for a double extraction turbine, the Ratio/Limiter receives input signals from the Speed LSS, P1 and P2 controllers. The ratio logic ratios these signals, based on the turbine performance parameters, to produce valve demand outputs. For a single EA turbine, one output controls the V1 (HP) valve and one controls the V2 (LP) valve. For a double extraction turbine, one output controls the V3 (LP) valve.

All descriptions of extraction only operation for the P1 controller apply to the P2 controller used when configured for a double extraction turbine. When in control, the P1 controller is in fact controlling all valves through the ratio limiter. This is because any individual valve movement affects the flow to other valves, so those valves need to be moved as well. Ex: If P1 extraction flow needs to increase then V2 will have to close, however because more flow is diverted from the turbine, inlet flow will need to increase to maintain load, so V1 will have to be opened at the same time. However, during enabling and disabling, or during an input failure, the P1 control logic will ramp the V2 valve open or closed as a means to move in to or out of P1 extraction control. Where the V2 valve is referred to when describing P1 control, the P2 controller will be moving the V3 valve.

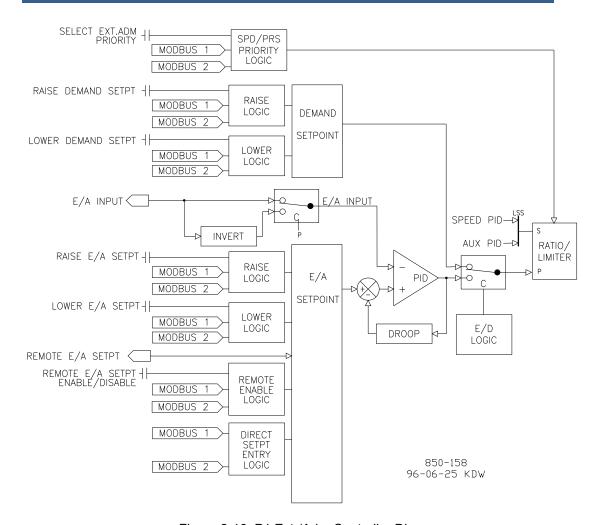


Figure 2-16. P1 Extr/Adm Controller Diagram

#### P1/P2 Controller Input

Depending on the control action required, the P1/P2 PID's input signal can be inverted. When used with a typical extraction, admission or extraction/admission turbine application this input should not require inverting.

Upon a loss of the P1/P2 input signal during operation, the 505DE can be programmed to trip, continue running and ramp the V2/V3 valve to its open limit, continue running and ramp the V2/V3 valve to its closed limit, or to switch to manual mode and maintain the PID demand for P1/P2. When a failed input is sensed the V2/V3 valve limiter steps to the V2/V3 valve's last position, then ramps at a 1% per second rate to its min or max limit, depending on the programmed settings. The 505DE senses an input failure and issues an alarm if the 4–20 mA P1/P2 input signal goes below 2 mA or above 22 mA.

## **Extraction Control**

Extraction control can be automatically or manually enabled and used after one of the 505DE's start modes has been completed, and related permissives met. Typically a turbine is controlling speed/load at a rated speed setting and loaded to a minimum load point before extraction control is enabled. After a start-up, the V1 and V2 valve limiters should normally both be fully open. If the V1 valve limiter is not fully opened, it will act as a speed/load limiter and will interfere with automatic governor operation.

When configured for Extraction control the 505DE's V2 valve limiter is high signal selected with the output of the Ratio/Limiter. Because the V2 valve limiter is automatically ramped to 100% during system start-up, the V2 valve cannot be moved below its 100% open position; except by its valve limiter. All related Extraction enable permissives must be met before the 505DE will allow the P1 PID to take control of a process.

The Extraction and/or Admission enable permissives are:

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

There are two ways of enabling/disabling extraction control: manually or automatically. The manual enable/disable routine requires the operator to use the V2 valve limiter's raise/lower commands to bring the valve position to a point where the P1 controller can take over, and the automatic enable/disable routine automatically lowers the valve limiter when the operator selects enable. Automatic enabling/ disabling can only be performed if the "Automatic Enable?" setting is programmed "Yes". With automatic Extraction enabling programmed, an operator can also manipulate the valve limiter to enable and disable Extraction control manually if desired.

#### Manual Enable / Disable

To manually enable Extraction control slowly lower the V2 valve limiter until the P1 PID takes control of its process, then continue running the V2 valve limiter to its minimum (closed) position. If the V2 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 505DE will allow the V2 valve limiter to be lowered, and Extr/Adm control enabled.

To disable Extraction control slowly raise the V2 valve limiter until the P1 PID loses control of its respective process, then continue to increase the V2 valve limiter to its maximum (open) position.

#### Automatic Enable / Disable

After receiving an enable command, the 505DE will automatically lower the V2 valve limiter at the "V2 valve limiter rate" setting. Once the P1 PID takes control of its process, the LP valve limiter will continue lowering to its minimum (closed) position at five times the "V2 Valve Limiter Rate" setting.

The V2 valve limiter may be stopped at any time during the automatic enabling routine by momentarily issuing a V2 limiter raise or lower command (or by entering a valid setpoint). Stopping the automatic enabling routine halts the V2 valve limiter. The P1 PID's output will still continue to be enabled. This allows an operator to manually adjust the V2 valve limiter as desired. By re-issuing an enable command, the enable routine will continue lowering the V2 valve limiter. If a contact is programmed for this function, it will have to be opened and re-closed to re-issue an enable command.

The 505DE only accepts an Extraction enable command if all related permissives are met (see above list). An enable/disable command may be given from the 505DE HMI, a contact input, or through 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 505DE trip condition is cleared. If the contact is open it must be closed to issue an enable command. If the contact is closed, it must be opened and re-closed to issue an enable command.

Upon receiving a disable command the 505DE will instantly step the V2 valve limiter to the V2 valve's present position, then raise the V2 limiter to its maximum (open) position at the "V2 valve limiter rate" setting. At some point, depending on system conditions the P1 PID will lose control of its process.

The V2 valve limiter may be stopped at any time during the automatic disabling routine by momentarily issuing a V2 limiter raise or lower command. Upon stopping the automatic disabling routine an operator can continue the disabling routine manually as desired or re- issue a disable command. By re-issuing a disable command the disable routine will continue raising the LP valve limiter to its maximum (open) position.

With automatic Extraction enabling programmed, an operator can also enable and disable Extraction control manually if desired.

#### ADMISSION or EXTR/ADM Control

The procedure for enabling the P1 PID with Admission or Extraction/Admission applications is the same. In all cases it is assumed that an external trip valve or a trip-and- throttle valve is used to completely stop any admission steam from entering the turbine upon a system shutdown condition.

Admission (Adm) or extraction/admission (Extr/Adm) control can be enabled and performed after one of the start routines has been completed. After a start-up, the V1 and V2 valve limiters should normally both be fully open. If either limiter is not fully opened, it will interfere with automatic governor operation.

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

Adm or Extr/Adm Enabling procedure:

- 1. Verify that all "P1 enable permissives" are met (listed above).
- 2. Match the P1 setpoint to that of the pressure on the plant side of the Extr/Adm T&T valve. (Skip this step if Setpoint Tracking is used.)
- 3. Vary the P1 Demand setpoint to match the turbine's internal P1 pressure to that of the pressure on the plant side of the Extr/Adm T&T valve.
- 4. Open the Extr/Adm Trip-and-Throttle valve.
- 5. Enable P1 control.

All the functions required to bumplessly enable and disable Adm or Extr/Adm control can be performed through the 505DE HMI, contact inputs, or Modbus.

The 505DE only accepts an enable command if all related permissives are met (see enable permissive list above). An enable/disable command may be given from the 505DE HMI, a contact input, or through 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 505DE trip condition is cleared. If the contact is open it must be closed to issue an enable command. If the contact is closed, it must be opened and re-closed to issue an enable command.

The following procedure allows Adm or Extr/Adm control to be disabled in a controlled manner:

Adm or Extr/Adm Disabling procedure:

- Disable P1 control. (At this point the V2 Demand setpoint will step to the P1 PID's last position, take control of the process from the PID, then ramp back to the setting that was used to enable P1 control. This setting should be at or close to the zero flow level.)
- If necessary manually adjust the V2 Demand setpoint to reach zero Extr/Adm flow.
- 3. Close the Extr/Adm Trip-and-Throttle valve.

## **EXTR/ADM Control Status Messages**

- Disabled—P1 control is not enabled and will have no effect.
- Enabled—P1 has been enabled but is not active or in control. Permissives have not been met (speed < "E/A enable speed" setting, generator or tie breaker open).
- Active / Not in Cntl—P1 has been enabled but the turbine is on a operating limit with Speed.
- Priority selected or the V2 valve limiter is limiting P1 PID output.
- In Control—P1 PID is in control of its process.
- Active w/Rmt Setpt—P1 has been enabled and the Remote P1 setpoint is in control of the setpoint but the turbine is on a operating limit with Speed Priority selected or the V2 valve limiter is limiting the P1 PID output.
- Control w/Rmt Setpt—P1 is in control and the Remote P1 setpoint is positioning the P1 PID setpoint.
- Inhibited—P1 cannot be enabled; the P1 input signal has failed, a controlled stop is selected, or the unit is shut down.

# **EXTR/ADM Dynamics**

The P1 PID uses its own set of dynamic settings. These values are programmable and may be tuned at any time. Refer to Chapter 4 of this manual for information on P1 PID Dynamic Adjustments.

## **EXTR/ADM Droop**

When sharing control of a parameter with another external controller, the P1 PID can also receive a programmable DROOP feedback signal for control loop stability. This feedback signal is a percentage of the P1 PID's output. By including this second parameter into the control loop, the P1 PID becomes satisfied, and does not fight with the other external controller over the shared parameter. If P1 droop is used, the P1 input signal will not match the P1 setpoint when in control. The difference will depend on the amount (%) of droop programmed and the output of the P1 PID. The Droop value fed back to the Extr/Adm PID is equal to the following defaulted settings:

PID OUTPUT % x 'P1 DROOP %' x 'RATED P1 SETPOINT' x 0.0001 Example: 25% x 5% x 600 psi x 0.0001 = 7.5 psi

## **EXTR/ADM Setpoint**

The P1 setpoint may be adjusted from the 505DE HMI, external contacts, Modbus commands, or through a 4–20 mA analog input signal. A specific setting can also be directly entered from the 505DE HMI or through Modbus commands.

The P1 setpoint range must be defined in the program mode. Program settings 'Min P1 Setpoint' and 'Max P1 Setpoint' define the range of the P1 setpoint and control.

When a raise or lower P1 Setpoint command is issued, the setpoint moves at the programmed 'P1 Setpt Rate' setting. If a P1 raise or lower command is selected for longer than three seconds, the P1 setpoint will move at the fast rate which is three times the P1 setpoint rate. The P1 setpoint rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a setpoint will move for an accepted raise or lower command from a contact input is 120 milliseconds (240 milliseconds for a 505DE HMI or Modbus command). If the P1 setpoint rate is programmed for 10 psi/sec, the smallest increment it will move is 1.2 psi (2.4 psi for Modbus).

A specific setpoint may also be directly entered through the 505DE HMI or Modbus. When this is performed, the setpoint will ramp at the 'P1 Setpt Rate' (as defaulted in Service mode).

When ramping to a valid setting, the setpoint ramps at the P1 Setpoint "entered" rate that is defaulted to the P1 setpoint rate. This "entered" rate is tunable through the Service mode.

#### **EXTR/ADM Setpoint Tracking**

This feature is programmable and usable only if the 505DE is programmed for an admission or extraction/admission application.

To reduce the number of steps required to enable P1 Extr/Adm control bumplessly, the P1 Extr/Adm setpoint can be programmed to track the P1 Extr/Adm process input when disabled. This tracking feature allows the P1 PID to be satisfied when enabled, thus there is no immediate or radical process correction required. After the P1 control is enabled, its setpoint can be moved, as required, to another setting.

## **EXTR/ADM Setpoint with No Tracking**

If the Extr/Adm control is programmed not to use the setpoint tracking feature, the setpoint will remain at its last setting (running or shutdown). With this configuration, when Extr/Adm control is enabled and the sensed process signal does not match setpoint, the Extr/Adm control will ramp the Extr/Adm process up or down to match the two signals. When the 505DE is powered-up, the setpoint is reset to the 'Setpt Initial Value'. With this configuration, if one of the permissives is lost or Extr/Adm control is disabled, the Extr/Adm setpoint will remain at its last setting until otherwise adjusted.

All pertinent Extr/Adm control parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# Remote Extr/Adm Setpoint

One of the 505DE's analog inputs can be programmed to position the P1 PID setpoint. This allows the P1 setpoint to be positioned remotely by a process control or distributed plant control system.

A programmed analog input's 4 mA and 20 mA settings determine the Remote P1 Setpoint range. The Remote P1 Setpoint range is tunable in the Service mode, but cannot be set outside of the min and max Extr/Adm Setpoint settings.

When enabled, the Remote P1 Setpoint may not match the P1 setpoint. In this case, the P1 setpoint will ramp to the Remote P1 Setpoint value at the programmed 'P1 Setpoint Rate' setting (as defaulted in the Service mode). Once matched, the 'Rmt P1 Setpt Max Rate' setting limits the rate that the Remote P1 Setpoint can move the P1 setpoint. If the 'Rmt P1 Setpt Max Rate' were set at 10 and the Remote P1 Setpoint analog input instantly moved from 0 units to 1000 units, the P1 setpoint will move to 1000 units at 10 units/sec.

If the milliamp signal to the Remote P1 Setpoint input is out of range (below 2 mA or above 22 mA) an alarm will occur and the Remote P1 Setpoint will be inhibited until the input signal is corrected and the alarm is cleared.

#### Remote EXTR/ADM Setpt Messages

Depending on configuration and system conditions, the Remote P1 Setpoint may be in one of the following states (505DE HMI or Modbus Status messages):

- Disabled—The Remote Setpoint function is disabled and will have no effect on the P1 setpoint.
- Enabled—The Remote Setpoint has been enabled, but permissives are not met.
- Active—The Remote Setpoint has been enabled, and permissives are met, but the P1 PID is not in control.
- In Control—The Remote Setpoint is in control of the P1 setpoint, and the P1 PID is in control.

 Inhibited—Remote Setpoint cannot be enabled; Remote Setpoint input signal is failed, P1 input signal is failed, or a controlled stop is selected.

## Remote EXTR/ADM Enable Logic

There are three different options for enabling Remote P1 Setpoint and P1 Extr/Adm control. They are as follows:

- A Remote Enable contact input, the 505DE HMI, or Modbus
- Both the Remote P1 Enable and P1 Enable commands programmed
- No enable commands programmed

When only the Remote Enable contact input is programmed, selecting 'Enable' will enable both P1 control and Remote P1 control. This configuration allows both functions to be enabled with one command if this is the normal operation mode. If 'Disable' is selected, both control modes are disabled.

A contact input can be programmed to enable and disable the Remote P1 Setpoint function. When this contact is open the remote setpoint is disabled, and when it is closed the remote setpoint is enabled. The contact can be either open or closed when a 505DE trip condition is cleared. If the contact is open it must be closed to enable the remote setpoint. If the contact is closed it must be opened and re-closed to enable the remote setpoint.

When both Remote P1 Enable and P1 Control Enable contact inputs are programmed, each function is enabled by its respective command selection. If Remote P1 Enable is selected, only the Remote P1 Setpoint will be enabled. If P1 Control Enable is selected, only P1 control will be enabled. If Remote P1 Disable is selected, only the Remote P1 Setpoint will be disabled. If P1 Control Disable is selected, both Remote P1 control and P1 control will be disabled. Separate commands for Remote P1 control enable and P1 control enable are always available on the 505DE HMI or Modbus.

If no external contact inputs are programmed for the 'Enable' commands, P1 Control and Remote P1 Control must be enabled from either the 505DE HMI or through Modbus. Since the 505DE HMI and Modbus provide both Remote Extr/Adm Enable and Extr/Adm Control Enable commands, they will operate in the same manner as 'both enables programmed'.

All pertinent Remote Extr/Adm Setpoint parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus 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.

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

When enabled, the Cascade PID can move the speed setpoint at a variable rate up to the 'Max Speed Setpoint Rate' setting (programmed on the CASCADE CONTROL page).

Since Cascade is a secondary speed setting function, the Speed PID must be in control of the 505DE's LSS bus in order for Cascade to take control. When the 505DE is configured for a generator application, both the utility tie and generator breakers must be closed, before the Cascade PID can begin controlling a process. When not configured for a generator application, turbine speed must be greater than the minimum governor setpoint before the Cascade PID can begin controlling.

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

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

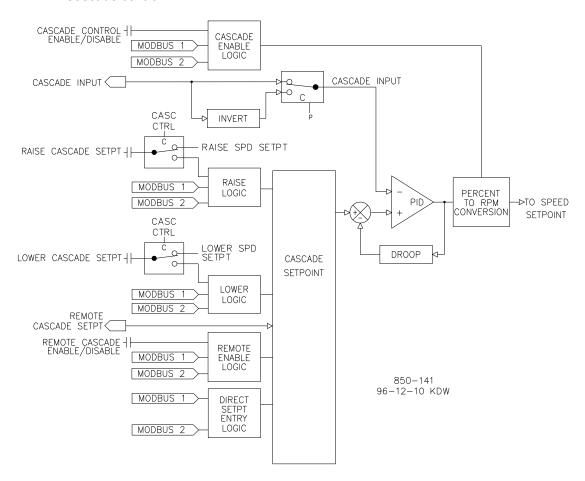


Figure 2-17. Cascade Functional Diagram

## **Cascade Control Status Messages**

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

Cascade control is automatically disabled on a shutdown condition, and must be re- enabled after a successful system startup. Cascade control is disabled if Remote Speed Setpoint or Auxiliary (Configured as Enable/Disable) is enabled. Should another parameter on the LSS bus take control of governor valve position from the Speed PID, Cascade control will stay active and begin controlling again when the Speed PID is the lowest parameter on the LSS bus.

All pertinent cascade control parameters are available through Modbus communications. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

#### **Cascade Dynamics**

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

## **Cascade Setpoint**

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

The Cascade setpoint range must be defined in the program mode. Program settings 'Min Cascade Setpoint' and 'Max Cascade Setpoint' define the range of the Cascade setpoint and control.

When a raise or lower Cascade Setpoint command is issued, the setpoint moves at the programmed 'Casc Setpt Slow Rate' setting. If a Cascade raise or lower command is selected for longer than three seconds, the Cascade setpoint will move at the 'Casc Setpt Fast Rate' setting. The Cascade setpoint rate, fast rate delay, and fast rate can all be adjusted in the Service mode.

The shortest length of time a setpoint will move for an accepted raise or lower command is 120 milliseconds (240 milliseconds for 505DE HMI or Modbus command). If the Cascade setpoint rate is programmed for 10 psi/sec, the smallest increment it will move is 1.2 psi (2.4 psi for 505DE HMI or Modbus).

A specific setpoint may also be directly entered from the 505DE HMI or through Modbus communications. When this is performed, the setpoint will ramp at the 'Casc Setpt Entered Rate' (as defaulted in Service mode). When a valid setpoint value is entered, the setpoint will ramp at the Cascade Setpoint Rate to the newly entered setpoint value. This 'Entered' rate is tunable through the Service mode.

## **Cascade Setpoint Tracking**

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

## Cascade Setpoint with No Tracking

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

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

#### Cascade Droop

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

PID OUTPUT % x 'CASCADE DROOP %' x 'MAX CASC SETPOINT' x 0.0001

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

The 'CASCADE DROOP %' and 'MAX CASC SETPOINT' values are set in the Program Mode and the 'PID output %' is determined by the Cascade demand.

#### **Invert Cascade**

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

# **Remote Cascade Setpoint**

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

The programmed Analog input's 4 mA and 20 mA settings determine the Remote Cascade Setpoint (RCS) range. The Remote Cascade Setpoint range is tunable in the Service mode, but cannot be set outside of the min and max Cascade Setpoint settings.

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

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

#### **Remote Casc Setpt Messages**

Depending on configuration and system conditions, the Remote Cascade Setpoint may be in one of the following states (505DE HMI screen messages):

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

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

## **Remote Cascade Enable Logic**

There are three different options for enabling Remote Cascade Setpoint as follows:

- A Remote Enabled Contact Input programmed
- 505DE HMI
- Modbus

A contact input can be programmed to enable and disable the Remote Cascade Setpoint (RCS). When this contact is open the RCS is disabled, and when it is closed the RCS is enabled. The contact can be either open or closed when a 505DE trip condition is cleared. If the contact is open it must be closed to enable the RCS input. If the contact is closed, it must be opened and re-closed to enable the RCS input.

When both Remote Cascade Enable and Cascade Control Enable commands are programmed, each function is enabled by its respective command selection. If Remote Cascade Enable is selected, only the Remote Cascade Setpoint will be enabled. If Cascade Control Enable is selected, only Cascade control will be enabled. If Remote Cascade Disable is selected, only the Remote Cascade Setpoint will be disabled. If Cascade Control Disable is selected, both Remote Cascade control and Cascade control will be disabled.

If no external contact inputs are programmed for the 'Enable' commands, Cascade Control and Remote Cascade Control must be enabled from either the 505DE HMI or from Modbus. Since the 505DE HMI and Modbus provide both Remote Cascade Enable and Cascade Control Enable commands, they will operate in the same manner as 'both enables programmed'.

All pertinent Remote Cascade control parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Auxiliary Control**

The 505DE offers two identical Auxiliary Controllers, feeding the same speed LSS bus. Here, one is described.

The Auxiliary PID controller can be used to limit or control generator power, plant import/export power, turbine inlet pressure, turbine exhaust pressure, pump/ compressor discharge pressure, or any other auxiliary parameters, directly related to turbine speed/load. The Auxiliary input is a 4 to 20 mA current signal. The PID control amplifier compares this input signal with the Auxiliary setpoint to produce a control output to the digital LSS (low-signal select) bus. The LSS bus sends the lowest signal to the Ratio/Limiter logic.

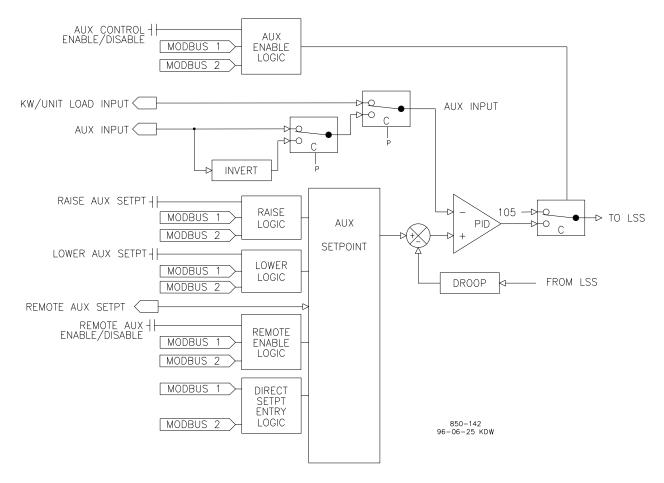


Figure 2-18. Aux Control Overview

# Auxiliary as a Limiter (not using Enable/Disable)

When configured as a limiter, the Auxiliary control is low signal selected (LSS) with the Speed PID, allowing it to limit on any process including or directly related to turbine speed/load. To configure the Auxiliary controller to function as a limiter, program the 'Use Aux Enable' setting to 'NO'.

When Auxiliary is configured to act as a limiter the Auxiliary PID will 'limit' the LSS bus when the input reaches the setpoint. For any programmed Ratio/Limiter mode of operation the Auxiliary control is always capable of limiting turbine load.

The Aux setpoint initializes to the programmed 'Setpt Initial Value' setting on a power- up-reset. This setpoint may be adjusted at any time and will remain at a setting (running or shutdown), provided a power-up-reset did not occur. Depending on configuration and system conditions, the Auxiliary Limiter may be in one of the following states:

- Auxiliary is Enabled—Auxiliary has been enabled but the generator and utility tie breaker permissives have not been met (generator applications only).
- Aux Active / Not Lmting—Auxiliary is configured as a limiter but is not limiting the LSS bus.
- Aux Active w/Rmt Setpt—Auxiliary is not in control of the LSS bus and the remote Auxiliary input is in command of the setpoint.

- Aux Control w/Rmt Setpt—Auxiliary is limiting the LSS bus and the remote Auxiliary analog input is in command of the setpoint.
- Auxiliary is Inhibited—Auxiliary cannot be enabled, the input signal has failed.

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

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

# Auxiliary as a Controller (using Enable/Disable)

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

To configure the Auxiliary controller to function as a controller, program the 'Use Aux Enable' setting to 'YES'. The Speed PID will only track the Auxiliary PID LSS bus signal up to 100% speed/load. Thus if turbine speed/load reaches 100%, the Speed PID will protect the unit by limiting unit speed/load to less than or equal to 100%. Depending on the configuration and system conditions, the Auxiliary PID may be in one of the following states:

- Auxiliary is Disabled—Auxiliary is disabled and will have no effect on the LSS bus.
- Auxiliary is Enabled—Auxiliary has been enabled but the generator and utility tie breaker permissives have not been met (generator applications only).
- Aux Active / Not in Ctrl—Auxiliary has been enabled, permissives met, but is not in control of the LSS bus.
- Aux Active w/Rmt Setpt—Auxiliary has been enabled but is not in control of the LSS bus and the remote Auxiliary input is controlling the setpoint.
- Auxiliary in Control—Auxiliary is in control of the LSS bus.
- Aux Control w/Rmt Setpt—Auxiliary is in control of the LSS bus and the remote Auxiliary analog input is in control of the setpoint.
- Auxiliary is Inhibited—Auxiliary cannot be enabled; input signal is failed, 505DE is in Frequency Control, controlled shutdown is selected, unit is shut down or Auxiliary control is not programmed.

For generator applications, Auxiliary control can be configured to be disabled when the generator and/or utility tie breakers are open. Program settings 'Tiebkr Open Aux Dsbl' and 'Genbkr Open Aux Dsbl' may be configured to deactivate Auxiliary control depending on system breaker positions. When both settings are programmed 'NO', the Auxiliary control will always stay 'active'.

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

Auxiliary control may be enabled from the 505DE HMI, remote contact inputs, or Modbus communications. The last command given from any of these three sources dictates the state Auxiliary control will be in. If an external Auxiliary Enable contact is programmed, disable is selected when the contact is open and enable is selected when it is closed. The contact can be either open or closed when a trip condition is cleared. If the contact is open, it must be closed to enable. If the contact is closed, it must be opened and re-closed to enable.

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

# **Auxiliary Dynamics**

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

#### **Generator Load Limiter/Control**

On generator applications, the Auxiliary PID may be programmed to use the 'KW/UNIT LOAD' input signal instead of the Auxiliary input signal for limiting or control. This is the same input signal (KW/Unit Load input) used by the Speed PID for kW droop. This configuration allows the Auxiliary PID to limit or control generator power. Program the 'USE KW/UNIT LOAD INPUT' to 'YES' if this configuration is desired.

# **Auxiliary Droop**

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

LSS BUS OUTPUT % x 'AUX DROOP %' x 'MAX AUX SETPOINT' x 0.0001

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

The 'AUXILIARY DROOP %' and 'MAX AUX SETPOINT' values are set in the Program Mode and the 'LSS bus output %' is determined by the Auxiliary demand.

# **Invert Auxiliary Input**

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

# **Auxiliary Setpoint**

The Auxiliary setpoint can be adjusted from the 505DE HMI, external contact inputs, Modbus commands, or through a 4–20 mA analog input. A specific setting can also be directly entered from the 505DE HMI or through Modbus commands.

The Auxiliary setpoint range must be defined in the program mode. Program settings 'Min Aux Setpoint' and 'Max Aux Setpoint' define the range of the Auxiliary setpoint and control.

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

The shortest length of time a setpoint will move for an accepted raise or lower command is 120 milliseconds (240 milliseconds for a 505DE HMI or Modbus command). If the Auxiliary setpoint rate is programmed for 10 psi/sec, the smallest increment it will move is 1.2 psi (2.4 psi for the 505DE HMI or Modbus).

A specific setpoint may also be directly entered from the 505DE HMI or through Modbus communications. When this is performed, the setpoint will ramp at the 'Aux Setpt Rate' (as defaulted in Service mode).

When a valid setpoint value is entered, the setpoint will ramp at the "Aux Setpt Rate" setting to the newly entered setpoint value. This 'Entered' rate is tunable through the Service mode.

All pertinent auxiliary control parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Remote Auxiliary Setpoint**

The Auxiliary setpoint can be positioned through an analog signal. This allows the Auxiliary setpoint to be positioned remotely by a process control or distributed plant control system.

The analog input's 4 mA and 20 mA settings determine the Remote Auxiliary Setpoint's range. The Remote Auxiliary Setpoint range is tunable in the Service mode, but cannot be set outside of the min and max Auxiliary Setpoint settings.

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

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

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

# **Remote Auxiliary Enable Logic**

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

When the Auxiliary PID is programmed to function as a limiter, the Remote Auxiliary Setpoint may be enabled at any time once the 505DE has been started.

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

- A Remote Enable contact input is programmed
- Both enable commands programmed; Remote Aux Enable and Auxiliary Enable
- No enable commands programmed

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

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

If no external contact inputs are programmed for the 'Enable' commands, Auxiliary Control and Remote Auxiliary Control must be enabled from either the 505DE HMI or from Modbus. Since the front panel and Modbus provide both Remote Auxiliary Enable and Auxiliary Control Enable commands, they will operate in the same manner as 'both enables programmed'.

All pertinent Remote Auxiliary Setpoint parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Valve Limiters**

The valve limiters limit the valve output signals to aid in starting up and shutting down the turbine.

The output of the V1 valve limiter is low-signal selected with the output of the Ratio/ Limiter. The lowest signal will control the V1 valve position. Thus the V1 valve limiter limits the maximum V1 valve position.

The output of the V2 valve limiter is high-signal selected with the output of the Ratio/ Limiter when configured for Extraction steam turbines, and low-signal-selected when configured for Admission or Extraction/Admission steam turbines. Thus the V2 valve limiter limits the minimum or maximum V2 valve position depending on the configuration selected.

The output of the V3 valve limiter is always high-signal selected with the output of the Ratio/Limiter, used only for double extraction turbine configurations.

The valve limiters can be used to trouble shoot system dynamic problems. If it is believed that the 505DE 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, to not allow the system to reach a dangerous operating point.

The level of each valve limiter can be adjusted through the 505DE HMI, contact inputs, or Modbus communications. When raise or lower commands are received, the respective limiter ramps up or down, at its programmed 'Valve Limiter Rate'. In all cases a limiter's range is defaulted to 0-100%. Each Valve Limiter's 'Rate' and 'Max Valve position' settings can be adjusted in the Service mode.

The shortest length of time a setpoint will move for an accepted raise or lower command is 120 milliseconds (240 milliseconds for a 505DE HMI or Modbus command). If a Valve limiter's rate is programmed for 10 %/sec, the smallest increment it will move is 1.2 % (2.4 % for a 505DE HMI or Modbus command).

A specific setpoint may also be directly entered from the 505DE HMI, (not through Modbus). When a valid setpoint value is entered, the respective limiter will ramp at its 'Valve Limiter Rate' to the newly entered setpoint value. This 'Entered' rate is tunable through the Service mode.

#### Min Valve Lift Limiters

The "Min V1 Lift" limiter is used with only Admission or Extr/Adm applications to limit the V1 valve's minimum position above 0% to insure HP section cooling steam. This limiter is prevents the Ratio/Limiter from taking the V1 valve fully closed. Unless specified by the turbine manufacture, this setting should be set to zero. The "Min V1 Lift" limiter is only active if the following conditions are true:

- Admission or Extr/Adm is programmed
- Extr/Adm control is enabled
- V1 valve demand is above the Min V1 Lift limiter

The "Min V2 Lift" limiter is used to limit the V2 valve's minimum position. This limiter is active at all times and prevents the Ratio/Limiter from taking the V2 valve fully closed. However, during shutdown conditions the V2 valve is taken fully closed. Unless specified by the turbine manufacture, this setting should be set to zero.

The "Min V3 Lift" limiter functions identical to the "Min V2 Lift" limiter.

All pertinent valve limiter parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Emergency Shutdown**

When an Emergency Shutdown condition occurs, all valve output signals are stepped to zero milliamps, the Shutdown relay de-energizes, and the shutdown cause (first shutdown condition sensed) is displayed on the 505DE HMI and is available through Modbus.

Up to five Emergency Shutdown inputs (contact inputs) can be programmed to allow the 505DE to indicate the cause of an emergency shutdown. By wiring trip conditions directly into the 505DE, instead of a trip string, the 505DE can pass a trip signal directly to its output relay (to trip the T&T valve), and also indicate the first trip condition sensed. All trip conditions are indicated through the 505DE HMI and Modbus communications.

Once latched, the last trip indication cannot be reset. This allows an operator to confirm what the trip condition was hours or days after the unit has been reset and restarted.

In addition to the dedicated Shutdown relay, the other programmable relays may be configured as Shutdown condition or Trip relays.

The Shutdown Condition relay may be programmed to indicate a shutdown condition on a remote panel or to a plant DCS. The Shutdown Indication relay is normally de-energized. This relay will energize upon any shutdown condition and stay energized until all trips have been cleared. The 'Reset Clears Trip' function has no effect on the programmable Shutdown Indication relay.

When programmed as a Trip relay, the respective relay will function like the dedicated Shutdown relay (normally energized and de-energizes on a shutdown) to indicate the position of the dedicated Shutdown relay.

# **Controlled Shutdown**

The 505DE'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:

- All control PIDs and functions are disabled except the Speed and Extr/Adm PIDs.
- All Extr/Adm control is disabled (the V2 and/or V3 limiters are raised for Extraction applications).
- 3. Once the generator breaker is open (if generator app), the Speed Setpoint is ramped to the configured cooldown speed at the configured rate.
- 4. After the Speed Setpoint reaches cooldown speed, it pauses for the cooldown time.
- 5. When the cooldown time is complete, the speed setpoint is ramped to zero at the configured rate.
- 6. A trip is not issued when a Controlled Shutdown sequence is completed. The 505DE will be reset and in the 'Ready To Start' state.



On generator applications, the 505DE can be configured to automatically issue a generator breaker open command upon reaching a min load level.

A controlled shutdown can be initiated or aborted from the 505DE HMI, a programmed contact input or either Modbus communication link. A confirmation step is built into the 505DE HMI, but is not required if a controlled shutdown command is initiated by a programmed contact input or Modbus communication link.

The controlled shutdown sequence can be aborted at any time. During a controlled shutdown sequence, choosing the abort controlled shutdown command from the 505DE HMI, contact input or Modbus will stop the Controlled Shutdown sequence. At this point the shutdown sequence can be re-initiated when desired, or the unit can be brought back to a fully operational state.

If an external contact is programmed to issue a controlled shutdown command, closing the contact will initiate the controlled shutdown sequence. The shutdown sequence will go through the same steps described above, with the exception that verification of the shutdown sequence is not needed. Opening the programmed contact will stop the sequence. The contact can be either open or closed when a trip condition is cleared. If the contact is open it must be closed to issue the command. If the contact is closed it must be opened and re-closed to issue the command. The Modbus initiated Control Shutdown Sequence requires two commands. One Modbus Command will start the controlled shutdown sequence and the other to stop it.

The speed sensor failure is overridden when a controlled shutdown is initiated.



This command can be disabled. When disabled, the Controlled Stop feature is disabled from the 505DE HMI, Modbus, and contact commands.

# **Overspeed Test Function**

The 505DE's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505DE'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 505DE HMI or with external contacts. This test is not available through Modbus.

An overspeed test is allowed only under the following conditions:

- The Speed PID must be in control.
- The Auxiliary, Cascade, Extr/Adm, and Remote Speed Setpoint functions must be disabled.
- If configured for a generator application the Generator breaker must be open.
- The Speed Setpoint must be at the "Max Governor Speed" setting.



An Overspeed Test is not allowed when Auxiliary is configured as a Limiter. To be able to perform an Overspeed Test in this case, Auxiliary needs to be removed from the configuration first. After completion of the Test, Auxiliary should be re-configured again.

If these conditions are not met, the 505DE HMI will display an "Overspeed Test Not Permissible" message.

An overspeed test can be performed through an external contact, if the 'Overspeed Test' function is programmed to a 'Contact Input # Function' setting. When configured this contact performs the same function as selecting the overspeed test enable button on the 505DE HMI.

There are two programmable relay options available to indicate overspeed status. One programmable relay option indicates an Overspeed Trip condition. The second relay option provides indication that an Overspeed Test is being performed.

See the operations chapter of this manual for a complete Overspeed Test Procedure. All pertinent overspeed test parameters are available through the Modbus links. See Volume 2, Chapter 7 for a complete listing of Modbus parameters.

# **Local / Remote Function**

The 505DE's Local / Remote function allows an operator at the turbine skid or 505DE to disable any remote command (from a remote Control Room) that may put the system in an unsafe condition. This function is typically used during a system startup or shutdown to allow only one operator to manipulate the 505DE control modes and settings.

The Local/Remote function must first be programmed before an operator can select Local or Remote mode. If this function is not programmed all contact inputs and Modbus commands (when Allow Modbus X commands is programmed true) are active at all times. If the Local/Remote function is programmed Local and Remote modes can be selected through a programmed contact input, the 505DE HMI, or Modbus command.

When Local mode is selected, the 505DE is defaulted to be operable from port 3 only. This is the port that the HMI is connected to for configuration. This mode disables all contact inputs and Modbus commands, with exceptions noted below:

```
External trip Contact In
                                     (defaulted in program)
External trip 2 Contact In
                                     (active at all times, if programmed)
                                     (active at all times, if programmed)
External trip 3 Contact In
External trip 4 Contact In
                                     (active at all times, if programmed)
External trip 5 Contact In
                                     (active at all times, if programmed)
External trip 6 Contact In
                                     (active at all times, if programmed)
                                     (active at all times, if programmed)
External trip 7 Contact In
External trip 8 Contact In
                                     (active at all times, if programmed)
External trip 9 Contact In
                                     (active at all times, if programmed)
External trip 10 Contact In
                                     (active at all times, if programmed)
Override MPU Fault Contact In
                                     (active at all times, if programmed)
Freq Arm/Disarm Contact In
                                     (active at all times, if programmed)
Generator breaker Contact In
                                     (active at all times, if programmed)
Utility tie breaker Contact In
                                     (active at all times, if programmed)
Start permissive Contact In
                                     (active at all times, if programmed)
Select On-line dynamics Contact In (active at all times, if programmed)
Local / Remote Contact In
                                     (active at all times, if programmed)
Select Extr/Adm Priority Contact In
                                     (active at all times, if programmed)
Local / Remote Modbus Command
                                     (active at all times, if Modbus programmed)
Trip Command Modbus Command
                                     (active at all times, if Modbus programmed)
```

When the Remote mode is selected the 505DE can be operated through Modbus Port 3, contact inputs, and/or all other Modbus commands.

When using a contact input to select between Local and Remote modes, a closed contact input selects the Remote mode and an open contact input selects the Local mode.

Optionally a relay can be programmed to indicate when Local mode is selected (energizes when the Local mode is selected). There is also indication of the Local / Remote mode selection through Modbus (address is true when the Remote mode is selected and false when the Local mode is selected).

The 505DE is defaulted to only allow control operation though its HMI connected to Port 3, when the Local mode is selected. If desired, this defaulted functionality can be changed in the 505DE's Service mode. The 505DE can be modified to also allow operation through contacts inputs, or Modbus port #1 or Modbus port #2 when the Local mode is selected.

# Relays

The 505DE has up to 48 relay outputs available. Two of these relays are dedicated; one for a system shutdown command from the 505DE and one for alarm indication. The other 22 relays can be programmed for a variety of indications and system functions.

Each output function can be assigned to as many relays as desired for redundancy. When assigned to multiple outputs, each relay simply functions at the same time, it is up to the user to wire multiple relay outputs to suit their needs.

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

The dedicated Alarm relay is normally de-energized. This relay will energize upon an alarm condition and stay energized until the alarm condition is cleared. Optionally this relay can be configured to toggle on and off repeatedly when an alarm condition has occurred. With this configuration if a reset command is given and the alarm condition still exists, the relay will stop toggling and stay energized. The relay will start toggling again, upon a new alarm condition. This option can be used to inform the operator when another alarm condition has occurred.

Any relay can be programmed to function as a level switch. When programmed as a level switch, the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level). See the configuration chapter for a list of parameters available for use as level switches.

The present relay state (energized / de-energized) and relay configuration is indicated through Modbus as well.

Relays not used as level switches can be programmed to indicate control states. Except for the Trip relay, when programmed to indicate a state or event, relay will energize upon the respective state or event occurring. See the configuration chapter for a list of options for relays used to indicate a control mode or state.

# **Relay Clarifications**

The Shutdown Condition relay may be programmed to indicate a shutdown condition on a remote panel or to a plant DCS. The Shutdown Indication relay is normally de-energized. This relay will energize upon any shutdown condition and stay energized until all trips have been cleared. The 'RESET CLEARS TRIP' function has no effect on the programmable Shutdown Indication relay.

When programmed as a Trip relay, the respective relay will function like the dedicated "Shutdown" relay (normally energized and de-energizes on a shutdown) to indicate the position of the dedicated Shutdown relay. This relay output can be programmed to indicate a trip only initiated by the 505DE, by setting the 'Ext trips in Trip Relay' option to NO. Using this option, 505DE trip annunciation will only occur if the 505DE tripped the turbine, and will not annunciate when the other external devices shutdown the unit (external trips).

The Alarm Condition relay may be programmed to indicate an alarm condition on a remote control panel or to a DCS. The Alarm Indication relay is normally deenergized. This relay will energize upon any alarm condition and stay energized until all alarms have been cleared. If the 'BLINK ALARMS' option is 'YES' the programmable Alarm Condition relay will toggle on and off repeatedly when an alarm condition has occurred. With this configuration if a reset command is given and the alarm condition still exists, the relay will stop toggling and stay energized.

The 505DE Control Status OK relay is normally energized, and will only deenergize if unit input power is lost, the 505DE's CPU fails, or the 505DE is in configure mode – IO Lock.

The Overspeed Test Enable relay will energize when an Overspeed Test is active. This relay functions like the 505DE HMI overspeed test indication. It is energized when and overspeed test is active, and repeatedly toggles on and off when turbine speed is above the internal (to the 505DE) turbine Overspeed trip setting.

An Underspeed Switch function can be programmed to indicate a turbine underspeed or overpower condition. If the Underspeed option is configured, once turbine speed reaches a level above the minimum governor speed setting, then decreases 100 rpm below the minimum governor speed setting, the respective relay energizes (indicating an underspeed condition). The 'Underspeed setting' is adjustable under the 'Speed Setpoints' section.

When the Sync Enabled function is programmed, the assigned relay energizes when a synchronize command is given. After the unit generator or utility breaker is closed this function becomes disabled and the relay de-energizes. The 505DE's Synchronization function can be used to synchronize across a generator breaker or utility breaker.

When the Sync / Load Shr Active function is programmed, the assigned relay energizes when synchronizing or Load Sharing is active. When both the generator and utility breaker inputs are closed (Load Sharing not selected) this function becomes disabled and the relay de-energizes.

When the Modbus Command function is programmed, the assigned relay energizes when the respective Modbus command "Turn On Modbus Relay X" is issued, then de-energizes when the respective Modbus command "Turn Off Modbus Relay X" is issued. This feature allows a 505DE relay to be driven directly from Modbus to control a system related function (i.e. synchronizing). In addition, the assigned relay can be momentarily energized using the Modbus command "Momentarily Energize Modbus Relay X" (i.e. voltage raise/lower commands). See Volume 2, Chapter 7 for more information on Modbus commands.

# Chapter 3. Configuration Procedures

# Programming the 505DE

Before the 505DE can be used to operate any turbine, it must be configured with valid program settings. A 505DE Program Settings Worksheet is provided at the end of this manual. This chapter contains additional information related to completing this worksheet and programming the specific application. It is recommended that this worksheet be completed and used to document your specific program.

When the 'Save Settings on Control' button is chosen on the 505DE PCI tool, all configuration (program mode) values and saved service mode changes are stored in the nonvolatile memory (EEPROM) of the 505DE control. If power is removed from the 505DE all saved values will return once power is restored. No batteries or back up power is required.

# NOTICE

Choose the 'Save Settings on Control' button to permanently save any minimum or maximum actuator settings into the 505DE. If variables are tuned or changed but not stored in EEPROM by selecting the 'Save Settings on Control' button, then those changes will be lost if power is removed from the control or if the control receives a CPU reset.

If 'Save Settings on Control' is not chosen before a power cycle or re-start of the 505DE application takes place, parameters changed since 'Save Settings on Control' was last executed will be lost.

Also, parameters can be saved to – and loaded from file using the save to file and load from file functions found on the configuration menu screen. 'Save Settings on Control' should be executed after loading settings from file but before unlocking I/O. When the I/O is unlocked, the control will reset any settings that are not saved to the EEPROM.



The field-configured portion of the program will be zeroed out after factory repair. To prevent damage to your equipment, you must reconfigure the 505DE before the unit is put back into service.

# **Using the 505DE PCI Tool**

The 505DE is configured and tuned using the 505DE Personal Computer Interface (PCI) tool. The 505DE PCI tool also serves as a Human Machine Interface (HMI) for the 505DE control system. Operation, configuration and tuning are available when connected to Modbus Port 3, and only operation is available when connected to Modbus Ports #1 or #2.

For those familiar with the 505 and 505E control systems, most parameters will look similar, but service and configure level parameters will be grouped together on screens under the appropriate headers instead of being separated into different Configure and Service menus. For example, 'number of gear teeth' is a configure logon level only parameter and 'speed PID settings' can be changed when logged into service mode, but both are displayed on the Speed Settings page. Parameters are separated by logon level, and will appear grayed out when the logon level does not allow access to them. In the 505DE, all necessary settings are in either Configure mode or in Service mode, and all are available for adjustment through the 505DE PCI tool. Debug tools should be used by qualified personnel only.

On any given PCI screen there will be some parameters confined to the configure logon and the rest will be available under the service logon. To logon at the configure level the turbine must be shutdown. Upon successful logon the 505DE will enter IO Lock. Service mode can be active at any time including during turbine operation. Parameters available when logged in at the Service level are always available when logged in at the configure level. Over the course of this manual, parameters may be referred to as configurable, programmable, tunable, changeable, etc. Do not take any contextual language to mean that a parameter is restricted to the configure level; available at the service level; or available only through debug access. While every attempt is made to use the correct language, calling a setting a configuration setting does not necessarily mean it is found only at the configure logon level. Look to each parameter's description in this chapter or the full 'configuration' worksheet to see which parameters are available only when logged on as configure, and which can be accessed when in service.

The configuration (again, this includes configure and service parameters) section of the 505DE is split into twelve headers, some with multiple screens beneath them. For example, under the auxiliary control header, there are two configuration screens, one for auxiliary controller #1 and one for auxiliary controller #2. For most applications, only a portion of the available functions will be used, and the 505DE PCI applies visibility logic to display only the screens and parameters that apply to the application being configured. For example, if a single valve turbine is configured, then extraction/admission screens and functions will not be displayed. Visibility logic is also applied within screens. For example, if 'number of critical speed bands' is set to zero, no critical band settings will be displayed. If no auto start type (no idle) is selected, then 'number of critical speed bands' will not be displayed. The 12 possible 505DE configuration headers are:

Application Settings
Turbine Start
Speed Settings
Operating Parameters
Extraction/Admission
Cascade Control
Auxiliary Control
Analog Inputs
Analog Outputs and Proportional Actuator Outputs
Contact Inputs
Relay Outputs
Integrating Actuator Outputs (if modules installed)

The following list gives a broader overview of the configuration architecture of the 505DE. It is expanded to include sub-screens (indented) and general visibilities requirements are included in parentheses:

**Application Settings** 

Analog Scale Divisors (for Modbus)

**Turbine Start** 

**Speed Settings** 

**Operating Parameters** 

V1A Curve

V1B Curve (if split range for any turbine type)

V2 Curve (if single extraction and/or admission)

V3 Curve (if double extraction)

Extraction/Admission Steam Map (if any extraction and/or admission type)

P1 Controller

P2 Controller (if double extraction)

Auxiliary Control (if use 1 or 2 auxiliary controllers)

Auxiliary Controller #2 (if use 2 auxiliary controllers)

Cascade Control (if use cascade)

Analog Inputs

Analog Outputs and Proportional Actuator Outputs

**Contact Inputs** 

Contact Inputs #2 (if second DIO module installed)

**Contact Outputs** 

Contact Outputs #2 (if second DIO module installed)

Integrating Actuator Outputs (if modules installed)

This Chapter will be structured according to the manner in which program (again meaning any setting, configure or service) parameters are organized, with the 'Application Settings' screen first, the 'Turbine Start' screen second and so on.

Note for 'YES – NO', or 'Boolean' configuration items, check boxes are used. A checked box is always a positive, correlating to a 'YES' to a question. In function, Boolean configuration items are selecting a 1 for YES and a 0 for no within the 505DE software. So:

YES = checked = 1 = TRUE NO = unchecked = 0 = FALSE

# The Main Menu

Upon start up, the 505DE PCI tool will open the Main Menu page. This page is primarily for navigation during normal operation. The 505DE HMI can be used as the configuration tool and HMI, or as only an HMI connected to Modbus 1 or Modbus 2. The '505DE HMI Selection' field determines which port will be connected to, which in turn determines whether configuration will be available or not. When 'Modbus 3 – Configuration' is selected, then the configuration screens are always accessible, no matter what the logon level. When Modbus 1 or Modbus 2 is selected, then configuration screens are not available.

The Main Menu also provides the location for changing the 505DE logon. The configuration screens can always be viewed by any user, however all items are locked to editing when logged on as 'Run'. When logged on as 'Service', items that may need to be adjusted while the 505DE is operating are available for editing. When logged in as 'Configure', all items can be changed. To log in as 'Configure', the turbine must be shutdown and IO Lock applied.

From this page, to access configuration screens choose the 'Configuration' button.

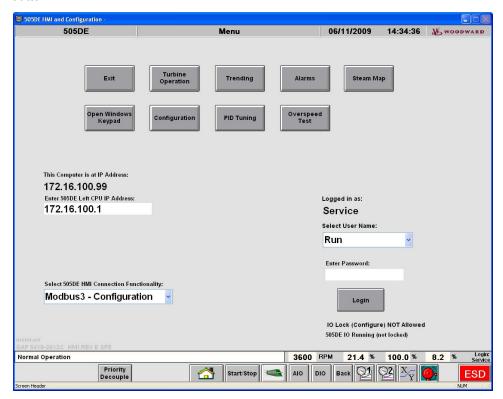


Figure 3-1. 505DE PCI Main Menu

# The Configuration Menu

Upon choosing Configuration, the Application Configuration Screen is opened. All Configuration screens are headed by tabs labeled with each of the configuration screens. The menu is structured as follows:

**Application Settings** 

Analog Scale Divisors (for Modbus)

**Turbine Start** 

**Speed Settings** 

**Operating Parameters** 

V1A Curve

V1B Curve (if split range for any turbine type)

V2 Curve (if single extraction and/or admission)

V3 Curve (if double extraction)

Extraction/Admission Steam Map (if any extraction and/or admission type)

P1 Controller

P2 Controller (if double extraction)

Auxiliary Control (if use 1 or 2 auxiliary controllers)

Auxiliary Controller #2 (if use 2 auxiliary controllers)

Cascade Control (if use cascade)

Analog Inputs

Analog Outputs and Proportional Actuator Outputs

Contact Inputs

Contact Inputs #2 (if second DIO module installed)

Contact Outputs

Contact Outputs #2 (if second DIO module installed)

Integrating Actuator Outputs (if modules installed)

The default menu shows just the 12 main configuration categories.



Tabs for the sub-screens appear when the top-level screen is selected. For example, when 'Extraction Admission' is selected for a double extraction turbine, the P1 and P2 controller tabs appear to the right of the 'Extraction Admission' tab.



The P1 and P2 tabs will remain visible while navigating to them.



Choosing 'Extraction Admission' again, or choosing any other tab will hide the P1 and P2 Controller tabs.



Figure 3-2. Configuration Menu

# Application Settings Screen

The Application Settings configuration screen contains settings that apply to the overall application and drive visibility for further configuration, three text string fields for identifying the configuration, and communications configuration.

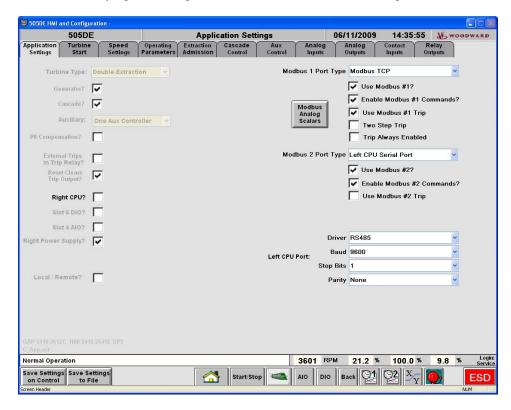


Figure 3-3. Application Settings Screen as Defaulted (Normal Operation)

In Figure 3-3, the login level is Configure; so all items are available for editing. Note in Figure 3-4, the login level is Service, so items restricted to the Configure level are grayed out.

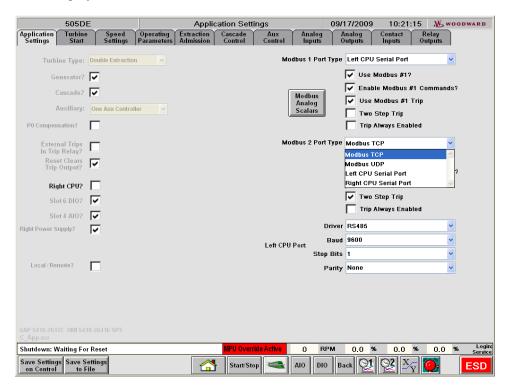


Figure 3-4. Application Settings Screen All Parameters (Service Level)

TURBINE TYPE? C = 0 (0,4)

Turbine Type appears on the 505DE PCI as a pulldown box to select a Single Valve, Single Extraction, Single Admission, Single Extraction/Admission or Double Extraction Turbine. In function, it sets an integer value in the 505DE software with 0=Single Valve, 1=Single Extraction, 2=Single Admission, 3=Single Extraction/Admission and 4=Double Extraction.

GENERATOR? C = 0 (0,1)

Programming this setting to 1 (checked) will enable Generator control functions. Leaving it at 0 (unchecked) will setup the 505DE for Mechanical Drive applications.

CASCADE? C = 0 (0,1)

Programming this setting to 1 (checked) will enable cascade control.

AUXILIARY? C = 0 (0,2)

The Auxiliary Controllers setting appears on the 505DE PCI as a pulldown box to select no aux control, one aux controller, or two aux controllers. In function, it sets an integer value in the 505DE software with 0=no aux, 1=one aux controller. 2=two aux controllers.

P0 Compensation? C = 0 (0,1)Programming this setting will enable Inlet Steam Pressure Compensation.

This option requires an extra Analog Input to be configured.

EXTERNAL TRIPS IN TRIP RELAY? C = 1 (0,1)

Leave the box checked to allow the external trip input(s) to de- energize the Trip Relay output. When unchecked, an external trip contact input to the 505DE will shut down the 505DE but will not de-energize the 505DE's trip relay output.

#### RESET CLEARS TRIP OUTPUT?

C = 0 (0,1)

Check the box to configure the Reset Clears Trip Relay output function. When checked, a Reset command will energize the trip relay output even when a trip condition is still sensed by the 505DE—typically due to one of the external trip inputs. Once reset, the unit will be 'Ready to Start' as soon as all external trip inputs are closed. When unchecked, the trip relay output will be de-energized on a 505DE trip and will not energize until all trips have been cleared and a 'Reset' command is given.

Right CPU? S = 0 (0,1)

Programming this setting to 1 (checked) will enable alarming and communications for a Redundant CPU. When loaded with the 505DE application, the redundant CPU is automatically ready to assume control if needed or requested.

Slot 6 DIO? C = 0 (0,1)

Programming this setting to 1 (checked) will enable I/O alarming and selection functions for the second Discrete (Contact) Input / Output Module.

ot 4 AIO? C = 0 (0,1)

Programming this setting to 1 (checked) will enable I/O alarming and selection functions for the second Analog Input / Output Module.

Right Power Supply? C = 0 (0,1)

Programming this setting to 1 (checked) will enable I/O alarming for a redundant Power Supply Module. When inserting or removing a Power Supply card from the MicroNet<sup>TM</sup> chassis make sure the input power plug, to the card, is disconnected.

LOCAL / REMOTE? C = 0 (0,1)

Check this box if using Local/Remote control logic. If unchecked, all programmed inputs are enabled at all times. If checked, this permits the unit to go from Remote control to Local control. Local and Remote control are determined by the configuration settings. Contact Inputs, Modbus 1, and Modbus 2 can each be configured to have control in Local mode, Remote mode, or both.

CONTACTS C = 0 (0.2)

When 'Local' is configured for Contact Inputs, they will be enabled when the control is in Local mode and disabled when the control is in Remote mode. If 'Remote' is configured for Contact Inputs, they will be disabled in Local mode and enabled in Remote mode. Contacts will be enabled in both modes if 'Both' is configured.

MOD 1 C = 1 (0,2)

When 'Local' is configured for Modbus 1, commands from Modbus 1 will be enabled when the control is in Local mode and disabled when the control is in Remote mode. If 'Remote' is configured for Modbus 1, commands from Modbus 1 will be disabled in Local mode and enabled in Remote mode. Modbus 1 will be enabled in both modes if 'Both' is configured.

MOD 2 C = 1 (0,2)

When 'Local' is configured for Modbus 2, commands from Modbus 2 will be enabled when the control is in Local mode and disabled when the control is in Remote mode. If 'Remote' is configured for Modbus 2, commands from Modbus 2 will be disabled in Local mode and enabled in Remote mode. Modbus 2 will be enabled in both modes if 'Both' is configured.

#### MODBUS (X) PORT TYPE?

S = 0 (0,3)

This pull down selection box determines which port the Modbus 1 server will be directed to. In function, the text in the pulldown box represents: 0=TCP, 1=UDP, 2=Left CPU Serial Port, 3=Right CPU (if installed) Serial Port. If TCP is selected, the Network address is ONE (1) for Modbus 1 and TWO (2) for Modbus 2. If UDP is selected, the network port is 5001 for Modbus 1 and 5002 for Modbus 2. If Ethernet communications are selected (UDP or TCP), and a second (right) CPU is installed and configured, each Modbus server configured will be available in parallel through the second CPU Ethernet port. The network address (TCP) or port (UDP) will remain the same as those available through the left CPU but at the right CPU's IP Address. Configuring a Modbus Server for a serial port does not enable a parallel communication link for that Modbus server. An error will occur if the same serial port is assigned to both Modbus 1 and Modbus 2. Since Modbus reads are always available, the 'USE MODBUS PORT (X)' box does not need to be checked to change which port is used.

USE MODBUS PORT (X)?

S = 0 (0.1)

Check the box to use Modbus Port 1. Modbus Reads are available at all times. This box enables alarming and allows the user to select whether to allow Modbus commands to be written to the 505DE, and to configure how Modbus will trip the 505DE.

**ENABLE MODBUS (X) COMMANDS?** 

S = 1(0,1)Allows a Modbus Client to write Modbus commands to the 505DE.

USE MODBUS (X) TRIP?

S = 1(0,1)

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

USE MODBUS (X) 2-STEP TRIP?

S = 0 (0,1)

If using a Modbus Trip, is this a two-step trip? If checked, requires both the Trip command and the Trip Acknowledge command to go active within 5 seconds before a trip from the Modbus link will be executed.

ALWAYS ENABLE MODBUS (X) TRIP?

S = 0 (0,1)

When using Local / Remote with Modbus disabled in Local selection, checking this box will still allow a trip via Modbus. If checked, the trip command from Modbus is still active even though all other Modbus commands are disabled. When left unchecked, all Modbus commands are disabled when in Local mode.

To use the right CPU serial port, it must be selected as a port and the 'SECOND CPU?' setting must be checked. When using either serial port for Modbus Communications, the following settings become available for each port configured:

DRIVER S = 0 (0, 2)

From the pulldown box, select RS-232, RS-422 or RS-485 Communications. Each is represented by an integer in the 505DE: 0 = RS-232, 1 = RS-422 and 2 = RS-485.

**BAUD RATE** S = 9(0, 11)

From the pulldown box, select the data rate (kbps) that matches that of the Modbus Serial client. Each is represented by an integer in the 505DE:

1 = 300 2 = 6000 = 1103 = 12004 = 18005 = 24006 = 48007 = 96008 = 192009 = 3840010 = 5760011 = 112500

STOP BITS S = 0 (0, 2)

From the pulldown box, select 1, 2 or 1.5 stop bits. Each is represented by an integer in the 505DE: 0 = 1 stop bit, 1 = 2 stop bits or 2 = 1.5 stop bits. PARITY S = 0 (0.2)

From the pulldown box, select None, Odd or Even. Each is represented by an integer in the 505DE: 0 = None, 1 = Odd or 2 = Even.

Note: For serial and TCP Ethernet communications, the type is RTU (as opposed to ASCII) and the network addresses for Modbus 1 and Modbus 2 are 1 and 2, respectively. The timeout for both ports is defaulted to 2 seconds. It is possible for qualified personnel to adjust these through an OPC debug interface such as Control Assistant. For UDP Ethernet communications the ports are always 5001 and 5002, respectively. For nearly every communication link problem, it is a matter of addressing, physical connection or incompatibility and the only useful information is whether the link is there or not. In rare cases an error code may be useful. Error Codes are also accessible through debug (see Table 3-1 and Chapter 5).

TCP Ethernet Modbus network address 3 is reserved for the 505DE PCI tool and must not be used for Modbus TCP communications to Modbus slaves 1 and 2.

Modbus Server and CPU Port	OPC (debug) Tag	*Dflt(Lo, Hi)
Mod 1 Timeout (left CPU)	COMM.MOD1.TIME_OUT_1	*2(0,180)
Mod 2 Timeout (left CPU)	COMM.MOD2.TIME_OUT_1	*2(0,180)
Mod 1 Timeout (right CPU)	COMM.MOD1.TIME_OUT_2	*2(0,180)
Mod 2 Timeout (right CPU)	COMM.MOD2.TIME_OUT_2	*2(0,180)
Mod 1 Net Addr (left CPU)	COMM.MOD1.NET_ADDR_1	*1(1,247)
Mod 2 Net Addr (left CPU)	COMM.MOD2.NET_ADDR_1	*2(1,247)
Mod 1 Net Addr (right CPU)	COMM.MOD1.NET_ADDR_2	*1(1,247)
Mod 2 Net Addr (right CPU)	COMM.MOD2.NET_ADDR_2	*2(1,247)
Mod 1 ASC/RTU (left CPU)	COMM.MOD1.ASC_RTU_1	*2(1,2)
Mod 2 ASC/RTU (left CPU)	COMM.MOD2.ASC_RTU_1	*2(1,2)
Mod 1 ASC/RTU (right CPU)	COMM.MOD1.ASC_RTU_2	*2(1,2)
Mod 2 ASC/RTU (right CPU)	COMM.MOD2.ASC_RTU_2	*2(1,2)
Mod 1 Error Code (left CPU)	COMM.MOD1.ERR_NUM_1	read only (see Chapter 5)
Mod 2 Error Code (left CPU)	COMM.MOD2.ERR_NUM_1	read only (see Chapter 5)
Mod 1 Error Code (right CPU)	COMM.MOD1.ERR_NUM_2	read only (see Chapter 5)
Mod 2 Error Code (right CPU)	COMM.MOD2.ERR_NUM_2	read only (see Chapter 5)

Table 3-1. Communications Debug items

Note: General OPC communications are available through an off-platform server connection – Woodward's Servlink OPC Server (SOS). SOS provides a compliant local OPC server for use with many OPC clients as well as Woodward debug tools such as Control Assistant. OPC communications should be implemented by qualified personnel only. OPC items are listed with Modbus Parameters in Chapter 5.

# **Modbus Analog Scalars Popup**

Choosing the "Modbus Analog Scalars" button on the Application Settings screen will open the Modbus Analog Scalars dialog box. It is used to scale Modbus parameters for transmission via Modbus. Analog Scale factors have no affect on configuration parameters.

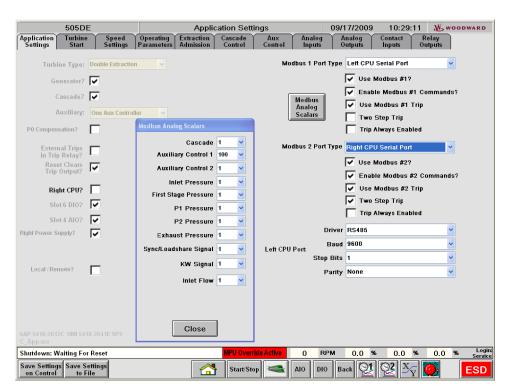


Figure 3-5. Modbus Analog Scalars Popup

For broad compatibility, the 505DE Modbus drivers provide data in integer format limited to a size of 32,764. Any decimal places are truncated. Because the 505DE accepts a range of Engineering units for its control and measurement parameters, scale factors are provided to give the user control over the accuracy of the data displayed. Analog reads are divided by their respective scale factor before being transmitted over Modbus. Analog writes are multiplied by their respective scale factor upon being received over Modbus. On the Modbus client side, analog read values should be multiplied by their scale factor upon receipt, and analog writes should be divided by their scale factor before transmission.

The pulldown selection boxes display the scale factors that will be used, and in function each configures an integer that tells the 505DE which scale factor to use. The integers zero to five select the following scale factors:

0 = 300	3 = 1
1 = 100	4 = .1
2 = 10	5 = .01

The analog scaling selections were chosen because they too are transmitted via Modbus for use in the client application, and so they must fit within the range of 0–32764. All scale factors are themselves multiplied by 100 before transmission, to retain the possibility scale factors less than zero (decimal places). The range of scale factors, from .01 to 300 are transmittable via Modbus, and allow values to be scaled from two decimal places to over 9.8 million.

Example: A value to be transmitted over Modbus is 100,000. Since Modbus is unable to transmit a number greater than 32,764, an incorrect value would be read in the client application. Selecting a scale factor (divisor) of 10 reduces the number to 10,000 for transmission. Multiplying by the same scale factor restores the original value of 100,000. Note that truncation affects numbers that need to be scaled down. If the number was 100,005, then 10,000 would still be transmitted and when restored would be 100,000.

Example: A value to be transmitted over Modbus is 1.56. Since Modbus will truncate the .56, a scale factor (divisor) of .01 is selected to increase the number to 156 for transmission. In the client application, the scale factor is multiplied by the value, to restore 1.56 as a real value. If a scale factor of .1 was chosen, only one decimal place would be retained, and when multiplied by .1 again in the client application, the result would be 1.5.

Static values can be used for scale factors on the client side, or to prevent errors resulting from changing a scale factor on one but not the other, the scale factors can be read from Modbus and used dynamically to adapt to whatever scale factor is chosen in the 505DE configuration.

#### ("TEXT") SCALE FACTOR

S = 3(0, 5)

Scale factors are available for the following items:

Cascade
Auxiliary 1
Auxiliary 2
Inlet Pressure
First Stage Pressure
P1 Pressure
P2 Pressure
Exhaust Pressure
Sync/Load Share
KW
Decoupling Values
Seal Gas PID
Inlet Flow

# **Turbine Start Screen**

The Turbine Start Screen displays necessary items to configure the start type, speeds, hold times and rates for the 505DE to use during a start.

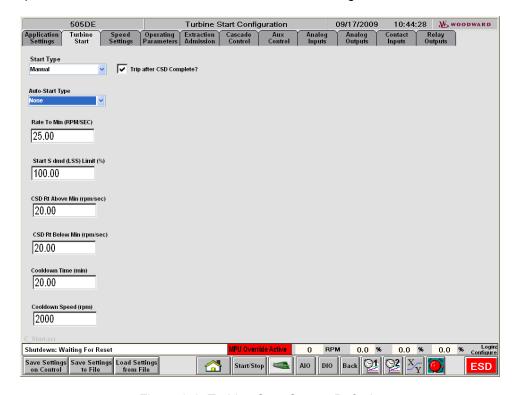


Figure 3-6. Turbine Start Screen Default

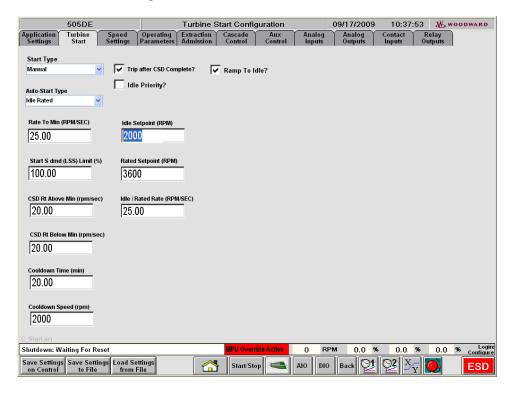


Figure 3-7. Turbine Start Screen with Idle/Rated

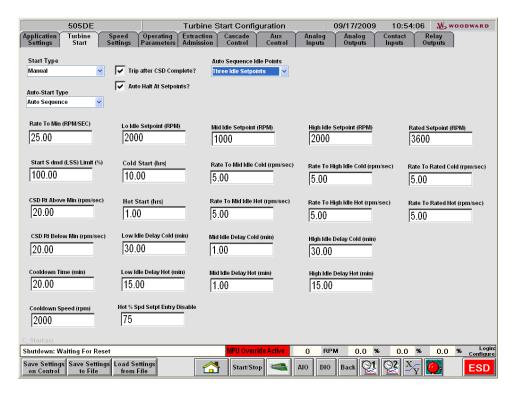


Figure 3-8. Turbine Start Screen with Auto Sequence

START TYPE? C = 1 (0,2)

Start Type appears on the 505DE PCI as a pulldown box to select a Manual, Semiautomatic or Automatic start. In function, it sets an integer value in the 505DE software with 0=manual, 1=semiauto and 2=auto.

When configured for a manual start mode, the operator controls the turbine speed from zero up to the minimum control speed using an external tripthrottle valve. The Manual Start Sequence would be: Push RUN. The actuators automatically move to max position. Lastly, the operator slowly opens the trip-throttle valve until the governor takes control.

When configured for a semiauto start mode, the 505DE's V1 limiter is used to control turbine speed (like the T&T is used in a manual start). The operator must open the V1 limiter manually (slowly) to open the control valve and bring the turbine speed from zero up to the minimum control speed. The Semi-automatic Start Sequence would be: Open the T&T valve and then push RUN. The operator then raises the V1 valve limiter until the speed PID takes control.

When configured for an automatic start mode, the 505DE controls the turbine speed from zero up to the minimum control speed. The Automatic Start Sequence would be: Operator opens the trip-throttle valve, then push RUN. The V1 valve limiter opens automatically until the governor takes control. (One of the three start modes must be selected before the unit will run)

#### **AUTO START TYPE?**

C = 0 (0,2)

Auto Start Type appears on the 505DE PCI as a pulldown box to select no auto start type, Idle/Rated start, or Auto Start Sequence start. In function, it sets an integer value in the 505DE software with 0=no auto start type, 1=Idle/Rated and 2=Auto Start Sequence.

- If Idle/Rated is selected (and a start is issued), the control will ramp from a programmable Idle speed to a programmable Rated speed setpoint when Rated is selected through HMI, Modbus or external switch.
- If Auto Start Sequence is selected (and a start is issued), the 505DE automatically accelerates the speed setpoint to a programmable low idle speed and holds for a programmable time then ramps either to the rated speed setpoint or to the next programmable idle speed. The sequence holds for a programmable time at each programmed idle setpoint, then ramps to the programmable rated speed setpoint. During operation, the start sequence can be actuated or halted through the 505DE HMI, Modbus or external switch.

#### TRIP AFTER CSD COMPLETE

S = 0 (0,1)

Select this box if it is desired to trip the system after a Controlled Shutdown. If this option is not selected, the system will not be tripped after a CSD, it will remain in the "Reset: Ready to Start" state.

RATE TO MIN (RPM/SEC)

S = 10.0 (0.01, 2000)

Enter the speed setpoint acceleration rate to minimum. This is the rate the setpoint moves from zero to the lowest controlling speed on a start command (assuming the turbine is at zero speed). The minimum controlling speed will be either 'idle' if idle/rated is used or 'low idle' if the auto start sequence is used. If neither of these startup features is used, the min speed will be the minimum governor speed setpoint.

START S DMD (LSS) LIMIT (%)

S = 101.0 (0.0, 101.0)

Enter a value to limit the speed demand percentage during a turbine start. This value will limit the valve by limiting the PID output. When the actual speed reaches the setpoint, this limit is disabled to give the Speed PID full control of the actuator output.

CSD RATE ABOVE MIN (%/SEC)

S = 20 (.01,500)

During a controlled shutdown, the 505DE will ramp the speed setpoint towards the cooldown speed at this rate when the speed setpoint is above Min Governor.

CSD RATE BELOW MIN (%/SEC)

S = 20 (.01,500)

During a controlled shutdown, the 505DE will ramp the speed setpoint towards the Cool Down speed at this rate when the speed setpoint is below Min Governor.

TURBINE COOLDOWN TIME (MIN)

S = 5(.01,500)

During a controlled shutdown, the 505DE will remain at the configured Cool Down Speed for this amount of time before it shuts down.

TURBINE COOLDOWN SPEED (RPM)

S = 1000 (0,20000)

During a controlled shutdown, the 505DE will ramp to and remain at this speed for the configured Cool Down Time before it shuts down. Set the Cooldown Speed to less than Rated Speed for a proper Cooldown Sequence during a Controlled Shutdown.

**IDLE / RATED SETTINGS** 

Idle/Rated Settings are used when AUTO START TYPE is set to Idle/Rated.

#### USE RAMP TO IDLE FUNCTION?

S = 1(0.1)

Leave checked to allow the speed setpoint to return to idle speed (when idle is selected). If unchecked, the Idle/ Rated function acts as a 'Ramp to Rated' function and will not return to idle. When unchecked, closing the Idle/Rated contact accelerates the speed setpoint towards Rated and opening the contact stops the acceleration. Reclosing the contact resumes acceleration to rated speed.

**IDLE PRIORITY?** 

S = 0 (0,1)

If checked, the speed setpoint will move to Idle whenever Idle is selected (and USE RAMP TO IDLE is checked). If unchecked, the setpoint will move to Idle only if Remote Speed Setpoint is not enabled, Cascade control is not enabled, an Auxiliary 'controller' (as opposed to limiter) is not enabled, Extraction/Admission control is not enabled, and the Generator Breaker is open.

IDLE SETPT (RPM)

C = 1000 (0.0, 20000)

Enter the Idle Speed setpoint. This is the lowest speed control setpoint when using the Idle/Rated function.

RATED SETPT (RPM)

C = 3600 (0.0, 20000)

Enter the Rated Speed setpoint. This is the speed control setpoint that the unit accelerates to when using the Idle/Rated function.

(Must be greater than or equal to the 'Minimum Governor Speed' Setting)

IDLE/RATED SETPT RATE (RPM/SEC)

S = 5.0 (0.01, 2000)

Enter the Idle/Rated rate (rpm/second). This is the rate at which the speed setpoint moves between the Idle and Rated speed setpoints when using the Idle/Rated commands.

#### AUTO START SEQUENCE SETTINGS

The following settings are used when AUTO START TYPE is set to Auto Start Sequence.

#### **AUTO SEQUENCE IDLE SETPOINTS**

C = 1(1,3)

When AUTO START TYPE is set to Auto Start Sequence, the Number of Idle Setpoints setting appears on the 505DE PCI as a pull down box to select one idle setpoint, two idle setpoints, or three idle setpoints. In function, it sets an integer value in the 505DE software with 1 = one idle setpoint, 2=two idle setpoints and 3=three idle setpoints.

# AUTO HALT AT IDLE SETPTS?

S = 0 (0,1)

Check the box to automatically halt the auto start sequence at the idle setpoints. This feature would result in the unit automatically stopping/halting at all configured idle setpoints. Also, if the unit is started and the speed is above the low idle setpoint, the sequence will be halted. Leave the box unchecked to allow the control to perform its automatic start sequence routine without interruption.

#### COLD START (> xx HRS)

S = 10 (0.0, 200)

Enter the time in hours allowed after a trip before the 'cold start' sequence curves are to be used. If this much time has expired (or more) after a trip condition, then the control will use the cold start values. If less than this time has expired, the control will interpolate between the hot and cold start values to determine rates and hold times.

#### HOT START (< xx HRS)

S = 1.0 (0.0, 200)

Enter the maximum time allowed after a trip for the 'hot start' sequence curves to be used. If less than this time has expired after a trip condition, then the control will use the hot start values.

(Must be less than or equal to the 'Cold Start' Hours)

#### LOW IDLE SETPT (RPM)

C = 1000 (0.0, 20000)

Enter the Low Idle Speed Setting. This is the first hold speed when using the automatic start sequence. The speed setpoint will remain at this setting until the low idle delay/hold time has expired. When a start is issued and speed is less than the low idle setpoint, the speed setpoint will proceed to the low idle setpoint at the 'RATE TO MIN' setting.

#### LOW IDLE DELAY TIME - COLD (MINUTES)

S = 1.0 (0.0, 500)

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

#### LOW IDLE DELAY TIME - HOT (MINUTES)

S = 1.0 (0.0, 500)

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.

(Must be less than or equal to the 'Low Idle Delay—Cold' Setting)

#### MID IDLE SETPT (RPM)

C = 2000 (0.0, 20000)

Enter the Mid Idle Speed Setting. This is the second hold speed when using three idle setpoints in the automatic start sequence. If using less than three idle setpoints, mid idle is not used. The speed setpoint will remain at this setting until the Mid Idle Delay/hold time has expired.

(Must be greater than the 'Low Idle' Setting)

#### RATE TO MID IDLE - COLD (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the cold start rate to mid idle. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to mid idle when a cold start is determined.

# RATE TO MID IDLE - HOT (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the hot start rate to mid idle. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to mid idle when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the midi idle setpoint.

(Must be greater than or equal to the 'Rate to Mid Idle—Cold' Setting)

#### MID IDLE DELAY TIME - COLD (MINUTES)

S = 1.0 (0.0, 500)

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

#### MID IDLE DELAY TIME - HOT (MINUTES)

S = 1.0 (0.0, 500)

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

(Must be less than or equal to the 'Mid Idle Delay—Cold' Setting)

#### HIGH IDLE SETPT (RPM)

C = 2000 (0.0, 20000)

Enter the Hi Idle Speed Setting. This is the second hold speed when using two idle setpoints in the automatic start sequence, or the third hold speed when using three idle speeds. If using only one idle setpoint, the hi idle settings are not used. The speed setpoint will remain at this setting until the Hi Idle Delay/hold time has expired.

(Must be greater than the 'Low Idle' and/or 'mid idle' Settings)

#### RATE TO HIGH IDLE - COLD (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the cold start rate to high idle. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to high idle when a cold start is determined.

#### RATE TO HIGH IDLE - HOT (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the hot start rate to high idle. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to high idle when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the hi idle setpoint.

(Must be greater than or equal to the 'Rate to Hi Idle—Cold' Setting)

#### HIGH IDLE DELAY TIME - COLD (MINUTES)

S = 1.0 (0.0, 500)

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

#### HIGH IDLE DELAY TIME - HOT (MINUTES)

S = 1.0 (0.0, 500)

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

(Must be less than or equal to the 'Hi Idle Delay—Cold' Setting)

## RATED SETPT (RPM)

C = 3600 (0.0, 20000)

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

(Must be greater than or equal to the 'Minimum Governor' Setting)

#### RATE TO RATED - COLD (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the cold start rate to the rated speed setpoint. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to rated when a cold start is determined.

#### RATE TO RATED - HOT (RPM/SEC)

S = 5.0 (0.01, 500)

Enter the hot start rate to the rated speed setpoint. This is the programmable rate, in rpm per second that the speed setpoint will accelerate at when moving to rated when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold rates to determine the acceleration rate to the rated setpoint.

(Must be greater than or equal to the 'Rate to Rated—Cold' Setting)

#### HOT % SPEED SETPOINT ENTRY DISABLE

S = -1 (-1, 101)

Enter a value to disable the Preset Speed Setpoint while the turbine is cold. As long as the "Hot Percentage" is below this configured value then the Preset Speed Setpoint will be disabled.

# **Speed Settings Screen**

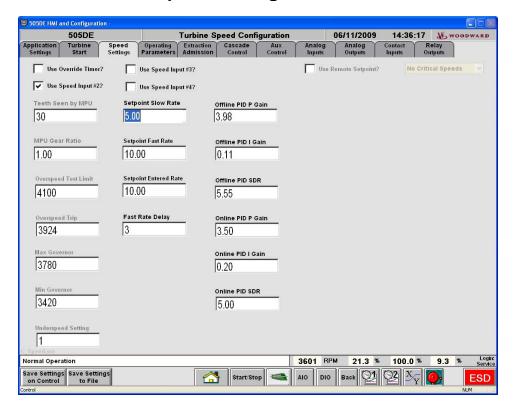


Figure 3-9. Speed Settings Screen

(The maximum turbine speed is 20000 rpm and the maximum speed input frequency is 20000 hertz.)

(Speed Input #1 is always active for safety)	
USE SPEED INPUT #2?	S = 0 (0,1)
Check if used.	
USE SPEED INPUT #3?	S = 0 (0,1)
Check if used.	
USE SPEED INPUT #4?	S = 0 (0,1)
Check if used.	

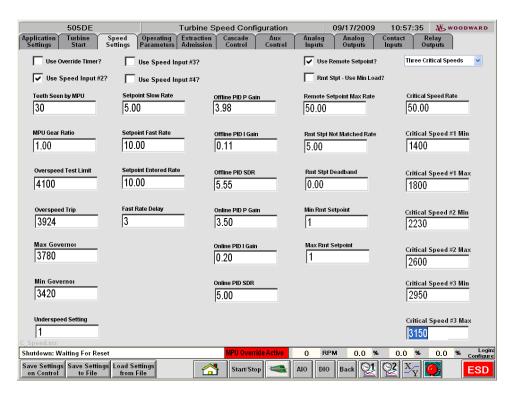


Figure 3-10. Speed Settings Screen with all parameters

#### USE MPU OVERRIDE TIMER?

S = 0 (0,1)

When checked, the MPU override will go OFF when the MPU Override Time expires after a start is initiated. This provides a maximum time for speed to be sensed on startup before a loss of speed is detected.

# MPU OVERRIDE TIME (SEC)

S = 600.0 (00, 600)

Sets the maximum time after a start is initiated for speed to be sensed above the failure level. Only used if 'Use MPU Override Timer?' is checked.

#### TEETH SEEN BY MPU

C = 60.0 (1.0, 500)

Enter the number of teeth on the speed gear that the speed sensor is monitoring. This detects rotational frequency and is used to calculate speed in RPM.

#### MPU GEAR RATIO

C = 1.0 (0.05, 100)

Enter the speed sensor gear ratio. This value is the ratio of the speed sensor gear to the turbine shaft. This gear ratio is the result of dividing the speed of the speed sensor gear by the speed of the turbine shaft.

#### OVERSPEED TEST LIMIT (RPM)

C = 1100 (0.0, 20000)

Set the overspeed test limit (in rpm). This is the maximum speed setpoint the control will increase to when overspeed testing the unit. The setpoint can only be raised to this level when the overspeed test function is being performed.

#### **OVERSPEED TRIP**

C = 1000 (0.0, 20000)

Set the 505DE's overspeed trip level (in rpm). This is the governor overspeed trip setpoint only and is not to be used as ultimate overspeed protection.

(Must be less than the 'Overspeed Test Limit' Setting)

#### MAX GOVERNOR (RPM)

C = 0.0 (0.0, 20000)

Set the maximum governor control speed. This is the normal governor operation upper limit. For turbine/generator applications, this value must be at least equal to [Rated Speed + (Droop % x Rated Speed)]. (Must be less than the 'Overspeed Trip Level' Setting)

#### MIN GOVERNOR (RPM)

C = 0.0 (0.0, 20000)

Set the minimum governor control speed. This is the normal governor operation lower limit.

(Must be less than the 'Maximum Governor Speed' Setting)

#### UNDERSPEED SETTING (RPM)

S = 1 (0.0, 20000)

Only used if an underspeed relay is programmed. Speed setting for the underspeed indication.

#### SPEED SETPOINT SLOW RATE (RPM/SEC)

S = 5.0 (0.01, 100)

Enter the speed setpoint slow rate in rpm per second. This the speed setpoint rate for normal operation.

## SPEED SETPOINT FAST RATE (RPM/SEC)

S = 10 (0.01, 500)

The rate that is used if a speed setpoint raise or lower command is active for the fast rate delay time.

SPEED SETPOINT ENTERED RATE (RPM/SEC)

S = 20 (0.01, 100)

This is the rate that the Speed setpoint will move when setpoint is entered from the 505DE HMI or Modbus.

#### FAST RATE DELAY (SEC)

S = 3.0 (0, 100)

If a speed setpoint raise or lower command is active for the fast rate delay time, the SETPT FAST RATE is selected.

#### OFF-LINE PROPORTIONAL GAIN

R = 5.0 (0.0, 100)

Enter the off-line PID proportional gain percentage. This value is used to set speed/load control response when the Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 5 rps (repeats per second).

#### **OFF-LINE INTEGRAL GAIN**

R = 0.5 (0.01, 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 Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is open. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5%.

# OFF-LINE SDR

S = 5.0 (0.01, 100)

Enter the off-line PID derivative ratio. This value is used to set speed/load control response when the Generator or Utility Tie breaker contacts are open (if the unit is a generator) or if the turbine speed is below minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is open. This value can be changed in the Service Mode while the turbine is operating. A recommended starting value is 5% (see Chapter 4—PID Dynamics Settings for more information). The derivative term is removed from the response calculation when set to 100 or .01. In this case, the speed PID will be P-I controller.

#### ON-LINE PROPORTIONAL GAIN

R = 5.0 (0.0, 100)

Enter the on-line PID proportional gain percentage. This value is used to set speed/load control response when the Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is closed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 5%.

#### ON-LINE INTEGRAL GAIN

R = 0.5 (0.01, 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 Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is closed. This value can be changed in the Run Mode while the turbine is operating. A recommended starting value is 0.5 rps.

ON-LINE SDR S = 5.0 (0.01,100)

Enter the on-line PID derivative ratio. This value is used to set speed/load control response when the Generator and Utility Tie breaker contacts are closed (if the unit is a generator) or if the turbine speed is above minimum governor speed (if the unit is not a generator) or when the Select Dynamics function is used and the contact is closed. This value can be changed in the Service Mode while the turbine is operating. A recommended starting value is 5% (see Chapter 4—PID Dynamics Settings for more information). The derivative term is removed from the response calculation when set to 100 or .01. In this case, the speed PID will be P-I controller.

#### USE REMOTE SPEED SETPOINT?

S = 0 (0.1)

Check if using an analog input to set the Speed/Load Setpoint.

#### RMT SETPT - USE MIN LOAD?

S = 0 (0,1)

When checked, the speed setpoint cannot be lowered/decreased by the Remote Speed Setpoint input below the rated/synchronous speed setpoint plus the 'Min Load Bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When unchecked, the remote speed setpoint can move the speed setpoint down to the higher of the minimum governor setting or the remote speed setpoint input 4 mA value.

#### RMT SPEED SETPT MAX RATE (RPM/SEC)

S = 50.0 (0.01, 500)

The rate that the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the remote input.

#### RMT NOT MATCHED RATE (RPM/SEC)

S = 50.0 (0.01, 500)

The rate that the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint.

#### REMOTE DEADBAND VALUE

S = 0.0 (0.0, 100)

This setting is the remote speed setpoint deadband in RPM.

#### MINIMUM REMOTE SETPOINT

S = 0 (0.0, 20000)

Minimum setting allowed by the remote input.

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

#### MAXIMUM REMOTE SETPOINT

S = 0 (0.0, 20000)

Maximum setting allowed by the remote input.

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

## NUMBER OF CRITICAL SPEEDS

C = 0 (0,3)

Select the number of critical speeds needed. The text selected in the pulldown box sets an integer in the 505DE representing the number of bands used: 0 = no critical bands, 1 = one critical band, 2 = two critical bands, 3 = three critical bands. Within a critical speed band, the speed setpoint cannot be stopped. These bands are used to protect the turbine and driven device from speeds that have inherently high vibration. (Must program either 'Idle/Rated' or 'Auto Start Sequence' to use critical speed avoidance. The lowest critical speed min must be greater than idle or low idle.)

## CRITICAL SPEED RATE (RPM/SEC)

S = 50.0 (1.0, 2000)

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

(Must be greater than the 'Speed Setpt Slow Rate' Setting)

CRITICAL SPEED 1 MIN (RPM) C = 1.0 (1.0, 20000)Set the lower limit of the first critical speed avoidance band. (Must be less than the 'Critical Speed 1 Max' Setting) CRITICAL SPEED 1 MAX (RPM) C = 1.0 (1.0, 20000)Set the upper limit of the first critical speed avoidance band. (Must be less than the 'Minimum Governor Speed' Setting) CRITICAL SPEED 2 MIN (RPM) C = 1.0 (1.0, 20000)Set the lower limit of the second critical speed avoidance band. (Must be less than the 'Critical Speed 2 Max' Setting) CRITICAL SPEED 2 MAX (RPM) C = 1.0 (1.0, 20000)Set the upper limit of the second critical speed avoidance band. (Must be less than the 'Minimum Governor Speed' Setting) CRITICAL SPEED 3 MIN (RPM) C = 1.0 (1.0, 20000)Set the lower limit of the third critical speed avoidance band. (Must be less than the 'Critical Speed 2 Max' Setting) CRITICAL SPEED 3 MAX (RPM) C = 1.0 (1.0, 20000)Set the upper limit of the third critical speed avoidance band. (Must be less than the 'Minimum Governor Speed' Setting)

# **Operating Parameters Screen**

The Operating Parameters Screen will display items, as they are required. For a single valve, mechanical drive turbine, only the V1 valve limiter settings will be displayed. As the turbine type (Application Settings) selection changes, the V2 and/or V3 valve limiter settings will be displayed. If Generator (Application Settings) is checked, the generator parameters will be displayed. Tabs appear on the configuration menu for the valve linearization pages. Clicking on the Operating Parameters tab will alternately display and hide the valve curve tabs. Clicking any tab other than the valve curve tabs will hide the valve curve tabs.

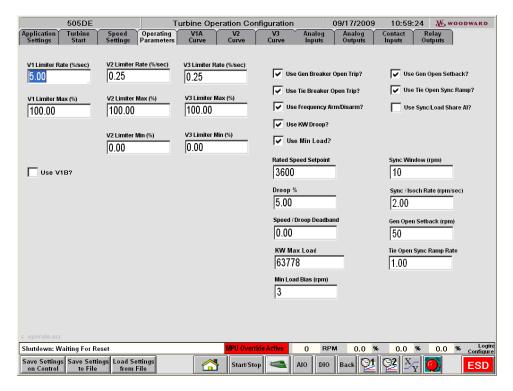


Figure 3-11. Operating Parameters

#### V1 LMTR RATE (%/SEC)

S = 5 (0.1, 25)

The V1 valve limiter rate is used when raise and lower commands are issued.

V1 MAX LIMIT (%)

S = 100 (55, 101)

The V1 limiter maximum setting is normally set to 100%, but can be set lower to provide a maximum valve lift setting.

V1 MIN LIMIT (%)

S = 0.00 (0.0, 45)

The V1 limiter minimum setting is normally set to 0%, but this can be set to provide a minimum valve lift setting – when using admission only.

V2 LMTR RATE (%/SEC)

S = 5 (0.1, 25)

The V2 valve limiter rate is used when raise and lower commands are issued.

V2 MAX LIMIT (%)

S = 100 (55, 101)

The V2 limiter maximum setting is normally set to 100%, but can be set lower to provide a maximum valve lift setting.

V2 MIN LIMIT (%)

S = 0.00 (0.0, 45)

The V2 limiter minimum setting is normally set to 0%, but can be set to provide a minimum valve lift setting for cooling.

V3 LMTR RATE (%/SEC)

S = 5 (0.1, 25)

The V3 valve limiter rate is used when raise and lower commands are issued.

V3 MAX LIMIT (%)

S = 100 (55, 101)

The V3 limiter maximum setting is normally set to 100%, but can be set lower to provide a maximum valve lift setting.

V3 MIN LIMIT (%)

S = 0.00 (0.0, 45)

The V3 limiter minimum setting is normally set to 0%, but can be set to provide a minimum valve lift setting for cooling.

(The following settings are only available for a Generator application.)

**USE GEN BREAKER OPEN TRIP?** 

C = 0 (0,1)

Check if opening the generator breaker is to initiate a turbine trip. If checked, the unit will trip when the generator breaker opens after being closed unless a Controlled Stop is selected. If unchecked, the speed setpoint will instantly reset to the 'Gen Open Setpoint' that is defaulted to 50 rpm below rated speed.

USE TIE BREAKER OPEN TRIP?

C = 0 (0,1)

Check if opening the utility breaker is to initiate a turbine trip. If checked, the unit will trip when the utility breaker opens after being closed unless a Controlled Stop is selected. If unchecked and the generator breaker is closed, the speed setpoint will instantly reset to the speed last seen by the unit and move to the 'Rated Speed Setpoint' and an alarm is issued. If unchecked and the generator breaker is open, there is only an alarm when the utility breaker opens.

USE FREQ ARM/DISARM?

C = 0 (0.1)

If checked, frequency control must be armed before the unit will switch into frequency control. If unchecked, frequency control is always armed and the unit will go into frequency control whenever the generator breaker is closed and the utility breaker is open.

(Cannot program both Freq Arm/Disarm and Load Sharing)

USE KW DROOP?

C = 0 (0,1)

Check to use kW droop (generator load control) or leave unchecked to use internal Speed droop (turbine inlet valve position). If checked, generator kW feedback is used as the controlling parameter for stability when the unit is on-line. If left unchecked, internal LSS demand/actuator position droop is used. If using Decoupling, leave this unchecked to avoid instability in decoupling situations.

USE MIN LOAD?

S = 0 (0,1)

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

RATED SPEED SETPOINT (RPM)

C = 3600 (0.0, 20000)

Set the generator's rated speed setpoint.

(Must be greater than or equal to the 'Minimum Governor Speed' Setting and less than the 'Maximum governor Speed' Setting))

DROOP (%)

S = 5.0 (0.0, 10)

Enter the droop percentage. Typically set between 4-6% and not more than 10%. If droop is required, the unit must be programmed as a 'Generator Application'.

SPEED / DROOP DEADBAND (RPM)

S = 0.0 (0.0, 100.0)

This setting is the dead band for speed droop in RPM.

KW MAX LOAD (kW)

C = 20000 (0.1, 20000)

Enter the max load. This setting specifies the kW droop range. (Must be less than or equal to the 'KW Input at 20 mA' Setting)

MIN LOAD BIAS (RPM)

S = 10 (0.0, 500)

This is the value the speed setpoint will increase to upon the generator breaker closure (when the utility tie is closed).

USE GEN BRKR OPEN SETBACK?

S = 1 (0,1)

When left checked, the speed setpoint is instantly set to the 'Gen Breaker Open Setpt' when the generator breaker opens.

USE TIE BRKR OPEN SYNC RAMP?

S = 1(0,1)

If unchecked, the speed setpoint is instantly set to the last utility bus speed setting and holds. When left checked, the speed setpoint is instantly set to the last utility bus speed setting and moves to the synchronous (rated) speed setpoint after the utility breaker opens and the generator breaker is still closed.

USE SYNC / LOAD SHARE ANALOG INPUT?

S = 0 (0,1)

When checked, the speed setpoint is instantly set to the 'Gen Breaker Open Setpt' when the generator breaker opens.

SYNC WINDOW (RPM)

S = 10 (0, 100)

When configured for a generator, the sync window defines the speed window around rated speed (operating parameters rated speed), where the sync window rate will be active.

SYNC WINDOW RATE (RPM/SEC)

S = 2.0 (0.1, 100)

The rate the speed setpoint moves at when within the 'Sync Window' and the generator beaker is open. This is normally set slower than the slow rate to accommodate synchronizing to the bus. The Sync Window Rate is also active in isochronous (island) mode.

GEN BRKR OPEN SETBACK (RPM)

S = 50 (0.0, 20000)

This setpoint is defaulted to 50 rpm below the synchronous (rated) speed setpoint (only used if 'Gen Breaker Open Setback' is checked). (Must be between the 'Minimum Governor' and 'Rated Speed Setpt' settings)

TIEBRKR OPEN RATE (RPM/SEC)

S = 1.0 (0.1, 20000)

Rate the setpoint moves to rated speed after the utility breaker opens (only used if 'Tiebrkr Open Sync Ramp' is checked).

SYNC / LD SHARE BIAS GAIN (%)

S = 5.0 (0.1, 100)

When using the Sync or Sync/LD Share analog input, the speed setpoint bias is multiplied by this value to change performance. It is set based on the same calculation as the droop value. A value of 5 will give full load (rpm equivalent) adjustment.

SYNC / LD SHARE BIAS DEADBAND (RPM)

S = 5.0 (0.1, 100)

This value sets the dead band for the Sync or Sync/LD Share analog input.

To add lag to the synchronizing analog input, do so on the analog input configuration screen.

When configured for a single valve turbine, the relevant performance values appear on the Operating Parameters screen, whereas they would appear on the Performance screen for an extraction and/or admission turbine. See the Performance Values section for description of Min and Max Power, Max Inlet Flow and Rated Inlet pressure.

# V (x) Curves Screen

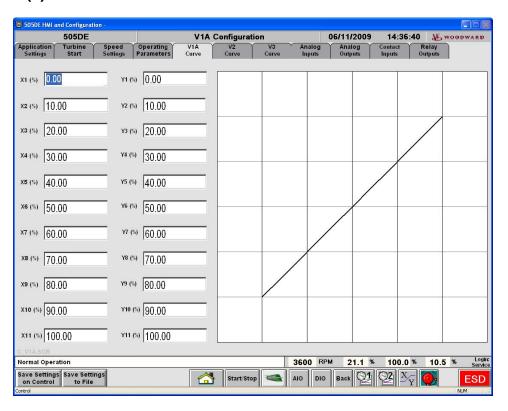


Figure 3-12. V (x) Curves Screen

X-1 VALUE S = 0.0 (-5, 110)X1 is the input point #1 of the actuator linearization curve, in percentage. (Must be less than the 'X-2 Value')

Y-1 VALUE S = 0.0 (-5, 110)

Y1 is the output point #1 of the actuator linearization curve, in percentage.

X-2 VALUE S = 10.0 (-5, 110)

X2 is the input point #2 of the actuator linearization curve, in percentage. (Must be between the 'X-1 Value' and the 'X-3 Value' settings)

Y-2 VALUE S = 10.0 (-5, 110)

Y2 is the output point #2 of the actuator linearization curve, in percentage.

X-3 VALUE S = 20.0 (-5, 110) X3 is the input point #3 of the actuator linearization curve, in percentage. (Must be between the 'X-2 Value' and the 'X-4 Value' settings)

Y-3 VALUE S = 20.0 (-5, 110)

Y3 is the output point #3 of the actuator linearization curve, in percentage.

X-4 VALUE S = 30.0 (-5, 110) X4 is the input point #4 of the actuator linearization curve, in percentage. (Must be between the 'X-3 Value' and the 'X-5 Value' settings)

Y-4 VALUE S = 30.0 (-5, 110)Y4 is the output point #4 of the actuator linearization curve, in percentage. S = 40.0 (-5, 110)X-5 VALUE X5 is the input point #5 of the actuator linearization curve, in percentage. (Must be between the 'X-4 Value' and the 'X-6 Value' settings) S = 40.0 (-5, 110)Y-5 VALUE Y5 is the output point #5 of the actuator linearization curve, in percentage. X-6 VALUE S = 50.0 (-5, 110)X6 is the input point #6 of the actuator linearization curve, in percentage. (Must be between the 'X-5 Value' and the 'X-7 Value' settings) Y-6 VALUE S = 50.0 (-5, 110)Y6 is the output point #6 of the actuator linearization curve, in percentage. X-7 VALUE S = 60.0 (-5, 110)X7 is the input point #7 of the actuator linearization curve, in percentage. (Must be between the 'X-6 Value' and the 'X-8 Value' settings) Y-7 VALUE S = 60.0 (-5.110)Y7 is the output point #7 of the actuator linearization curve, in percentage. X-8 VALUE S = 70.0 (-5, 110)X8 is the input point #8 of the actuator linearization curve, in percentage. (Must be between the 'X-7 Value' and the 'X-9 Value' settings) Y-8 VALUE S = 70.0 (-5, 110)Y8 is the output point #8 of the actuator linearization curve, in percentage. X-9 VALUE S = 80.0 (-5, 110)X9 is the input point #9 of the actuator linearization curve, in percentage. (Must be between the 'X-8 Value' and the 'X-10 Value' settings) Y-9 VALUE S = 80.0 (-5, 110)Y9 is the output point #9 of the actuator linearization curve, in percentage. S = 90.0 (-5, 110)X-10 VALUE X10 is the input point #10 of the actuator linearization curve, in percentage. (Must be between the 'X-9 Value' and the 'X-11 Value' settings) Y-10 VALUE S = 90.0 (-5, 110)Y10 is the output point #10 of the actuator linearization curve, in percentage. X-11 VALUE S = 100.0 (-5, 110)X11 is the input point #11 of the actuator linearization curve, in percentage. (Must be greater than the 'X-10 Value') Y-11 VALUE S = 100.0 (-5, 110)Y11 is the output point #11 of the actuator linearization curve, in percentage.

If operating a single valve turbine, the next three sections do not apply.

# **Steam Map Principles**

Before configuring the extraction/admission map, read the Steam Map description below. This discusses steam maps and how to convert your steam map information into a format usable by the 505DE 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 505DE uses the values programmed to calculate the turbine's internal pressure ratios and limits. In order to get these values from your steam map, you must first check the following conditions and, if necessary, modify the map so it meets these conditions:

- The map must be linear (all lines straight).
- Lines extraction/admission flow = 0% and extraction/admission flow =100% must be parallel, and lines V2(V3) valve = 0% and V2(V3) valve = 100% must be parallel.

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

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

- The horizontal x-axis shows turbine power (S).
- The vertical y-axis shows inlet flow or V1 valve position (V1).
- 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 V1=100 is the maximum V1 flow limiter. The V1 flow limiter prevents turbine operation beyond the desired maximum inlet flow limit.
- The parallel lines called P(x)=0 and P(x)=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 V2(V3)=0 and V2(V3)=100 define the V2(V3) valve position range (from closed to 100% open).

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

**NOTE!** The pertinent points in the 505DE have been re-labeled and differ from those in the 505E and the 5009. While this seems to add unnecessary complication, it makes it much easier to discuss all points on the steam map, especially in the double extraction case. Point A in the 505E is point C in the 505DE. Point C in the 505DE is point D in the 505DE. Point B in the 505E is point E in the 505DE. Refer to the map examples and descriptions.

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

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

The remaining pair of lines on opposite sides of the envelope must correspond to V2(V3)=0 (extraction valve closed) and V2(V3)=100 (extraction valve fully open). Note that the V2(V3)=0 line is parallel to the V2(V3)=100 line (condition 2).

The 505DE can be configured for three different types of double valve steam turbines, extraction only, admission only, or extraction/admission units. It can also be configured for a triple valve double extraction turbine. Following are examples for each of these configurations. Please proceed to the appropriate configuration for your application.

# Single Extraction Only Steam Map

Before a turbine's extraction steam map can be programmed into the control, it must have the intersection points C, D, & E (refer to Figure 3-4).

Typically Point D, the intersection of the V2(V3)=0 line and the P(x)=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 V2(V3)=0 line and the P(X)=0 line until they cross or intersect. This point where the V2(V3)=0 line intersects the P(x)=0 line is defined as Point D, and is required by the control to calculate the turbine's internal pressure ratios and limits.

The eight required values can be taken from the converted steam map. As an example, the following data was derived, using the steam map in Figure 3-13.

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

The MAX HP FLOW value is the flow where the V1=100 line crosses the HP-axis (about 108 000 lb/h; 48 989 kg/h).

Point C is where the P1=0 and V2=100 lines intersect (MAX POWER @ MIN EXTRACTION = about 15 062 kW; HP FLOW @ MIN EXTRACTION = about 36 000 lb/h; 16 330 kg/h).

Point D is where the V2=0 and P1=0 lines intersect (MIN POWER @ MIN EXTRACTION = about –3000 kW; MIN HP FLOW @ MIN EXTRACTION = about 6000 lb/h; 2722 kg/h).

Point E is where the V2=0 and P1=100 lines intersect (MIN POWER @ MAX EXTRACTION = about 3623 kW; HP FLOW @ MAX EXTRACTION = about 86 000 lb/h; 39 010 kg/h).

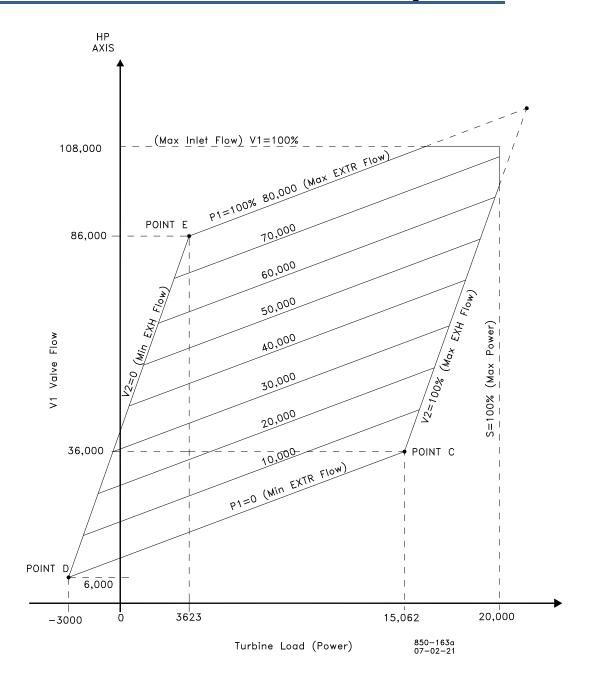


Figure 3-13. Typical Extraction Steam Map

# **Single Admission Only Steam Map**

Before a turbine's admission steam map can be programmed into the control, it must have the intersection points C, D, & E (refer to Figure 3-14).

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

If only point C exists, your map will have to be modified to include points D & E. The V2=0 line will need to be created. To create the V2=0 line you must know the minimum required steam flow through the back-end of the turbine. In our example steam map (Figure 3-15) the minimum required flow was 10 000 lb/h (4536 kg/h).

- Extend the zero admission (or induction) line (P1=100%). Refer to Figure 3-16.
- Find your turbine's minimum back-end steam flow (this will be point E's HP flow).
- 3. Mark the intersection of the zero admission line and the turbine's minimum back-end (cooling) steam flow. This mark will be Point E for programming.
- 4. Draw a line parallel to the V2=100 line, through the mark created in step 3. This will be your V2=0 line or V2 valve closed line.
- Mark the intersection of the P1=100 and the V2=100 line. This will be Point D
  for programming. Typically Point D the intersection of the V2=100 line and
  the P1=100 line does not exist.

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

The nine required values can be taken from the converted steam map. An example has been provided using the steam map in Figure 3-15.

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 V1=100 line crosses the HP-axis (about 105 000 lb/h; 47 628 kg/h).

Point C is where the P1=0 and V2=100 lines intersect (MAX POWER @ MAX ADMISSION = about 9500 kW; V1 FLOW @ MAX ADMISSION = about 75 000 lb/hr; 34 020 kg/h).

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

Point E is where the V2=0 and P1=100 lines intersect (MIN POWER @ MIN ADMISSION = about 700 kW; HP FLOW @ MIN ADMISSION = about 10 000 lb/h; 4536 kg/h). This point was used because 10 000 lb/h (4536 kg/h) is the minimum back-end cooling steam flow required by the turbine.

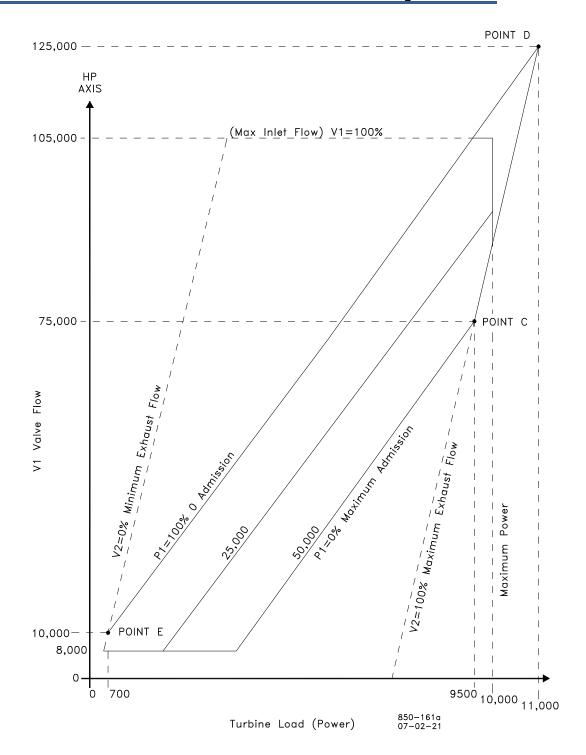


Figure 3-14. Typical Admission Steam Map

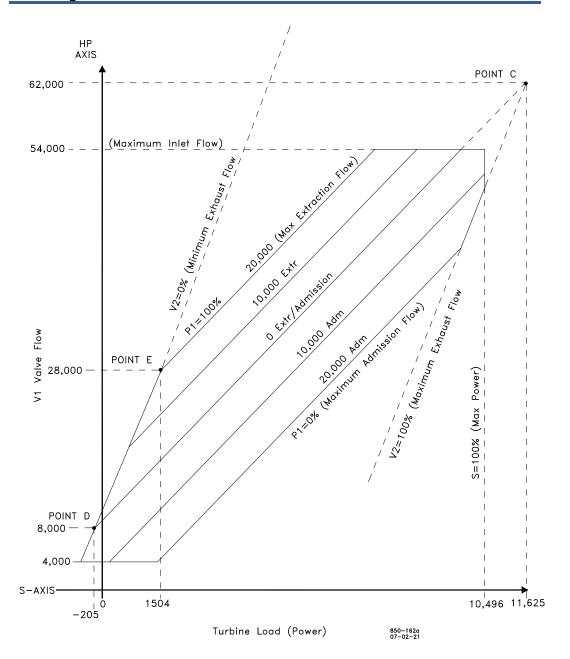


Figure 3-15. Typical Extraction & Admission Steam Map

Point E is where the V2=100 and P1=100 lines intersect (MAX POWER @ MIN ADMISSION = about 11 000 kW; MAX HP FLOW @ MIN ADMISSION = about 125 000 lb/h; 56 700 kg/h).

An additional parameter, MIN V2 LIFT in percent (see Admission and Extraction/Admission Shared Data) would also be set to 8000/105 000 = 7.6%

# Single Extraction & Admission Steam Map

Before a turbine's extraction/admission steam map can be programmed into the control, it must have the intersection points C, D, & E (refer to Figure 3-16).

If points C & E already exist, the only conversion necessary is the extension of the V2=0 line and the zero extraction and admission flow line until they cross or intersect (this is Point D for programming). If point C does not exist, the extension of the V2=100 line and the zero extraction and admission flow line until they cross or intersect is Point C for programming.

If points E & D do not exist, your map will have to be modified to include points E & D. The V2=0 line will need to be created. To create the V2=0 line you must know the minimum required steam flow through the back-end of the turbine. In our example steam map (Figure 3-16) the minimum required flow was 8000 lb/h (3629 kg/h).

- 1. Extend the maximum extraction line. Refer to Figure 3-6.
- 2. Extend the zero extraction & admission line.
- 3. Find your turbine's minimum back-end steam flow (this will be point D's V1 flow).
- 4. Mark the intersection of the zero extraction & admission flow line and the turbine's minimum back-end steam flow. This mark will be Point D for programming.
- 5. Draw a line parallel to the V2=100 line, through the mark created in step 4. This will be your V2=0 line or V2 valve closed line.
- 6. Mark the intersection of the maximum extraction line and the created V2=0 line. This will be Point E for programming.

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

The ten required values can be taken from the converted steam map. An example has been provided below, using the steam map in Figure 3-15.

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 V1=100 line crosses the HP-axis (about 54 000 lb/h; 24 494 kg/h).

Point C is where the P1=0 Extr/Adm and V2=100 lines intersect (MAX POWER @ 0 EXTR/ADM = about 11 625 kW; MAX HP FLOW @ 0 EXTR/ADM = about 62 000 lb/h; 28 123 kg/h).

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

Point D is where the V2=0 and zero extraction & admission flow lines intersect (MIN POWER @ ZERO EXTRACTION/ADMISSION = about –205 kW; MIN HP FLOW @ ZERO EXTRACTION/ADMISSION = about 8000 lb/h; 3629 kg/h).

Point E is where the V2=0 and P1=100 lines intersect (MIN POWER @ MAX EXTRACTION = about 1504 kW; MIN HP FLOW @ MAX EXTRACTION = about 28 000 lb/h; 12 701 kg/h).

An additional parameter, MIN V1 LIFT (%), would also be set to 4000/54000 = 7.4%.

# **Double Extraction Map**

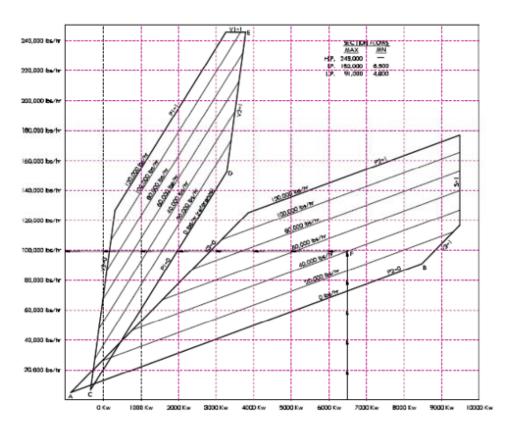


Figure 3-16a. Generic Double Extraction Steam Map

The steam map is a graphic representation of the operating range of the turbine. This map is supplied by the turbine vendor to depict turbine performance to the customer. It defines the operating characteristics of the turbine but can also be used to define the HP (V1), IP (V2), and LP (V3) relationships. The axes of the steam map represent power output along the horizontal and inlet steam flow along the vertical axes.

Figure 3-16a shows an example of a double extraction turbine steam map. The steam map for each turbine is unique to itself; however the maps are similar enough to each other so that the same descriptions and procedures apply to all. This example will be referenced throughout the remainder of this report.

Notice that there are actually two regions on the steam map. The region to the left is the map for P1 extraction and the region on the right is the map for P2 extraction. These regions are used concurrently when retrieving information from the map. The P2 extraction map is drawn for the condition where P1 extraction equals zero. Therefore, as long as P1 extraction equals zero, plotting a point on the P2 extraction map simply requires a vertical line drawn downward to determine power output and a horizontal line to the left to indicate the required inlet steam flow for those conditions.

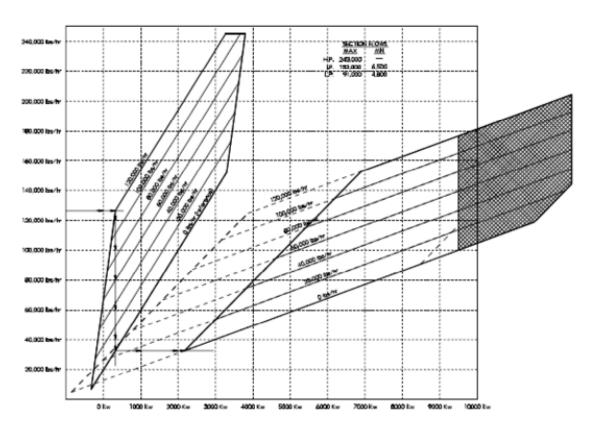


Figure 3-16b. Double Extraction Steam map (P1=1)

The map changes drastically however, once flow is extracted from P1. Since the P2 extraction map is drawn for the condition of P1 extraction equals to zero, once there is P1 extraction flow, the P2 extraction map is no longer valid and must be redrawn for the new P1 extraction condition. Figure 3-16b shows the new location of the P2 extraction steam map for the condition of maximum P1 extraction. Notice how the P2 extraction map moves to the right and up along the P2 extraction flow lines as P1 extraction is increased from zero.

To find the new location of the P2 extraction map, start with the maximum P1 and V2=0. From this, draw a line vertically downward to intersect the P1=0 line. A horizontal line is then drawn from this intersection to intersect with the P2=0 line. This intersection point is now the new location of the V3=0 and P2=0 intersection. The rest of the P2 extraction map moves accordingly. The portion of the P2 extraction map that is shaded shows the part of the map that is no longer a valid operational area due to the fact that the S=1 line does not move.

In contradiction to single extraction, an operating point on the double extraction map is represented by two points as it is shown in figure 3-16c.

An operating point is defined with three parameters (S, P1, P2). These three points are controlled by the three valves. If V1 and V2 are known the value of P1 is determined on P1 map. (Point OP). To find the second point, a vertical line from OP should be drawn to intersect the P2=0 line. A horizontal line from the intersection point should be drawn to the P2 map. According the value of V3, the P2 amount will be determined. (The OP' also explains the value of S. In conclusion, when the amounts of the valve demands are known, the values of the desired parameters can be found on the map and vice versa. That means if the values of the desired parameters (S, P1, P2) are known we can determine the valve demands.

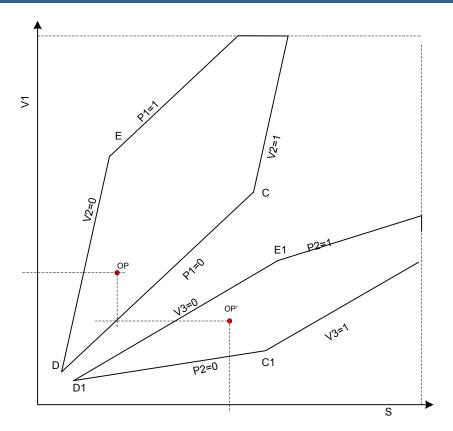


Figure 3-16c. Finding Operating Point on the Double Extraction Map

The key point is that absolute power values are not needed for the P1 map. Power values must still be entered, but only their relevance to one another (C power, D power, E power) must be maintained. For display and multiple limit stability, the 505DE requires that the P1 map be translated so that its P1=0 line is coincident with (on top of) the P2=0 line on the P2 map. The P1 map must maintain its V1 inlet flow values, the angle formed by the P1=0 line and the V2=0 line at point D, and the V2 and P1 sides must stay parallel. This is achieved by sliding the P1 map to the right until point D is on top of the P2=0 line, then rotating the P1 map until the P1=0 line is coincident with the P2=0 zero line. During rotation, all the P1 flow values for A, B, C, D, and E are maintained, stretching the P1 map to a larger appearance.

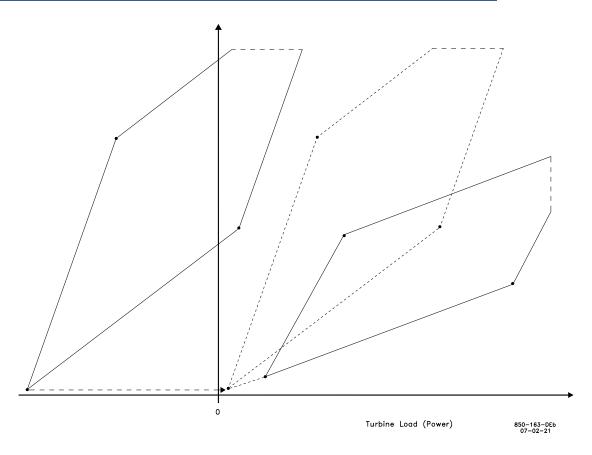


Figure 3-17. Move P1 map until point D is on top of the P2=0 line

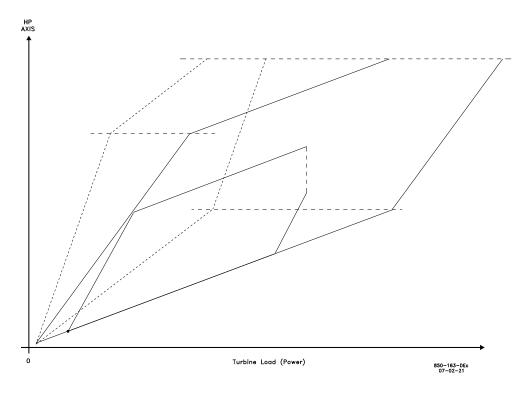


Figure 3-18. Rotate P1 map, maintaining angle at D, flow values

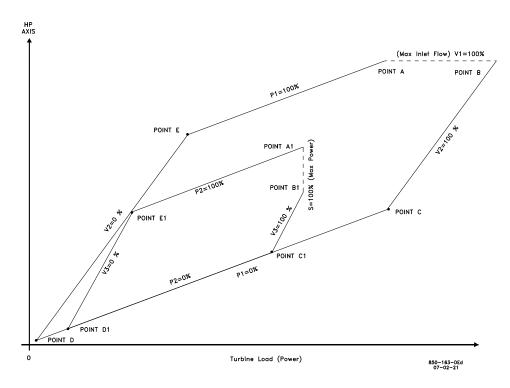


Figure 3-19. Double extraction steam map constructed for the 505DE

The values for points C, D, E, C1, D1, and E1 are determined from the axis in the same manner as for a single extraction map. Note that the C power value for the P1 map will most likely be greater than max load. This is OK since the P1 map doesn't require actual power values.

# **Turbine Performance Screen**

The turbine performance values screen appears when any type of extraction, admission, or double extraction turbine is selected. For double valve turbines, Max P2 Flow and C1, D1, and E1 points are not shown, and the plot displays a single extraction map.

The operating points for the P1 and P2 extraction controllers are indicated on the steam map by a line that represents the operating parameters as the 505DE is calculating them. These are indicated by circles on the figure below. Note that the P1 Extraction operating point occurs at the 1<sup>st</sup> corner made by the line, and the P2 Extraction operating point occurse at the 3<sup>rd</sup> corner.

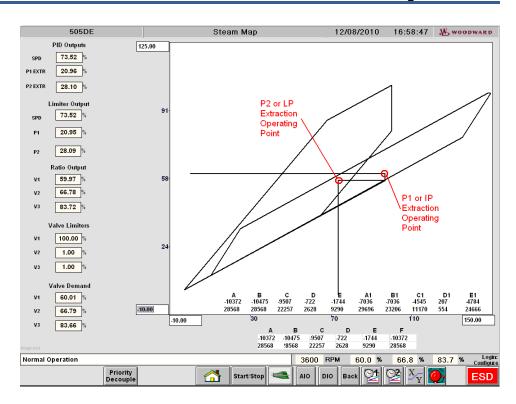


Figure 3-20. Turbine Performance screen (Double Extraction, Service)

# All Steam Map Data

PRIORITY #1 C = 0 (0,5)

A turbine can only control as many parameters as it has unlimited valves. If a valve becomes limited, then control of one process will be lost. The priority pulldown selection box allows the user to choose the order that control parameters are kept (or dropped) when turbine limits are reached. The text chosen in the pulldown selection box configures an integer in the 505DE. The following are in order of importance from the left, therefore in drop order from the right: 0 = S-P1-P2, 1 = S-P2-P1, 2 = P1-S-P2, 3 = P1-P2-S, 4 = P2-S-P1, 5 = P2-P1-S.

PRIORITY #2 C = 0 (0.5)

Priority #2 selections are the same as #1. Using a contact input or from the 505DE HMI or Modbus, the operator can switch between priority #1 and #2. MAX POWER (KW)

C = 10000 (0, 500000)

The maximum power limit of the turbine corresponds to the S = 100% line on the steam map.

MIN POWER (KW) C = 0 (0.15000)

Use if desired to reduce the power range. This does not affect min load.

MAX HP FLOW

C = 200000 (0, 990000)

The maximum steam flow through the V1 steam valve into the turbine corresponds to the HP=100% line on the steam map.

RATED INLET PRESSURE S = 650 (0, 500000)

The Inlet Pressure that the steam map is constructed for.

# **Extraction Steam Map Data**

MAX P1 FLOW (UNITS)

C = 120000 (0, 990000)

The maximum P1 extraction flow the turbine is capable of. This should be the P1 extraction flow value that occurs when inlet pressure is at rated (for the steam map), and P1 demand is at 100%. In most cases this is the flow value for the P1=1 line.

The next two entries correspond to Point C on the steam map.

MAX POWER @ MIN EXTR

C = 15050 (0.990000)

Maximum turbine power at min extraction. Power at Point C.

(Power must be greater than Point D)

HP FLOW @ MIN EXTR

C = 152500 (0, 990000)

HP valve steam flow at min extraction. Flow at Point C.

(Flow must be greater than Point D)

The next two entries correspond to Point D on the steam map.

MIN POWER @ MIN EXTR

C = 350 (-500000, 500000)

Minimum turbine power at min extraction. Power at Point D.

(Power must be less than Point C)

MIN HP FLOW @ MIN EXTR

C = 8000 (-500000, 500000)

HP valve steam flow at min extraction. Flow at Point D.

(Flow must be less than Point C)

The next two entries correspond to Point E on the steam map.

MIN POWER @ MAX EXTR

C = 300 (-500000, 500000)

Minimum turbine power at max extraction. Power at Point E.

(Power must greater than Point D)

MIN HP FLOW @ MAX EXTR

C = 128000 (0, 750000)

HP valve steam flow at max extraction. Flow at Point E

(Flow must be greater than Point D)

(Skip to MIN LP LIFT)

# **Admission Steam Map Data**

The next three entries correspond to Point C on the steam map.

MAX POWER @ MAX ADM

C = 15050 (0.990000)

Maximum turbine power at max admission. Power at Point C.

(Power must be less than Point D)

MAX HP FLOW @ MAX ADM

C = 152500 (0, 990000)

HP valve steam flow at max admission. Flow at Point C

(Flow must be less than Point D)

MAX ADMISSION FLOW

C = 0 (0, 20000)

Maximum possible admission flow.

The next two entries correspond to Point D on the steam map.

MAX POWER @ MIN ADM

C = -350 (-500000, 500000)

Minimum turbine power at max admission. Power at Point D.

(Power must be greater than Point C and Point E)

MAX HP FLOW @ MIN ADM

C = 8000 (-500000, 500000)

HP valve steam flow at max admission. Flow at Point D.

(Flow must be greater than Point C and Point E)

The next two entries correspond to Point E on the steam map.

MIN POWER @ MIN ADM

C = 300 (-500000, 500000)

Minimum turbine power at min admission. Power at Point E.

(Power must be less than Point D)

MIN HP FLOW @ MIN ADM

C = 128000 (0, 750000)

HP valve steam flow at min admission. Flow at Point E.

(Flow must be less than Point D)

(Skip to EXTR/ADM DEMAND RATE)

# **EXTR and Admission Steam Map Data**

The next two entries correspond to Point C on the steam map

MAX POWER @ 0 EXTR/ADM

C = 15050 (0, 990000)

Maximum turbine power at zero Extr/Adm. Power at Point C.

(Power must be greater than Point D)

MAX HP FLOW @ 0 EXTR/ADM

C = 152500 (0, 990000)

HP valve steam flow at zero Extr/Adm. Flow at Point C.

(Flow must be greater than Point D)

MAX ADMISSION FLOW

C = 10 (0, 20000)

Maximum possible admission flow.

The next two entries correspond to Point D on the steam map.

MIN PWR @ 0 EXTR/ADM

C = -350 (-500000, 500000)

Minimum power at zero extraction and admission flow. Power at Point D (Power must be less than Point C)

MIN HP FLOW @ 0 EXTR/ADM

C = 8000 (-500000, 500000)

HP valve steam flow at zero extraction and admission flow. Flow at Point D (Flow must be less than Point C)

The next two entries correspond to Point E on the steam map.

MIN POWER @ MAX EXTR

C = 300 (-500000, 500000)

 $\label{eq:minimum turbine power at max admission. Power at Point E.$ 

(Power must be greater than Point D)

MIN HP FLOW @ MAX EXTR

C = 128000 (0, 750000)

HP valve steam flow at max admission. Flow at Point E.

(Flow must be greater than Point D)

(Skip to EXTR/ADM DEMAND RATE)

#### **Admission and Extraction/Admission Shared Data**

MIN V1 LIFT (%)

C = 0.0 (0, 100)

The minimum position limit the V1 valve will close to when Extr/Adm or admission control is enabled.

MIN V2 LIFT (%)

C = 0.0 (0.100)

The minimum position limit the V2 valve output when configured for admission or Extr/Adm.

V2 VALVE LIMITER RATE (%/SEC)

C = 1.0 (0.01, 25)

The rate at which the V2 valve limiter moves when adjusted and during enabling and disabling Extr/Adm control.

# **Double Extraction Steam Map Data**

#### MAX P1 FLOW (UNITS)

C = 120000 (0.990000)

The maximum P1 extraction flow the turbine is capable of. This should be the P1 extraction flow value that occurs when inlet pressure is at rated (for the steam map), and P1 demand is at 100%. In most cases this is the flow value for the P1=1 line.

MAX P2 FLOW (UNITS)

C = 70000 (0, 750000)

The maximum P2 extraction flow the turbine is capable of. This should be the P2 extraction flow value that occurs when inlet pressure is at rated (for the steam map), and P1 demand is at 100%. In most cases this is the flow value for the P2=1 line.

#### P1 Map Data

The next two entries correspond to Point C on the steam map.

MAX POWER @ MIN EXTR

C = 15050 (0, 990000)

Maximum turbine power at min extraction. Power at Point C.

(Power must be greater than Point D)
HP FLOW @ MIN EXTR

C = 152500 (0, 990000)

HP valve steam flow at min extraction. Flow at Point C.

(Flow must be greater than Point D)

The next two entries correspond to Point D on the steam map.

MIN POWER @ MIN EXTR

C = -350 (-500000, 500000)

Minimum turbine power at min extraction. Power at Point D.

(Power must be less than Point C)

MIN HP FLOW @ MIN EXTR

C = 8000 (-500000, 500000)

HP valve steam flow at min extraction. Flow at Point D.

(Flow must be less than Point C)

The next two entries correspond to Point E on the steam map.

MIN POWER @ MAX EXTR

C = 300 (-500000, 500000)

Minimum turbine power at max extraction. Power at Point E.

(Power must greater than Point D)

MIN HP FLOW @ MAX EXTR

C = 128000 (0.750000)

HP valve steam flow at max extraction. Flow at Point E

(Flow must be greater than Point D)

#### P2 Map Data

The next two entries correspond to Point C1 on the steam map.

MAX POWER @ MIN EXTR

C = 8500 (-20000, 500000)

Maximum turbine power at min extraction. Power at Point C1.

(Power must be greater than Point D1)

HP FLOW @ MIN EXTR

C = 91000 (0, 750000)

HP valve steam flow at min extraction. Flow at Point C1.

(Flow must be greater than Point D1)

The next two entries correspond to Point D1 on the steam map.

MIN POWER @ MIN EXTR

C = -850 (-50000, 500000)

Minimum turbine power at min extraction. Power at Point D1.

(Power must be less than Point C1)

MIN HP FLOW @ MIN EXTR

C = 100 (-500000, 500000)

HP valve steam flow at min extraction. Flow at Point D1. (Flow must be less than Point C1)

The next two entries correspond to Point E1 on the steam map.

MIN POWER @ MAX EXTR

C = 3850 (-20000, 500000)

Minimum turbine power at max extraction. Power at Point E1.

(Power must greater than Point D1)

MIN HP FLOW @ MAX EXTR

C = 125000 (0, 750000)

HP valve steam flow at max extraction. Flow at Point E1.

(Flow must be greater than Point D1)

# **Extraction / Admission Controller Screens**

Choose the Extraction Admission tab on the configuration menu, and then choose the P1 or P2 tab that appear next to the Extraction Admission tab. Only P1 controller parameters are shown in this manual. The P2 controller has identical settings.

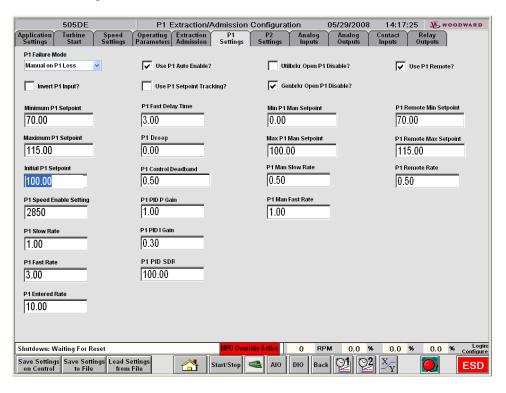


Figure 3-21. P1 Settings Screen (remote enabled, Service level)

# **ACTION ON LOSS OF P1 INPUT**

S = 0 (0,3)

This pull down selection box tells the 505DE what action to take if the P1 analog input fails. While text is selected within the pull down box, in actuality, an integer is configured in the 505DE. This integer represents: 0=P1 control in manual, 1=trip the turbine, 2=min V2 (in manual), 3=max V2 (disables P1).

#### **INVERT P1 INPUT?**

C = 0 (0,1)

Check if Extr/Adm control will be reverse acting. If left unchecked, control will be forward acting. Typically this will be left unchecked; when programmed for Coupled HP & LP mode, the only time this input would be inverted is if the LP valve needs to close when the input exceeds the setpoint (the ratio logic provides an inversion).

#### USE AUTOMATIC P1 ENABLE?

C = 0 (0,1)

If checked, extraction control can be enabled with either a contact input or from the 505DE HMI. This setting does not mean that extraction will automatically enable at some point with no operator action. If left unchecked, the LP Valve Limiter is used to enable extraction control. The limiter must be lowered manually to enable extraction control.

#### USE P1 SETPOINT TRACKING?

C = 0 (0.1)

If checked, the setpoint will track the Extr/Adm input to allow bumpless transfer to control mode. If left unchecked, the setpoint will initialize to the 'Setpoint Initial Value' on power-up.

# TIE BRKR OPEN P1 DISABLE?

C = 1 (0.1)

Leave checked if desired that the P1 control will be disabled when the utility breaker is open. If unchecked, then P1 control will not be disabled when the utility breaker is open.

#### GEN BRKR OPEN P1 DISABLE?

C = 1 (0,1)

Leave checked if desired that the P1 control will be disabled when the generator breaker is open. If unchecked, then P1 control will not be disabled when the generator breaker is open.

#### P1 MIN EXTR/ADM SETPT

S = 0.0 (-1000000, 1000000)

Set the minimum Extr/Adm setpoint. This value is the minimum setpoint value that the Extr/Adm setpoint can be decreased/lowered to (lower limit of Extr/Adm setpoint).

#### P1 MAX EXTR/ADM SETPT

S = 100 (-1000000, 1000000)

Set the maximum Extr/Adm setpoint. This value is the maximum setpoint value that the Extr/Adm setpoint can be increased/raised to (upper limit of Extr/Adm setpoint).

(Must be greater than the 'Min Extr/Adm Setpt' Setting)

# P1 SETPT INITIAL VALUE (UNITS)

S = 50 (-1000000, 1000000)

Set the setpoint initialization value. When not using the 'P1 Automatic Enable' function, this is the value that the P1 setpoint initializes to upon power-up or when re-setting from IO Lock (configure level).

(Must be less than or equal to the 'Max P1 Setpoint' Setting)

#### P1 SPEED ENBL SETTING

S = 1000 (0, 20000)

The speed must be above this setting before the P1 controller will become active. This is a permissive only. The 505DE does not automatically ENABLE P1 control when speed is above this value. If already enabled, the P1 controller will activate when speed exceeds this value.

#### P1 SLOW RATE (UNITS/SEC)

S = 5.0 (0.01, 1000)

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

#### P1 FAST RATE (UNITS/SEC)

S = 15 (0.01, 5000)

This value is the rate that the P1 Setpoint will move when a raise or lower P1 setpoint command has been active for longer than the fast rate delay.

# P1 ENTERED RATE (UNITS/SEC)

S = 15 (0.01, 5000)

This value is the rate that the P1 Setpoint will move when a setpoint is directly input through the 505DE HMI or Modbus.

# P1 FAST RATE DELAY (SEC)

S = 3.0 (0.0, 1000)

If a raise or lower P1 setpoint command is active for longer than this setting, then the P1 fast rate will be used.

# P1 DROOP (%)

S = 0.0 (0.0, 100)

Enter the droop percentage. This setting is for cases where there is another controller on the P1 header that is trying to control at the same pressure. This may cause the 505DE and other controller to 'fight'. The P1 droop setting introduces an offset to the P1 PID so the PID can control with the other controller. This also means that controlled pressure will be offset from the setpoint by this amount.

#### PID CONTROL DEADBAND (%)

dflt = 0.0 (0.0, 50)

The P1 PID controller integrator dead band setting defines the error between the setpoint and the process that will be tolerated before the PID adjusts its output.

# P1 PID PROPORTIONAL GAIN (%)

R = 1.0 (0.0, 100)

Enter the Extr/Adm PID proportional gain. This value is used to set P1 control response. This value can be changed in the Run Mode while the turbine is operating. If unknown, a recommended starting value is 1%.

#### P1 PID INTEGRAL GAIN (rps)

R = 0.3 (0.001, 50)

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

#### P1 PID DERIVATIVE RATIO (%)

S = 100 (0.01, 100)

Enter the Extr/Adm PID derivative ratio. This value is used to set Extr/Adm control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%. The derivative term is removed from the response calculation when set to 100 or .01. If left at the default of 100, the P1 controller will be a P-I controller.

#### P1 MAN MIN SETPOINT (%)

S = 0.0 (0, 100)

Set the minimum P1 manual setpoint. This value is the minimum setpoint value that the P1 manual demand (0-100% of P1 PID) can be decreased/lowered to

# P1 MAN MAX SETPOINT (%)

S = 100 (0, 100)

Set the maximum P1 manual setpoint. This value is the maximum setpoint value that the P1 manual demand (0-100% of P1 PID) can be increased/raised to.

# P1 MAN SLOW RATE (%/SEC)

S = 5.0 (0.01, 1000)

This value is the rate (in % PID output per second) at which the P1 manual setpoint moves when adjusted.

# P1 MAN FAST RATE (%/SEC)

S = 15 (0.01, 5000)

This value is the rate that the P1 Setpoint will move when a raise or lower P1 setpoint command has been active for longer than the P1 fast rate delay.

#### USE P1 REMOTE?

C = 0 (0,1)

Check to allow the Extr/Adm setpoint to be adjusted from an analog input. This setting also activates P1 Manual Remote.

(Must program a 'remote Extr/Adm setpoint' analog input)

# P1 REMOTE MIN

S = 0 (-1000000, 1000000)

Minimum setting allowed by the remote input. Must be above the 4 mA value of the P1 remote analog input.

(Must be between the 'Minimum Extr Setpt' and the 'Maximum Extr Setpt' settings)

#### P1 REMOTE MAX

S = 100 (-1000000, 1000000)

Maximum setting allowed by the remote input. Must be below the 20 mA value of the P1 remote analog input.

(Must be between the 'Minimum Extr Setpt' and the 'Maximum Extr Setpt' settings)

#### P1 REMOTÉ RATE

S = 5.0 (0.01, 5000)

Set the Extr/Adm setpoint rate. This value is the rate (in units per second) at which Extr/Adm setpoint moves when adjusted.

# Cascade Control Screen

If 'Use Cascade' is checked on the Application Settings screen, then the Cascade Control tab will be available on the configuration menu.

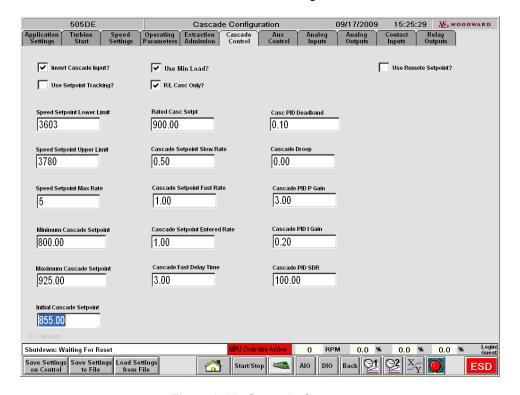


Figure 3-22. Cascade Screen

## **INVERT CASCADE INPUT?**

C = 0 (0,1)

Check if the cascade control will be reverse acting. If left unchecked, the control will be forward acting. Typically this will be left unchecked, the only time the input would be inverted is if the V1 valve needs to open when the input exceeds the setpoint. An example where the invert would be used is for turbine inlet pressure control.

#### USE SETPOINT TRACKING?

C = 0 (0,1)

If checked, the cascade setpoint tracks the cascade input to provide bumpless transfer to cascade control when it is enabled. If left unchecked, the cascade setpoint remains at the last position except on power-up or reset from IO Lock, when it will initialize to the cascade setpoint initial value.

USE MIN LOAD?

C = 1 (0, 1)

When checked, the speed setpoint cannot be lowered/decreased by the Cascade control PID below the rated/synchronous speed setpoint plus the 'Min Load Bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When left unchecked, the Cascade control PID can move the speed setpoint down to the cascade minimum speed setting value.

#### SPEED SETPOINT LOWER LIMIT (RPM)

S = 3605 (0.0, 20000)

Set the minimum speed setpoint that the cascade controller can lower the speed setpoint to. To protect the unit, this value should be at or above rated speed if the unit is a generator.

(Must be greater than or equal to the 'Minimum Governor Speed Setpt' Setting)

# SPEED SETPOINT UPPER LIMIT (RPM)

S = 3780 (0.0, 20000)

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

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

## MAX SPEED SETPOINT RATE (RPM/SEC)

S = 20 (0.1, 100)

Set the maximum rate at which the cascade control can vary the speed setpoint.

# MIN CASCADE SETPOINT (UNITS)

S = 0.0 (-20000, 20000)

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

# MAX CASCADE SETPOINT (UNITS)

S = 100 (-20000, 20000)

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

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

# CASCADE SETPT INITIAL VALUE (UNITS)

S = 100 (-20000, 20000)

Set the setpoint initialization value. When not using the Setpoint Tracking function, this is the value that the cascade setpoint initializes to upon power-up or reset from IO Lock.

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

#### RATED CASCADE SETPT

S = 100 (-20000, 20000)

Only used to determine the extraction control Droop.

SETPT SLOW RATE (UNITS/SEC)

S = 5 (0.01, 1000)

Enter the normal rate of change for the cascade setpoint.

#### SETPT FAST RATE (UNITS/SEC)

S = 15 (0.01, 5000)

Enter the fast rate of change for the cascade setpoint. The fast rate is used when a raise or lower command has been active for longer than the fast rate delay.

#### SETPT ENTERED RATE (UNITS/SEC)

S = 5 (0.01, 1000)

This is the rate that the Cascade setpoint will move when setpoint is entered from the 505DE HMI or via Modbus.

# CASC FAST RATE DELAY (SEC)

S = 3.0 (0.0, 100)

If a raise or lower command is active for longer than the fast rate delay, then the cascade setpoint fast rate will be used.

#### CASC PID INT DEADBAND

dflt = 0.1 (0.0, 50)

Cascade PID controller integrator deadband setting in engineering units.

#### CASCADE DROOP (%)

S = 0.0 (0.0, 100)

Enter the droop percentage. This setting is for cases where there is another controller applied to the same parameter as the cascade controller. This may cause the 505DE and other controller to 'fight'. The droop setting introduces an offset to the cascade PID so the PID can control with the other controller. This also means that controlled parameter will be offset from the setpoint by this percentage of the rated setpoint.

# CASCADE PID PROPORTIONAL GAIN (%)

R = 5.0 (0.0, 100)

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

# CASCADE PID INTEGRAL GAIN

R = 0.3 (0.001, 50.0)

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 Run Mode while the turbine is operating. If unknown, a recommended starting value is 0.3 rps.

#### CASCADE PID DERIVATIVE RATIO (%)

S = 100 (0.0101, 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%. A value of 100 or .01 turns of the derivative term in the PID calculation, making the controller a P-I controller.

#### USE REMOTE CASCADE SETTING?

C = 0 (0,1)

Check to allow the Cascade setpoint to be adjusted from an analog input.

(Must program a 'remote cascade setpoint' analog input)

#### RMT CASC SETPT MAX RATE

S = 5 (0.01, 1000)

Rate the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the remote cascade input setting.

#### REMOTE NOT MATCHED RATE

S = 5 (0.01, 1000)

Rate the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint.

#### MINIMUM RMT CASC SETTING

S = 0 (-20000, 20000)

Minimum setting allowed by the remote input.

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

#### MAXIMUM RMT CASC SETTING

S = 100 (-20000, 20000)

Maximum setting allowed by the remote input.

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

#### REMOTE DEADBAND VALUE

S = 0.0 (0.0, 500)

Remote cascade setting input deadband in engineering units.

# **Auxiliary Control Screens**

If 'Aux Type' on the Application Settings screen is selected to be one or two Aux Controllers, then the Auxiliary Control tab will be available on the configuration menu.

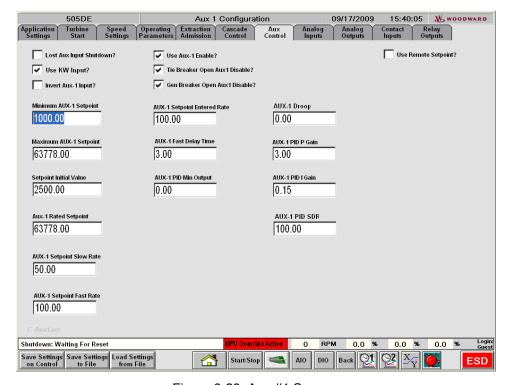


Figure 3-23. Aux #1 Screen

#### LOST AUX INPUT SHUTDOWN?

C = 0 (0.1)

Check if a shutdown command is to be given when the auxiliary input fails. If left unchecked, then no shutdown command will be given when the auxiliary input fails, only an alarm.

**USE KW INPUT?** 

C = 0 (0,1)

If checked, allows the AUX control channel to use the kW Input as its controlled parameter. When checked, no aux analog input is needed. When left unchecked, an AUX analog input must be programmed.

**INVERT AUX INPUT?** 

C = 0 (0,1)

Check if the auxiliary control will be reverse acting. If left unchecked, then the control will be forward acting. Typically the controller will need to be forward acting, the only time the input would be inverted is if the valve needs to open when the input exceeds the setpoint. An example where the invert would be checked is for turbine inlet pressure control.

USE AUX ENABLE?

C = NO (Yes/No)

Check if using the Auxiliary control enable/disable feature. If checked, Aux will require an ENABLE command to enable Aux control. If unchecked, then the Auxiliary function will be enabled constantly and will act as a controlling limiter. An example of using Aux as a limiter is using Aux to limit the maximum kW load that the unit carries. The Aux PID is not normally in control of the valve output. But if the Aux (kW) input exceeds the setpoint, the Aux PID controller would decrease and take control of the valve until the kW level decreases below the maximum kW (Aux) setting. Alternatively, if the Aux enable is used, the Aux setpoint tracks the Aux input. When enabled, the Aux PID takes control of the valve and the speed setpoint tracks the speed/load of the unit for bumpless transfer between modes.

#### TIEBRKR OPEN AUX DSBL?

C = 1(0,1)

Leave checked if the auxiliary control should be disabled when the utility breaker opens. If unchecked, then auxiliary control will not be disabled when the utility breaker is opened.

GENBRKR OPEN AUX DSBL?

C = 1(0,1)

Leave checked if the auxiliary control should be disabled when the generator breaker opens. If unchecked, then auxiliary control will not be disabled when the generator breaker is opened.

MIN AUX SETPOINT (UNITS)

S = 0.0 (-20000, 20000)

Set the min aux setpoint. This value is the minimum setpoint value that the auxiliary setpoint can be decreased/lowered to (lower limit of aux setpoint).

MAX AUX SETPOINT (UNITS)

S = 100 (-20000, 20000)

Set the max aux setpoint. This value is the maximum setpoint value that the auxiliary setpoint can be increased/raised to (upper limit of aux setpoint). (Must be greater than the 'Min Aux Setpt' Setting)

SETPT INITIAL VALUE (UNITS)

S = 0.0 (-20000, 20000)

Set the setpoint initialization value. When not using the Aux Enable function, this is the value that the auxiliary setpoint initializes to upon power- up or exiting the program mode.

(Must be less than or equal to the 'Max Aux Setpoint' Setting)

RATED AUX SETPT

S = 100 (-20000, 20000)

Only used to determine the auxiliary control Droop. (Must be between the 'Minimum Auxiliary Setpoint' and the 'Maximum Auxiliary Setpoint' settings)

AUX SLOW RATE (UNITS/SEC)

S = 5 (0.01, 1000)

The slow rate is the normal rate of change the aux setpoint will move at when being adjusted.

AUX FAST RATE (UNITS/SEC)

S = 15 (0.01, 5000)

If a raise or lower command is active for longer than the fast rate delay time, then the fast rate will be used to move the aux setpoint.

AUX SETPT ENTERED RATE (UNITS/SEC)

S = 5 (0.01, 1000)

This is the rate that the Aux setpoint will move when a setpoint is entered from the 505DE HMI or over Modbus communications.

#### FAST RATE DELAY (SEC)

S = 3.0 (0.0, 100)

If an Aux raise or lower command is active for longer than the fast rate delay time, then the aux setpoint fast rate will be used.

AUX PID MIN OUTPUT

S = 0.00 (0.0, 50)

The Auxiliary PID cannot output a lower value to the LSS. This can be used to stop the Aux PID from taking the LSS low enough to take the unit off-line or below Min Gov.

AUX DROOP (%)

S = 0 (0.0, 100)

The droop setting allows the Aux Controller to control the same process as another controller by offsetting its PID output.

AUX PID PROPORTIONAL GAIN (%)

R = 1.0 (0.0, 100)

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

**AUX PID INTEGRAL GAIN** 

R = 0.3 (0.001, 50)

Enter the aux 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 0.3 rps.

**AUX PID DERIVATIVE RATIO (%)** 

S = 100 (0.01, 100)

Enter the aux PID derivative ratio. This value is used to set auxiliary control response. This value can be changed in the Service Mode while the turbine is operating. If unknown, a recommended starting value is 100%. A value of 100 or .01 removes the derivative ratio from the PID calculation, making the Aux controller a P-I controller.

USE REMOTE AUX SETTING?

C = 0 (0,1)

Check to allow the aux setpoint to be adjusted from an analog input. (Must program a 'remote auxiliary setpoint' analog input)

AUX RMT SETPT RATE

S = 5 (0.01, 1000)

Rate the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the analog input.

AUX REMOTE NOT MATCHED RATE

S = 5 (0.01, 1000)

Rate the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint.

MINIMUM RMT AUX SETTING

S = 0 (-20000, 20000)

Minimum setting allowed by the remote analog input.

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

MAXIMUM RMT AUX SETTING

S = 100 (-20000, 20000)

Maximum setting allowed by the remote analog input.

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

REMOTE DEADBAND VALUE

S = 0.0 (0.0, 500)

Remote aux setting input deadband in engineering units.

# **Analog Inputs Screen**

The Analog Inputs screen allows you to select functions and set ranges for the 16 Analog Inputs available on the 505DE. Because the 505DE covers a wide range of applications, no analog inputs are pre-programmed.

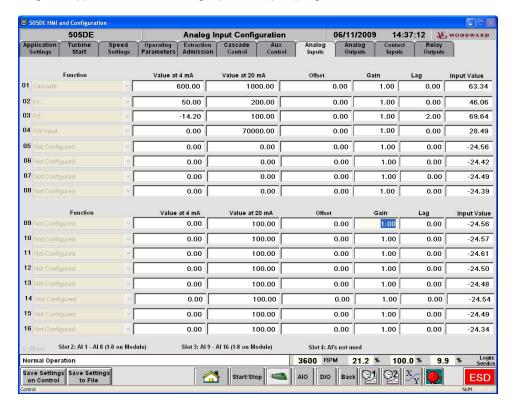


Figure 3-24. Analog Input Screen (Configure)

# ANALOG INPUT # (X) FUNCTION

C = 0.0 (0,60)

Select Analog Input functions as needed. To make an input redundant, select its redundant counterpart to another analog input channel. If an input is selected but its corresponding function not programmed, a configuration alarm and start lock will occur. Also, an alarm will notify if an input has been programmed on more than one channel. Functionally there is no danger of programming a function to two different channels; however, the higher number duplicate channel will be ignored.

#### **Analog Input Options**

0: Not Configured 13: First Stage Pressure

1: KW Input 14: SG PID

2: Remote Speed Setpoint 15: SG PID Setpoint

3: Cascade 16: P1

4: Remote Cascade Setpoint 17: P1 Setpoint

5: Aux 1 18: Pressure Compensation

6: Aux 1 Remote Setpoint 19: Inlet Pressure

7: Aux 2 20: Inlet Pressure Setpoint 8: Aux 2 Remote Setpoint 21: Exhaust Pressure

9: Sync Input 22: Exhaust Pressure Setpoint

10: Sync / Load Share Input 23: P2

11: Load Share Input12: Heat Soak Input24: P2 Setpoint25: Spare

#### **Redundant Inputs**

26: Red. KW Input 38: Red. First Stage Pressure

27: Red. Remote Speed Setpoint 39: Red. SG PID

28: Red. Cascade 40: Red. SG PID Setpoint

29: Red. Remote Cascade Setpoint 41: Red. P1

30: Red. Aux 1 42: Red. P1 Setpoint

31: Red. Aux 1 Remote Setpoint 43: Red. Pressure Compensation

32: Red. Aux 2 44: Red. Inlet Pressure

33: Red. Aux 2 Remote Setpoint34: Red. Sync Input45: Red. Inlet Pressure Setpoint46: Red. Exhaust Pressure

35: Red. Sync / Load Share Input 47: Red. Exhaust Pressure Setpoint

36: Red. Load Share Input 48: Red. P2

37: Red. Heat Soak Input 49: Red. P2 Setpoint

Table 3-2. Analog Input Options

# INPUT (X)-4 mA VALUE (UNITS)

C = 0.0 (-20000, 20000)

Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog input.

INPUT (X)-20 mA VALUE (UNITS)

C = 100 (-20000, 20000)

Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog input.

(Must be greater than the 'Input 4 mA Value' Setting

INPUT (X)-Offset

S = 0.0 (-20000, 20000)

An addend added to the input value evenly across its range. Used for fine adjustments when calibrating field devices.

INPUT (X)-Gain

S = 1.0 (-20000, 20000)

A factor multiplied by the input value evenly across its range. Used for fine adjustments when calibrating field devices.

INPUT (X)-Lag

S = 0.0 (-20000, 20000)

Applies a Lag filter to an analog input. The Lag filter can be used to smooth out control of a bumpy process or sensitive transmitter. Be aware that it will also introduce an amount of delay into any control process using an input with a Lag.

# **Analog Outputs Screen**

The Analog Outputs screen allows you to select functions and set ranges for the 8 analog outputs and four proportional actuator outputs available on the 505DE. Because the 505DE covers a wide range of applications, no analog outputs are pre-programmed. The proportional actuator outputs are defaulted for V1, V1B, V2 and V3, however can be programmed as any available analog output function. When programmed for a valve demand, the proportional actuator outputs have the typical actuator configuration parameters. When programmed for a function other than valve demand, the proportional actuator outputs become simple 4-20 mA outputs. The proportional actuator outputs have no offset and gain settings.

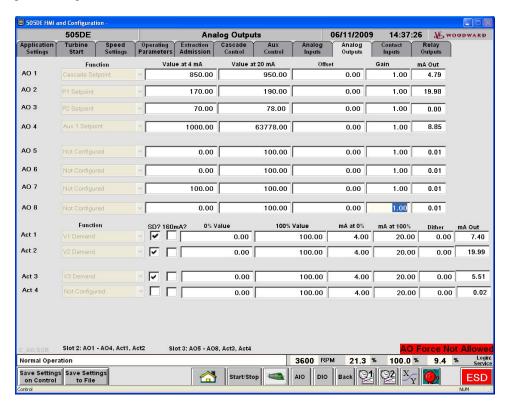


Figure 3-25. Analog Output Screen

#### ANALOG OUTPUT # (X) FUNCTION

C = 0 (0,30)

Choose the analog output function desired. Any analog output can be configured as a valve driver; however, it is recommended that the four proportional actuator drivers be used – unless additional integrating actuator drivers are used. The function that the readout uses must be programmed or an alarm will occur. For example, to use the Cascade Setpoint readout, the 'Use Cascade' function must be programmed. Functions may be programmed to as many outputs as desired and they will function identically. The 505DE does not have any current sharing redundant outputs. On board actuator drivers may be installed if redundant actuator control is needed.

#### **Analog Output Options**

0: Not Configured	15: Aux 2 Setpoint
1: Turbine Speed	16: Aux 2 Input
2: Turbine Speed Setpoint	17: V1 Demand
3: Turbine Load	18: V1B Demand
4: Cascade Input	19: V2 Demand
5: Cascade Setpoint	20: V3 Demand

6: Cascade PID Demand 21: V1 Limiter Position 7: SG PID Setpoint 22: V2 Limiter Position 8: SG PID Input 23: V3 Limiter Position

9: SG PID Demand 24: P1 Setpoint

10: Heat Soak Percentage 25: P1

11: Sync/Ldshare Speed Bias 26: P2 Setpoint

12: First Stage Pressure 27: P2

13: Aux 1 Setpoint14: Aux 1 Input28: Inlet Pressure29: Exhaust Pressure

Table 3-3. Analog Output Options

#### VALUE AT 4 MA (UNITS)

C = 0.0 (-20000, 20000)

Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog output.

VALUE AT 20 MA (UNITS)

C = 100 (-20000, 20000)

Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog.

(Must be greater than the 'Value at 4 mA' Setting)

OUTPUT (X)-OFFSET

S = 0.0 (-20000, 20000)

An addend added to the input value evenly across its range. Used for fine adjustments when calibrating field devices.

OUTPUT (X)-GAIN

S = 1.0 (-20000, 20000)

A factor multiplied by the input value evenly across its range. Used for fine adjustments when calibrating field devices.

# **Analog Combo Actuator Outputs**

The four proportional actuator outputs are also configured on the analog output page. When on-board actuator controller modules are not installed, these outputs should be used to drive the turbine's servo valves. When configured for a valve demand (V1 demand, V1B demand, V2 demand, V3 demand), the valve output is calibrated, as needed using the mA at 0% and mA at 100% values. When using the proportional output for a function other than a valve demand, it should be configured with values at 4 mA and values at 20 mA, as shown previously and in the analog outputs description. The Actuator function selection is the same as in Table 4-2. Table 4-3 shows actuator driver electrical specifications.

Configuring two analog combo actuator outputs for the same parameter will cause them to work as a redundant pair, sharing current when both are intact, and transferring current to the remaining channel if one fails. Redundant pairs can be configured for any available parameter.



Actuator outputs used as redundant pairs are setup by configuring two outputs as the same demand. No more than two outputs should be configured as the same valve demand.

Driver Limits 20–160 mA Range 4–20 mA Range

Overcurrent 217 mA 26 mA Undercurrent 5 mA 0.6 mA 10-200 mA 2-24 mA Max Output Current Range Max Output Impedance  $360 \Omega$  $45 \Omega$ Min Stop Adjust Range 10-80 mA 2-20 mA Max Stop Adjust Range 100-200 mA 10-24 mA

Table 3-4. Actuator Driver Limits

# USE ACT (X) FAULT SHUTDOWN?

C = 1(0,1)

Leave checked if desired to issue a trip whenever an actuator fault is detected. If checked, the 505DE will issue a shutdown if the respective actuator has a fault. If unchecked, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

#### ACTUATOR (X) IS 20-160 mA?

C = 0 (0,1)

Select actuator #1 output current range. Leave unchecked for 4–20 mA or check for 20–160 mA.

VALUE AT 0%

C = 0.0 (-20000, 20000)

Enter the valve demand value that should 0% of the analog output range. This can be set to 100 to invert the valve output.

VALUE AT 100%

C = 100.0 (-20000, 20000)

Enter the valve demand value that should 100% of the analog output range. This can be set to 0 to invert the valve output.

MA AT 0%

C = 4.0 (-20000, 20000)

Enter the mA current that should be output when the analog output function is at 0%. This can be adjusted when stroking the valve demand to ensure that the valves are seated fully.

MA AT 100%

C = 20.0 (-20000, 20000)

Enter the mA current that should be output when the analog output function is at 100%. This can be adjusted when stroking the valve demand to ensure that the valves are open to their full load position.

(Must be greater than the 'MA AT ZERO' Setting)

**DITHER** 

S = 0.0 (0.0, 10)

Enter the dither, in milliamps. Enter 0.0 if no dither is required.

# Forcing (Calibrating) Analog and Proportional Actuator Outputs

Analog and proportional actuator outputs are forced by clicking on the text labeling the channels at left. The value adjustment popup will open. To force the channel, check the 'forcing?' box. When forced, the text label will turn red. Closing the adjust popup will not remove the force, so multiple outputs can be forced. A message on the bottom of the screen indicates when forcing is allowed. The force will be removed when forcing permissives are lost. Forcing permissives are:

The user is logged in at the Service level AND the 505DE speed is below 100 rpm AND the 505DE emergency shutdown input is closed (not active) AND overspeed trip is not active.

To ensure proper control resolution, do not calibrate the span of the actuator output to less than a range of 100 mA (20–160 mA output) or 12 mA (4–20 mA output). If necessary, the actuator to valve linkage may need to be adjusted to ensure proper 505DE to valve resolution.



Before calibrating or testing valve-controlling outputs, the unit must be tripped and the steam supply removed. This is to ensure that opening the control valve(s) will not allow steam into the turbine. Opening the valve in an open loop condition, with steam applied, may cause an overspeed. Overspeeding the turbine may cause damage to turbine and can cause severe injury or death to personnel. STEAM TO THE TURBINE MUST BE SHUT OFF BY OTHER MEANS while forcing valve demand outputs.

# NOTICE

Choose the 'Save Settings on Control' button to permanently save any minimum or maximum actuator settings into the 505DE. If variables are tuned or changed but not stored in EEPROM by selecting the 'Save Settings on Control' button, then those changes will be lost if power is removed from the control or if the control receives a CPU reset.

The next figure shows that Act 4 has been configured for a function other than valve demand, and that actuator 1 output has been forced to 50% (12 mA).

To calibrate a redundant pair, fail one by removing a wire, then stroke the remaining channel to verify valve position. Repeat for the other output. Be sure to check the stroke with both channels sharing current to the actuator.

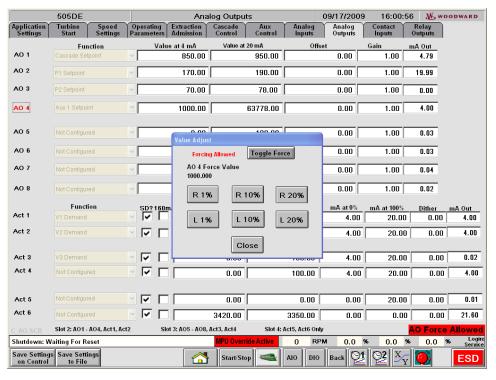


Figure 3-26. Forcing an analog or proportional actuator output

# **Contact Input Screens**

Contact Inputs 1-4 are designated for Shutdown, Alarm, Speed Raise and Speed Lower, respectively. All other contact inputs are configurable. If a second DIO module is installed and the 'Second DIO' setting on the Application Settings screen is checked, then a second discrete I/O screen will appear.



Figure 3-27. Contact Inputs Screen

# CONTACT INPUT (X) FUNCTION

C = 0 (0.96)

Select the needed function on the desired input channel. To make an input redundant, select its redundant counterpart on a second channel.

# **Contact Input Options**

Contact Input Options		
0: Not Configured		
1: Permanent ESD	36: Raise Aux-2 Setpoint	
2: Permanent RESET	37: Lower Aux-2 Setpoint	
3: Permanent Raise Speed Stpt	38: Enbl/Dsbl Aux-2 Control	
4: Permanent Lower Speed Stpt	39: Enbl/Dsbl Aux-2 Remote Setpoint	
5: Generator Breaker Closed	40: Open HP/V1 Valve Limiter	
6: Utility Breaker Closed	41: Close HP/V1 Valve Limiter	
7: Enable Overspeed Test	42: Open IP/V2 Valve Limiter	
8: External Run (Start)	43: Close IP/V2 Valve Limiter	
9: Start Permissive	44: Open LP/V3 Valve Limiter	
10: Idle/Rated	45: Close LP/V3 Valve Limiter	
11: Enable Synchronization	46: Raise P1 Extraction Demand	
12: Controlled Shutdown	47: Lower P1 Extraction Demand	
13: Halt/Continue Auto Start Sequence	48: Enbl/Dsbl P1 Extraction Demand	
14: Override MPU Fault	49: Enbl/Dsbl P1 Remote Demand	
15: Select Online PID Dynamics	50: Raise P2 Extraction Demand	
16: Local/Remote	51: Lower P2 Extraction Demand	
17: Enbl/Dsbl Remote Speed Setpoint	52: Enbl/Dsbl P2 Extraction Demand	
18: Arm/Disarm Frequency Control	53: Enbl/Dsbl P2 Remote Demand	
19: Raise P1 Extraction Setpoint	54: External Trip 2	
20: Lower P1 Extraction Setpoint	55: External Trip 3	
21: Enbl/Dsbl P1 Extraction Control	56: External Trip 4	
22: Enbl/Dsbl P1 Extr. Remote Setpoint	57: External Trip 5	
23: Raise P2 Extraction Setpoint	58: Spare	
24: Lower P2 Extraction Setpoint	59: Spare	
25: Enbl/Dsbl P2 Extraction Control	60: Spare	
26: Enbl/Dsbl P2 Extr. Remote Setpoint	61: Spare	
27: Select Priority Mode	62: Spare	
28: Raise Cascade Setpoint	63: Spare	
29: Lower Cascade Setpoint	64: Spare	
30: Enbl/Dsbl Cascade Control	65: Spare	
31: Enbl/Dsbl Cascade Remote Setpoint	66: Spare	
32: Raise Aux-1 Setpoint	67: Spare	
33: Lower Aux-1 Setpoint	68: Spare	
34: Enbl/Dsbl Aux-1 Control	69: Spare	
35: Enbl/Dsbl Aux-1 Remote Setpoint	70: Auto-Synchronize Real-Time Clock	

# **Redundant Contact Inputs**

Redundant Contact Inputs		
	76: Red. Emergency Shutdown	111: Red. Raise Aux-2 Setpoint
	77: Red. System Reset	112: Red. Lower Aux-2 Setpoint
	78: Red. Raise Speed Setpoint	113: Red. Enbl/Dsbl Aux-2 Control
	79: Red. Lower Speed Setpoint	114: Red. Enbl/Dsbl Aux-2 Rmt. Setpoint
	80: Red. Generator Breaker Closed	115: Red. Open HP/V1 Valve Limiter
	81: Red. Utility Breaker Closed	116: Red. Close HP/V1 Valve Limiter
	82: Red. Enable Overspeed Test	117: Red. Open IP/V2 Valve Limiter
	83: Red. External Run (Start)	118: Red. Close IP/V2 Valve Limiter
	84: Red. Start Permissive	119: Red. Open LP/V3 Valve Limiter
	85: Red. Idle/Rated	120: Red. Close LP/V3 Valve Limiter
	86: Red. Enable Synchronization	121: Red. Raise P1 Extr. Demand
	87: Red. Controlled Shutdown	122: Red. Lower P1 Extr. Demand
	88: Red. Halt/Continue Auto Start Seq.	123: Red. Enbl/Dsbl P1 Extr. Demand
	89: Red. Override MPU Fault	124: Red. Enbl/Dsbl P1 Remote Demand
	90: Red. Select Online PID Dynamics	125: Red. Raise P2 Extr. Demand
	91: Red. Local / Remote	126: Red. Lower P2 Extr. Demand
	92: Red. Enbl/Dsbl Rmt. Speed Setpoint	127: Red. Enbl/Dsbl P2 Extr. Demand
	93: Red. Arm/Disarm Frequency Control	128: Red. Enbl/Dsbl P2 Remote Demand
	94: Red. Raise P1 Extraction Setpoint	129: Red. External Trip 2
	95: Red. Lower P1 Extraction Setpoint	130: Red. External Trip 3
	96: Red. Enbl/Dsbl P1 Extraction Control	131: Red. External Trip 4
	97: Red. Enbl/Dsbl P1 Extr. Rmt. Stpnt.	132: Red. External Trip 5
	98: Red. Raise P2 Extraction Setpoint	133: Spare
	99: Red. Lower P2 Extraction Setpoint	134: Spare
	100: Red. Enbl/Dsbl P2 Extraction Control	135: Spare
	101: Red. Enbl/Dsbl P2 Extr. Rmt. Stpnt.	136:Spare.
	102: Red. Select Priority Mode	137: Spare
	103: Red. Raise Cascade Setpoint	138: Spare
	104: Red. Lower Cascade Setpoint	139: Spare
	105: Red. Enbl/Dsbl Cascade Control	140: Spare.
	106: Red. Enbl/Dsbl Cascade Rmt. Stpnt.	141: Spare
	107: Red. Raise Aux-1 Setpoint	142: Spare
	108: Red. Lower Aux-1 Setpoint	143: Spare
	109: Red. Enbl/Dsbl Aux-1 Control	144: Spare
	110: Red. Enbl/Dsbl Aux-1 Rmt. Setpoint	145: Red. Auto-Sync. Real-Time Clock

Table 3-5. Contact Input Options

# **Relay Outputs**

Relay Outputs #1 and #2 are designated as the shutdown and alarm output. The rest of the relay outputs are configurable. Relay outputs reflect the status of certain control parameters, or function as level switches. When the turbine is shutdown, the Enable Force check box can be checked, at which point relay output forcing will be allowed. Selecting a force button for one of the outputs will invert the status of the output, and a force indication will tell the operator that a certain relay is forced. If Enable force is unchecked, the turbine is reset, or speed increases over 1000 rpm, any forces will be disabled.

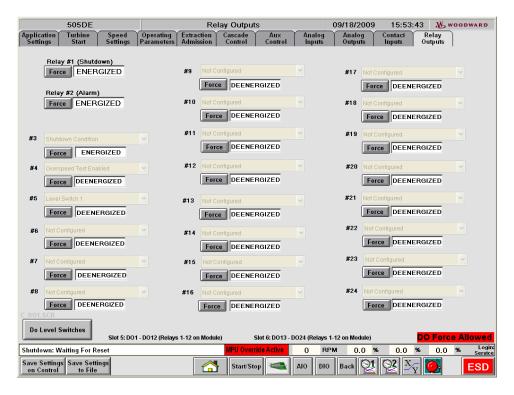


Figure 3-28a. Relay Output Screen

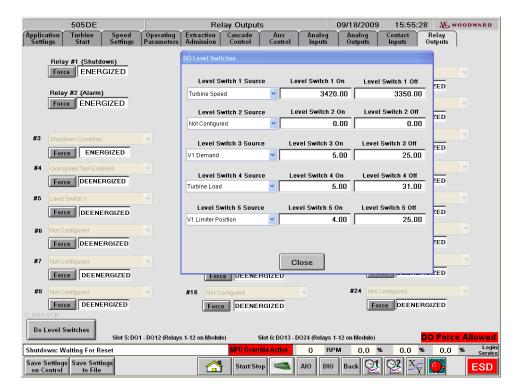


Figure 3-28b. DO Level Switches

#### RELAY OUTPUT (X) FUNCTION

C = 0 (0,70)

Select the needed function on the desired relay output channel. A given function can be assigned to as many output channels as desired.

#### **Relay Output Options**

Relay Out	out Options
0: Not Configured	35: Secondary Priority Active
1: Shutdown Condition	36: Steam Map Limiter In Control
2: Trip Relay	37: Modbus Command Selected
3: Alarm Condition	38: Cascade Control Enabled
4: Control Status OK (Under Power)	39: Cascade Control Active
5: Overspeed Trip	40: Remote Cascade Setpoint Enabled
6: Overspeed Test Enabled	41: Remote Cascade Setpoint Active
7: Speed PID in Control	42: Aux-1 Control Enabled
8: Remote Speed Setpoint Enabled	43: Aux-1 Control Active
9: Remote Speed Setpoint Active	44: Remote Aux-1 Setpoint Enabled
10: Underspeed Switch	45: Remote Aux-1 Setpoint Active
11: Auto Start Sequence Halted	46: Aux-2 Control Enabled
12: On-Line Speed PID Dynamics Mode	47: Aux-2 Control Active
13: Local Control Mode	48: Remote Aux-2 Setpoint Enabled
14: Frequency Control Armed	49: Remote Aux-2 Setpoint Active
15: Frequency Control Active	50: Spare
16: Synchronization Enabled	51: Spare
17: Sync./Load Share Active	52: Spare
18: Load Sharing Control	53: Spare
19: Open Generator Breaker	54: Spare
20: Generator Breaker Status	55: Spare
21: Utility Breaker Status	56: Extra PID Enabled
22: P1 Extr. Control Enabled	57: Extra PID Active
23: P1 Extr. Control Active	58: Extra PID in Control
24: P1 Extr. PID In Control	59: Remote Extra PID Setpoint Enabled
25: Remote P1 Extr. Setpoint Enabled	60: Remote Extra PID Setpoint Active
26: Remote P1 Extr. Setpoint Active	61: Extra PID Manual Demand Active
27: P1 Extr. Manual Demand Active	62: HP/V1 Valve Limiter In Control
28: P2 Extr. Control Enabled	63: IP/V2 Valve Limiter In Control
29: P2 Extr. Control Active	64: LP/V3 Valve Limiter In Control
30: P2 Extr. PID in Control	65: Level Switch 1
31: Remote P2 Extr. Setpoint Enabled	66: Level Switch 2
32: Remote P2 Extr. Setpoint Active	67: Level Switch 3
33: P2 Extr. Manual Demand Active	68: Level Switch 4

Table 3-6. Relay Output Options

69: Level Switch 5

#### **Level Switches**

If any of the Level Switches 1-5 are chosen, then the Level Switch function itself will have to be configured.

#### LEVEL SWITCH (X) FUNCTION

34: Secondary Priority Selected

C = 0 (0,40)

Select the parameter to base the level switch on.

O. Not Configured

#### **Level Switch Options**

U: Not Configured	
1: Turbine Speed	17: V1 Demand
2: Turbine Speed Setpoint	18: V1B Demand
3: Turbine Load	19: V2 Demand
4: Cascade Input	20: V3 Demand
5: Cascade Setpoint	21: V1 Limiter Position
6: Cascade PID Demand	22: V2 Limiter Position
7: SG PID Setpoint	23: V3 Limiter Position

8: SG PID Input 24: P1 Setpoint

9: SG PID Demand 25: P1

10: Heat Soak Percenctage 26: P2 Setpoint

11: Sync/Ldshare Speed Bias 27: P2

12: First Stage Pressure13: Aux 1 Setpoint28: Inlet Pressure29: Exhaust Pressure

 14: Aux 1 Input
 30: Spare

 15: Aux 2 Setpoint
 31: Spare

 16: Aux 2 Input
 32: Spare

Table 3-7. Level Switch Options

LEVEL SWITCH (X) ENERGIZE (ON) C = 0 (-10000000,10000000)
Set the value above, which the level switch will energize.

LEVEL SWITCH (X) DE-ENERGIZE (OFF) C = 0 (-10000000,10000000)

Set the value below, which the level switch will de-energize.

#### **Program Configuration Error Messages**

The 505DE has logic that prevents a turbine start when there are program errors. Program errors may exist in any number of combinations. In the 505DE, configure errors are annunciated as non-latching alarms. They appear within the alarm screen, but cannot be cleared by an alarm reset. Instead, configuration error alarms will clear when the respective program error is corrected.

This section of the manual identifies the various configuration error messages that may appear and explains the meaning of the error.

#### **Start Program Errors**

#### **Speed Program Errors**

Speed Input > 20000 Hz—The maximum speed input is 20000 hertz. This is a limitation of the 505DE's hardware / speed sensing circuitry. The frequency input of the speed sensor must be less than this value. The gear the speed sensor is mounted on may need to be changed to one with fewer teeth to decrease the frequency seen by the speed probes.

#### **Critical Speed Program Errors**

Crit Rate < Slow Rate—The acceleration rate (rpm/second) through the critical speed avoidance band must be faster than the normal speed setpoint rate. Lo Idle set in Critical—Either the idle speed setpoint (when using idle/rated) or the low idle setpoint (when using the auto start sequence) was programmed within a critical speed avoidance band.

Mid Idle set in Critical—The Mid idle speed setpoint (when using the auto start sequence) was programmed within a critical speed avoidance band.

Hi Idle set in Critical—The hi idle speed setpoint (when using the auto start sequence) was programmed within a critical speed avoidance band.

Critical Band < Idle—The critical speed avoidance band min is below the min speed setpoint (idle or low idle).

#### **Idle Program Errors**

Idle Setpt > Min Gov—The Idle Speed setpoint was programmed at a higher speed than the minimum governor speed setpoint.

#### **Generator Program Errors**

KW Max Load > KW Input—The KW Max Load setting was programmed at a higher value than the maximum KW input (KW input at 20 mA).

No Utility Brkr Config—The unit is programmed for a generator application but no utility tie breaker contact input was programmed. This is a requirement.

No Gen Brkr Config—The unit is programmed for a generator application but no utility tie breaker contact input was programmed. This is a requirement.

No Freq Arm/Dsarm Prgmd—The frequency arm/disarm function was programmed but no means of arming or disarming were programmed. Either Modbus 1, Modbus 2 or Modbus 2 commands must be enabled or a contact input must be programmed to arm/disarm frequency control.

Sync / Load Share Error—'Use Sync/LoadShare?' requires that a Sync input or a Sync/Load Share input or a Load Share Input are programmed. If either the I/O or configured parameter is programmed without the other, this error will occur. It will also occur if the synchronizing analog input or load share analog input was programmed with the sync/load share analog input. If the application needs to perform both synchronizing and load sharing with analog signals, only the sync/load sharing analog input needs to be programmed. Alternately, the sync input can be used with the load share input.

Freq Arm & Ld Shr Pgmd—Both the frequency arm/disarm function and the load share control functions were programmed. Only one of these modes can be programmed—either freq arm/disarm OR Load Sharing.

#### **Steam Map Error**

Steam Map Prgm Error—The map coordinates have been entered incorrectly. The calculations for power and flow in the control are wrong. Entries for points C, D, and E must be so the following equations are NOT TRUE.

 $(HPc-HPd) (Se-Sd) > (HPe-HPd) (Sc-Sd) \qquad [for extraction or extr/adm] \\ or \\ (HPd-HPe) (Sd-Se) < (HPe-HPc) (Sd-Sc) \qquad [for admission only units]$ 

Where: HPc = Flow at Point C

HPc = Flow at Point C
HPe = Flow at Point E
HPd = Flow at Point D
Sc = Power at Point C
Se = Power at Point E
Sd = Power at Point D

In addition, the relative levels of HPc, HPe, HPd, Sc, Se, and Sd must be correct. The following must be TRUE.

HPe > HPc > HPd and Sc > Se > Sd

The same conditions apply for the P2 map when configured for a double extraction turbine.

#### **Contact Input Program Errors**

- Two Identical Contacts—Two contact inputs were programmed for the same function.
- Contact #xx Program Err—The specified contact input was programmed for a function that is not also programmed to be used. Either the contact input was mis-programmed or the function required is mis-programmed. For example, contact input #1 is programmed for Remote Cascade Setpoint Enable but Remote Cascade Setpoint was not programmed under the Cascade Program Block.

#### **Analog Input Program Errors**

- Two Identical Analogs—Two analog inputs were programmed for the same function.
- Analog #x Program Err—The specified analog input was programmed for a function that is not also programmed to be used. Either the analog input was mis-programmed or the function required is mis-programmed. For example, analog input #1 is programmed for Remote Cascade Setpoint but Remote Cascade Setpoint was not programmed under the Cascade Program Block.
- No Rmt Speed Input Prgm—The remote speed setpoint control function was programmed but no remote speed setpoint analog input was configured.
- No KW Analog Input—Either the auxiliary control function was programmed to use the kW input or kW droop was programmed but no kW analog input was configured.
- No Sync/Loadshare Analog Input—A sync/loadshare function was programmed but no sync/loadshare analog input was configured.
- No Cascade Analog Input—The cascade control function was programmed but no cascade analog input was configured.
- No Rmt Casc Input Prgm—The remote cascade setpoint control function was programmed but no remote cascade setpoint analog input was configured.
- No Aux #1 Analog Input—The auxiliary control function was programmed but no auxiliary analog input was configured.
- No Rmt Aux #1 Input Prgm—The remote Aux #1 setpoint control function was programmed but no remote Aux #1 setpoint analog input was configured.
- No Aux #2 Analog Input—The auxiliary control function was programmed but no auxiliary analog input was configured.
- No Rmt Aux #2 Input Prgm—The remote Aux #2 setpoint control function was programmed but no remote Aux #2 setpoint analog input was configured.
- KW & Aux Config for Aux—The Aux #1 and/or Aux #2 control functions were programmed to use the KW analog input but an Aux #1 and/or Aux #2 analog input was configured also. With this configuration, only the KW analog input is used for Aux #1 and or Aux #2.
- No P1/P2 Input—The turbine type was programmed for extraction/admission or double extraction, but no P1 and/or P2 (as required) analog input was configured.
- No Rmt P1 Input—The remote P1 setpoint control function was programmed but no remote Extr/Adm analog input was configured.
- No Rmt P2 Input—The remote P2 setpoint control function was programmed but no remote Extr/Adm analog input was configured.

#### **Relay Program Errors**

Relay #x Program Error—The specified relay was programmed for a function that is not also programmed to be used. Either the relay was mis-programmed or the function required is mis-programmed. For example, relay #1 is programmed for Remote Cascade Setpoint Enabled but Remote Cascade Setpoint was not programmed under the Cascade Program Block.

#### **Readout Program Errors**

Readout #x Program Err—The specified readout was programmed for a function that is not also programmed to be used. Either the readout was misprogrammed or the function required is mis-programmed. For example, readout #1 is programmed for Cascade Setpoint but Cascade Control was not programmed under the Cascade Program Block.

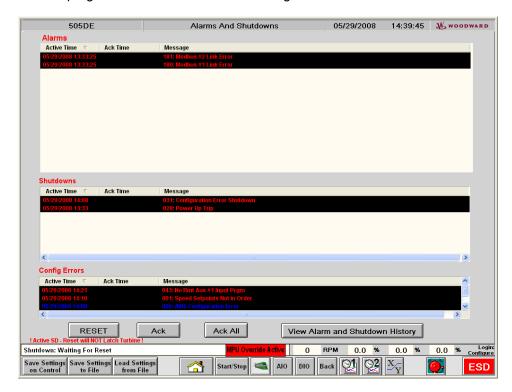


Figure 3-29. Configuration Errors appear on the alarm screen when they exist

## Chapter 4. Operation

The 505DE can be controlled entirely from the Control Screen on the 505DE HMI. Operator controls for functions will appear as they are configured, including generator parameters, aux and cascade controls and extraction controls. Clicking on one of the valve graphics will open a valve limiter control window. Clicking on the turbine graphic will show a small steam map graphic (click again to close). Unit Control messages and start messages are shown on the left side of the screen footer. Control messages for the individual controllers featured in the 505DE are displayed in each controller's box. Figure 4-1 shows the case where all operating features available in the 505DE are being used. Each operator interface is explained in greater detail later on in this chapter.

The 505DE HMI can be shutdown and re-started with no affect on turbine operation (other than it won't be available for monitoring turbine operation). Communication channel (Mod1, Mod2, Mod3) can be changed, communication cables can be unplugged, etc, with no affect on turbine operation. Turbine operation will only be affected if the 505DE is configured to allow commands on the channel to which the 505DE is currently connected, and commands are issued by selecting the desired command and confirming its action.

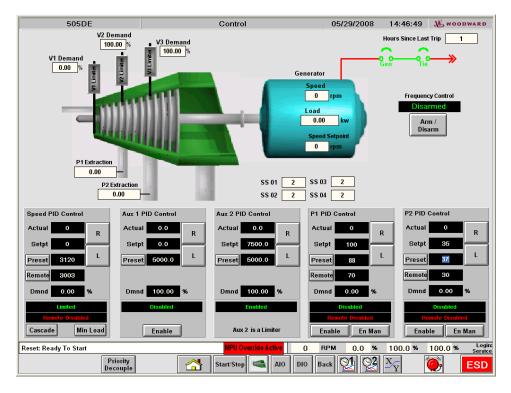


Figure 4-1. 505DE HMI Control Screen (Max Configuration)

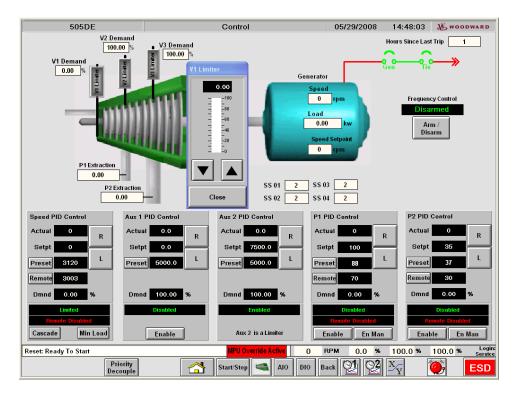


Figure 4-2. Valve Limiter Popup

#### **Starting Procedures**

Refer to the turbine manufacturer's operating procedures for complete information on turbine start up, and Chapter 2 of this manual for procedures, depending on the start mode selected. From the 505DE HMI, the Start/Stop popup can be opened from the Start/Stop button on the screen footer no matter which screen is open. The following is a typical start-up procedure:



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.

#### Start/Stop Popup

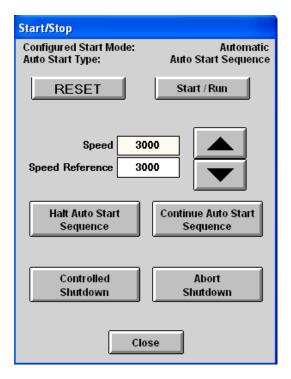


Figure 4-3. Start / Stop Popup (Configured for auto-seq)

- Press the RESET button to clear all alarms and trips and cause any
  extraction and/or admission valves to move to their ready-to-start positions. If
  the 505DE's 'RESET CLEARS TRIP' setting is programmed "YES", the
  505DE's shutdown relay will reset or energize upon pressing the RESET key
  after a shutdown. If the 'RESET CLEARS TRIP' setting is programmed "NO",
  the 505DE's shutdown relay will reset or energize upon pressing the RESET
  key only after all trip conditions are cleared.
- 2. Press the Start/Run key, after the extraction valves open, to initiate the selected start-up mode. If a semi-automatic start mode is configured, the valve limiter must be manually increased to open the control valve. Click on the valve graphics to open their respective valve limiter control pop-ups.
  - A 'Start Perm Not Closed' alarm will be issued if the application is using a Start Permissive contact input and this contact input was not closed when the Start command was issued.
- Control Messages on the left side of the screen footer will tell the operator what the next speed setpoint is, at what rate the speed setpoint is moving there, etc.
- 4. After the selected start-up mode has been performed, the turbine will operate at the minimum or idle speed setting. The 505DE's speed setpoint will move to minimum governor speed unless an idle speed is programmed. The Idle/Rated or Auto Start Sequence functions must be programmed for the turbine to control at idle speed. When using the Auto Start Sequence, the 505DE will begin stepping through its sequence once at low idle. This sequence may be stopped, rated speed may be selected (if using idle/rated) or the operator may vary turbine speed with raise/lower commands through the 505DE HMI Start/Stop screen, external switches, or Modbus.

The 'Start/Run' and 'Reset' commands can be selected from the 505DE HMI contact input closures (if programmed) or from a Modbus communications link. In addition, start status' are available through Modbus. See Volume 2, Chapter 7 for addresses and lookup tables.

#### **Controlled Shutdown**

To perform a controlled shutdown, choose 'Controlled Shutdown' on the 505DE HMI Start/Stop popup or close the Controlled Shutdown contact input (if programmed) or select Controlled Shutdown from a Modbus communications link. This function can be stopped or aborted by choosing 'Abort Shutdown' from the 505DE HMI Start/Stop popup, opening the contact, or selecting Abort Controlled Shutdown from a Modbus communications link.

The Controlled Shutdown sequence can be restarted by re-selecting 'Controlled Shutdown' from the 505DE HMI Start/Stop popup, re-closing the contact, or re-selecting Controlled Shutdown from a Modbus communications link.

#### Idle/rated Start

For details on the idle/rated startup, refer to chapter 2. When a Start/Run command is issued, the 505DE screen footer displays the Idle/Rated status. The speed setpoint is instantly set to the actual turbine's speed. To increase the speed to the programmed 'Rated Setpt' setting, issue a Rated command to the 505DE. A Rated command can be issued by choosing 'Rated' on the 505DE HMI Start/Stop popup, closing the Idle/Rated contact (if programmed) or selecting a Go To Rated command from a Modbus communications link.

When the speed setpoint is moving to the Rated Setpoint setting it can be stopped at any point that is not within a critical speed avoidance band by issuing a Speed Setpt Raise or Lower command. This can be done from the 505DE HMI Start/Stop Popup or Speed/Load Control Window, closing a Speed Raise/Lower contact input or selecting Speed Raise or Lower from a Modbus communications link.

The Speed setpoint will again ramp to the Rated Speed setting if the Rated command is re-issued. To re-issue the Rated command choose 'Rated' on the 505DE HMI Start/Stop popup, toggle the Idle/Rated contact open and closed again (if programmed) or select Go To Rated from a Modbus communications link.

The Speed setpoint will ramp to the Idle Speed setting upon startup. However, the Idle Speed setting can be re-selected, when conditions allow, (see Chapter 2) by choosing the 'Idle' command from the 505DE HMI Start/Stop popup, opening the Idle/Rated contact (if programmed), or selecting Go To Idle from a Modbus communications link.

Another feature of the Idle/Rated function is the "Ramp to Rated" option that allows the Speed setpoint to only move to the Rated Speed setting; Idle is not selectable. Deselecting the 'Ramp To Idle' option under Start Settings enables the "Ramp to Rated" feature. When this feature is used with the Idle/Rated contact input, any method of selecting idle stops the speed setpoint at its current location—rather than ramping it back to Idle. To continue ramping to the Rated Speed setting, re-close the contact, choose 'Rated' on the 505DE HMI Start/Stop popup or select Go To Rated from a Modbus communications link.

Idle Rated Status messages will be displayed on the left side of the screen footer, and are available over Modbus. See Volume 2, Chapter 7 for addresses and lookup tables.

#### **Auto Start Sequence**

When a Start/Run command is issued, the 505DE shows the Status of the Auto Start Sequence on the left side of the screen footer. This sequence is automatic, however the sequence can be halted. Halting the Auto Start Sequence can be performed by selecting 'Halt' on the 505DE HMI Start/Stop popup, opening the Halt/ Continue contact (if programmed), selecting Halt from a Modbus communications link, or selecting Speed Setpt Raise or Lower by any method. If the sequence is started while the turbine still has speed, the speed setpoint is instantly set to the turbine's actual speed and the sequence will be in the "halted" state. To provide feedback, a relay can be programmed to indicate the Auto Start Sequence is halted. The Sequence can be restarted again by pressing the 'Continue' button on the 505DE HMI, closing the Halt/Continue contact, or selecting Continue from a Modbus communications link.

Auto Start Sequence Status messages will be displayed on the left side of the screen footer, and are available over Modbus. See Volume 2, Chapter 7 for addresses and lookup tables.

## Speed/Load PID Control 0 Actual R Setpt 0 Preset 0 Remote 2850 % Dmnd 0.00Limited Remote Disabled Cascade Min Load

#### **Speed Control**

Figure 4-4. Speed/Load Control Window (Cascade Configured)

Once the turbine is in speed control at minimum governor speed or rated speed, the speed setpoint can be adjusted from the Speed/Load Control Window on the 505DE HMI, Speed Setpoint Raise or Lower contact inputs, or commands through a Modbus link. In addition the setpoint can be directly entered from the Speed/Load Control Window or over Modbus.

To directly enter the speed setpoint either from the 505DE HMI or from Modbus, the entered value must be between minimum and maximum governor settings. Also, if the unit is driving a generator and the unit is on-line, the speed setpoint cannot be set below the 3% minimum load setting that is automatically set upon breaker closure, but can be adjusted by the 'Min Load Bias' setting. The speed setpoint cannot be directly entered when Auxiliary is enabled or when Auxiliary is configured as a limiter. In this case the Raise and Lower commands should be used.

Both the speed setpoint and the Modbus Entered Speed setpoint are available over Modbus to provide feedback for directly entered Modbus values. If an incorrect value is entered, when confirmed, the feedback will simply not be updated.

Note the Cascade button in the preceding figure. Since speed control and cascade control are mutually exclusive, to enable Cascade, the user will need to switch to the cascade window. See the Cascade Control description.

Speed/Load Control Status messages and Speed/Load Remote Control Status messages will be displayed on the bottom of the Speed/Load Control Window, and are available over Modbus. See Volume 2, Chapter 7 for addresses and lookup tables.

If configured for generator operation, the Min Load button will be available. Choosing the Min Load button will open a dialog to allow the user to change the minimum load that the turbine can be lowered to while online. This load is set as the LSS (speed PID) percentage at breaker closure. If the breaker is closed with low steam pressure, then at high steam pressure the turbine may not be able to reach low enough load. The raise and lower buttons are increment buttons that will change the min load setting by 0.5% with each push. This should not be confused with the Min Load Bias found on the operating parameters screen. The Min Load Bias is an rpm value that is added to the speed reference upon breaker closure to avoid reverse power.

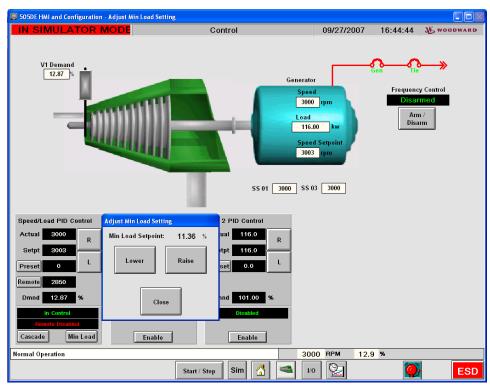


Figure 4-5. Min Load setting adjustment window (single valve turbine, simulation mode)

## **Overspeed Test Function**

The 505DE's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505DE's internal overspeed trip logic and any external overspeed trip device's settings and logic. The Overspeed Trip Test window can only be accessed via Modbus 3. An overspeed test can only be activated when the speed setpoint has been raised to the maximum governor limit and the unit is Off-Line (if driving a generator). Before these conditions are met, the overspeed popup will indicate the overspeed test permissives are not met.



Figure 4-6. Overspeed Test Perms Not Met

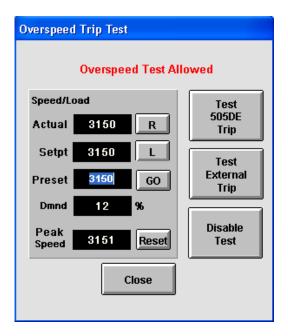


Figure 4-7. Overspeed Test Allowed

#### Overspeed Test Procedure (from The 505DE HMI)

 Disable all other controllers (Aux, Cascade, Extraction), and raise the Speed Setpoint to the maximum governor setting. At this point, the Overspeed popup should indicate that overspeed testing is available.



An Overspeed Test is not allowed when Auxiliary is configured as a Limiter. To be able to perform an Overspeed Test in this case, Auxiliary needs to be removed from the configuration first. After completion of the Test, Auxiliary should be re-configured again.

- If desired, clear the 'Highest Speed Reached' value, to record the highest speed reached during this overspeed test.
- Select the Test 505DE Trip button to enable an overspeed test of the 505DE's internal overspeed trip. This will permit speed raise commands above max governor.
- Or select the Test External Trip button to enable the test for an external device whose setting is above that of the 505DE. This will permit speed raise commands above max governor and will override the 505DE's internal overspeed trip.
- After enabling either the internal or external overspeed tests, a 60 second overspeed test timer begins. The timer is active when no speed raise/lower commands are being given. If the timer is allowed to expire, the overspeed test is automatically disabled and speed setpoint is ramped back to maximum governor if the speed is below the trip level. If the speed is above the trip level, the 505DE will trip. This is the same result as disabling the test via the Disable test button.

Alternatively the turbine's overspeed logic and circuitry can be tested remotely, by programming an Overspeed Test contact input. The Overspeed Test contact functions like the Test 505DE Trip button. When the conditions outlined in the above procedure are met, closing this contact allows the Speed setpoint to be increased up to the "Overspeed Test limit" setting. An Overspeed Test Enabled relay can be programmed to provide test enabled feedback.

The Overspeed Test function cannot be performed over Modbus; however, the Overspeed Test statuses are available for monitoring.

### **Auxiliary Control**

The control screen of the 505DE HMI has Auxiliary control windows for the Aux-1 controller and the Aux-2 controller. Each window is only displayed if its respective Auxiliary function is programmed. The Remote Field will not appear if remote is not programmed. The Enable Field will not appear if 'Use Aux Enable' is not programmed.

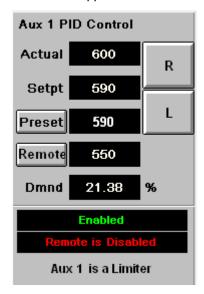


Figure 4-8. Aux 1 Controller Window (inverted, low inlet pressure limiter)

#### Auxiliary as a Controller (using Aux Enable/Disable)

When auxiliary control is used as a controller, as opposed to a limiter, the enable/disable function is used to select Auxiliary control. Auxiliary control can be enabled by choosing the 'Enable' button the 505DE HMI or by closing the Aux Control Enable/Disable contact (if programmed) or by selecting Aux Enable from a Modbus communications link.

With this configuration, prior to enabling Auxiliary control, the Auxiliary setpoint tracks the Auxiliary analog input to accommodate bumpless transfers between control modes. As a result, the Auxiliary setpoint cannot be changed until the Auxiliary PID is enabled. Once enabled, the Auxiliary setpoint can be changed by pressing the raise and lower buttons on the 505DE HMI, closing a Aux Setpt Raise/ Lower contact input, or selecting Aux Setpoint Raise or Lower from a Modbus communications link. In addition, the Auxiliary setpoint can be directly set to a value by entering a new Auxiliary Setpoint in the 'Preset' field on the 505DE HMI, then choosing 'GO', or by the same process of entry and confirmation through a Modbus communications link.

MESSAGE	MEANING
Disabled	Aux is not selected
In Ctrl w/ Rmt Setpt	Aux is in control, Aux PID is controlling the actuator and the setpoint is in Remote control
Active w/ Rmt Setpt	Aux is in control, Aux PID is not controlling the actuator, setpoint is in Remote control
Enabled w/ Rmt Setpt	Aux is enabled but not in control of the setpt, setpt is in Remote control
In Control	Aux is in control, Aux PID is controlling the actuator
Active/Not in Control	Aux is in control, Aux PID is not controlling the actuator
Inhibited	Aux is inhibited and cannot be enabled
Enabled	Aux is enabled but not in control of the setpt

Table 4-1. Auxiliary as a Controller Messages

Auxiliary control can be disabled by: choosing 'Disable' on the 505DE HMI, opening the Aux Control Enable/Disable contact (if programmed), or selecting "Aux Disable" from a Modbus communications link. Auxiliary control is automatically disabled if Cascade control is enabled or Remote Speed Setpoint control is enabled. Aux control is disabled and 'inhibited' if a controlled shutdown is selected, the Auxiliary input fails or the unit shuts down. Auxiliary control can be enabled but not active if the generator and/or utility breaker disable features are programmed.

#### Auxiliary as a Limiter (not using 'Aux Enable')

When Auxiliary control is used as a limiter, as opposed to a controller, the enable/disable function is not used and Auxiliary control is always enabled.

The Auxiliary setpoint can be raised or lowered by pressing the raise or lower buttons on the 505DE HMI, closing the Auxiliary Setpoint Raise/Lower contact inputs, or selecting Auxiliary Setpoint Raise or Lower from a Modbus communications link. In addition, the Auxiliary setpoint can be directly set to a value entering the new value in the 'Preset' field on the 505DE HMI and selecting 'GO'. Entering a new Aux Setpt through Modbus is carried out in the same fashion by entering a setpoint and then confirming it.

MESSAGE	MEANING
Disabled	Aux is not selected
In Ctrl w/ Rmt Setpt	Aux is in control, Aux PID is controlling the actuator and the setpoint is in Remote control
Active w/ Rmt Setpt	Aux is in control, Aux PID is not controlling the actuator, setpoint is in Remote control
Enabled w/ Rmt Setpt	Aux is enabled but not in control of the setpt, setpt is in Remote control
In Control	Aux is in control, Aux PID is controlling the actuator
Active/Not Limiting	Aux is in control, Aux PID is not limiting the actuator
Inhibited	Aux is inhibited and cannot be enabled
Enabled	Aux is enabled but not in control of the setpt

Table 4-2. Auxiliary as a Limiter Messages

Auxiliary control is inhibited if a controlled shutdown is selected, the Auxiliary input fails, or the unit shuts down. Auxiliary control can be 'enabled' but not 'active' if the generator and/or utility breaker disable features are programmed. Aux will be In Control if the Auxiliary PID is active and limiting the Auxiliary input parameter.

The following auxiliary control indications are available through the Modbus links: Aux is Enabled, Aux is Active, Aux is In Control, Aux is Inhibited, Aux Active/Not Limiting, Aux Active/Not In Control, and the Aux Input Failed Alarm. In addition to these indications the Aux Setpoint, Aux Input, and Aux PID Output analog values are also available. See Volume 2, Chapter 7 for addresses and lookup tables.

Relay indications can be programmed to indicate Aux Control Active, Aux Control Enabled, or Aux PID In Control status parameters.

#### **Remote AUX Setpoint**

The Remote Auxiliary Setpoint function is used to allow the Auxiliary setpoint to be remotely positioned by an analog input. The Remote Aux Setpoint can be enabled via the 'Remote' button on the 505DE HMI, closing the Remote Aux Setpoint Enable/Disable contact (if programmed), or selecting Remote Aux Enable from a Modbus communications link.

The Remote Aux Setpoint can be disabled via the 'Disable Remote' button on the 505DE HMI, opening the Remote Aux Control Enable/Disable contact (if programmed), or selecting Remote Aux Disable from a Modbus communications link.

MESSAGE	MEANING
Disabled	Remote Aux Setpoint is not selected
In Control	Remote Aux Setpoint is in control, Aux PID is controlling the actuator
Active	Remote Aux Setpoint is in control, Aux PID is not controlling the actuator
Enabled	Remote Aux Setpoint is enabled but not in control of the Setpt
Inhibited	Remote Aux Setpoint is inhibited and cannot be enabled

Table 4-3. Remote AUX Messages

The following remote auxiliary control indications are available through the Modbus links: Remote Aux is Disabled, Remote Aux is Enabled, Remote Aux is Active, Remote Aux is In Control, Remote Aux is Inhibited, and Remote Aux Input Failed Alarm. In addition to these indications, the Remote Aux Input Setpoint is also available.



Relay indications can be programmed to indicate Remote Aux Control Active and Remote Aux Control Enabled status parameters.

#### **Remote Speed Setpoint**

The Speed PID setpoint can be remotely set by an analog input, if programmed. The Remote Speed Setpoint input can be enabled by via the 'Remote' button on the Speed/Load Window of the 505DE HMI, closing the Remote Speed Setpoint Enable/ Disable contact (if programmed), or selecting Enable Remote Speed Setpt Control from a Modbus communications link.

The Remote Speed Setpoint input can be disabled by via the 'Remote' button on the Speed/Load Window of the 505DE HMI, opening the Remote Speed Control Enable/ Disable contact (if programmed), or selecting Disable Remote Speed Setpt Control from a Modbus communications link.

MESSAGE	MEANING
Disabled	Remote is not selected
Inhibited	Remote is inhibited and cannot be in control
Enabled	Remote is enabled but not in control of the Setpt
Active	Remote is in control of the Setpt but not in control of the actuator output
In Control	Remote is in control of the Setpt and in control of the actuator output

Table 4-4. Remote Speed Messages

The following Remote control indications are available through the Modbus links: Remote Speed Setpt is Enabled, Remote Speed Setpt is Active, Remote Speed Setpt is In Control, Remote Speed Setpt is Inhibited, and the Remote Speed Setpt Input Failed Alarm. In addition to these indications, Remote Speed Setpt Input analog value is also available.

Relay indications can be programmed to indicate Remote Speed Setpt Active and Remote Speed Setpt Enabled status parameters.

#### Synchronizing and/or Load sharing

The Synchronizing feature allows an analog input to bias the speed setpoint when using a DSLC for synchronization. The Synchronizing analog input can be enabled by pressing 'Sync Enable' button on the 505DE HMI, closing the Sync Enable contact (if programmed), or selecting Sync Enable from either Modbus communications link.

The Synchronizing & Load Sharing feature allows an analog input to bias the speed setpoint when using a DSLC for synchronizing and load sharing. Load sharing is enabled automatically based on the generator and utility breaker status inputs. The Sync/Load Share input is enabled by pressing the 'Enable' button on the 505DE HMI, closing the Sync/Ld Share Enable contact (if programmed), or selecting Enable from either Modbus communications link.

The Synchronizing or Sync/Ld Share inputs are disabled by pressing 'Disable' button on the 505DE HMI, opening the respective function's Enable/Disable contact (if programmed), or selecting the Sync Disable command from either Modbus communications link. The Synchronizing analog input is automatically disabled when the generator breaker closes, but can be re-enabled with the generator breaker closed, to allow synchronization across a tie line breaker. The Sync/Load Share analog input is automatically disabled when the generator breaker opens. The table below lists the possible synchronizing/load sharing control messages.

MESSAGE 3	MEANING
Disabled	Function is in disabled mode
Inhibited	Function is inhibited and cannot be enabled
Enabled	Function is enabled but not in control of the Setpt
In Control	Function is in control of the actuator output

Table 4-5. Synch/Load Sharing Control Messages

The following synchronizing and load sharing control indications are available through the Modbus links: Generator Breaker Status, Utility Tie Breaker Status, Frequency Control Enabled, Sync is Enabled, Sync or Load Share is In Control, Sync or Load Share is Inhibited, and the Sync/Loadshare Input Failed Alarm. In addition to these indications, Sync/Loadshare Input analog value is also available.

Relay indications can be programmed to indicate Sync Enabled, Sync/Loadshare Enabled, Load Share Control and Frequency Control status parameters.

#### Cascade

For this screen to be active, the Cascade function must be programmed. The Cascade PID dynamic and droop values can be adjusted from the configure screen for Cascade when logged into Service mode.

Cascade control can be enabled by pressing the 'Enable' button in the Cascade window on the 505DE HMI, closing the Cascade Control Enable/Disable contact (if programmed), or selecting Cascade Enable from either Modbus communications link.

Cascade control can be disabled by pressing the 'Disable' button in the Cascade window on the HMI, opening the Cascade Control Enable/Disable contact (if programmed), or selecting Cascade Disable from either Modbus communication link. Cascade control is also disabled if Auxiliary control is enabled (or active as a limiter) or Remote Speed Setpoint is enabled. Cascade control is disabled and 'inhibited' if a controlled shutdown is selected, the cascade input fails, or the unit shuts down. Cascade control can be 'enabled but not active' if the generator breaker is open. Since the Cascade PID controls through the Speed setpoint and Speed PID, Cascade will only be "In Control" when the Speed PID is "In Control" of the actuator output. See Table 4-6 for all possible cascade control messages.

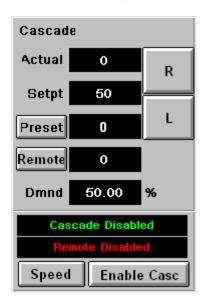


Figure 4-9. Cascade Controls

The Cascade setpoint can be configured to either track the input for bumpless transfer into control or remain at the last setting. When using the tracking option, the cascade setpoint cannot be changed until Cascade control is enabled.

The Cascade setpoint can be changed by pressing the Raise 'R' and Lower 'L' buttons in the Cascade window, closing a cascade Setpt Raise/Lower contact input, or selecting Cascade Setpoint Raise or Lower commands from either Modbus communications link. In addition, the Cascade setpoint can be directly set to a preset value by pressing the 'GO' button (press the 'Preset' button and touch the number to adjust the value) on the Entered Cascade Setpoint window or by entering a new Cascade Setpt through either Modbus communications link.

MESSAGE	MEANING
Disabled	Cascade control is disabled
Inhibited	Cascade is inhibited and cannot be in control
Enabled	Cascade is enabled but not in control of actuator
In Control	Cascade is in control of actuator output
Active	Cascade is active but Speed PID is not in control of actuator
Limited	The cascade PID is limited

Table 4-6. Cascade Control Messages

The following Cascade control indications are available through the Modbus links: Cascade is Disabled, Cascade is Enabled, Cascade is Active, Cascade is In Control, Cascade is Inhibited, and the Cascade Input Failed Alarm. In addition to these indications the Cascade Setpoint, Cascade Input, and Cascade PID Output analog values are also available.

Relay indications can be programmed to indicate Cascade Control Active, and Cascade Control Enabled.

#### **Remote Cascade Setpoint**

The Cascade control setpoint can be remotely positioned by an analog input (if programmed). The Remote Cascade Setpoint input can be enabled by pressing the 'Remote' and 'Enbl' buttons next to the Remote Cascade Setpoint on the Cascade status window, closing the Remote Cascade Setpoint Enable/Disable contact (if programmed), or selecting Remote Cascade Enable from either Modbus communications link.

Remote Cascade Setpoint input is disabled by pressing the 'Remote' and then 'Disable' buttons next to the Remote Cascade Setpoint on the Cascade status window, opening the Remote Cascade Enable/Disable contact (if programmed), or selecting Remote Cascade Disable from either Modbus communications link. See the table below for all possible Remote Cascade control messages.

MESSAGE	MEANING
Disabled	Remote is not selected
Inhibited	Remote is inhibited and cannot be enabled
Enabled	Remote is enabled but not in control of the Setpt
Active	Remote is in control of the Setpt but not in control of the actuator output
In Control	Remote is in control of the Setpt and in control of the actuator output

Table 4-7. Remote Cascade Messages

The remote cascade control indications shown are available through the Modbus links: Remote Cascade is Disabled, Remote Cascade is Enabled, Remote Cascade is Active, Remote Cascade is In Control, Remote Cascade is Inhibited, and Remote Cascade Input Failed Alarm. In addition to these indications, the Remote Cascade Input Setpoint is also available.

Relay indications can be programmed to indicate Remote Cascade Control Active and Remote Cascade Control Enabled status.

#### **Extraction/ Admission Controllers**

The figure below shows the screen for EXT/ADM. The Extr/Adm PID dynamic and droop values can be adjusted from the configuration screens when in Service mode.

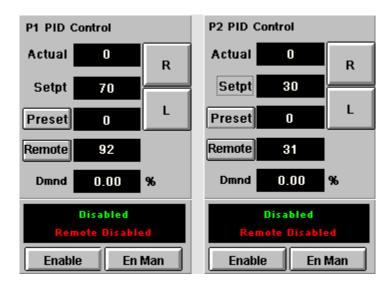


Figure 4-10. EXT/ADM Controls

#### **Enabling Extraction Control**

There are two ways of enabling/disabling extraction control: manually or automatically. The manual enable/disable routine uses the valve limiter's raise/lower commands, and automatic enable/disable routine uses an enable/disable command. Automatic enabling/disabling can only be performed if the "Automatic Enable?" setting is programmed "Yes". With automatic Extr/Adm enabling programmed, an operator can also enable and disable Extraction control manually if desired.

To manually enable Extraction control press the corresponding valve graphic, V2 for P1 or the V3 graphic for P2 extraction, to adjust the valve limiter and slowly lower it until the Extr/Adm PID takes control of its process, then continue running the valve limiter to its minimum, almost closed, position (it should never be fully closed to avoid blocking off steam from the downstream sections of the turbine). If the valve limiter is not closed to the configured limit, it will act as an extraction limiter and will interfere with automatic governor operation. All related Extraction permissives must be met before the 505DE will allow the valve limiter to be lowered and Extr/Adm control to be enabled.

If programmed for auto enable, Extr/Adm control can be enabled by pressing the 'Enable' button in the P1 window on the 505DE HMI, closing the Extr/Adm Control Enable/ Disable contact (if programmed), or selecting Extr/Adm Enable from either Modbus communications link.

If programmed for auto enable, Extr/Adm control is disabled by pressing the 'Disable' button in the P1 window on the 505DE HMI, opening the Extr/Adm Control Enable/Disable contact (if programmed), or selecting Extr/Adm Disable from either Modbus communications link.

For Admission or Extraction/Admission units, refer to Chapter 2 for a detailed startup procedure.

Extr/Adm control is disabled and 'inhibited' if a controlled shutdown is selected or the unit shuts down. If the Extr/Adm input fails, the controllers can be configured to take a variety of actions including go to manual control, disable extraction, maintain current valve position, or trip the unit. Extr/Adm control can be 'enabled but not active' if the generator and/or utility tie breaker are open or speed is too low, depending on configuration. Since the Extr/Adm PID controls through the ratio/limiter and LP Valve Limiter, Extr/Adm will only be "In Control" when the ratio/limiter is "In Control" of the actuator output and not limited by a steam map limit. See Table 4-8 for all possible Extr/Adm control messages.

The Extr/Adm setpoint can be configured to either track the input, if admission or Extr/Adm, for bumpless transfer into control or remain at the last setting. When using the tracking option, the Extr/Adm setpoint cannot be changed until Extr/Adm control is enabled.

The Extr/Adm setpoint can be changed by pressing the Raise 'R' and Lower 'L' buttons in the P1 or P2 window, closing a Extr/Adm Setpt Raise/Lower contact input, or selecting Extr/Adm Setpoint Raise or Lower commands from either Modbus communications link. In addition, the Extr/Adm setpoint can be directly set to a preset value by pressing the 'GO' button (touch the number to adjust the value) on the P1 or P2 window or by entering a new Extr/Adm setpt through either Modbus communications link.

Manual Valve position (% P1/P2 flow) control is enabled Inhibited P1/P2 is inhibited and cannot be enabled Limited P1/P2 is in control but limited Tracking Manual is In Control; the P1/P2 PID is tracking
Limited P1/P2 is in control but limited
Tracking Manual is In Control: the P1/P2 PID is tracking
the Manual setpoint.
Active P1/P2 pressure control is active but not in
control of the actuator output
In Control P1/P2 is in control of actuator output
Enabling The P1/P2 valve limiter is ramping down
Disabling The P1/P2 valve limiter is ramping up
Enabled P1/P2 is enabled but not in control of the setpoint
Disabled P1/P2 control is disabled; the valve limiter is 100% open

Table 4-8. Extr/Adm Control Messages

The following Extr/Adm control indications are available through the Modbus links: Extr/Adm is Enabled, Extr/Adm is Active, Extr/Adm is In Control, Extr/Adm is Inhibited, and the Extr/Adm Input Failed Alarm. In addition to these indications the Extr/Adm Setpoint, Extr/Adm Input, Extr/Adm Manual Demand, and Extr/Adm PID Output analog values are also available.

Relay indications can be programmed to indicate Extr/Adm Control Active and Extr/Adm Control Enabled states.

#### Remote EXTR/ADM Setpoint

The Extr/Adm control setpoint can be remotely positioned by an analog input (if programmed). The Remote Extr/Adm Setpoint input can be enabled by pressing the front panel YES key from the Remote Extr/Adm Status screen (screen 4), closing the Remote Extr/Adm Setpoint Enable/Disable contact (if programmed), or selecting Remote Extr/Adm Enable from either Modbus communications link.

Remote Extr/Adm Setpoint input is disabled by pressing the 'Enbl' button next to the Remote Extr/Adm Setpoint on the P1 or P2 status window, opening the Remote Extr/Adm Enable/Disable contact (if programmed), or selecting Remote Extr/Adm Disable from either Modbus communications link. See the table below for all possible Remote Extr/Adm control messages.

MESSAGE	MEANING
Disabled	Remote P1/P2 is not selected
Inhibited	Remote P1/P2 cannot be enabled
Enabled	Remote P1/P2 is enabled but not in control of the setpt
Active	Remote P1/P2 is in control of the setpt but not in control of the actuator output
In Control	Remote P1/P2 is in control of the actuator output

Table 4-9. Remote Extr/Adm Messages

The remote Extr/Adm control indications shown in Table 4-9 are available through the Modbus links: Remote Extr/Adm is Enabled, Remote Extr/Adm is Active, Remote Extr/Adm is In Control, Remote Extr/Adm is Inhibited, and Remote Extr/Adm Input Failed Alarm. In addition to these indications, the Remote Extr/Adm Input Setpoint is also available.

Relay indications can be programmed to indicate Remote Extr/Adm Control Active and Remote Extr/Adm Control Enabled states.

#### Manual EXTR/ADM

The Extr/Adm control can use Manual control mode. This is a manual valve demand, which is equivalent to the percentage of P1/P2 flow. The ratio limiter logic calculates the valve position based on the Manual demand as a percentage of Extr/Adm flow. Manual control can be enabled by pressing the "En Man" button on the P1 or P2 control window, closing the Manual Extr/Adm Demand Enable/Disable contact (if programmed), or selecting Manual Extr/Adm Enable from either Modbus communications link.

Manual control can be enabled by pressing the "Dis Man" button on the P1 or P2 control window, opening the Manual Extr/Adm Demand Enable/Disable contact (if programmed), or selecting Manual Extr/Adm Enable from either Modbus communications link. See the table below for all possible Remote Extr/Adm control messages.

MESSAGE	MEANING
Inhibited	Manual P1/P2 cannot be enabled
Tracking	Manual P1/P2 is not in control; Manual Demand is
	tracking the P1/P2 PID
In Control	Manual P1/P2 is in control of the actuator
Active	Manual P1/P2 is in control of the setpt but not in
	control of the actuator output
Enabled	Manual P1/P2 is enabled but not in control of the
	setpt
Disabled	Manual P1/P2 is not selected

Table 4-10. Manual Extr/Adm Messages

The Manual Extr/Adm control indications shown in the table above are available through the Modbus links: Manual Extr/Adm is Enabled, Manual Extr/Adm is Active, Manual Extr/Adm is In Control, Manual Extr/Adm is Inhibited, Manual Extr/Adm is Disabled, and Manual Extr/Adm is Tracking.

Relay indications can be programmed to indicate Manual Extr/Adm Demand Active state.

#### **Alarms**

Alarms are displayed in the top pane of the alarm screen.

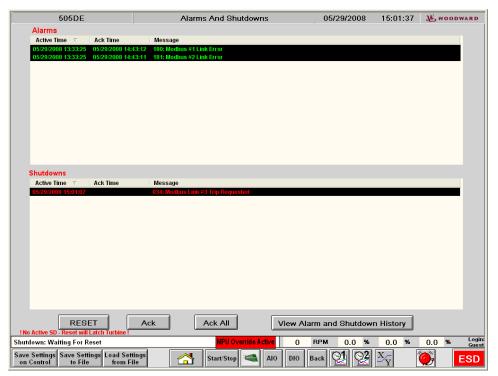


Figure 4-11. Alarm and Shutdown Screen

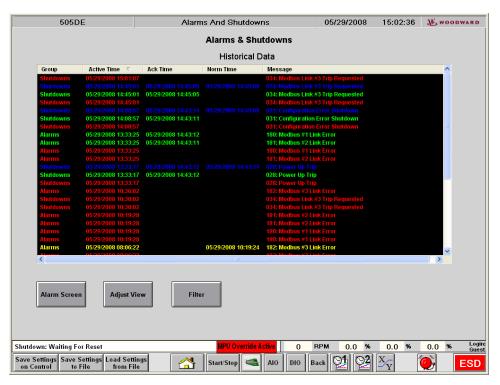


Figure 4-12. Alarm and Shutdown History Screen

Each individual alarm condition is available through the Modbus links to monitor the control status. A common alarm indication is also provided.

Relay indications can be programmed to indicate a 505DE common alarm, in addition to the dedicated Alarm Relay output.

001: Speed Input #1 Failed	101: Lower P1 Extraction Demand F
002: Speed Input #2 Failed	102: Enbl/Dsbl P1 Extraction Demand F
003: Speed Input #3 Failed	103: Enbl/Dsbl P1 Remote Demand F
004: Speed Input #4 Failed	104: Raise P2 Extraction Demand F
005: KW Input Failed	105: Lower P2 Extraction Demand F
006: Remote Spd Setpt Input Failed	106: Enbl/Dsbl P2 Extraction Demand F
007: Cascade Input Failed	107: Enbl/Dsbl P2 Remote Demand F
008: Remote Casc Setpt Input Failed	108: External Trip 1 F
009: Aux 1 Input Failed	109: External Trip 2 F
010: Aux 1 Remote Setpt Input Failed	110: External Trip 3 F
011: Aux 2 Input Failed	111: External Trip 4 F
012: Aux 2 Remote Setpt Input Failed	112: External Trip 5 F
013: Sync Input Failed	113: External Trip 6 F
014: Sync / Load Share Input Failed	114: External Trip 7 F
015: Load Share Input Failed	115: External Trip 8 F
016: Heat Soak Input Failed	116: External Trip 9 F
017: First Stage Pressure Input Failed	117: External Trip 10 F
018: SG PID Input Failed	118: Spare
019: SG PID Setpoint Input Failed	119: Spare
020: P1 Input Failed	120: Spare
021: P1 Setpoint Input Failed	121: Spare
022: Pressure Comp Input Failed	122: Spare
023: Inlet Pres Input Failed	123: Spare
024: Inlet Pres Setpt Input Failed	124: Spare
025: Exhaust Pres Input Failed	125: Spare
026: Exhaust Pres Setpt Input Failed	126: Spare
027: P2 Input Failed	127: Spare
028: P2 Setpoint Input Failed	128: Spare
029: KW Input F	129: Spare
030: Remote Speed Setpt Input F	130: Auto-Sync Real-Time Clock F
031: Cascade Input F	131: External Alarm 1 F
032: Remote Cascade Setpt Input F	132: External Alarm 2 F
033: Aux 1 Input F	133: External Alarm 3 F
034: Aux 1 Remote Setpt Input F	134: External Alarm 4 F
035: Aux 2 Input F	135: External Alarm 5 F
036: Aux 2 Remote Setpt Input F	136: External Alarm 6 F
037: Sync Input F	137: External Alarm 7 F
038: Sync / Load Share Input F	138: External Alarm 8 F
039: Load Share Input F	139: External Alarm 9 F
040: Heat Soak Input F	140: External Alarm 10 F
041: First Stage Pressure Input F	141: Slot 5 DIO Module Failed
042: SG PID Input F	142: Slot 6 DIO Module Failed
043: SG PID Setpt Input F	143: AO 01 Analog Output Fault
044: P1 Input F	144: AO 02 Analog Output Fault
045: P1 Setpt Input F	145: AO 03 Analog Output Fault

040 D	440 40 04 4 1 0 1 1 5 1
046: Pressure Comp Input F	146: AO 04 Analog Output Fault
047: Inlet Pressure Input F	147: AO 05 Analog Output Fault
048: Inlet Pressure Setpt Input F	148: AO 06 Analog Output Fault
049: Exhaust Pressure Input F	149: AO 07 Analog Output Fault
050: Exhaust Pressure Setpt Input F	150: AO 08 Analog Output Fault
051: P2 Input F	151: Act 01 Output Fault
052: P2 Setpt Input F	152: Act 02 Output Fault
053: Slot 2 AIO Module Failed	153: Act 03 Output Fault
054: Slot 3 AIO Module Failed	154: Act 04 Output Fault
055: External Trip F	155: Act 05 Output Fault
056: Reset F	156: Act 06 Output Fault
057: Speed Raise F	157: Spare
058: Speed Lower F	158: Turbine Trip
059: Generator Brkr Closed F	159: Overspeed Alarm
060: Utility Brkr Closed F	160: Speed Stuck in Critical
061: Enable Overspeed Test F	161: Rmt Spd Setpt Stuck in Critical
062: External Run (Start) F	162: Tie Breaker Opened
063: Start Permissive F	163: Gen Breaker Opened
064: Idle/Rated F	164: External Alarm #1
065: Enable Synchronization F	165: External Alarm #2
066: Controlled Shutdown F	166: External Alarm #3
067: Halt/Continue Auto Seq F	167: External Alarm #4
068: Override MPU Fault F	168: External Alarm #5
069: Select Online PID Dynamics F	169: External Alarm #6
070: Local/Remote F	170: External Alarm #7
071: E/D Remote Speed Setpt F	171: External Alarm #8
071: E/D Remote Speed Setpt F 072: Arm/Disarm Frequency Control F	
	172: External Alarm #10
073: Raise P1 Extraction Setpt F	
074: Lower P1 Extraction Setpt F 075: E/D P1 Control F	174: Power Supply #1 Fault
	175: Power Supply #2 Fault
076: E/D P1 Remote Setpt F	176: Chassis Temperature Alarm
077: Raise P2 Extraction Setpt F	177: Chassis Fan Fault
078: Lower P2 Extraction Setpt F	178: Backup CPU Fault
079: E/D P2 Extraction Control F	179: CPU Failover Occurred
080: E/D P2 Extr. Remote Setpt F	180: Modbus #1 Link Error
081: Select Priority Mode F	181: Modbus #2 Link Error
082: Raise Cascade Setpt F	182: Modbus #3 Link Error
083: Lower Cascade Setpt F	183: 2 Mod3 HMI's – Config Disabled
084: E/D Cascade Control F	Spare
085: E/D Cascade Remote Setpt F	Spare
086: Raise Aux-1 Setpt F	Spare
087: Lower Aux-1 Setpt F	Spare
088: E/D Aux-1 Control F	Spare
089: E/D Aux-1 Remote Setpt F	Spare
090: Raise Aux-2 Setpt F	Spare
091: Lower Aux-2 Setpt F	Spare
092: E/D Aux-2 Control F	Spare
093: E/D Aux-2 Remote Setpt F	Spare
094: Open HP/V1 Valve Limiter F	Spare
095: Close HP/V1 Valve Limiter F	Spare

096: Open IP/V2 Valve Limiter F	Spare
097: Close IP/V2 Valve Limiter F	Spare
098: Open LP/V3 Valve Limiter F	Spare
099: Close LP/V3 Valve Limiter F	Spare
100: Raise P1 Extraction Demand F	Spare

Table 4-11. Alarm Messages

Each individual trip condition is available through the Modbus links to monitor the control status. A common trip indication and the cause of the last turbine trip are also provided.

Relay indications can be programmed to indicate a 505DE Shutdown Condition (energizes for a shutdown condition) or a Trip Relay (de-energizes for a shutdown/trip), in addition to the dedicated Emergency Trip Relay output.

## **Trips / Shutdowns**

```
001: External ESD Trip Input
002: External Trip 1
003: External Trip 2
004: External Trip 3
005: External Trip 4
006: External Trip 5
007: External Trip 6
008: External Trip 7
009: External Trip 8
010: External Trip 9
011: External Trip 10
012: Overspeed Trip
013: Loss of Speed Signals
014: Act 01 Output Fault
015: Act 02 Output Fault
016: Act 03 Output Fault
017: Act 04 Output Fault
018: Act 05 Output Fault
019: Act 06 Output Fault
020: Spare
021: Aux 1 Input Failed
022: Aux 2 Input Failed
023: P1 Input Failed
024: P2 Input Failed
025: Speed in Critical Band Too Long
026: Gen Breaker Open Trip
027: Tie Breaker Open Trip
028: Power Up Trip
029: Controlled Shutdown Complete
030: Configure Active Shutdown
031: Configuration Error Shutdown
032: Modbus Link #1 Trip Requested
033: Modbus Link #2 Trip Requested
034: Modbus Link #3 Trip Requested
```

Table 4-12. Trip Messages

#### **Dual Dynamics (Speed/Load)**

The Speed PID has two sets of dynamics, On-Line and Off-Line; each include Proportional Gain, Integral Gain, and Derivative Ratio (SDR) variables. There are three cases that determine when the dynamics switch between On-Line and Off-Line:

- A "Select On-Line Dynamics" contact input is programmed
- Unit is driving a generator
- Unit is driving a mechanical drive (not a generator)

If a contact input is programmed to "Select On-Line Dynamics", it has priority regardless of the driven device. When the contact is closed, On-Line dynamics are selected; when open, Off-Line dynamics are selected.

If the unit is driving a generator and no "Select On-Line Dynamics" contact input is programmed, the Speed PID uses the Speed Off-Line dynamics when the generator or utility tie breaker contacts are open. The speed On-Line dynamics are used by the speed PID when the generator and utility tie breaker contacts are closed. If the speed dynamics select contact is programmed, the generator and utility tie contacts do not effect the dynamics selection.

If the unit is not driving a generator and no "Select On-Line Dynamics" contact input is programmed, the Speed Off-Line dynamic settings are used when the turbine speed is below minimum governor speed; On-Line dynamics are used if the turbine speed is above minimum governor speed. If the speed dynamics select contact is programmed, the turbine speed does not effect the dynamics selection.

A relay can be programmed to indicate that the On-Line Dynamics mode is selected.

#### Cascade, Auxiliary, Or EXTR/ADM Droop

The Cascade, Auxiliary, and Extr/Adm controllers can be programmed to use droop for control loop stability. If the parameter being controlled (Casc, Aux, Extr/Adm) is also being controlled by another device (letdown station, boiler, or other turbine), droop is typically required for control loop stability. If required, no less than 5% droop is recommended for stable operation.

#### **Tuning P & I Gains**

Proportional gain must be tuned to best respond to a system transient or step change. If system response is not known, a typical starting value is 5%. If proportional gain is set too high the control will appear to be overly sensitive, and may oscillate with a cycle time of less than 1 second.

Integral gain must be tuned for best control at steady state. If system response is not known a typical starting value is 0.5%. If the integral gain is set too high the control may hunt or oscillate at cycles times of over 1 second.

For best response the proportional gain and integral gain should be as high as possible. To obtain a faster transient response, slowly increase the proportional gain setting until the actuator or final driver output begins to oscillate or waver. Then adjust the integral gain as necessary to stabilize the output. If stability cannot be obtained with the integral gain adjustment, reduce the proportional gain setting.

A well-tuned system, when given a step change, should slightly overshoot the control point then come into control.

A PID control loop's gain is a combination of all the gains in the loop. The loop's total gain includes actuator gain, valve gain, valve linkage gain, transducer gain, internal turbine gains, and the 505DE's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 505DE's gain must be very low to be added to the system gain required for system stability.

In cases where a small change in the 505DE's output results in a large speed or load change (high mechanical gain) it may not be possible to take the 505DE's gains low enough to reach stable operation. In those cases the mechanical interface (actuator, linkage, servo, valve rack) design and/or calibration should be reviewed and changed to achieve a gain of one where 0-100% 505DE output corresponds to 0-100% valve travel.

#### **Tuning Derivative**

The value of the Derivative Ratio (DR) term can range from 0.01 to 100. If unsure of the correct value, set the Speed control's DR term to 5% and the Aux, Cascade, & Extr/Adm controllers' DR terms to 100%. In order 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 .0101 or 100 selects a PI only controller, input and feedback dominant respectively.

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

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

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

#### **Tuning Example**

If the system is unstable, verify if the governor is the cause. This can be checked by moving the valve limiter until it has control of the actuator output. If the system continues to oscillate when the valve limiter is in control of the valve, the system instability is caused by an external device/function. If the governor is causing the oscillation, time the oscillation cycle time. A rule-of-thumb is, if the system's oscillation cycle time is less than 1 second reduce the Proportional gain term. A rule-of-thumb is, if the system's oscillation cycle time is greater than 1 second reduce the Integral gain term (proportional gain may need to be increased also).

On an initial startup with the 505DE, 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 505DE'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. Increase Derivative Ratio (DR) to 100 (This is the default setting).
- 2. Reduce integral gain to minimum.
- 3. Increase proportional gain until system just starts to oscillate.
- 4. Record the system gain (G) and oscillation period (T).
- 5. 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 get the gain settings close, they can be fine-tuned from this point. Figure 4-13 shows the typical response to a load change when the dynamics are optimally adjusted.

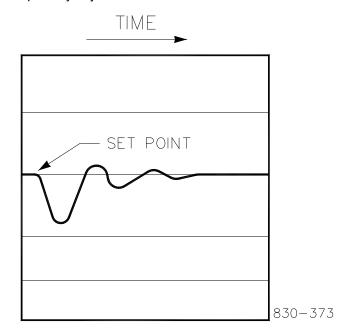


Figure 4-13. Typical Response to Load Change

*IMPORTANT* 

For additional information on PID settings refer to Volume 2.

## Chapter 5. Service Options

#### **Product Service Options**

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

**OEM and Packager Support:** Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

**Woodward Business Partner Support:** Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A Full Service Distributor has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An Authorized Independent Service Facility (AISF) provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A Recognized Engine Retrofitter (RER) is an independent company that
  does retrofits and upgrades on reciprocating gas engines and dual-fuel
  conversions, and can provide the full line of Woodward systems and
  components for the retrofits and overhauls, emission compliance upgrades,
  long term service contracts, emergency repairs, etc.
- A Recognized Turbine Retrofitter (RTR) is an independent company that
  does both steam and gas turbine control retrofits and upgrades globally, and
  can provide the full line of Woodward systems and components for the
  retrofits and overhauls, long term service contracts, emergency repairs, etc.

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

www.woodward.com/directory

### **Woodward Factory Servicing Options**

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

**Flat Rate Repair:** Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

**Flat Rate Remanufacture:** Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in "likenew" condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

## Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return authorization number:
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

#### Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.



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

#### **Replacement Parts**

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

#### **Engineering Services**

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

**Technical Support** is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

**Product Training** is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

**Field Service** engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: www.woodward.com.

#### **How to Contact Woodward**

For assistance, call one of the following Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Electrical Power Systems <u>Facility</u>	<u>FacilityPhone Number</u> Brazil+55 (19) 3708 4800	Turbine Systems <u>Facility</u>
China+86 (512) 6762 6727	China+ +86 (512) 6762 6727	China+ +86 (512) 6762 6727
Germany+49 (0) 21 52 14 51	Germany+ +49 (711) 78954-510	India++91 (129) 4097100
India+91 (129) 4097100	India+ +91 (129) 4097100	Japan++81 (43) 213-2191
Japan+81 (43) 213-2191	Japan+81 (43) 213-2191	Korea+82 (51) 636-7080
Korea++82 (51) 636-7080	Korea+82 (51) 636-7080	The Netherlands - +31 (23) 5661111
Poland+48 12 295 13 00	The Netherlands-+31 (23) 5661111	Poland+48 12 295 13 00
United States+1 (970) 482-5811	United States+1 (970) 482-5811	United States +1 (970) 482-5811

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

www.woodward.com/directory

### **Technical Assistance**

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
Control/Governor #1	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Seriai Nullibei	
Control/Governor #2	
Control/Governor #2	
Control/Governor #2 Woodward Part Number & Rev. Letter	
Control/Governor #2 Woodward Part Number & Rev. Letter Control Description or Governor Type Serial Number Control/Governor #3	
Control/Governor #2 Woodward Part Number & Rev. Letter Control Description or Governor Type Serial Number	
Control/Governor #2 Woodward Part Number & Rev. Letter Control Description or Governor Type Serial Number Control/Governor #3	

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

# Appendix A. Program Worksheet

Governor Serial N	Number _		
Application			Date
Site		Turbine _	ID
* = Service Level	Items		
APPLICATION SETTINGS			<u>Left CPU Port:</u>
Turbine Type			*Driver
Generator?	YES_	<u>NO</u>	<u>*Baud</u>
Cascade?	YES	NO	*Stop Bits
Auxiliary			*Parity
External Trips in Trip Relay?	YES	NO	
Reset Clears Trip Output?	YES_	<u>NO</u>	Right CPU Port:
*2 <sup>nd</sup> CPU?	YES	NO	*Driver
2 <sup>nd</sup> DIO?	YES	NO	*Baud
2 <sup>nd</sup> Power Supply?	YES_	<u>NO</u>	*Stop Bits
*Simulate?	YES	NO	*Parity
Local / Remote?	YES_	<u>NO</u>	
*Contacts			MODBUS ANALOG SCALARS
*Mod1			*Cascade
*Mod2			*Auxiliary Control 1
*Modbus 1 Port Type			*Auxiliary Control 2
*Use Modbus #1?	YES_	<u>NO</u>	*Inlet Pressure
*En Modbus #1 Commands?	YES	NO	*First Stage Pressure
*Use Modbus #1 Trip	YES	NO	*P1 Pressure
*Two Step Trip	YES_	NO	*P2 Pressure
*Trip Always Enabled	YES	NO	*Exhaust Pressure
*Modbus 2 Port Type			*Sync/Loadshare Signal
*Use Modbus #2?	YES	NO	*KW Signal
*Enable Modbus #2 Command	ls?YES	NO	*Decoupling
*Use Modbus #2 Trip	YES	NO	*Seal Gas PID
*Two Step Trip	YES	NO	*Inlet Flow
*Trip Always Enabled	YES_	NO	

TURBINE START		
Start Type		
Auto-Start Type	\/=0	110
*Trip After CSD Complete?	YES	NO
*Rate to Min		RPM/SEC
*Start S dmd (LSS) Limit		<u>%</u>
*CSD Rate Above Min		RPM/SEC
*CSD Rate Below Min		RPM/SEC
*Cooldown Time		MIN
*Cooldown Speed		RPMRPM
*Ramp to Idle?	YES	NO
*Idle Priority?	YES	NO
Idle Setpoint		RPM
Rated Setpoint		RPM
*Idle/Rated Rate		RPM/SEC
Auto Sequence Idle Setpoints		
*Auto Halt at Setpoints?	YES_	<u>NO</u>
*Cold Start ( > xx Hrs)		HRS
*Hot Start ( < xx Hrs)		HRS
Low Idle Setpoint		RPM
*Low Idle Delay Cold		MIN
*Low Idle Delay Hot		MIN
Mid Idle Setpoint		RPM
*Rate to Mid Idle Cold		RPM/SEC
*Rate to Mid Idle Hot		RPM/SEC
*Mid Idle Delay Cold		MIN
*Mid Idle Delay Hot		MIN
High Idle Setpoint		RPM
*Rate to High Idle Cold		RPM/SEC
*Rate to High Idle Hot		RPM/SEC
*High Idle Delay Cold	_	MIN
*High Idle Delay Hot		MIN
Rated Setpt		RPM
*Rate to Rated Cold		RPM/SEC
*Rate to Rated Hot		RPM/SEC
*Hot % Spd Setpt Entry Disable		%

SPEED SETTINGS		
*Use Override Timer?	YES	NO
*Use Speed Input #2?	YES	NO
*Use Speed Input #3?	YES	NO
*Use Speed Input #4?	YES	NO
*MPU Override Time	120	SEC
Teeth Seen by MPU		020
MPU Gear Ratio		
Max MPU Speed		RPM
Overspeed Test Limit		RPM
Overspeed Trip		RPM
Max Governor		RPM
Min Governor		RPM
*Underspeed Setting		RPM
*Setpoint Slow Rate		RPM/SEC
*Setpoint Fast Rate		RPM/SEC
*Setpoint Entered Rate		RPM/SEC
*Fast Rate Delay		SEC
*Off-Line PID P Gain		%
*Off-Line PID I Gain		rps
*Off-Line PID SDR		%
*On-Line PID P Gain		%
*On-Line PID I Gain		rps
*On-Line PID SDR		<u>%</u>
*Use Remote Setpoint?	YES	<u>NO</u>
*Rmt Stpt - Use Min Load?	YES	NO
*Remote Setpoint Max Rate		RPM/SEC
*Rmt Stpt Not Matched Rate		RPM/SEC
*Rmt Stpt Deadband		RPM
Min Rmt Setpoint		RPM
Max Rmt Setpoint		RPM
Critical Speed Bands		
*Critical Speed Rate		RPM/SEC
Critical Speed #1 Min		RPM
Critical Speed #1 Max		RPM
Critical Speed #2 Min		RPM
Critical Speed #2 Max		RPM
Critical Speed #3 Min		RPM
Critical Speed #3 Max		RPM

OPERATING PARAMETERS		
*V1 Limiter Rate		%/SEC
*V1 Limiter Max		%
*V1 Limiter Min		%
*V2 Limiter Rate		%/SEC
*V2 Limiter Max	-	%
*V2 Limiter Min		%
*V3 Limiter Rate		%/SEC
*V3 Limiter Max		%
*V3 Limiter Min		%
Use V1B?	YES	NO
Use Gen Breaker Open Trip?	YES	NO
Use Tie Breaker Open Trip?	YES	NO
Use Frequency Arm/Disarm?	YES	NO
Use KW Droop?	YES	NO
*Use Min Load?	YES	NO
Rated Speed Setpoint		RPM
*Droop %		%
*Speed/Droop Deadband		RPMRPM
KW Max Load		KW
*Min Load Bias		RPM
*Use Gen Open Setback?	YES	NO
*Use Tie Open Sync Ramp?	YES	NO
Use Sync/Load Share?	YES	NO
*Sync Window		RPMRPM
*Sync / Isoch Rate		RPM/SEC
*Gen Open Setback		RPM
*Tie Open Sync Ramp Rate		RPM/SEC
*Sync / Ld Shr Bias Gain		%
*Sync / Ld Shr Bias Deadband		RPMRPM

X2 (10.00)  % Y2 (10.00)  % X3 (20.00)  % Y3 (20.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y10 (90.00)  % X11 (100.00)  % Y1 (0.00)  % X2 (10.00)  % Y2 (10.00)  % X3 (20.00)  % Y3 (20.00)  % X6 (50.00)  % Y6 (50.00)  % X6 (50.00)  % Y10 (90.00)  % X11 (100.00)  % Y10 (90.00)  % X11 (100.00)  % Y10 (90.00)  % X2 (10.00)  % Y2 (10.00)  % X3 (20.00)  % Y3 (20.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y6 (50.00)  % X8 (70.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X11 (100.00)  % Y10 (90.00)  % X11 (100.00)  % Y10 (90.00)  % X11 (100.00)  % Y11 (100.00)  % X10 (90.00)  % Y10 (90.00)  % X11 (100.00)  % Y11 (100.00)  % X2 (10.00)  % Y10 (90.00)  % X3 (20.00)  % Y10 (90.00)  % X10 (90.00)  % Y10 (90.00)  % X11 (100.00)  % Y11 (100.00)  % X11 (100.00)  % Y11 (100.00)  % X2 (10.00)  % Y10 (90.00)  % X2 (10.00)  % Y10 (90.00)  % X3 (20.00)  % Y10 (90.00)  % X10 (90.00)  % Y10 (90.00)  %	V1A CURVE		
X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X2 (10.00)         % Y3 (20.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y8 (70.00)         %           X8 (70.00)         % Y1 (0.00)         %           X1 (10.00)         % Y1 (0.00)         %           X1 (10.00)         % Y1 (0.00)         %           X1 (0.00)         % Y3 (20.00)         %           X1 (1		% Y1 (0.00)	%
X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y1 (0.00)         %           X3 (20.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y3 (20.00)         %           X4 (30.00)         % Y5 (40.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y9 (80.00)         %           X1 (100.00)         % Y1 (100.00)         %           X1 (100.00)         % Y1 (100.00)         %           X2 (10.00)         % Y3 (20.00)         % <t< td=""><td>X2 (10.00)</td><td>% Y2 (10.00)</td><td></td></t<>	X2 (10.00)	% Y2 (10.00)	
X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X11 (100.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X9 (80.00)         % Y9 (80.00)         %           X11 (100.00)         % Y11 (100.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X2 (10.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %	X3 (20.00)		
X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (10.00)         %           Y11 (100.00)         % Y1 (10.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y3 (20.00)         %           X4 (30.00)         % Y5 (40.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y8 (70.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X1 (100.00)         % Y1 (0.00)         %           X1 (100.00)         % Y1 (0.00)         %           X1 (100.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X	X4 (30.00)		
X6 (50.00)	X5 (40.00)	% Y5 (40.00)	
X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y3 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X1 (100.00)         % Y1 (10.00)         %           X2 (10.00)         % Y2 (10.00)         %           X2 (10.00)         % Y3 (20.00)         %           X4 (30.00)         % Y1 (0.00)         %           X4 (30.00)         % Y2 (10.00)         %           X4 (30.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X		% Y6 (50.00)	
X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           V1B CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X9 (80.00)         % Y8 (70.00)         %           X9 (80.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X12 (10.00)         % Y1 (0.00)         %           X2 (10.00)         % Y3 (20.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %	X7 (60.00)	% Y7 (60.00)	
X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           V1B CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y5 (40.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y9 (80.00)         %           X9 (80.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X11 (100.00)         % Y1 (10.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X8 (70.00)         % Y1 (90.00)         %	X8 (70.00)	% Y8 (70.00)	%
V1B CURVE         X1 (0.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y9 (80.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X1 (100.00)         % Y1 (100.00)         %           X2 (10.00)         % Y1 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y7 (60.00)         %           X7 (60.00)         % Y1 (10.00)         %           X1 (10.00)         % Y1 (10.00)         % <td>X9 (80.00)</td> <td>% Y9 (80.00)</td> <td></td>	X9 (80.00)	% Y9 (80.00)	
V1B CURVE         X1 (0.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y9 (80.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X1 (100.00)         % Y1 (100.00)         %           X2 (10.00)         % Y1 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y7 (60.00)         %           X7 (60.00)         % Y1 (10.00)         %           X1 (10.00)         % Y1 (10.00)         % <td>X10 (90.00)</td> <td>% Y10 (90.00)</td> <td>%</td>	X10 (90.00)	% Y10 (90.00)	%
X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y8 (70.00)         %           X8 (70.00)         % Y1 (0.00)         %           X8 (70.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X1 (10.00	X11 (100.00)	% Y11 (100.00)	%
X2 (10.00)  % Y2 (10.00)  % X3 (20.00)  % Y3 (20.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X10 (90.00)  % Y1 (0.00)  % X2 (10.00)  % Y2 (10.00)  % X4 (30.00)  % Y3 (20.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y6 (50.00)  % X6 (50.00)  % Y7 (60.00)  % X6 (50.00)  % Y7 (60.00)  % X6 (50.00)  % Y1 (0.00)  % X6 (50.00)  % Y6 (50.00)  % X6 (50.00)  % Y7 (60.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X11 (100.00)  % Y11 (100.00)  % X11 (100.00)  % Y11 (100.00)  % X10 (90.00)  % Y11 (100.00)  % X11 (100.00)  % Y11 (100.00)  % X11 (100.00)  % Y11 (100.00)  % X1 (90.00)  % X10 (90.00)	V1B CURVE		
X3 (20.00)  % Y3 (20.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X10 (90.00)  % Y11 (100.00)  % X2 (10.00)  % Y2 (10.00)  % X4 (30.00)  % Y3 (20.00)  % X4 (30.00)  % Y5 (40.00)  % X5 (40.00)  % Y6 (50.00)  % X6 (50.00)  % Y7 (60.00)  % X6 (50.00)  % Y7 (60.00)  % X6 (50.00)  % Y9 (80.00)  % X6 (50.00)  % Y1 (10.00)  % X6 (50.00)  % Y6 (50.00)  % X8 (70.00)  % Y7 (60.00)  % X9 (80.00)  % Y9 (80.00)  % X9 (80.00)  % Y1 (10.00)  % X10 (90.00)  % Y1 (10.00)  % X11 (100.00)  % Y1 (10.00)  % X12 (10.00)  % Y1 (10.00)  % X13 (20.00)  % Y1 (10.00)  % X14 (30.00)  % Y1 (10.00)  % X15 (40.00)  % Y1 (10.00)  % X16 (50.00)  % Y1 (10.00)  % X17 (60.00)  % Y1 (10.00)  % X18 (70.00)  % Y1 (10.00)  % X19 (80.00)  % Y10 (90.00)  % X10 (90.00)  % Y10 (90.00)  %	X1 (0.00)	% Y1 (0.00)	
X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (10.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y7 (60.00)         %           X7 (60.00)         % Y3 (70.00)         %           X8 (70.00)         % Y3 (70.00)         %           X9 (80.00)         % Y10 (90.00)         %           X1 (100.00)         % Y1 (10.00)         %           X1 (10.00)         % Y10 (90.00)         %           X1 (10.00)         % Y1 (10.00)         %           X1 (10.00)         % Y1 (10.00)         %           X1 (10.00)         % Y1 (10.00)         %			
X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X10 (90.00)  % Y10 (90.00)  % X11 (100.00)  % Y1 (0.00)  % X2 (10.00)  % Y2 (10.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y6 (50.00)  % X6 (50.00)  % Y7 (60.00)  % X9 (80.00)  % Y1 (10.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X9 (80.00)  % Y1 (10.00)  % X11 (100.00)  % Y1 (10.00)  % X2 (10.00)  % Y1 (10.00)  % X3 (20.00)  % Y1 (10.00)  % X4 (30.00)  % Y1 (10.00)  % X5 (40.00)  % Y1 (10.00)  % X6 (50.00)  % Y1 (10.00)  % X7 (60.00)  % Y1 (10.00)  % X8 (70.00)  % Y1 (10.00)  % X9 (80.00)  % Y1 (10.00)  % X9 (80.00)  % Y1 (10.00)  % X9 (80.00)  % Y1 (10.00)  % X10 (10.00)  % X10 (10.00)  % Y1 (10.00)  % X10 (10.0	X3 (20.00)	% Y3 (20.00)	%
X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (0.00)         %           X12 (10.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X4 (30	X4 (30.00)	% Y4 (30.00)	%
X7 (60.00)	X5 (40.00)	% Y5 (40.00)	
X7 (60.00)	X6 (50.00)	% Y6 (50.00)	%
X8 (70.00)		% Y7 (60.00)	
X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (0.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X4 (30.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6		% Y8 (70.00)	%
X11 (100.00)         % Y11 (100.00)         %           V2 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         % <td>X9 (80.00)</td> <td></td> <td></td>	X9 (80.00)		
V2 CURVE           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y9 (80.00)         %	X10 (90.00)	% Y10 (90.00)	%
X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %	X11 (100.00)	% Y11 (100.00)	%
X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %	V2 CURVE		
X3 (20.00)		% Y1 (0.00)	
X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %			
X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y7 (60.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X10 (90.00)  % Y10 (90.00)  % X11 (100.00)  % Y11 (100.00)  % X2 (10.00)  % Y1 (0.00)  % X3 (20.00)  % Y3 (20.00)  % X4 (30.00)  % Y4 (30.00)  % X5 (40.00)  % Y5 (40.00)  % X6 (50.00)  % Y6 (50.00)  % X7 (60.00)  % Y8 (70.00)  % X8 (70.00)  % Y8 (70.00)  % X9 (80.00)  % Y9 (80.00)  % X9 (80.00)  % Y9 (80.00)  % X9 (80.00)  % Y9 (80.00)  % X10 (90.00)  % Y10 (90.00)  %			
X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %		% Y4 (30.00)	
X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           Y3 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %	X5 (40.00)		%
X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           V3 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %			
X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           V3 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %			
X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %           X11 (100.00)         % Y11 (100.00)         %           V3 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %	X8 (70.00)	% Y8 (70.00)	
X11 (100.00)       % Y11 (100.00)       %         V3 CURVE       X1 (0.00)       % Y1 (0.00)       %         X1 (0.00)       % Y2 (10.00)       %         X2 (10.00)       % Y3 (20.00)       %         X3 (20.00)       % Y4 (30.00)       %         X4 (30.00)       % Y5 (40.00)       %         X5 (40.00)       % Y6 (50.00)       %         X6 (50.00)       % Y7 (60.00)       %         X7 (60.00)       % Y8 (70.00)       %         X8 (70.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %	X9 (80.00)	% Y9 (80.00)	
V3 CURVE         X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %			%
X1 (0.00)         % Y1 (0.00)         %           X2 (10.00)         % Y2 (10.00)         %           X3 (20.00)         % Y3 (20.00)         %           X4 (30.00)         % Y4 (30.00)         %           X5 (40.00)         % Y5 (40.00)         %           X6 (50.00)         % Y6 (50.00)         %           X7 (60.00)         % Y7 (60.00)         %           X8 (70.00)         % Y8 (70.00)         %           X9 (80.00)         % Y9 (80.00)         %           X10 (90.00)         % Y10 (90.00)         %	X11 (100.00)	% Y11 (100.00)	%
X2 (10.00)       % Y2 (10.00)       %         X3 (20.00)       % Y3 (20.00)       %         X4 (30.00)       % Y4 (30.00)       %         X5 (40.00)       % Y5 (40.00)       %         X6 (50.00)       % Y6 (50.00)       %         X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %			
X3 (20.00)       % Y3 (20.00)       %         X4 (30.00)       % Y4 (30.00)       %         X5 (40.00)       % Y5 (40.00)       %         X6 (50.00)       % Y6 (50.00)       %         X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %	X1 (0.00)	% Y1 (0.00)	
X4 (30.00)       % Y4 (30.00)       %         X5 (40.00)       % Y5 (40.00)       %         X6 (50.00)       % Y6 (50.00)       %         X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %	X2 (10.00)		
X5 (40.00)       % Y5 (40.00)       %         X6 (50.00)       % Y6 (50.00)       %         X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %			
X6 (50.00)       % Y6 (50.00)       %         X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %			
X7 (60.00)       % Y7 (60.00)       %         X8 (70.00)       % Y8 (70.00)       %         X9 (80.00)       % Y9 (80.00)       %         X10 (90.00)       % Y10 (90.00)       %			
X8 (70.00)			
X9 (80.00)	X7 (60.00)		
X10 (90.00) % Y10 (90.00) %			
X10 (90.00)       % Y10 (90.00)       %         X11 (100.00)       % Y11 (100.00)       %			
X11 (100.00) % Y11 (100.00) %			%
	X11 (100.00)	% Y11 (100.00)	%

EXTRACTION ADMISSION		
Priority #1		
Priority #2		
Max Power		
Min Power		
Max HP Flow		
Rated Inlet Pressure		<u> </u>
Max P1 Flow		<del>-</del>
Max P2 Flow		
C Power		
C Flow		
D Power		
D Flow		
E Power		
E Flow		
C1 Power		
C1 Flow		
D1 Power		
D1 Flow		
E1 Power		
E1 Flow		
<u> LI FIOW</u>		
P1 SETTINGS		
*P1 Failure Mode	VEC	NO
Invert P1 Input?	YES	NO NO
Use P1 Auto Enable?	YES	NO
Use P1 Setpoint Tracking?	YES_	<u>NO</u>
Util Brkr Open P1 Disable?	YES	<u>NO</u>
Gen Brkr Open P1 Disable?	YES	NO
*Minimum P1 Setpoint		
*Maximum P1 Setpoint		
*Initial P1 Setpoint		
P1 Speed Enable Setting		RPM
*P1 Slow Rate		
*P1 Fast Rate		
*P1 Entered Rate		
*P1 Fast Delay Time		SEC
*P1 Droop		%
*P1 Control Dead Band		%
*P1 PID P Gain		%
*P1 PID I Gain		<u>rps</u>
*P1 PID SDR		%
*Min P1 Man Setpoint		%
*Max P1 Man Setpoint		%
*P1 Man Slow Rate		%/SEC
*P1 Man Fast Rate		%/SEC
Use P1 Remote?	YES	NO
*P1 Remote Min Setpoint		
*P1 Remote Max Setpoint		
*P1 Remote Rate	<u> </u>	

P2 SETTINGS *P2 Failure Mode		
Invert P2 Input?	YES	NO
Use P2 Auto Enable?	YES	NO NO
Use P2 Setpoint Tracking?	YES	NO
Util Brkr Open P2 Disable?	YES	NO
Gen Brkr Open P2 Disable?	YES	NO
*Minimum P2 Setpoint	120	110
*Maximum P2 Setpoint		·
*Initial P2 Setpoint		
P2 Speed Enable Setting		RPM
*P2 Slow Rate		
*P2 Fast Rate		_
*P2 Entered Rate		
*P2 Fast Delay Time		SEC
*P2 Droop		%
*P2 Control Dead Band		%
*P2 PID P Gain		%
*P2 PID I Gain		rps
*P2 PID SDR		%
*Min P2 Man Setpoint		<u>%</u>
*Max P2 Man Setpoint		%
*P2 Man Slow Rate		%/SEC
*P2 Man Fast Rate		%/SEC
Use P2 Remote?	YES	NO
*P2 Remote Min Setpoint		
*P2 Remote Max Setpoint		
*P2 Remote Rate		
CASCADE CONTROL		
CASCADE CONTROL Invert Cascade Input?	YES	NO
CASCADE CONTROL Invert Cascade Input? Use Setpoint Tracking?	YES YES	NO NO
Invert Cascade Input?		
Invert Cascade Input? Use Setpoint Tracking?	YES	NO NO NO
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit	YES YES	NO NO
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only?	YES YES	NO NO NO
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit	YES YES	NO NO NO RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Entered Rate	YES YES	NO NO NO RPM RPM/SEC
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Entered Rate *Casc Fast Delay Time	YES YES	NO NO NO RPM RPM
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band	YES YES	NO NO NO RPM RPM RPM/SEC
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Cascade Droop	YES YES	NO NO NO RPM RPM RPM/SEC  SEC
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Cascade Droop *Cascade PID P Gain	YES YES	NO NO NO RPM RPM RPM/SEC  SEC
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band *Cascade PID P Gain *Cascade PID I Gain	YES YES	NO NO NO RPM RPM RPM/SEC  SEC % rps
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR	YES YES YES	NO NO NO RPM RPM RPM/SEC  SEC  % rps %
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR Use Remote Setpoint?	YES YES	NO NO NO RPM RPM RPM/SEC  SEC % rps
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR Use Remote Setpoint? *Cascade Remote Rate	YES YES YES	NO NO NO RPM RPM RPM/SEC  SEC  % rps %
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc Alpha Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR Use Remote Setpoint? *Cascade Remote Rate *Rmt Not Matched Rate	YES YES YES	NO NO NO RPM RPM RPM/SEC  SEC  % rps %
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc PID Dead Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR Use Remote Setpoint? *Cascade Remote Rate *Rmt Not Matched Rate *Casc Remote Min Setpoint	YES YES YES	NO NO NO RPM RPM RPM/SEC  SEC  % rps %
Invert Cascade Input? Use Setpoint Tracking? Use Min Load? R/L Cascade Only? Speed Setpoint Lower Limit Speed Setpoint Upper Limit *Speed Setpt Max Rate *Minimum Cascade Setpt *Maximum Cascade Setpt *Initial Cascade Setpoint *Rated Casc Setpoint *Casc Setpt Slow Rate *Casc Setpt Fast Rate *Casc Setpt Entered Rate *Casc Fast Delay Time *Casc Alpha Band *Cascade PID P Gain *Cascade PID I Gain *Cascade PID SDR Use Remote Setpoint? *Cascade Remote Rate *Rmt Not Matched Rate	YES YES YES	NO NO NO RPM RPM RPM/SEC  SEC  % rps %

AUX1 CONTROLLER			
Lost Aux Input Shutdown?	YES	NO	
Use KW Input?	YES	NO	
Invert Aux1 Input?	YES	NO	<u>.</u>
Use Aux1 Enable?	YES	NO	
Tie Brkr Open Aux1 Disable?	YES	NO	
Gen Brkr Open Aux1 Disable?	YES	NO	
*Minimum Aux1 Setpoint			
*Maximum Aux1 Setpoint			
*Setpoint Initial Value			
*Aux1 Rated Setpoint			
*Aux1 Setpoint Slow Rate			
*Aux1 Setpoint Fast Rate			
*Aux1 Setpoint Entered Rate			
*Aux1 Fast Delay Time			SEC
*Aux1 PID Min Output			
*Aux1 Droop			%
*Aux1 PID P Gain			<del>//</del> %
*Aux1 PID I Gain			rps
*Aux1 PID SDR			— <u>153</u> %
Use Remote Setpoint?	YES	NO	/0
*Aux1 Remote Rate	ILO_	110	
*Aux1 Rmt Not Matched Rate			
*Aux1 Remote Min Setpoint			
*Aux1 Remote Max Setpoint			
*Aux1 Remote Dead Band			
Aux i Nelliote Dead Balld			
AUX2 CONTROLLER			
AUX2 CONTROLLER Lost Aux Input Shutdown?	YES	NO	
Lost Aux Input Shutdown?	YES YES	NO NO	
Lost Aux Input Shutdown? Use KW Input?	YES YES YES	NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input?	YES YES	NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable?	YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable?	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable?	YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate	YES YES YES YES	NO NO NO	SEC
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time	YES YES YES YES	NO NO NO	SEC
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output	YES YES YES YES	NO NO NO	SEC
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold	YES YES YES YES	NO NO NO	
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 Droop	YES YES YES YES	NO NO NO	%
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 Droop *Aux2 PID P Gain	YES YES YES YES	NO NO NO	<u>%</u> %
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 Droop *Aux2 PID I Gain *Aux2 PID I Gain	YES YES YES YES	NO NO NO	% % rps
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 Droop *Aux2 PID I Gain *Aux2 PID I Gain *Aux2 PID SDR	YES YES YES YES YES	NO NO NO NO NO	<u>%</u> %
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 Droop *Aux2 PID I Gain *Aux2 PID SDR Use Remote Setpoint?	YES YES YES YES	NO NO NO	% % rps
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 PID P Gain *Aux2 PID I Gain *Aux2 PID SDR Use Remote Setpoint? *Aux2 Remote Rate	YES YES YES YES YES	NO NO NO NO NO	% % rps
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 Droop *Aux2 PID I Gain *Aux2 PID I Gain *Aux2 PID SDR Use Remote Setpoint? *Aux2 Remote Rate *Aux2 Remote Rate *Aux2 Rate Rate	YES YES YES YES YES	NO NO NO NO NO	% % rps
Lost Aux Input Shutdown? Use KW Input? Invert Aux2 Input? Use Aux2 Enable? Tie Brkr Open Aux2 Disable? Gen Brkr Open Aux2 Disable? *Minimum Aux2 Setpoint *Maximum Aux2 Setpoint *Setpoint Initial Value *Aux2 Rated Setpoint *Aux2 Setpoint Slow Rate *Aux2 Setpoint Fast Rate *Aux2 Setpoint Entered Rate *Aux2 Fast Delay Time *Aux2 PID Min Output *Aux2 PID Threshold *Aux2 PID P Gain *Aux2 PID I Gain *Aux2 PID SDR Use Remote Setpoint? *Aux2 Remote Rate	YES YES YES YES YES	NO NO NO NO NO	% % rps

\*Aux2 Remote Dead Band

## **Analog and Discrete I/O Configuration**

	Allalog	and Discie
ANALOG INPUTS		
Al 01 Function		
*Al 01 Value at 4mA		
*AI 01 Value at 20mA		
*Offset *	Gain	*Lag
Al 02 Function		-
*Al 02 Value at 4mA		
*Al 02 Value at 20mA		
	Gain	*Lag
Al 03 Function		
*Al 03 Value at 4mA		
*AI 03 Value at 20mA		
*Offset *	Gain	*Lag
Al 04 Function		
*Al 04 Value at 4mA		
*Al 04 Value at 20mA		
	Gain	*Lag
Al 05 Function	Gairi	Lag
*Al 05 Value at 4mA		
*Al 05 Value at 20mA		
	Gain	*1 00
	Gaiii	*Lag
Al 06 Function		
*Al 06 Value at 4mA		
*Al 06 Value at 20mA		+1
	Gain	*Lag
Al 07 Function		
*AI 07 Value at 4mA		
*AI 07 Value at 20mA		
	Gain	*Lag
Al 08 Function		
*AI 08 Value at 4mA		
*Al 08 Value at 20mA		
	Gain	*Lag
Al 09 Function		
*Al 09 Value at 4mA		
*AI 09 Value at 20mA		
	Gain	*Lag
Al 10 Function		
*AI 10 Value at 4mA		
*Al 10 Value at 20mA		
	Gain	*Lag
Al 11 Function		
*Al 11 Value at 4mA		
*Al 11 Value at 20mA		
	Gain	*Lag
Al 12 Function		
*Al 12 Value at 4mA		
*AI 12 Value at 20mA		
*Offset *	Gain	*Lag
Al 13 Function		
*AI 13 Value at 4mA		
*Al 13 Value at 20mA		
	Gain	*Lag
Al 14 Function		
*Al 14 Value at 4mA		
*Al 14 Value at 20mA		
*Offset *	Gain	*Lag

Al 15 Function	
*AI 15 Value at 4mA	
*Al 15 Value at 20mA	<del></del>
*Offset *Gain	*Lag
Al 16 Function	
*Al 16 Value at 4mA	
*Al 16 Value at 20mA	
*Offset *Gain	*Lag
Al 17 Function	
*AI 17 Value at 4mA	
*Al 17 Value at 20mA	
*Offset *Gain	*Lag
Al 18 Function	==:9
*Al 18 Value at 4mA	
*Al 18 Value at 20mA	
*Offset *Gain	*Lag
Al 19 Function	- 3
*Al 19 Value at 4mA	
*AI 19 Value at 20mA	
*Offset *Gain	*Lag
Al 20 Function	
*AI 20 Value at 4mA	
*Al 20 Value at 20mA	
*Offset *Gain	*Lag
Al 21 Function	<del>-</del>
*Al 21 Value at 4mA	<del></del>
*Al 21 Value at 20mA	
*Offset *Gain	*Lag
Al 22 Function	-
*Al 22 Value at 4mA	
*AI 22 Value at 20mA	
*Offset *Gain	*Lag
Al 23 Function	
*AI 23 Value at 4mA	
*AI 23 Value at 20mA	
*Offset *Gain	*Lag
Al 24 Function	
*Al 24 Value at 4mA	
*AI 24 Value at 20mA	
*Offset *Gain	*Lag
ANALOG OUTPUTS	
AO 1 Function	
*AO 1 Value at 4mA	
*AO 1 Value at 20mA	
*Offset	*Gain

ANALOG COTT CTO	
AO 1 Function	
*AO 1 Value at 4mA	
*AO 1 Value at 20mA	
*Offset	*Gain
AO 2 Function	
*AO 2 Value at 4mA	
*AO 2 Value at 20mA	·
*Offset	*Gain
AO 3 Function	·
*AO 3 Value at 4mA	
*AO 3 Value at 20mA	
*Offset	*Gain
·	

AO 4 Function				ACT 4 Function	
*AO 4 Value at 4mA				*SD?	
*AO 4 Value at 20mA				*160 mA?	
*Offset	*Gain			*0% Value	
AO 5 Function				*100% Value	
*AO 5 Value at 4mA				*mA at 0%	
*AO 5 Value at 20mA				*mA at 100%	
*Offset	*Gain			*Dither	
AO 6 Function				ACT 5 Function	
*AO 6 Value at 4mA				*SD?	
*AO 6 Value at 20mA				*160 mA?	
*Offset	*Gain			*0% Value	
AO 7 Function				*100% Value	
*AO 7 Value at 4mA				*mA at 0%	
*AO 7 Value at 20mA				*mA at 100%	
*Offset	*Gain			*Dither	
AO 8 Function				ACT 6 Function	
*AO 8 Value at 4mA				*SD?	
*AO 8 Value at 20mA				*160 mA?	
*Offset	*Gain			*0% Value	
AO 9 Function				*100% Value	
*AO 9 Value at 4mA				*mA at 0%	
*AO 9 Value at 20mA				*mA at 100%	
*Offset	*Gain			*Dither	
AO 10 Function	- Juli			<u> Diaioi</u>	
*AO 10 Value at 4mA				CONTACT INPUTS	3
*AO 10 Value at 20mA				SLOT5	_
*Offset	*Gain			CI #1	Em
AO 11 Function	Juni			CI #2	
*AO 11 Value at 4mA				CI #3	
*AO 11 Value at 20mA				CI #4	
*Offset	*Gain			CI #5	
AO 12 Function				CI #6	
*AO 12 Value at 4mA				CI #7	
*AO 12 Value at 20mA				CI #8	
*Offset	*Gain			CI #9	
				CI #10	
ACT 1 Function				CI #11	
*SD?	YES	NO		CI #12	
*160 mA?	YES	NO		CI #13	
*0% Value	_			CI #14	
*100% Value				CI #15	
*mA at 0%			mΑ	CI #16	
*mA at 100%			mΑ	CI #17	
*Dither	-		mA	CI #18	
				CI #19	
ACT 2 Function				CI #20	
*SD?	YES	NO		CI #21	
*160 mA?	YES	NO		CI #22	
*0% Value				CI #23	
*100% Value				CI #24	
*mA at 0%			mΑ	CI #25	
*mA at 100%			mA	CI #26	
*Dither			Ма	CI #27	
	-			CI #28	
ACT 3 Function				CI #29	
*SD?	YES	NO		CI #30	
*160 mA?	YES	NO		CI #31	
*0% Value				CI #32	
*100% Value				CI #33	
*mA at 0%			mA	CI #34	
*mA at 100%	-		mA	CI #35	
*Dither			mΑ	CI #36	
<del></del>					

ACT 4 Function			
*SD?	YES	NO	
*160 mA?	YES	NO	
*0% Value			
*100% Value			
*mA at 0%			mΑ
*mA at 100%			mΑ
*Dither			mΑ
ACT 5 Function			
<u>*SD?</u>	YES	NO	
*160 mA?	YES	NO	
*0% Value			
*100% Value			
*mA at 0%			mA
*mA at 100%			mA
*Dither			<u>mA</u>
ACT 6 Function			
<u>*SD?</u>	YES	NO	
*160 mA?	YES	NO	
*0% Value			
*100% Value			
*mA at 0%			mΑ
*mA at 100%			mΑ
*Dither			<u>mA</u>

<u>3LU13</u>	
CI #1	Emergency Shutdown (Trip Input)
CI #2	Reset
CI #3	Raise Speed Setpoint
CI #4	Lower Speed Setpoint
CI #5	
CI #6	
CI #7	
CI #8	
CI #9	
CI #10	
CI #11	
CI #12	
CI #13	
CI #14	
CI #15	
CI #16	
CI #17	
CI #18	
<u>CI #19</u>	
CI #20	
CI #21	
CI #22	
CI #23	
CI #24	
CI #25	
CI #26	
<u>CI #27</u>	
CI #28	
CI #29	
CI #30	
CI #31	
CI #32	
CI #33	
CI #34	
CI #35	
CI #36	

CI #37	RELAY OUTPUTS	
CI #38	SLOT5	
CI #39	RELAY #1	Trip
CI #40	RELAY #2	Alarm
CI #41	RELAY #3	
CI #42	RELAY #4	
CI #43	RELAY #5	
CI #44	RELAY #6	
CI #45	RELAY #7	
CI #46	RELAY #8	
CI #47	RELAY #9	
CI #48	RELAY #10	
SLOT 6	RELAY #11	
CI #49	RELAY #12	
CI #50	RELAY #13	
CI #51	RELAY #14	
<u>CI #52</u>	RELAY #15	
<u>CI #53</u>	RELAY #16	
<u>CI #54</u>	RELAY #17	
CI #55	RELAY #18	
<u>CI #56</u>	RELAY #19	
CI #57	RELAY #20	
CI #58	RELAY #21	
<u>CI #59</u>	RELAY #22	
CI #60	RELAY #23	
<u>CI #61</u>	RELAY #24	
<u>CI #62</u>	SLOT6	
CI #63	RELAY #25	
CI #64	RELAY #26	
CI #65	RELAY #27	
CI #66	RELAY #28	
CI #67	RELAY #29	
CI #68	RELAY #30	
CI #69	RELAY #31	
CI #70	RELAY #32	
CI #71	RELAY #33	
CI #72	RELAY #34	
CI #73	RELAY #35	
CI #74	RELAY #36	
CI #75	RELAY #37	
CI #76	RELAY #38	
CI #77	RELAY #39	
CI #78	RELAY #40	
CI #79	RELAY #41	
CI #80	RELAY #42	
	RELAY #43	
<u>CI #81</u>		
<u>CI #82</u>	RELAY #44	
<u>CI #83</u>	RELAY #45	
<u>CI #84</u>	RELAY #46	
CI #85	RELAY #47	
<u>CI #86</u>	RELAY #48	
CI #87	<u>-</u>	
CI #88	-	
CI #89	-	
<u>CI</u> #90	_	
<u>CI #91</u>	_	
CI #92	_	
<u>CI #93</u>	_	
<u>CI #94</u>	_	
CI #95	_	
CI #96	_	

#### **DO Level Switches**

Level Switch 1 Source
Level Switch 1 On
Level Switch 1 Off
Level Switch 2 Source
Level Switch 2 On
Level Switch 2 Off
Level Switch 3 Source
Level Switch 3 On
Level Switch 3 Off
Level Switch 4 Source
Level Switch 4 On
Level Switch 4 Off
Level Switch 5 Source
Level Switch 5 On
Level Switch 5 Off

# Appendix B. Bills of Materials

### 505DE Kit for 8262-1023

Component Item No	E/C Rev	Qty		Description
3799-301	D	5	EΑ	Panel - NetCon IIIB VME Blank
5417-028	В	4	EΑ	Cable - NetCon Low Density Analog Black 10 ft
5417-173	В	2	EΑ	Cable - MicroNet High Density Analog/Discrete GRA 10 ft UL
5441-693	В	2	EΑ	Module - HD Discrete I/O FTM (24 In/12 Out)
5453-829	NEW	1	EΑ	Chassis - MicroNet Plus 8 Slot, Redund with Smart Fans
5466-1158	NEW	2	EA	Module - Simplex 48/24 HDDIO-2 SMART-PLUS (Backward Compat)
5466-316	J	2	EΑ	Module - Analog Combo
5501-371	С	2	EΑ	Module - MicroNet Simplex MPU & AIO FTM
B26361V1	Н	1	EΑ	Manual - 505DE Double Extraction Configuration & Operation
B26361V2	F	1	EΑ	Manual - 505DE Double Extraction Installation
BCD85225	G	1	EΑ	Manual - 505DE CD - Interface Program and Documentation
1796-3031	Α	1	EA	Key - Runtime Indusoft Operator Workstation for Windows XP/2K/NT - Runtime & USB 4000TAG (IND-40520-RT-USB)
3061-1230	NEW	4	EΑ	Label - 505DE Chassis Label
5466-1001	С	1	EA	Module - Power Supply, 2 Slot, 110 Vac/125 Vdc Input, MicroNet-Plus
5466-1035	K	1	EA	Module - MicroNet CPU, PowerPC-5200, 400 MHz, 64 MB Flash, 128 MB RAM (Dual CAN)

## 505DE Kit for 8262-1024

Component Item No	E/C Rev	Qty		Description
3799-301	D	5	EA	Panel - NetCon IIIB VME Blank
5417-028	В	4	EA	Cable - NetCon Low Density Analog Black 10 ft
5417-173	В	2	EA	Cable - MicroNet High Density Analog/Discrete GRA 10 ft UL
5441-693	В	2	EA	Module - HD Discrete I/O FTM (24 In/12 Out)
5453-829	NEW	1	EA	Chassis - MicroNet Plus 8 Slot, Redund with Smart Fans
5466-1158	NEW	2	EA	Module - Simplex 48/24 HDDIO-2 SMART-PLUS (Backward Compat)
5466-316	J	2	EA	Module - Analog Combo
5501-371	С	2	EA	Module - MicroNet Simplex MPU & AIO FTM
B26361V1	Н	1	EA	Manual - 505DE Double Extraction Configuration & Operation
B26361V2	F	1	EA	Manual - 505DE Double Extraction Installation
BCD85225	G	1	EA	Manual - 505DE CD - Interface Program and Documentation
1796-3031	Α	1	EA	Key - Runtime Indusoft Operator Workstation for Windows XP/2K/NT - Runtime & USB 4000TAG (IND-40520-RT-USB)
3061-1230	NEW	4	EA	Label - 505DE Chassis Label
5466-1002	С	1	EA	Module - Power Supply, 2 Slot, 220 Vac Input, MicroNet-Plus
5466-1035	K	1	EA	Module - MicroNet CPU, PowerPC-5200, 400 MHz, 64 MB Flash, 128 MB RAM (Dual CAN)

## 505DE Kit for 8262-1040

Component Item No	E/C Rev	Qty		Description
3799-301	D	1	EA	Panel - NetCon IIIB VME Blank
5417-028	В	6	EA	Cable - NetCon Low Density Analog Black 10 ft
5417-173	В	2	EA	Cable - MicroNet High Density Analog/Discrete GRA 10 ft UL
5441-693	В	2	EA	Module - HD Discrete I/O FTM (24 In/12 Out)
5453-829	NEW	1	EA	Chassis - MicroNet Plus 8 Slot, Redund with Smart Fans
5466-1158	NEW	2	EA	Module - Simplex 48/24 HDDIO-2 SMART-PLUS (Backward Compat)
5466-316	J	3	EA	Module - Analog Combo
5501-371	С	3	EA	Module - MicroNet Simplex MPU & AIO FTM
B26361V1	Н	1	EA	Manual - 505DE Double Extraction Configuration & Operation
B26361V2	F	1	EA	Manual - 505DE Double Extraction Installation
BCD85225	G	1	EA	Manual - 505DE CD - Interface Program and Documentation
1796-3031	Α	1	EA	Key - Runtime Indusoft Operator Workstation for Windows XP/2K/NT - Runtime & USB 4000TAG (IND-40520-RT-USB)
3061-1230	NEW	4	EA	Label - 505DE Chassis Label
5466-1001	С	2	EA	Module - Power Supply, 2 Slot, 110 Vac/125 Vdc Input, MicroNet-Plus
5466-1035	K	2	EA	Module - MicroNet CPU, PowerPC-5200, 400 MHz, 64 MB Flash, 128 MB RAM (Dual CAN)

## 505DE Kit for 8262-1041

Component Item No	E/C Rev	Qty		Description
3799-301	D	1	EA	Panel - NetCon IIIB VME Blank
5417-028	В	6	EA	Cable - NetCon Low Density Analog Black 10 ft
5417-173	В	2	EA	Cable - MicroNet High Density Analog/Discrete GRA 10 ft UL
5441-693	В	2	EA	Module - HD Discrete I/O FTM (24 In/12 Out)
5453-829	NEW	1	EA	Chassis - MicroNet Plus 8 Slot, Redund with Smart Fans
5466-1158	NEW	2	EA	Module - Simplex 48/24 HDDIO-2 SMART-PLUS (Backward Compat)
5466-316	J	3	EA	Module - Analog Combo
5501-371	С	3	EA	Module - MicroNet Simplex MPU & AIO FTM
B26361V1	Н	1	EA	Manual - 505DE Double Extraction Configuration & Operation
B26361V2	F	1	EA	Manual - 505DE Double Extraction Installation
BCD85225	G	1	EA	Manual - 505DE CD - Interface Program and Documentation
1796-3031	Α	1	EA	Key - Runtime Indusoft Operator Workstation for Windows XP/2K/NT - Runtime & USB 4000TAG (IND-40520-RT-USB)
3061-1230	NEW	4	EA	Label - 505DE Chassis Label
5466-1002	С	2	EA	Module - Power Supply, 2 Slot, 220 Vac Input, MicroNet-Plus
5466-1035	K	2	EA	Module - MicroNet CPU, PowerPC-5200, 400 MHz, 64 MB Flash, 128 MB RAM (Dual CAN)

## **Revision History**

#### Changes in Revision H—

- Updated Regulatory Compliance information
- Major technical updates throughout

#### Changes in Revision G-

Replaced PN 5466-258 with new PN 5466-1158 in Appendix B

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26361V1H.





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