WOODWARD

**Product Manual 85018V1
(Revision E)**
Original Instructions

505E Digital Governor
for Extraction Steam Turbines

Volume 1

Manual 85018 consists of 2 volumes (85018V1 & 85018V2).

Installation and Operation Manual

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Important Definitions

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

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

⚠ WARNING Overspeed / Overtemperature / Overpressure	The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage. The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠ WARNING Personal Protective Equipment	The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to: - Eye Protection - Hearing Protection - Hard Hat - Gloves - Safety Boots - Respirator Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

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

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

NOTICE	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.
Battery Charging Device	

Electrostatic Discharge Awareness

NOTICE **Electrostatic Precautions**	Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts: • Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control). • Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards. • Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices. To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715, Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

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

Regulatory Compliance

European Compliance for CE Marking:
These listings are limited only to those units bearing the CE Marking.

EMC Directive:	Declared to 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
ATEX – Potentially Explosive Atmospheres Directive:	Declared to 94/9/EEC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres. Zone 2, Category 3, Group II G, EEx nA II T3 X

North American Compliance:
These listings are limited only to those units bearing the UL agency identification.

UL:	UL Listed for Class I, Division 2, Groups A, B, C, & D T3B at 60 °C Ambient (rear enclosure provided) T3C at 65 °C Ambient (rear enclosure omitted) For use in Canada and the United States. UL File E156028

Other International Compliance

C-Tick (ACA/RSM):	Declared to Australian Radiocommunications Act of 1992 and the New Zealand Radiocommunications Act of 1989.
Gost-R:	Certified for use in explosive atmospheres within the Russian Federation per Gost-R certificate РОСС US.ГБ04.В01002 with marking 2ExnAIIT3X

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

Special Conditions for Safe Use
Wiring must be in accordance with North American Class I, Division 2 or European Zone 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Field wiring must be stranded copper wire rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

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

![WARNING]	**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.
	Do not use any test points on the power supply or control boards unless the 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, Division 2.
	Ne pas utiliser les bornes d'essai du block d'alimentation ou des cartes de commande à moins de se trouver dans un emplacement non dangereux.

Chapter 1.
General Information

Introduction

This manual (85018) describes the Woodward 505E Digital Governor for steam turbines with controlled extraction and/or admission pressure control. English versions are 9907-165, 9907-166, and 9907-167. The option charts below show the differences between the part numbers. Volume 1 of this manual provides installation instructions, describes the control, and explains the configuration (programming) and operating procedures. Volume 2 includes notes on applying the control to specific applications, Service mode information, and 505E hardware specifications.

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.

Manual 85017 describes the 505 Digital Governor for steam turbines without extraction pressure control.

Part Number Options

Part Number   Power
9907-165   HVAC (180–264 Vac)
9907-166   AC/DC (88–132 Vac) or (90–150 Vdc)
9907-167   LVDC (18–32 Vdc)
Optional Bulkhead Mounting Box (NEMA 4X) P/N 8923-439

505 controllers now utilize a special polyacrylate conformal coating material to coat and protect their internal circuit boards from corrosive environments. This new polyacrylate material replaces the previous silicon conformal coating and provides an improved barrier between board components and sulfur-based gases. 505 controls that have this coating will have a label on the side stating "SULFUR RESISTANT CONFORMAL COATED". All 505 controllers shipped from Woodward with the revision letters listed below, or subsequent letters, were shipped with the new polyacrylate conformal coating material:

Table 1-1. 505s with Polyacrylate Coated Boards

Part Number	Revision	Label on 505
9907-165	V	9907-165V
9907-166	V	9907-166V
9907-167	T	9907-167T

General Installation and Operating Notes and Warnings

This Equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D (Class I, Zone 2, Group IIC) or non-hazardous locations.

This equipment is suitable for use in European Zone 2, Group II environments per compliance with EN60079-15, Electrical apparatus for explosive atmospheres – Type of protection 'n'

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

Field wiring must be stranded copper wire rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

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

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

⚠ WARNING	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 or Zone 2 applications.

⚠ 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 ou Zone 2.

505E Software Changes Covered in this Manual Revision

1. PROGRAM MODE: Made all start modes default to false to ensure a customer programmed the unit. Also added an error check to ensure Rated Speed (when programmed as a gen set) was less than max gov.
2. SERVICE MODE: Changed the hold changes for Min Load to come from the Breaker Logic header's Hold Changes input. Previously the hold changes command was selected under the Speed Control Settings header.
3. SPEED SETPOINT RATES: Changed the minimum adjustment range for all speed setpoint rates to 0.01 (was 0.1).
4. AUX LIMITER or CONTROLLER: Added logic to ensure the inhibited status of Aux control when the input is failed. In addition, changed Aux re-enable logic such that when a failed aux input is restored there is no glitch to the speed LSS. Also changed breaker open logic to correct a Gen Opening Aux actuator output glitch.
5. AUX CONTROLLER: Changed the speed setpoint aux biasing logic to only allow the speed control limiting action (while in aux control) to be active when the speed setpoint reaches max gov. Prior to this fix the speed limiter could come into control during an extreme transient.

6. AUX DIRECT ENTERED SETPT: Changed Aux Entered setpoint to be reset/ stopped on a shutdown pulse rather than held disabled on a shutdown condition. This change allows the Aux Limiter function direct setpoint entry even when the unit is tripped.
7. AUX, CASC, and EXTR DROOP: Changed the droop feedback lag-tau tunable range from a max of 10 to a max of 1000.
8. DECOUPLED CASCADE CONTROL: Added a lag to the speed the speed setpoint is using during a utility tie breaker open setback. Also updated the logic used to reset the speed setpoint to minimize to bump experienced when Decoupled Casc is disabled. Changed logic to fix a problem where breaker opening while in the Cascade decoupled mode would cause the HP valve to close then open unexpectedly.
9. MODBUS: Changed the Gen and Tie Open alarms for Aux, Casc, and Remote to match the Modbus listing—the software eventlatch inputs were reversed/backwards with the Modbus listing.
10. CONTROLLED STOP: Made the Controlled Stop abort if speed raise/lower is selected or another control mode is selected. This can be tuned-out by setting CNTRL_STOP.RL_STOP.IN_2=*false in the debug mode.
11. ANALOG INPUTS: Changed max setting on the delay time's tunable range from 3 ms to 3000 ms. The analog input failure delay setting is defaulted to zero but can be adjusted up to 3000msec using the debug mode MAIN.AIx.LATCH_DLY where x is the analog input number. Added a tunable single pole filter (LAG) to each analog input. Output/input = 1/(1+st) where t = 1/(2(pi)f) = LAG_TAU. The Lag-tau is defaulted to zero but can be adjusted in the debug mode using MAIN.AIx_LAG.LAG_TAU where x is the analog input number (1-6).

General Description

General

The 505E is a 32-bit microprocessor-based control designed to control single extraction, extraction/admission, or admission steam turbines. The 505E 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 505E can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

Operator Control Panel

The 505E is a field configurable steam turbine control and operator control panel (OCP) integrated into one package. A comprehensive operator control panel, including a two- line (24 characters each) display, and a set of 30 keys is located on the 505E's front panel. This OCP is used to configure the 505E, make On-Line program adjustments, and operate the turbine/system. Easy to follow instructions are presented in English through the OCP's two-line display and operators can view actual and setpoint values from the same screen.

Turbine Control Parameters

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

Communications

The 505E can communicate directly with plant Distributed Control Systems and/or CRT based operator control panels, through two Modbus® * communication ports. These ports support RS-232, RS-422, or RS-485 communications using ASCII or RTU MODBUS transmission protocols. Communications between the 505E and a plant DCS can also be performed through hardwired connections. Since all 505E PID setpoints can be controlled through analog input signals, interface resolution and control is not sacrificed.

*—Modbus is a trademark of Schneider Automation Inc.

Additional Features

The 505E also provides the following features: First-Out Trip Indication (5 total trip inputs), Critical Speed Avoidance (2 speed bands), Auto Start Sequence (hot & cold starts), Dual Speed/Load Dynamics, Zero Speed Detection, Peak Speed Indication for Overspeed trip, and Isochronous Loadsharing between units.

Using the 505E

The 505E control has two normal operating modes, the Program Mode and the Run Mode. The Program Mode is used to select the options needed to configure the control to your specific turbine application. 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, there is a Service Mode which can be used to enhance system operation while the unit is running. Refer to Volume 2 for information on the Service Mode.

505E Inputs and Outputs

Control Inputs

Two speed inputs which are jumper configurable for MPU (magnetic pickup units) inputs or proximity probes.

Six analog inputs are available. One is dedicated as the extraction/admission input. The remaining five are configurable. The sixth analog input has isolation circuitry and should be used for a self-powered signal that is not isolated.

Sixteen contact inputs are 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. Ten additional contact inputs can be configured. If the unit is not used in a generator application, then twelve additional contact inputs can be configured.

Four function keys on the front panel of the control. F1 and F2 are dedicated to alarm and overspeed test, respectively. F3 and F4 can be used to enable or disable various functions of the control.

Control Outputs

Two actuator outputs with linearization curves for the HP and the LP valve outputs.

Six 4–20 mA outputs, for meters or other readouts.

Eight Form-C relay contact outputs, six that are configurable. The two dedicated relay outputs are for shutdown and alarm indication.

Control Communications

Two 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.

One computer (PC) port to be used for program configuration storage.
An overview of the 505E functions is shown in Figure 1-1. Use this block diagram to match the control features to the site-specific application required.

Figure 1-1a. Overview of 505E Functionality (Notes)
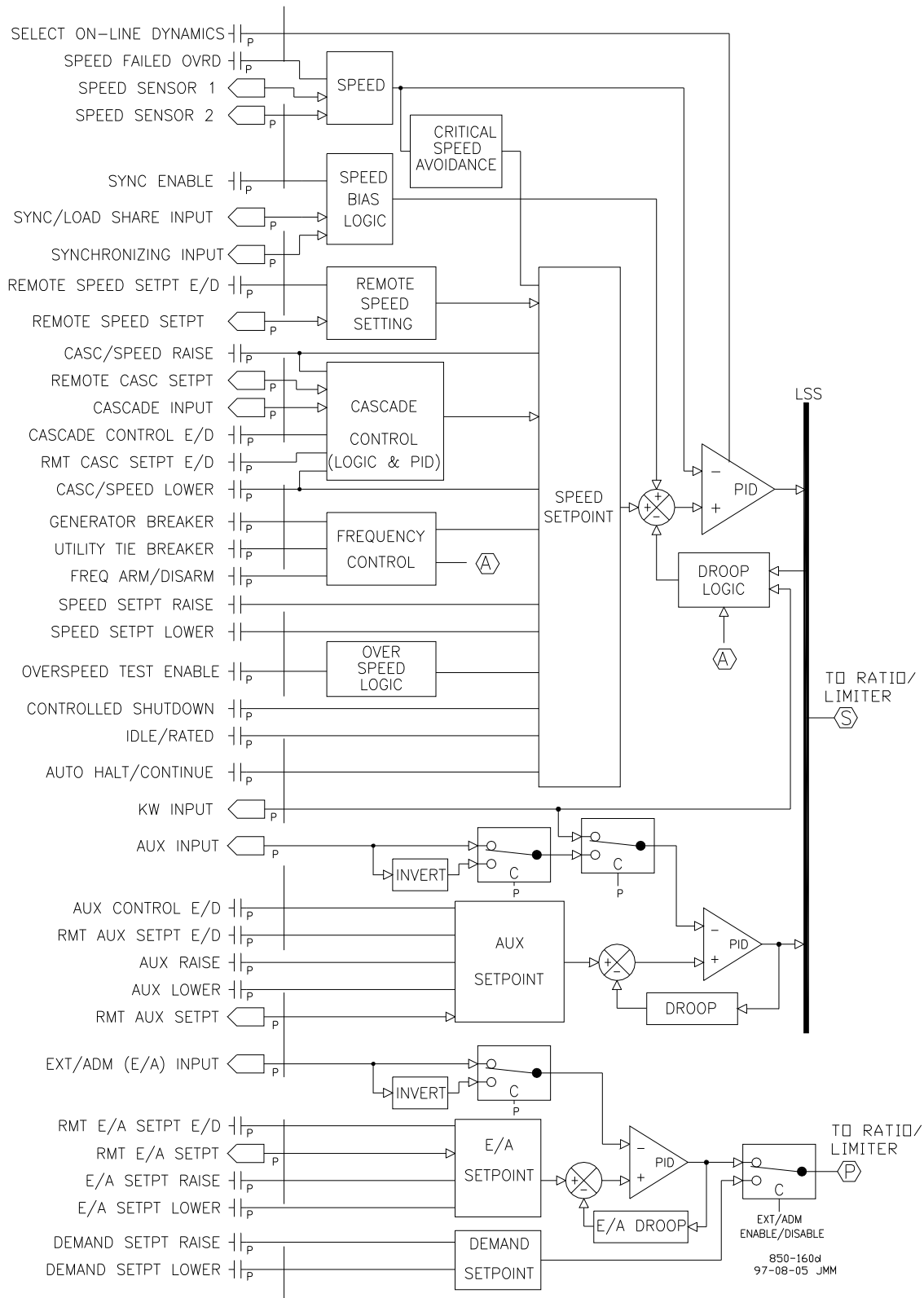
Figure 1-1b. Overview of 505E Functionality
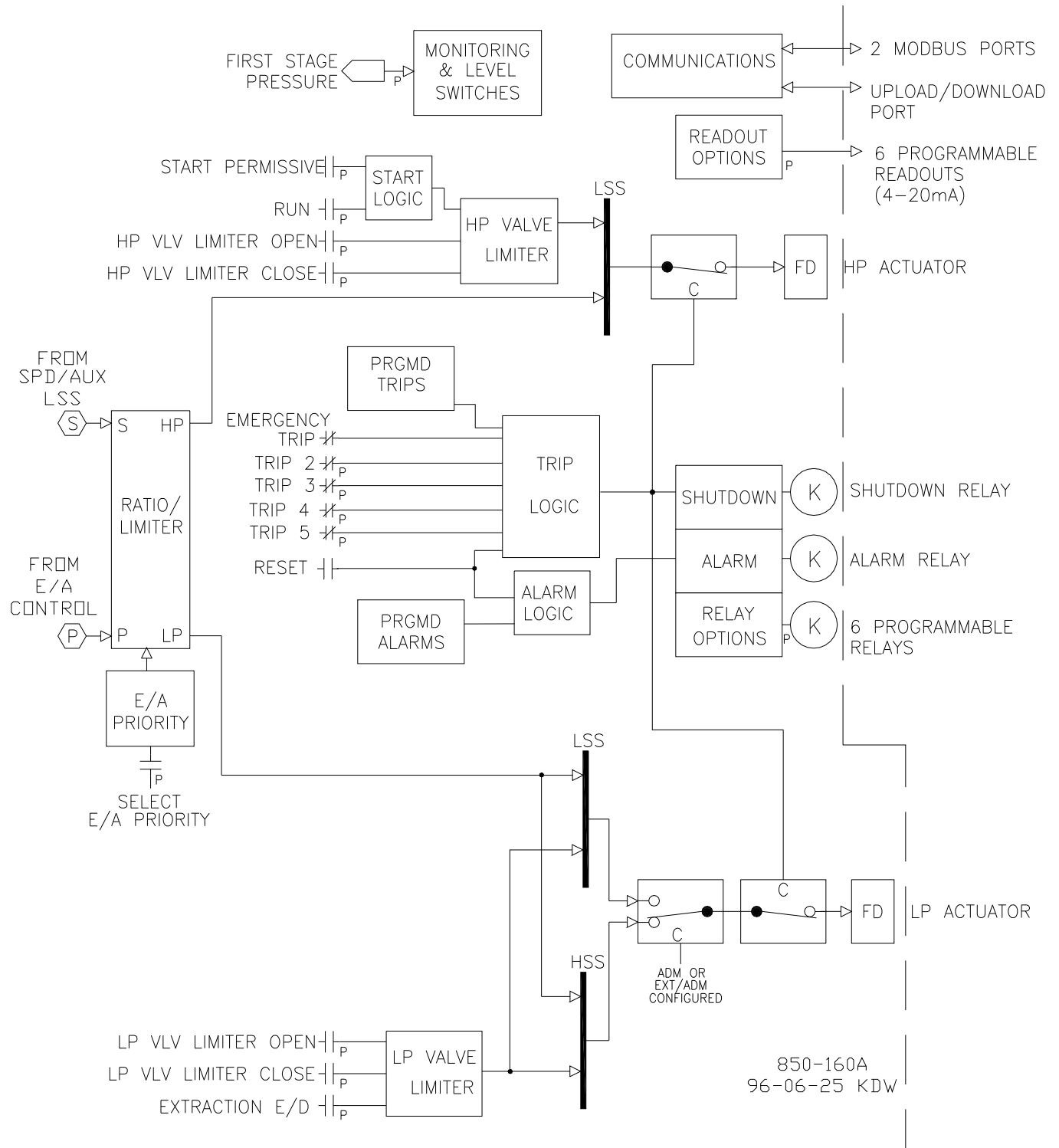
Figure 1-1c. Overview of 505E Functionality

Control Overview

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

The 505E has two independent control channels available, the speed/load and 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 controller can act as either a control channel or as a limiting channel. All three of these PID controllers have the option of utilizing an analog input signal to remotely position their setpoints. Additional features of the 505E include frequency control, isochronous loadsharing, critical speed avoidance, idle/rated control, and an automatic start sequence. There are two serial communications ports which can be used to monitor and control the turbine using Modbus protocol.

Extraction Turbines

The 505E 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. (The 505E can also operate the governor valve and the first extraction valve of multiple extraction turbines).

Single automatic extraction turbines have a high pressure stage and a low pressure stage, each controlled by a valve. Steam enters the turbine through the HP valve (see Figure 1-2). 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 505E's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.
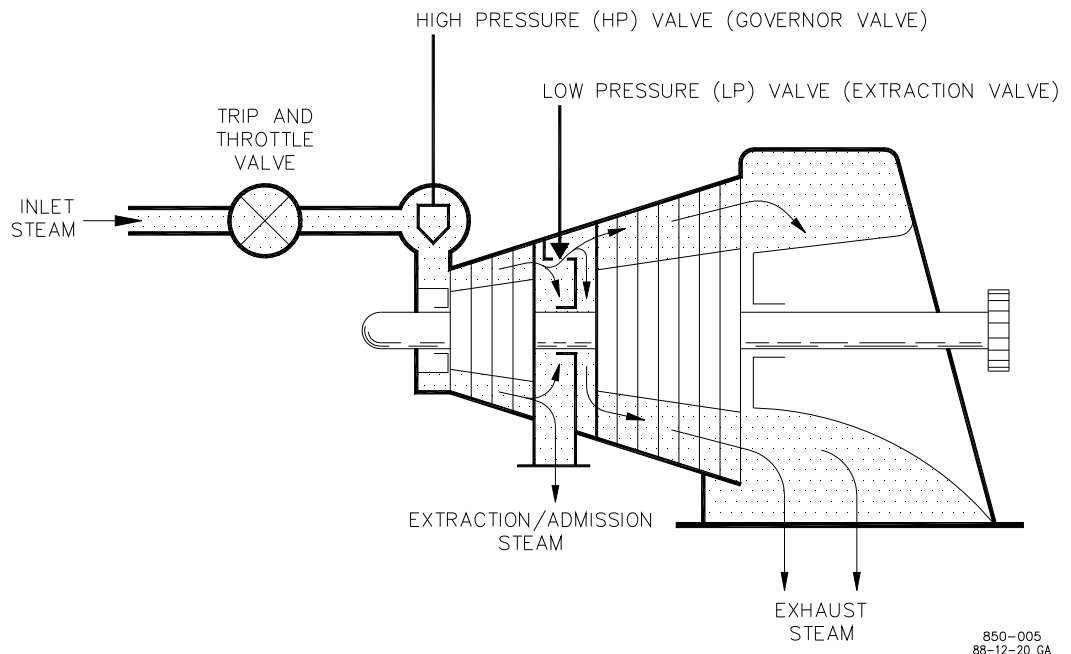
Figure 1-2. Typical Extraction and/or Admission Steam Turbine

Admission Turbines

The 505E 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 1-3) 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 505E's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.
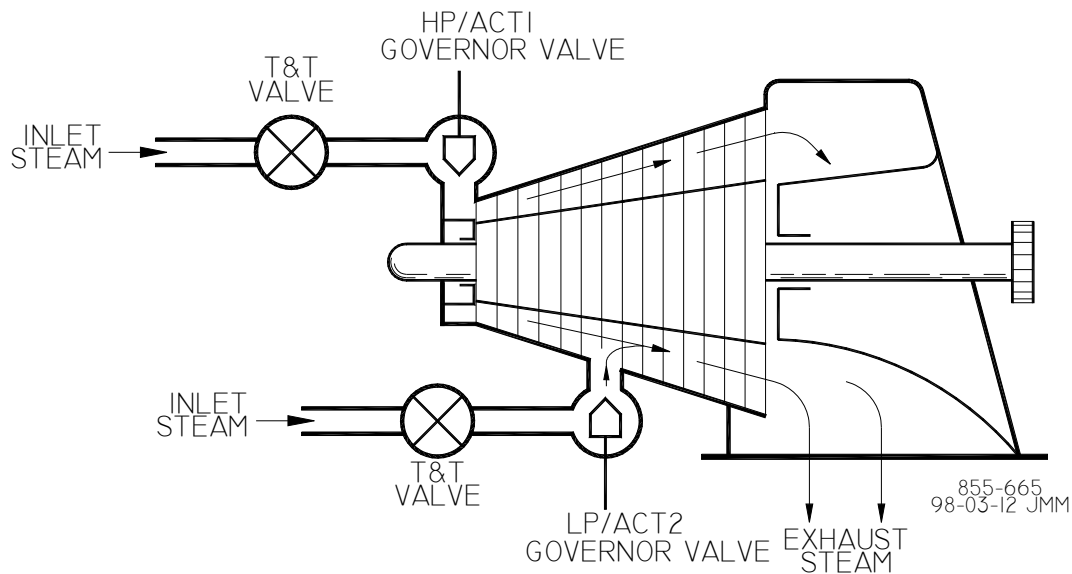
Figure 1-3. Typical Admission Steam Turbine

Extraction and Admission Turbines

The 505E 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 (see Figure 1-2). 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 505E's ratioing logic based on the turbine performance parameters to minimize valve/process interaction.

Speed Control

The speed control receives a turbine speed signal from one or two 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 keypad on the front of the control, remote contact inputs or Modbus. The setpoint can also be directly set by entering the new setpoint from the keypad, or through either Modbus communications link. In addition, a remote speed setpoint analog input can be programmed to remotely position the speed setpoint.

Remote Speed Setpoint

One of the 4–20 mA inputs can be configured to remotely adjust the speed setpoint. Typically, a process control external to the 505E 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 505E'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 front-panel keypad, remote contact inputs or the communication line.

Auxiliary Control

The Auxiliary control channel can be used to either control a parameter or limit a parameter. The Auxiliary PID controller 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 input is a 4–20 mA current signal. The Auxiliary PID control amplifier compares this input signal with a 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 which determines HP and LP valve positions. The Auxiliary control amplifier can also receive a programmable (optional) droop feedback signal to increase system stability. This is a direct feedback using a portion of the Auxiliary control amplifier output.

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

Remote Aux Setpoint

One of the 4–20 mA inputs can be configured to remotely adjust the 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 front panel keypad, the remote contact inputs, or the communication links.

Load Sharing Input

The 505E is capable of using an analog input to accept a load sharing signal from Woodward's Digital Synchronizer and Load Control (DSLC™). This input in conjunction with the DSLC allows the control to isochronously loadshare with any other system using a DSLC. The 505E's internal summing junction adds this signal with the speed/load PID's reference. In addition to loadsharing, the DSLC input to the 505E 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 keypad on the front of the control, the remote contact inputs, or the communication links. Also, the setpoint can be directly set by entering the new setpoint from the keypad or through either Modbus communications link. 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 505E'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 front-panel keypad, the remote contact inputs or either Modbus communication link.

Extraction/Admission Control

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

The Extr/Adm control can also receive a programmable (optional) droop feedback signal to increase the stability of the extraction control loop.

The Extr/Adm setpoint is adjustable with raise or lower commands through the keypad on the front of the control, the remote contact inputs, or the communication links. Also, the setpoint can be directly set by entering the new setpoint from the keypad or through either Modbus communications link. In addition, a remote extr/adm setpoint analog input can be programmed to remotely position the Extr/Adm setpoint.

Remote Extraction/Admission Setpoint

One of the 4–20 mA inputs can be configured to remotely adjust the Extr/Adm setpoint. The remote setpoint input directly affects the 505E's Extr/Adm setpoint. The maximum rate at which the remote input signal can change the 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 front-panel keypad, the remote contact inputs or either Modbus communication link.

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.

Ratio/limiter Decoupling

In most cases, the 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. There are cases when this ratioing is not desired, these cases require decoupling of one or both valve outputs.

There are three decoupling options available in the 505E: decouple HP (or inlet), decouple LP (or exhaust), or decouple both HP and LP. When controlling either inlet or exhaust pressure or flow and extraction/admission pressure or flow, it is desirable to limit valve interaction when inlet or exhaust conditions are constant and only the extraction demand is changing.

Inlet (HP) decoupling is typically used when controlling turbine inlet pressure and extraction or admission pressure/flow at constant levels. If the inlet pressure changes, both the HP and LP valve positions must be changed to maintain inlet and extraction/ admission. However, if inlet conditions are constant and only the extraction/admission demand changes (more or less extraction flow needed), only the LP valve will move to maintain extr/adm control.

Exhaust (LP) decoupling is typically used when controlling turbine exhaust/back pressure and extraction or admission pressure/flow at constant levels. If the exhaust changes, both the HP and LP valve positions must be changed to maintain exhaust and extraction/ admission. However, if exhaust conditions are constant and only the extraction/admission demand changes (more or less extraction flow needed), only the HP valve will move to maintain extr/adm control.

Decoupling both valves (HP & LP) is typically used when controlling turbine inlet pressure and turbine exhaust pressure (or for controlling two independent parameters related to the turbine/process). If the inlet pressure changes and exhaust conditions are constant, only the HP valve position must be changed. Likewise, if exhaust pressure changes and inlet conditions are constant, only the LP valve position must be changed.

HP and LP Valve Limiters

The HP and LP valve limiters limit the HP and LP valves to aid in starting and shutting down the turbine. The limiters are adjusted through the keypad, 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 HP valve limiter is low-signal selected with the output of the ratio/ limiter. The lowest signal will control the HP valve position, thus the HP valve limiter limits the maximum HP valve position.

The output of the LP valve limiter is high-signal selected with the output of the ratio/ limiter when configured for extraction steam turbines, and low-signal selected when configured for admission or extraction/admission steam turbines, thus the LP valve limiter limits the minimum or maximum LP valve position depending on the configuration selected.

See the Starting Procedures in Chapter 3 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 505E 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.

Starting Features

The 505E provides options for three different starting modes: automatic, semi-automatic, and manual. One of these modes must be programmed to get the turbine from a shutdown state to speed control at minimum speed. 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 505E can provide automatic speed control and critical speed avoidance. A 'Run' command can be given through the 505E 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.

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 low idle speed, hold there until the programmed warm-up time has expired, then go to a programmed high idle speed, hold there until the programmed high idle warm-up time has expired, and finally move to the programmed rated speed setpoint. 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 505E keypad, 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 505E programming, two 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 505E 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.
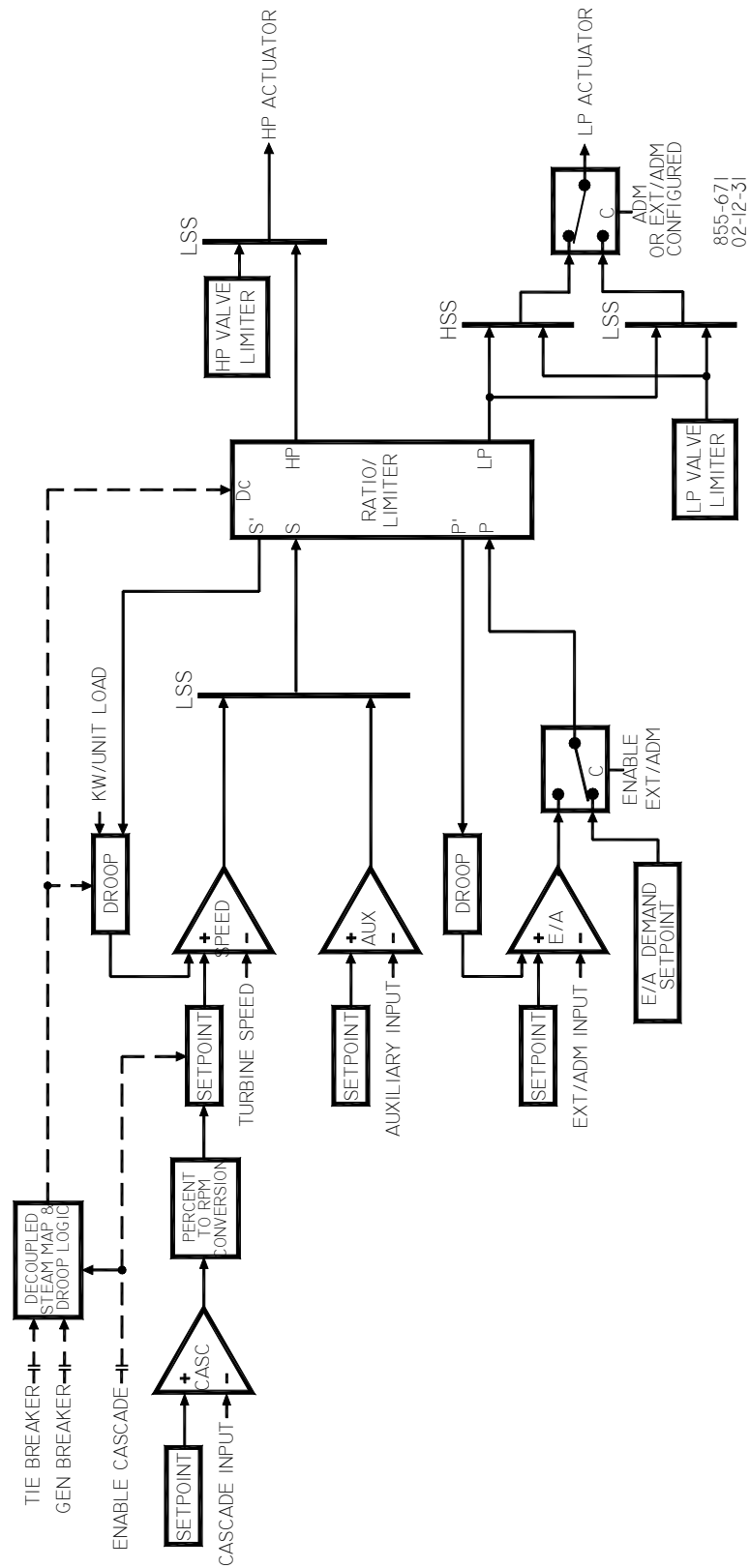
Figure 1-4. Overview with Auxiliary Configured as a Limiter
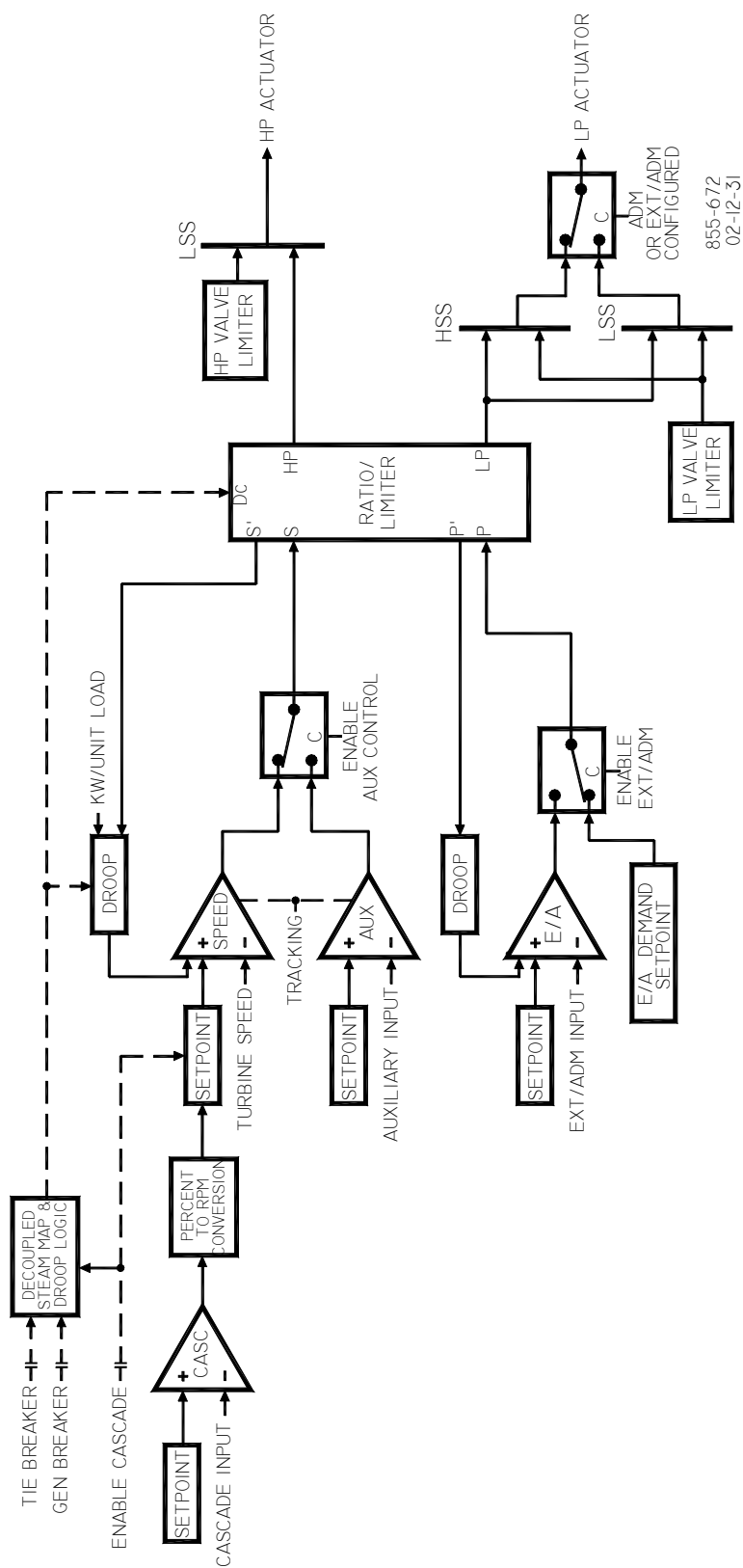
Figure 1-5. Overview with Auxiliary Configured as a Controller
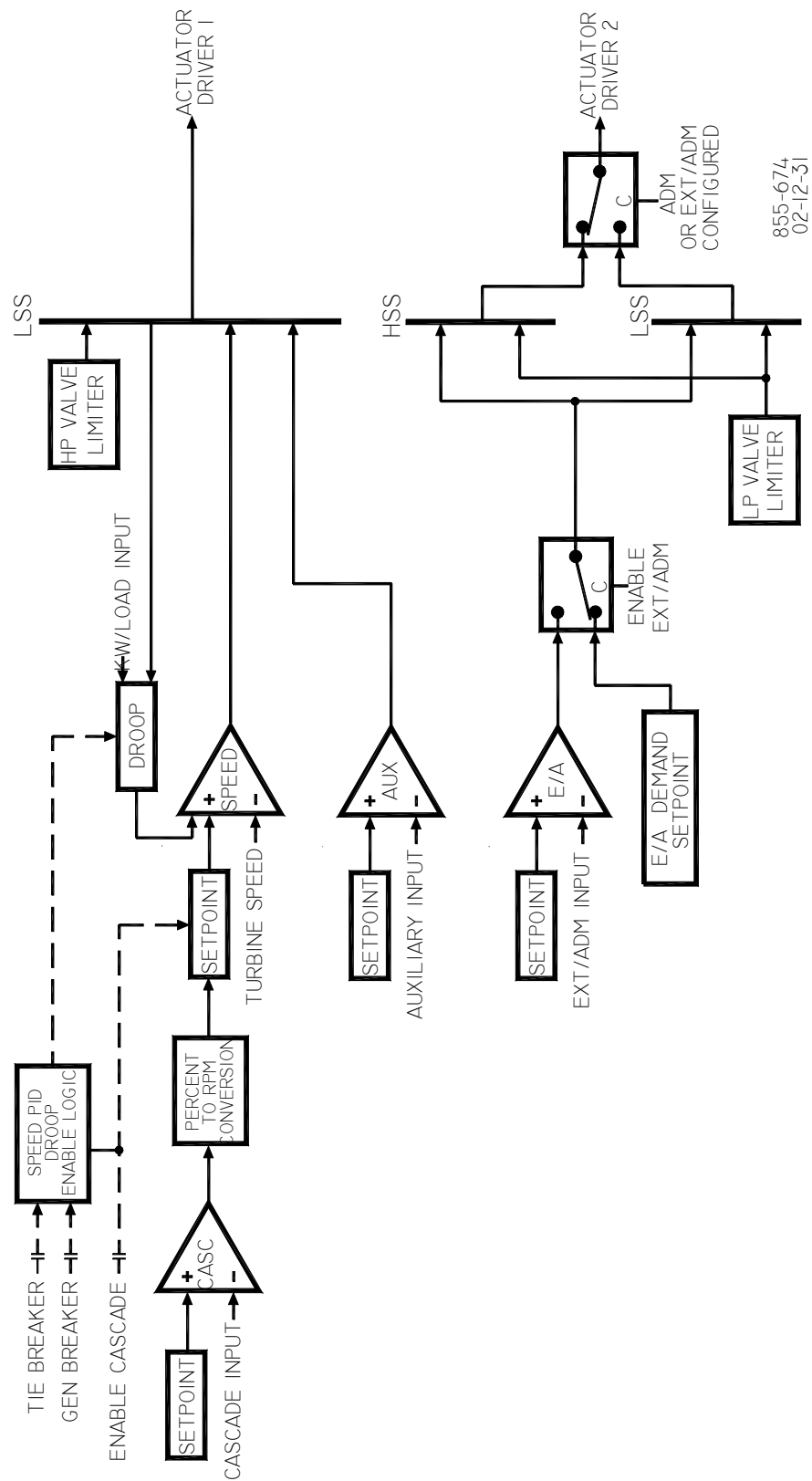
Figure 1-6. Overview with Decoupled HP & LP Ratio/Limiter, Auxiliary Configured as a Limiter
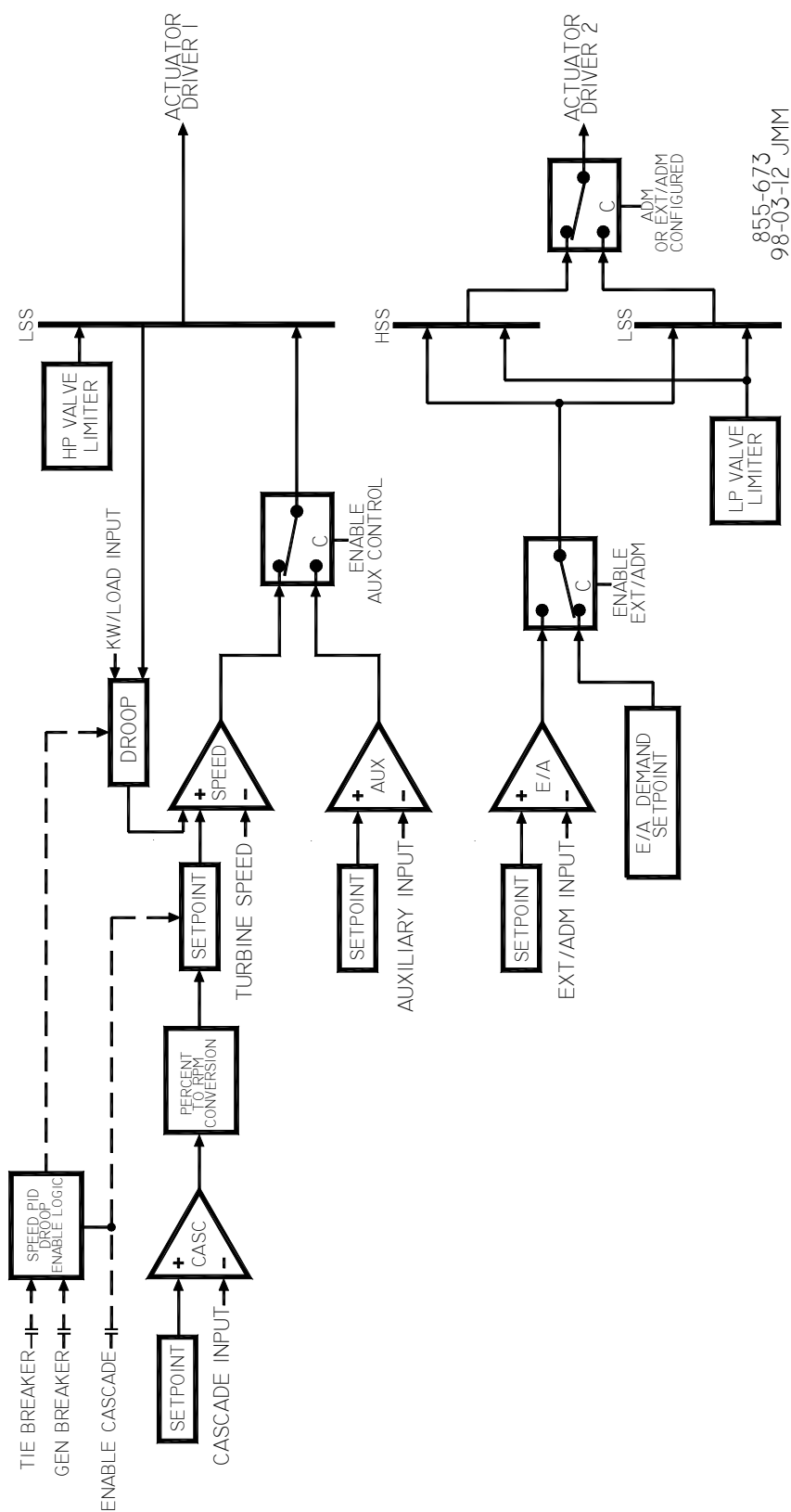
Figure 1-7. Overview with Decoupled HP & LP Ratio/Limiter, Auxiliary Configured
as a Controller

Keypad and Display

The 505E's service panel consists of a keypad and LED display located on the front of the control as shown in Figure 1-8. The LED display has two, 24 character lines that can be used to display operating parameters and troubleshooting parameters in plain English. Also, there are 30 keys available to provide complete control from the front of the 505E. No additional control panels are required to operate the turbine; every turbine control function can be performed from the 505E's front panel.
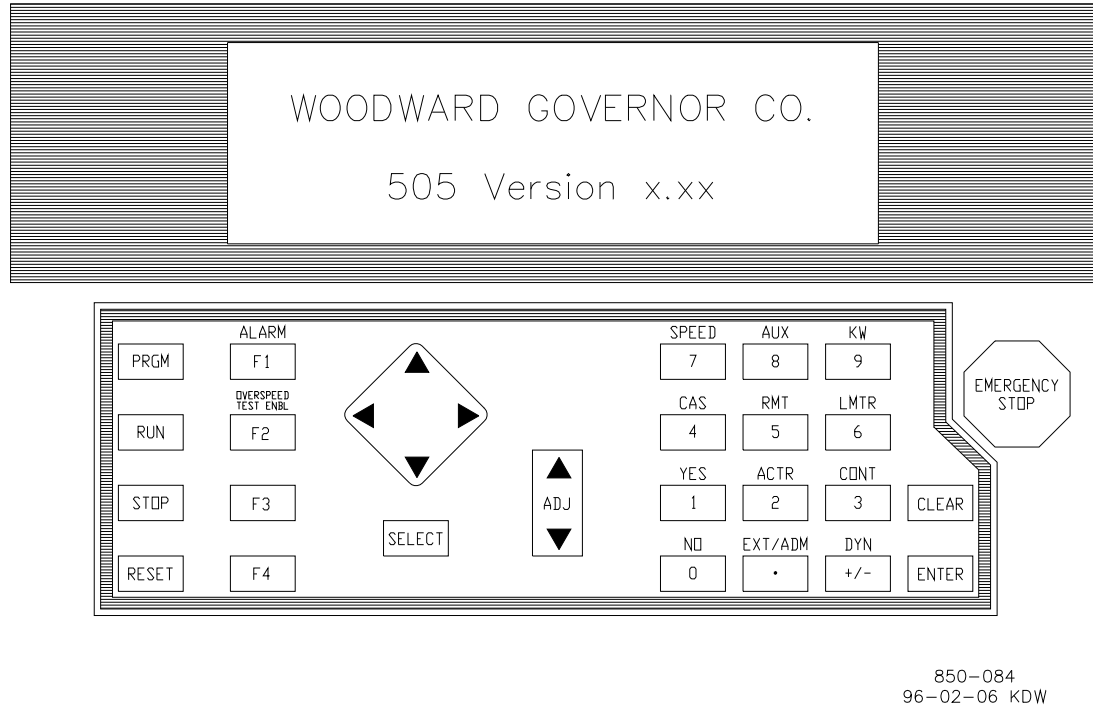
Figure 1-8. 505E Key Pad and Display

A description of each key's function follows. Some descriptions refer to the function blocks contained in the programming (chapter 4) and operating flowcharts (chapter 5).

SCROLL:
    The large diamond shaped button in the middle of the keypad with arrows at each of it's four corners. The (scroll left, right) moves the display left or right through the function blocks of the Program or Run Mode. The (scroll up, down) moves the display up or down within a function block of the Program or Run Mode.

SELECT:
    The Select key is used to select control of the 505E display's top or bottom line variable. The @ sign is used to indicate which line (variable) can be adjusted by the adjust keys. Only when there is a changeable variable on both lines (dynamics, valve calibration modes) does the "select key" and @ sign determine which line variable can be adjusted. When there is only one adjustable parameter displayed on the screen the "select key" and @ sign's position are irrelevant.

ADJ (adjust):

In the Run Mode, the " " (adjust up) moves any adjustable parameter up (larger) and the " " (adjust down) moves any adjustable parameter down (smaller).

PRGM (program):

When the control is shutdown this key selects the Program Mode. While in the Run Mode this key selects a Program Monitor Mode. In the Program Monitor Mode the program can be viewed but not changed.

RUN:

Initiates a turbine run or start command when the unit is ready to start.

STOP:

Initiates a controlled turbine shutdown (Run Mode) once verification is given. The "Stop" command can be disabled through a Service Mode setting (under 'Key Options').

RESET:

Resets/clears Run Mode alarms and shutdowns. Pressing the key also returns the control to the (Controlling Parameter / Push Run or Prgm) status after a shutdown.

0/NO:

Enters 0/NO or disable.

1/YES:

Enters 1/YES or enable.

2/ACTR (actuator):

Enters 2 or displays the actuator position (Run Mode).

3/CONT (control):

Enters 3 or displays the parameter which is in control (Run Mode); press the Scroll down arrow to display the control's last trip cause, steam map priority, highest speed reached, and local/remote status (if used).

4/CAS (cascade):

Enters 4 or displays the cascade control information (Run Mode).

5/RMT (remote):

Enters 5 or displays the remote speed setpoint control information (Run Mode).

6/LMTR (valve limiters):

Enters 6 or displays the valve limiter information (Run Mode)

7/SPEED:

Enters 7 or displays the speed control information (Run Mode).

8/AUX (auxiliary):

Enters 8 or displays the auxiliary control information (Run Mode).

9/KW (load):

Enters 9 or displays the kW/load or first stage pressure information (Run Mode).

. / EXT/ADM (extraction/admission):

Enters a decimal point or displays the extraction/admission information (Run Mode).

CLEAR:

Clears Program Mode and Run Mode entries and takes display out of it's present mode.

ENTER:

Enters new values in the Program Mode, and allows the "direct entry" of specific setpoint values in the Run Mode.

DYNAMICS (+/–):

Accesses the dynamic settings of the parameter controlling the actuator position in the Run Mode. The dynamics adjustments can be disabled through a Service Mode setting (under 'Key Options'). This key will also change the sign of a value being entered.

ALARM (F1):
> Displays the reason for any alarm condition (last/newest alarm) when the key's LED indicator is illuminated. Press the Scroll down arrow (diamond key) to display additional alarms.

OVERSPEED TEST ENABLE (F2) :
> Permits the speed reference to be raised beyond the maximum controlling speed setpoint to test either the electrical or mechanical overspeed trip.

F3 (function key):
> Programmable function key for enabling or disabling programmable control functions.

F4 (function key):
> Programmable function key for enabling or disabling programmable control functions.

EMERGENCY SHUTDOWN BUTTON:
> Large red octagonal button on the front of the enclosure. This is an Emergency Shutdown command for the control.

Watchdog Timer/CPU Fault Control

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

Chapter 2.
Installation Procedures

Introduction

This chapter provides instructions on how to mount and connect the 505E into a system. Hardware dimensions, ratings, and jumper configurations are given to allow a customer to mount, wire, and configure the 505E package to a specific application.

Electrical ratings, wiring requirements, and options, are provided to allow a customer to fully install the 505E into a new or existing application.

Mechanical Data and Hardware Installation

If so labeled on the enclosure, the 505E is UL/CUL listed for use in hazardous locations in UL file E156028. This Equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D (Class I, Zone 2, Group IIC) or non-hazardous locations only.

This equipment is suitable for use in European Zone 2, Group II environments per compliance with EN60079-15, Electrical apparatus for explosive atmospheres – Type of protection 'n'

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

Field wiring must be stranded copper wire rated at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

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

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

⚠ **WARNING**	**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 or Zone applications.** **Do not use any test points on the power supply or control boards unless the 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 ou Zone.** **Ne pas utiliser les bornes d'essai du block d'alimentation ou des cartes de commande à moins de se trouver dans un emplacement non dangereux.**

Enclosures

Figure 2-1 shows 505E control layout and mounting pattern. The 505E digital control is housed in a flush mount enclosure. This enclosure is designed for installation within a control room panel or cabinet and, by itself, cannot be bulkhead-mounted. The 505E package, when properly installed within a NEMA 4 or IP56 panel or cabinet meets NEMA 4X or IP56 ratings respectively. A gasket is attached to the rear side of the package's bezel to properly seal the 505E's face-plate to a panel. All field wiring connects to the 505E through removable terminal blocks located on the 505E's back side.

The 505E's internal components are industrial grade. These components include the CPU (central processing unit), its memory, the switching power supply, all relays, all Input/ Output circuitry, and all circuitry for the front panel display, touch keypad, and the serial communications.

An optional NEMA-4X enclosure is available to allow the 505E to be bulkhead mounted (Figure 2-2). The 505E digital control mounts on the front door of the optional enclosure. This allows for easy service access through the enclosure's front door. This bulkhead mounted enclosure has two removable gland plates attached to the bottom. A user may cut appropriately sized conduit openings (up to 1.5"/38 mm) as required, in the removable gland plates for wiring access. For EMI reasons, it is recommend that all low-current wire (terminals 52 through 121) be separated from all high-current wire (terminals 1 through 51).

Mounting

The standard 505E package must be mounted to allow sufficient room for wiring access. Eight front panel screws permit secure mounting. The standard 505E weighs approximately 4 kg (9 lb), and has an operating range of –25 to +65 °C (18 to 149 °F) ambient air temperature.

The optional enclosure permits the control to be bulkhead mounted. See Figure 2-2 for mounting dimensions. This enclosure weighs approximately 10 kg (22 lb) and allows an operating range of –20 to +60 °C (–4 to +140 °F) ambient air temperature.

505E Hardware Jumpers

To allow the 505E the flexibility of interfacing with different types of speed probes, transducers, and communication cables, user changeable jumpers are used. These jumpers are accessed by taking the 505E's back cover off and are located on the I/O module. Refer to Table 2-1 for jumper options and Figure 2-4 for jumper locations. Each set of jumpers are used to select between two or three interface options for one circuit (see Figure 2-3). Of the three position jumper options provided only one interface option at a time can be selected. Power should be removed before the jumpers are accessed, and proper ESD precautions should be taken before any contact is made with any part of the circuit board.
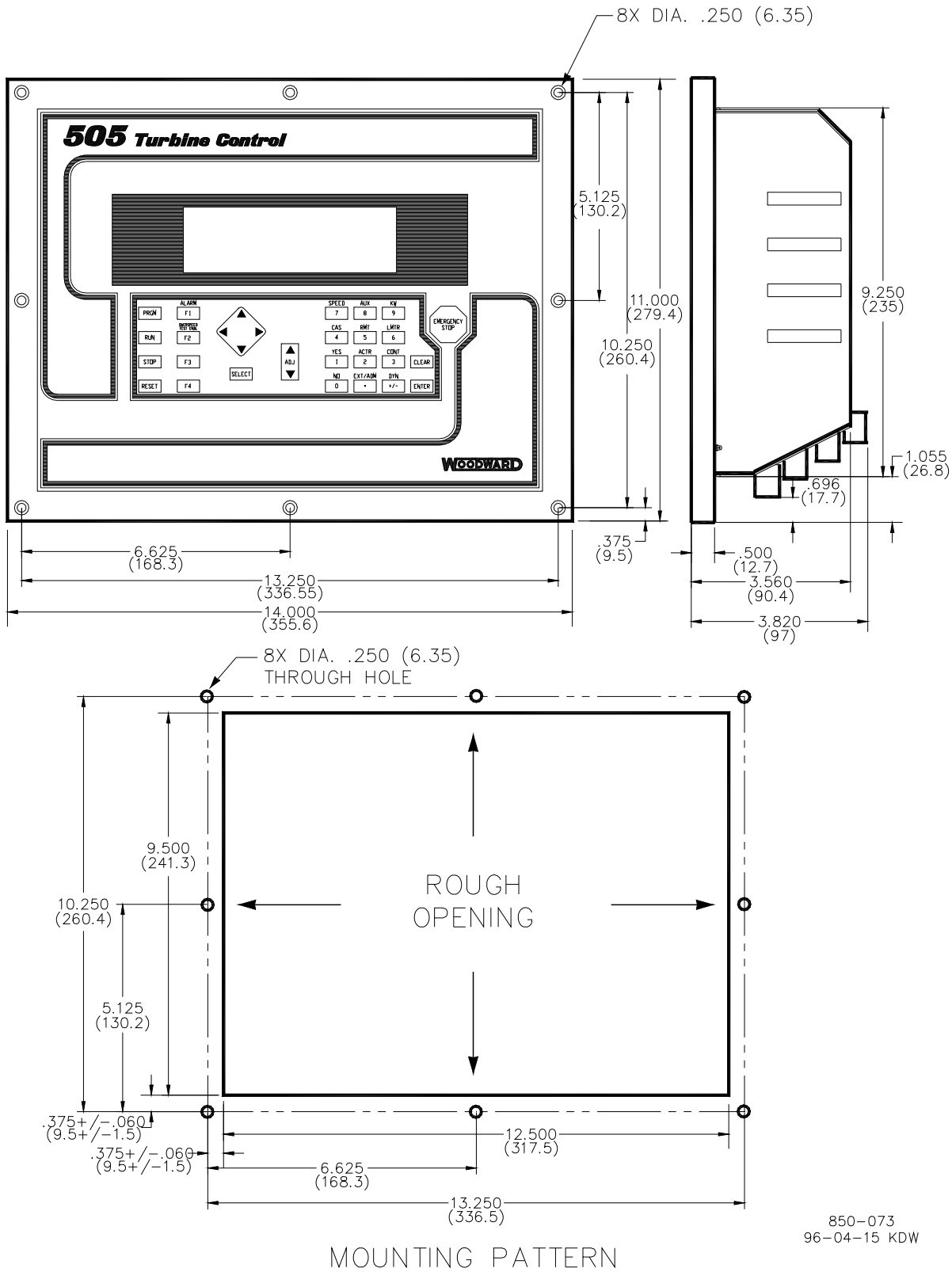
Figure 2-1. 505E Control Layout (Standard Enclosure)

3.000
(76.2)

14.000 (355.6)

2X Ø .440(11.2)
.380(9.6)

7.688
(195.3)
MAX

6.000
(152.4)

21.250
(546.1)

20.000
(508)

.625
(15.9)
TYP

2X .440 (11.2)
.380 (9.6)

1.250
(31.8)
TYP

20.000 (508.0)

.125
(3.2)
MAX

2X GLAND PLATE ⚠3

5.250
(133.3)

2.625 (66.7)

2.205
(56.0)

2.469
(62.7)

1.700
(43.2)

.850
(21.6)

1.103
(28.0)

1.844
(46.8)

3.688 (93.7)

4.906
(124.6)

6.750
(171.4)

SEE DETAIL "F"

DETAIL "F"
GLAND CUTOUT IN
ENCLOSURE BODY
TYP 2 PLACES

CUSTOMER OUTLINE AND INSTALLATION NOTES:

⚠1 DIMENSIONS ARE IN INCHES WITH MILLIMETERS
(MM) SHOWN IN PARENTHESIS.

⚠2 #8-32 STUD IN ENCLOSURE BODY WALL IS PROVIDED
FOR CUSTOMER GROUND WIRE.

⚠3 GLAND PLATES ARE PROVIDED FOR INSTALLATION
OF CONDUIT HUBS FOR WIRE ENTRY INTO THE
ENCLOSURE.

850-143
96-04-15 KDW

Figure 2-2. 505E Bulkhead-Mounted Enclosure

1606-848
REUSABLE
CLIP

OPTION 1   OPTION 2

TWO POSITION JUMPERS

OPTION 1   OPTION 2   OPTION 3

THREE POSITION JUMPERS

850-082
96-03-19 KDW
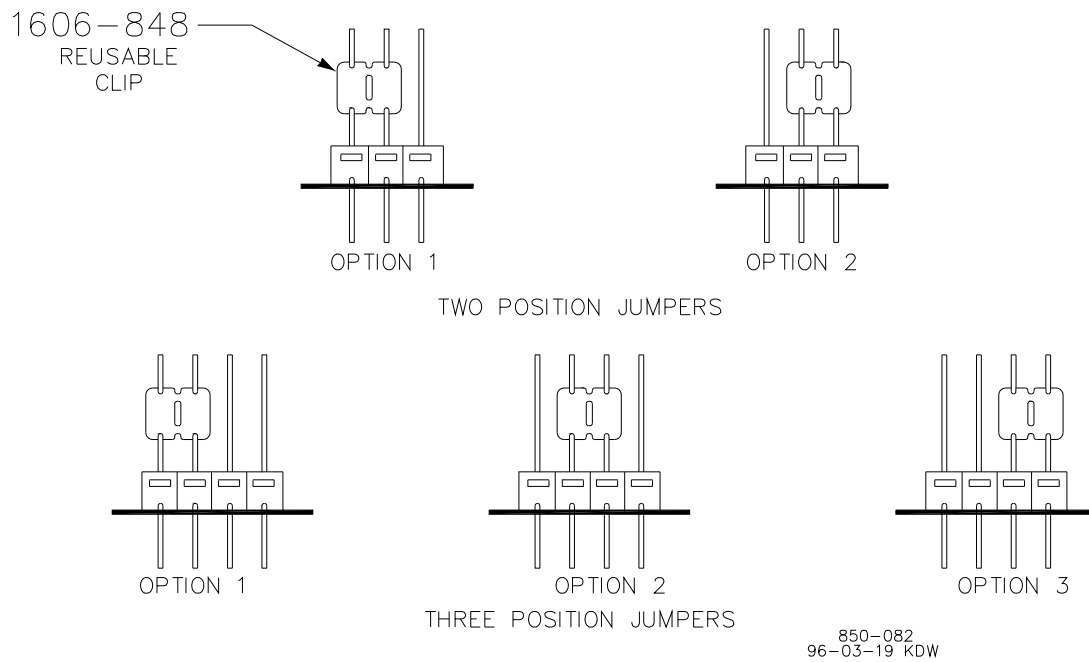
Figure 2-3. Jumper Options

SW1

SYSTEM RESET
SWITCH

JPR5 JPR7
JPR4 JPR6

JPR22 JPR23 JPR24   JPR28 JPR29 JPR30   J1

JPR9 JPR8
JPR11 JPR10
JPR13 JPR12
JPR15 JPR14
JPR17 JPR16

U82

JPR18
JPR20
JPR19
JPR21

JPR25
JPR26
JPR27

JPR31
JPR32
JPR33

TB1   TB2   TB3

850-071
96-09-24 KDW
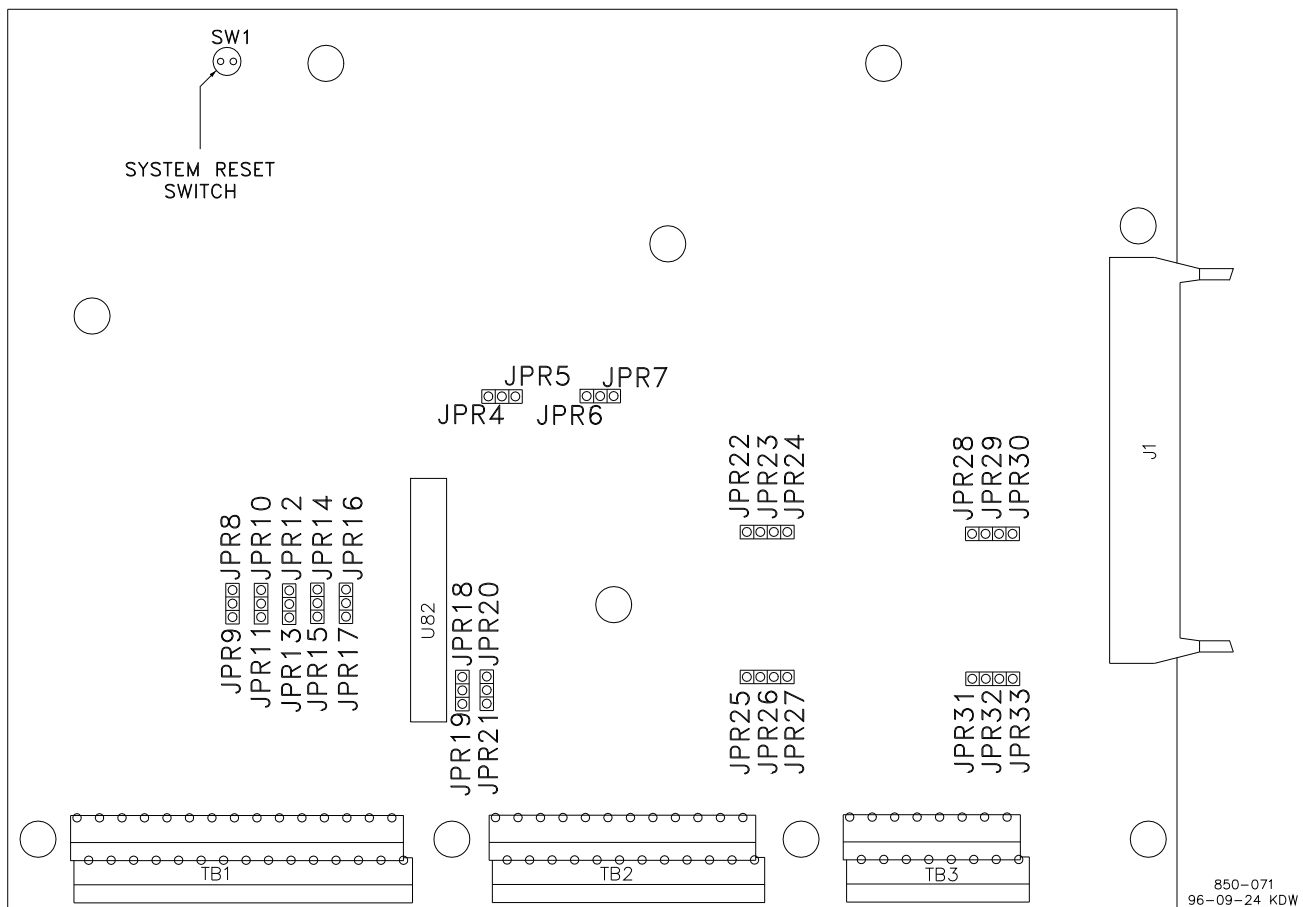
Figure 2-4. Jumper Locations

Function	Jumpers
SPEED SENSOR #1—MPU	JPR7, JPR21 *
SPEED SENSOR #1—PROX. PROBE	JPR6, JPR20
SPEED SENSOR #2—MPU	JPR5, JPR19 *
SPEED SENSOR #2—PROX. PROBE	JPR4, JPR18
EXT/ADM INPUT—LOOP POWERED- (2 WIRE)	JPR10
EXT/ADM INPUT—SELF-POWERED	JPR11 *
ANALOG INPUT #2—LOOP POWERED- (2 WIRE)	JPR8
ANALOG INPUT #2—SELF-POWERED	JPR9 *
ANALOG INPUT #3—LOOP POWERED- (2 WIRE)	JPR14
ANALOG INPUT #3—SELF-POWERED	JPR15 *
ANALOG INPUT #4—LOOP POWERED- (2 WIRE)	JPR12
ANALOG INPUT #4—SELF-POWERED	JPR13 *
ANALOG INPUT #5—LOOP POWERED- (2 WIRE)	JPR16
ANALOG INPUT #5—SELF-POWERED	JPR17 *
COMM PORT #1 NO TERMINATIONS	JPR23, JPR26 *
COMM PORT #1 RS485/RS422 RECEIVE TERMINATION	JPR22, JPR25
COMM PORT #1 RS422 TRANSMIT TERMINATION	JPR24, JPR27
COMM PORT #2 NO TERMINATIONS	JPR29, JPR32 *
COMM PORT #2 RS485/RS422 RECEIVE TERMINATION	JPR28, JPR31
COMM PORT #2 RS422 TRANSMIT TERMINATION	JPR30, JPR33

 * = DEFAULT

Table 2-1. Jumper Options Chart

Electrical Connections

⚠ **WARNING**	**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.**

⚠ **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, Division 2.**

NOTICE	**Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagrams shown in this section.**

Refer to Figure 2-7 for a representative 505E I/O interface schematic, and Volume 2 of this manual, for hardware Input/Output specifications.

All inputs and outputs to the 505E are made through "CageClamp" terminal blocks on the bottom of the 505E package. For EMI reasons, it is recommend that all low-current wire (terminals 52 through 121) be separated from all high-current wire (terminals 1 through 51).

The terminal blocks are screwless CageClamp style blocks. The spring clamp can be actuated by using a standard 3 mm or 1/8" flat bladed screwdriver or a snap-on thumb lever (Figure 2-5). Two snap-on thumb levers are provided with the 505E unit. The 505E terminal blocks accept wires from 0.08–2.5 mm² (27–12 AWG) wire. Two 18 AWG or three 20 AWG wires can be easily installed in each terminal.
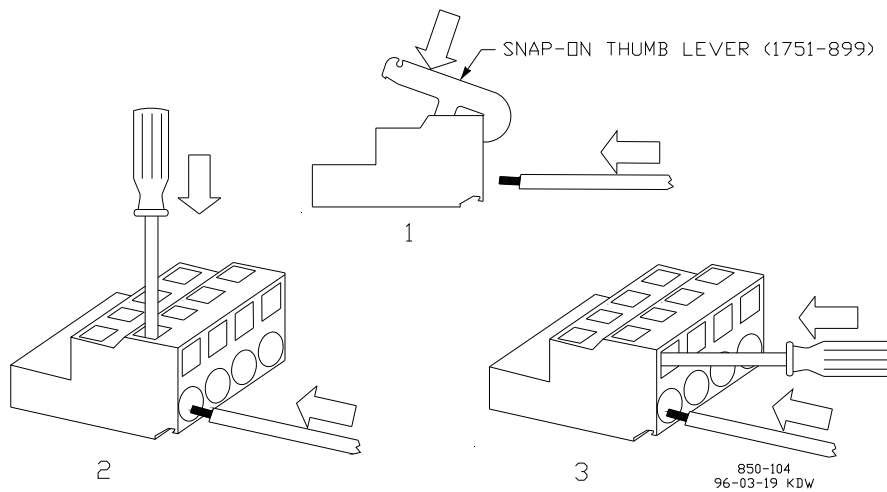
Figure 2-5. CageClamp Terminal Blocks

The 505E control's terminal blocks are designed to be removed by hand. After 505E input power is disconnected, the terminal blocks can be removed one at a time by prying them off using ones finger tips. When removing a terminal block, never pull on the wires connected to the terminal block.

Wires for the fixed mounted power terminals should be stripped 5–6 mm (0.22") long. Wire for the pluggable I/O terminals should be stripped 8–9 mm (0.33") long.

When a bulkhead enclosure is required, all electrical connections must be made through the gland plates provided on the bottom of the bulkhead mount enclosure to the terminal blocks inside. See Figure 2-2.

Power Supplies

The 505E is available with three different input power source selections. The part number of the 505E depends on the rating of the input power source it can accept. The ratings of the required input power source on each unit can be identified by the back panel sticker or control part number. The sticker will show the correct source power ratings for each unit by a punched hole next to the rating. Refer to Volume 2 for all power supply specifications.

The 505E's input power supply terminal blocks accept wires from 0.08–2.5 mm² (27–12 AWG) wire. Internal fuses, in series with each input power trace, are used to protect the 505E's input circuitry. All fuses are rated as slow-blow type fuses. These fuses are accessed by taking the 505E's back cover off and are located on its power supply module (bottom module). Refer to Figure 2-8 for fuse locations. The ratings for the different sources of input power accepted by the 505E and the 505E's internal fuse sizes are listed as follows:

18–32 Vdc	(6.25A internal fuse, 77VA maximum draw)
88–132 Vac @ 47–63 Hz or 90–150 Vdc	(2.5A internal fuse, 143VA maximum draw)
180–264 Vac @ 47–63 Hz	(1.5A internal fuse, 180VA maximum draw)
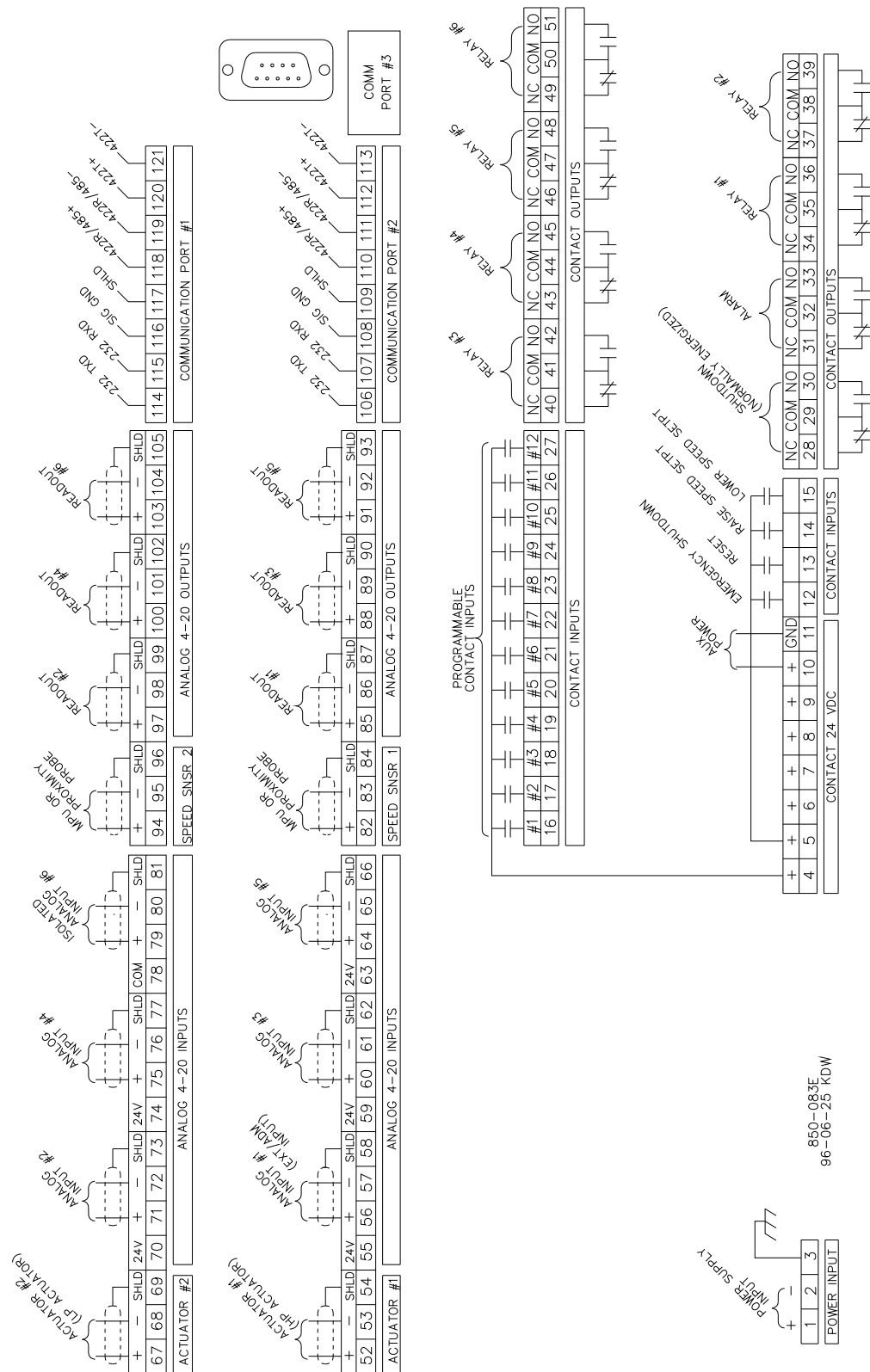
Figure 2-6. Control Wiring Diagram
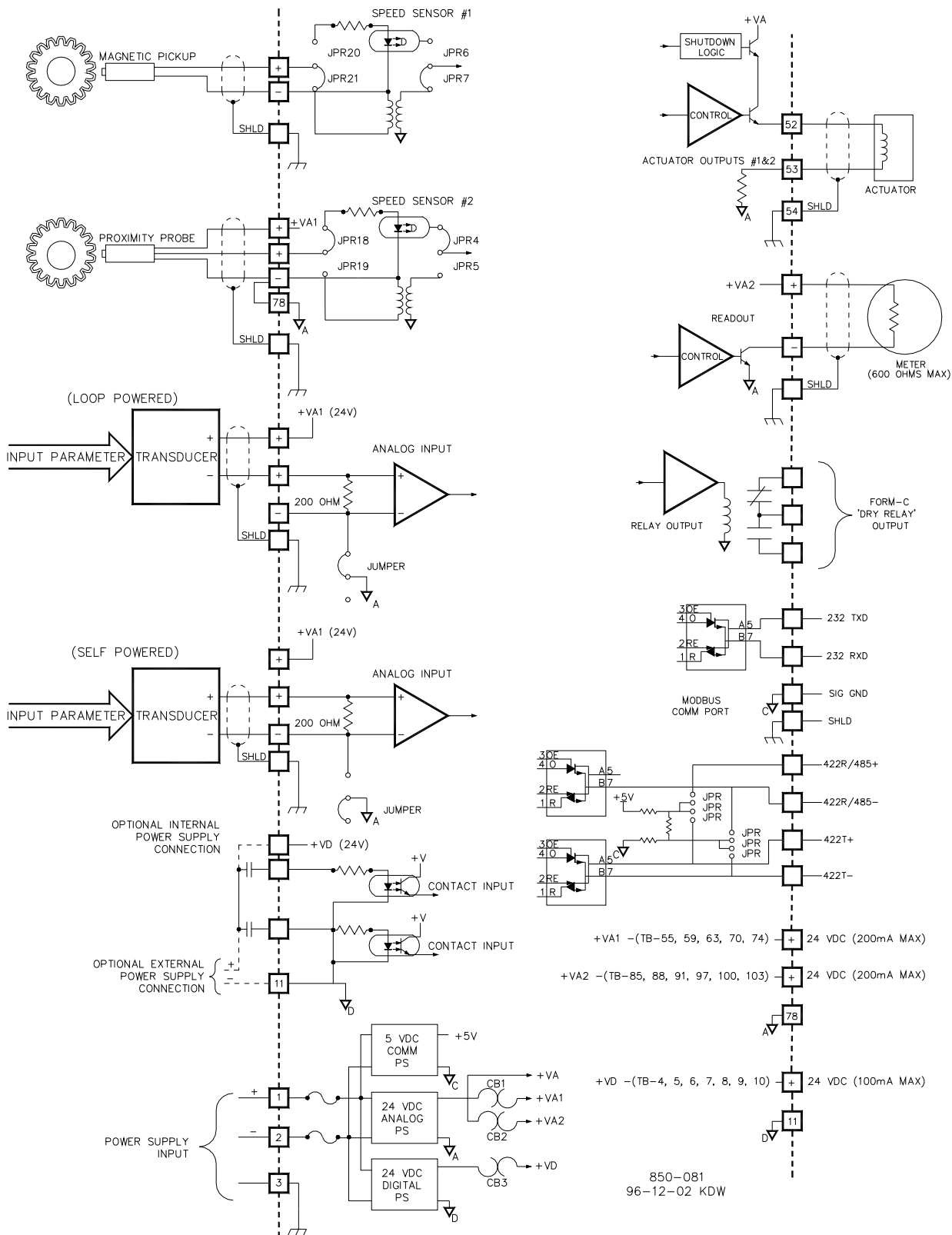
Figure 2-7. Representative 505E I/O Schematic

Each 505E requires a power source capable of a certain output voltage and current. In most cases this power rating is stated in volt-amperes (VA). The maximum VA of a source can be calculated by taking the rated output voltage times the maximum output current at that voltage. This value should be greater than or equal to the 505E VA requirement.

505E power supply holdup times are determined by the 505E power supply and input power used. The below times are based on worse case conditions (i.e. 88 Vac with a possible range of 88-132 Vac when power is lost). These holdup times should be used when the 505E is powered by an Uninterruptable Power Source (UPS) to evaluate if the UPS's switch over time is quick enough to avoid a system trip. A UPS's switch-over time must be less than the below specified holdup times:

Power Supply Holdup Times

18–32 Vdc Power Supply	14 milliseconds
88–132 Vac @ 47–63 Hz or 90–150 Vdc Power Supply	30 milliseconds
180–264 Vac @ 47–63 Hz Power Supply	58 milliseconds
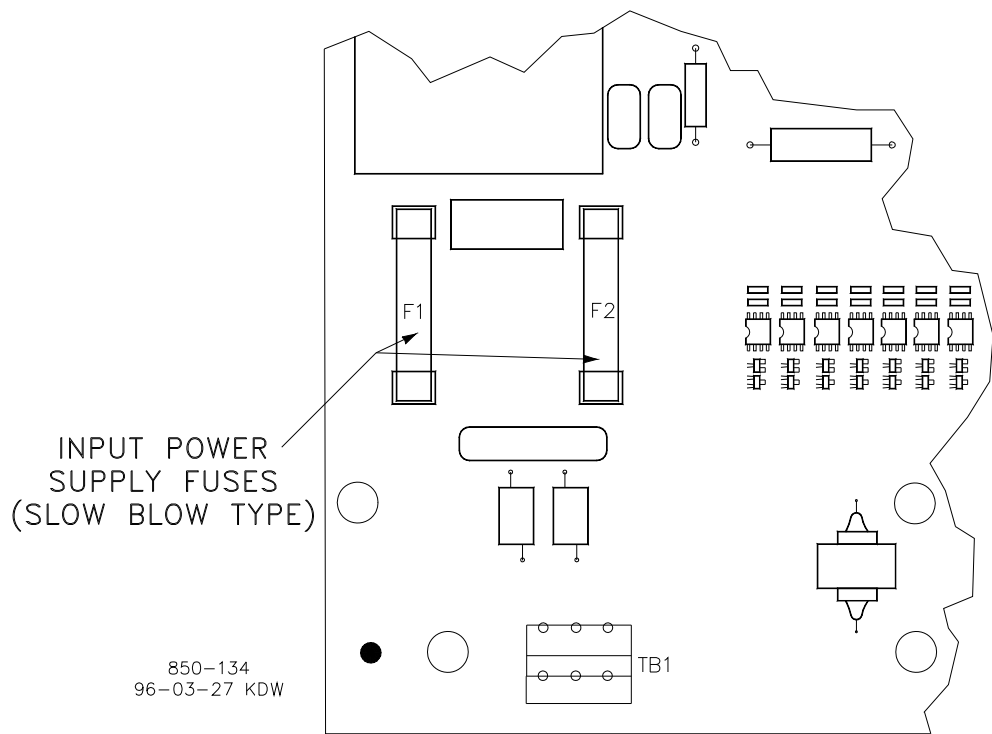
Figure 2-8. Fuse Location

A 24 V power supply is available within the 505E to power external transducers or devices. This supply has two breaker protected output channels. One power supply channel (VA1) is capable of providing 24 Vdc ±10%, @ 200 mA maximum output current, to power 505E current inputs and auxiliary devices. Power connections can be made through terminals 55, 59, 63, 70, and 74 with terminal 78 as the common. Refer to Figure 2-7.

⚠ **WARNING**   **The total current draw through terminals 55, 59, 63, 70, and 74 cannot exceed 200 mA or the 505E's internal power supply breaker (CB1) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.**

The second power supply channel is capable of providing 24 Vdc ±10%, @ 200 mA maximum output current, to power 505E current outputs and auxiliary devices. Power connections can be made through terminals 85, 88, 91, 97, 100, and 103 with terminal 78 as the common. Refer to Figure 2-7.

⚠️ **WARNING** | **The total current draw through terminals 85, 88, 91, 97, 100 and 103 cannot exceed 200 mA or the 505E's internal power output breaker (CB2) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.**

Shields and Grounding

An individual shield termination is provided at the terminal block for each of the speed sensor inputs, actuator outputs, analog inputs, analog outputs, and communications ports. All of these inputs should be wired using shielded, twisted-pair wiring. The shields should be connected to earth ground at all intermediate terminal blocks, as well as terminated at the control terminal block. The exposed wire length, beyond the shield, should be limited to one inch. Relay outputs, contact inputs, and power supply wiring do not normally require shielding, but can be shielded if desired.

For EMI reasons, it is recommend that all low-current wire (terminals 52 through 121) be separated from all high-current wire (terminals 1 through 51). Input Power ground terminal #3 should also be wired to external ground. Refer to Figure 2-7.
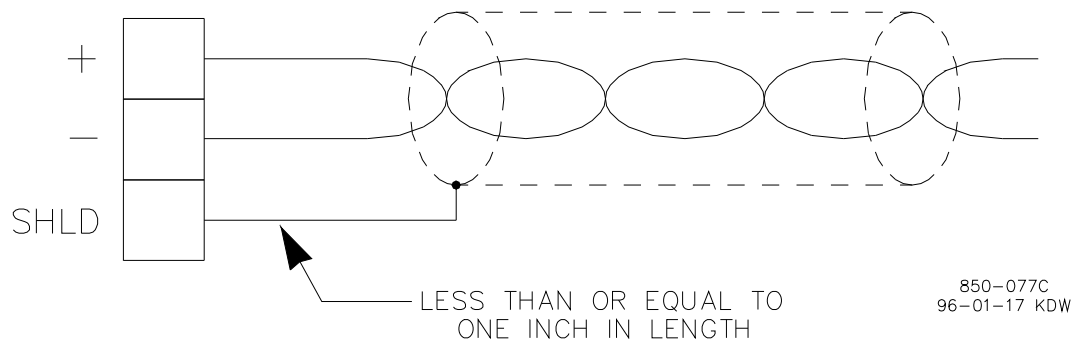
Figure 2-9. Shielded Wire Connections

Speed Sensor Inputs

To sense speed, the control accepts signals from one or two passive magnetic pickup units (MPUs) or active proximity probes mounted off of a gear which is connected or coupled to the turbine's rotor.

Because of the differences between passive MPUs, active proximity probes, and the sensing circuits required for each type, jumpers are provided to allow field configuration of each speed input depending on the type of probe used. See Table 2-1 for jumper options, and Figure 2-4 for jumper locations. Verification of jumper location is recommended before system startup or operation.

A passive MPU provides a frequency output signal corresponding to turbine speed by sensing the movement of a gear's teeth past the MPU's pole piece. The closer the MPU's pole piece is to a gear's teeth and the faster the gear turns the higher a passive MPU's output amplitude will be. The 505E must sense an MPU voltage of 1 to 25 Vrms for proper operation.

With proper MPU, gear size, and MPU-to-gear clearance, speed measurement should be capable down to 100 Hz. Standard MPU clearance is recommended to be .010" to .040" from tooth face to pole piece. For information on selecting the correct MPU or gear size please refer to Woodward manual 82510. See Figure 2-7 for wiring schematic.

A proximity probe may be used to sense very low speeds. With a proximity probe, speed can be sensed down to 0.5 Hz. The input voltage must be between 16 and 28 Vdc for proper operation. The speed sensor input channels are isolated, so either channel can be jumper configured for a MPU or proximity probe. The 505E can be programmed to turn on or off a turbine turning gear using a relay output programmed as a speed switch when a proximity probe is used. See Figure 2-7 for proximity probe wiring schematic.

It is not recommended that gears mounted on an auxiliary shaft coupled to the turbine rotor be used to sense turbine speed. Auxiliary shafts tend to turn slower than the turbine rotor (reducing speed sensing resolution) and have coupling gear back-lash, resulting in less than optimum speed control. For safety purposes it is also not recommend that the speed sensing device sense speed from a gear coupled to a generator or mechanical drive side of a system's rotor coupling.

An application may use two of the same type of speed probes or two different types of speed probes, i.e. one MPU and one proximity probe. Both speed sensing inputs use the same programmed gear ratio and number of teeth to calculate speed, thus the speed probes used should sense speed from the same gear.

The 505E can be programmed to sense only one speed input signal. However, it is recommended that the 505E be programmed to sense two speed inputs, and that two speed probes be used with all applications to increase system reliability.

IMPORTANT	**The speed signal that the 505E can accept must be within the following limits:**
	    (T x M x R)/60 must be < 15000 Hz
	        T = Gear Teeth
	        M = Overspeed Test Limit Setting
	        R = Gear Ratio

If the signal is not within these limits, the 505E will respond with a speed sensor frequency error during the program checking procedure.

Contact Inputs

In general, contacts must change state for a minimum of 15 milliseconds for the control to sense and register a change in state. All contact inputs accept dry contacts. Contact wetting voltage is available through terminals 4, 5, 6, 7, 8, 9, and 10. If desired, an external 18-26 Vdc power source can be used for the circuit wetting voltage. In this case terminal 11 (contact input common) must be connected to the external power source's common to establish a common reference point. Each contact input pulls 2.5 mA when closed, and requires at least 1 mA and 14 Vdc to recognize a closure command. See Figures 2-6 & 2-7 for wiring information, and Volume 2 for input specifications.

⚠️ **WARNING** | **The total current draw through terminals 4, 5, 6, 7, 8, 9, and 10 cannot exceed 100 mA or the 505E's internal power output breaker (CB3) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.**

If the 16 contact inputs available, four have functions already assigned to them (preset) and cannot be changed, the other 12 are user-configurable. The Preset Contact Inputs are:

- External Emergency Shutdown
- External Reset
- Raise Speed Setpoint
- Lower Speed Setpoint

Before starting, the External Emergency Shutdown contact must have an external contact wired in and closed or be jumpered closed. The control will initiate an emergency shutdown any time the contact is opened. This input is typically tied into the system's trip string and provides trip feedback to the control.

The external reset contact can be used to remotely clear alarms and return the control to the (Controlling Parameter /Push Run or Prgm) state after a shutdown.

The raise and lower speed setpoint contact inputs can be used to remotely raise and lower speed or load.

Applications requiring external contact inputs must have the desired function assigned or configured to a specific input. There is a choice of twelve possible contact inputs and thirty-eight programmable functions. If the 505E is configured for a generator application two of the contacts must be configured for the Generator and Utility breaker inputs. The Generator Breaker contact must be wired so it is closed when the generator breaker is closed. The Utility Tie Breaker contact must be wired so it is closed when the utility tie breaker is closed.

Refer to Chapter 4 of this manual for a complete list of programmable contact input functions.

Analog Inputs

Analog inputs # 1, 2, 3, 4, and 5 may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. Jumpers are available to match the analog input circuit to the transducer being interfaced with, or the power supply common may be jumpered on the terminal block. Verification of jumper location is recommended before system startup or operation. See Table 2-1 for jumper options and Figure 2-4 for jumper locations.

Because inputs 1–5 are not fully isolated, care must be taken in their application and maintenance to avoid "ground-loop" type problems. If interfacing to a non-isolated device with one of these inputs, the use of a loop isolator is recommended to break any return current paths, which could result in erroneous readings.

Analog input # 6 is a fully isolated input and is designed to be used with a non-isolated source such as a Distributed Control System (DCS). This input does not use or have jumpers for hardware configuration options. Refer to Figure 2-7, Option #1 for correct wiring configuration.

Analog input #1 is dedicated as the extraction/admission input signal. The remaining five analog inputs (2-6) are programmable. All 505E inputs have an input impedance of 200 Ω. Refer to Chapter 4 of this manual for a complete list of programmable analog input options.

Analog Outputs

Applications using the 505E analog outputs must have the desired analog value assigned or configured to a specific output. There is a choice of six possible 4–20 mA output drivers of which to use to display a parameter externally. The analog output connections for the 505E are shown in Figure 2-7. All 505E analog outputs can drive into a maximum of 600 Ω. Refer to Chapter 4 of this manual for a complete list of programmable analog output options.

Actuator Outputs

The two actuator output drive currents can be programmed to interface with Woodward Governor Company actuators (typically 20–160 mA drive currents) or non-Woodward actuators (4–20 mA drive currents). Each actuator output can be individually configured to interface with Woodward or non-Woodward type actuators. Actuator drive current is selected in the Program Mode.

Maximum impedance for each 4 to 20 mA actuator output driver is 360 Ω (actuator impedance + wire resistance). Maximum impedance for each 20 to 160 mA actuator output is 45 Ω (actuator impedance + wire resistance). Dither is available for either output.

Each actuator driver senses the drive current to allow over- and under-current shutdowns. Refer to Table 4-1 for driver details.

In addition, an eleven (11) point actuator linearization adjustment curve is available through the Service Mode for each actuator output (see Service Mode adjustments in Volume 2).

Relay Outputs

There are eight relay outputs available from the 505E. All relay contacts are Form C type contacts. For relay load ratings, refer to Appendix A in Volume 2.

IMPORTANT	Before installation verify that the 505E's relay contacts meet the power requirements of the circuit with which it is being interfaced. Interposing relays are required, in cases where the interfaced circuit demands relay contacts with a higher power rating. If interposing relays are required, it is recommended that interposing relays with surge (inductive kick-back) protection be used. Improper connection could cause serious equipment damage.

Two of the eight relay outputs available are dedicated to a function and are as follows:
- Shutdown relay—de-energizes for any shutdown condition
- Alarm relay—energizes for any alarm condition

The remaining six relays can be programmed to energize upon a function change of state or an analog value level. Applications requiring programmable relay outputs must have the desired switch condition or specific analog value assigned to them. Refer to Chapter 4 of this manual for a complete list of programmable relay output options.

Serial Communications

There are three serial communications ports on the 505E. Ports one and two are for Modbus communications and can be configured for RS-232, RS-422, or RS-485 communications. Figures 2-10, 11, and 12, show the communications port connections for ports #1 and #2. Ports one and two are accessed though terminal blocks located on the 505E's back side. RS-422 and RS-485 communication lines can function up to a length of 4000 feet. Refer to the Modbus section of this manual for a list of all the commands and parameters available through ports one and two. The third port, utilizing a 9-pin Sub-D connector, is dedicated for uploading and downloading unit configuration values at the factory.

The Program Mode can not be accessed through the communication ports. Program configuration must be done from the keypad on the front of the control.

Modbus Wiring

The 505E control can communicate to two devices via RS-232, RS-422, or RS-485 using an ASCII or RTU Modbus transmission protocol. Each communications port is brought out to terminal blocks for wiring. Each communications mode is wired to different terminals. The following sections identify the terminal landings required for each mode.

RS-232 Wiring
A RS-232 link is limited to a distance of 50 feet. The 505E control utilizes terminal blocks 114-117 and 106-109 for RS-232 connections. Figure 2-10 shows typical RS-232 communications connection. The transmit data (TXD), receive data (RXD), and signal ground (SIG GND) must be properly connected as shown. In addition the shield (SHLD) should be connected in at least one location.
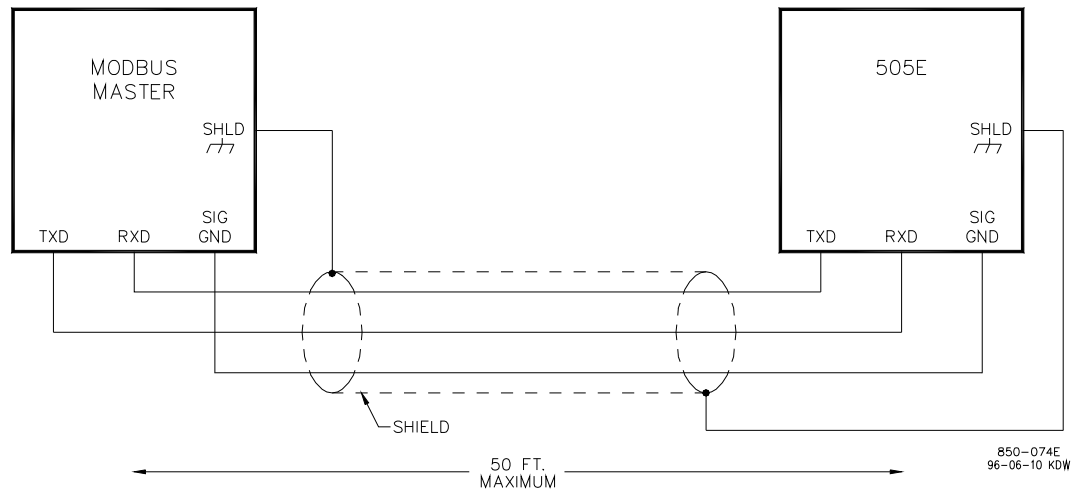
Figure 2-10. Typical RS-232 Communications

RS-422 Wiring
An advantage of RS-422 communications is that it uses a differential voltage and can accommodate much longer transmission distances. A RS-422 link can communicate up to a distance of 4000 feet. The 505E control utilizes terminal blocks 108- 113 and 116-121 for RS-422 connections. Figure 2-11 shows a typical RS-422 communications connection. The transmit data pairs (422T+ and 422T-), receive data pairs (422R+ and 422R-), and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505E control has termination resistors built-in, see the jumper option chart (Table 2-1) to connect the termination resistor.
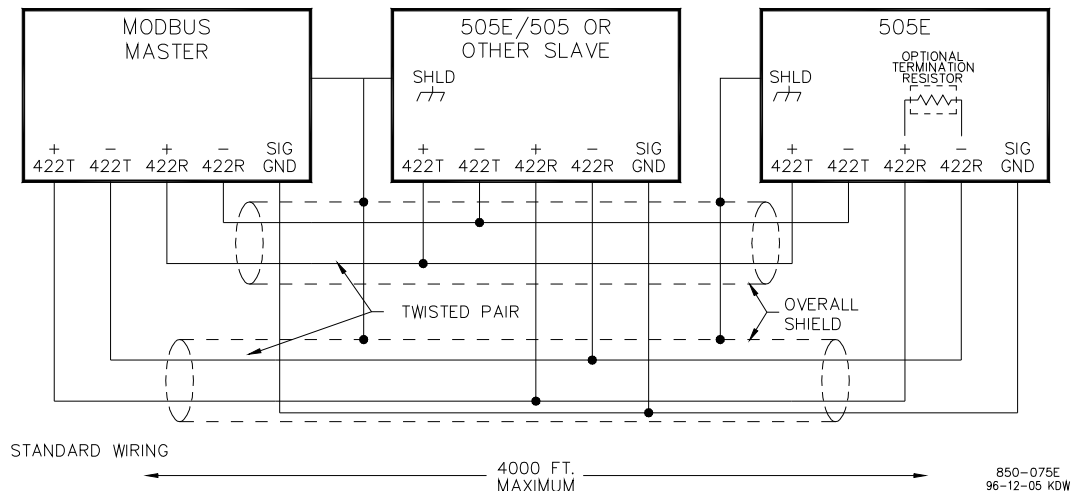
Figure 2-11. Typical RS-422 Communications

RS-485 Wiring

RS-485 communications can also accommodate transmission distances of up to a distance of 4000 feet. The 505E control utilizes terminal blocks 108-111 and 116-119 for RS-485 connections. Figure 2-12 shows a typical RS-485 communications connection. The data lines (422R+/485+ and 422R-/485-) and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505E control has termination resistors built-in, see the jumper option chart (Table 2-1) to connect the termination resistor.
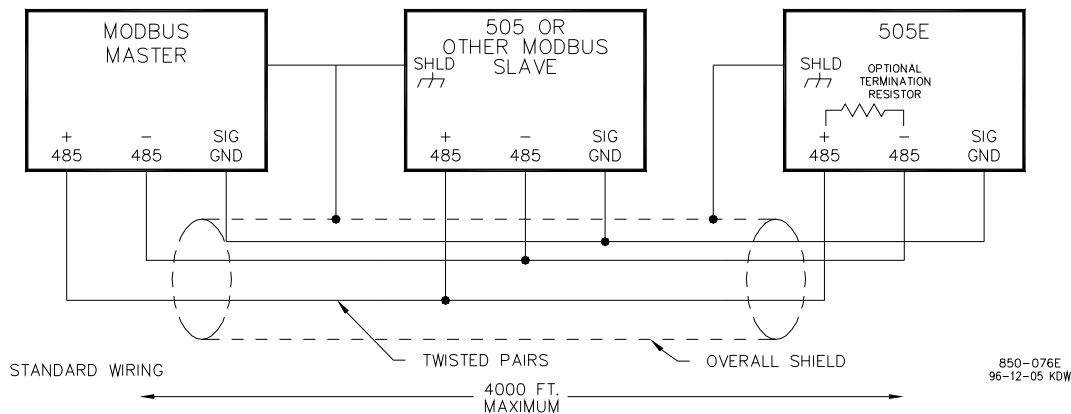
Figure 2-12. Typical RS-485 Communications

Communications Grounding and Shielding

All three 505E communications ports are fully isolated from earth ground. The RS-422 and RS-485 specifications state that a ground wire is needed if there is no other ground path between units. The preferred method to do this for isolated ports is to include a separate wire in the ground cable that connects the circuit grounds together. Connect the shield to earth ground in at least one location, see Figure 2-13a.

Non-isolated nodes may not have a signal ground available. If signal ground is not available, use the alternate wiring scheme as shown in Figure 2-13b. The alternate way is to connect all circuit grounds of isolated nodes to the shield, and then connect the shield to earth ground at a non-isolated node.
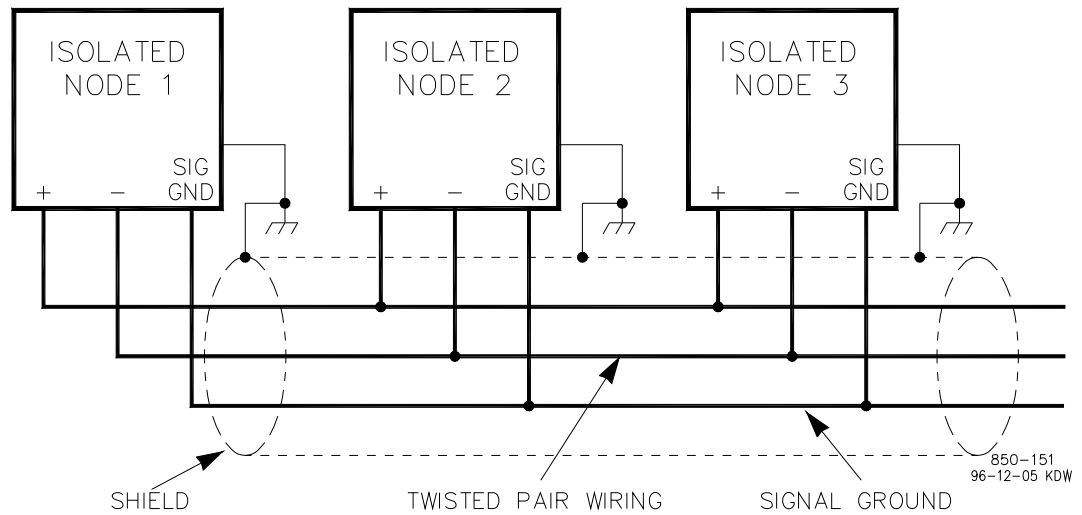
Figure 2-13a. Preferred Multipoint Wiring
(with a separate signal ground wire)
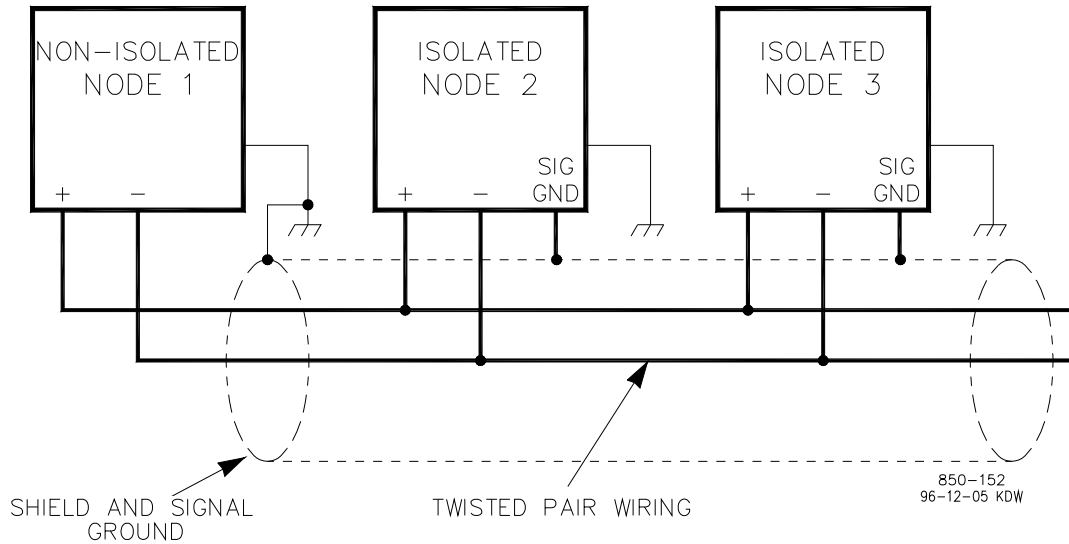
Figure 2-13b. Alternate Multipoint Wiring
(without a separate signal ground wire)

Chapter 3.
505E Control Description

Introduction

The 505E may be programmed to operate single extraction, single admission or single extraction/admission turbines. For each of these turbine applications, the 505E's Ratio/ Limiter may be configured to have the turbine's HP and LP valves interact differently depending on the turbine's function within a system.
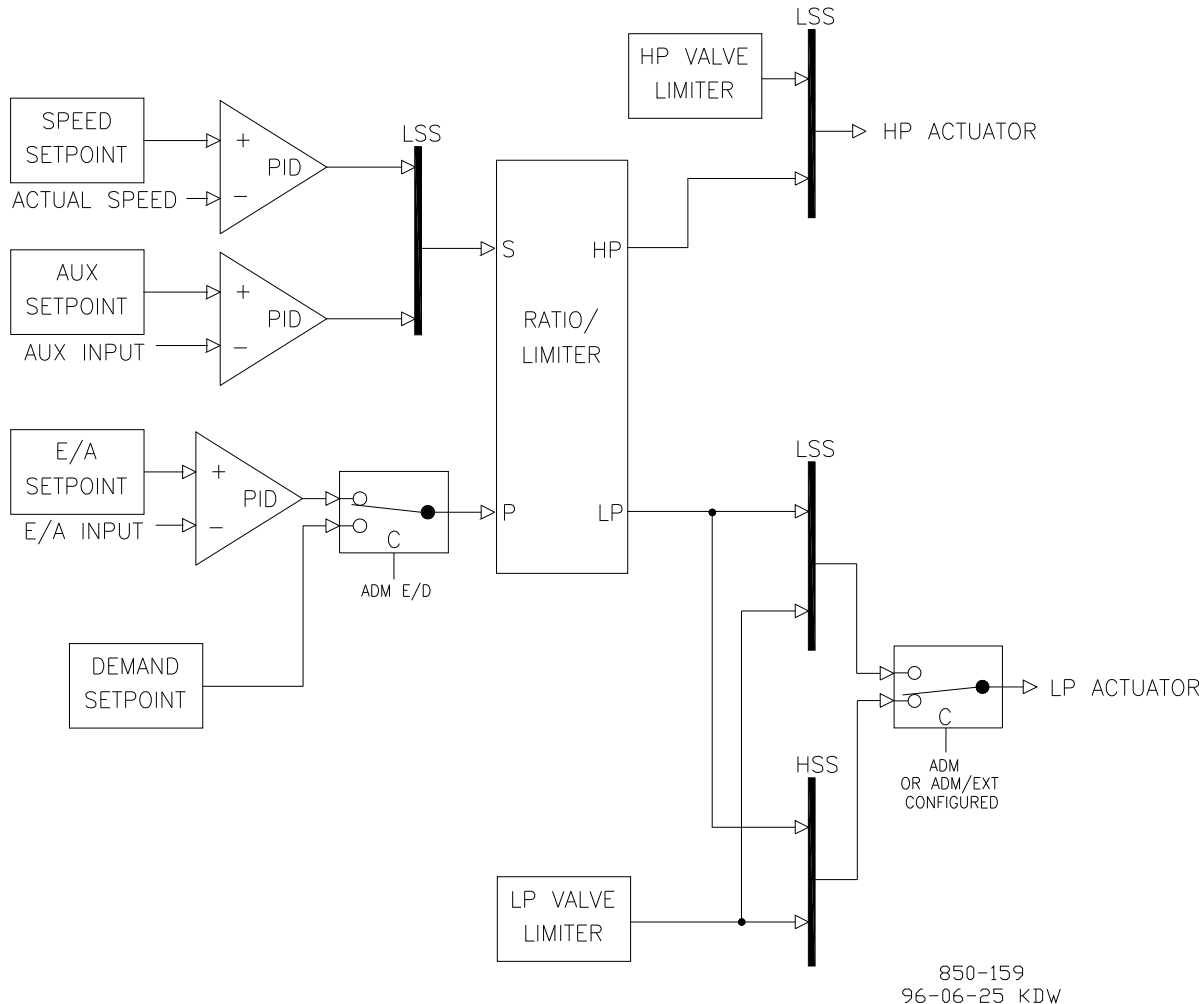
Figure 3-1. Basic Control Overview

Ratio/Limiter Configurations

The 505E 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 which 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 505E'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
* Decoupled INLET
* Decoupled EXHAUST
* Decoupled HP & LP

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. Turbine load and extr/adm pressure are controlled by moving both the HP and LP valves simultaneously. 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 505E's ratioing logic based on the programmed turbine performance parameters to minimize valve/process interaction.

To select the "COUPLED HP & LP" control action configure the program's "Decoupling?" setting to "No".

Decoulped Inlet

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

In this operating mode the turbine's HP and LP valve actions are de-coupled to allow control of a turbine's inlet pressure without interaction from extr/adm flow changes. With this mode of operation, turbine extr/adm pressure, is controlled by only moving the LP valve. Although turbine load is not controlled with this configuration, it is limited based on the turbine operating limits programmed.

The turbine's HP and LP valve actions are, however, still coupled to control turbine extr/adm pressure/flow without interaction from turbine inlet pressure or flow changes. Turbine inlet pressure is controlled by moving both the HP and LP valves simultaneously, thus no change in extr/adm pressure is created. For a change in either process the valves are repositioned to create a net effect of no pressure or flow change on the other process.

With this mode of operation:
- Turbine inlet pressure can be controlled through either the 505E's Auxiliary or Cascade PIDs.
- Extr/Adm pressure/flow can only be controlled through the 505E's Extr/Adm PID.

Decoupled Exhaust

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

In this operating mode the turbine's HP and LP valve actions are de-coupled to allow control of a turbine's exhaust pressure without interaction from extr/adm flow changes. With this mode of operation, turbine extr/adm pressure is controlled by only moving the HP valve.

The turbine's HP and LP valve actions are, however, still coupled to control turbine extr/adm pressure without interaction from turbine exhaust pressure or flow changes. Turbine exhaust pressure is controlled by moving both the HP and LP valves simultaneously, thus no change in extr/adm pressure is created. For a change in either process the valves are repositioned to create a net effect of no pressure or flow change on the other process.

With this mode of operation:
- Turbine exhaust pressure can be controlled through either the 505E's Auxiliary or Cascade PIDs.
- Extr/Adm pressure can only be controlled through the 505E's Extr/Adm PID.

Decoupled HP & LP

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

In this operating mode the turbine's HP and LP valve actions are fully de-coupled. The HP valve can be positioned by the 505E's Speed, Cascade, or Auxiliary PIDs. The LP valve can only be positioned by the 505E's Extr/Adm PID. The decoupled configuration allows control of a turbine's inlet pressure without interaction from exhaust flow changes. With this mode of operation, turbine exhaust pressure is controlled by only moving the LP valve.

The turbine's HP and LP valve actions are also decoupled to control turbine exhaust pressure/flow without interaction from turbine inlet pressure or flow changes. Turbine inlet pressure is controlled by only moving the HP valve, thus no change in exhaust pressure/flow is created. For a change in either process the respective valves are repositioned for a net effect of no pressure or flow change on the other process.

With this mode of operation, turbine inlet pressure can be controlled through either the 505E's Auxiliary or Cascade PIDs and turbine exhaust pressure is controlled through the Ext/Adm PID. Although turbine load is not controlled with this configuration, it is recommended to use the Auxiliary PID as a load limiter for unit protection.

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 Ext/Adm PID or the E/A demand setpoint, depending on selected modes, and represents Ext/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 Ext/ 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.

If programmed for decoupled operation, digital ramps are used to transfer between Ratio/ Limiters. During normal enabling and disabling of the decoupled ratio/limiter mode, these ramps take 50 seconds to completely ramp from one ratio/limiter to the next. with generator applications, this transfer is made within 40 milliseconds when switching to frequency control (gen or tie breaker opens).

If configured for a decoupled ratio/limiter mode, the control starts by using the Coupled ratio/limiter, then switches to the Decoupled ratio/limiter when the Auxiliary or Cascade PIDs are enabled. The auxiliary PID, when configured as a limiter, has no influence on the ratio/limiter selection. The control switches back to the Coupled ratio/limiter when the Auxiliary and/or Cascade PIDs are disabled.

The 'HP' output signal represents HP valve demand and is connected to the control's HP LSS bus (refer to Figures 1-4 and 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 1-4 and 1-5 for signal interconnections).
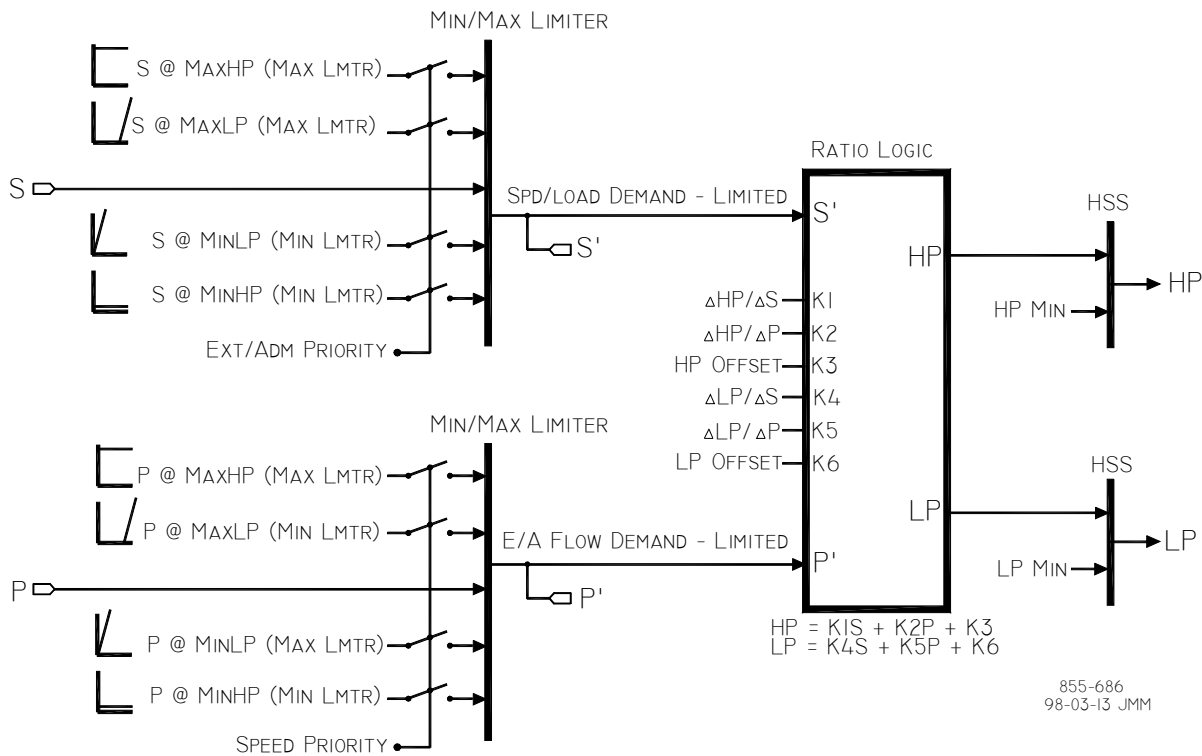
Figure 3-2. Coupled HP & LP Mode
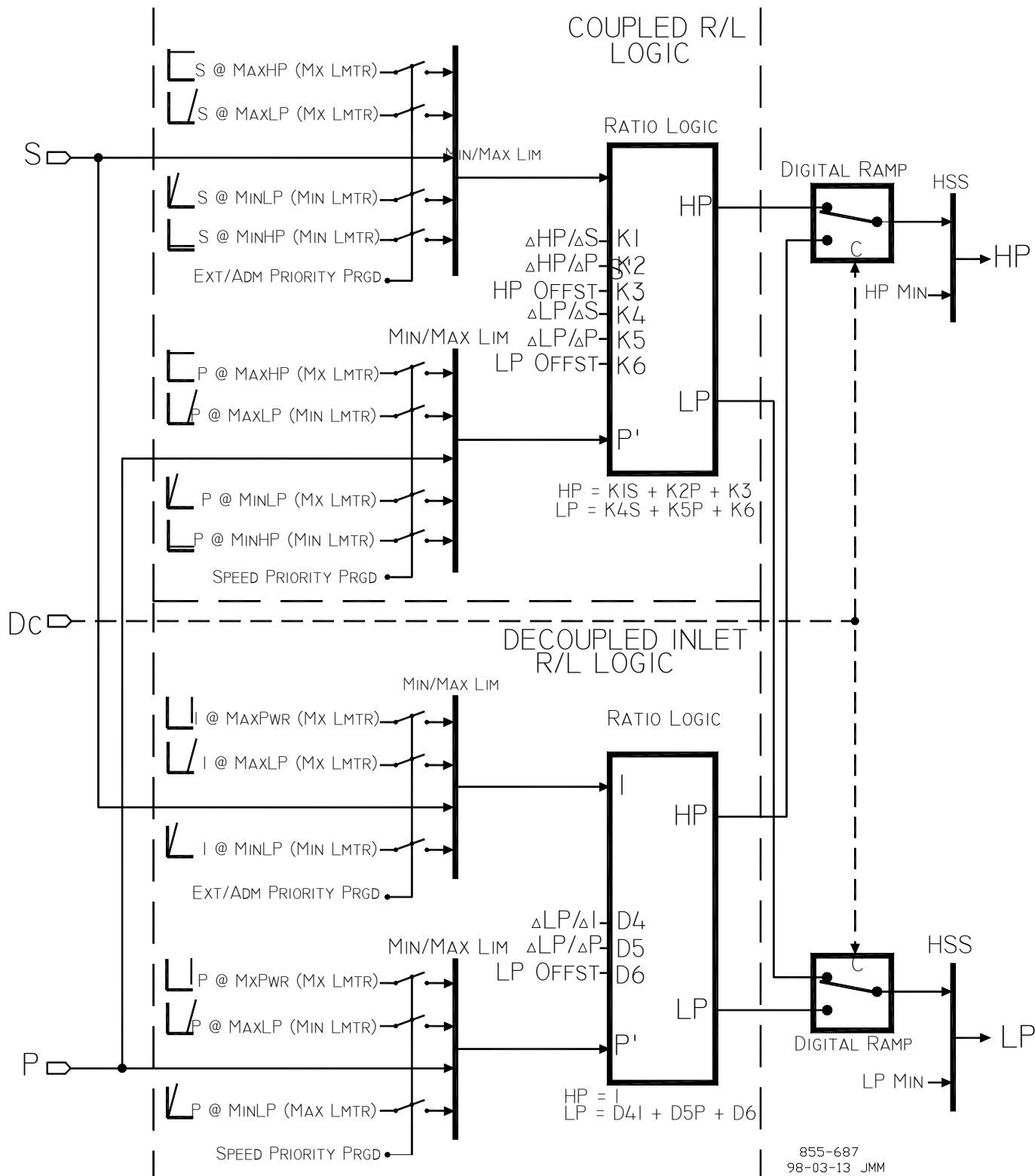
Figure 3-3. Decoupled Inlet (HP) Mode
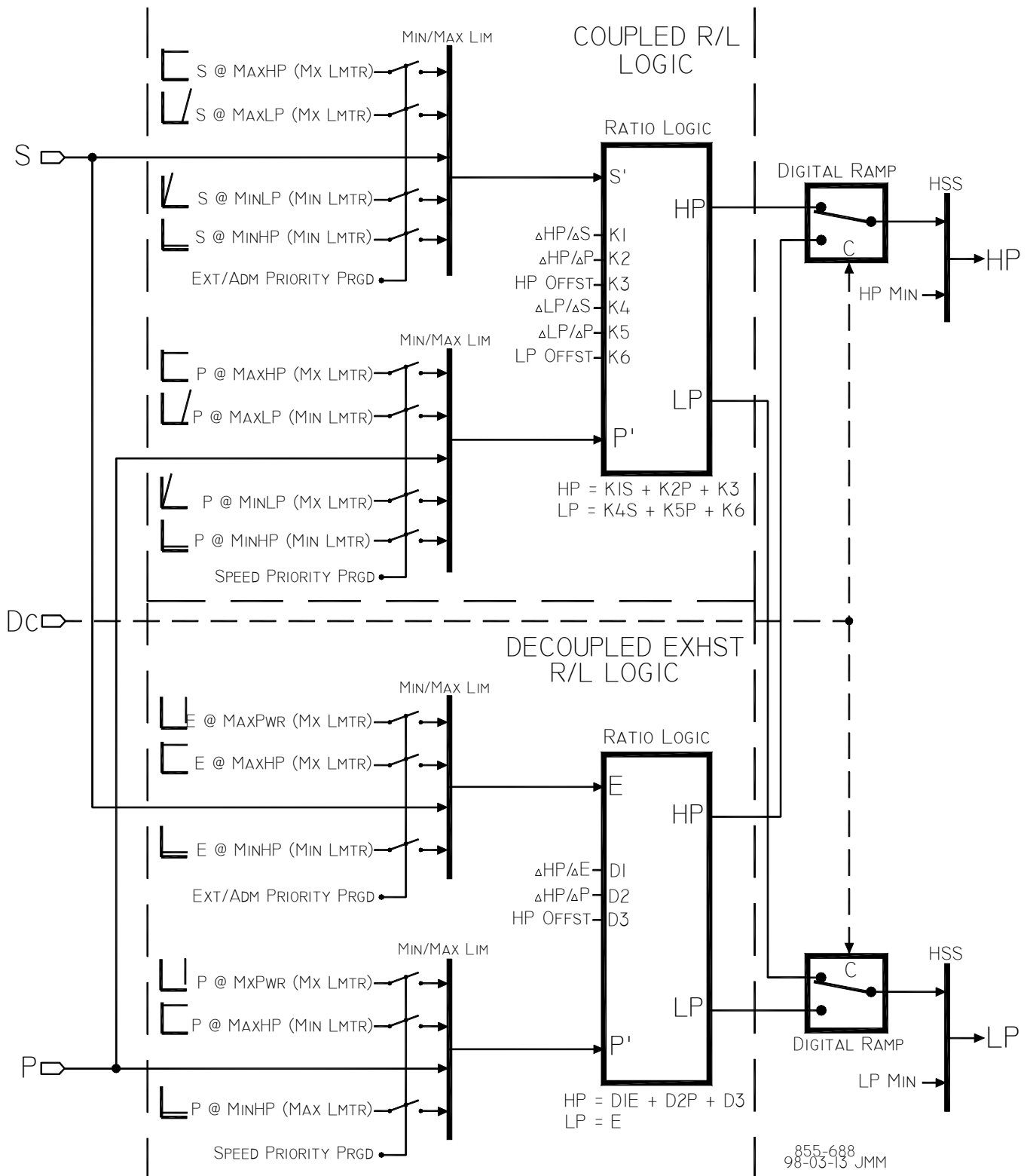
Figure 3-4. Decoupled Exhaust (LP) Mode
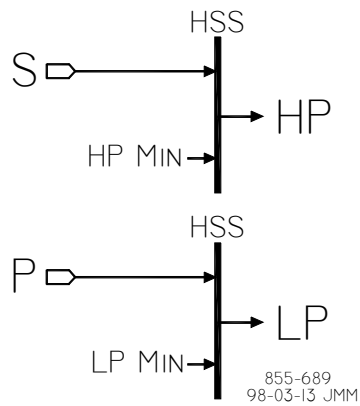
Figure 3-5. Decoupled HP & LP Mode

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 505E can only control one parameter. It is at these turbine limits that the 505E 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 505E 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 505E 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 505E 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 505E is programmed for 'Speed priority only' it will be in Speed priority at all times. If the 505E 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 505E 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 505E 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 505E keypad, 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 505E '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 by pressing the "CONT" key then the Scroll down key. Optionally a relay can be programmed to externally indicate the priority selected.

To select and de-select Extr/Adm priority from the 505E's keypad, press the "CONT" key to view the control screen, then press the Scroll Down key once to display the Priority Status Screen. With all priority permissives met (listed above) press the "Yes" key to select Extr/Adm priority, or press the "No" key to de-select Extr/Adm 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.
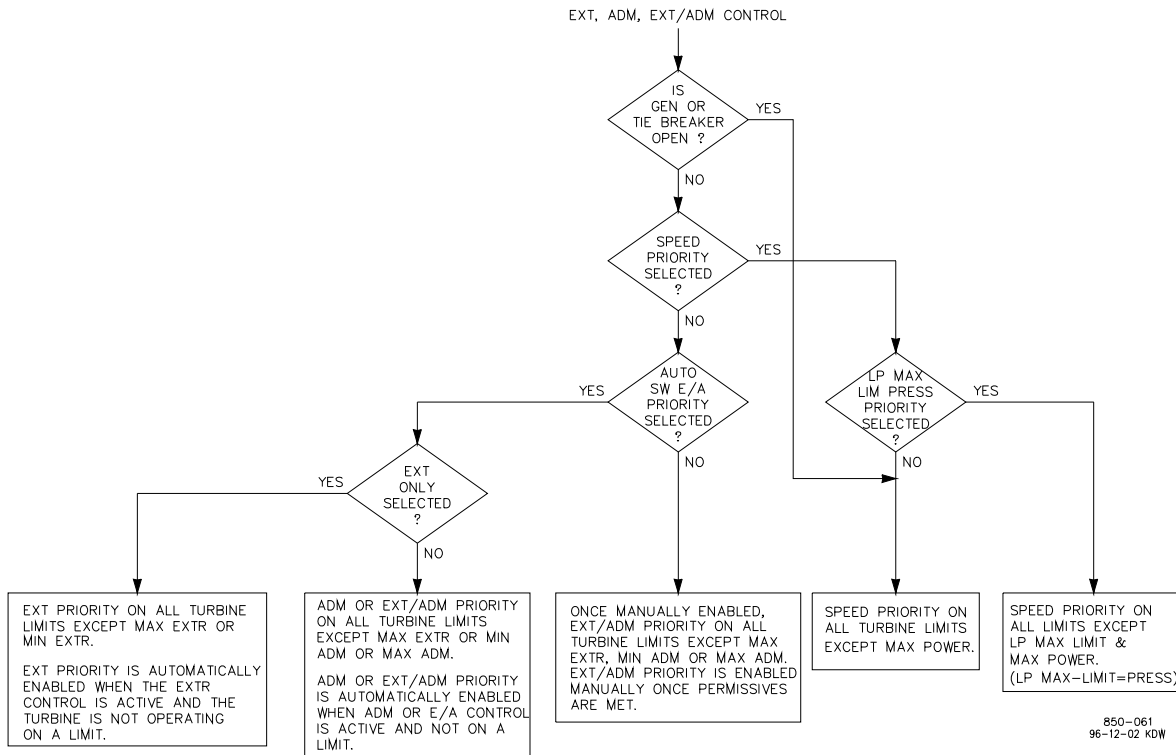
Figure 3-6. Priority Flow Diagram

Turbine Start

The 505E 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 'RUN' command is issued, the speed setpoint and HP valve limiter are manipulated automatically by the 505E 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 or auto start sequence is used.

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

If turbine speed is sensed when a 'RUN' command is issued, the control will instantly match the speed 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 the turbine speed is first sensed within a critical speed avoidance band when 'Run' 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 'RUN' command to be executed. Should the contact be open when a 'RUN' command is given, an alarm will be issued and the 505E display will indicate that the start permissive was not met (Start Perm Not Met). The alarm does not need to be cleared but the contact must be closed before the 505E will accept a 'RUN' command. After a 'RUN' 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 505E issues a shutdown if no speed signal is detected (i.e. magnetic pickup voltage less than 1Vrms 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 starts when the RUN command is initiated and re-arms the loss-of-speed detection when the time expires. The 505E 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 505E to override the loss-of-speed signal shutdown during a turbine startup. With the Automatic Override logic, the loss-of-speed signal failure is armed when the turbine trips and remains armed 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 re-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 505E'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 505E will ramp open the LP valve limiter to its maximum position.
    *   If programmed as extraction only, the LP valve position will ramp to the maximum limit until extraction is enabled.
    *   If programmed for any admission, the LP valve position will vary to maintain zero extraction/admission flow.

2. Issue a RUN command (verify T&T valve is closed before issuing)
    *   At this point the 505E will ramp open the HP valve to its maximum position at the 'HP 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 505E's Speed PID will take control of turbine speed by controlling turbine inlet (HP) 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 HP Valve Max and Min Limit, LP Valve Max and Min Limit, HP and LP Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.

⚠ **WARNING**	**The HP trip-and-throttle valve must be closed before pushing the 'RUN' key in Manual Start mode. If a RUN command is given while the trip-and-throttle valve is open, there exists a possibility of turbine runaway with resultant serious injury or loss of life.**
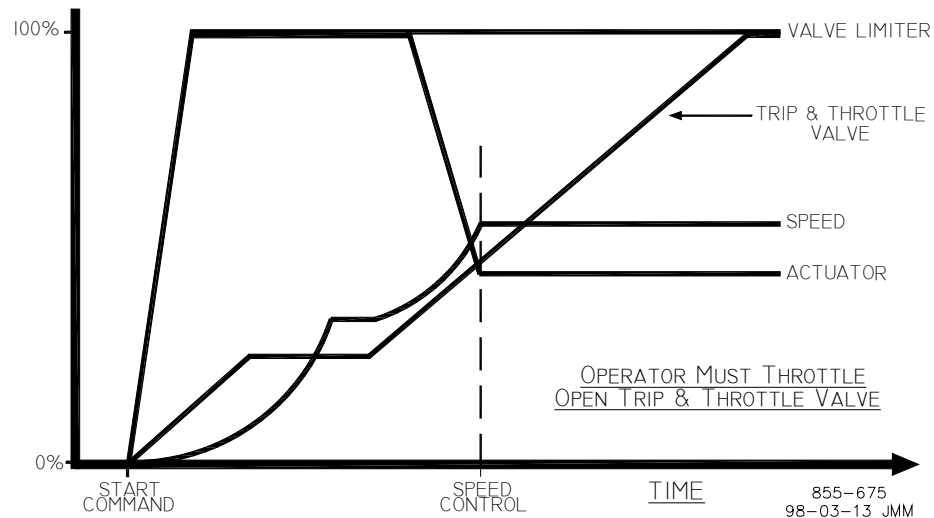
Figure 3-7. Manual Start Mode Example

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 505E will ramp open the LP valve limiter to its maximum position.
   - If programmed as extraction only, the LP valve position will ramp to the maximum limit until extraction is enabled.
   - If programmed for any admission, the LP 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 RUN command
   - At this point the speed setpoint will ramp to the minimum controlling speed setting at the 'Rate to Min' rate.

4. Raise the 505E's HP Valve Limiter at a controlled rate.
   - When turbine speed increases to the minimum controlling speed, the 505E's Speed PID will take control of turbine speed by controlling turbine inlet (HP) valve position.

5. Raise the 505E's HP Valve Limiter to 100%.
   - Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'Auto Start Sequence', if programmed, begins controlling.

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

The valve limiter will open at the 'HP Valve Limiter Rate' and may be moved using the 505E keypad, external contacts, or Modbus communications. The HP Valve Max and Min Limit, LP Valve Max and Min Limit, HP and LP Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.
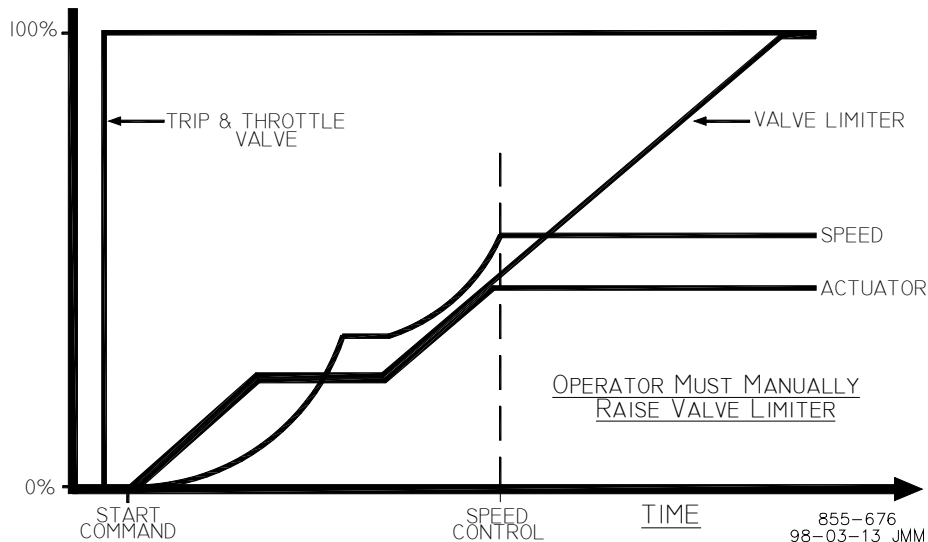
Figure 3-8. Semiautomatic Start Mode Example

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 505E will ramp open the LP valve limiter to its maximum position.
   - If programmed as extraction only, the LP valve position will ramp to the maximum limit until extraction is enabled.
   - If programmed for any admission, the LP 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 RUN command
    *   At this point the 505E will ramp open the HP valve to its maximum position at the 'HP 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 505E's Speed PID will take control of turbine speed by controlling turbine inlet valve HP position.
    *   Speed remains controlled at the minimum controlling setpoint 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 automatic start routine may be aborted at any time by issuing HP valve limiter raise or lower commands, or an emergency shutdown. The HP Valve Max and Min Limit, LP Valve Max and Min Limit, HP and LP Valve Limiter Rates, and the Rate to Min settings are tunable in the Service mode.
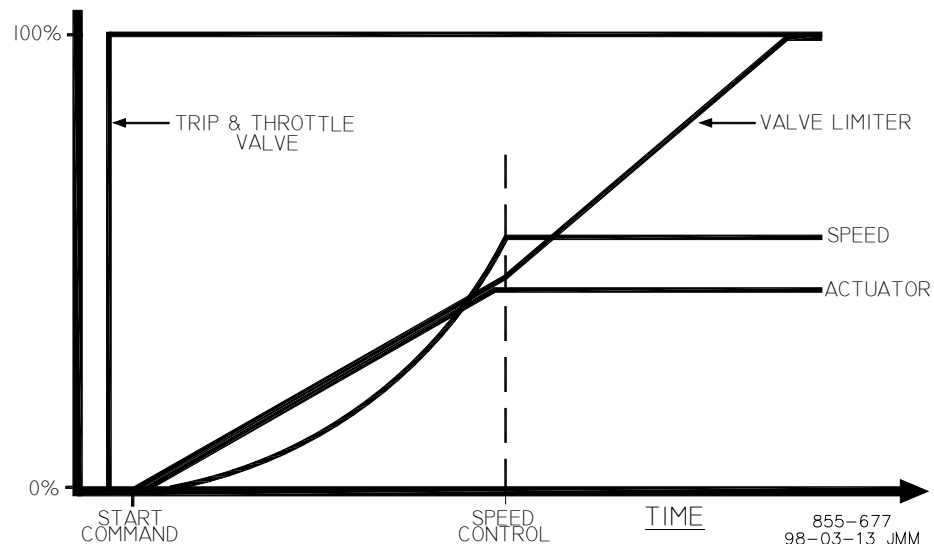
Figure 3-9. Automatic Start Mode

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, two 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 the critical band. If a Raise/Lower Speed Setpoint command is issued while in a critical band, the speed setpoint will ramp up or down (depending on raise or 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 (with the ENTER key) within the programmed critical speed band settings. In the event this is attempted, an error message will appear on the 505E front panel display.

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

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 and the speed setpoint will instantly return to idle. The "calculated length of time" is a value of three times the length of time it should normally take to accelerate through the band (based on the "Critical Speed Rate" setting). If the "Stuck in Critical" alarm occurs on a regular basis, it may be indicating that the "Critical Speed Rate" is set too fast for the turbine to respond to.

Critical speed bands are defined in the Program mode under the SPEED SETPOINT VALUES header. 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 rate in which the speed setpoint moves through a critical speed band is set by the 'Critical Speed Rate' setting. The 'Critical Speed Rate' setting should be set at but no higher than the turbine's rated maximum acceleration rate.

Idle/Rated

The 505E is equipped with an Idle/Rated function which allows the 505E to automatically ramp turbine speed to the application's Rated speed setting. When deselected, the turbine speed ramps down to the application's Idle speed setting (as defaulted in the Service Mode).

The Idle/Rated function can be used with any 505E start mode (manual, semiautomatic, automatic). When a RUN command is issued, the speed setpoint will ramp from zero RPM up to and hold at the 'Idle Setpt' setting. When a ramp-to-rated command is given, the speed setpoint ramps to the 'Rated Setpt' setting 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 505E 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 505E's 'Idle Priority' and 'Use Ramp to Idle Function' Service mode settings can be configured to change the defaulted idle/rated logic.

Ramp to Rated Feature

The Idle/Rated function can be changed to a 'Ramp to Rated' function (see Service Mode). With this configuration, the speed 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.
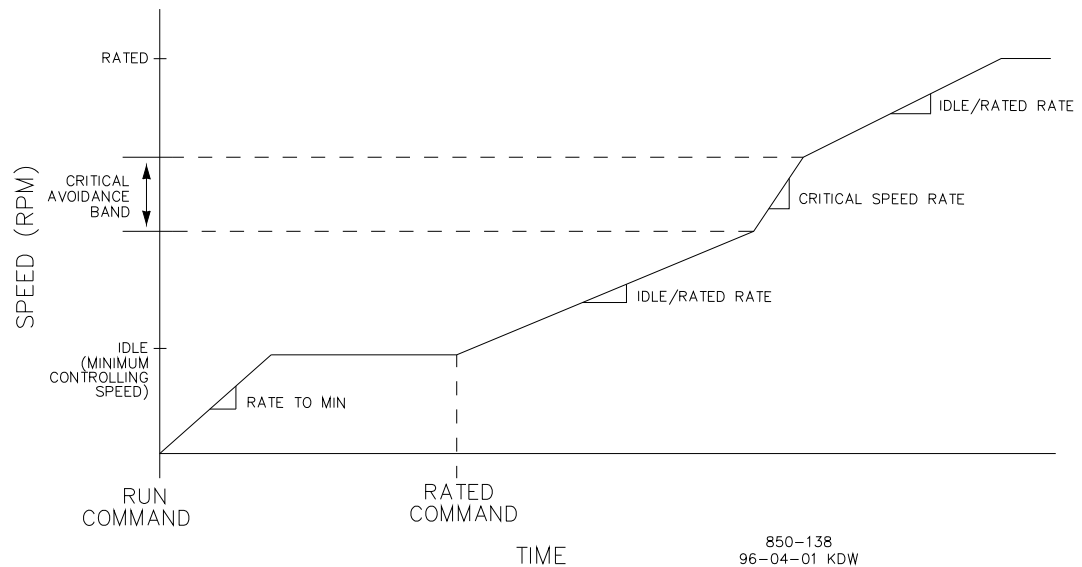
Figure 3-10. Idle / Rated Start

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

If a 505E 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 the Modbus links, refer to Chapter 6 for a complete listing.

Automatic Start Sequence

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

The 505E can be configured to utilize an Automatic Start Sequence to start the turbine. This sequencing logic allows the 505E 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), and is initiated by a 'RUN' command.

With this function, when a 'RUN' command is given, the Automatic Start Sequence ramps the speed setpoint to a low idle setpoint, holds at this setting for a duration, ramps the speed setpoint to a high idle setpoint, holds at this setting for a duration, then ramps the speed setpoint to a rated speed setting. All ramp rates and hold times are programmable for both hot start and cold start conditions. The control differentiates between hot and cold starts by using a hours-since-trip timer. This timer starts when a shutdown has been executed and turbine speed has decreased below the low idle speed setting.
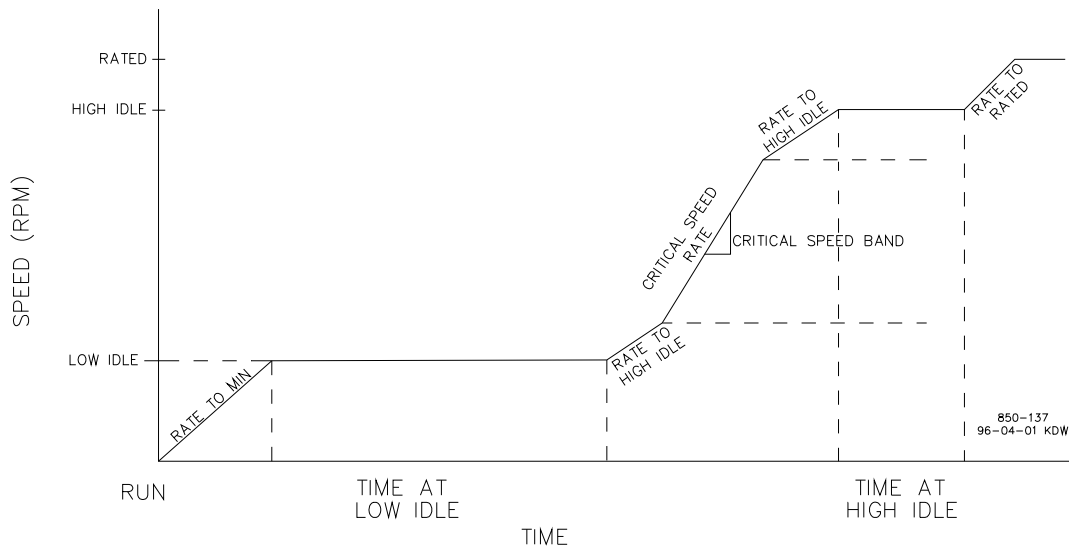
Figure 3-11. Automatic Start Sequence

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

If a turbine 'RUN' 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
LOW IDLE DELAY (HOT)	= 10 MIN
HI IDLE SETPT	= 2000 RPM
RATE TO HI IDLE (COLD)	= 5 RPM/SEC
RATE TO HI IDLE (HOT)	= 15 RPM/SEC
HI IDLE DELAY TIME (COLD)	= 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 505E 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 505E would use the Hot Start parameters. If the unit was tripped for 22 hours or longer and restarted, the 505E 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.

IMPORTANT | **The 505E 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 505E keypad, 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 505E keypad or through Modbus communications. When the sequence is halted, the delay timers do not stop if they have already started counting down. The sequence will resume when a Continue command is issued. If there were 15 minutes remaining to hold at an idle speed and the Halt command was issued for 10 minutes before 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 505E keypad, contact input, or Modbus. The last command given from any of these three sources determines the mode of operation. However, a shutdown condition will disable this function requiring it to be re-enabled after a start-up has been performed.

If a 505E 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. Alternatively, a relay can be programmed to indicate when the Auto Start Sequence is halted.

An option is available to automatically halt the auto start sequence at the idle setpoints. This feature would result in the unit automatically stopping or halting at the low idle setpoint and at the high 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

If neither the Idle/Rated or 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 or two MPUs or proximity probes. The 'MPU Gear Ratio' and the 'Teeth Seen By MPU' settings are configured to allow the 505E to calculate actual turbine speed. One MPU and one proximity probe 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 both inputs. The 505E'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).

> **IMPORTANT**
>
> **The 505E is factory set (jumpers installed) to interface with passive MPUs, if proximity probes are used, the jumpers must be changed (see Chapter 2 for jumper options).**
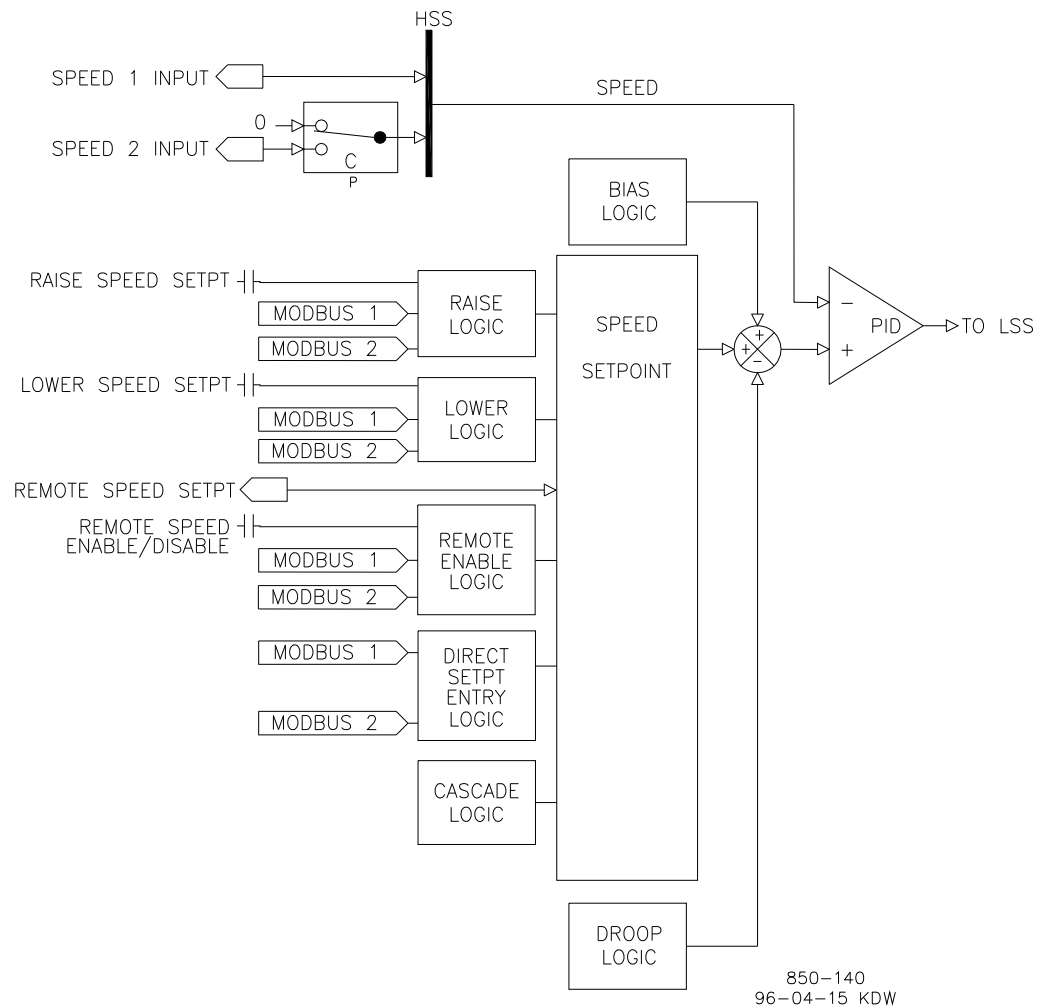
Figure 3-12. Speed Control Functional Diagram

Speed PID Operational Modes

The Speed PID operates in one of the following modes, depending on configuration and system conditions:
1. Speed Control
2. Frequency Control
3. Unit Load Control (droop)
    *   Turbine HP and LP valve position control
    *   Generator Load control

Speed Control

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

While in the Speed Control mode, the Speed PID will control a turbine at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). With this configuration, no form of droop or second controlling parameter is used by the PID for stability or control. Refer to Figure 3-13.

All pertinent speed control parameters are available through Modbus communications. See Chapter 6 for a list of all Modbus parameters.
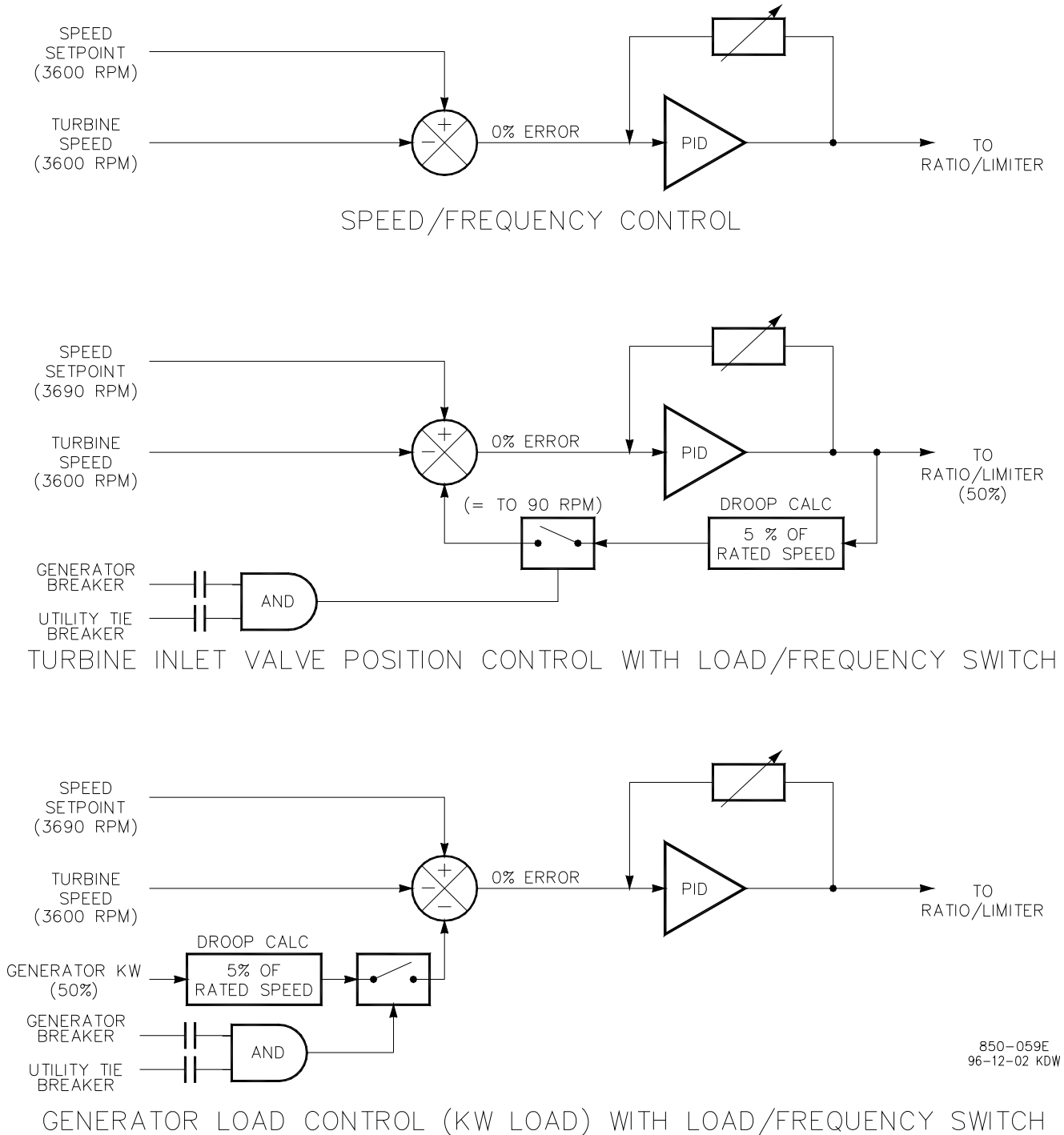
Figure 3-13. Speed PID Control Modes

Frequency Control

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

The Speed PID operates in a Frequency control mode when the generator breaker is closed and the utility tie 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). Refer to Figure 3-13.

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 can be programmed to energize when the unit is in Frequency control.

Unit Load Control

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

Giving the Speed PID two parameters to control allows it to control unit load and act as a stabilizing effect for any change in bus frequency. With this configuration, when bus frequency decreases or increases, unit load increases and decreases respectively, based on the unit's droop setting. The net effect is a more stable bus. See Figure 3-14 for a frequency and load relationship diagram.

The term "droop" was derived from an isolated unit's speed reaction to an increase in load when another parameter (unit load) is fed back to a Speed PID's summing junction. The Droop term, as used throughout this manual refers to a PID's second controlling parameter. A second parameter representing unit load is fed back into the 505E's Speed PID to allow it to control two parameters; speed when operating in an isolated mode, and unit load when paralleled to an infinite bus. See Figure 3-13.
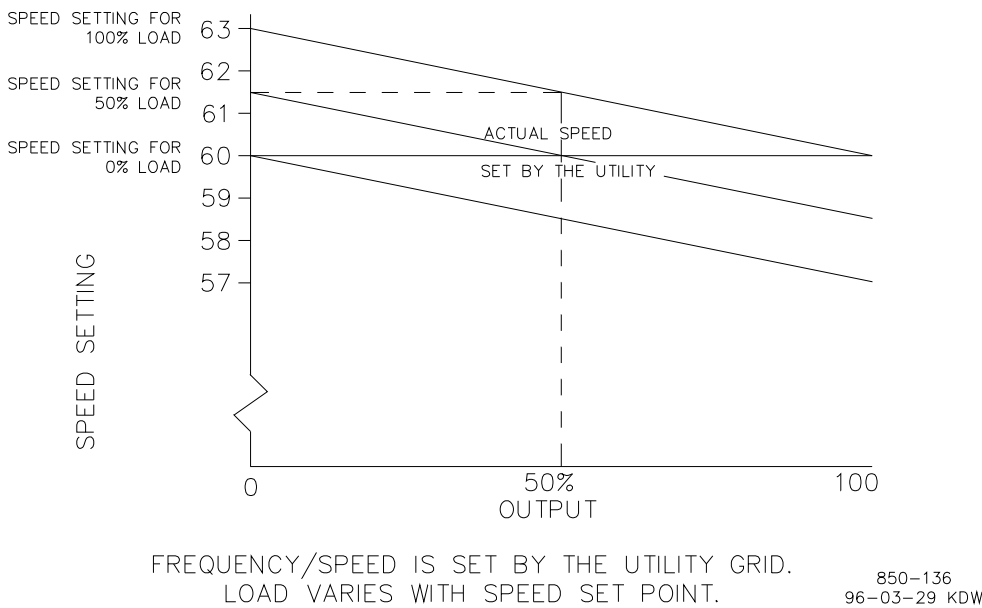
Figure 3-14. Frequency and Unit Load Relationship

Because the 505E'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 systems which do not have droop or loadsharing capability. When a turbine generator set is paralleled with a utility bus, the utility determines the unit frequency/speed, thus the 505E must control another parameter.

The 505E 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.

It is recommended that a Woodward Real Power Sensor or equivalent watt transducer be used to sense generator load and feed it back to the 505E's kW input for kW droop control. However, if kW droop is not used or programmed, the 505E 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 505E will issue an alarm and revert to its internal calculated load value.

> **IMPORTANT**
>
> **When using one of the Ratio/limiter's decoupled modes it is recommended that kW droop not be used. Since unit power is effected by the position of both valves, using kW droop would reduce the desired decoupling action.**

To configure the 505E for generator load control when paralleled to a infinite bus, program the 'kW DROOP' setting to 'YES', and program the 505E to accept an analog input from a Watt transducer sensing generator load. To configure the 505E 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 505E is programmed to control unit load using turbine valve positions, the 505E 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.

Speed Setpoint

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

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.
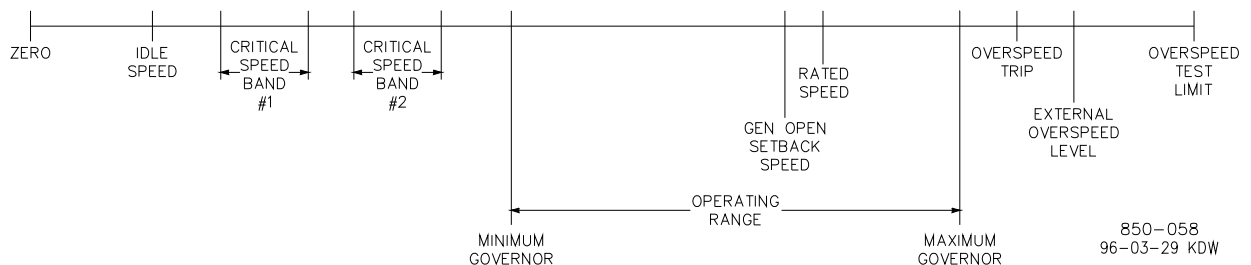
Figure 3-15. Speed Relationships

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 is 120 milliseconds (240 milliseconds for a 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 Modbus).

The speed setpoint may be set to a specific level, by directly entering a setpoint value through the 505E keypad or Modbus communications. To enter a specific setpoint from the 505E keypad, press the SPEED key to view the speed control screen, press the ENTER key, enter the setpoint level desired, then press the ENTER key again. If a valid number was entered, the setting will be accepted and the Speed setpoint will ramp to the "entered" setpoint level. If an invalid number is "entered" the setting will not be accepted and the 505E's screen will momentarily display a value out-of-range message.

After a valid setpoint value is entered and accepted, the setpoint will ramp at the speed setpoint slow rate (defaulted setting) 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 under the Service mode's "Speed Control Settings" header.

When using the ENTER key from the front panel keypad, the 505E 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 505E 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 which interfaces to the 505E discretely. 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 505E to reduce the chance of reverse powering a unit upon closing the generator breaker. With the utility tie breaker closed, when a generator breaker closed indication is received, the Speed setpoint is stepped to the Minimum Load setting. The Minimum Load setting is defaulted to a 3% (changeable in the Service Mode). To disable the use of the Minimum Load Setpoint, configure the 'Use Min Load' setting (under the Service mode's 'BREAKER LOGIC' header) to 'No'.

See Chapter 6 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 other type of loadsharing 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. 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 baseloaded mode. Frequency control can be armed or disarmed while connected to an isolated or infinite bus, however, when Armed, a unit will switch to Frequency control if the plant-to-utility tie breaker opens. When Disarmed, a unit will stay in a unit-load control mode when the plant-to-utility tie breaker opens.

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

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

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

If the 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 505E is configured for a generator application, the utility tie and generator breakers determine which set of dynamics is used by the Speed PID. The speed PID's off- line dynamics are selected when either the utility tie or generator breakers are open. The Speed PID's on-line dynamics are selected if both breakers are closed (see Table 3-1).

When not configured for a generator application, the 505E 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' setting . (see Table 3-1).

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

*The contact input option has priority, when programmed.

Table 3-1. 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 (under REMOTE SPEED SETTINGS), 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 in-control of the 505E'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 505E keypad, external contact or Modbus. The last command given from any of these three sources dictates the enabled/disabled state. It does not matter whether the last command was given from the keypad or other devices.

A contact input can be programmed to perform as an external "Remote Speed 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 re-closed 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 inhibited 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 (505E front panel screen 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 enabled. The input signal has failed, a controlled stop is selected, the unit is shut down, or RSS is not programmed.

When enabled, the Remote Speed 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 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.

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

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

Synchronization

Automatic generator synchronization can be performed through a Woodward Digital Synchronizer & Load Control (DSLC). The DSLC connects to a 505E analog input to bias the 505E'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 505E 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 which interfaces to the 505E discretely. This Sync rate is defaulted to two RPM/SEC and is only adjustable through the 505E'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 505E must be configured to accept the DSLC's analog Speed Bias signal and have this input enabled. A 'Sync Enable' contact input or function key (F3 or F4) can be programmed to enable the 505E's synchronizing input when synchronization is desired. The Sync Enable command becomes disabled when the generator breaker closes, however, it may re-enabled again to allow the DSLC to perform tie breaker synchronizations. To re-enable this input the 'Sync Enable' contact must be opened and re-closed. Typically a double pole single throw (DPST) switch is used on a site's synchronizer control panel to select automatic synchronizing by enabling both the DSLC sync mode and 505E analog input at the same time.

To configure the 505E to utilize a DSLC for generator synchronization only, program the 'Synchronizing input' function to the 'ANALOG INPUT #6' setting and program the 'Sync Enable' function to a 'CONTACT INPUT X' setting. Analog Input #6 is isolated and is the only input directly compatible with the DSLC's output signal. The 'Synchronizing input' function has preset range and gain settings that are tunable only 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. See Volume 2 of this manual or Woodward manual 02007 for more information on applying the DSLC.

When programming a Function Key (F3 or F4), instead of a contact input, to enable the 505E's analog Synchronizing input, a 505E relay output can also be programmed to select a DSLC's synchronizing mode.

To configure the 505E for this functionality, program the 'Sync Enable' function to a 'FX KEY PERFORMS' setting, and the 'Sync Enabled' function to a 'RELAY X ENERGIZES ON' setting.

When the 505E is programmed to use the DSLC for Synchronization, the RMT key can also be used to access and enable the Synchronizing function and monitor all synchronization mode messages. See Chapter 5 for information on how to enable this function through the RMT key. By pressing the RMT key and scrolling up or down through the RMT screens, the following synchronizing mode messages can be viewed:

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 / Loadsharing

A Woodward Digital Synchronizer & Load Control (DSLC) is used with a 505E 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 505E's internal speed/load setpoint. The Utility Tie Breaker Contact is used to select unit load control through the DSLC or through the 505E's internal load setpoint. When the 505E'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 505E via its Speed Bias signal. To configure the 505E to utilize a DSLC for generator synchronizing and load sharing, program the 'Sync/Load Share input' function to the 'Analog Input #6' setting and program the 'Sync/Ld Share Enable' function to a 'Contact Input #X' setting. Analog Input #6 is isolated, and the only input directly compatible with the DSLC's output 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 Tie Breaker contact, Generator Breaker contact, and Sync/Ld Share Enable contact define the state of the 505E's synchronizing and loadsharing operating modes (See Table 3-2).

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

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

When using the 'Sync/Ld Share Enable' contact input, it only enables or disables the 505E'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 505E 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 a Function Key can be programmed to enable the 505E's synchronizing mode.
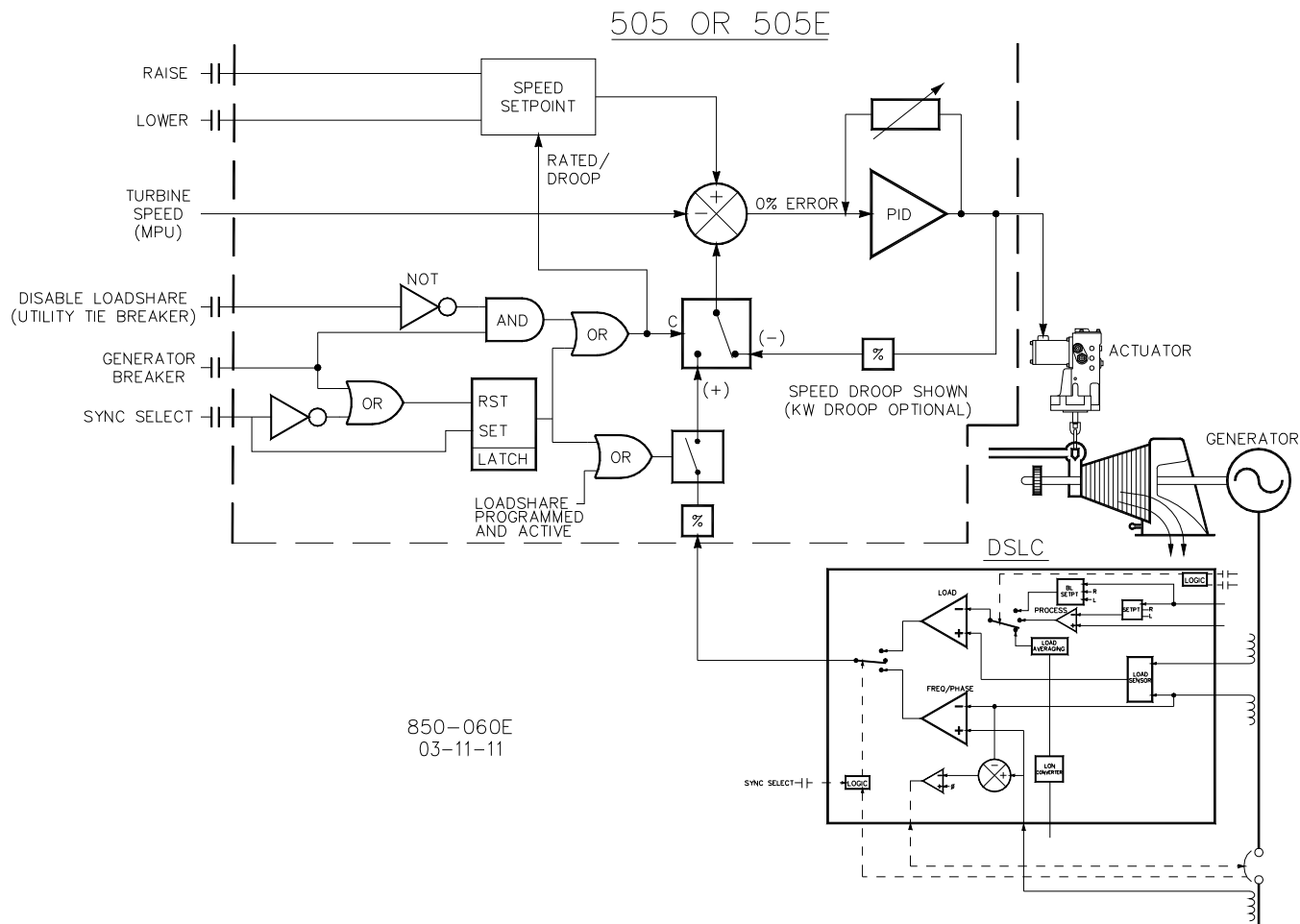
Figure 3-16. Loadsharing Logic

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 3-2. Load Sharing Logic

When the 505E is programmed to use the DSLC for Synchronization and Load Sharing, the RMT key can be used to access and enable the Sync/Load Share function and monitor all function mode messages. See Chapter 5 for information on how to enable this function through the RMT key. By pressing the RMT key and scrolling up or down through the RMT screens, 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 loadsharing parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Extraction and/or Admission Turbine Control

The Extr/Adm PID accepts a 4 to 20 mA current signal from terminals 55, 56, and 57 (Analog Input #1) 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. The Ratio/Limiter receives input signals from the Speed LSS and Extr/Adm control PIDs. The ratio logic ratios these signals, based on the turbine performance parameters, to produce two output signals, one to control the HP valve and one to control the LP valve. The limiter logic keeps the outputs to the valves within the boundaries of the turbine steam map.
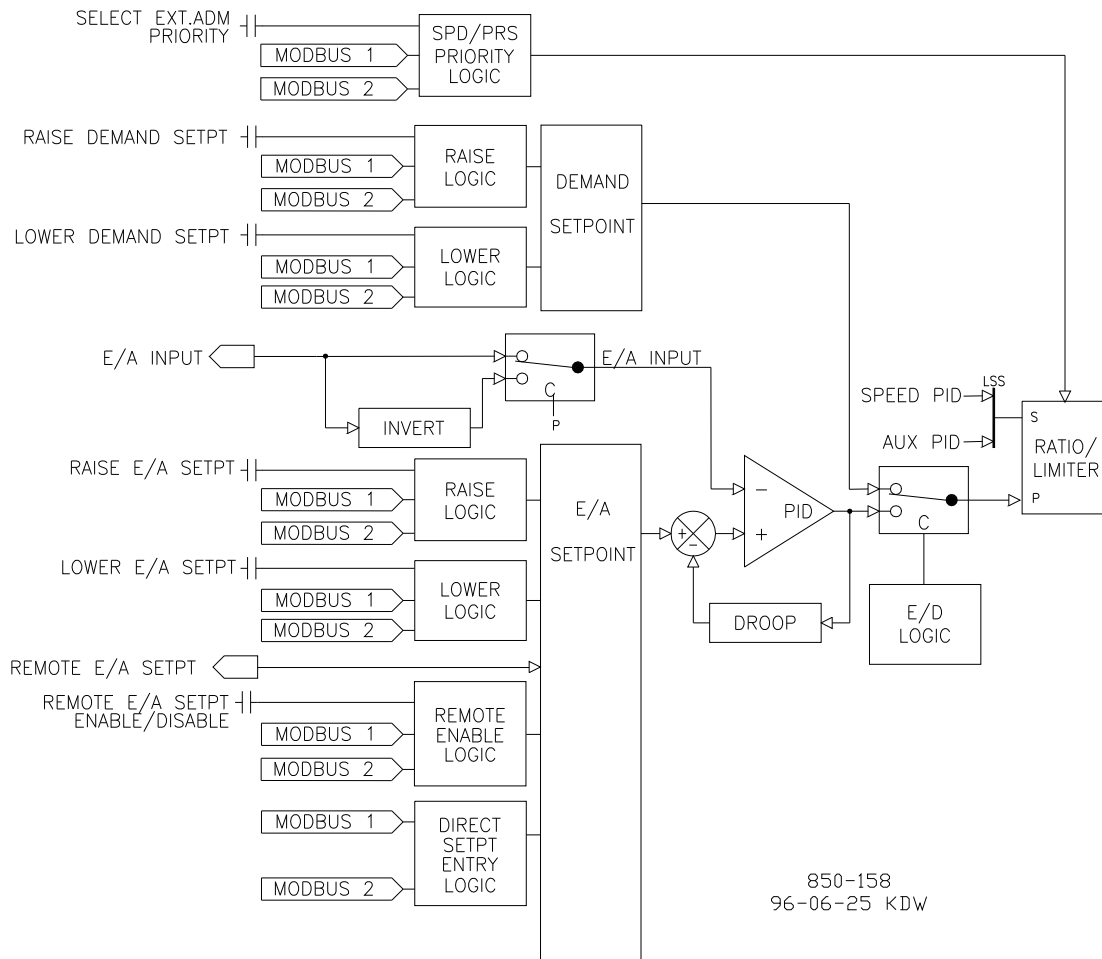
Figure 3-17. Extr/Adm Control Diagram

EXTR/ADM Input

Depending on the control action required, the Extr/Adm 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 Extr/Adm input signal during operation, the 505E can be programmed to trip, continue running and ramp the LP valve to its open limit, or continue running and ramp the LP valve to its closed limit. When a failed input is sensed the LP valve limiter steps to the LP valve's last position, then ramps at a 1% per second rate to its min or max limit, depending on the programmed settings. The 505E senses an input failure and issues an alarm if the 4–20 mA Extr/Adm input signal goes below 2 mA or above 22 mA.

Extraction Control

Extraction control can be automatically or manually enabled and performed after one of the 505E's three starts have been accomplished, 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 HP and LP valve limiters should normally both be fully open. If the HP valve limiter is not fully opened, it will act as a speed/load limiter and will interfere with automatic governor operation.

When configured for Extraction control the 505E's LP valve limiter is high signal selected with the output of the Ratio/Limiter. Because the LP valve limiter is automatically ramped to 100% during system start-up the LP valve cannot be controlled below its 100% open position. All related Extraction enable permissives must be met before the 505E will allow the Extr/Adm 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 uses the LP 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 Extraction enabling programmed, an operator can also enable and disable Extraction control manually if desired.

Manual Enable / Disable

To manually enable Extraction control slowly lower the LP valve limiter until the Extr/Adm PID takes control of its process, then continue running the LP valve limiter to its minimum (closed) position. If the LP valve limiter is not fully closed, it will act as an extraction limiter and will interfere with automatic governor operation. All related Extraction permissives must be met before the 505E will allow the LP valve limiter to be lowered, and Extr/Adm control enabled.

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

Automatic Enable / Disable

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

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

The 505E only accepts an Extraction enable command if all related permissives are met (see above list). An enable/disable command may be given from the 505E keypad, 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 505E 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.

To enable and disable Extraction control from the 505E's keypad, press the Ext/Adm key to view the Extr/Adm control screen, then press the Scroll Down key once to display the Extraction Status Screen. At this point press the "Yes" key to enable the function, or press the "No" key to disable the function.

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

The LP valve limiter may be stopped at any time during the automatic disabling routine by momentarily issuing a LP 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 Extr/Adm PID with Admission or Extraction/Admission applications is the same. In all cases it is assumed that an external trip valve or a trip-and- throttle valve is used to completely stop any admission steam from entering the turbine upon a system shutdown condition.

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

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

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

All the functions required to bumplessly enable and disable Adm or Extr/Adm control can be performed through the 505E keypad, contact inputs, or Modbus. To perform the above procedure from the 505E's keypad, press the Ext/Adm key to view the Extr/Adm control screen (adjust setpoint), press the Scroll Down key to display the "Extr/Adm Demand" screen (adjust to match pressures), then press the Scroll Up key to display the Extr/Adm Status screen (press the "Yes" key to enable the function).

The 505E 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 505E keypad, 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 505E 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:
1. Disable Adm or Extr/Adm control. (At this point the Extr/Adm Demand setpoint will step to the Extr/Adm PID's last position, take control of the process from the PID, then ramp back to the setting that was used to enable Extr/Adm control. This setting should be at or close to the zero flow level.)
2. If necessary manually adjust the Demand setpoint to reach zero Extr/Adm flow.
3. Close the Extr/Adm Trip-and-Throttle valve.

EXTR/ADM Control Status Messages

*   Disabled—Extr/Adm control is not enabled and will have no effect.
*   Enabled—Extr/Adm 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—Extr/Adm has been enabled but the turbine is on a operating limit with Speed
*   Priority selected or the LP valve limiter is limiting Extr/Adm PID output.
*   In Control—Extr/Adm PID is in control of its process.
*   Active w/Rmt Setpt—Extr/Adm has been enabled and the Remote Extr/Adm setpoint is in control of the setpoint but the turbine is on a operating limit with Speed Priority selected or the LP valve limiter is limiting Extr/Adm PID output.

- Control w/Rmt Setpt—Extr/Adm is in control and the Remote Extr/Adm setpoint is positioning the Extr/Adm setpoint.
- Inhibited—Extr/Adm cannot be enabled; the Extr/Adm input signal has failed, a controlled stop is selected, or the unit is shut down.

EXTR/ADM Dynamics

The Extr/Adm PID uses its own set of dynamic settings. These values are programmable and may be tuned at any time. Refer to Chapter 5 of this manual for information on Extr/Adm PID Dynamic Adjustments.

EXTR/ADM Droop

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

PID OUTPUT % x 'EXTR/ADM DROOP %' x 'RATED EXTR/ADM SETPOINT' x 0.0001

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

The 'Rated Extr/Adm Setpoint' is defaulted as the 'Max Extr/Adm Setpoint' and can be adjusted in the Service Mode. The 'Extr/Adm Droop %' and 'Max Extr/Adm Setpoint' values are set in the Program Mode and the 'PID output %' is determined by the Extr/Adm demand.

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

EXTR/ADM Setpoint

The Extr/Adm setpoint may be adjusted from the 505E keypad, external contacts, Modbus commands, or through a 4–20 mA analog input signal. A specific setting can also be directly entered from the 505E keypad or through Modbus commands.

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

When a raise or lower Extr/Adm Setpoint command is issued, the setpoint moves at the programmed 'Extr/Adm Setpt Rate' setting. If an Extr/Adm raise or lower command is selected for longer than three seconds, the Extr/Adm setpoint will move at the fast rate which is three times the Extr/Adm setpoint rate. The Extr/Adm 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 Modbus command). If the Extr/Adm 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 505E keypad or Modbus communications. When this is performed, the setpoint will ramp at the 'Extr/Adm Setpt Rate' (as defaulted in Service mode). To "enter" a specific setpoint from the 505E keypad, press the Ext/Adm key to view the Extr/Adm control screen, press the ENTER key, enter the setpoint level desired, then press the ENTER key again. If a valid number was entered, equal-to or between the min and max setpoint settings, the setting will be accepted and the Extr/Adm setpoint will ramp to the "entered" setpoint level. If an invalid number is "entered", the setting will not be accepted and the 505E's screen will momentarily display a value out-of-range message.

When ramping to a valid setting, the setpoint ramps at the Extr/Adm Setpoint "entered" rate which is defaulted to the E/A setpoint rate. This "entered" rate is tunable through the Service mode.

EXTR/ADM Setpoint Tracking

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

To reduce the number of steps required to enable Extr/Adm control bumplessly, the Extr/Adm setpoint can be programmed to track the Extr/Adm process input when disabled. This tracking feature allows the Extr/Adm PID to be satisfied when enabled, thus there is no immediate or radical process correction required. After the Extr/Adm 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 505E 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.

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

Remote Extr/Adm Setpoint

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

The Remote Extr/Adm Setpoint range is determined by the programmed analog input's 4 mA and 20 mA settings. The Remote Extr/Adm 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 Extr/Adm Setpoint may not match the Extr/Adm setpoint. In this case, the Extr/Adm setpoint will ramp to the Remote Extr/Adm Setpoint value at the programmed 'Extr/Adm Setpoint Rate' setting (as defaulted in the Service mode). Once matched, the fastest the Remote Extr/Adm Setpoint can move the Extr/Adm setpoint is limited by the programmed 'Rmt Ext/Adm Setpt Max Rate' setting. If the 'Rmt Extr/Adm Setpt Max Rate' were set at 10 and the Remote Extr/Adm Setpoint analog input instantly moved from 0 units to 1000 units, the Extr/Adm setpoint will move to 1000 units at 10 units/sec.

If the milliamp signal to the Remote Extr/Adm Setpoint input is out of range (below 2 mA or above 22 mA) an alarm will occur and the Remote Extr/Adm 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 Extr/Adm Setpoint may be in one of the following states (505E front panel screen messages):
- Disabled—The Remote Setpoint function is disabled and will have no effect on the Extr/Adm 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 Extr/Adm PID is not in control.
- In Control—The Remote Setpoint is in control of the Extr/Adm setpoint, and the Extr/Adm PID is in control.
- Inhibited—Remote Setpoint cannot be enabled; Remote Setpoint input signal is failed, Extr/Adm input signal is failed, or a controlled stop is selected.

Remote EXTR/ADM Enable Logic

There are three different options for enabling Remote Extr/Adm Setpoint and Extr/Adm control. They are as follows:
- One Remote Enable contact input or function key command programmed
- Both the Remote Extr/Adm Enable and Extr/Adm Enable commands programmed
- No enable commands programmed

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

A contact input can be programmed to enable and disable the Remote Extr/Adm 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 505E 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 Extr/Adm Enable and Extr/Adm Control Enable commands are programmed, each function is enabled by its respective command selection. If Remote Extr/Adm Enable is selected, only the Remote Extr/Adm Setpoint will be enabled. If Extr/Adm Control Enable is selected, only Extr/Adm control will be enabled. If Remote Extr/Adm Disable is selected, only the Remote Extr/Adm Setpoint will be disabled. If Extr/Adm Control Disable is selected, both Remote Extr/Adm control and Extr/Adm control will be disabled.

If no external contact input or function keys are programmed for the 'Enable' commands, Extr/Adm Control and Remote Extr/Adm Control must be enabled from either the front panel keypad or through Modbus. Since the front panel 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'.

To enable and disable the Remote Setpoint from the 505E's keypad, press the Ext/Adm key to view the Extr/Adm control screen, then press the Scroll Down key until the Remote Extr/Adm Status Screen is displayed. At this point press the "Yes" key to enable the function, or press the "No" key to disable the function.

Refer to Volume 2 of this manual for information on related Service mode tunables. All pertinent Remote Extr/Adm Setpoint parameters are available through the Modbus links. See Chapter 6 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 under the CASCADE CONTROL header).

Since Cascade is a secondary speed setting function, the Speed PID must be in control of the 505E's LSS bus in order for Cascade to take control. When the 505E 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 505E keypad, a contact input, or Modbus communications. The last command given from any of these three sources dictates the Cascade PID's control state.

If a contact input is programmed to function as a Cascade Enable contact, when the contact is open Cascade control is disabled, and when it is closed Cascade control is enabled. This contact can either be open or closed when a trip condition is cleared. If the contact is open it must be closed to enable Cascade control. If the contact is closed it must be opened and re-closed to enable Cascade control.
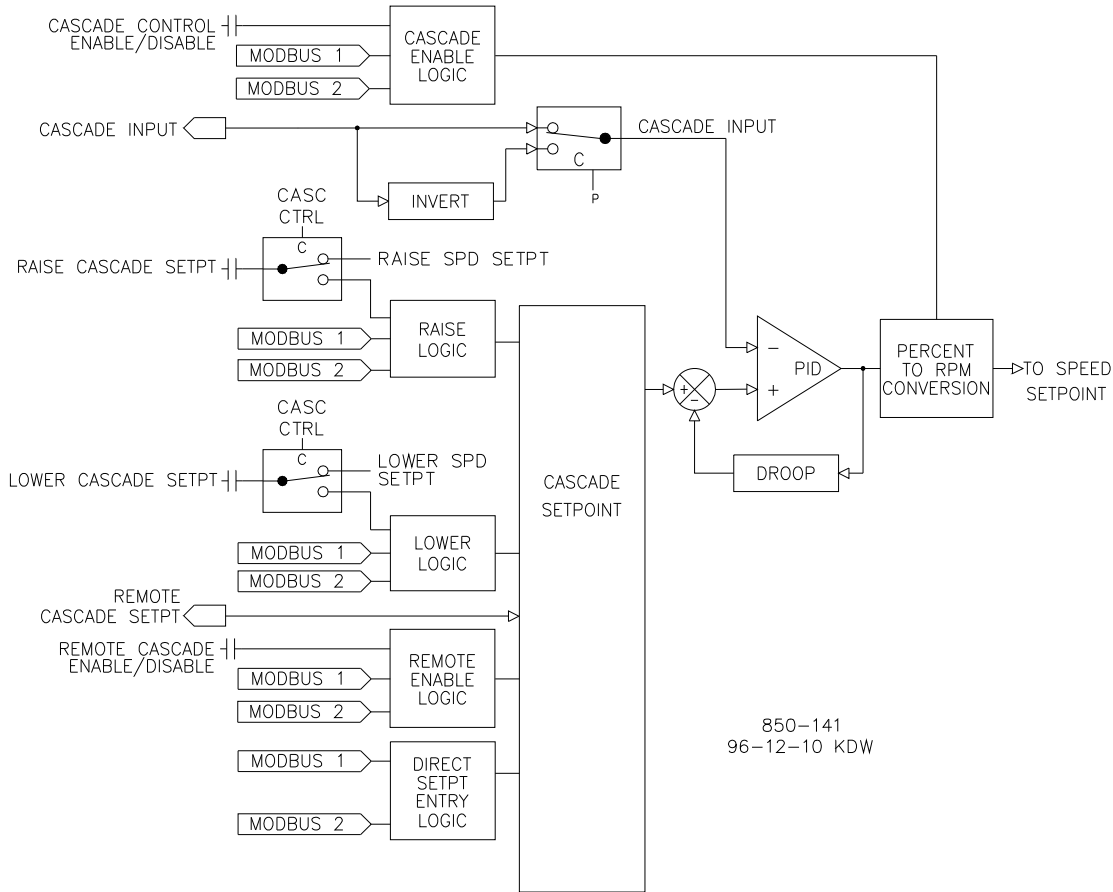
Figure 3-18. Cascade Functional Diagram

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 cannot be enabled; the Cascade input signal has failed, a controlled stop is selected, the unit is shut down, or cascade control is not programmed.

Cascade control is automatically disabled on a shutdown condition, and must be re- enabled after a successful system startup. Cascade control is disabled if Remote Speed Setpoint is 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 the Modbus links, refer to Chapter 6 for a complete listing of Modbus parameters.

Cascade Dynamics

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

Cascade Setpoint

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

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

When a raise or lower Cascade Setpoint command is issued, the setpoint moves at the programmed 'Casc Setpt Rate' setting. If a Cascade raise or lower command is selected for longer than three seconds, the Cascade setpoint will move at the fast rate which is three times the cascade setpoint rate. 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 a 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 Modbus).

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

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.

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

Invert Cascade

Depending on the control action required, the Cascade input signal can be inverted. If a decrease in 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 505E'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 Remote Cascade Setpoint (RCS) range is determined by the programmed Analog input's 4 mA and 20 mA settings. 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 505E keypad, contact input, or Modbus communications. The last command given from any of these three sources dictates enable/disable.

If the milliamp signal to the Remote Cascade 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 (505E front panel 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; input signal is failed, Cascade input signal is failed, a controlled stop is selected, the unit is shut down, or the remote cascade control is not programmed.

When enabled, the Remote Cascade setpoint may not match the Cascade setpoint. In this case, the Cascade setpoint will ramp to the Remote Cascade setpoint at the programmed 'Casc Setpt Rate' setting (as defaulted in the Service mode). Once in control, the fastest the Remote Cascade setpoint will adjust the Cascade setpoint is at the programmed 'Rmt Cascade Max Rate' setting. If the 'Rmt Cascade Max 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 and Cascade control as follows:
- One Remote Enable contact input or function key command
- Both enable commands programmed; Remote Casc Enable and Cascade Enable
- No enable commands programmed

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

A contact input can be programmed to enable and disable the Remote Cascade Setpoint (RCS) input/function. When this contact is open the RCS is disabled, and when it is closed the RCS is enabled. The contact can be either open or closed when a 505E 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. However, if before the Cascade PID was 'In-control', a Cascade disabled command is given, only Cascade control will be disabled.

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

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

Auxiliary Control

The Auxiliary PID controller can be used to limit or control generator power, plant import/ export power, turbine inlet pressure, turbine exhaust pressure, pump/compressor discharge pressure, or any other auxiliary parameters, directly related to turbine speed/load. The 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.
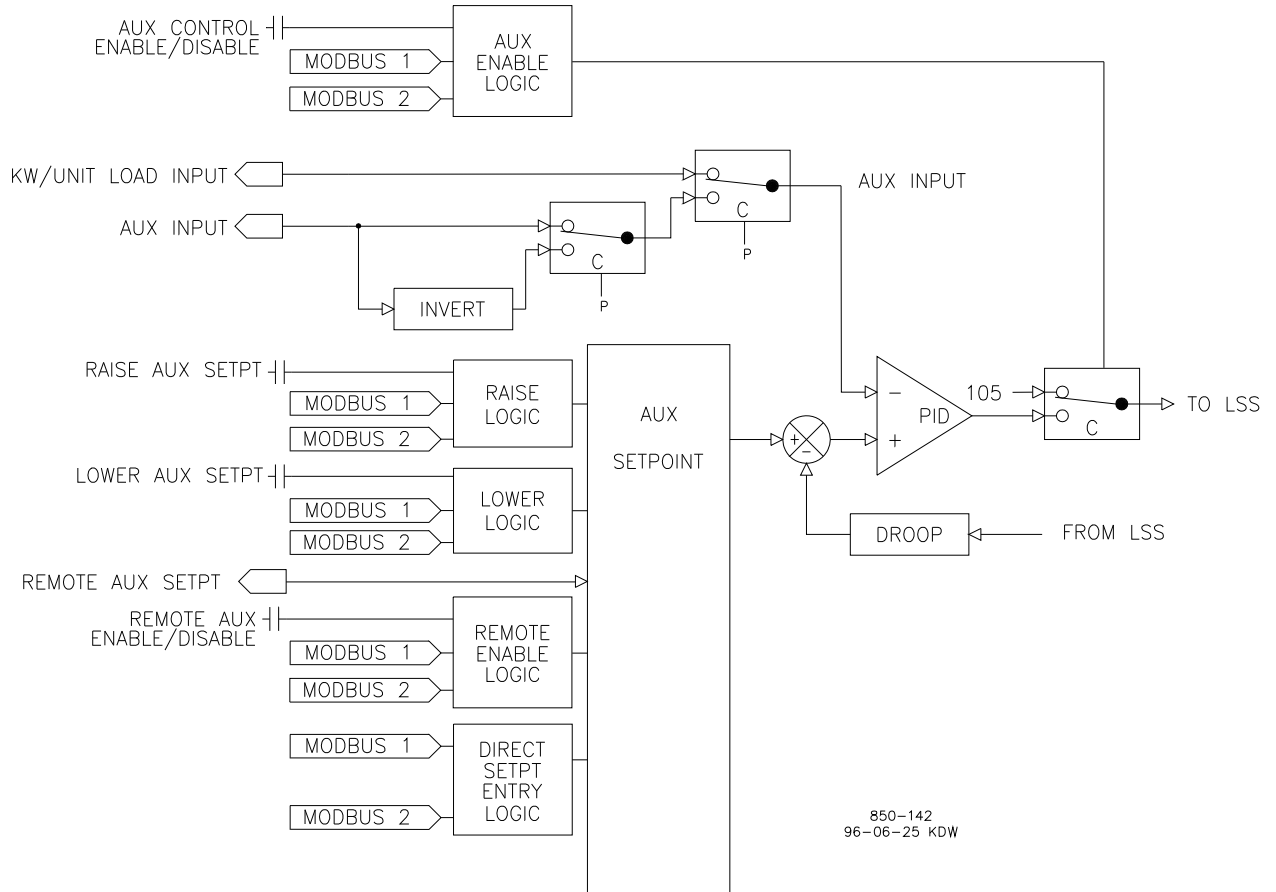
Figure 3-19. Aux Control Overview

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, the Speed PID tracks a few % above the Auxiliary PID's LSS bus signal. When the Auxiliary PID is disabled, its setpoint tracks the Auxiliary 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, 505E 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 505E keypad, remote contacts, or Modbus communications. The last command given from any of these three sources dictates which state the Auxiliary control is in. If an external Auxiliary Enable contact is programmed, disable is selected when the contact is open and enable is selected when it is closed. The contact can be either open or closed when a trip condition is cleared. If the contact is open, it must be closed to enable. If the contact is closed, it must be opened and re-closed to enable.

When configured as enable/disable controller, the Auxiliary control will automatically be disabled upon a shutdown condition. Auxiliary control will be disabled and inhibited when the 505E 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 505E keypad, external contacts,
Modbus commands, or through a 4–20 mA analog input. A specific setting can
also be directly entered from the 505E keypad 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 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 Modbus).

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

To enter a specific setpoint from the 505E keypad, press the AUX key to view the
Auxiliary control screen, press the ENTER key, enter the setpoint level desired,
then press the ENTER key again. If a valid number was entered, equal-to or
between the min and max setpoint settings, the setting will be accepted and the
Auxiliary setpoint will ramp to the "entered" setpoint level. If an invalid number is
"entered", the setting will not be accepted and the 505E's screen will momentarily
display a value out-of-range message.

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.

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

Remote Auxiliary 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 Remote Auxiliary Setpoint's range is determined by the analog input's 4 mA and 20 mA settings. 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 (505E front panel screen messages):
- 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 505E keypad, 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 when the 505E is in the RUN mode.

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

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

When only one Remote Enable command is programmed (either F-key or contact input), selecting 'Enable' will enable both Auxiliary control and Remote Auxiliary control. This configuration allows both functions to be enabled with one command. If '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 input or function keys are programmed for the 'Enable' commands, Auxiliary Control and Remote Auxiliary Control must be enabled from either the front panel keypad or from Modbus. Since the front panel and Modbus provide both Remote Auxiliary Enable and Auxiliary Control Enable commands, they will operate in the same manner as 'both enables programmed'.

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

Valve Limiters

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

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

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

The valve limiters also can be used to trouble shoot system dynamic problems. If it is believed that the 505E 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 505E keypad, contact input, 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 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 Modbus command).

To "enter" a specific setpoint from the 505E keypad, press the "LMTR" key to view the Valve Limiter screen, press the ENTER key, enter the setpoint level desired, then press the ENTER key again. If a valid number was entered, equal-to or between the min and max limiter settings, the setting will be accepted and the Valve Limiter will ramp to the "entered" level. If an invalid number is "entered", the setting will not be accepted and the 505E's screen will momentarily display a value out-of-range message.

A specific setpoint may also be directly entered from the 505E keypad, (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.

To adjust a limiter's level from the 505E's keypad, press the "LMTR" key to view the limiter screen. If the desired limiter (HP or LP) screen is not displayed press the Scroll Up/Down key to display it. Then press the Adjust Up/Down key as desired.

Min HP and LP Lift Limiters

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

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

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

Emergency Shutdown

When an Emergency Shutdown condition occurs, both 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 505E's front panel. Pressing the scroll down key from this screen will reveal any additional shutdown conditions that were sensed. See Chapter 5 for a detailed list of the possible shutdown (Trip) conditions.

Up to five Emergency Shutdown inputs (contact inputs) can be programmed to allow the 505E to indicate the cause of an emergency shutdown. By wiring trip conditions directly into the 505E, instead of a trip string, the 505E 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 505E's front panel and Modbus communications.

The cause of the last trip can also be seen by pressing the 'CONT' key, then pressing the Scroll Down key until the Trip Status Screen is displayed. The last trip indication, is latched-in and can be viewed at any time after a trip and before the next trip condition is latched in. Once latched-in the last trip indication cannot be reset. This allows an operator to confirm what the trip condition was hours or days after the unit has been reset and restarted.

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

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

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

Controlled Shutdown

The 505E's Controlled Shutdown function is used to stop the turbine in a controlled manner, as opposed to an Emergency Trip. When a STOP command (controlled shutdown) is issued the following sequence is performed:
1. All control PIDs and functions are disabled except the Speed and Extr/Adm PIDs.
2. The Extr/Adm control is disabled (the LP limiter is raised for Extraction applications).
3. The Speed Setpoint is ramped to zero at the speed setpoint slow rate.
4. After the Speed Setpoint reaches zero, the HP valve limiter is instantly stepped to zero.
5. When the valve limiter reaches zero, the 505E executes a Shutdown command.
6. A "TRIP / Shutdown Complete" message is displayed on the 505E front panel.

IMPORTANT	On generator applications, the 505E does not automatically issue a generator breaker open command upon reaching a min load level.

With the control in the run mode and the turbine turning, when the 505E's "STOP" key is pressed, the control will display a message prompting the operator to verify the command (Manual Shutdown ? / Push YES or NO). At this point if the "YES" key is pressed the control will perform the controlled shutdown sequence explained above. Pushing the "NO" key will cause, no change in the 505E's operation, and the 'CONTROLLING PARAMETER' screen will be displayed. This verification feature prevents an unwanted shutdown if the STOP key is accidentally pushed.

A controlled shutdown can be initiated or aborted from the 505E front panel, a programmed contact input or either Modbus communication link. Verification is not required if a controlled shutdown command is initiated by a programmed contact input or Modbus communication link.

The controlled shutdown sequence can be aborted at any time. During a controlled shutdown sequence, by pressing the STOP key, the 505E will display a 'Manual Shutdown In Ctrl / Push NO to Disable' message. Pressing the "NO" key from this screen will cause the shutdown sequence to be aborted, and the control to display a 'Manual Shutdown Stopped / Push YES to Continue' message. At this point the shutdown sequence can be re-initiated when desired, or the unit can be brought back to a fully operational state.

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

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

IMPORTANT	This command can be disabled through the Service Mode, if desired (see Key Options). When disabled, the Controlled Stop feature is disabled from front panel, Modbus, and contact commands.

See Chapter 5 of this Volume for all 505E Service panel messages.

Overspeed Test Function

The 505E'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 505E'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 front panel of the control or with external contacts. This test is not permissible through the Modbus.

An overspeed test is allowed only under the following conditions:
- The Speed PID must be in control.
- The Auxiliary, Cascade, 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.

If the OSPD key is pressed or an external Overspeed Test contact is closed (if programmed) and the above conditions are not met the control will display a "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 the 505E's front panel OSPD key.

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

See Chapter 5 of this manual for a complete Overspeed Test Procedure. All pertinent overspeed test parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Local / Remote Function

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

The Local/Remote function must first be programmed before a Local or Remote mode can be selected by an operator. This function can be programmed under the OPERATING PARAMETERS BLOCK. If this function is not programmed all contact inputs and Modbus commands (when Modbus is programmed) are active at all times. If the Local/ Remote function is programmed, Local and Remote modes can be selected through a programmed contact input, programmed function key (F3, F4), or Modbus command.

When Local mode is selected, the 505E is defaulted to be operable from its front panel only. 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)
External trip 3 Contact In	(active at all times, if programmed)
External trip 4 Contact In	(active at all times, if programmed)
External trip 5 Contact In	(active at all times, if programmed)
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 505E can be operated through its front panel, contact inputs, and/or all Modbus commands.

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

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

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

All pertinent local/remote control parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Function Keys

Function keys F3 & F4 are located on the 505E's front panel. They can be programmed independently to function as a control panel switch. These keys allow functions to be enabled and disabled from the 505E's front panel, without requiring the use of an external switch. The following is a list of the programmable options for the function keys:

Local / Remote	Cascade Enable
Idle / Rated	Remote Cascade Setpoint Enable
Halt Continue Auto Start Seq	Auxiliary Enable
Remote Speed Setpoint Enable	Remote Auxiliary Setpoint Enable
Sync Enable	Relay Output
Frequency Control Arm / Disarm	Select Extr/Adm Priority
Extr/Adm Control Enable	Remote Extr/Adm Setpt Enable

A two step process is required to enable or disable any function. Pressing a programmed function key will cause the 505E's service panel to display the current state of the function and prompt the operator to press the YES or NO keys to enable or disable the function.

A function's prompt will change depending on the state of the function at that time. As an example, if the F3 key is programmed to allow an operator to enable and disable the 505E's Remote Speed Setpoint, when the F3 key is pressed a (Push Yes to Enable / Rmt Spd Setpt Disabled) message will appear on the front panel display. Pressing YES will enable the Remote Speed Setpoint function and the message will change to (Push No to Disable / Rmt Spd Setpt In Control).

Relays

The 505E has eight relay outputs available. Two of these relays are dedicated; one for a system shutdown command from the 505E and one for alarm indication. The other six relays can be programmed for a variety of indications, and system functions.

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

The dedicated Alarm relay is normally de-energized. This relay will energize upon an alarm condition and stay energized until the alarm condition is cleared. Optionally this relay can be configured through the 505E's Service mode, 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 of the other six relays can be programmed to function as a level switch or a mode or condition indication. When programmed as a level switch the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level). The following is a list of the 505E's relay options:

Speed	Auxiliary Input
Speed Setpoint	Aux Setpoint
Extr/Adm Input	Extr/Adm Demand
Extr/Adm Setpoint	First Stage Pressure
KW Input	HP Valve Demand
Sync/Load Share Input Level	LP Valve Demand
Cascade Input	HP Valve Limiter
Casc Setpoint	LP Valve Limiter

The present relay state (energized / de-energized) and relay configuration is indicated through both Modbus communication links.

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. The following is a list of options for relays if used to indicate a control mode or state:

Shutdown Condition	Sync Enabled
Trip Relay (additional trip relay output)	Sync / Load Shr Active
Alarm Condition	Load Share Control
505E Control Status OK	Casc Control Enabled
Overspeed Trip	Cascade Control Active
Overspeed Test Enabled	Remote Casc Setpt Enabled
Speed PID in Control	Remote Casc Setpt Active
Remote Speed Setpt Enabled	Aux Control Enabled
Remote Speed Setpt Active	Aux Control Active
Underspeed Switch	Auxiliary PID in Control
Auto Start Sequence Halted	Remote Aux Setpt Enabled
On-Line PID Dynamics Mode	Remote Aux Setpt Active
Local Control Mode	HP Valve Limiter in Control
Frequency Control Armed	LP Valve Limiter in Control
Frequency Control	F3 Key Selected
Extr/Adm Control Enabled	F4 Key Selected
Extr/Adm Control Active	Remote Extr/Adm Sept Enabled
Extr/Adm PID in Control	Remote Extr/Adm Sept Active

Steam Map Limiter in Control   Extr/Adm Priority Selected
Modbus Command   Extr/Adm Priority Active

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 505E initiated trip by setting the 'Ext
trips in Trip Relay' option to NO. Using this option, 505E trip annunciation will
only occur if the 505E tripped the turbine and not annunciate when the other
external devices shuts down the unit (external trips).

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

The 505E Control Status OK relay is normally energized, and will only de-
energize if unit input power is lost, the 505E's CPU fails, or the 505E is in the
program mode.

The Overspeed Test Enable relay will energize when an Overspeed Test is
performed. This relay functions like the 505E OSPD key's LED (it repeatedly
toggles on and off when turbine speed is above the turbine Overspeed trip
setting).

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

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

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

When the (F3,F4) Key Selected function is programmed, the assigned relay energizes when the respective function key is pressed and an enable/disable command issued. This feature allows the 505E's F3 and F4 function keys to be used as panel switches to select and/or enable system related functions (i.e. synchronizing).

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 505E 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" is issued (i.e. voltage raise/lower commands). Refer to Chapter 6 of this manual for more information on Modbus commands.

Chapter 4.
Configuration Procedures

Program Architecture
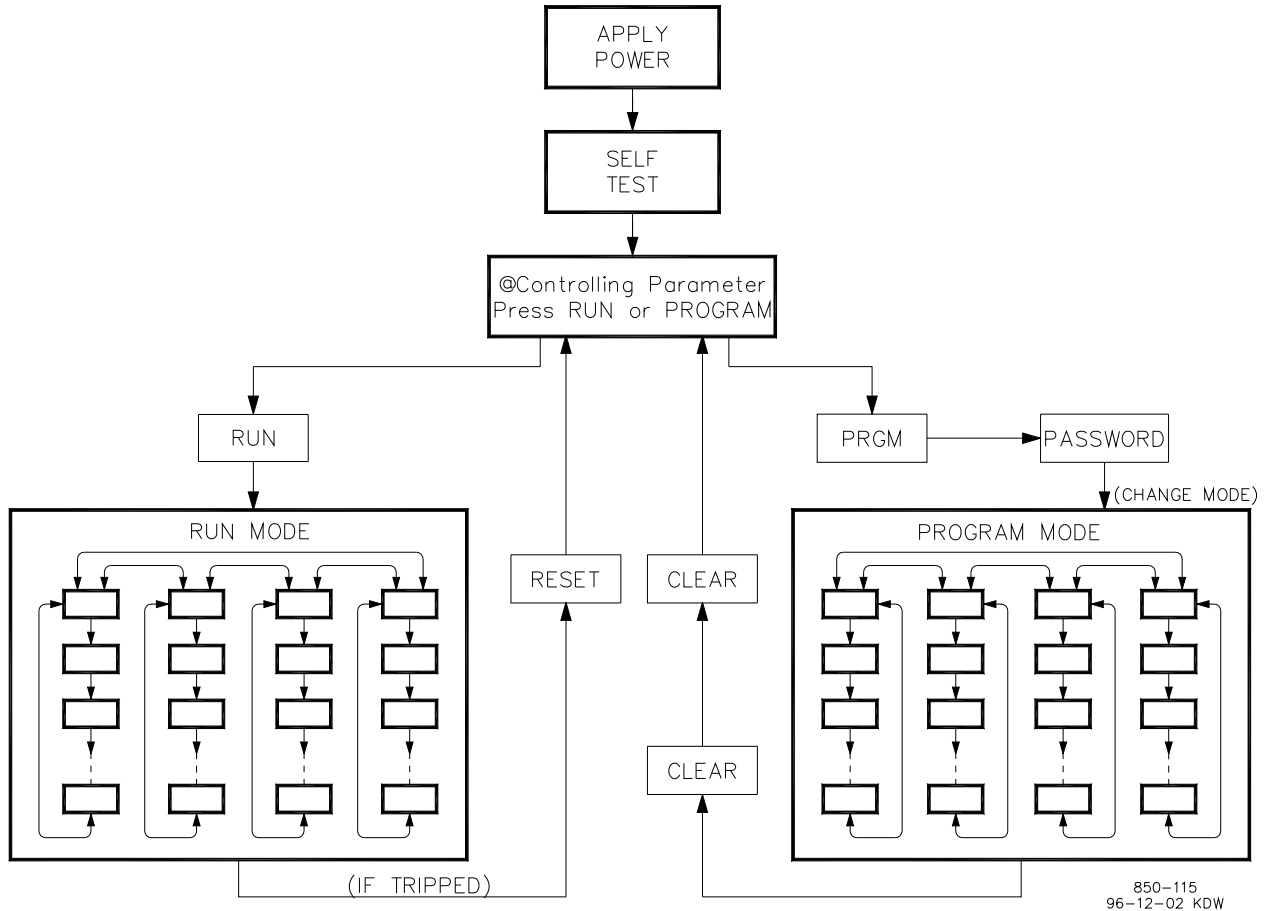
Figure 4-1. Basic Program Architecture

The 505E is easy to program, due in large part to the menu-driven software. Basic program architecture is illustrated in Figure 4-1. When the control is powered up, and after the brief CPU self test has been completed, the control displays a ready status (Controlling Parameter/Push Run or Program). The operating procedures are divided into two sections: the Program Mode (Figure 4-3) and the Run Mode (refer to Chapter 6 for RUN Mode information). The Program Mode is used to configure the 505E for the specific application and set all operating parameters. The Run Mode is the normal turbine operation mode and is used to view operating parameters and run the turbine.

The program cannot be changed or altered while the turbine is running, however, it can be accessed and all programmed values monitored. This minimizes the possibility of introducing step disturbances into the system. To monitor or review the program while in the run mode, simply press the 'PRGM' key then step across or step down as necessary. If a wrong key is pressed the display will revert to the last screen displayed before entering the program mode or the screen designated to the key pressed.
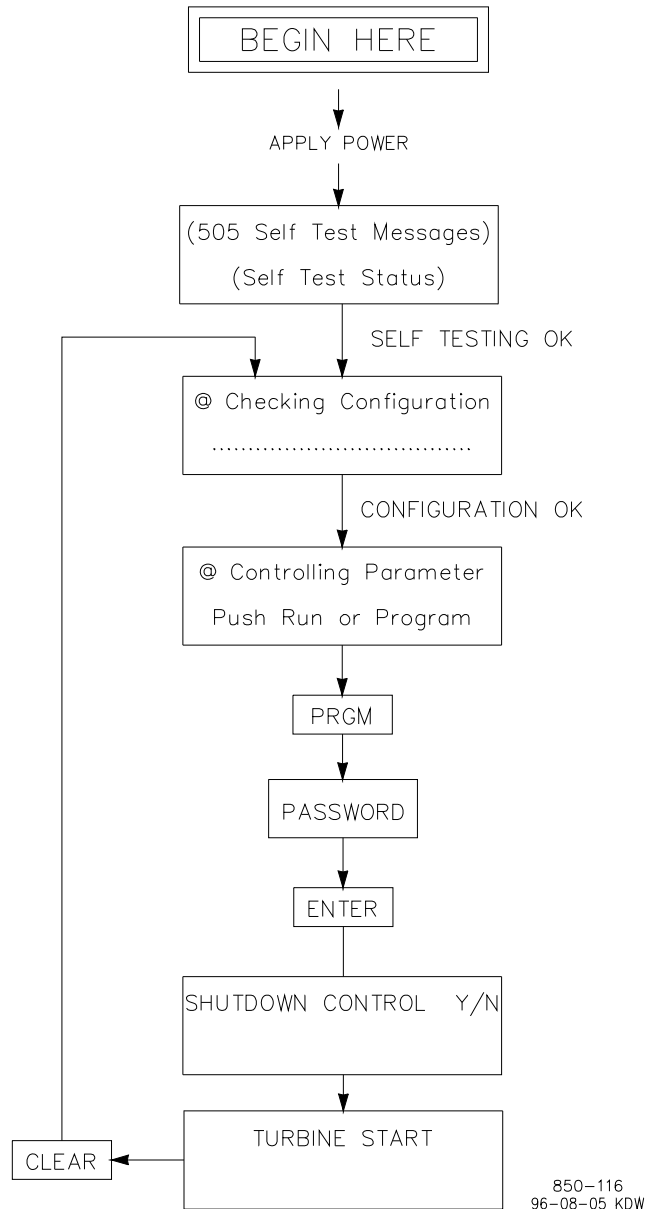
Figure 4-2. Initial 505E Program Mode Entry

The touch keypad has several dual-function keys. Pushing any dual-function key in the Program Mode enters the appropriate numeric or yes/no value printed on the key. Pushing the key in the Run Mode enters the operating parameter printed on the key, unless the "ENTER" key has been pressed to enter a specific numeric setpoint value.

Programming the 505E

Before the 505E can be used to operate any turbine, it must be configured with a valid program. A 505E Program Mode 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.

Figure 4-2 illustrates the 505E screens displayed when power is applied and how to enter the Program Mode from this point. The password is required to protect against both intentional and inadvertent program changes. The password can be changed if desired, refer to Volume 2 for information on changing passwords.

The 505E program mode (configuration) may be accessed once the configuration check is complete and the turbine is not running. For safety reasons the program may be monitored only and no changes will be accepted if the turbine is running. By pressing the PRGM key and entering the password (1113) then pressing ENTER on the 505E keypad the 'SHUTDOWN CONTROL Y/N' prompt will appear. If YES is pressed the 505E will issue a shutdown and the program mode will be accessed. If NO is pressed the 505E will revert to the Select Mode screen and the program mode will not have been accessed.

All configuration (program mode) values and saved service mode changes are stored in the nonvolatile memory (EEPROMS) of the 505E control. If power is removed from the 505E all saved values will return once power is restored. No batteries or back up power is required.

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

Using Program Menus

Once the Program Mode has been entered with the password, the specific application information must be entered into the 505E. Figure 4-3 illustrates the 505E configuration menus and the questions/options available under each header/column.

The arrow keys (SCROLL LEFT, SCROLL RIGHT) allow you to move right or left across the tops of the function the Program mode columns. The SCROLL UP and SCROLL DOWN keys allow you to move up or down the columns. In the Program Mode, the control will not step down beyond the current step with an invalid entry (or with no entry). A valid entry must be made before the control will allow you to step down to the next parameter.'

The control displays previously entered values with each program step. If a displayed value is satisfactory, press the SCROLL UP, SCROLL DOWN, or ENTER keys to continue. If a new value is required, enter it, then press ENTER. The ENTER key must be pressed to enter any new value. Also, when the ENTER key is pressed, the control will automatically advance to the next step.

To return to the header of a program block, press the CLEAR key. To completely exit out of the Program Mode, press the CLEAR key from the top of the header. This will save the programmed values and initiate the program configuration check procedure.

All steps in the program must contain valid entries. The default values are listed along with any adjustment ranges, where applicable. If an invalid entry is made, the control displays an invalid entry message. If ENTER is pressed, the control displays the program step again so a valid entry can be made.

Figure 4-3a. Program Mode Blocks

Figure 4-3b. Program Mode Blocks

C

D

TURB PERFORMANCE VALUES

USE DECOUPLING? — NO

YES

DECOUPLE INLET (HP)? — YES

NO

DECOUPLE EXHAUST (LP)? — YES

NO

DECOUPLE HP & LP? — NO / YES

MAX POWER

MAX HP FLOW

EXTRACTION ONLY? — NO

YES

USE AUTOMATIC ENABLE?

EXTRACTION ONLY? — NO

YES

USE AUTOMATIC ENABLE?

ADMISSION ONLY? — YES

NO

EXTRACTION & ADMISSION? — YES / NO

EXTRACTION ONLY? — NO

YES

USE AUTOMATIC ENABLE?

MAX POWER @ MIN EXTR

MAX HP FLOW @ MIN EXTR

MIN POWER @ MIN EXTR

MIN HP FLOW @ MAX EXTR

MIN POWER @ MIN EXTR

MIN HP FLOW @ MIN EXTR

ADMISSION ONLY? — NO

YES

MAX POWER @ MAX ADM

MAX HP FLOW @ MAX ADM

MAX ADMISSION FLOW

MIN POWER @ MIN ADM

MIN HP FLOW @ MIN ADM

MAX POWER @ MIN ADM

MAX HP FLOW @ MIN ADM

EXTRACTION & ADMISSION? — NO

YES

MAX POWER @ 0 EXTR/ADM

MAX HP FLOW @ 0 EXTR/ADM

MAX ADMISSION FLOW

MIN POWER @ MAX EXTR

MIN HP FLOW @ MAX EXTR

MIN POWER @ 0 EXTR/ADM

MIN HP FLOW @ 0 EXTR/ADM

EXTR/ADM DEMAND RATE

USE SETPT TRACKING

MIN HP LIFT (%)

MIN LP LIFT (%)

LP VALVE LIMITER RATE

SPEED **CONTROL** PRIORITY? — NO

YES

LP MAX LMT E/A PRIORITY

AUTO SWITCH E/A PRIORITY

DRIVER CONFIGURATION

ACT#1 (HP) IS 4-20 mA?

INVERT DRIVER OUTPUT?

USE ACT#1 FLT SHUTDOWN

ACT 1 (HP) DITHER (%)

ACT#2 (LP) IS 4-20 mA?

INVERT DRIVER OUTPUT?

USE ACT#2 FLT SHUTDOWN

ACT 2 (LP) DITHER (%)

CLEAR — TO EXIT THE PROGRAM MODE PUSH (CLEAR)

850-167
96-06-25 KDW

Figure 4-3c. Program Mode Blocks
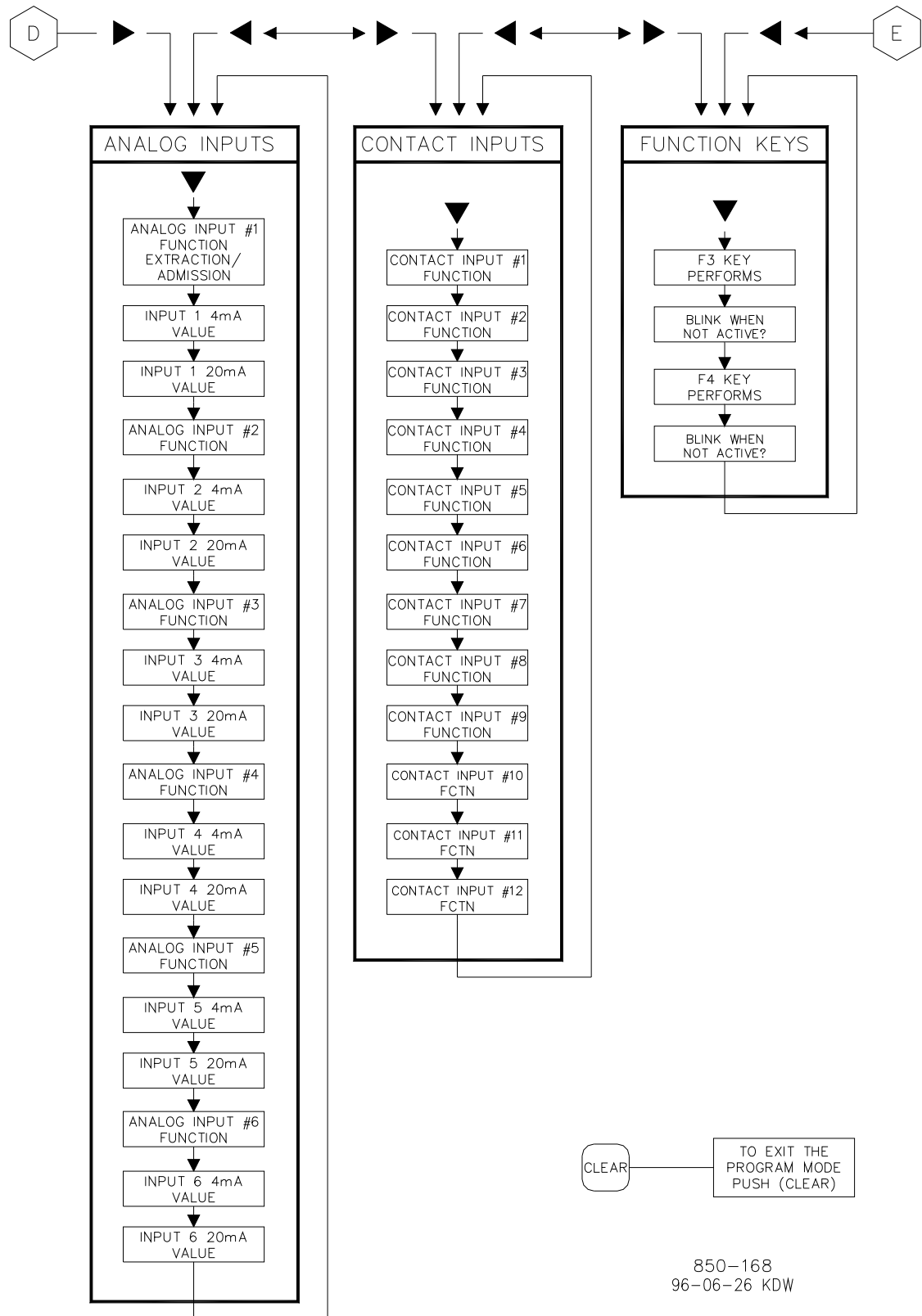
Figure 4-3d. Program Mode Blocks

```
  (E)──────▶┐  ┌──◀──────▶┐  ┌──◀──────▶┐  ┌──◀──────(F)

         AUXILIARY          CASCADE            READOUTS
          CONTROL           CONTROL

            ▼                  ▼                   ▼
          ┌─────┐           ┌─────┐        ┌──────────────┐
          ╱ USE  ╲   NO     ╱ USE  ╲  NO   │ANALOG READOUT│
         ╱AUXILIARY╲────▶  ╱ CASCADE╲────▶ │     1 IS     │
         ╲CONTROL? ╱       ╲CONTROL?╱      └──────────────┘
          ╲─────╱           ╲─────╱        ┌──────────────┐
            │YES               │YES        │  READOUT 1   │
      ┌──────────┐        ┌─────────┐      │ 4 mA VALUE   │
      │LOST AUX INPUT│    │  INVERT │      └──────────────┘
      │  SHUTDOWN?   │    │ CASCADE?│      ┌──────────────┐
      └──────────┘        └─────────┘      │  READOUT 1   │
      ┌──────────┐        ┌─────────┐      │ 20 mA VALUE  │
      │  USE KW  │        │MIN CASCADE│    └──────────────┘
      │  INPUT?  │        │  SETPT   │     ┌──────────────┐
      └──────────┘        └─────────┘      │ANALOG READOUT│
      ┌──────────┐        ┌─────────┐      │     2 IS     │
      │  INVERT  │        │MAX CASCADE│    └──────────────┘
      │   AUX?   │        │  SETPT   │     ┌──────────────┐
      └──────────┘        └─────────┘      │  READOUT 2   │
      ┌──────────┐        ┌─────────┐      │ 4 mA VALUE   │
      │ MIN AUX  │        │CASC SETPT│     └──────────────┘
      │  SETPT   │        │RATE (/SEC)│    ┌──────────────┐
      └──────────┘        └─────────┘      │  READOUT 2   │
      ┌──────────┐          ╱─────╲        │ 20 mA VALUE  │
      │ MAX AUX  │   YES   ╱  USE  ╲       └──────────────┘
      │  SETPT   │◀──────╱ SETPT    ╲      ┌──────────────┐
      └──────────┘       ╲TRACKING? ╱      │ANALOG READOUT│
      ┌──────────┐        ╲─────╱          │     3 IS     │
      │AUX SETPT RATE│       │NO            └──────────────┘
      │ UNITS/SEC  │      ┌─────────┐      ┌──────────────┐
      └──────────┘        │  SETPT  │      │  READOUT 3   │
          ╱─────╲         │INITIAL VALUE│  │ 4 mA VALUE   │
    YES  ╱  USE  ╲        └─────────┘      └──────────────┘
    ◀──╱AUX ENABLE╲       ┌─────────┐      ┌──────────────┐
       ╲    ?    ╱        │SPEED SETPT│    │  READOUT 3   │
        ╲─────╱           │LOWER LIMIT│    │ 20 mA VALUE  │
          │NO             └─────────┘      └──────────────┘
      ┌──────────┐        ┌─────────┐      ┌──────────────┐
      │  SETPT   │        │SPEED SETPT│    │ANALOG READOUT│
      │INITIAL VALUE│     │UPPER LIMIT│    │     4 IS     │
      └──────────┘        └─────────┘      └──────────────┘
      ┌──────────┐        ┌─────────┐      ┌──────────────┐
      │AUX DROOP │        │MAX SPD RATE│   │  READOUT 4   │
      └──────────┘        │ (RPM/SEC) │    │ 4 mA VALUE   │
      ┌──────────┐        └─────────┘      └──────────────┘
      │ AUX PID  │        ┌─────────┐      ┌──────────────┐
      │PROP GAIN │        │ CASCADE │      │  READOUT 4   │
      └──────────┘        │  DROOP  │      │ 20 mA VALUE  │
      ┌──────────┐        └─────────┘      └──────────────┘
      │ AUX PID  │        ┌─────────┐      ┌──────────────┐
      │INTEGRAL GAIN│     │CASC PID │      │ANALOG READOUT│
      └──────────┘        │PROP GAIN│      │     5 IS     │
      ┌──────────┐        └─────────┘      └──────────────┘
      │AUX DERIVITIVE│    ┌─────────┐      ┌──────────────┐
      │  RATIO   │        │CASC PID │      │  READOUT 5   │
      └──────────┘        │INTEGRAL GAIN│  │ 4 mA VALUE   │
      ┌──────────┐        └─────────┘      └──────────────┘
      │TIEBRKR OPEN│      ┌─────────┐      ┌──────────────┐
      │AUX DISABLE│       │CASC DERIVITIVE│ │  READOUT 5   │
      └──────────┘        │  RATIO  │      │ 20 mA VALUE  │
      ┌──────────┐        └─────────┘      └──────────────┘
      │GENBRKR OPEN│        ╱─────╲        ┌──────────────┐
      │AUX DISABLE│        ╱  USE  ╲  NO   │ANALOG READOUT│
      └──────────┘        ╱REMOTE CASC╲──▶ │     6 IS     │
          ╱─────╲         ╲ SETTING ╱      └──────────────┘
    NO  ╱  USE   ╲         ╲─────╱         ┌──────────────┐
    ◀─╱REMOTE AUX ╲          │YES          │  READOUT 6   │
      ╲ SETTING  ╱        ┌─────────┐      │ 4 mA VALUE   │
       ╲─────╱            │REMOTE CASC│    └──────────────┘
          │YES            │ MAX RATE │     ┌──────────────┐
      ┌──────────┐        └─────────┘      │  READOUT 6   │
      │REMOTE AUX│        ┌─────────┐      │ 20 mA VALUE  │
      │ MAX RATE │        │CASC UNITS│     └──────────────┘
      └──────────┘        │OF MEASURE│
      ┌──────────┐        └─────────┘
      │AUX UNITS │
      │OF MEASURE│
      └──────────┘

                          ┌─────┐    ┌──────────────┐
                          │CLEAR├────│ TO EXIT THE  │
                          └─────┘    │ PROGRAM MODE │
                                     │ PUSH (CLEAR) │
                                     └──────────────┘

                                         850-169
                                      96-06-25 KDW
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Figure 4-3e. Program Mode Blocks

Figure 4-3f. Program Mode Blocks

Program Blocks

Figure 4-3 shows the 15 program columns. To program the control, simply step through the blocks as described above and configure the control features for the desired application. The first nine program columns must be programmed for every installation. The remaining six columns contain optional features which can be selected if desired. The 13 columns and their basic functions are described in detail below.

Required Configuration Blocks:
- Turbine Start—to configure start mode, idle/rated, and auto start sequence settings;
- Speed Control—to configure MPU or PROX PROBE information and speed control dynamics settings;
- Speed Setpoint Values—to configure speed setpoints, overspeed trip setpoint, remote speed setting control and critical speed avoidance bands;
- Operating Parameters—to configure the unit for generator application and to use the local /remote function;
- Extraction / Admission Control—to configure extraction/admission control information;
- Driver Configuration—to configure driver outputs;
- Turbine Performance Values—to configure unit ratio and limiting logic and steam map;
- Analog Inputs—to configure analog input options;
- Contact Inputs—to configure contact input options;

Optional Configuration Blocks:
- Function Keys—to configure F3 and F4 function keys options;
- Auxiliary Control—to configure auxiliary control information;
- Cascade Control—to configure cascade control information;
- Readouts—to configure analog readout options;
- Relays—to configure relay options;
- Communications—to configure Modbus communication options.

Each of the program blocks are described in detail below. Figure 4-3 can be referred to for a graphical program block reference. After a column has been configured and the display is back at the top of the column, use the left or right arrow keys to select the next column to configure or check.

All control program questions will be displayed on the top line of the display; all entries made will be displayed on the lower line of the display. At the beginning of each column the control will display the header, pushing the down arrow will access the column.

The program blocks (Figure 4-3) contain information detailing each question and/or 505E program configuration option. Each question/option shows the default (dflt) value and the adjustable range of that parameter (shown in parentheses). In addition, any additional constraints on the configuration are shown in italics following the description. There is a program mode worksheet in the appendix of this manual that should be completed/filled in and used as a guide for your particular application. This worksheet can also be used for future reference to document your application program.

Turbine Start Block

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

MANUAL START?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to configure a manual start mode. When configured for a manual start mode, the operator controls the turbine speed from zero up to the minimum control speed using an external trip-throttle valve. The Manual Start Sequence would be: Push RUN. The actuators automatically move to max position. Lastly, the operator slowly opens the trip-throttle valve until the governor takes control.

AUTOMATIC START?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to configure an automatic start mode. When configured for an automatic start mode, the 505E controls the turbine speed from zero up to the minimum control speed. The Automatic Start Sequence would be: Operator opens the T&T valve, then push RUN. The HP valve limiter opens automatically until the governor takes control.

SEMIAUTOMATIC START?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to configure a semiautomatic start mode. When configured, the 505E's HP limiter must be manually opened by the operator, slowly, to open the control valve and bring the turbine speed from zero up to the minimum control speed. The Semi-automatic Start Sequence would be: Open the T&T valve, then push RUN. The valve limiter must then be raised by the operator until governor takes control.
    (One of the three start modes must be selected before the unit will run)

RATE TO MIN (RPM/SEC)   dflt= 10.0 (0.01, 2000)
    Enter the speed setpoint acceleration rate to minimum followed by the ENTER key. 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.

HP VALVE LIMITER RATE (% / SEC)   dflt= 5.0 (0.01, 25)
    Enter the HP Valve Limiter Rate, in percent per second, followed by ENTER. This is the rate at which the HP valve limiter moves when RUN is selected or when the limiter setting is changed through open/close commands. When using a semiautomatic or automatic start, this setting should be very slow—typically less than 2 %/sec. When using a manual start, this setting is less critical and can be left at the default of 5 % / sec.

USE IDLE/RATED ?   dflt= NO (Yes/No)
    Select YES followed by ENTER if this function is desired. If NO, skip to 'Use Auto Start Sequence'. If YES is selected, the control will ramp from a programmable Idle speed to a programmable Rated speed setpoint when Rated is selected through keypad, Modbus or external switch.

IDLE SETPT (RPM)   dflt= 1000 (0.0, 20000)
    Enter the Idle Speed setpoint desired followed by the ENTER key. This is the lowest speed control setpoint when using the Idle/Rated function.

RATED SETPT (RPM)   dflt= 3600 (0.0, 20000)
    Enter the Rated Speed setpoint desired followed by the ENTER key. 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)   dflt= 5.0 (0.01, 2000)
    Enter the Idle/Rated rate (rpm/second) followed by ENTER. This is the at which the speed setpoint moves between Idle and Rated speed setpoints when using the Idle/Rated commands.

USE AUTO START SEQUENCE ?   dflt= NO (Yes/No)

Enter YES followed by ENTER if this function is desired. If NO is selected followed by ENTER, then the program will step to 'Reset Clears Trip Output' question. If this function is programmed and RUN is selected, the 505E automatically accelerates the speed setpoint to a programmable low idle speed and holds for a programmable time then ramps to a programmable high idle speed and holds for a programmable time then ramps to programmable rated speed setpoint. The start sequence can be actuated or halted through the keypad, Modbus or external switch.

COLD START (> xx HRS)   dflt= 10 (0.0, 200)

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

HOT START (< xx HRS)   dflt= 1.0 (0.0, 200)

Enter the maximum time allowed after a trip for the 'hot start' sequence curves to be used followed by the ENTER key. 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)   dflt= 1000 (0.0, 20000)

Enter the Low Idle Speed Setting followed by the ENTER key. 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.

LOW IDLE DELAY TIME—COLD (MINUTES)   dflt= 1.0 (0.0, 500)

Enter the cold start hold time desired at low idle followed by ENTER. 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)   dflt= 1.0 (0.0, 500)

Enter the hot start hold time at low idle followed by ENTER. 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)

RATE TO HI IDLE—COLD (RPM/SEC)   dflt= 5.0 (0.01, 500)

Enter the cold start rate to high idle followed by ENTER. 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 HI IDLE—HOT (RPM/SEC)   dflt= 5.0 (0.01, 500)

Enter the hot start rate to high idle followed by ENTER. 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)

HI IDLE SETPT (RPM)   dflt= 2000 (0.0, 20000)

Enter the Hi Idle Speed Setting followed by the ENTER key. This is the second hold speed when using the automatic start sequence. The speed setpoint will remain at this setting until the Hi Idle Delay/hold time has expired.

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

HI IDLE DELAY TIME—COLD (MINUTES)   dflt= 1.0 (0.0, 500)

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

HI IDLE DELAY TIME—HOT (MINUTES)   dflt= 1.0 (0.0, 500)
    Enter the hot start hold time desired at hi idle followed by ENTER. 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)

RATE TO RATED SETPT—COLD (RPM/SEC)   dflt= 5.0 (0.01, 500)
    Enter the cold start rate to the rated speed setpoint followed by ENTER.
    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 SETPT—HOT (RPM/SEC)   dflt= 5.0 (0.01, 500)
    Enter the hot start rate to the rated speed setpoint followed by ENTER. 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)

RATED SETPT (RPM)   dflt= 3600 (0.0, 20000)
    Enter the Rated Speed Setting followed by the ENTER key. 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)

AUTO HALT AT IDLE SETPTS?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to automatically halt the auto start
    sequence at the idle setpoints. This feature would result in the unit
    automatically stopping/halting at the low idle setpoint and at the high idle
    setpoint. Also, if the unit is started and the speed is above the low idle
    setpoint, the sequence will be halted. Select NO to allow the control to
    perform its automatic start sequence routine without interruption.

EXTERNAL TRIPS IN TRIP RELAY ?   dflt= YES (Yes/No)
    Select YES followed by the ENTER key to allow the external trip input(s) to
    de- energize the Trip Relay output. When set to NO, an external trip contact
    input to the 505 will shut down the 505 control but will not de-energize the
    505's trip relay output.

RESET CLEARS TRIP OUTPUT ?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to configure the Reset Clears Trip
    Relay output function. When set to YES, a Reset command will energize the
    trip relay output even when a trip condition is still sensed by the 505E—
    typically due to one of the external trip inputs. Once reset, the unit will be
    'Ready to Start' as soon as all external trip inputs are closed. When NO, the
    trip relay output will be de-energized on a 505E trip and will not energize
    until all trips have cleared and a 'Reset' command is given.

Speed Control Block

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

    *(The maximum turbine speed is 20000 rpm and the maximum speed input
    frequency is 15000 hertz.)*

TEETH SEEN BY MPU   dflt= 60.0 (1.0, 300)
    Enter the number of teeth on gear that the speed probe is mounted on
    followed by the ENTER key.

MPU GEAR RATIO   dflt= 1.0 (0.05, 100)

  Enter the speed sensor gear ratio followed by the ENTER key. 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.

FAILED SPEED LEVEL (RPM)   dflt= 250 (0.5, 1000)

  Enter the Failed Speed Level (in rpm) followed by the ENTER key to set the
  speed probe input failure level. If speed drops below this level, the control
  will determine the speed input device is failed and issue an alarm. If all
  speed inputs fail, the 505E will issue a trip on loss of speed inputs.
  (Must be greater than or equal to 0.0204 x Overspeed Test Limit setting)

USE SPEED INPUT #2?   dflt= NO (Yes/No)

  Select YES followed by ENTER if both speed inputs are to be used.

FAILED SPEED LEVEL (RPM)   dflt= 250 (0.5, 1000)

  Enter the failed speed level (in rpm) followed by the ENTER key to set the
  speed probe input failure level. If speed drops below this level, the control
  will determine the speed input device is failed and issue an alarm. If all
  speed inputs fail, the 505E will issue a trip on loss of speed inputs.
  (Must be greater than or equal to 0.0204 x Overspeed Test Limit setting)

OFF-LINE PROPORTIONAL GAIN   dflt= 5.0 (0.0, 100)

  Enter the off-line PID proportional gain, in repeats-per-second (rps) followed
  by ENTER. 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.

OFF-LINE INTEGRAL GAIN   dflt= 0.5 (0.01, 50)

  Enter the off-line PID integral gain percentage followed by ENTER. This
  value is used to set speed/load control response when the Generator or
  Utility Tie breaker contacts are open (if the unit is a generator) or if the
  turbine speed is below minimum governor speed (if the unit is not a
  generator) or when the Select Dynamics function is used and the contact is
  open. This value can be changed in the Run Mode while the turbine is
  operating. A recommended starting value is 0.5%.

OFF-LINE DERIVATIVE RATIO   dflt= 5.0 (0.01, 100)

  Enter the off-line PID derivative ratio followed by ENTER. 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 5—PID Dynamics Settings
  for more information).

ON-LINE PROPORTIONAL GAIN   dflt= 5.0 (0.0, 100)

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

ON-LINE INTEGRAL GAIN   dflt= 0.5 (0.01, 50)

   Enter the on-line PID integral gain, in repeats-per-second (rps) followed by
   ENTER. 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 DERIVATIVE RATIO   dflt= 5.0 (0.01,100)

   Enter the on-line PID derivative ratio followed by ENTER. 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 5—PID Dynamics Settings
   for more information).

Speed Setpoint Values Block

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

   *(The maximum turbine speed is 20000 rpm and the maximum speed sensor
   input frequency is 15000 hertz.)*

OVERSPEED TEST LIMIT (RPM)   dflt= 1100 (0.0, 20000)

   Set the overspeed test limit (in rpm) followed by the ENTER key. 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 LEVEL (RPM)   dflt= 1000 (0.0, 20000)

   Set the 505E's overspeed trip level (in rpm) followed by the ENTER key.
   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 SPEED SETPOINT (RPM)   dflt= 0.0 (0.0, 20000)

   Set the maximum governor control speed followed by the ENTER key. 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 SPEED SETPOINT (RPM)   dflt= 0.0 (0.0, 20000)

   Set the minimum governor control speed followed by the ENTER key. This
   is the normal governor operation lower limit.
   (Must be less than the 'Maximum Governor Speed' Setting)

SPEED SETPOINT SLOW RATE (RPM/SEC)   dflt= 5.0 (0.01, 100)

   Enter the speed setpoint slow rate in rpm per second followed by the
   ENTER key. This the rate of speed change for normal operation.

USE REMOTE SPEED SETPOINT ?   dflt= NO (Yes/No)

   Set to YES followed by ENTER if using an analog input to set the
   Speed/Load Setpoint.

RMT SPEED SETPT MAX RATE (RPM/SEC)   dflt= 50.0 (0.01, 500)

   Enter the Maximum Rate of speed change for remote speed setpoint
   operation followed by the ENTER key.

USE CRITICAL SPEEDS ?   dflt= NO (Yes/No)
    If NO, skip to 'SPEED SETPOINT VALUES BLOCK' heading.
    Set to YES followed by ENTER to use the critical speed avoidance logic.
    When set to YES, allows up to two critical speed avoidance bands to be
    programmed. Within the band, the speed 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)   dflt= 50.0 (1.0, 2000)
    Set the rate that the speed setpoint will move through the critical speed
    avoidance ranges (in rpm/second) followed by the ENTER key
    (Must be greater than the 'Speed Setpt Slow Rate' Setting)

CRITICAL SPEED 1 MAX (RPM)   dflt= 1.0 (1.0, 20000)
    Set the upper limit of the critical speed avoidance band followed by the
    ENTER key.
    (Must be less than the 'Minimum Governor Speed' Setting)

CRITICAL SPEED 1 MIN (RPM)   dflt= 1.0 (1.0, 20000)
    Set the lower limit of the critical speed avoidance band followed by the
    ENTER key.
    (Must be less than the 'Critical Speed 1 Max' Setting)

USE CRITICAL SPEED 2 ?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key to use the second critical speed
    avoidance band. If NO, skip to 'SPEED SETPOINT VALUES BLOCK'
    heading.

CRITICAL SPEED 2 MAX (RPM)   dflt= 1.0 (1.0, 20000)
    Set the upper limit of the critical speed avoidance band followed by the
    ENTER key.
    (Must be less than the 'Minimum Governor Speed' Setting)

CRITICAL SPEED 2 MIN (RPM)   dflt= 1.0 (1.0, 20000)
    Set the lower limit of the critical speed avoidance band followed by the
    ENTER key.
    (Must be less than the 'Critical Speed 2 Max' Setting)

Operating Parameters Block

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

GENERATOR APPLICATION?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key if the turbine is driving a generator.
    If YES, requires a Generator breaker and Utility Tie breaker to be
    programmed as contact inputs. If NO, skip to the 'Use Local/Remote'
    question.

USE GEN BREAKER OPEN TRIP?   dflt= NO (Yes/No)
    Select YES followed by the ENTER key if opening the generator breaker is
    to initiate a turbine trip. If YES, the unit will trip when the generator breaker
    opens after being closed unless a Controlled Stop is selected. If NO, the
    speed setpoint will instantly reset to the 'Gen Open Setpoint' which is
    defaulted to 50 rpm below rated speed.

USE TIE BREAKER OPEN TRIP?   dflt= NO (Yes/No)
> Select YES followed by the ENTER key if opening the utility tie breaker is to
> initiate a turbine trip. If YES, the unit will trip when the utility tie breaker
> opens after being closed unless a Controlled Stop is selected. If NO and the
> generator breaker is closed, the speed 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 NO and the generator breaker is open, there is only an
> alarm when the utility tie breaker opens.

USE KW DROOP?   dflt= NO (Yes/No)
> Set to YES to use kW droop (generator load control) or NO to use internal
> Speed droop (turbine inlet valve position) followed by the ENTER key. If
> YES, generator kW feedback is used as the controlling parameter for
> stability when the unit is on-line. If NO, internal LSS demand/actuator
> position droop is used. If using Decoupling, set this to NO.

KW MAX LOAD (kW)   dflt= 20000 (0.1, 20000)
> Enter the max load followed by the ENTER key. This setting limits the
> maximum load the turbine/generator can carry.
> *(Must be less than or equal to the 'KW Input at 20 mA' Setting)*

DROOP (%)   dflt= 5.0 (0.0, 10)
> Enter the droop percentage followed by the ENTER key. Typically set
> between 4-6% and not more than 10%. If droop is required, the unit must be
> programmed as a 'Generator Application'.

RATED SPEED SETPOINT (RPM)   dflt= 3600 (0.0, 20000)
> Set the generator's rated speed setpoint followed by the ENTER key.
> *(Must be greater than or equal to the 'Minimum Governor Speed' Setting
> and less than the 'Maximum governor Speed' Setting))*

USE FREQ ARM/DISARM?   dflt= NO (Yes/No)
> Set to YES is using frequency control arm/disarm followed by the ENTER
> key. If YES, frequency control must be armed before the unit will switch into
> frequency control. If NO, frequency control is always armed and the unit will
> go into frequency control whenever the generator breaker is closed and the
> utility tie breaker is open.
> *(Cannot program both Freq Arm/Disarm and Loadsharing)*

USE LOCAL/REMOTE?   dflt= NO (Yes/No)
> Set to YES if using Local/Remote control logic followed by the ENTER key.
> If YES, permits the unit to go from REMOTE (Modbus, contact input and
> front panel) control to LOCAL (front panel) control only. If NO, all
> programmed inputs are active at all times. Refer to the Service Mode
> information in Volume 2 for additional settings on the Local/Remote function.

Extraction / Admission Control

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

LOST E/A INPUT = TRIP?   dflt= NO (Yes/No)
> Set to YES if the unit is to trip on loss of extraction/admission analog input
> signal.

LOST E/A INPUT = MAX LP?   dflt= NO (Yes/No)
> Set to YES if LP valve output is to go to maximum (100%) on loss of
> extraction/ admission analog input signal.

LOST E/A INPUT = MIN LP?   dflt= NO (Yes/No)

    Set to YES if LP valve output is to go to minimum (0%) on loss of extraction/
    admission analog input signal.

IMPORTANT   **If the Response to all 'Lost E/A Input' questions is "NO", the 505E will disable extraction/admission control and switch to manual setpoint at the last demand value.**

INVERT EXTR/ADM INPUT?   dflt= NO (Yes/No)

    Select YES followed by ENTER if Ext/Adm control will be reverse acting. If
    NO, control will be forward acting. Typically this will be set to NO; when
    programmed for Coupled HP & LP, Decoupled Inlet, or Decoupled Exhaust
    modes 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). When programmed for the Decoupled HP & LP modes, this
    value is set to YES if the LP valve output needs to open when the input
    exceeds the setpoint (the ratioing logic is not providing an inversion).

MIN EXTR/ADM SETPT   dflt= 0.0 (-20000, 20000)

    Set the minimum extr/adm setpoint followed by ENTER. This value is the
    minimum setpoint value that the extr/adm setpoint can be
    decreased/lowered to (lower limit of extr/adm setpoint).

MAX EXTR/ADM SETPT   dflt= 100 (-20000, 20000)

    Set the maximum extr/adm setpoint followed by ENTER. 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)

SETPT RATE (units/sec   dflt= 5.0 (0.01, 1000)

    Set the extr/adm setpoint rate followed by ENTER. This value is the rate (in
    units per second) at which extr/adm setpoint moves when adjusted.

SETPT INITIAL VALUE (UNITS)   dflt= 100 (-20000, 20000)

    Set the setpoint initialization value followed by ENTER. When not using the
    Extr/Adm 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 Extr/Adm Setpoint' Setting)

EXTR/ADM DROOP (%)   dflt= 0.0 (0.0, 100)

    Enter the droop percentage followed by the ENTER key. If required, typically
    set between 4-6%.

PID PROPORTIONAL GAIN (%)   dflt= 1.0 (0.0, 100)

    Enter the Extr/Adm PID proportional gain value followed by ENTER. This
    value is used to set auxiliary control response. This value can be changed in
    the Run Mode while the turbine is operating. If unknown, a recommended
    starting value is 1%.

PID INTEGRAL GAIN (%)   dflt= 0.3 (0.001, 50)

    Enter the Extr/Adm PID integral gain value, in repeats-per-second (rps),
    followed by ENTER. 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.

PID DERIVATIVE RATIO (%)   dflt= 100 (0.01, 100)

    Enter the Extr/Adm PID derivative ratio followed by ENTER. 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%.

TIEBRKR OPEN E/A DISABLE ?   dflt= YES (Yes/No)

    Select YES followed by ENTER if the extr/adm control will be disabled when
    the utility tie breaker opens. If NO is selected, then extr/adm control will not
    be disabled when the utility tie breaker is opened.

GENBRKR OPEN E/A DISABLE ?   dflt= YES (Yes/No)
> Select YES followed by ENTER if the extr/adm control will be disabled when the generator breaker opens. If NO is selected, then extr/adm control will not be disabled when the generator breaker is opened.

E/A SPEED ENBL SETTING   dflt= 1000 (0, 20000)
> Value of speed as a permissive for enabling Extr/Adm control. The speed must be above this setting before control with be active.

USE REMOTE SETTING?   dflt=NO (Yes/No)
> Set to YES to allow the Extr/Adm setpoint to be adjusted from an analog input.
> *(Must program a 'remote extr/adm setpoint' analog input)*

REMOTE SETPT MAX RATE   dflt= 5.0 (0.01, 1000)
> Set the extr/adm setpoint rate followed by ENTER. This value is the rate (in units per second) at which extr/adm setpoint moves when adjusted.

EXT/ADM UNITS OF MEASURE   (must choose from list)

Options:	psi	#/hr
	kPa	kg/hr
	kg/cm²	bar
	t/h	atm
	k#/hr	(none)

Extraction / Admission

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

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

The 505E uses the values programmed to calculate the turbine's internal pressure ratios and limits. In order to get these values from your steam map, you must first check the following conditions and, if necessary, modify the map so it meets these conditions:
* The map must be linear (all lines straight).
* Lines extraction/admission flow = 0% and extraction/admission flow =100% must be parallel, and lines LP valve = 0% and LP valve = 100% must be parallel.

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

The lines on the envelope define the operating characteristics of your turbine. Refer to the example steam maps in this manual. The different lines or limits of a Steam map are:
* The horizontal axis shows turbine power (S).
* The vertical axis shows HP valve position (HP).
* The vertical line called S=100 is the maximum power limiter. This limiter prevents turbine operation beyond the maximum power limit.
* The horizontal line called HP=100 is the maximum HP flow limiter. The HP flow limiter prevents turbine operation beyond the desired maximum HP flow limit.

- The parallel lines called P=0 and P=100 define the extraction/admission flow range (from no flow or maximum admission flow to maximum extraction flow). The "P" term is used to represent pressure demand.
- The parallel lines called LP=0 and LP=100 define the LP valve position range (from closed to 100% open).

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

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

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

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

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

Extraction Only Steam Map
Before a turbine's extraction steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 4-4).

Typically Point C the intersection of the LP=O line and the P=0 line does not exist. If this is the case it will be necessary to convert your steam map. The only conversion necessary is the extension of the LP=0 line and the P=0 line until they cross or intersect. This point where the LP=0 line intersects the P=0 line is defined as Point C, and is required by the control to calculate the turbine's internal pressure ratios and limits.

The eight values needed can be taken from the converted steam map. As an example, the following data was derived, using the above steam map in Figure 4-4.

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

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

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

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

Point C is where the LP=0 and P=0 lines intersect (MIN POWER @ MIN EXTRACTION = about –3000 kW; MIN HP FLOW @ MIN EXTRACTION = about 6000 lb/h; 2722 kg/h).
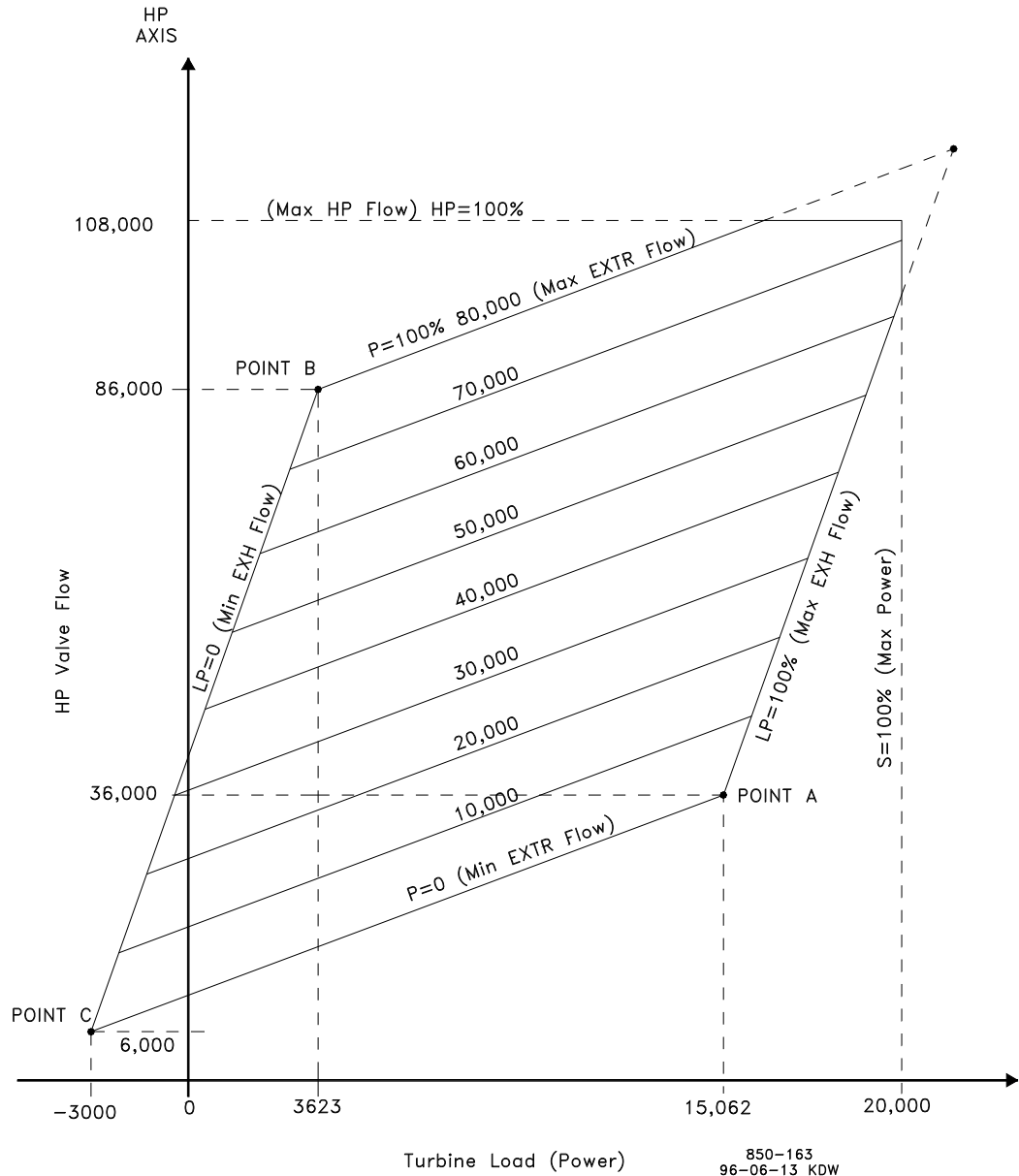
Figure 4-4. Typical Extraction Steam Map

Admission Only Steam Map
Before a turbine's admission steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 4-5).

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

If only point A exists, your map will have to be modified to include points B & C. The LP=0 line will need to be created. To create the LP=0 line you must know the minimum required steam flow through the back-end of the turbine. In our example steam map (Figure 4-5) the minimum required flow was 10 000 lb/h (4536 kg/h).

1. Extend the zero admission (or induction) line (p=100%). Refer to Figure 4-5.
2. Find your turbine's minimum back-end steam flow (this will be point B's HP flow).
3. Mark the intersection of the zero admission line and the turbine's minimum back-end (cooling) steam flow. This mark will be Point B for programming.
4. Draw a line parallel to the LP=100 line, through the mark created in step 3. This will be your LP=0 line or LP valve closed line.
5. Mark the intersection of the P=100 and the LP=100 line. This will be Point C for programming. Typically Point C the intersection of the LP=100 line and the P=100 line does not exist.

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

The nine values needed can be taken from the converted steam map. An example has been provided using the steam map in Figure 4-5.

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

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

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

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

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

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

An additional parameter, MIN HP LIFT (%), would also be set to 8000/105 000 = 7.6%
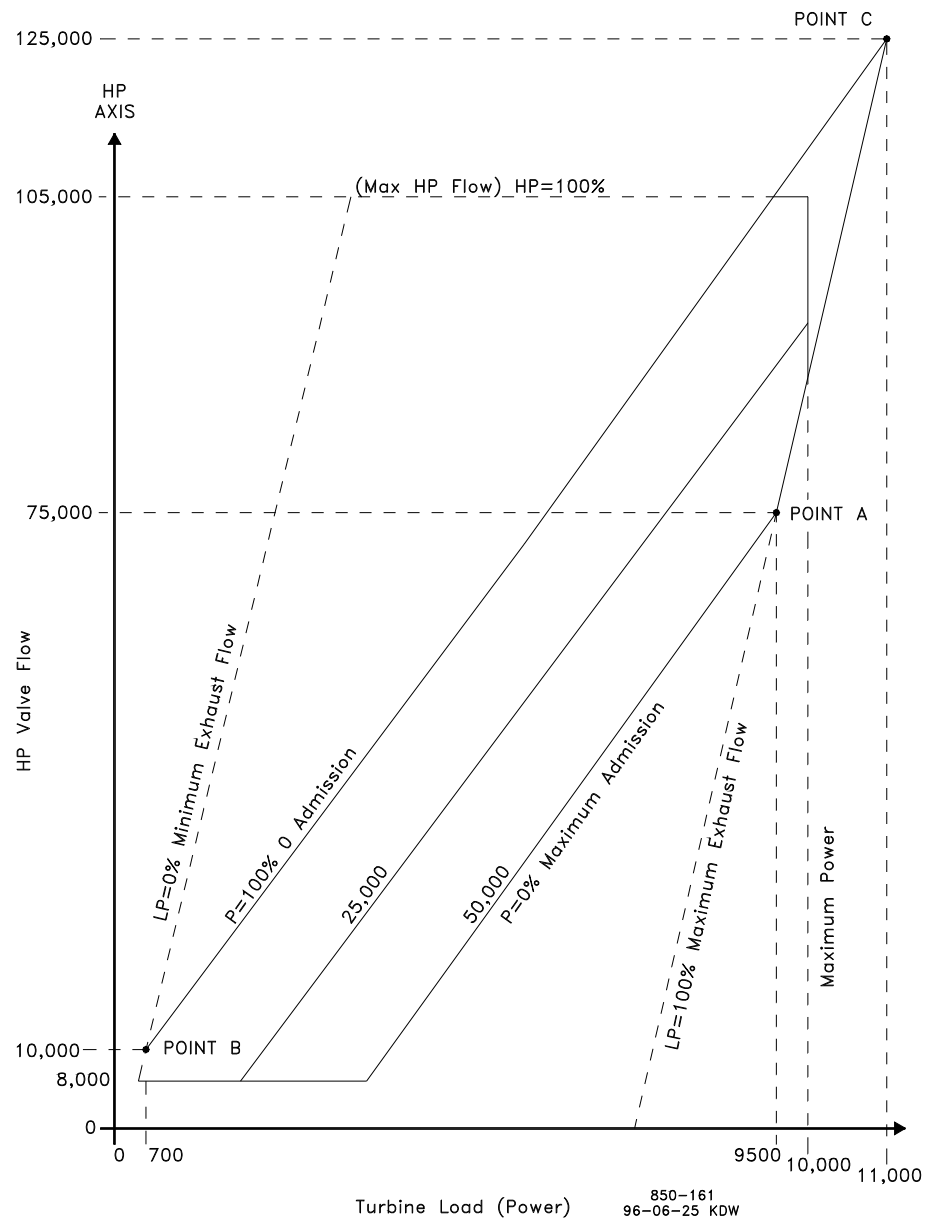
Figure 4-5. Typical Admission Steam Map

Extraction & Admission Steam Map
Before a turbine's extraction/admission steam map can be programmed into the control, it must have the intersection points A, B, & C (refer to Figure 4-6).

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

If points B & C do not exist, your map will have to be modified to include points B & C. The LP=0 line will need to be created. To create the LP=0 line you must know the minimum required steam flow through the back-end of the turbine. In our example steam map (Figure 4-6) the minimum required flow was 8000 lb/h (3629 kg/h).

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

Points A, B, and C are required by the control to calculate the turbine's internal pressure ratios and limits.
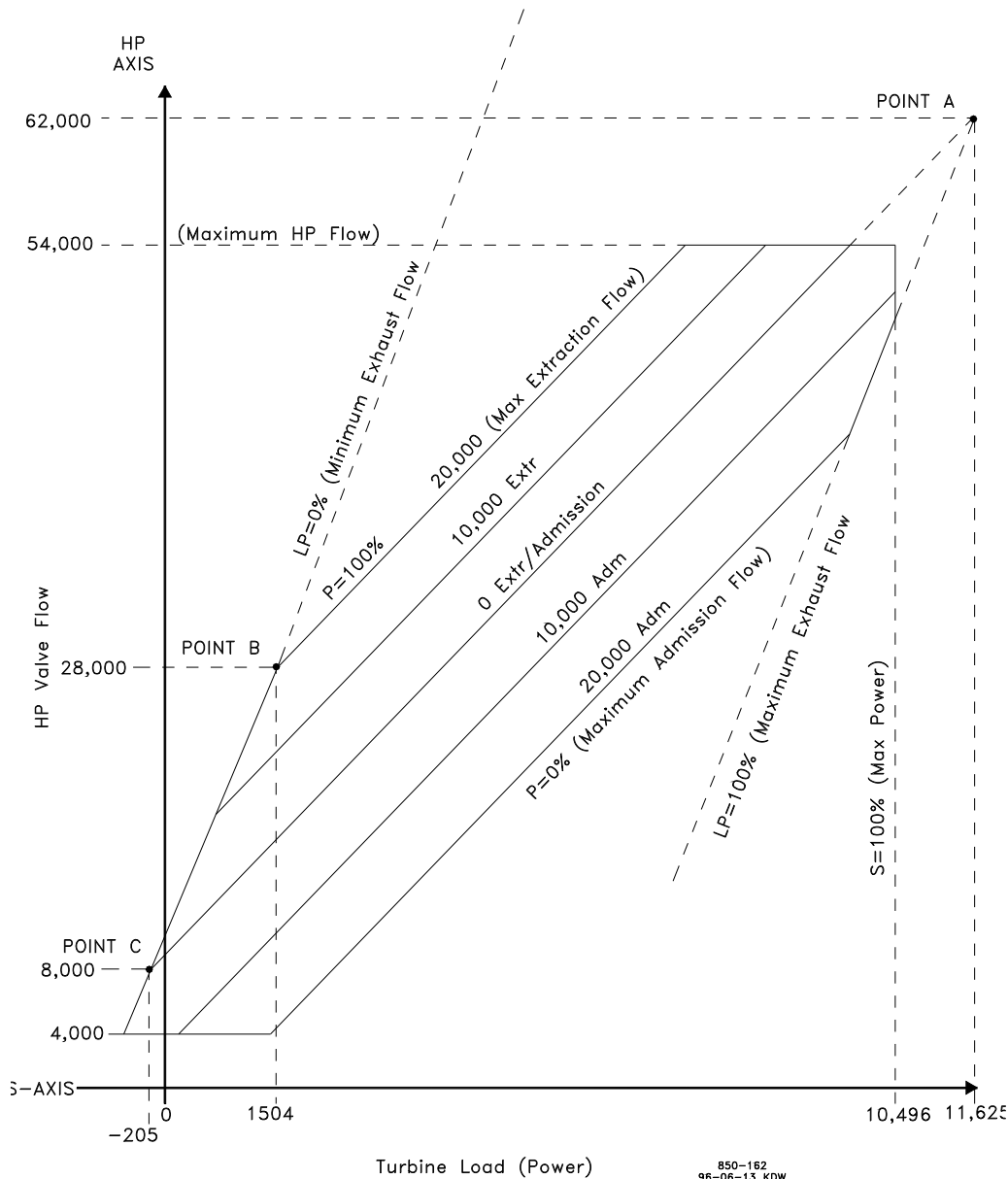
Figure 4-6. Typical Extraction & Admission Steam Map

The ten values needed can be taken from the converted steam map. An example has been provided below, using the steam map in Figure 4-6.

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

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

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

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

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

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

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

Turb Performance Values Block

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

USE DECOUPLING ?   dflt= NO (Yes/No)
    If NO, skip to 'Max Power' Entry. It is recommended to set the KW Droop to
    NO if Generator Application and using Decoupling.
DECOUPLE INLET (HP) ?   dflt= NO (Yes/No)
    If YES, skip to 'Max Power' Entry.
    This mode is typically used when the two controlled parameters during
    normal operation are turbine inlet pressure and extr/adm pressure
DECOUPLE EXHAUST (LP) ?   dflt= NO (Yes/No)
    If YES, skip to 'Max Power' Entry.
    This mode is typically used when the two controlled parameters during
    normal operation are turbine extr/adm pressure and exhaust pressure.
DECOUPLE HP & LP ?   dflt= YES (Yes/No)
    If YES, skip to 'Decouple HP & LP Data' Entry.
    This mode is typically used when the two controlled parameters during
    normal operation are turbine inlet pressure and exhaust pressure.
MAX POWER   dflt= 100 (0, 20000)
    Maximum power limit of the turbine (corresponds to the S = 100% line on
    the steam map).
MAX HP FLOW   dflt= 100 (0, 20000)
    Maximum steam flow through the HP steam valve into the turbine
    (corresponds to the HP=100% line on the steam map).
EXTRACTION ONLY ?   dflt= NO (Yes/No)
    Set to YES if the turbine being controlled only extracts steam from the LP
    valve. If YES, skip to 'Extraction Steam Map Data' Entry.
ADMISSION ONLY ?   dflt= NO (Yes/No)
    Set to YES if the turbine being controlled only admits or inducts steam into
    the LP valve. If YES, skip to 'Admission Steam Map Data' Entry.

EXTR AND ADMISSION ?   dflt= YES (Yes/No)
>   Set to YES if the turbine being controlled extracts and admits steam through the LP valve. If YES, skip to 'Extr/Adm Steam Map Data' Entry.

Extraction Steam Map Data

USE AUTOMATIC ENABLE ?   dflt= NO (Yes/No)
>   If YES, extraction control can be enabled with either a contact input or from the front panel. If NO, the LP Valve Limiter is used to enable extraction control. The limiter must be lowered manually to enable extraction control.

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

MAX POWER @ MIN EXTR   dflt= 50 (0, 20000)
>   Maximum turbine power at min extraction. Power at Point A.
>   *(Power must be greater than Point C)*

HP FLOW @ MIN EXTR   dflt= 10 (0, 20000)
>   HP valve steam flow at min extraction. Flow at Point A.
>   *(Flow must be greater than Point C)*

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

MIN POWER @ MAX EXTR   dflt= 10 (0, 20000)
>   Minimum turbine power at max extraction. Power at Point B.
>   *(Power must greater than Point C)*

MIN HP FLOW @ MAX EXTR   dflt= 50 (0, 20000)
>   HP valve steam flow at max extraction. Flow at Point B
>   *(Flow must be greater than Point C)*

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

MIN POWER @ MIN EXTR   dflt= 0.0 (-20000, 20000)
>   Minimum turbine power at min extraction. Power at Point C.
>   *(Power must be less than Point A)*

MIN HP FLOW @ MIN EXTR   dflt= 0.0 (-20000, 20000)
>   HP valve steam flow at min extraction. Flow at Point C.
>   *(Flow must be less than Point A*

(Skip to MIN LP LIFT)

Admission Steam Map Data

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

MAX POWER @ MAX ADM   dflt= 50 (0, 20000)
>   Maximum turbine power at max admission. Power at Point A.
>   *(Power must be less than Point C)*

MAX HP FLOW @ MAX ADM   dflt= 10 (0, 20000)
>   HP valve steam flow at max admission. Flow at Point A
>   *(Flow must be less than Point C)*

MAX ADMISSION FLOW   dflt= 0 (0, 20000)
>   Maximum possible admission flow.

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

MIN POWER @ MIN ADM   dflt= 10 (0, 20000)
  Minimum turbine power at min admission. Power at Point B.
  (Power must be less than Point C)
MIN HP FLOW @ MIN ADM   dflt= 50 (0, 20000)
  HP valve steam flow at min admission. Flow at Point B.
  (Flow must be less than Point C)

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

MAX POWER @ MIN ADM   dflt= 0 (-20000, 20000)
  Maximum turbine power at min admission. Power at Point C.
  (Power must be greater than Point A and Point B)
MAX HP FLOW @ MIN ADM   dflt= 0 (-20000, 20000)
  HP valve steam flow at min admission. Flow at Point C.
  (Flow must be greater than Point A and Point B)

(Skip to EXTR/ADM DEMAND RATE)

EXTR and Admission Steam Map Data

The next two entries correspond to Point A on the steam map

MAX POWER @ 0 EXTR/ADM   dflt= 100 (0, 20000)
  Maximum turbine power at zero extr/adm. Power at Point A.
  (Power must be greater than Point C)
MAX HP FLOW @ 0 EXTR/ADM   dflt= 10 (0, 20000)
  HP valve steam flow at zero extr/adm. Flow at Point A.
  (Flow must be greater than Point C)
MAX ADMISSION FLOW   dflt= 10 (0, 20000)
  Maximum possible admission flow.

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

MIN POWER @ MAX EXTR   dflt= 10 (0, 20000)
  Minimum turbine power at max admission. Power at Point B.
  (Power must be greater than Point C)
MIN HP FLOW @ MAX EXTR   dflt= 50 (0, 20000)
  HP valve steam flow at max admission. Flow at Point B.
  (Flow must be greater than Point C)

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

MIN PWR @ 0 EXTR/ADM   dflt= 0.0 (-20000, 20000)
  Minimum power at zero extraction and admission flow. Power at Point C
  (Power must be less than Point A)
MIN HP FLOW @ 0 EXTR/ADM   dflt= 0.0 (-20000, 20000)
  HP valve steam flow at zero extraction and admission flow. Flow at Point C
  (Flow must be less than Point A)

(Skip to EXTR/ADM DEMAND RATE)

Decouple HP & LP Data

XTRACTION ONLY ?   dflt= NO (Yes/No)
  Set to YES, if the turbine being controlled only extracts steam through the
  LP valve. If NO, skip to 'Admission Only' Entry.

USE AUTOMATIC ENABLE ?   dflt= NO (Yes/No)
 If YES, extraction control can be enabled with either a contact input or from
 the front panel. If NO, the LP Valve Limiter must be lowered manually to
 enable extraction control. Skip to 'Min LP Lift' Entry.
ADMISION ONLY ?   dflt= NO (Yes/No)
 YES, if the turbine being controlled only admits or inducts steam into the LP
 valve. If YES, skip to 'Extr/Adm Demand Rate' Entry.
EXTR AND ADMISSION ?   dflt= YES (Yes/No)
 YES, if the turbine being controlled extracts and admits steam through the
 LP valve. If YES, skip to 'Extr/Adm Demand Rate' Entry.

Shared Data

EXTR/ADM DEMAND RATE (% / SEC)   dflt= 0.5 (0.0, 10)
 The rate at which the demand value is moved during enabling and disabling
 admission or extr/adm control.
USE SETPOINT TRACKING ?   dflt= NO (Yes/No)
 If 'YES', the setpoint will track the extr/adm input to allow bumpless transfer
 to control mode. If 'NO', the setpoint will initialize to the 'Setpoint Initial
 Value' on power-up.
MIN HP LIFT (%)   dflt= 0.0 (0, 100)
 The minimum position limit the HP valve will close to when extr/admission or
 admission control is enabled.
MIN LP LIFT (%)   dflt= 0.0 (0, 100)
 The minimum position limit the LP valve output.
LP VALVE LIMITER RATE (%/SEC)   dflt= 1.0 (0.01, 25)
 The rate at which the LP valve limiter moves when adjusted and during
 enabling and disabling extr/adm control.
SPEED PRIORITY ?   dflt= YES (Yes/No)
 If YES, the speed/load parameter has priority when a valve reaches the end
 of its useful travel and extraction/admission will be sacrificed. If NO, skip to
 'Extr/Adm Priority?'.
LP MAX LIMIT = E/A PRIOR?   dflt= NO (Yes/No)
 If YES, extraction/admission priority is selected for the LP=100% (or
 maximum) limit and speed priority for all other valve lift limits. If NO, all limits
 will be set for speed/load priority.
AUTO SW E/A PRIORITY?   dflt= YES (Yes/No)
 If YES, selects auto Extraction/Admission priority switching when
 permissives are met. If NO, selects manual switching which can be
 performed through the keypad, Modbus, or external contact.

Driver Configuration Block

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

ACTUATOR 1 (HP) IS 4–20 mA ?   dflt= NO (Yes/No)
 Select actuator #1 output current range. Select YES for 4–20 mA or NO for
 20–160 mA followed by the ENTER key. Most Woodward actuators are 20–
 160 mA.
INVERT DRIVER OUTPUTS ?   dflt= NO (Yes/No)
 Set to YES to invert actuator driver outputs followed by the ENTER key.
 This is normally set to NO.

USE ACT 1 FAULT SHUTDOWN ?   dflt= YES (Yes/No)
    Select YES followed by ENTER to issue a trip whenever an actuator fault is detected. If YES, the 505E will issue a shutdown if Actuator 1 has a fault. If NO, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

ACTUATOR 1 (HP) DITHER   dflt= 0.0 (0.0, 10)
    Enter the dither, in milliamps, for actuator #1 followed by the ENTER key. Enter 0.0 if no dither is required. Woodward TM-type actuators typically require dither. This value can be changed in the Run Mode while the turbine is operating. See Run Mode—Chapter 5.

(RUN MODE)-ACT 1 (HP) CAL. INFO: Min _____mA Max _____mA
    This is not a program setting and this does not show up in the program mode. This information is here only to provide a place to document calibration changes made in the RUN mode under the ACTUATOR heading while stroking the actuator. Refer to the Stroke Actuators section at the end of Chapter 4.

ACTUATOR 2 (LP) IS 4–20 mA ?   dflt= NO (Yes/No)
    Select actuator #2 output current range. Select YES for 4–20 mA or NO for 20- 160 mA followed by the ENTER key. Most Woodward actuators are 20–160 mA.

USE ACT 2 FAULT SHUTDOWN?   dflt= YES (Yes/No)
    Select YES followed by ENTER to issue a trip whenever an actuator fault is detected. If YES, the 505E will issue a shutdown if Actuator 2 has a fault. If NO, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

ACTUATOR 2 (LP) DITHER   dflt= 0.0 (0.0, 10)
    Enter the dither, in milliamps, for actuator #2 followed by the ENTER key. Enter 0.0 if no dither is required. Woodward TM-type actuators typically require dither. This value can be changed in the Run Mode while the turbine is operating. See Run Mode—Chapter 5.

(RUN MODE)—ACT 2 (LP) CAL. INFO: Min _____mA Max _____mA
    This is not a program setting and this does not show up in the program mode. This information is here only to provide a place to document calibration changes made in the RUN mode under the ACTUATOR heading while stroking the actuator. Refer to the Stroke Actuators section at the end of Chapter 4.

Analog Inputs Block

When this header appears in the display, press the down arrow key to configure this block or press a left or right arrow key to select another block to configure. (No two analog inputs can be programmed for the same function. In addition, the function that the analog input uses must be programmed or an error message will occur. For example, to use the Cascade Input, the 'Use Cascade' function must be programmed.)

The first five (1–5) analog inputs are differential inputs that can be from a self-powered or a loop-powered (24 Vdc from 505E) transducer. However, analog input #6 is an isolated analog input and should be used when isolation is required (refer to Chapter 2 for information on the analog input hardware).

ANALOG INPUT # 1 FUNCTION   (extr/adm input)
INPUT 1–4 mA VALUE (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 4 milliamps (mA) on
    the analog input followed by the ENTER key. If the value on the display is
    correct, just select the ENTER key which will advance you to the next
    question.
INPUT 1–20 mA VALUE (UNITS)   dflt= 100 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 20 milliamps (mA)
    on the analog input followed by the ENTER key. If the value on the display
    is correct, just select the ENTER key which will advance you to the next
    question.
    (Must be greater than the 'Input 4 mA Value' Setting

ANALOG INPUT # 2 FUNCTION   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.
                ANALOG INPUT OPTIONS

(Not Used)	Remote Cascade Setpt
Remote Speed Setpt	Auxiliary Input
Synchronizing Input	Remote Aux Setpt
Sync/Load Share Input	First Stage Press Input
KW/Unit Load Input	Remote Extr/Adm Setpt
Cascade Input	

INPUT 2–4 mA VALUE (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 4 milliamps (mA) on
    the analog input followed by the ENTER key. If the value on the display is
    correct, just select the ENTER key which will advance you to the next
    question.
INPUT 2–20 mA VALUE (UNITS)   dflt= 100 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 20 milliamps (mA)
    on the analog input followed by the ENTER key. If the value on the display
    is correct, just select the ENTER key which will advance you to the next
    question.
    (Must be greater than the 'Input 4 mA Value' Setting)

Analog Inputs # 3 through # 6 are entered following the same rules as described
for Analog Input # 2.

Contact Inputs Block

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

*(If unit is configured as a 'Generator Set', then contact inputs must be
programmed for generator and tie breaker contacts. Also, each contact input
option may be configured only once. In addition, the function that the contact
input uses must be programmed or an error message will occur. For example, to
use the Cascade Control Enable contact input, the 'Use Cascade' function must
be programmed.)*

CONTACT INPUT 1 FUNCTION   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.

<div align="center">CONTACT INPUT OPTIONS</div>

(Not Used)	Casc Setpt Raise
Generator Breaker	Casc Setpt Lower
Utility Tie Breaker	Casc Control Enable
Overspeed Test	Remote Casc Setpt Enable
External Run	Aux Setpt Raise
Start Permissive	Aux Setpt Lower
Idle / Rated	Aux Control Enable
Halt / Continue Auto Start Sequence	Remote Aux Setpt Enable
Override MPU Fault	HP Valve Limiter Open
Select On-Line Dynamics	HP Valve Limiter Close
Local / Remote	LP Valve Limiter Open
Remote Speed Setpt Enable	LP Valve Limiter Close
Sync Enable	Extr/Adm Demand Raise
Freq Control Arm/Disarm	Extr/Adm Demand Lower
Extr/Adm Setpt Raise	External Trip 2
Extr/Adm Setpt Lower	External Trip 3
Extr/Adm Control Enable	External Trip 4
Remote Extr/Adm Setpt Enable	External Trip 5
Select Extr/Adm Priority	Controlled Shutdown (Manual)

Contact Inputs # 2 through # 12 are entered following the same rules as described for Contact Input # 1.

Function Keys Block

When this header appears in the display, press the down arrow key to configure this block or press a left or right arrow key to select another block to configure. Each function key option may be configured only once. In addition, the function that the function key uses must be programmed or an error message will occur. For example, to use the Cascade Control Enable function key, the 'Use Cascade' function must be programmed.

F3 KEY PERFORMS   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by selecting the NO key until the option desired appears, then press the YES or ENTER keys to select the option/function.

<div align="center">OPTIONS FOR FUNCTION KEYS F3 & F4</div>

(Not Used)	Remote Extr/Adm Setpt Enable
Local / Remote	Select Extr/Adm Priority
Idle / Rated	Casc Control Enable
Halt / Continue Auto Start Sequence	Remote Casc Setpt Enable
Remote Speed Setpt Enable	Aux Control Enable
Sync Enable	Remote Aux Setpt Enable
Freq Arm / Disarm	Energize Relay Output
Extr/Adm Control Enable	

BLINK F3 LED WHEN NOT ACTIVE ?   dflt= NO (Yes/No)
    Select YES followed by ENTER to blink the function key's LED when the function is not active but is enabled. The LED will be ON whenever the function is active. If NO, the function key LED is ON when the function is enabled, active, or in control.

F4 KEY PERFORMS   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by selecting the NO key until the option desired appears, then press the YES or ENTER keys to select the option/function.

BLINK F4 LED WHEN NOT ACTIVE ?   dflt= NO (Yes/No)
    Select YES followed by ENTER to blink the function key's LED when the
    function is not active but is enabled. The LED will be ON whenever the
    function is active or in control. If NO, the function key LED is ON when the
    function is enabled, active, or in control.

Auxiliary Control Block

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

USE AUXILIARY CONTROL?   dflt= NO (Yes/No)
    Select YES followed by ENTER to configure the auxiliary control function.
    Select NO if the auxiliary function is not used.
LOST AUX INPUT SHUTDOWN?   dflt= NO (Yes/No)
    Select YES followed by ENTER if a shutdown command is to be given when
    the auxiliary input fails. If NO, then no shutdown command will be given
    when the auxiliary input fails, only an alarm.
USE KW INPUT?   dflt= NO (Yes/No)
    If YES, allows the AUX control channel to use the kW Input programmed.
    When YES, no aux analog input is needed. When NO, an AUX analog input
    must be programmed.
INVERT AUX INPUT?   dflt= NO (Yes/No)
    Select YES followed by ENTER if the auxiliary control will be reverse acting.
    If NO, then the control will be forward acting. Typically this will be set to NO,
    the only time the input would be inverted is if the valve needs to open when
    the input exceeds the setpoint. An example where the invert would be YES
    is for turbine inlet pressure control.
MIN AUX SETPOINT (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the min aux setpoint followed by ENTER. 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)   dflt= 100 (-20000, 20000)
    Set the max aux setpoint followed by ENTER. 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)
AUX SETPOINT RATE (UNITS/SEC)   dflt= 5.0 (0.01, 1000)
    Set the aux setpoint rate followed by ENTER. This value is the rate (in units
    per second) at which aux setpoint moves when adjusted.
USE AUX ENABLE?   dflt= NO (Yes/No)
    Select YES followed by ENTER if using the Auxiliary control enable/disable
    feature. If YES, Aux will require an ENABLE command to enable Aux
    control. If NO, then the Auxiliary function will be enabled constantly and will
    act as a controlling limiter. An example of using Aux as a limiter is using Aux
    to limit the maximum kW load that the unit carries. The Aux PID is not
    normally in control of the valve output. But if the Aux (kW) input exceeds the
    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.
SETPT INITIAL VALUE (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the setpoint initialization value followed by ENTER. 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)

AUX DROOP (%)   dflt= 0.0 (0.0, 100)
   Enter the droop percentage followed by the ENTER key. If required, typically
   set between 4-6% and not more than 10%.
AUX PID PROPORTIONAL GAIN (%)   dflt= 1.0 (0.0, 100)
   Enter the aux PID proportional gain value followed by ENTER. 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   dflt= 0.3 (0.001, 50)
   Enter the aux PID integral gain value, in repeats-per-second (rps), followed
   by ENTER. 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 (%)   dflt= 100 (0.01, 100)
   Enter the aux PID derivative ratio followed by ENTER. This value is used to
   set auxiliary control response. This value can be changed in the Service
   Mode while the turbine is operating. If unknown, a recommended starting
   value is 100%.
TIEBRKR OPEN AUX DSBL ?   dflt= YES (Yes/No)
   Select YES followed by ENTER if the auxiliary control will be disabled when
   the utility tie breaker opens. If NO is selected, then auxiliary control will not
   be disabled when the utility tie breaker is opened.
GENBRKR OPEN AUX DSBL ?   dflt= YES (Yes/No)
   Select YES followed by ENTER if the auxiliary control will be disabled when
   the generator breaker opens. If NO is selected, then auxiliary control will not
   be disabled when the generator breaker is opened.
USE REMOTE AUX SETTING ?   dflt= NO (Yes/No)
   Set to YES to allow the aux setpoint to be adjusted from an analog input.
   (Must program a 'remote auxiliary setpoint' analog input)
REMOTE AUX MAX RATE (UNITS/SEC)   dflt= 5.0 (0.1, 1000)
   Enter the maximum rate at which the remote input will move the aux
   setpoint followed by the ENTER key.
AUXILIARY UNITS OF MEASURE: (must choose from list)
   Scroll through the option list by using the Adjust Up/Down Arrows or by
   selecting the NO key until the option desired appears, then press the YES or
   ENTER keys to select the option/function.
   Options: psi   t/h
              kPa   k#/hr
              MW   #/hr
              kW   kg/cm²
              degF   bar
              degC   atm
              (none)

Cascade Control Block

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

USE CASCADE CONTROL?   dflt= NO (Yes/No)
   Select YES followed by ENTER to configure the cascade control function.
   Select NO if the cascade function is not used.
INVERT CASCADE INPUT?   dflt= NO (Yes/No)
   Select YES followed by ENTER if the cascade control will be reverse acting.
   If NO is selected, the control will be forward acting. Typically this will be set
   to NO, the only time the input would be inverted is if the HP valve needs to
   open when the input exceeds the setpoint. An example where the invert
   would be YES is for turbine inlet pressure control.

MIN CASCADE SETPOINT (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the minimum cascade setpoint followed by ENTER. 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)   dflt= 100 (-20000, 20000)
    Set the maximum cascade setpoint followed by ENTER. 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)

CASC SETPT RATE (UNITS/SEC)   dflt= 5.0 (0.01, 1000)
    Set the cascade setpoint rate followed by ENTER. This value is the rate (in
    units per second) at which cascade setpoint moves when adjusted.

USE SETPOINT TRACKING?   dflt= NO (Yes/No)
    Select YES or NO followed by ENTER. If YES, the cascade setpoint tracks
    the cascade input to provide bumpless transfer to cascade control when it is
    enabled. If NO, the cascade setpoint remains at the last position except on
    power-up or exiting the program mode.

SETPT INITIAL VALUE (UNITS)   dflt= 100 (-20000, 20000)
    Set the setpoint initialization value followed by ENTER. When not using the
    Setpoint Tracking function, this is the value that the cascade setpoint
    initializes to upon power-up or exiting the program mode.
    (Must be less than or equal to the 'Max Cascade Setpt' Setting)

SPEED SETPOINT LOWER LIMIT (RPM)   dflt= 3605 (0.0, 20000)
    Set the minimum speed setpoint that the cascade controller can lower the
    speed setpoint to followed by ENTER. To protect the unit, this value should
    be at or above rated speed if the unit is a generator.
    *(Must be greater than or equal to the 'Minimum Governor Speed Setpt'
    Setting)*

SPEED SETPOINT UPPER LIMIT (RPM)   dflt= 3780 (0.0, 20000)
    Set the maximum speed setpoint that cascade controller can raise the
    speed setpoint to followed by the ENTER key.
    *(Must be less than or equal to the 'Maximum Governor Speed Setpt'
    Setting)*

MAX SPEED SETPOINT RATE (RPM/SEC)   dflt= 20 (0.1, 100)
    Set the maximum rate at which the cascade control can vary the speed
    setpoint followed by the ENTER key.

CASCADE DROOP (%)   dflt= 0.0 (0.0, 100)
    Enter the droop percentage followed by the ENTER key. If needed, typically
    set between 4-6% and not more than 10%.

CASCADE PID PROPORTIONAL GAIN (%)   dflt= 5.0 (0.0, 100)
    Enter the cascade PID proportional gain value followed by ENTER. 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   dflt= 0.3 (0.001, 50.0)
    Enter the cascade PID integral gain value, in repeats-per-second (rps)
    followed by ENTER. 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 (%)   dflt= 100 (0.0101, 100)
    Enter the cascade PID derivative ratio followed by ENTER. 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%.

USE REMOTE CASCADE SETTING?   dflt= NO (Yes/No)
    Set to YES to allow the Cascade setpoint to be adjusted from an analog
    input.
    (Must program a 'remote cascade setpoint' analog input)

RMT CASCADE MAX RATE (UNITS/SEC)   dflt= 5.0 (0.01, 1000)
    Enter the maximum rate at which the remote input will move the cascade
    setpoint followed by the ENTER key.
CASCADE UNITS OF MEASURE: (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.
    Options: psi   kPa
              MW   kW
              degF   degC
              t/h   k#/hr
              kg/cm²   bar
              atm   #/hr
              (none)

Readouts

When this header appears in the display, press the down arrow key to configure
this block or press a left or right arrow key to select another block to configure. All
six 4–20 mA analog readouts may be configured. The function that the readout
uses must be programmed or an error message will occur. For example, to use
the Cascade Setpoint readout, the 'Use Cascade' function must be programmed.

ANALOG READOUT # 1 FUNCTION   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.
                        ANALOG READOUT OPTIONS
    (Not Used)
    Actual Speed   Rmt Cascade Setpt
    Speed Setpoint   Auxiliary Input
    Remote Speed Setpt   Auxiliary Setpoint
    Sync/Load Share Input   Rmt Auxiliary Setpt
    Sync Input   Speed/Load Demand
    KW Input   Extr/Adm Demand
    Extr/Adm Input   HP Valve Limiter Setpt
    Extr/Adm Setpt   LP Valve Limiter Setpt
    Rmt Extr/Adm Setpt   HP Valve Demand
    Cascade Input   LP Valve Demand
    Cascade Setpoint   First Stage Press Input

READOUT 1–4 mA VALUE (UNITS)   dflt= 0.0 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 4 milliamps (mA) on
    the analog output followed by the ENTER key. If the value on the display is
    correct, just select the ENTER key which will advance you to the next
    question.
READOUT 1–20 mA VALUE (UNITS)   dflt= 100 (-20000, 20000)
    Set the value (in engineering units) that corresponds to 20 milliamps (mA)
    on the analog output followed by the ENTER key. If the value on the display
    is correct, just select the ENTER key which will advance you to the next
    question.
    (Must be greater than the 'Readout 4 mA Value' Setting)

Readouts #2 through #6 are entered following the same rules as described for
Readout #1.

Relays Block

When this header appears in the display, press the down arrow key to configure this block or press a left or right arrow key to select another block to configure. You may configure up to six relays in addition to the two pre-assigned relays (Alarm, Shutdown). The relay can be configured as either a level switch or as an indication. An example of a level switch is a Speed Switch and an example of an indication is Cascade Control Enabled.

USE RELAY # 1?   dflt= NO (Yes/No)
    Press YES followed by ENTER to use this relay output. Press NO followed
    by ENTER to skip to the next 'USE RELAY' question.
IS RELAY # 1 A LEVEL SWITCH?   dflt= NO (Yes/No)
    Press YES followed by ENTER to use this relay output as a level switch.
    Press NO followed by ENTER to skip to the 'RELAY ENERGIZES ON:'
    question.
RELAY # 1 IS LEVEL SWITCH FOR :   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.

            OPTIONS FOR RELAYS IF USED TO INDICATE A LEVEL

Actual Speed	Aux Setpoint
Speed Setpoint	Speed/Load Demand
KW Input	Extr/Adm Demand
Sync/Load Share Input	HP Valve Limiter
Extr/Adm Input	LP Valve Limiter
Extr/Adm Setpoint	HP Valve Demand Output
Cascade Input	LP Valve Demand Output
Cascade Setpoint	First Stg Pressure
Aux Input	

RELAY 1 ON LEVEL (UNITS)   dflt= 0.0 (-20000, 20000)
    Enter the level switch ON setting in engineering units followed by the
    ENTER key. There is an ON and an OFF setting for each level switch
    option. This allows the user to program the desiredhysteresis for the function selected.
RELAY 1 OFF LEVEL (UNITS)   dflt= 0.0 (-20000, 20000)
    Enter the level switch OFF setting in engineering units followed by the
    ENTER key.
    (Must be less than the 'Relay On Level' Setting)
RELAY 1 ENERGIZES ON :   (must choose from list)
    Scroll through the option list by using the Adjust Up/Down Arrows or by
    selecting the NO key until the option desired appears, then press the YES or
    ENTER keys to select the option/function.

            OPTIONS FOR RELAYS IF USED TO INDICATE STATE

Shutdown Condition	Extr/Adm PID in Control
Trip Relay (add'l trip relay output)	Remote Extr/Adm Setpt Enabled
Alarm Condition	Remote Extr/Adm Setpt Active
505E Control Status OK	Cascade Control Enabled
Overspeed Trip	Cascade Control Active
Overspeed Test Enabled	Remote Casc Setpt Enabled
Speed PID in Control	Remote Casc Setpt Active
Remote Speed Setpt Enabled	Aux Control Enabled
Remote Speed Setpt Active	Aux Control Active
Underspeed Switch	Auxiliary PID in Control
Auto Start Sequence Halted	Remote Aux Setpt Enabled
On-Line PID Dynamics Mode	Remote Aux Setpt Active
Local Control Mode	HP Valve Limiter in Control
Frequency Control Armed	LP Valve Limiter in Control
Frequency Control	Extr/Adm Priority Enabled

      Sync Enabled   Extr/Adm Priority Active

      Sync / Load Share Active   Steam Map Limiter in Control

      Load Share Control   F3 Key Selected

      Extr/Adm Control Enabled   F4 Key Selected

      Extr/Adm Control Active   Modbus Command Selected

Relays # 2 through # 6 are entered following the same rules as described for Relay # 1.

Communications Block

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

USE COMMUNICATIONS?   dflt= NO (Yes/No)
    Set to YES followed by ENTER to use the Modbus communications feature of the 505E. There are two identical Modbus ports available. Either or both can be configured for use. Select NO followed by ENTER if Modbus communications will not be used.

USE MODBUS PORT 1?   dflt= NO (Yes/No)
    Set to YES followed by ENTER to use the Modbus Port 1. Set to NO followed by ENTER to skip to 'Use Modbus Port 2'. If the displayed value is already correct, simply select ENTER.

ASCII OR RTU   dflt= 2 (1, 2)
    Enter the integer corresponding to the Modbus transmission mode required followed by the ENTER key. Enter a '1' for ASCII mode or a '2' for RTU mode. For more information on the difference between these modes, refer to Chapter 6. If the displayed value is already correct, simply select ENTER.

MODBUS DEVICE NUMBER   dflt= 1 (1, 247)
    Enter the integer corresponding to the Modbus device number/address required followed by the ENTER key. If the displayed value is already correct, simply select ENTER.

COMMUNICATIONS MODE   dflt= 1 (1, 3)
    Enter the integer corresponding to the serial communications mode required followed by the ENTER key. Enter a '1' for RS-232, a '2' for RS-422 or a '3' for RS-485 communications. If the displayed value is already correct, simply select ENTER.

BAUD RATE   dflt= 9 (1, 11)
    Enter the integer corresponding to the communications baud rate followed by the ENTER key. If the displayed value is already correct, simply select ENTER.

1 = 110	2 = 300	3 = 600	4 = 1200
5 = 1800	6 = 2400	7 = 4800	8 = 9600
9 = 19200	10 = 38400	11 = 57600	

STOP BITS   dflt= 1 (1, 3)
    Enter the integer corresponding to the stop bits required followed by the ENTER key. If the displayed value is already correct, simply select ENTER. Enter a '1' for 1 stop bit, a '2' for 1.5 stop bits or a '3' for 2 stop bits.

PARITY   dflt= 1 (1, 3)
    Enter the integer corresponding to the parity required followed by the ENTER key. If the displayed value is already correct, simply select ENTER. Enter a '1' for none, a '2' for odd parity or a '3' for even parity.

USE MODBUS PORT 2?   dflt= NO (Yes/No)
    Set to YES followed by ENTER to use the Modbus Port 2. If the displayed value is already correct, simply select ENTER. Modbus Port # 2 is entered following the same rules as described for Modbus Port # 1.

Exiting the Program Mode
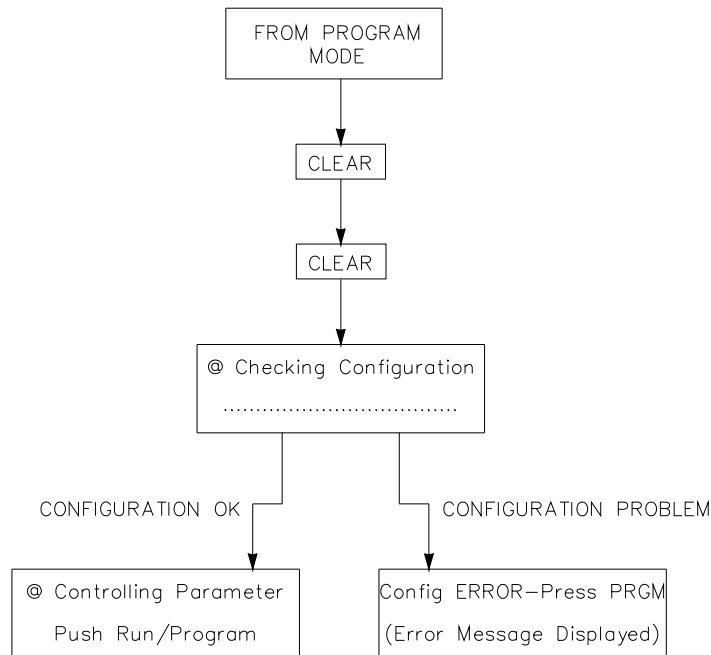
Figure 4-7. Exiting the Program Mode

Once the programming steps have been completed, the Program Mode can be exited (refer to Figure 4-7 Exiting the Program Mode). To exit the Program mode the "CLEAR' key is pressed twice. This initiates the 505E to save the configuration and to begin a Configuration Check procedure. If there are no errors in the programming, the 505E front-panel will return to the ready state and display the 'Controlling Parameter/Press Run or Program' screen. However, if there is an error in the program, the 'Config ERROR–Press PRGM' display will appear along will the programming error(s) discovered. The next section identifies the various configuration error messages and explains the meaning of the error.

Program Configuration Error Messages

When the Program Mode is exited, the control automatically performs a completeness check on the configured program to assure that required program blocks have values loaded into them. This check cannot determine if the values entered are realistic, but it makes sure that values have been loaded into required parameters. If any errors are found in the program, the 'Config ERROR– Press PRGM' display will appear along with the programming error(s) discovered. If there is more than one error discovered, they can be displayed by pressing the down arrow key. This key will scroll through all the error messages and allow you to determine their cause(s).

The configuration error message alerts you that a programming change is required before the configured program can operate the turbine. You must re-enter the Program Mode and fix the problem before the control will allow the turbine to run. The completeness check will continue to fail until the control is satisfied that the configured program is complete.

This section of the manual identifies the various configuration error messages that may appear and explains the meaning of the error.

Start / Speed Program Errors
No Start Mode Selected—RUN was selected but no start mode was selected in the Program mode. One of the three start modes must be selected in the Program mode under the Start Block.
Speed > 15000 Hz—The maximum speed input is 15000 hertz. This is a limitation of the 505E's hardware / speed sensing circuitry. The frequency input of the speed sensor must be less than this value. The gear the speed sensor is mounted on may need to be changed to one with less teeth, this will decrease the frequency seen by the speed probes.
Spd #1 Fld < Freq Range—The failed speed setting for speed input #1 is below the minimum allowed setting. The minimum allowed setting is calculated as follows: (Overspeed Test Limit) * (0.0204).
Spd #2 Fld < Freq Range—The failed speed setting for speed input #2 is below the minimum allowed setting. The minimum allowed setting is calculated as follows: (Overspeed Test Limit) * (0.0204).

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.
Crit Spd Err / No Idle—A critical speed avoidance band was programmed but neither idle/rated or auto start sequence was programmed. To use the critical speed avoidance logic one of these functions that uses an idle speed must be programmed.
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.
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.
Rated Speed > Max Gov—The Rated Speed setpoint was programmed at a higher speed than the maximum 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 a function key or a contact input must be programmed to arm/disarm frequency control if you wish to use the frequency arm/disarm function.
Sync & Sync/Ld Shr Pgmd—Both the synchronizing analog input and the sync/load share or load share analog inputs were programmed. 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.
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 Prgm 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 A, B, and C must be so the following equation is not true.

$$(HPa-HPc)\ (Sb-Sc) > (HPb-HPc)\ (Sa-Sc) \qquad \text{[for extraction or extr/adm]}$$

or

$$(HPc-HPb)\ (Sc-Sb) < (HPb-HPa)\ (Sc-Sa) \qquad \text{[for admission only units]}$$

    Where: HPa = Flow at Point A
                HPb = Flow at Point B
                HPc = Flow at Point C
                Sa = Power at Point A
                Sb = Power at Point B
                Sc = Power at Point C

In addition, the relative levels of HPa, HPb, HPc, Sa, Sb, and Sc must be correct
(refer to Program mode worksheets).

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 Analog Input—A synchronizing contact input was programmed but no
    synchronizing analog input was configured.
No Ld Share Analog In—A load share or sync/ load share contact input was
    programmed but no load share 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 Analog Input—The auxiliary control function was programmed but no
    auxiliary analog input was configured.
KW & Aux Config for Aux—The auxiliary control function was programmed to use
    the KW analog input but an auxiliary analog input was configured also. With
    this configuration, only the KW analog input is used for the auxiliary
    controller.
No Rmt Aux Input Prgm—The remote auxiliary setpoint control function was
    programmed but no remote auxiliary setpoint analog input was configured.
No Rmt Extr/Adm Input—The remote extr/adm setpoint control function was
    programmed but no remote extr/adm analog input was configured.

Function Key Program Errors
Identical Function Keys—Both function keys were programmed for the same
        function.
No F-Key Relay Prgmd—A function key was programmed to energize a relay but
        no relay outputs were configured for F3 or F4 key relays.
F3 Key Program Error—The F3 key was programmed for a function that is not
        also programmed to be used. Either F3 was mis-programmed or the
        function required was mis-programmed. For example, the F3 key is
        programmed for Remote Cascade Setpoint Enabled but Remote Cascade
        Setpoint was not programmed under the Cascade Program Block.
F4 Key Program Error—The F4 key was programmed for a function that is not
        also programmed to be used. Either F4 was mis-programmed or the
        function required was mis-programmed. For example, the F4 key is
        programmed for Remote Cascade Setpoint Enabled but Remote Cascade
        Setpoint was not programmed under the Cascade Program Block.

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 mis-
        programmed 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.

Valve / Actuator Calibration and Test

Before initial operation or after a turbine overhaul where any actuator or valve
travel may have been affected, the below Valve Calibration procedure should be
followed to insure that the 505E is calibrated to both valves.

The 505E uses its actuator output currents to sense HP and LP valve positions.
These valve positions are used by the 505E to calculate internal turbine ratios,
and operating limits. Thus if the 505E is not correctly calibrated to each control
valves actual travel, it will incorrectly calculate turbine operating limits. It is
recommend that each valve be manually stroked after the 505E's output has
been calibrated to insure that the 505E's screen and actual valve position match
as closely as possible.

After a valid program has been entered the actuator and valve minimum and
maximum positions can be adjusted and tested, if needed. Actuator and valve
positions are determined by the drive current to the actuator. The maximum
actuator current can not be adjusted lower than the minimum actuator current
(see Table 4-1 below). The minimum actuator current can not be adjusted higher
than the maximum actuator current. The driver current ranges are determined by
the setting in the Program Mode under the Driver Configuration Block.

When adjusting or testing actuator and valve travel, verify that sufficient valve
over travel at the minimum stop is achieved (1-2%). This assures that each valve
can fully close to completely shut off the steam flow to the turbine.

Driver Limits	20–160 mA Range	4–20 mA Range
Overcurrent	217 mA	26 mA
Under current	5 mA	0.6 mA
Max Output Current Range	10-200 mA	2-24 mA
Max Output Impedance	45 Ω	360 Ω
Min Stop Adjust Range	10-80 mA	2-20 mA
Max Stop Adjust Range	100-200 mA	10-24 mA

Table 4-1. Actuator Driver Limits

To ensure proper control to actuator resolution do not calibrate the span of the actuator output to less than a range of 100 mA (20–160 mA output) or 12 mA (4–20 mA output). If necessary, the actuator to valve linkage may need to be adjusted to ensure proper 505E to valve resolution.

Figure 4-8 graphically shows the steps available to stroke the actuators or valves. The stroking option is only available when the 505E control is in a shutdown state. The emergency shutdown input has to be closed or jumpered, as this input being open will shut off the current outputs of the 505E.

After enabling the stroke mode, there are options available to adjust the minimum and maximum stops and to manually stroke the output(s). The manual adjustment mode can be used to stroke the actuators and valves from 0 to 100% after the minimum and maximum positions have been adjusted. This allows both the actuator and valve to be tested for binding, play, resolution, linearity, and repeatability. The actuator and valve positions can be varied by using the ADJ UP and DOWN keys or keying in the position desired and pressing the ENTER key. When the ENTER key is pressed, the actuator output will step to the entered position.

As a safety precaution, if turbine speed ever exceeds 1000 rpm, the STROKE ACTUATORS mode will be automatically disabled, and actuator currents taken to zero.

Calibration / Stroking Procedure

> ⚠️ **WARNING**   **Before calibrating or testing, the unit must be tripped and the steam supply removed. This is to ensure that opening the control valve(s) will not allow steam into the turbine. Overspeed sensing and its relay are disabled during this process. Overspeeding the turbine may cause damage to turbine and can cause severe injury or death to personnel. STEAM TO THE TURBINE MUST BE SHUT OFF BY OTHER MEANS DURING THIS PROCESS.**

1. The 505E's Emergency shutdown contact input must be closed or jumpered throughout this procedure (or the 505E's actuator current outputs will go to ZERO current).
2. Execute a system RESET command (Press the 505E "Reset" key).
3. Press the 505E's front panel "Emergency Shutdown" button.
4. Press the ACT key then the SCROLL DOWN key until the "Stroke Actuators—Dsbld, Steam Must be Off" message appears. (Verify that the turbine's steam supply has been shutoff before by an external Trip and Throttle valve.)
5. Press the "YES" key (This will cause the screen to display a "HP Valve to Min—Enabld, Min Curr Adjust * 20.000 message if the unit was programmed for 20–160 mA output).

6. Press the "YES" key to enable this mode or the "Scroll Down Arrow" to step to the mode desired. (Refer to Figure 4-8).

6a. **HP Valve to Min—Enabld, Min Curr Adjust * XXX.XX**—Press YES to force the actuator output to the minimum stop. The message will display 'At Min' and the actuator output current will move to its minimum setting. The minimum current value can be adjusted only when the 'at sign' (@) is on the bottom line of the display. Press the SELECT key to move the @ symbol between the top and bottom lines. Press the ADJ UP or DOWN keys to change the 0% actuator current level. Press the SCROLL DOWN ARROW to step the next desired mode, or the "CLEAR" key twice to save changes, and exit Calibration mode.

6b. **HP Valve to Max—Enabld, Max Curr Adjust * XXX.XX**—Press YES to force the actuator output to the maximum stop. The message will display 'At Max' and the actuator output current will move to its maximum setting. The maximum current value can be adjusted only when the 'at sign' (@) is on the bottom line of the display. Press the SELECT key to move the @ symbol between the top and bottom lines. Press the ADJ UP or DOWN keys to change the 100% actuator current DOWN ARROW to step the next desired mode, or the "CLEAR" key twice to save changes and exit Calibration mode.

6c. **Manually Adjust—Enabld, Stroke HP Valve XXX.XX**—Press the ADJ UP, ADJ DOWN keys from this screen to move the HP valve's output current between 0-100% at a 5%/second rate. This allows both the actuator and valve to be tested for binding, play, resolution, linearity, and repeatability.

Press the "YES" key at any time to allow a setting to be directly Entered. The message will display 'Manual' when the ENTER mode is allowed. When in the 'Manual' mode, press the "ENTER" key, followed by the setting desired then press the "ENTER" key again. This will step the actuator output to a specific position instantly. Press the "ADJ UP/DOWN" or "No" keys at any time to switch back to the "Enabld" mode.

When calibration is complete, 0 to 100% valve position as displayed by the 505E must equal 0 to 100% actual valve travel. Press the SCROLL DOWN ARROW to step the next desired mode, or the "CLEAR" key twice to save changes and exit Calibration mode.

6d. **LP Valve to Min—Enabld, Min Curr Adjust * XXX.XX**—Press YES to force the actuator output to the minimum stop. The message will display 'At Min' and the actuator output current will move to its minimum setting. The minimum current value can be adjusted only when the 'at sign' (@) is on the bottom line of the display. Press the SELECT key to move the @ symbol between the top and bottom lines. Press the ADJ UP or DOWN keys to change the 0% actuator current level. Press the SCROLL DOWN ARROW to step the next desired mode, or the "CLEAR" key twice to save changes and exit Calibration mode.

6e. **LP Valve to Max—Enabld, Max Curr Adjust * XXX.XX**—Press YES to force the actuator output to the maximum stop. The message will display 'At Max' and the actuator output current will move to its maximum setting. The maximum current value can be adjusted only when the 'at sign' (@) is on the bottom line of the display. Press the SELECT key to move the @ symbol between the top and bottom lines. Press the ADJ UP or DOWN keys to change the 100% actuator current level. Press the DOWN ARROW to step the next desired mode, or the "CLEAR" key twice to save changes and exit Calibration mode.

6f. **Manually Adjust—Enabld, Stroke LP Valve XXX.XX**—Press the ADJ UP,
     ADJ DOWN keys from this screen to move the LP valve's output current
     between 0-100% at a 5%/second rate. This allows both the actuator and
     valve to be tested for binding, play, resolution, linearity, and repeatability.

     Press the "YES" key at any time to allow a setting to be directly Entered.
     The message will display 'Manual' when the ENTER mode is allowed. When
     in the 'Manual' mode, select "ENTER" followed by the setting desired then
     press the "ENTER" key. This will step the actuator output to a specific
     position instantly. Press the "ADJ UP/DOWN" or "No" keys at any time to
     switch back to the "Enabld" mode.

     When calibration is complete, 0 to 100% valve position as displayed by the
     505E must equal 0 to 100% actual valve travel. Press the SCROLL DOWN
     ARROW to step the next desired mode, or the "CLEAR" key twice to save
     changes and exit Calibration mode.

7. **Press the CLEAR key twice to permanently save any minimum or
    maximum actuator settings into the 505E. If variables are tuned or
    changed but not stored in EEPROM by pressing CLEAR twice, then
    those changes will be lost if power is removed from the control or if the
    control receives a CPU reset.**

If changes are made to the minimum or maximum current values, they can be
recorded on the Program Mode worksheets under the 'Driver Configurations'
block.

Pressing any available Run Mode key will exit the STROKE
ACTUATORS/VALVE mode. Exiting the STROKE ACTUATORS/VALVE mode
by a RUN MODE key will not permanently save any calibration changes.

NOTICE **Press the CLEAR key twice to permanently save any minimum or
maximum actuator settings into the 505E. If variables are tuned or
changed but not stored in EEPROM by pressing CLEAR twice, then
those changes will be lost if power is removed from the control or if
the control receives a CPU reset.**

STROKE ACTUATOR/VALVE MESSAGES

MESSAGE 7	MEANING
Dsbld	Stroke actuator/valve function is disabled
Enabld	Stroke actuator/valve function is enabled
At Min	Actuator output is set to the minimum value (0%)
At Max	Actuator output is set to the maximum value (100%)
Manual	Actuator output is in manual mode

STROKE
(ONLY WHEN TURBINE IS SHUT DOWN)

ACTUATOR

SCREEN #1
| HP Valve Dmd | xxxx % |
| LP Valve Dmd | xxxx % |

SCREEN #2
| HP Valve Dither | * x.xx |
| LP Valve Dither | * x.xx |
ADJ ▲ INCREASES DITHER
▼ DECREASES DITHER

SCREEN #3
| HP Valve Out | xxxx mA |
| LP Valve Out | xxxx mA |

SCREEN #4
| Stroke Actuator | msg 7 |
| STEAM MUST BE OFF!!! | |
YES ENABLES ACT STROKE
NO DISABLES ACT STROKE

SCREEN #5
| HP Valve to Min | msg 7 |
| Min Curr Adjust | * xxx |
YES SETS ACT OUTPUT TO MIN
ADJ ▲ INCREASES mA OUTPUT
▼ DECREASES mA OUTPUT

SCREEN #6
| HP Valve to Max | msg 7 |
| Max Curr Adjust | * xxx |
YES SETS ACT OUTPUT TO MAX

SCREEN #7
| Manually Adjust | msg 7 |
| Stroke HP Valve | * xxx |
YES ENABLES MANUAL POS'N "ENTER"
NO DISABLES MANUAL POS'N "ENTER"
ADJ ▲ INCREASES ACTUATOR OUTPUT
▼ DECREASES ACTUATOR OUTPUT
ENTER WHEN IN MANUAL MODE, DIRECT ENTRY OF ACT POSITION

SCREEN #8
| LP Valve to Min | msg 7 |
| Min Curr Adjust | * xxx |
YES SETS ACT OUTPUT TO MIN
ADJ ▲ INCREASES mA OUTPUT
▼ DECREASES mA OUTPUT

SCREEN #9
| LP Valve to Max | msg 7 |
| Max Curr Adjust | * xxx |
YES SETS ACT OUTPUT TO MAX

SCREEN #10
| Manually Adjust | msg 7 |
| Stroke LP Valve | * xxx |
YES ENABLES MANUAL POS'N "ENTER"
NO DISABLES MANUAL POS'N "ENTER"
ADJ ▲ INCREASES ACTUATOR OUTPUT
▼ DECREASES ACTUATOR OUTPUT
ENTER WHEN IN MANUAL MODE, DIRECT ENTRY OF ACT POSITION

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Screen 4 shown only when the unit is shut down.
Screens 5-10 shown only when Stroke Actuator is set to YES.

The asterisk (*) denotes a tunable parameter. To adjust this parameter, the "@" symbol must be on the display line containing the asterisk. The @ symbol is moved with the SELECT key.

NOTE: If changes are made to the Min or Max current values, they can be recorded on the PROGRAM MODE worksheets under the "Driver Configuration" header.
To save changes CLEAR must be pressed twice.

Figure 4-8. Stroke Actuator/Valve

Chapter 5.
505E Operation

Run Mode Architecture
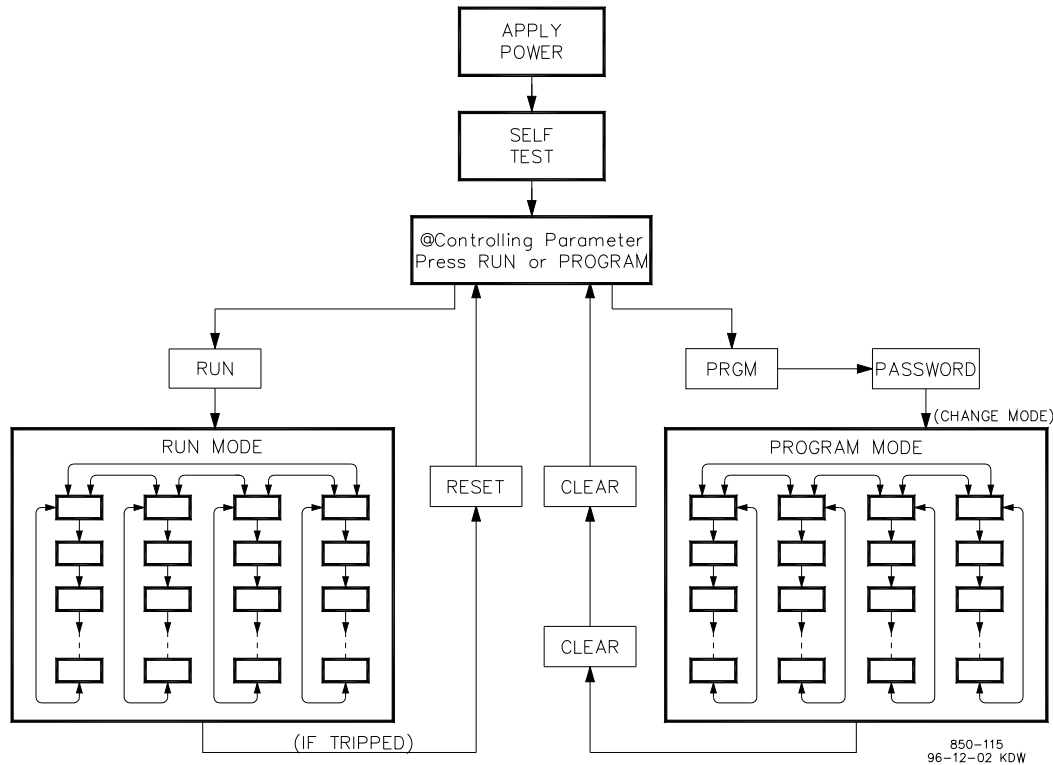
Figure 5-1. Basic Program Architecture

The 505E is designed to be interfaced with through a user-friendly service panel, discrete and analog input/outputs or Modbus communications. Basic program architecture is illustrated in Figure 5-1. When the control is powered up and after the brief CPU self test has been completed, the control displays a ready status (Controlling Parameter/Push Run or Program). The 505E's operating architecture is divided into two sections: the Run Mode and the Program Mode. The Program Mode is used to configure the 505E for the specific application and set all operating parameters (see Chapter 4). The Run Mode is simply the normal turbine operation mode and is used to view operating parameters and run the turbine.

An overview of Run mode keys and screens is shown in Figure 5-2. This diagram shows all of the potential screens that could appear. However, only the screens that are related to the 505E's programmed functionality will appear. Figure 5-2 also shows the keys that are active for each screen. The 'hot' keys (Speed, Aux, etc.) are always active if the function is programmed. The ADJUST UP/DOWN, ENTER, YES/NO keys, however, are only active with certain screens. Figure 5-2 can be referred to, when determining what keys are active and what screens will appear on the display.

IDLE/RATED MESSAGES
MESSAGE 1
Stopped
Mvg to Idle
At Idle Spd
In Crit Band
Mvg to Rated
At Rated Spd
Rtd Inhibited
Idle Inhibited

AUTO START MESSAGES
MESSAGE 2
Disabled
Halted
Mvg Low Idle
At Low Idle
Mvg Hi Idle
In Crit Band
At High Idle
Mvg to Rated
Completed

REMOTE MESSAGES
MESSAGE 4
Disabled
Inhibited
Enabled
Active
In Control

E/A or AUX MSGS (if using aux enable)
MESSAGE 5
Disabled
Inhibited
Enabled
Active/Not in Ctrl
Active w/Rmt Setpt
In Control
Remote Control

AUX MESSAGES (if using aux as limiter)
MESSAGE 5
Inhibited
Enabled
Enabled w/Rmt Setpt
Active w/Rmt Setpt
Active/Not Lmting
Control w/Rmt Setpt
In Control

CASCADE CONTROL MESSAGES
MESSAGE 6
Disabled
Inhibited
Enabled
In Control
Active/Not Spd Ctrl
Active w/Rmt Setpt
In Ctrl w/Rmt Setpt

CONTROL PARAMETER
MESSAGE 7
Controlling Parameter
Control at Two Limits
Remote Auxiliary
Auxiliary Control
Manual Start
Auto Start
Semi Auto Start
Idle/Rated Start
Auto Start Sequence
Frequency/Speed
Synchronizing
Load Share/Speed
Remote Cascade/Speed
Cascade/Speed
Remote/Speed
Speed/On-Line
Speed/Off-Line
LP Min Limit
LP Max Limit
HP Min Limit
HP Max Limit
Max Power Limit
HP Valve Limiter
HP Max Actuator

CONTROL PARAMETER
MESSAGE 7A
Manual Admission Demand
Manual Extr/Extr Demand
Extr/Adm Control
Admission Control
Extraction Control
E/A Ctrl w/ Rmt Setpt
Adm Ctrl w/ Rmt Setpt
Extr Ctrl w/ Rmt Setpt
Max Adm Limit Control
Min Adm Limit Control
Min Extr Limit Control
Max Extr Limit Control
LP Min Limit Control
LP Max Limit Control
HP Min Limit Control
HP Max Limit Control
Max Power Limit Control
LP Valve Limiter Control
LP Max Actuator Control
Min HP & Min Prs Limits
Min LP & Min Prs Limits
Max LP & Min Prs Limits
Min HP & Min LP Limits
Max Pwr & Min Prs Limits
Max HP & Max Prs Limits
Min LP & Max Prs Limits
Max Pwr & Max LP Limits
Max HP & Min LP Limits
Max HP & Max Pwr Limits
Max HP & Max LP Limits
Ready to Start
Start Perm Not Met
Configuration Error
Controlled Shutdown
Shutdown

TRIP MESSAGES
MESSAGE 8
External Trip Input
Enter Shutdown Button
Overspeed
All Speed Probes Failed
Act #1 (HP) Fault
Act #2 (LP) Fault
Aux Input Failed
External Trip 2
External Trip 3
External Trip 4
External Trip 5
Comm Link #1 Trip
Comm Link #2 Trip
Extr/Adm Input Failed
Tie Breaker Opened
Generator Breaker Open
Power Up Trip
Shutdown Complete

PRIORITY MESSAGES
MESSAGE 10
Speed Priority Active
Extr Priority Active
E/A Priority Active
Adm Priority Active
Ext Active/Spd Selected
Prs Active/Spd Selected
Adm Active/Spd Selected
Spd Active/ Ext Selected
Spd Active/ Prs Selected
Spd Active/ Adm Selected
Auto Switching Config'd
Priority Swtch Not Used
Priority Xfer Inhibited

UNITS OPTIONS (for AUX and CASC)
psi
kPa
MW
kW
degF
degC
t/h
k#/hr
#/hr
kg/cm²
bar
atm
none

Table 5-1. Overview of Run Mode
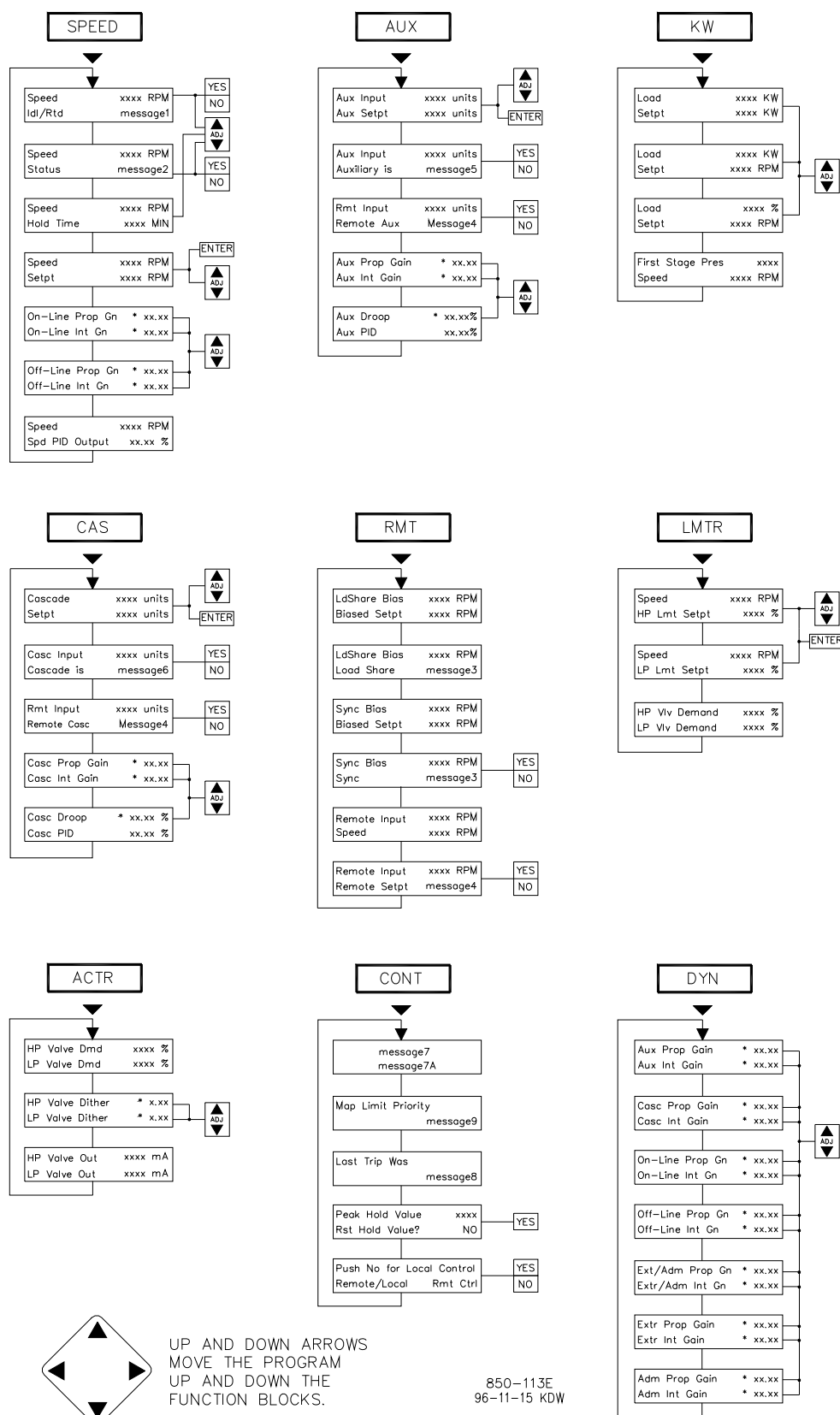
Figure 5-2a. Overview of Run Mode
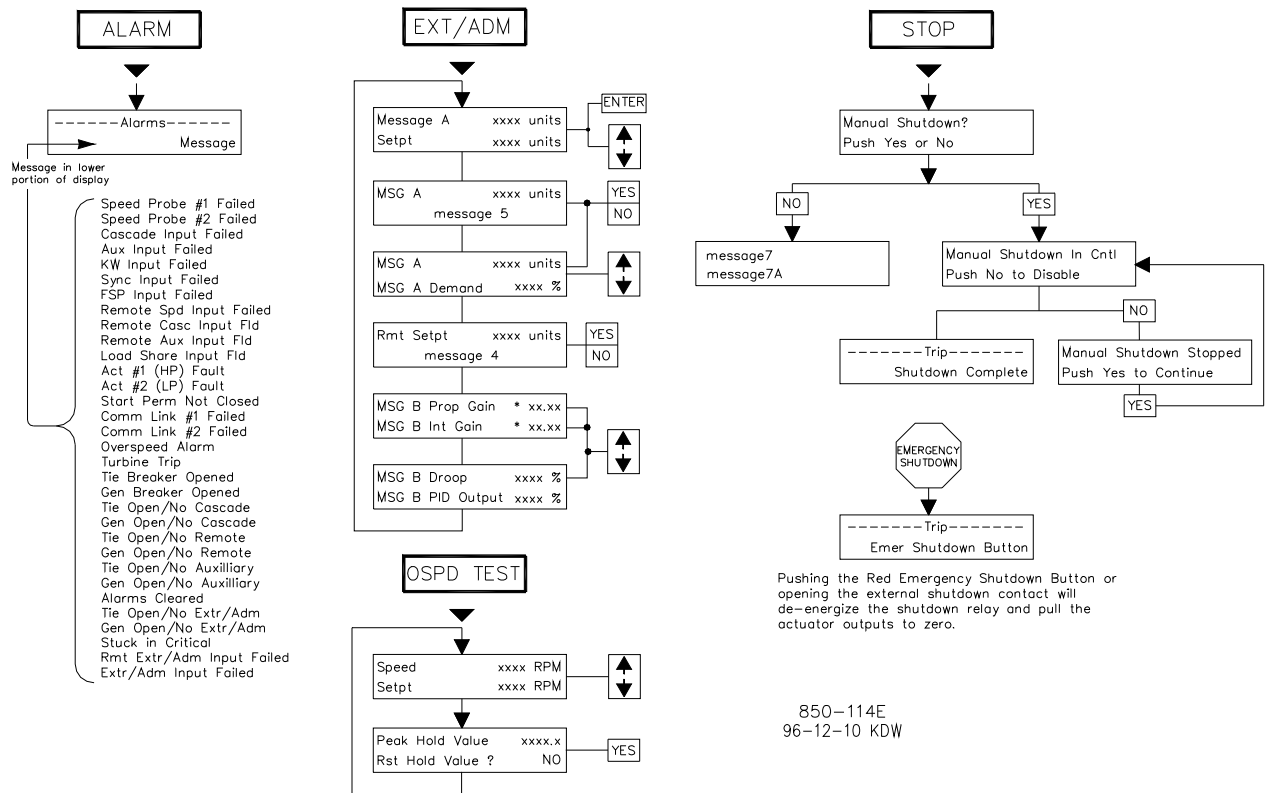
Figure 5-2b. Overview of Run Mode

Keypad and Display

The 505E is a field configurable steam turbine control and operator control panel (OCP) integrated into one package. The 505E's service panel consists of a 30-key keypad and LED display located on the front of the control. The LED display has two, 24 character lines that can be used to display operating parameters and trouble-shoot parameters in plain English. The service panel is used to configure the 505E, make On-Line program adjustments, and operate the turbine/system. No additional panels are required to operate the turbine, every turbine control function can be from the 505E's front panel. However, the turbine can also be operated remotely. Every front panel control operation can be performed remotely through contacts or Modbus communications. For safety purposes, however, the 505E's Overspeed Test function cannot be performed through a Modbus link.

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            WOODWARD GOVERNOR CO.

            505 Version x.xx
```



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                                                850-084
                                                96-02-06 KDW
```
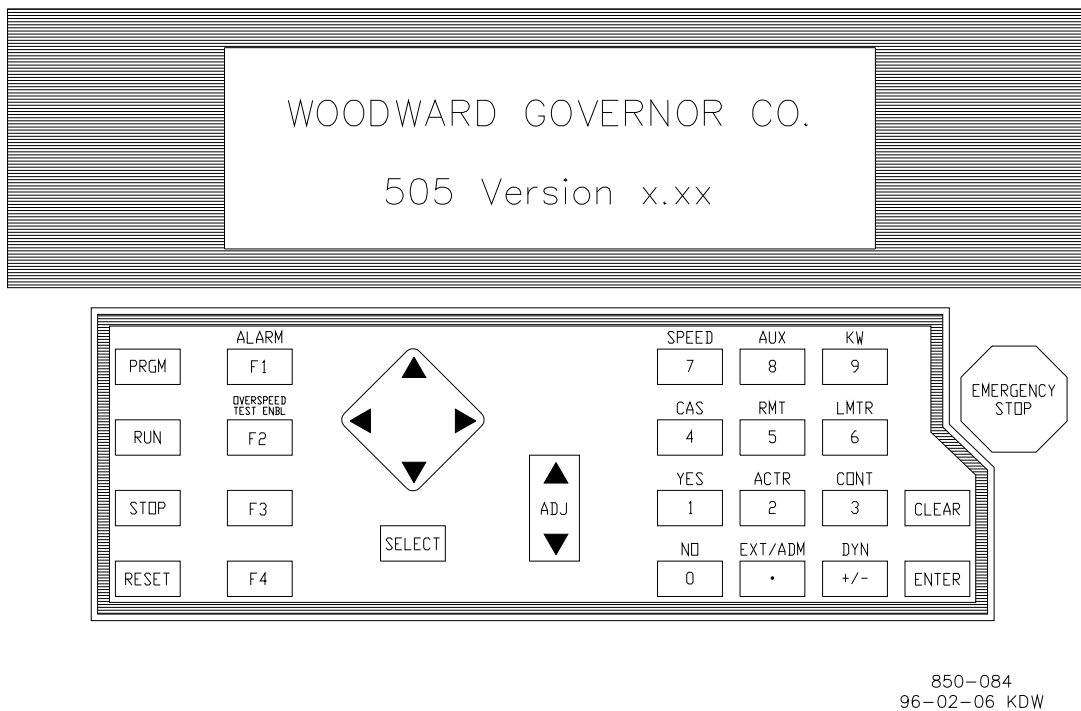
Figure 5-3. 505E Keypad and Display

Run Mode Front Panel Keys

For a detailed description of each 505E key functionality see Chapter 1.
Of the thirty front panel keys, not all are active at all times in the Run mode.
However, from the front panel, the keys that are active will be apparent since
there is immediate display feedback when an active key is pressed. When a
respective "Hot" key (Aux, Casc, kW, etc.) function is not programmed, a
'Function Not Programmed' message will be appear if the key is pressed. The
following are generalizations when determining what keys will function:

- The ADJUST UP/DOWN keys are active when a setpoint is displayed and
  the setpoint is not in a remote control or tracking mode.
- The ENTER key is active whenever the ADJUST UP/DOWN keys are
  active. This is when the setpoint is shown on the display and the setpoint is
  not in remote control or tracking mode.
- The YES/NO keys are active whenever a status indication is shown on the
  display and an enable/disable function is valid.
- The CAS, AUX, kW, and RMT keys are only active if the function is
  configured in the Program Mode.
- The SPEED, ACTR, LMTR, CONT, EXT/ADM, and DYN keys are always
  active.
- The PRGM, RUN, STOP, RESET, and ALARM keys are always active.
- The F3 and F4 function keys are only active if they are configured.
- The OVERSPEED TEST ENBL is conditionally active (only active when
  OSPD test is permissible).

Starting Procedures

Refer to the turbine manufacturer's operating procedures for complete information on turbine start up, and Chapter 3 of this manual for a step by step procedure, depending on the start mode selected. The following is a typical start-up procedure:

⚠️ **WARNING**	**The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.**
	The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

1. Press the RESET key to clear all alarms and trips and increase the LP Valve Limiter to 100%. If the 505E's 'RESET CLEARS TRIP' setting is programmed "YES", the 505E'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 505E's shutdown relay will reset or energize upon pressing the RESET key ONLY after all trip conditions are cleared.
2. Press the RUN key to initiate the selected start-up mode. The front panel display will automatically jump to the SPEED screen (if auto or manual start is programmed) or to the LMTR screen (if semiauto start is programmed). If a semi-automatic start mode is configured, the valve limiter must be manually increased to open the control valve.
    *   A 'Start Perm Not Closed' alarm will be issued if the application is using a Start Permissive contact input and this contact input was not closed when the RUN command was issued.
3. After the selected start-up mode has been performed, the turbine will operate at the minimum or idle speed setting. The 505E'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 505E 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 or 'enter' commands through the 505E's keypad, external switches, or communication links.

The 'Run' and 'Reset' commands can be selected from the 505E's service panel, contact input closures (if programmed), or from a Modbus communications link. In addition, the following indications are available through the Modbus links: Speed Setpt Moving to Min, Start Permissive Closed, and Start Permissive Not Closed Alarm indication.

Speed Key Screens

Figure 5-4 shows the possible screens that may appear if the SPEED key is pressed. Only the screens related to the Speed control's programmed functionality will be displayed. In addition, the order of the screens may change depending on the status of the control. Screens 4, 5 and 6 will always appear. If idle/rated is programmed, screen 1 will appear. If the auto start sequence if programmed, screens 2 and 3 will appear. Once the auto start sequence is complete, these screens no longer appear.

```
                        ┌─────────────┐
                        │    SPEED    │
                        └─────────────┘
                               ▼

                 ┌────────────────────────┐  ┌─────┐
                 │ Speed        xxxx RPM   │  │ YES │  SELECTS RATED
   SCREEN #1     │ Idl/Rtd      message1   │  ├─────┤
                 └────────────────────────┘  │ NO  │  SELECTS IDLE
                                              └─────┘

                 ┌────────────────────────┐  ┌─────┐
                 │ Speed        xxxx RPM   │  │ YES │  SELECTS CONTINUE AUTO SEQUENCE
   SCREEN #2     │ Status       message2   │  ├─────┤
                 └────────────────────────┘  │ NO  │  SELECTS HALT AUTO SEQUENCE
                                              └─────┘

                 ┌────────────────────────┐  ┌─────┐
                 │ Speed        xxxx RPM   │  │  ▲  │  INCREASES SPEED SETPT
   SCREEN #3     │ Hold Time    xxxx MIN   │  ├─────┤
                 └────────────────────────┘  │  ▼  │  DECREASES SPEED SETPT
                                              └─────┘

                                              ┌───────┐  DIRECT ENTRY OF SPEED SETPT
                 ┌────────────────────────┐   │ ENTER │
                 │ Speed        xxxx RPM   │   └───────┘
   SCREEN #4     │ Setpt        xxxx RPM   │  ┌─────┐
                 └────────────────────────┘  │  ▲  │  INCREASES SPEED SETPT
                                              ├─────┤
                                              │  ▼  │  DECREASES SPEED SETPT
                                              └─────┘

                 ┌────────────────────────────┐
                 │ On-Line Prop Gn  * xx.xxx  │
   SCREEN #5     │ On-Line Int  Gn  * xx.xxx  │  ┌─────┐
                 └────────────────────────────┘  │  ▲  │  INCREASES GAIN SETTINGS
                                                  ├─────┤
                 ┌────────────────────────────┐  │  ▼  │  DECREASES GAIN SETTINGS
                 │ Off-Line Prop Gn * xx.xxx  │  └─────┘
   SCREEN #6     │ Off-Line Int  Gn * xx.xxx  │
                 └────────────────────────────┘

                 ┌────────────────────────┐
                 │ Speed         xxxx RPM  │
   SCREEN #7     │ Spd PID Output  xxxx %  │
                 └────────────────────────┘

                                        850-118g
                                        97-08-05 JMM
```

- Screen 1 shown only if Idle/Rated control is configured and speed is less than the rated setpt. Once above rated speed, screen 1 appears after screen 4.

- Screens 2 & 3 are shown only if Auto Start Sequence is configured and speed has not reached the rated setpt.

- Screens 5 & 6 are shown only if dynamics adjustments are used.

The asterisk (*) denotes a tunable parameter. To adjust this parameter the "@" symbol must be on the display line containing the asterisk. The @ symbol is moved with the SELECT key.

Figure 5-4. SPEED Key Screens

Idle/rated Start

For details on the idle/rated startup, refer to chapter 3. When a RUN command is issued, the 505E automatically displays the SPEED screen and shows 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, select the Rated command. A Rated command can be issued by pressing the front panel YES key from the Idle/Rtd screen (screen 1), 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 by pressing the ADJUST UP or DOWN from the front panel SPEED screen (screens 1, 2, 3, or 4), 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 press the front panel YES key from the Idle/Rtd screen (screen 1), 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 3) by pressing the front panel NO key from the Idle/Rtd screen (screen 1), opening the Idle/Rated contact (if programmed), or selecting Go To Idle from a Modbus communications link.

Another feature of Idle/Rated function is the 'Ramp to Rated' option which allows the Speed setpoint to only move to the Rated Speed setting; Idle is not selectable. This feature is configurable in the Service Mode only. When this feature is used with the Idle/Rated contact input, closing the contact results in the Speed setpoint ramping to the Rated Speed setting and opening the contact stops the speed setpoint ramp—rather than selecting Idle. To continue ramping to the Rated Speed setting, re-close the contact, press the front panel YES key from the Idle/Rtd screen (screen 1) or select Go To Rated from a Modbus communications link.

Table 5-2 lists the Idle/Rated status messages that may appear on the front panel display and the meanings of each.

MESSAGE 1	MEANING
Stopped	Idle/Rated ramp has been stopped
Mvg to Idle	Speed Setpt is moving to idle
At Idle Spd	Speed Setpt is at the idle Setpt
In Crit Band	Setpt is moving thru the critical avoidance band
Mvg to Rated	Speed Setpt is moving to the rated Setpt
At Rated Spd	Speed Setpt is at the rated Setpt
Rtd Inhibited	Selection of rated is not allowed
Idle Inhibited	Selection of idle is not allowed

Table 5-2. Idle/Rated Messages

The following indications are available through the Modbus links: Ramping to Idle, At Idle, Turbine in Critical Speed Band, Ramping to Rated, and At Rated. In addition to these indications, the Idle Speed Setpoint and Rated Speed Setpoint analog values are also available.

Auto Start Sequence

When a RUN command is issued, the 505E automatically displays the SPEED screen (unless used with the Semiautomatic start mode) and shows the Status of the Auto Start Sequence (screen 2). The Speed setpoint is instantly set to the turbine's actual speed and the sequence will continue from this point. This sequence is automatic, however the sequence can be halted. Halting the Auto Start Sequence can be performed by pressing the front panel NO key from the Sequence Status screen (screen 2), opening the Halt/ Continue contact (if programmed), selecting Halt from a Modbus communications link, or selecting Speed Setpt Raise or Lower. 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 front panel YES key from the Sequence Status screen (screen 2), closing the Halt/Continue contact, or selecting Continue from a Modbus communications link. Table 5-3 lists the Auto Start status messages that may appear on the display and the meanings of each.

MESSAGE 2	MEANING
Disabled	Auto Start Sequence is disabled
Halted	Sequence has been halted
Mvg Low Idle	Speed Setpt is moving to low idle
At Low Idle	Speed Setpt is holding at the low idle Setpt
Mvg Hi Idle	Speed Setpt is moving to high idle
In Crit Band	Setpt is moving through the critical avoidance band
At High Idle	Speed Setpt is holding at the high idle Setpt
Mvg to Rated	Speed Setpt is moving to rated Setpt
Completed	Auto Start Sequence is completed

Table 5-3. Auto Start Messages

The following Auto Start Sequence indications are available through the Modbus links: Setpt Moving to Min, Setpt at Low Idle, Ramping to High Idle, Setpt at High Idle, Turbine in Critical Speed Band, Ramping to Rated, and At Rated. In addition to these indications, the Low Idle Speed Setpoint, Low Idle Delay Time, Time Remaining at Low Idle, Low Idle to High Idle Rate, High Idle Speed Setpoint, High Idle Delay Time, Time Remaining at High Idle, High Idle to Rated Rate, Rated Speed Setpoint, Run Time (hours), and Hours Since Trip analog values are also available providing comprehensive sequence information.

Direct Setpoint Entry

The Speed setpoint can be directly set to a specific value, that is not within a critical speed avoidance band, using the ENTER key from the Speed Setpt screen (screen 4). The messages that appear on the display are shown in Figure 5-5. There are limits on the range of the Speed setpoint that can be entered. The Speed setpoint must be below the maximum governor setting and above the idle setting. Once above minimum governor speed, 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 3% minimum load setting (tunable in the Service Mode).

The Speed setpoint can also be directly entered from either of the Modbus links, however, the allowed range is between the minimum and maximum governor speed settings. The allowed setpoint range is limited between the minimum load and the maximum governor settings if the unit is driving a generator and the unit is on-line. Both the speed setpoint and the Modbus Entered Speed setpoint are available over the communication link to provide feedback for directly entered Modbus values.

```
┌─────────────────────────┐
│                         │
│        ENTER            │
│                         │
└─────────────────────────┘
              │
              ▼
┌─────────────────────────┐
│ New Setpoint value      │
│                  xxxx   │
└─────────────────────────┘
```

Use Number Keys to set new setpt and press ENTER.

The new setpoint value must be within the allowed setpoint range or the display will issue an error message.

```
┌─────────────────────────┐
│ Value xxx.xx Accepted   │
│ Press ENTER to continue │
└─────────────────────────┘
```

The setpoint will move to the new entered value at the "entered rate." The Entered Rate is defaulted to the slow rate setting but can be adjusted in the Service Mode if desired. Selecting the Adjust Up or Adjust Down arrows will stop the setpoint at its present position.

Error Messages:

```
┌──────────────────────────┐   ┌──────────────────────────┐   ┌──────────────────────────┐
│ New value less than min  │   │ New value more than max  │   │ Setpt Entrd in Crit Bnd  │
│ Press ENTER to continue  │   │ Press ENTER to continue  │   │ Press SPEED key          │
└──────────────────────────┘   └──────────────────────────┘   └──────────────────────────┘
```

```
850-135
96-04-15 KDW
```

Figure 5-5. Direct Setpoint Entry

Speed Control

Once the turbine is in speed control at minimum governor speed or rated speed, the speed setpoint can be adjusted with the ADJUST UP or DOWN front panel keys from the Speed screen (screen 4), Speed Setpoint Raise or Lower contact inputs, or commands through a Modbus link. In addition the setpoint can be directly entered using the ENTER key from a Setpoint display or through the communication links (see Direct Setpoint Entry above).

The following speed control indications are available through the Modbus links: Speed PID in Control and Speed at or above Min Gov. In addition to these indications the Speed Setpoint, Actual Turbine Speed, Speed Sensor #1 Input, Speed Sensor #2 Input, and Speed Control PID Output analog values are also available.

Overspeed Test Function

The 505E'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 505E's internal overspeed trip logic and any external overspeed trip device's settings and logic. Figure 5-6 shows the screens that are displayed when the 'OSPD' key is pressed. These will only be displayed when the speed setpoint has been raised to the maximum governor and the unit is Off-Line (if driving a generator). Before these conditions are met, the screen will indicate the overspeed test permissives are not met.

```
                          ┌─────────────────────┐
                          │        F2           │
                          └─────────────────────┘
                                    │
                                    ▼
                                    │
                                    ▼
              ┌─────────────────────────────────┐     ┌─────┐
              │ Speed            xxxx RPM        │     │  ▲  │   INCREASES SPEED SETPT
SCREEN #1     │                                 │─────│ ADJ │
              │ Setpt            xxxx RPM        │     │  ▼  │   DECREASES SPEED SETPT
              └─────────────────────────────────┘     └─────┘
                                    │
                                    ▼
              ┌─────────────────────────────────┐     ┌─────┐
              │ Peak Hold Value  xxxx RPM        │     │ YES │   CLEARS PEAK SPEED REACHED
SCREEN #2     │                                 │─────│     │
              │ Rst Hold Value?         NO       │     └─────┘        850-128
              └─────────────────────────────────┘                 96-06-25 KDW
```
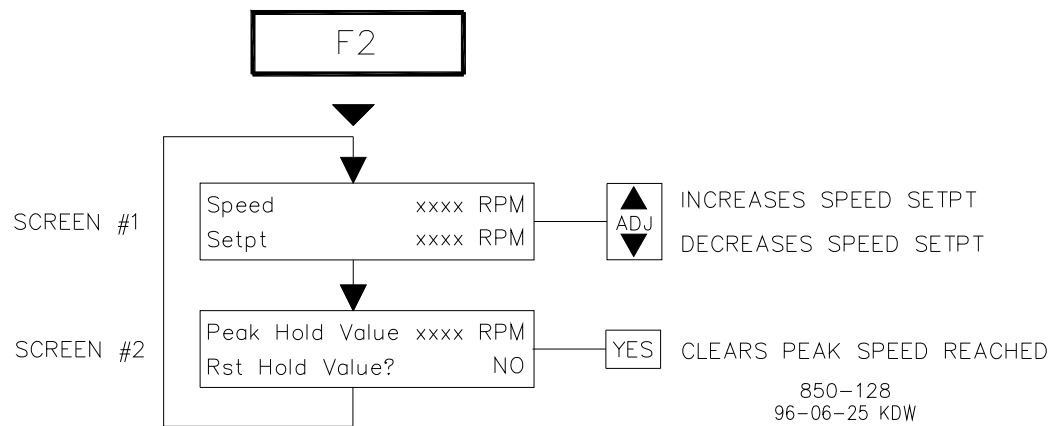
Figure 5-6. Overspeed Test Enable Key Screens

Overspeed Test Procedure (from The 505E's Service Panel)

- Raise the Speed Setpoint to the maximum governor setting.
- If desired, clear the 'Highest Speed Reached' value, to record the highest speed reached during this overspeed test. To accomplish this, press the OSPD key, scroll down to screen 2 and press the YES key. Note: This value can also be cleared or read from under the Control (CONT) key.
- Press the OSPD key and Adjust Up command at the same time to allow the Speed Setpoint to be raised for testing. The Overspeed Test Enable LED in the OSPD key will turn ON when the setpoint is raised above the maximum governor setting.
- (If the OSPD key is released while below the trip setting, the speed setpoint will move back to the maximum governor setting).
- Once turbine speed reaches the 505E's internal OVERSPEED TRIP LEVEL setting, the OSPD key's LED will blink and the screen will flash a 'Speed > Trip' message.
- If the OSPD key is released while the Overspeed Test LED is blinking, the unit will trip on overspeed.
- If an external device's trip setting is being tested the Speed Setpoint can be raised up to the 505E's OVERSPEED TEST LIMIT setting, by not releasing the OSPD key and continuing to adjust the 505E's Speed Setpoint. The Overspeed Test LED will blink at a faster rate when the OVERSPEED TEST LIMIT is reached, indicating the maximum speed setpoint is reached and the unit should have tripped on the external trip device.

Alternatively the turbine's overspeed logic and circuitry can be tested remotely, by programming an Overspeed Test contact input. The Overspeed Test contact functions as the OSPD key on the 505E's service panel. 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. The testing procedure is similar to using the OSPD key. An Overspeed Test Enabled relay can be programmed to provide the same status feedback as the front panel Overspeed Test LED.

The Overspeed Test function cannot be performed over the communications links, however, the Overspeed Test Permissive, Overspeed Test In Progress, Overspeed Alarm, and Overspeed Trip indications are available through the Modbus links.

F3 and F4 Keys

The F-key (F3 & F4) screens appear only when programmed for a specific function. The screens that appear will vary depending on the function programmed. The F-keys can be programmed to perform a variety of functions including:

Local / Remote	Extr/Adm Control Enable
Idle / Rated	Remote Extr/Adm Setpt Enable
Halt / Continue Auto Start Sequence	Casc Control Enable
Remote Speed Setpt Enable	Remote Casc Setpt Enable
Sync Enable	Aux Control Enable
Freq Arm / Disarm	Remote Aux Setpt Enable
Energize Relay Output	Select Ext/Adm Priority

In the RUN mode, the assigned function may be selected or deselected by pressing the assigned function key, then the Yes or No keys respectively. The screen will display the present status of the function and prompt the appropriate (Yes/No) key required to change the status.

Limiter (LMTR) Key Screens

Figure 5-7 shows the screens that appear when the LMTR key is pressed. These screens are always active and always displayed. The order in which the screens appears varies with the position of the HP Valve Limiter. When the HP Valve Limiter is at maximum (typically 100%), screen 2 appears first when the LMTR key is pressed.

During normal operation the HP Valve Limiter setting is at 100% and not limiting. Typically, the only time this parameter is adjusted is during a start sequence or to troubleshoot system dynamics problems.

The HP valve demand can be viewed from screen 3 and the HP limiter setpoint can be viewed from screen 1. To manually position the HP governor valve with the HP Valve Limiter setpoint, the HP limiter setpoint must be decreased below the HP actuator demand signal (LSS bus output). Once below or equal to this signal, the limiter setting will be the actuator output signal and thus governor valve position will be set manually by the limiter.

The LP valve demand can be viewed from screen 3 and the LP limiter setpoint can be viewed from screen 2. To manually position the LP governor valve with the LP Valve Limiter setpoint, the LP limiter setpoint must be increased above (or decreased below if admission or extr/adm) the LP actuator demand signal (HSS bus output/LSS if any admission is possible). Once above (below if admission or extr/adm) or equal to this signal, the limiter setting will be the actuator output signal and thus governor valve position will be set manually by the limiter.

The valve limiters can be adjusted with the ADJUST UP or DOWN front panel keys from screens 1 or 2, HP or LP Valve Limiter Raise or Lower contact inputs (if programmed), or commands through a Modbus link. In addition the setpoint can be directly entered using the ENTER key from screens 1 or 2.

The following valve limiter indications are available through the Modbus links: HP Valve Limiter at Min, HP Valve Limiter at Max, and HP Valve Limiter In Control of actuator output, LP Valve Limiter at Min, LP Valve Limiter at Max, and LP Valve Limiter In Control of actuator output. In addition to these indications the HP Valve Limiter Setpoint, HP Valve Demand, HP Valve Output, LP Valve Limiter Setpoint, LP Valve Demand, and LP Valve Output analog values are also available.
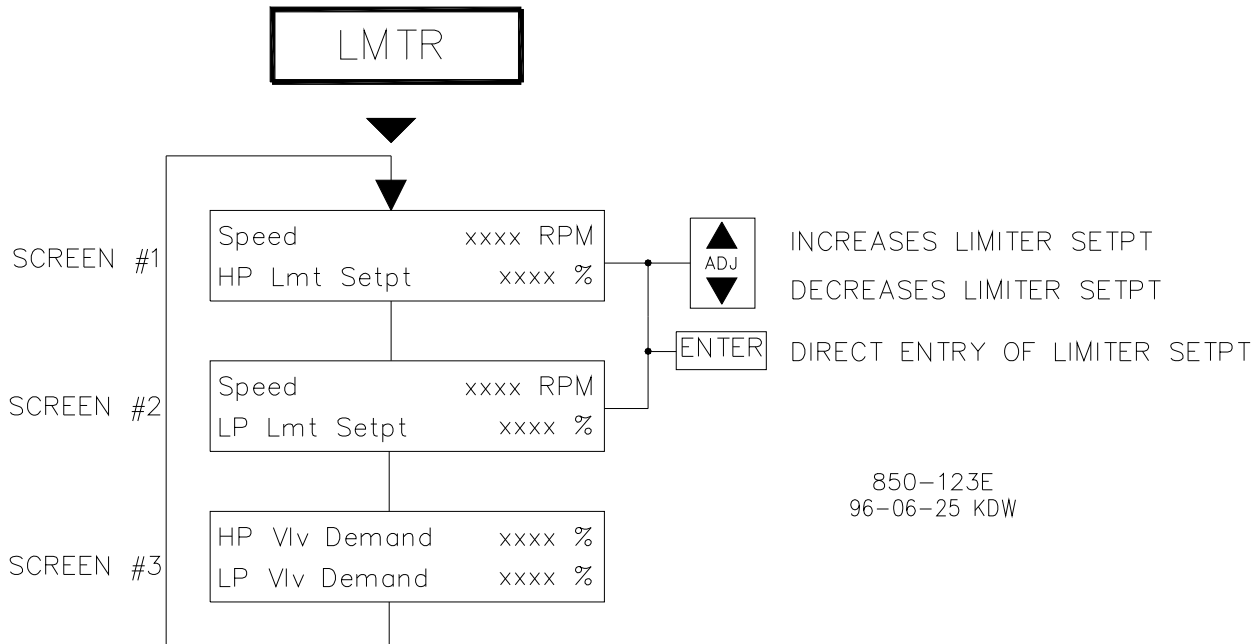
Figure 5-7. LMTR Key Screens

Actuator (ACTR) Key Screens

Figure 5-8 shows the possible screens that may appear if the ACTR key is pressed. The only parameter that can be adjusted from these screens is the dither setting. To adjust the dither setting (if required), the @ symbol must be on the display line containing the asterisk/dither value to tune. The @ symbol is moved using the SELECT key.

The communications links will display the HP Valve Demand, LP Valve Demand, HP Valve Position in milliamps, LP Valve Position in milliamps, values as well as the actual Actuator Output Current for both actuators in milliamps.
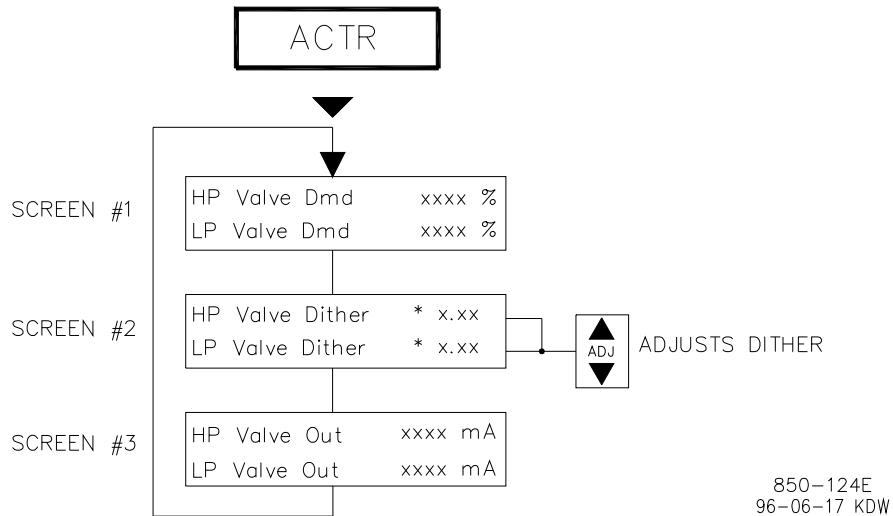
```
                        ┌──────────────┐
                        │    ACTR      │
                        └──────────────┘
                               ▼

          ┌────────────────────────────────┐
          │  ┌──────────────────────────┐   │
SCREEN #1 │  │ HP Valve Dmd      xxxx % │   │
          │  │ LP Valve Dmd      xxxx % │   │
          │  └──────────────────────────┘   │
          │                                  │
          │  ┌──────────────────────────┐   │      ▲
SCREEN #2 │  │ HP Valve Dither   * x.xx │───────┤ADJ│  ADJUSTS DITHER
          │  │ LP Valve Dither   * x.xx │   │      ▼
          │  └──────────────────────────┘   │
          │                                  │
          │  ┌──────────────────────────┐   │
SCREEN #3 │  │ HP Valve Out     xxxx mA │   │
          │  │ LP Valve Out     xxxx mA │   │
          │  └──────────────────────────┘   │
          └────────────────────────────────┘
                                              850-124E
                                              96-06-17 KDW
```

The asterisk (*) denotes a tunable parameter. To adjust this parameter the
"@" symbol must be on the display line containing the asterisk. The @ symbol
is moved with the SELECT key.

Figure 5-8. ACTR Key Screens

Control (CONT) Key Screens

Figure 5-9 shows the screens that appear when the CONT key is pressed. The CONT key allows operators to monitor what 505E parameters are controlling governor valve positions (screen 1). From screen 2 the steam map limiter priority can be seen and changed (if programmed). From screen 3 the cause of the last turbine shutdown can be viewed and from screen 4 the highest turbine speed reached can be viewed and cleared, if desired. Screen 5 can be used to change and display the Local/Remote status, if used.

Figure 5-9. CONT Key Screens

Table 5-4 shows a complete listing of all possible controlling parameters and their meanings.

LINE 1 CONTROLLING PARAMETER MESSAGE

MESSAGE 7	MEANING
Controlling Parameter	Displayed during shutdown, config error, or starting
Control at TWO LIMITS	Both actuators are limited due to two limits reached
HP Max Actuator	HP actuator output is at its maximum position
HP Valve Limiter	HP Valve Limiter is in control of the actuator output
Max Power Limit	At Steam Map max power limit (S=100%)
HP Max Limit	HP valve cannot be opened further (at max limit)
HP Min Limit	HP valve cannot be closed further (at min limit)
LP Max Limit	LP valve cannot be opened further (at max limit)
LP Min Limit	LP valve cannot be closed further (at min limit)
Manual Start	505E is running and in the Manual start mode
Auto Start	505E is running and in the Automatic start mode
Semi Auto Start	505E is running and in the Semi-automatic start mode
Idle / Rated Start	505E is running and in the Idle/Rated sequence mode
Auto Start Sequence	505E is in the Automatic Start Sequence mode
Remote / Speed	Speed PID is in control, the Speed Setpt is in Remote Ctrl
Speed / On-Line	Speed PID is in control using On-Line dynamics
Speed / Off-Line	Speed PID is in control using Off-Line dynamics
Frequency / Speed	Speed PID in control with gen breaker closed and tie breaker open
Synchronizing	Speed PID in control with Synchronizing analog input biasing
Load Share / Speed	Speed PID in control with Sync/Ld Share analog input biasing
Auxiliary Control	Aux PID is in control of the actuator output
Remote Auxiliary	Aux PID is in control and the Aux Setpt is in remote ctrl
Cascade / Speed	Casc & Speed PIDs are in control
Rmt Cascade / Speed	Casc & Speed PIDs are in control, and Casc Setpt is in remote control

LINE 2 CONTROLLING PARAMETER MESSAGE

MESSAGE 7 A	MEANING
Shutdown	Control is tripped
Controlled Shutdown	A controlled shutdown is being executed
Configuration Error	The 505E program has been configured incorrectly
Start Perm Not Met	Start permissive contact is not closed
Ready to Start	Start permissives are OK and unit is ready to start
Max HP & Max LP Limits	HP and LP valves are at their max limits
Max HP & Max PWR Limits	HP is at max limit and Spd/Ld Dmd is at max limit
Max HP & Min LP Limits	HP is at max limit and E/A PID is at min limit
Max PWR & Max LP Limits	LP is at max limit and Spd/Ld Dmd is at max limit
Min LP & Max Prs Limits	LP is at min limit and E/A PID is at max limit
Max HP & Max Prs Limits	HP is at max limit and E/A PID is at max limit
Max Pwr & Min Prs Limits	Spd/Ld Dmd is at max limit and E/A PID is at min limit
Min HP & Min LP Limits	HP and LP valves are at their min limits
Max LP & Min Prs Limits	LP is at max limit and E/A PID is at min limit
Min LP & Min Prs Limits	LP is at min limit and E/A PID is at min limit
Min HP & Min Prs Limits	HP is at min limit and E/A PID is at min limit
LP Max Actuator Control	LP valve output is at maximum
LP Valve Limiter Control	LP Valve Limiter is in control of the actuator output
Max Power Limit Control	At Steam Map max power limit (S=100%)
HP Max Limit Control	HP valve cannot be opened further (at max limit)
HP Min Limit Control	HP valve cannot be closed further (at max limit)
LP Max Limit Control	LP valve cannot be opened further (at max limit)
LP Min Limit Control	LP valve cannot be closed further (at min limit)
Max Extr Limit Control	Ext/Adm PID is at maximum (100%)
Min Extr Limit Control	Ext/Adm PID is at minimum (0.0%)
Max Adm Limit Control	Ext/Adm PID is at maximum (100%)
Min Adm Limit Control	Ext/Adm PID is at minimum (0.0%)
Extr Ctrl w/ Rmt Setpt	Ext PID is in control and Extr Setpt is in remote ctrl
Adm Ctrl w/ Rmt Setpt	Adm PID is in control and Adm Setpt is in remote ctrl
E/A Ctrl w/ Rmt Setpt	Ext/Adm PID is in control and Ext/Adm Setpt is in remote ctrl
Extraction Control	Extraction PID is in control
Admission Control	Admission PID is in control
Extr/Adm Control	Extraction/Admission PID is in control
Manual Extr/Adm Demand	Extr/Adm Demand is in manual mode (Ext/Adm disabled)
Manual Admission Demand	Adm Demand is in manual mode (Adm disabled)

Table 5-4. Controlling Parameter Messages

For a complete listing of Shutdown/Trip causes, refer to the Trips section later in this chapter.

Table 5-5 lists the Priority status messages that may appear on the front panel display and the meanings of each.

MESSAGE 9	MEANING
Speed Priority Active	Speed Priority is Active for steam map limit(s)
Extr Priority Active	Extraction Priority is Active for steam map limit(s)
E/A Priority Active	Extr/Adm Priority is Active for steam map limit(s)
Adm Priority Active	Admission Priority is Active for steam map limit(s)
Ext Active/Spd Selected	Speed Priority is selected but Extraction Priority is in control
Prs Active/Spd Selected	Speed Priority is selected but Extr/Adm Priority is in control
Adm Active/Spd Selected	Speed Priority is selected but Admission Priority is in control
Spd Active/ Ext Selected	Extraction Priority is selected but Speed Priority is in control
Spd Active/ Prs Selected	Extr/Adm Priority is selected but Speed Priority is in control
Spd Active/ Adm Selected	Admission Priority is selected but Speed Priority is in control
Priority Xfer Inhibited	Priority transfer selected but allowed-permissives are not met; on a limit, generator or tie breaker open
Auto Switching Config'd	Priority transfer selected but not used; auto transfer is configured
Priority Swtch Not Used	Priority transfer selected but not used (speed priority is programmed and switching to Ext/Adm is not permitted)

Table 5-5. Priority Messages

The Controlling Parameter, Priority Status, and Highest Speed Reached values are available through the Modbus links.

Dynamics (DYN) Key Screens

Figure 5-10 shows the possible screens that may appear if the DYN key is pressed. This mode is used to adjust controller dynamics. When the DYN key is pressed, the dynamics for the parameter that is in control, at that time will be displayed. To tune the dynamic settings of the other controllers, the key for the specific controller must be pressed and the STEP DOWN selected until the dynamics parameters appear. For information on tuning PIDs, refer to Chapter 3 of this manual.

To adjust the gain settings, the @ symbol must be on the respective display line of the value to be adjusted. The @ symbol is moved by pressing the SELECT key.

The controller dynamics are adjustable from the 505E's Service panel only, they cannot be adjusted remotely.

DYN

SCREEN #1
```
Aux Prop Gain    * xx.xx
Aux Int Gain     * xx.xx
```

SCREEN #2
```
Casc Prop Gain   * xx.xx
Casc Int Gain    * xx.xx
```

▲
ADJ   INCREASES GAIN
▼   DECREASES GAIN

SCREEN #3
```
On-Line Prop Gn  * xx.xx
On-Line Int Gn   * xx.xx
```

SCREEN #4
```
Off-Line Prop Gn * xx.xx
Off-Line Int Gn  * xx.xx
```

SCREEN #5
```
Ext/Adm Prop Gn  * xx.xx
Ext/Adm Int Gn   * xx.xx
```

SCREEN #6
```
Extr Prop Gain   * xx.xx
Extr Int Gain    * xx.xx
```

SCREEN #7
```
Adm Prop Gain    * xx.xx
Adm Int Gain     * xx.xx
```

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- Screen displayed varies with the parameter "in control" or the actuator output. Only the parameter "in control" will be displayed.
- Screen 1 shown only if Auxiliary Control is configured and Aux is in control.
- Screen 2 shown only if Cascade Control is configured and Casc is in control.

The asterisk (*) denotes a tunable parameter. To adjust this parameter, the "@" symbol must be on the line containing the asterisk. The @ symbol is moved with the SELECT key.

Figure 5-10. DYN Key Screens

Stop Key Screens

Figure 5-11 shows the possible screens that may appear if the STOP key is pressed. The STOP key is used to perform a controlled/manual turbine shutdown or stop. To perform a Manual Shutdown, select YES from the Status screen 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 pressing the front panel NO key from the Manual Shutdown Status screen, opening the contact, or selecting Abort Controlled Shutdown from a Modbus communications link.

The Controlled Shutdown sequence can be restarted again by pressing the front panel YES key from the Manual Shutdown Status screen, re-closing the contact, or re-selecting Controlled Shutdown from a Modbus communications link. The link will display the Controlled Stop In Progress and Controlled Shutdown Trip Completed status indications.

CONTROLLED SHUTDOWN

```
                    ┌─────────────────┐
                    │      STOP       │
                    └─────────────────┘
                             ▼
                             ▼
                    ┌─────────────────┐
                    │ Manual Shutdown? │
                    │ Push Yes or No   │
                    └─────────────────┘
                             ▼
        ┌────────┐                      ┌────────┐
        │   NO   │                      │  YES   │            850-127
        └────────┘                      └────────┘            96-03-27 KDW
             ▼                               ▼
  ┌──────────────────────┐      ┌──────────────────────────┐  ┌─────┐
  │ Controlling Parameter │      │ Manual Shutdown? (Status) │──│ YES │ ENABLES SHUTDOWN
  │            message7   │      │ Push Yes or No           │  └─────┘
  └──────────────────────┘      └──────────────────────────┘  ┌─────┐
                                                               │ NO  │ DISABLES SHUTDOWN
                                                               └─────┘
```
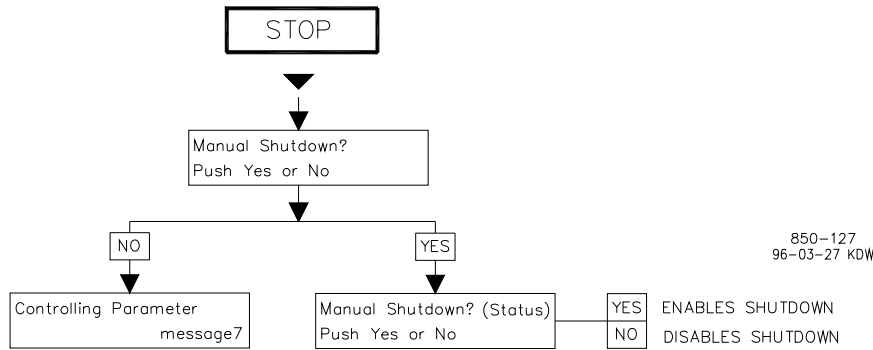
The speed setpoint moves to the minimum (zero) at the fast rate. Once at the minimum, the valve limiter moves to its minimum position. At the minimum valve limiter position, a trip is issued. The shutdown relay will de-energize and the actuator outputs are pulled to zero. The front panel displays the following:

```
              ┌──────────────────────┐
              │ ───────Trip───────   │
              │   Shutdown Complete   │
              └──────────────────────┘
```
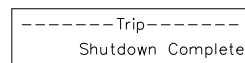
Figure 5-11. STOP Key Screens

Auxiliary (AUX) Key Screens

For this key to be active, the Auxiliary function must be programmed. Figure 5-12 shows the possible screens that may appear if the AUX key is pressed. Only the screens related to the Auxiliary control's programmed functionality will be displayed. If Remote Aux Setpoint is programmed, screen 3 will appear. The Auxiliary PID dynamics and droop level (if required) can be adjusted from these screens.

```
                    ┌─────────────────┐
                    │      AUX        │
                    └─────────────────┘
                             ▼
                             ▼
              ┌──────────────────────────┐    ▲
  SCREEN #1   │ Aux Input     xxxx units  │    ▼      ADJUSTS AUX SETPOINT
              │ Aux Setpt     xxxx units  │   ┌───────┐
              └──────────────────────────┘   │ ENTER │ DIRECT ENTRY OF AUX SETPT
                                             └───────┘
              ┌──────────────────────────┐   ┌─────┐
  SCREEN #2   │ Aux Input     xxxx units  │   │ YES │ ENABLES AUX CONTROL (IF USED)
              │ Aux Control    message5   │   └─────┘
              └──────────────────────────┘   ┌─────┐
                                             │ NO  │ DISABLES AUX CONTROL (IF USED)
                                             └─────┘
              ┌──────────────────────────┐   ┌─────┐
  SCREEN #3   │ Rmt Aux Input  xxxx units │   │ YES │ ENABLES REMOTE AUX SETTING
              │ Rmt Aux Control Message4  │   └─────┘
              └──────────────────────────┘   ┌─────┐
                                             │ NO  │ DISABLES REMOTE AUX SETTING
                                             └─────┘
              ┌──────────────────────────┐
  SCREEN #4   │ Aux Prop Gain    * xx.xx  │
              │ Aux Int Gain     * xx.xx  │    ▲
              └──────────────────────────┘    ▼      ADJUSTS SETTINGS
              ┌──────────────────────────┐
  SCREEN #5   │ Aux Droop      * xx.xx%   │            850-119a
              │ Aux PID          xx.x%    │            97-08-05 JMM
              └──────────────────────────┘
```

Screen 3 shown only if Remote Auxiliary control is configured.
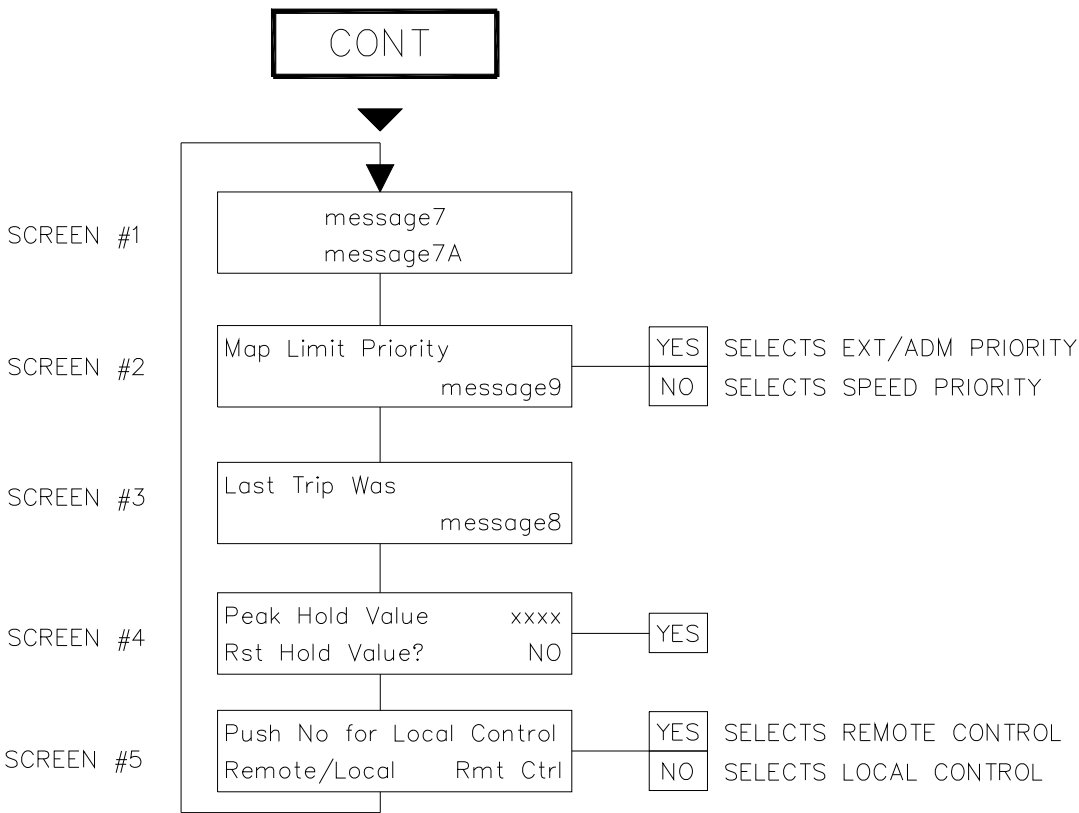Screen 4 shown only if dynamics adjustments are used.

The asterisk (*) denotes a tunable parameter. To adjust this parameter the "@" symbol must be on the display line containing the asterisk. The @ symbol is moved with the SELECT key.

"Units" are determined by the AUX UNITS configured.

Figure 5-12. AUX Key Screens

Auxiliary as a Controller (using 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 pressing the front panel YES key from the Status screen (screen 2) or by closing the Aux Control Enable/Disable contact (if programmed) or by selecting Aux Enable from either 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 ADJUST UP or DOWN keys from the front panel Aux Setpt screen (screen 1), closing a Aux Setpt Raise/ Lower contact input, or selecting Aux Setpoint Raise or Lower from either Modbus communications link. In addition, the Auxiliary setpoint can be directly set to a value by pressing the front panel ENTER key from the Auxiliary Setpoint screen or by "Entering" a new Auxiliary Setpoint through either Modbus communications link.

Auxiliary control is disabled by pressing the front panel NO key from the Aux Status screen (screen 2), opening the Aux Control Enable/Disable contact (if programmed), or selecting "Aux Disable" from either Modbus communications link see Table 5-6). Auxiliary control is also 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 tie breaker disable features are programmed.

MESSAGE 5	MEANING
Disabled	Aux control is disabled
Inhibited	Aux is inhibited and cannot be enabled
Enabled	Aux is enabled but not in control due to gen/tie breaker status
Active /Not In Ctrl	Aux is active but the PID is not in control (valve limiter control)
Active w/Rmt Setpt	Aux is active but not in control and the Setpt is in remote control
In Control	Aux is active and in control of the actuator output
Remote Control	Aux is in control and the Setpt is in remote control

Table 5-6. Auxiliary Messages (if using Aux enable)

Auxiliary as a Limiter (not using Enable/Disable)

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 changed by issuing Auxiliary Setpt Raise or Lower commands. This can be done by pressing the ADJUST UP or DOWN from the front panel Aux Setpt screen (screen 1), closing the Auxiliary Setpoint Raise/Lower contact inputs, or selecting Auxiliary Setpoint Raise or Lower from either Modbus communications link. In addition, the Auxiliary setpoint can be directly set to a value by selecting the front panel ENTER key from the Aux Setpt screen or "Entering" a new Aux Setpt through either Modbus communications link.

Auxiliary control is inhibited if a controlled shutdown is selected, the Auxiliary input fails, or the unit shuts down. See Table 5-7. Auxiliary control can be 'enabled' but not 'active' if the generator and/or utility tie breaker disable features are programmed. Aux will be In Control if the Auxiliary PID is active and limiting the Auxiliary input parameter.

MESSAGE 5	MEANING
Inhibited	Aux is inhibited and is not active
Enabled	Aux is enabled but generator or tie breaker is open
Enabled w/Rmt Setpt	Aux is enabled but not active and the Setpt is in Remote control
Active w/Rmt Setpt	Aux is active but not limiting and the Setpt is in Remote control
Active /Not Lmting	Aux is active but not limiting the actuator output
Control w/Rmt Setpt	Aux is in control (limiting) and the Setpt is in Remote control
In Control	Aux is in control and limiting the actuator output

Table 5-7. Auxiliary Messages (if using Aux as a limiter)

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.

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. When configured to an analog input, this function/input can be enabled by pressing the front panel YES key from the Remote Aux Status screen (screen 3), closing the Remote Aux Setpoint Enable/Disable contact (if programmed), or selecting Remote Aux Enable from either Modbus communications link.

Remote Auxiliary Setpoint is disabled by pressing the front panel NO key from the Remote Aux Status screen (screen 3), opening the Remote Aux Control Enable/Disable contact (if programmed), or selecting Remote Aux Disable from either Modbus communications link. See Table 5-8 for all possible Remote Aux control messages.

MESSAGE 4	MEANING
Disabled	Remote Aux Setpoint is not selected
Inhibited	Remote Aux Setpoint is inhibited and cannot be enabled
Enabled	Remote Aux Setpoint is enabled but not in control of the Setpt
Active	Remote Aux Setpoint is in control, Aux PID is not controlling the actuator
In Control	Remote Aux Setpoint is in control, Aux PID is controlling the actuator

Table 5-8. Remote AUX Messages

The following remote auxiliary control indications are available through the Modbus links: 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.

IMPORTANT	Relay indications can be programmed to indicate Remote Aux Control Active and Remote Aux Control Enabled status parameters.

Remote / Speed Bias (RMT) Key Screens

For this key to be active, the Remote Speed Setting, Synchronizing, or Load Sharing functions must be programmed. The Synchronizing and Load Sharing functions are configured by programming the respective function to an analog input. Figure 5-13 shows the possible screens that may appear if the RMT key is pressed. Only the screens related to the functions programmed will be displayed. Screens 3 and 4 appear when the Synchronizing analog input is programmed, screens 1 and 2 appear when Sync/Load Sharing analog input is programmed, and screens 5 and 6 appear when Remote Speed Setpoint input is programmed.

```
                         ┌──────────┐
                         │   RMT    │
                         └──────────┘
                              ▼

SCREEN #1    ┌─────────────────────────────┐
             │ Ld Share Bias    xxxx RPM   │
             │ Biased Setpt     xxxx RPM   │
             └─────────────────────────────┘

SCREEN #2    ┌─────────────────────────────┐  ┌─────┐
             │ Ld Share Bias    xxxx RPM   │  │ YES │  ENABLES SYNC INPUT BIAS
             │ Load Share       message3   │  ├─────┤
             └─────────────────────────────┘  │ NO  │  DISABLES SYNC INPUT BIAS
                                               └─────┘
SCREEN #3    ┌─────────────────────────────┐
             │ Sync Bias        xxxx RPM   │
             │ Biased Setpt     xxxx RPM   │
             └─────────────────────────────┘

SCREEN #4    ┌─────────────────────────────┐  ┌─────┐
             │ Sync Bias        xxxx RPM   │  │ YES │  ENABLES SYNC INPUT BIAS
             │ Sync             message3   │  ├─────┤
             └─────────────────────────────┘  │ NO  │  DISABLES SYNC INPUT BIAS
                                               └─────┘
SCREEN #5    ┌─────────────────────────────┐
             │ Speed            xxxx RPM   │
             │ Remote Input     xxxx RPM   │
             └─────────────────────────────┘

SCREEN #6    ┌─────────────────────────────┐  ┌─────┐
             │ Remote Input     xxxx RPM   │  │ YES │  ENABLES REMOTE SPEED SETPT
             │ Remote Setpt     message4   │  ├─────┤
             └─────────────────────────────┘  │ NO  │  DISABLES REMOTE SPEED SETPT
                                               └─────┘
                                                          850-122
                                                          96-06-25 KDW
```

Screens 1 & 2 are shown only if Load Sharing control or Sync/Ld Sharing is configured.
Screens 3 & 4 are shown only if Synchronizing is configured and Load Sharing is not.
Screens 5 & 6 are shown only if Remote speed Setting control is configured.

Figure 5-13. RMT Key Screens

Remote Speed Setpoint

The Speed PID setpoint can be remotely set by an analog input, if programmed. This Remote Speed Setpoint input can be enabled by pressing the front panel YES key from the Remote Speed Status screen (screen 6), closing the Remote Speed Setpoint Enable/ Disable contact (if programmed), or selecting Enable Remote Speed Setpt Control from either Modbus communications link (see Table 5-9).

Remote Speed Setpoint input is disabled by pressing the front panel NO key from the Remote Speed Status screen (screen 6), opening the Remote Speed Control Enable/ Disable contact (if programmed), or selecting Disable Remote Speed Setpt Control from either Modbus communications link.

MESSAGE 4	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 5-9. 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 Loadsharing

The Synchronizing feature allows an analog input to bias the speed setpoint when using a DSLC for synchronization. The Synchronizing analog input is enabled by pressing the front panel YES key from the Sync Status screen (screen 4), closing the Sync Enable contact (if programmed), issuing an enable demand through an "F" key, 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 tie breaker status inputs. The Sync/Load Share input is enabled by pressing the front panel YES key from the Sync Status screen (screen 4), closing the Sync/Ld Share Enable contact (if programmed), issuing an enable command through an "F" key, or selecting Sync Enable from either Modbus communications link.

The Synchronizing or Sync/Ld Share inputs are disabled by pressing the front panel NO key from the respective Status screen, 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. Table 5-10 lists the possible synchronizing/loadsharing 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 5-10. Control Messages

The following synchronizing and loadsharing control indications are available through the Modbus links: Generator Breaker Status, Utility Tie Breaker Status, Frequency Control, Sync is Enabled, Sync or Loadshare is In Control, Sync or Loadshare 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, Loadshare Control and Frequency Control status parameters.

Unit Load (KW) Key Screens

This key is active if the unit is programmed for a generator application or if a first stage pressure analog input is configured. Figure 5-14 shows the possible screens that may appear if the kW key is pressed. Only the screens related to the functions programmed will be displayed. If a first stage pressure analog input is configured, screen 4 will appear. When the unit is programmed for a generator application, only one of the first three screens will appear, depending on the mode of operation (governor valve position droop or KW/unit load input signal droop).

Screen 1 or 2 is displayed when the unit is programmed with a KW/Unit Load analog input and the input is not failed. Screen 3 is displayed if no KW/Unit Load analog input is programmed or the input is failed. When the units on the 'Load' parameter are 'KW' or 'MW', the screen is displaying actual load units from the KW/Unit Load analog input. When units on the 'Load' parameter is '%', the screen is displaying a calculated load value.

The bottom line of the display on screens 1, 2, & 3 show the calculated Load Setpoint. This value and units change depending on the droop mode the 505E is presently using. If the droop is based on the KW input, the units are in 'KW' or 'MW'. If the droop is LSS/ Speed Demand (governor valve position), the units are in 'rpm'.

The Load Setpoint can be changed when the unit is On-Line from screens 1, 2, or 3 by selecting the ADJUST UP or DOWN. In addition, the Load Setpt can be adjusted by closing a Speed Setpoint Raise/Lower contact inputs or selecting Speed Setpoint Raise or Lower commands from either Modbus communications link. In addition, the Load setpoint can be directly set to a value by pressing the ENTER key from the SPEED screen and entering a speed setpoint value, or Entering a new Speed/Load Setpoint through either Modbus communications link.

```
                          ┌──────────────────┐
                          │       KW         │
                          └──────────────────┘
                                   ▼
                                   ▼
              ┌──────────────────────────────┐
              │ Load              xxxx KW     │
SCREEN #1     │ Setpt             xxxx RPM    │          ▲
              └──────────────────────────────┘        ┌───┐  INCREASES THE LOAD SETPT
                                                       │ADJ│
              ┌──────────────────────────────┐        └───┘  DECREASES THE LOAD SETPT
              │ Load              xxxx %      │          ▼
SCREEN #2     │ Setpt             xxxx RPM    │
              └──────────────────────────────┘

              ┌──────────────────────────────┐
              │ First Stage Press    xxxx     │
SCREEN #3     │ Speed             xxxx RPM    │                    850-120a
              └──────────────────────────────┘                    97-08-05 JMM
```
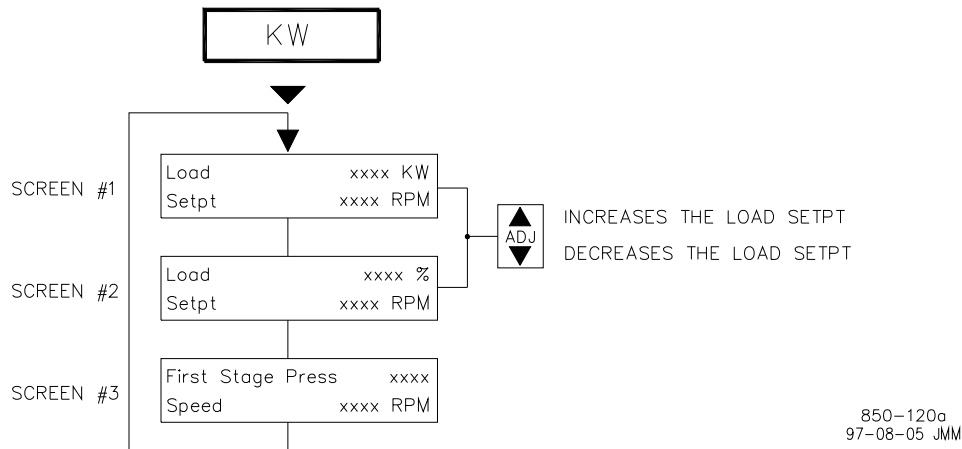
- Screen 1 shown only if a KW analog input is programmed and input is not failed.
- Screen 2 shown only if no KW analog input is programmed or KW input is failed.
- Screen 3 shown only if a First Stage Pressure analog input is programmed.

NOTE
- The "KW" units can be changed to "MW" in the Service mode if desired.
- If no kw input is programmed, the Load units and value will be in calculated load percent.

Figure 5-14. KW Key Screens

Cascade (CAS) Key Screens

For this key to be active, the Cascade function must be programmed. Figure 5-15 shows the possible screens that may appear if the CAS key is pressed. Only the screens related to the Cascade functionality programmed will be displayed. Only when the Remote Cascade Setpoint is programmed, will screen 3 appear. The Cascade PID dynamic and droop values can be adjusted from these screens.

Cascade control can be enabled by pressing the front panel YES key from the Status screen (screen 2), closing the Cascade Control Enable/Disable contact (if programmed), or selecting Cascade Enable from either Modbus communications link.

Cascade control is disabled by pressing the front panel NO key from the Cascade Status screen (screen 2), opening the Cascade Control Enable/Disable contact (if programmed), or selecting Cascade Disable from either Modbus communications link. Cascade control is also disabled if Auxiliary control is enabled or Remote Speed Setpoint input 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 and/or utility tie breaker are 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 5-11 for all possible cascade control messages.
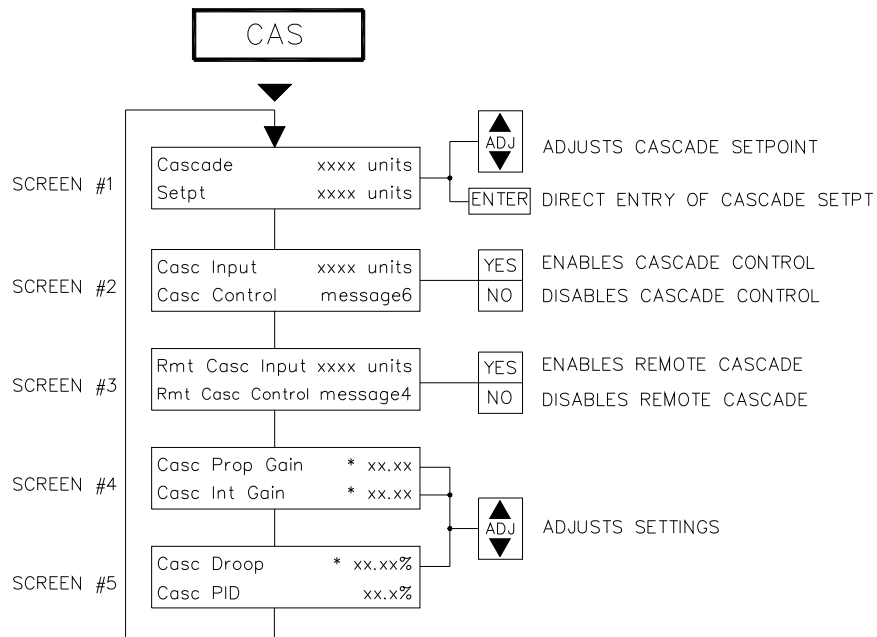
Figure 5-15. CAS Key Screens

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 ADJUST UP or DOWN keys from the Cascade setpoint screen (screen 1), 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 value by pressing the front panel ENTER key from the Cascade Setpt screen or by Entering a new Cascade Setpt through either Modbus communications link.

The Cascade Setpt Raise/Lower contact inputs have a dual function. If either contact is closed and the Cascade control is active, the cascade setpoint will be adjusted. If either contact is closed and the Cascade control is not active, the Speed setpoint will be adjusted. The advantage of this feature is that only one set of raise/lower switches is required to adjust either setpoint.

The Cascade setpoint can be directly set to a value by selecting the front panel ENTER key from the Cascade Setpt screen or by Entering a new Cascade Setpt through either Modbus communications link.

MESSAGE 6	MEANING
Disabled	Cascade control is disabled
Inhibited	Cascade is inhibited and cannot be enabled
Enabled	Cascade is enabled but not in control of actuator
In Control	Cascade is in control of actuator output
Active /Not Spd Ctrl	Cascade is active but Speed PID is not in control of actuator
Active w/Rmt Setpt	Cascade is active but Speed PID is not in control, Setpt is in remote control
In Ctrl w/Rmt Setpt	Cascade is in control, Speed PID is in control, Setpt is in remote control

Table 5-11. Cascade Control Messages

The following Cascade control indications are available through the Modbus links: 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 front panel YES key from the Remote Cascade Status screen (screen 3), 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 front panel NO key from the Remote Cascade Status screen (screen 3), opening the Remote Cascade Enable/Disable contact (if programmed), or selecting Remote Cascade Disable from either Modbus communications link. See Table 5-12 for all possible Remote Cascade control messages.

MESSAGE 4	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 5-12. Remote Cascade Messages

The remote cascade control indications shown in Table 5-11 are available through the Modbus links: 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 (EXT/ADM) Key Screens

This key is always active. Figure 5-16 shows the possible screens that may appear if the EXT/ADM key is pressed. Only the screens related to the Extraction/Admission functionality programmed will be displayed. Only when the Remote Extr/Adm Setpoint is programmed, will screen 4 appear. The Extr/Adm PID dynamic and droop values can be adjusted from screens 5 and 6.
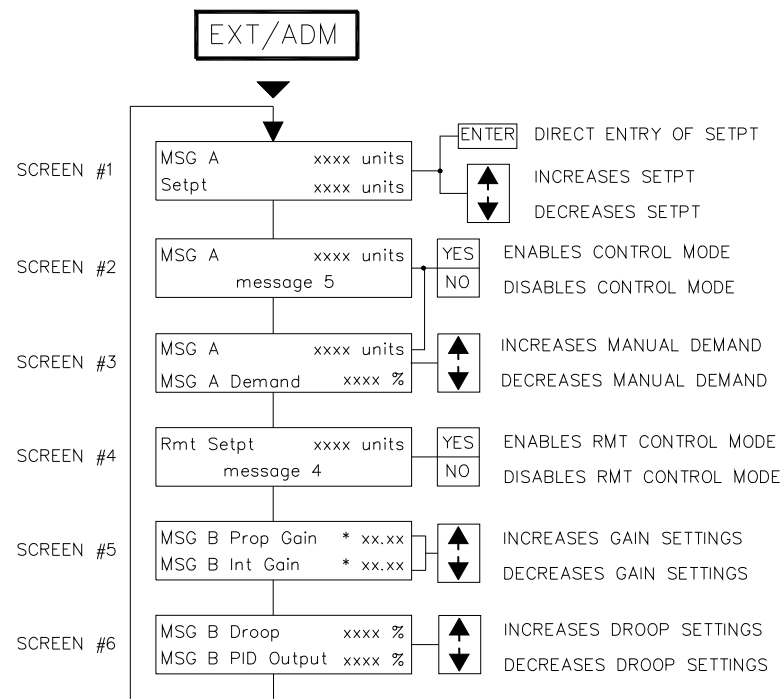
Figure 5-16. EXT/ADM Key Screens

Enabling Extraction Control

There are two ways of enabling/disabling extraction control: manually or automatically. The manual enable/disable routine uses the LP valve limiter's raise/lower commands, 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 LMTR key and slowly lower the LP valve limiter until the Extr/Adm PID takes control of its process, then continue running the LP valve limiter to its minimum (closed) position. If the LP valve limiter is not fully closed, it will act as an extraction limiter and will interfere with automatic governor operation. All related Extraction permissives must be met before the 505E will allow the LP valve limiter to be lowered, and Extr/Adm control enabled.

If programmed for auto enable, Extr/Adm control can be enabled by pressing the front panel YES key from the Status screen (screen 2), 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 front panel NO key from the Extr/Adm Status screen (screen 2), 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 3 for a detailed startup procedure.

Extr/Adm control is disabled and 'inhibited' if a controlled shutdown is selected, the Extr/Adm input fails, or the unit shuts down. 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 5-13 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 ADJUST UP or DOWN keys from the extr/adm setpoint screen (screen 1), 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 value by pressing the front panel ENTER key from the Extr/Adm Setpt screen or by Entering a new extr/adm Setpt through either Modbus communications link.

The extr/adm setpoint can be directly set to a value by selecting the front panel ENTER key from the Extr/Adm Setpt screen or by Entering a new extr/adm Setpt through either Modbus communications link.

MESSAGE 5	MEANING
Extraction is Disabled	Extraction control is disabled
Extraction is Inhibited	Extraction is inhibited and cannot be enabled
Extraction is Enabled	Extraction is enabled but not in control of actuator
Extraction In Control	Extraction is in control of actuator output
Extr Active /Not In Ctrl	Extraction is active but limited
Extr Active w/Rmt Setpt	Extraction is active but limited, Setpt is in remote ctrl
Extr In Ctrl w/Rmt Setpt	Extraction is in control, and Setpt is in remote ctrl
Admission is Disabled	Admission control is disabled
Admission is Inhibited	Admission is inhibited and cannot be enabled
Admission is Enabled	Admission is enabled but not in control of actuator
Admission is In Control	Admission is in control of actuator output
Adm Active /Not In Ctrl	Admission is active but limited
Adm Active w/Rmt Setpt	Admission is active but limited, Setpt is in remote ctrl
Adm In Ctrl w/Rmt Setpt	Admission is in control, and Setpt is in remote ctrl
Extr/Adm is Disabled	Extr/Adm control is disabled
Extr/Adm is Inhibited	Extr/Adm is inhibited and cannot be enabled
Extr/Adm is Enabled	Extr/Adm is enabled but not in control of actuator
Extr/Adm In Control	Extr/Adm is in control of actuator output
Extr/Adm Active /Not In Ctrl	Extr/Adm is active but limited
Extr/Adm Active w/Rmt Setpt	Extr/Adm is active but limited, Setpt is in remote ctrl
Extr/Adm Ctrl w/Rmt Setpt	Extr/Adm is in control, and Setpt is in remote ctrl

Table 5-13. 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.

The following shows the messages that will appear on screens 2 & 3 for message A and screens 5 & 6 for message B.

MESSAGE A	MEANING
Ext Input	Unit is configured for Extraction control.
Ext/Adm	Unit is configured for Extraction/Admission control.
Admission	Unit is configured for Admission control.

MESSAGE B	MEANING
Ext	Unit is configured for Extraction control.
E/A	Unit is configured for Extraction/Admission control.
Adm	Unit is configured for Admission control.

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 front panel NO key
from the Remote Extr/Adm Status screen (screen 4), opening the Remote
Extr/Adm Enable/Disable contact (if programmed), or selecting Remote Extr/Adm
Disable from either Modbus communications link. See Table 5-14 for all possible
Remote Extr/Adm control messages.

MESSAGE 4	MEANING
Rmt Extraction Disabled	Remote Extraction is not selected
Rmt Extraction Inhibitd	Remote Extraction is inhibited and cannot be enabled
Rmt Extraction Enabled	Remote Extraction is enabled but not in control of the Setpt
Remote Extract Active	Remote Extraction is in control of the Setpt but not in control of the actuator output
Remote Extr In Control	Remote Extraction is in control of the Setpt and in control of the actuator output
Remote Ext/Adm Disabled	Remote Extr/Adm is not selected
Rmt Extr/Adm Inhibited	Remote Extr/Adm is inhibited and cannot be enabled
Remote Extr/Adm Enabled	Remote Extr/Adm is enabled but not in control of the Setpt
Remote Extr/Adm Active	Remote Extr/Adm is in control of the Setpt but not in control of the actuator output
Rmt Extr/Adm In Control	Remote Extr/Adm is in control of the Setpt and in control of the actuator output
Rmt Admission Disabled	Remote Admission is not selected
Rmt Admission Inhibited	Remote Admission is inhibited and cannot be enabled
Rmt Admission Enabled	Remote Admission is enabled but not in control of the Setpt
Remote Admission Active	Remote Admission is in control of the Setpt but not in control of the actuator output
Remote Adm In Control	Remote Admission is in control of the Setpt and in control of the actuator output

Table 5-14. Remote Extr/Adm Messages

The remote Extr/Adm control indications shown in Table 5-14 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.

Alarms

The ALARM key is always active in the RUN mode. Figure 5-17 shows the
screen that appears when this key is pressed. If there are no alarms detected,
the screen will display the 'Alarms Cleared' message. When an alarm is
detected, the Alarm relay is energized and the front panel Alarm key illuminates.
In addition, the screen will automatically "jump" to the ALARM screen (as
defaulted in the Service mode) and display the alarm condition.

Table 5-15 lists all the potential alarm conditions and their cause. If more than
one alarm condition is present, pressing the Down Arrow key will scroll through
all active alarms. To view the most recent alarm, select the ALARM key. To clear
any alarms that are no longer present, press the front panel RESET key, close
the Reset contact input, or select Reset from either Modbus communications link.

```
          ---------------ALARMS---------------

               (alarm messages)
```

Figure 5-17. ALARM Screen

ALARM MESSAGES	MEANING
Speed Probe #1 Failed	Speed probe #1 failure—(less than Failed Speed Level or less than 1Vrms)
Speed Probe #2 Failed	Speed probe #2 failure—(less than Failed Speed Level or less than 1Vrms)
Cascade Input Failed	Cascade input failure detected (> 22 mA or < 2 mA)
Extr/Adm Input Failed	Extr/Adm input failure detected (> 22 mA or < 2 mA)
Aux Input Failed	Auxiliary input failure detected (> 22 mA or < 2 mA)
KW Input Failed	KW input failure detected (> 22 mA or < 2 mA)
FSP Input Failed	FSP input failure detected (> 22 mA or < 2 mA)
Remote Spd Input Failed	Remote Speed Setpt input failure(> 22 mA or < 2 mA)
Remote Casc Input Fld	Remote Casc Setpt input failure (> 22 mA or < 2 mA)
Remote Aux Input Fld	Remote Aux Setpt input failure (> 22 mA or < 2 mA)
Rmt Extr/Adm Input Fld	Remote Aux Setpt input failure (> 22 mA or < 2 mA)
Load Share Input Fld	Load Share input failure detected(> 22 mA or < 2 mA)
Sync Input Fld	Sync input failure detected (> 22 mA or < 2 mA)
Act #1 (HP) Fault	HP (Actuator #1) fault detected (an open or short circuit was sensed)
Act #2 (LP) Fault	LP (Actuator #2) fault detected (an open or short circuit was sensed)
Start Perm Not Closed	Run was selected while the Start Perm contact in was not closed
Comm Link #1 Failed	Modbus com link #1 was detected as failed—time out error
Comm Link #2 Failed	Modbus com link #2 was detected as failed—time out error
Turbine Trip	Turbine tripped alarm indication
Overspeed	Turbine overspeed alarm—speed is above trip level
Stuck In Critical Band	Turbine speed was stuck or forced into the critical band too long
Tie Breaker Opened	Utility Tie breaker was opened after it was closed
Gen Breaker Opened	Generator breaker was opened after it was closed
Tie Open / No Cascade	Utility Tie breaker was opened when Cascade was active
Gen Open / No Cascade	Generator breaker was opened when Cascade was active
Tie Open/ No Remote	Utility Tie breaker was opened when Remote Spd Setpt was active
Gen Open/No Remote	Generator breaker was opened when Remote Spd Setpt was active
Tie Open / No Auxiliary	Utility Tie breaker was opened when Auxiliary was active
Gen Open / No Auxiliary	Generator breaker was opened when Auxiliary was active
Tie Open / No Extr Adm	Utility Tie breaker was opened when Extr/Adm control was active
Gen Open / No Extr Adm	Generator breaker was opened when Extr/Adm control was active
Alarms Cleared	All alarms are cleared—no alarms are present

Table 5-15. Alarm Messages

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 505E common alarm, in addition to the dedicated Alarm Relay output.

Trips

Figure 5-18 shows the screen that appears when there is a trip condition. The cause of the last trip can be seen under the CONT key (screen 2). Table 5-16 lists all the potential trip conditions and their cause.

```
---------------TRIP--------------

        (trip messages)
```

Figure 5-18. TRIP Screen

MESSAGE 8	MEANING
External Trip Input	External Trip contact input was opened
External Trip 2	External Trip #2 contact input was opened
External Trip 3	External Trip #3 contact input was opened
External Trip 4	External Trip #4 contact input was opened
External Trip 5	External Trip #5 contact input was opened
Emer Shutdown Button	Emergency Shutdown on the 505E front panel was pressed
Overspeed	Turbine overspeed was sensed
All Speed Probes Failed	Loss of all speed probes was sensed
Act #1 (HP) Fault	Actuator #1 fault detected (an open or short circuit was sensed)
Act #2 (LP) Fault	Actuator #2 fault detected (an open or short circuit was sensed)
Aux Input Failed	Aux analog input failure detected (> 22 mA or < 2 mA)
Comm Link #1 Trip	Modbus #1 communication link trip was commanded
Comm Link #2 Trip	Modbus #2 communication link trip was commanded
Extr/Adm Input Failed	Ext/Adm analog input failure detected (> 22 mA or < 2 mA)
Tie Breaker Opened	Utility tie breaker was opened after it was closed
Generator Breaker Open	Generator breaker was opened after it was closed
Power Up Trip	505E lost power and CPU was reset or the Program mode was exited
Shutdown Complete	Controlled shutdown was performed and completed

Table 5-16. Trip 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 505E 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.

Speed, Casc, Aux, and Ext/Adm Dynamics Adjustments

Dynamic control values are programmed in the program mode and adjusted in the RUN mode. While in the run mode, pressing the DYN key calls up the dynamic adjustments of the parameter in control. The Proportional and Integral Gain dynamic adjustments are available under their respective keys (i.e. SPEED, CAS, AUX, & EXT/ADM). The Derivative term adjustments are made in the Service Mode—(7-4 see volume 2). To adjust the gain settings, the @ symbol must be on the display line containing the asterisk/gain value to tune. The @ symbol is moved using the SELECT key. The ADJUST UP and DOWN keys can then be used to adjust the function on the line with the @ symbol.

The Speed, Cascade, Auxiliary, and Extr/Adm controls are PID controllers. The response of each control loop can be adjusted by selecting the dynamics mode as described above. Proportional gain, integral gain (stability), and SDR (speed derivative ratio) are the adjustable and interacting parameters used to match the response of the control loop with the response of the system. They correspond to the P (proportional), I (integral), and D (derivative) terms, and are displayed by the 505E as follows:

    P = Proportional gain (%)
    I = Integral gain (%)
    D = Derivative (determined by SDR and I)

IMPORTANT   **If an older type 505E is being replaced by a new 505E, the " P & D " terms may be the same, however, the " I " term should be reduced by a factor of 10 from the old 505E's reset value to achieve the same control response.**

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 505E's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 505E'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 505E's output results in a large speed or load change (high mechanical gain) it may not be possible to take the 505E'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% 505E output corresponds to 0-100% valve travel.

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 Off-Line dynamics are used by the Speed PID when the generator or utility tie breaker contacts are open. The speed On-Line dynamics are used by the speed PID when the generator and utility tie breaker contacts are closed. If the speed dynamics select contact is programmed, the generator and utility tie contacts do not 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 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-of-rate 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 505E, 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 505E'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 5-19 shows the typical response to a load change when the dynamics are optimally adjusted.
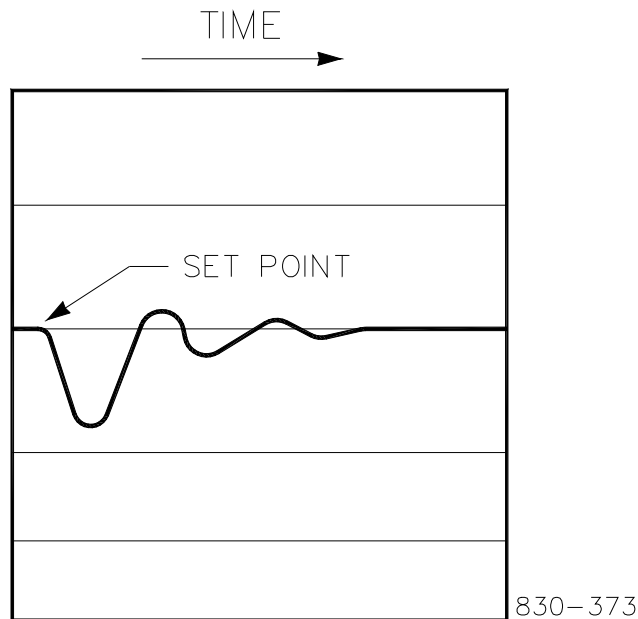
Figure 5-19. Typical Response to Load Change

IMPORTANT | **For additional information on PID settings refer to Volume 2.**

Chapter 6.
Communications

Modbus Communication

The 505E control can communicate with plant distributed control systems (DCS) and/or CRT based operator control panels through two Modbus communication ports. These ports support RS-232, RS-422, or RS-485 communications using ASCII or RTU MODBUS transmission protocols. Modbus utilizes a master/slave protocol. This protocol determines how a communication network's master and slave devices establish and break contact, how a sender is identified, how messages are exchanged, and how errors are detected.

Monitor Only

The two Modbus communication ports, as defaulted from the factory, are not configured to accept "write" commands. Although these ports are not configured, they continue to update all information to all registers. This allows the 505E to be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, this device can be used to monitor all the 505E's controlling parameters, modes, etc. without effecting control of the turbine.

To use a 505E port to only monitor 505E parameters and operational modes, (Boolean and analog write commands are ignored), program the 'Use Modbus Port' setting to 'NO'.

Monitor and Control

Once a Modbus port is configured within the 505E's Program Mode, the 505E will accept RUN mode commands from an external network master device (DCS, etc.). This allows a Modbus compatible device to monitor and perform all 505E RUN mode parameters and commands except for the Overspeed Test enable, On-Line/Off-Line Dynamics select, and Override Failed Speed Signal commands.

Both Modbus ports are independent of each other, and can be used simultaneously. The last command given between the two ports has priority or is the mode or function selected.

To use a 505E Modbus port to monitor and operate the 505E, program the 'Use Modbus Port' setting to 'YES' for the desired port(s).

Modbus Communication

The 505E control supports two Modbus transmission modes. A mode defines the individual units of information within a message and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in the following table.

CHARACTERISTIC	ASCII	RTU
Coding System	hexadecimal (uses ASCII printable binary characters: 0-9, A-F)	8-bit binary
Start Bits	1	1
Data Bits per Char	7	8
Parity	even, odd, or none	even, odd, or none
Stop Bits	1, 1.5, or 2	1, 1.5, or 2
Baud Rate	110, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, or 57600	110, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, or 57600
Error Checking	LRC (Longitudinal Redundancy Check)	CRC (Cyclical Redundancy Check)

Table 6-1. ASCII vs RTU Modbus

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 6-1 below).
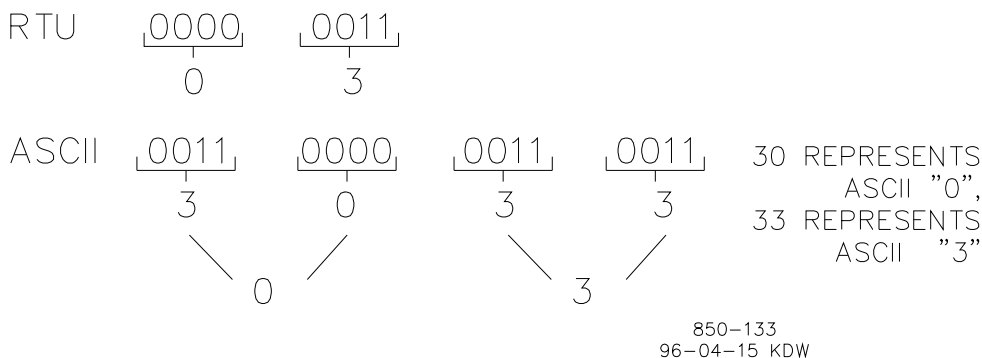
Figure 6-1. ASCII/RTU Representation of 3

The Modbus protocol allows one master and up to 247 slaves on a common network. Each slave is assigned a fixed, unique device address in the range of 1 to 247. With the Modbus protocol, only the network master can initiate a transaction. A transaction consists of a request from the master to a slave unit and the slave's response. The protocol and Modbus device number are set in the Program Mode and can be adjusted in the Service Mode, if required.

The 505E control is programmed to function as a slave unit only. As a slave unit, the 505E will only respond to a transaction request by a master device. The 505E can directly communicate with a DCS or other Modbus supporting device on a single communications link, or through a multi-dropped network. If multi-dropping is used, up to 246 devices (505Es or other customer devices) can be connected to one Master device on a single network. The device number is programmed under the 505E's communications block and can be changed in the service mode, if needed.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information. See Figure 6-2.

	BEGINNING OF FRAME	SLAVE ADDRESS	FUNCTION CODE	DATA	ERROR CHECK CODE	END OF FRAME
ASCII	:	2 CHARS 8 BITS	2 CHARS 8 BITS	4 BITS DATA PER CHAR	2 CHAR 8 BITS	CR LF
RTU	3−CHAR DEAD TIME	1 CHAR 8 BITS	1 CHAR 8 BITS	8 BITS DATA PER CHAR	2 CHAR 16 BITS	3 CHAR DEAD TIME

855−382
93−09−27 DAR

Figure 6-2. Modbus Frame Definition

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

Modbus Function Codes

CODE	DEFINITION	REFERENCE ADDRESS
01	Read Digital Outputs (Raise/Lower and Enable/Disable Commands)	0XXXX
02	Read Digital Inputs (Status Indications / Alarms and Trips)	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs (Speed, Setpt, etc)	3XXXX
05	Write Single Discrete Output (Raise/Lower and Enable/Disable Commands)	0XXXX
06	Write Single Register (Enter Setpt Directly)	4XXXX
08	Loopback Diagnostic Test (supports sub-function 0 only)	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

Table 6-2. Modbus Function Codes

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the control issues an alarm message. The error codes are defined in the following table. The exception error status and respective error codes can be viewed in the Service mode under PORT # SETTINGS, where # is the number of the port (1 or 2).

If the control has not received a message for the configured time-out period, the control will alarm with an error message, but no message is sent to the master. This time-out is defaulted to 2 seconds and only applies to units using both monitor and control (adjustable in the Service Mode).

Modbus Slave Exception Error Codes

CODE	ERROR MESSAGE	TO MASTER	DESCRIPTION
0	No Error	0	No Error.
1	Bad Modbus function	1	The specified function is not supported for this control.
2	Bad Modbus data address	2	The Modbus value address is not valid for this control.
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid.
9	Bad Modbus checksum	None	Message checksum did not match.
10	Bad Modbus message	None	Message could not be decoded.
n/a	Lost Modbus link	None	No messages received for the configured time-out period.

Table 6-3. Modbus Error Codes

Port Adjustments

Before the 505E will communicate with the master device, the communication parameters must be verified. These values are set in the Program Mode and can be adjusted, if required, from the Service Mode.

Modbus Communication Port Adjustments

PARAMETER	ADJUSTMENT RANGE
Baud Rate	110 TO 57600
Parity	NONE, ODD, or EVEN
Stop Bits	1 TO 2
Driver	RS232, RS422, or RS485

505E Control Modbus Addresses

The Modbus communication ports in the 505E control are programmed for unique Modbus addresses. A complete listing of these addresses for your application is located at the end of this section. The Modbus address listing consists of Boolean Writes, Boolean Reads, Analog Reads, and Analog Writes. The Boolean reads and writes are also referred to as input and holding coils. The analog reads and writes are also referred to as input registers and holding registers.

All values that can be addressed by Modbus are considered to be discrete and numeric. The discretes are a 1 bit binary, on or off value and the numerics are 16 bit values. Discretes are sometimes referred to as coils or digitals and numerics are referred to as registers or analogs. All read/write registers are interpreted by the 505E as signed 16 bit integer values. Since Modbus can only handle integers, values that require a decimal point in the Modbus Master Device are multiplied by a scaling constant before being sent by the 505E. See Tables 6-7 & 6-8 for defaulted communication constants and ranges.

The maximum number of discretes and registers that can be transmitted in one packet is dependent on each implementation of Modbus. The following table defines these limits.

MODE OF TRANSMISSION	MAX DISCRETES	MAX REGISTERS
ASCII	944	59
RTU	1188	118

Table 6-4. Maximum Modbus Discrete and Analog Values

Boolean Writes (Holding Coils)

Holding coils are logical signals that are both readable from and writable to the 505E control. An example of a Boolean write value would be raise or lower commands. A logical true denoted by the value 1 will cause the command listed in the description to be executed. For example, if a 1 is written to address 0:0010 and this corresponded to a speed raise command, the speed setpoint will increase until a 0 is written to address 0:0010. The 505E control supports function codes 1, 5, and 15. These correspond to reading selected holding coils, writing to a single holding coil, and writing to multiple holding coils, respectively. The holding coils available are listed in Table 6-5.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writable to, the 505E control. An example of a Boolean read value would be a turbine trip status indication. The input coil will have the value 1 if the statement in the description column is true and a 0 if false. The '1:' term in the address identifies an input coil. The 505E control supports Modbus function code 2, which involves reading selected input coils. The input coils available are listed in Table 6-6.

Analog Reads (Input Registers)

Input registers are analog values that are readable from, but not writable to, the 505E control. An example of an analog read value would be turbine speed. The values of the input registers are stored internal to the control as floating point numbers representing engineering units (i.e. KPA or RPM). The values that are transmitted are integer values ranging from -32767 to +32767. Since Modbus can only handle integers, values that require a decimal point must be multiplied by a scaling constant in the 505E before being sent across the Modbus link. For example, these input registers may be listed as the Modbus value 'x100' or 'cascade scale factor' under the description heading to denote the value is multiplied by a scaling constant (refer to Modbus Scale Factors later in this section). This will allow transmission of decimal parts of a unit if this is necessary for better resolution.

See the 505E Service mode for defaulted communication constants and ranges. The 505E control supports Modbus function code 4, which involves reading selected input registers. The input registers available are listed in Table 6-7.

Analog Writes (Holding Registers)

Holding registers are analog values that are writable to the 505E control. These values can also be read from by a device performing error checking. An example of an analog write value would be a direct speed setpoint value as opposed to raise and lower setpoint commands. The value of the holding registers are also stored in the control as numbers representing engineering units (i.e. PSI or RPM). Once again, if decimal points are required, a scaling factor must be used (refer to Modbus Scale Factors later in this section). The 505E control supports Modbus function codes 3, 6, and 16. These correspond to reading selected holding registers, writing to a single holding register, and writing to multiple holding registers, respectively. The holding registers available are listed in Table 6-8.

The following tables give the address and description of all Boolean and analog, reads and writes.

ADDR	DESCRIPTION	ADDR	DESCRIPTION
0:0001	Emergency Shutdown	0:0041	Spare
0:0002	Emerg Shutdown Acknowledge	0:0042	Modbus Alarm Acknowledge
0:0003	Controlled Shutdown	0:0043	Turn On/Energize Modbus Relay 1
0:0004	Abort Controlled Shutdown	0:0044	Turn Off/De-Energize Modbus Relay 1
0:0005	System Reset	0:0045	Turn On/Energize Modbus Relay 2
0:0006	Start/Run	0:0046	Turn Off/De-Energize Modbus Relay 2
0:0007	Open HP Valve Limiter	0:0047	Turn On/Energize Modbus Relay 3
0:0008	Close HP Valve Limiter	0:0048	Turn Off/De-Energize Modbus Relay 3
0:0009	Lower Speed Setpoint	0:0049	Turn On/Energize Modbus Relay 4
0:0010	Raise Speed Setpoint	0:0050	Turn Off/De-Energize Modbus Relay 4
0:0011	Go To Rated (Idle/Rated)	0:0051	Turn On/Energize Modbus Relay 5
0:0012	Go To Idle (Idle/Rated)	0:0052	Turn Off/De-Energize Modbus Relay 5
0:0013	Halt Auto Start Sequence	0:0053	Turn On/Energize Modbus Relay 6
0:0014	Continue Auto Start Sequence	0:0054	Turn Off/De-Energize Modbus Relay 6
0:0015	Enable Rmt Speed Setpt	0:0055	Spare
0:0016	Disable Rmt Speed Setpt	0:0056	Spare
0:0017	Go To Modbus Entered Speed Setpt	0:0057	Enable Extraction Control
0:0018	Spare	0:0058	Disable Extraction Control
0:0019	Arm Frequency Control	0:0059	Lower Extraction Setpoint
0:0020	Disarm Frequency Control	0:0060	Raise Extraction Setpoint
0:0021	Sync Enable	0:0061	Enable Rmt Extr Setpoint Control
0:0022	Sync Disable	0:0062	Disable Rmt Extr Setpoint Control
0:0023	Enable Cascade Control	0:0063	Go To Modbus Entered Extr Setpt
0:0024	Disable Cascade Control	0:0064	Open LP Valve Limiter
0:0025	Lower Cascade Setpoint	0:0065	Close LP Valve Limiter
0:0026	Raise Cascade Setpoint	0:0066	Decrease Extr/Adm Demand
0:0027	Enable Rmt Cascade Setpt	0:0067	Increase Extr/Adm Demand
0:0028	Disable Rmt Cascade Setpt	0:0068	Enable Extr/Adm Priority
0:0029	Go To Modbus Entered Casc Setpt	0:0069	Disable Extr/Adm Priority
0:0030	Spare	0:0070	Spare
0:0031	Enable Aux Control (Aux controller only)	0:0071	Spare
0:0032	Disable Aux Control (Aux controller only)	0:0072	Spare
0:0033	Lower Aux Setpoint	0.0073	Spare
0:0034	Raise Aux Setpoint	0.0074	Spare
0:0035	Enable Rmt Aux Setpt Control	0.0075	Momentarily Energize Modbus Relay #1
0:0036	Disable Rmt Aux Setpt Control	0.0076	Momentarily Energize Modbus Relay #2
0:0037	Go to Modbus Entered Aux Setpt	0.0077	Momentarily Energize Modbus Relay #3
0:0038	Spare	0.0078	Momentarily Energize Modbus Relay #4
0:0039	Select Remote Ctrl (Remote/Local)	0.0079	Momentarily Energize Modbus Relay #5
0:0040	Select Local Ctrl (Remote/Local)	0.0080	Momentarily Energize Modbus Relay #6

Table 6-5. Boolean Write Addresses

ADDR	DESCRIPTION	ADDR	DESCRIPTION
1:0001	Alarm—MPU #1 Failed	1:0060	Spare
1:0002	Alarm—MPU #2 Failed	1:0061	Spare
1:0003	Alarm—Cascade Input Failed	1:0062	Spare
1.0004	Alarm—Aux Input Failed	1:0063	Spare
1:0005	Alarm—KW Input Failed	1:0064	Shutdown Exits (Trip Indication)
1:0006	Alarm—Sync Input Failed	1:0065	ESD Acknowledge Enable
1:0007	Alarm—First Stg Prs Input Failed	1:0066	Moving to Min Spd Setpt
1:0008	Alarm—Rmt Speed Input Failed	1:0067	Idle/Rtd—Ramping to Idle
1:0009	Alarm—Rmt Casc Input Failed	1:0068	Idle/Rtd—At Idle
1:0010	Alarm—Rmt Aux Input Failed	1:0069	Idle/Rtd—Ramping to Rated
1:0011	Alarm—Loadshare Input Failed	1:0070	Idle/Rtd—At Rated
1:0012	Alarm—Actuator #1 Failed	1:0071	Auto Seq—Setpt at Low Idle
1:0013	Alarm—Actuator #2 Failed	1:0072	Auto Seq—Ramping to High Idle
1:0014	Alarm—Start Permissive Not Met	1:0073	Auto Seq—Setpt at High Idle
1:0015	Alarm—Comm Link #1 Failed	1:0074	Auto Seq—Ramping to Rated
1:0016	Alarm—Comm Link #2 Failed	1:0075	Auto Seq—At Rated
1:0017	Alarm—Generator Breaker Open	1:0076	Speed PID In Control (not Aux ctrl)
1:0018	Alarm—Turbine Trip	1:0077	Spd Sensor 1 Failed Override ON
1:0019	Alarm—Tie Breaker Open	1:0078	Spd Sensor 2 Failed Override ON
1:0020	Alarm—Overspeed Alarm	1:0079	Overspeed Test Permissive
1:0021	Alarm—Tie Brkr Open/No Aux	1:0080	Overspeed Test In Progress
1:0022	Alarm—Gen Brkr Open/No Aux	1:0081	Speed at or above Min Gov
1:0023	Alarm—Tie Brkr Open/No Casc	1:0082	Turbine In Critical Speed Band
1:0024	Alarm—Gen Brkr Open/No Casc	1:0083	Remote Speed Setpt is Enabled
1:0025	Alarm—Tie Brkr Open/No Rmt	1:0084	Remote Speed Setpt is Active
1:0026	Alarm—Gen Brkr Open/No Rmt	1:0085	Remote Speed Setpt is in Control
1:0027	Alarm—Stuck in Critical Alarm	1:0086	Remote Speed Setpt is Inhibited
1:0028	Alarm—Tie Brkr Open / No Extr	1:0087	Speed PID in Control (not lmted)
1:0029	Alarm—Gen Brkr Opn / No Extr	1:0088	Spare
1:0030	Alarm—Extraction Input Failed	1:0089	Spare
1:0031	Alarm—Rmt Extr Input Failed	1:0090	Generator Breaker Closed
1:0032	Alarm—Spare	1:0091	Utility Tie Breaker Closed
1:0033	Alarm—Spare	1:0092	Synchronizing Rate Selected
1:0034	Alarm—Spare	1:0093	Synchronizing is Enabled
1:0035	Alarm—Spare	1:0094	Sync or Load Share is in Control
1:0036	Alarm—Spare	1:0095	Sync/Load Share is Inhibited
1:0037	Alarm—Spare	1:0096	Spare
1:0038	Alarm Not Acknowledged	1:0097	Freq Control Armed
1:0039	Alarm Acknowledge	1:0098	Frequency Control Active
1:0040	Alarm Exists (Common Alarm)	1:0099	Spare
1:0041	Trip—External Trip	1:0100	Cascade is Enabled
1:0042	Trip—ESD Button	1:0101	Cascade is Active
1:0043	Trip—Overspeed Trip	1:0102	Cascade is in Control
1:0044	Trip—Loss of Speed Signals	1:0103	Cascade is Inhibited
1:0045	Trip—Actuator #1 Failed	1:0104	Rmt Cascade is Enabled
1:0046	Trip—Actuator #2 Failed	1:0105	Rmt Cascade is Active
1:0047	Trip—Aux Input Failed	1:0106	Rmt Cascade is in Control
1:0048	Trip—External Trip 2	1:0107	Rmt Cascade is Inhibited
1:0049	Trip—External Trip 3	1:0108	Spare
1:0050	Trip—Modbus Link #1 Trip	1:0109	Auxiliary is Enabled
1:0051	Trip—Modbus Link #2 Trip	1:0110	Auxiliary is Active
1:0052	Spare	1:0111	Auxiliary is in Control
1:0053	Trip—Tie Breaker Open	1:0112	Aux Active/Not Limiting
1:0054	Trip—Gen Breaker Open	1:0113	Aux Active/Not in Control
1:0055	Trip—Power UP	1:0114	Auxiliary is Inhibited
1:0056	Trip—Manual Stop	1:0115	Remote Aux is Enabled
1:0057	Trip—External Trip 4	1:0116	Remote Aux is Active
1:0058	Trip—External Trip 5	1:0117	Rmt Aux is in Control
1:0059	Trip—Extr/Adm Input Failed	1:0118	Rmt Aux in Inhibited

Table 6-6a. Boolean Read Addresses

ADDR	DESCRIPTION	ADDR	DESCRIPTION
1:0119	Spare	1:0164	Contact In 2 (Closed)
1:0120	Extraction is Enabled	1:0165	Contact In 3 (Closed)
1:0121	Extraction is Active	1:0166	Contact In 4 (Closed)
1:0122	Extraction is in Control (not lmtd)	1:0167	Contact In 5 (Closed)
1:0123	Extraction is Inhibited	1:0168	Contact In 6 (Closed)
1:0124	Remote Extr is Enabled	1:0169	Contact In 7 (Closed)
1:0125	Remote Extr is Active	1:0170	Contact In 8 (Closed)
1:0126	Remote Extr is in Control	1:0171	Contact In 9 (Closed)
1:0127	Rmt Extr is Inhibited	1:0172	Contact In 10 (Closed)
1:0128	Pressure Priority Enabled	1:0173	Contact In 11 (Closed)
1:0129	Pressure Priority Active	1:0174	Contact In 12 (Closed)
1:0130	Speed Priority Active	1:0175	Aux Enable/Disable Config'd
1:0131	Priority Transfer Permissible	1:0176	Sync Function Configured
1:0132	Spare	1:0177	ESD Control Configured
1:0133	Controlled Stop in Progress	1:0178	Manual Start Configured
1:0134	LP Valve Limiter is Open	1:0179	Auto Start Configured
1:0135	LP Valve Limiter is Closed	1:0180	Semi-Auto Start Configured
1:0136	LP Valve Limiter In Control	1:0181	Idle/Rated Start Configured
1:0137	HP Valve Limiter is Open	1:0182	Auto Start sequence Configured
1:0138	HP Valve Limiter is Closed	1:0183	First Stage Pressure Configured
1:0139	HP Valve Limiter In Control	1:0184	Remote Control Configured
1:0140	Rmt/Local—Remote Selected	1:0185	Loadsharing Configured
1:0141	Rmt/Local—Modbus 1 or 2 Active	1:0186	ESD (Trip) Configured
1:0142	Start Perm (Contact in Closed)	1:0187	Gen Set Configured
1:0143	At Steam Map at Limit	1:0188	Cascade Control Configured
1:0144	At Min Press Limit	1:0189	Remote Cascade Control
1:0145	At HP Max Limit	1:0190	Aux Control Configured
1:0146	At HP Min Limit	1:0191	Remote Aux Configured
1:0147	At LP Max Limit	1:0192	Modbus1 (or 2) Lcl/Rmt Actv Config'd
1:0148	At LP Min Limit	1:0193	Start Permissive Configured
1:0149	At Max Power Limi	1:0194	Frequency Arm/Disarm Config'd
1:0150	At Max Press Limit	1:0195	Frequency Control Config'd
1:0151	Shutdown Relay Energized	1:0196	MPU 2 Configured
1:0152	Alarm Relay Energized	1:0197	Local/Remote Configured
1:0153	Relay 1 Energized	1:0198	Local/Remote ESD Always Active
1:0154	Relay 2 Energized	1:0199	Cascade Setpt Tracking Config'd
1:0155	Relay 3 Energized	1:0200	KW Input Config'd and not Failed
1:0156	Relay 4 Energized	1:0201	Ext/Adm Configured
1:0157	Relay 5 Energized	1:0202	Admission-only Configured
1:0158	Relay 6 Energized	1:0203	Extr Enable/Disable Configured
1:0159	ESD Contact Input (Closed)	1:0204	Priority Selection Configured
1:0160	Reset Contact Input (Closed)	1:0205	Rmt Extr/Adm Setpt Configured
1:0161	Raise Spd Cont Input (Closed)	1:0206	Ext/Adm Setpt Tracking Config'd
1:0162	Lower Spd Cont Input (Closed)	1:0207	Spare
1:0163	Contact In 1 (Closed)	1:0208	505E/505D Config'd (E=True/D=False)

Table 6-6b. Boolean Read Addresses

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0001	Cause of last turbine trip *	none	none
3:0002	Speed Sensor #1 Input	rpm	none
3:0003	Speed Sensor #2 Input	rpm	none
3:0004	Actual Turbine Speed	rpm	none
3:0005	Actual Speed (%)	%	100
3:0006	Speed Setpoint (%)	%	100
3:0007	Speed Setpoint	rpm	none
3:0008	Speed Droop Setpoint	rpm	none
3:0009	Load (%)Speed Droop	%	100
3:0010	Speed PID Output (%)	%	100
3:0011	Min Governor Speed Setpoint	rpm	none
3:0012	Highest Speed Reached	rpm	none
3:0013	Idle / Rated—Idle Speed	rpm	none
3:0014	Idle / Rated—Rated Speed	rpm	none
3:0015	Auto Seq-Low Idle Speed Setpt	rpm	none
3:0016	Auto Seq-Low Idle Delay Time	min	100
3:0017	Auto Seq-Time Left At Low Idle	min	100
3:0018	Auto Seq-Low Idle to High Idle Rate	rpm/sec	none
3:0019	Auto Seq-High Idle Speed Setpoint	rpm	none
3:0020	Auto Seq-High Idle Delay Time	min	100
3:0021	Auto Seq-Time Remaining At High Idle	min	100
3:0022	Auto Seq-High Idle to Rated Rate	rpm/sec	none
3:0023	Auto Seq—Rated Speed Setpt	rpm	none
3:0024	Auto Seq—Run Time Hours	hrs	none
3:0025	Auto Seq—Hours Since Trip	hrs	none
3:0026	Cascade Setpoint (Scaled)	casc units	casc scale factor
3:0027	Cascade PID Output (%)	%	100
3:0028	Cascade Input (%)	%	100
3:0029	Cascade Setpoint (%)	%	100
3:0030	Cascade Scale Factor	none	none
3:0031	Cascade Input (Scaled)	casc units	casc scale factor
3:0032	Remote Cascade Input (Scaled)	casc units	casc scale factor
3:0033	Aux Setpoint (Scaled)	aux units	aux scale factor
3:0034	Aux PID Output (%)	%	100
3:0035	Aux Input (%)	%	100
3:0036	Aux Setpoint (%)	%	100
3:0037	Aux Scale Factor	none	none
3:0038	Aux Input (Scaled)	aux units	aux scale factor
3:0039	Remote Aux Input (Scaled)	aux units	aux scale factor
3:0040	Remote Speed Setpoint Input	rpm	none
3:0041	FSP Scale Factor	none	none
3:0042	FSP Input (Scaled)	fsp units	fsp scale factor
3:0043	Loadshare Scale Factor	none	none
3:0044	Sync / Loadshare Input (Scaled)	rpm	ldshr scale factor
3:0045	KW Scale Factor	none	none
3:0046	KW Input (Scaled)	kw units	kw scale factor
3:0047	HP Valve Limiter Output (%)	%	100
3:0048	LP Valve Limiter Output (%)	%	100
3:0049	Actuator 1 Demand (%)	%	100
3:0050	Actuator 2 Demand (%)	%	100
3:0051	Extr/Adm Manual Demand (%)	%	100
3:0052	Extraction Setpoint (Scaled)	extr units	extr scale factor
3:0053	Extraction PID Output (%)	%	100
3:0054	Extraction Input (%)	%	100
3:0055	Extraction Setpoint (%)	%	100

Table 6-7a. Analog Read Addresses

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0056	Extraction Scale Factor	none	none
3:0057	Extraction Input (Scaled)	extr units	extr scale factor
3:0058	Remote Extr Input (Scaled)	extr units	extr scale factor
3:0059	Spare		
3:0060	Modbus Entered Speed Setpoint (fdbk)	rpm	none
3:0061	Modbus Entered Cascade Setpt (fdbk)	casc units	casc scale factor
3:0062	Modbus Entered Aux Setpt (fdbk)	aux units	aux scale factor
3:0063	Modbus Entered Extr Setpt (fdbk)	extr units	extr scale factor
3:0064	S-term Limited by Map	%	100
3:0065	P-term Limited by Map	%	100
3:0066	HP Demand from Map	%	100
3:0067	LP Demand from Map	%	100
3:0068	S-term Demand	%	100
3:0069	P-term Demand	%	100
3:0070	Controlling Parameter (upper line)	none	none
3:0071	Controlling Parameter (lower line)	none	none
3:0072	Extraction/Admission Input	%	100
3:0073	Analog Input 2	%	100
3:0074	Analog Input 3	%	100
3:0075	Analog Input 4	%	100
3:0076	Analog Input 5	%	100
3:0077	Analog Input 6	%	100
3:0078	Analog Output 1	mA	100
3:0079	Analog Output 2	mA	100
3:0080	Analog Output 3	mA	100
3:0081	Analog Output 4	mA	100
3:0082	Analog Output 5	mA	100
3:0083	Analog Output 6	mA	100
3:0084	Actuator #1 Output	mA	100
3:0085	Actuator #2 Output	mA	100
3:0086	Spare		
3:0087	KW Units (3 = MW 4 = KW)	none	none
3:0088	Spare		
3:0089	Analog Input 2 Configuration *	none	none
3:0090	Analog Input 3 Configuration *	none	none
3:0091	Analog Input 4 Configuration *	none	none
3:0092	Analog Input 5 Configuration *	none	none
3:0093	Analog Input 6 Configuration *	none	none
3:0094	Analog Output 1 Configuration *	none	none
3:0095	Analog Output 2 Configuration *	none	none
3:0096	Analog Output 3 Configuration *	none	none
3:0097	Analog Output 4 Configuration *	none	none
3:0098	Analog Output 5 Configuration *	none	none
3:0099	Analog Output 6 Configuration *	none	none
3:0100	Relay 1 Configuration *	none	none
3:0101	Relay 2 Configuration *	none	none
3:0102	Relay 3 Configuration *	none	none
3:0103	Relay 4 Configuration *	none	none
3:0104	Relay 5 Configuration *	none	none
3:0105	Relay 5 Configuration *	none	none
3:0106	Contact Input 1 Configuration *	none	none
3:0107	Contact Input 2 Configuration *	none	none
3:0108	Contact Input 3 Configuration *	none	none
3:0109	Contact Input 4 Configuration *	none	none
3:0110	Contact Input 5 Configuration *	none	none
3:0111	Contact Input 6 Configuration *	none	none

Table 6-7b. Analog Read Addresses

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0112	Contact Input 7 Configuration *	none	none
3:0113	Contact Input 8 Configuration *	none	none
3:0114	Contact Input 9 Configuration *	none	none
3:0115	Contact Input 10 Configuration *	none	none
3:0116	Contact Input 11 Configuration *	none	none
3:0117	Contact Input 12 Configuration *	none	none
3:0118	Aux Units Configured *	none	none
3:0119	Cascade Units Configured *	none	none
3:0120	Extraction Units Configured*	none	none

* Refer to Look-up table at end of this section
Analog Read Addresses (Cont.)

Table 6-7c. Analog Read Addresses

ADDR	DESCRIPTION	UNITS	MULTIPLIER
4:0001	Modbus Entered Speed Setpoint	rpm	none
4:0002	Modbus Entered Casc Setpoint	casc units	casc scale factor
4:0003	Modbus Entered Aux Setpoint	aux units	aux scale factor
4:0004	Modbus Entered Extr Setpoint	extr units	extr scale factor
4:0005	Spare		
4:0006	Spare		
4:0007	Spare		
4:0008	Spare		

Table 7-8. Analog Write Addresses

Last Turbine Trip Cause

The cause of the last turbine trip (address 3:0001) is an integer that represents the following cause:

Value	Description
1.	Power up Shutdown
2.	Emergency Shutdown (front panel pushbutton)
3.	Overspeed Trip
4.	All Speed Probes Failed
5.	Act #1 (HP) Fault
6.	Act #2 (LP) Fault
7.	Aux Input Failed
8.	External Trip 2
9.	External Trip 3
10.	Comm Link #1 Trip
11.	Comm Link #2 Trip
12.	Utility Tie Breaker Opened
13.	Generator Breaker Opened
14.	External Trip Input
15.	Manual (controlled) Shutdown
16.	External Trip 4
17.	External Trip 5
18.	Extr/Adm Input Failed

505E Controlling Parameters

The controlling parameter status of the 505E uses two Analog Read registers (3:0070) & (3:0071) to identify the two parameters that are in control of the 505E. The analog register (3:0070) corresponds to the top line of the display. Analog register (3:0071) corresponds to the second line of the display. These variables follow what is displayed on the controlling parameter screen, under the 'CONT' key. The variables gives the current status of the control and is defined in the following table.

CONTROL STATUS   (Controlling Parameter—upper line of 'CONT' key display)
VALUE.............................. DESCRIPTION
1....................................... Speed / Off—Line
2....................................... Speed / On—Line
3....................................... Remote / Speed
4....................................... Cascade / Speed
5....................................... Remote Cascade / Speed
6....................................... Frequency / Speed
7....................................... Load Share / Speed
8....................................... Synchronizing
9....................................... Auto Start Sequence
10..................................... Idle / Rated Start
11..................................... Semi Auto Start
12..................................... Auto Start
13..................................... Manual Start
14..................................... Auxiliary
15..................................... Remote Auxiliary
16..................................... LP Min Limit
17..................................... HP Min Limit
18..................................... LP Max Limit
19..................................... HP Max Limit
20..................................... Max Power Limit
21..................................... HP Valve Limiter
22..................................... HP Max Actuator
23..................................... Control at Two Limits
24..................................... Controlling Parameter

Table 6-9a. Control Status

CONTROL STATUS   **(Controlling Parameter—lower line of 'CONT' key display)**
VALUE ....DESCRIPTION
1. ....Manual Admission Demand
2. ....Manual Extr/Extr Demand
3. ....Extr/Adm Control
4. ....Admission Control
5. ....Extraction Control
6. ....E/A Ctrl w/ Rmt Setpt
7. ....Adm Ctrl w/ Rmt Setpt
8. ....Extr Ctrl w/ Rmt Setpt
9. ....Max Adm Limit Control
10. ....Max Adm Limit Control
11. ....Min Extr Limit Control
12. ....Max Extr Limit Control
13. ....Min Adm Limit Control
14. ....Max Extr Limit Control
15. ....LP Min Limit Control
16. ....HP Min Limit Control
17. ....LP Max Limit Control
18. ....HP Max Limit Control
19. ....Max Power Limit Control
20. ....LP Valve Limiter Control
21. ....LP Max Actuator Control
22. ....Min HP & Min Prs Limits
23. ....Min LP & Min Prs Limits
24. ....Max LP & Min Prs Limits
25. ....Min HP & Min LP Limits
26. ....Max Pwr & Min Prs Limits
27 ....Max HP & Max Prs Limits
28. ....Min LP & Max Prs Limits
29. ....Max Pwr & Max LP Limits
30. ....Max HP & Min LP Limits
31. ....Max HP & Max Pwr Limits
32. ....Max HP & Max LP Limits
33. ....Ready to Start
34. ....Start Perm Not Met
35. ....Configuration Error
36. ....Controlled Shutdown
37. ....Shutdown

Table 6-9b. Control Status

Analog Read addresses 3:0088—0093 give the configuration value of the analog inputs, one to six in order. The configuration for the analog inputs are defined in the table below.

ANALOG INPUT CONFIGURATION
VALUE ....DESCRIPTION
1. ....Remote Speed Setpt
2. ....Synchronizing Input
3. ....Sync/Load Share Input
4. ....KW / Unit Load Input
5. ....Remote Extr/Adm Setpt
6. ....Cascade Input
7. ....Remote Cascade Setpt
8. ....Auxiliary Input
9. ....Remote Aux Setpt
10. ....First Stage Press Input
11. ....Speed/Load Demand
12. ....Ext/Adm Pressure Demand
13. ....(Not Used)

Table 6-10. Analog Input Configuration

Analog Read addresses 3:0094—0099 give the configuration value of the analog outputs, one to six in order. The configuration for the analog outputs are defined in the table below.

ANALOG OUTPUT CONFIGURATION
VALUE............................. DESCRIPTION
1... Actual Speed
2... Speed Setpoint
3... Remote Speed Setpt
4... Load Share Input
5... Sync Input
6... KW Input
7... Extr/Adm Input
8... Extr/Adm Setpt
9... Rmt Extr/Adm Setpt
10....................................... Cascade Input
11....................................... Cascade Setpoint
12....................................... Rmt Cascade Setpt
13....................................... Auxiliary Input
14....................................... Auxiliary Setpoint
15....................................... Rmt Auxiliary Setpt
16....................................... Speed/Load Demand
17....................................... Extr/Adm Demand
18....................................... HP Valve Limiter Setpt
19....................................... LP Valve Limiter Setpt
20....................................... HP Actuator Demand
21....................................... LP Actuator Demand
22....................................... First Stg Press Input
23....................................... (Not Used)

Table 6-11. Analog Output Configuration

Analog Read addresses 3:0100—0105 give the configuration value of the relays, one to six in order. The configuration for the relays are defined in the table below.
RELAY CONFIGURATION
VALUE............................. DESCRIPTION (level switch options)
1... Speed Level Switch
2... Speed Setpoint Level Switch
3... KW/MW Level Switch
4... Load Share Level Switch
5... Extr/Adm Level Switch
6... Extr/Adm Setpt Switch
7... Cascade Level Switch
8... Cascade Setpoint Level Switch
9... Aux Level Switch
10....................................... Aux Setpoint Level Switch
11....................................... Speed/Load Demand
12....................................... Extr/Adm Demand
13....................................... HP Valve Limiter
14....................................... LP Valve Limiter
15....................................... HP (Act 1) Output Level
16....................................... LP (Act 2) Output Level
17....................................... First Stage Pressure Level Switch

Table 6-12a. Relay Configuration

VALUE ....DESCRIPTION (state relay options)
21. ....Shutdown Condition
22. ....Trip Relay (additional trip relay output)
23. ....Alarm Condition
24. ....Control Status OK
25. ....Overspeed Trip
26. ....Overspeed Test Enabled
27. ....Speed PID in Control
28. ....Remote Speed Setpt Enabled
29. ....Remote Speed Setpt Active
30. ....Underspeed Switch
31. ....Auto Start Sequence Halted
32. ....On-Line PID Dynamics Mode
33. ....Local Control Mode
34. ....Frequency Control Armed
35. ....Frequency Control
36. ....Sync Enabled
37. ....Sync or Load Share Active
38. ....Load Share Control
39. ....Extr/Adm Control Enabled
40. ....Extr/Adm Control Active
41. ....Extr/Adm PID in Control
42. ....Rmt Ext/Adm Setpt Enabled
43. ....Rmt Ext/Adm Setpt Active
44. ....Casc Control Enabled
45. ....Cascade Control Active
46. ....Remote Casc Setpt Enabled
47. ....Remote Casc Setpt Active
48. ....Aux Control Enabled
49. ....Aux Control Active
50. ....Auxiliary PID in Control
51. ....Remote Aux Setpt Enabled
52. ....Remote Aux Setpt Active
53. ....HP Valve Limiter in Control
54. ....LP Valve Limiter in Control
55. ....Ext/Adm Priority Enabled
56. ....Ext/Adm Priority Active
57. ....Steam Map Limiter in Control
58. ....F3 Key Selected
59. ....F4 Key Selected
60. ....Modbus Command Selected
61. ....(Not Used)

Table 6-12b. Relay Configuration

Analog Read addresses 3:0106—0117 give the configuration value of the contact inputs, one to twelve in order. The configuration for the contact inputs are defined in the table below.

CONTACT INPUT CONFIGURATION

VALUE	DESCRIPTION
1.	Generator Breaker
2.	Utility Tie Breaker
3.	Overspeed Test
4.	External Run
5.	Start Permissive
6.	Idle / Rated
7.	Halt / Continue Auto Start Sequence
8.	Override MPU Fault
9.	Select On-Line Dynamics
10.	Local / Remote
11.	Remote Speed Setpt Enable
12.	Sync Enable
13.	(Not Used)
14.	Freq. Control Arm/Disarm
15.	Extr/Adm Setpt Raise
16.	Extr/Adm Setpt Lower
17.	Extr/Adm Control Enable
18.	Rmt Extr/Adm Setpt Enable
19.	Select Extr/Adm Priority
20.	Casc Setpt Raise
21.	Casc Setpt Lower
22.	Casc Control Enable
23.	Remote Casc Setpt Enable
24.	Aux Setpt Raise
25.	Aux Setpt Lower
26.	Aux Control Enable
27.	Remote Aux Setpt Enable
28.	HP Valve Limiter Close
29.	HP Valve Limiter Open
30.	LP Valve Limiter Close
31.	LP Valve Limiter Open
32.	Extr/Adm Demand Raise
33.	Extr/Adm Demand Lower
34.	External Trip 2
35.	External Trip 3
36.	External Trip 4
37.	External Trip 5
38.	Controlled Shutdown (Manual)
39.	(Not Used)

Table 6-13. Contact Input Configurations

Analog Read addresses 3:0118-0119 give the configuration value of the Aux units and the Cascade units, in order. The configuration for the units are defined in the table below

UNITS CONFIGURATION
VALUE ....DESCRIPTION
1. ....psi
2. ....kPa
3. ....MW
4. ....KW
5. ....degF
6. ....degC
7. ....t/h
8. ....k#/hr
9. ....#/hr
10. ....kg/cm²
11. ....bar
12. ....atm
13. ....(none)

Table 6-14. Units Configuration

Analog Read addresses 3:0120 give the configuration value of the Extraction / Admission units, in order. The configuration for the units are defined in the table below.

UNITS CONFIGURATION
VALUE ....DESCRIPTION
1. ....psi
2. ....kPa
3. ....kg/cm²
4. ....t/h
5. ....k#/hr
6. ....#/hr
7. ....kg/hr
8. ....bar
9. ....atm
10. ....(none)

Table 6-15. Units Configuration

Specific Address Information

Entering Setpoint from the Modbus

The setpoints for the Speed, Extraction, Cascade and Auxiliary can be entered through the Modbus link. When the setpoint is entered for any of these functions the setpoint will not move instantly, but the setpoint will move towards the entered setpoint at the 'entered rate' defined for the function in the program mode (see Direct Setpoint Entry information in Chapters 3 and 5). The direct setpoint entry from Modbus functions the same as entering the setpoint from the front panel of the control.

There is feedback provided to let the operator know what value was entered. This value will not change until a new value is entered from the Modbus. The addresses, 3:0060- :0063, are for speed, cascade, auxiliary, and extraction/admission respectively. When the a new value is entered from the Modbus, the setpoint will move to the new value. If the entered setpoint that is the same as the feedback, the operator can use a 'Go To Modbus Entered' setpoint command (0:0017, 0:0029, 0:0037, & 0:0063) instead of entering the setpoint again. This command needs to be used when the setpoint to be entered is the same as the feedback.

Modbus Scale Factors

Modbus has two limitations:
- only integers can be sent across;
- the value is limited between -32768 and 32767.

These limitations can be overcome by scaling the value before it is sent across the Modbus. The default scale factor for the analog values is 1. The scale factor can be changed in the Service Mode between 1 and 100. The following input and setpoint values that are sent across the Modbus have independent scale factors: Casc (3:0030), Aux (3:0037), FSP (3:0041), KW (3:0045), Sync/Load Share (3:0043), and Extr/Adm (3:0056). These scaled parameters and their scale factor are available through the Modbus.

Values that require a decimal point must be multiplied by the scale factor (10, 100) prior to being sent across the Modbus. The value sent must then be divided by the scale factor in the Master.

The Scale Factor adjusts all associated analog reads and writes accordingly. For example, the Cascade Scale Factor adjusts the cascade input and setpoint analog read values as well as the Entered Setpt analog write value.

For example, if the Cascade setpoint of 60.15 needs to be sent across the Modbus and have two decimal places, the Cascade Scale Factor would be set to 100 in the Service Mode. This will change the value so that the decimal places can be sent across the Modbus communications link (60.15 * 100 = 6015). After the value is sent across the Modbus, it must be rescaled in the Master to the original value (6015 / 100 = 60.15). A Directly Entered Cascade Setpoint (4:0002) of 61.5 would be sent across the link as 6150 and the 505E automatically divides the value by the Casc Scale Factor and uses the value of 61.5 as the setpoint desired.

Modbus Percentage

Some of the analog read addresses have percentages sent across. The formula used in the percentage calculation is ((actual/maximum) * 100). The percentage is multiplied by 100 before being sent across the Modbus to provide up to 2 decimal places, if desired.

Modbus Emergency Shutdown

Two different types of shutdown commands (emergency and controlled) can be issued through Modbus. The Emergency Shutdown command instantly takes the speed setpoint to zero and the HP & LP actuator currents to zero. Optionally the 505E can be configured to ignore this Emergency Shutdown command if it is desired to not allow the unit to be tripped through Modbus.

To avoid an inadvertent trip, the emergency shutdown command from Modbus can be configured to require a two step process before a shutdown command is issued. When the shutdown is a two step process Boolean write address 0:0001 starts the shutdown process. An "ESD ACKN ENABLE" feedback (1:0065) is given and an acknowledge on address 0:0002 has to be given within five seconds for the control to issue a shutdown command.

See Volume 2 for Service mode tunables.

For More Modbus Information

Detailed information on the Modbus protocol is presented in "Reference Guide PI- MBUS-300" published by AEC Corp./Modicon Inc., formerly Gould Inc. To implement your own source code, you must register with Modicon. Registration includes purchasing document PI-MBUS-303 and signing a non-disclosure agreement. You can register to use Modbus at your nearest Modicon field office. To find the office nearest you, contact Modicon Technical Support at 1-800-468-5342.

Chapter 7.
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 "like-new" condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return authorization number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

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

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.
- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: **www.woodward.com**.

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	**Engine Systems**	**Turbine Systems**
Facility----------------Phone Number	**Facility----------------Phone Number**	**Facility----------------Phone Number**
Brazil ------------- +55 (19) 3708 4800	Brazil ------------- +55 (19) 3708 4800	Brazil ------------- +55 (19) 3708 4800
China ----------- +86 (512) 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	
Control/Governor #2	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Control/Governor #3	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

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.
505E Program Mode Worksheet

Governor Serial Number _____

Application _____   Date _____

TURBINE START

Manual Start	YES _____	NO _____
Automatic Start	YES _____	NO _____
Semiautomatic Start	YES _____	NO _____
Rate to Min (RPM/Sec)		RPM/SEC
Valve Lmtr Rate (%/Sec)		%/SEC
Use Idle/Rated?	ES _____	NO _____
Idle Setpt (RPM)		RPM
Rated Setpt (RPM)		RPM
Idle/Rtd Rate (RPM/SEC)		RPM/SEC
Use Auto Start Sequence	YES _____	NO _____
Cold Start = (> xx Hrs)		HRS
Hot Start = (< xx Hrs)		HRS
Low Idle Setpt (RPM)		RPM
Low Idle Delay (Cold)		MIN
Low Idle Delay (Hot)		MIN
Rate to Hi Idle (Cold)		RPM/SEC
Rate to Hi Idle (Hot)		RPM/SEC
High Idle Setpt (RPM)		RPM
High Idle Delay (Cold)		MIN
High Idle Delay (Hot)		MIN
Rate to Rated (Cold)		RPM/SEC
Rate to Rated (Hot)		RPM/SEC
Rated Setpt (RPM)		RPM
Auto Halt at Idle Setpts	YES _____	NO _____
Ext Trips in Trip Relay?	YES _____	NO _____
Reset Clears Trip Output	YES _____	NO _____

SPEED CONTROL

Teeth Seen by MPU		
Gear Ratio 1 :		
Failed Speed Level(RPM)		RPM
Use Speed Input #2?	YES _____	NO _____
Failed Speed Level(RPM)		RPM
Off-Line Prop Gain		%
Off-Line Int Gain		rps
Off-Line Deriv Ratio		%
On-Line Prop Gain		%
On-Line Int Gain		rps
On-Line Deriv Ratio		%

SPEED SETPOINT VALUES

Overspeed Test Lmt (RPM)		RPM
Overspeed Trip (RPM)		RPM
Max Governor Speed (RPM)		RPM
Min Governor Speed (RPM)		RPM
Setpt Slow Rate(RPM/SEC)		RPM/SEC
Use Remote Speed Setpt ?	YES _____	NO _____
Rmt Spd Setpt Max Rate		RPM/SEC
Use Critical Speeds?	YES _____	NO _____
Critical Speed Rate		RPM/SEC
Critical Speed 1 Max		RPM
Critical Speed 1 Min		RPM
Use Critical Band 2 ?	YES _____	NO _____
Critical Speed 2 Max		RPM
Critical Speed 2 Min		RPM

OPERATING PARAMETERS

Generator Application?	YES _____	NO _____
Use Gen Brkr Open Trip ?	YES _____	NO _____
Use Tie Brkr Open Trip ?	YES _____	NO _____
Use KW Droop?	YES _____	NO _____
KW Max Load		KW
Droop (%)		%
Rated Spd Setpt		RPM
Use Freq Arm/Disarm ?	YES _____	NO _____
Use Local/Remote	YES _____	NO _____

EXTR / ADM CONTROL

Lost E/A Input = Trip ?	YES _____	NO _____
Lost E/A Input = Max LP?	YES _____	NO _____
Lost E/A Input = Min LP?	YES _____	NO _____
Invert Extr/Adm Input?	YES _____	NO _____
Min Extr/Adm Setpt		Units
Max Extr/Adm Setpt		Units
Setpt Rate (units/sec)		Units
Setpt Initial Value		Units
Extr/Adm Droop		%
PID Proportional Gain		%
PID Integral Gain		rps
PID Derivative Ratio		%
Tiebrkr Open E/A Disable	YES _____	NO _____
Genbrkr Open E/A Disable	YES _____	NO _____
E/A Speed Enable Setting		RPM
Use Remote Setting?	YES _____	NO _____
Remote Setpt Max Rate		Units
Ext/Adm Units Of Measure		

TURB PERFORMANCE VALUES

Use Decoupling ?	YES	NO
Decouple Inlet (HP) ?	YES	NO
Decouple Exhaust(LP) ?	YES	NO
Decouple HP & LP ?	YES	NO
Max Power		Units
Max HP Flow		Units
Extraction Only ?	YES	NO
Admission Only ?	YES	NO
Extraction & Admission?	YES	NO

EXTRACTION STEAM MAP DATA

Use Automatic Enable?	YES	NO
Max Power @ Min Extr		Units
Max HP Flow @ Min Extr		Units
Min Power @ Max Extr		Units
Min HP Flow @ Max Extr		Units
Min Power @ Min Extr		Units
Min HP Flow @ Min Extr		Units

ADMISSION STEAM MAP DATA

Max Power @ Max Adm	Units
Max HP Flow @ Max Adm	Units
Max Admission Flow	Units
Min Power @ Min Adm	Units
Min HP Flow @ Min Adm	Units
Max Power @ Min Adm	Units
Max HP Flow @ Min Adm	Units

EXTR AND ADMISSION STEAM MAP

Max Power @ 0 Extr/Adm	Units
Max HP Flow @ 0 Extr/Adm	Units
Max Admission Flow	Units
Min Power @ Max Extr	Units
Min HP Flow @ Max Extr	Units
Min Pwr @ 0 Extr/Adm	Units
Min HP Flow @ 0 Extr/Adm	Units

DECOUPLED HP & LP DATA

Extraction Only ?	YES	NO
Use Automatic Enable?	YES	NO
Admission Only ?	YES	NO
Extraction & Admission?	YES	NO

SHARED DATA

Extr/Adm Demand Rate		%/SEC
Use Setpoint Tracking ?	YES	NO
Min HP Lift (%)		%
Min LP Lift (%)		%
LP Valve Limiter Rate		%/SEC
Speed Control Priority?	YES	NO
LP Max Lmt E/A Priority?	YES	NO
Auto Switch E/A Priority	YES	NO

DRIVER CONFIGURATION

Act #1 (HP) is 4-20mA?	YES	NO
Invert Driver Output ?	YES	NO
Use Act 1 Flt Shutdown	YES	NO
Act 1 (HP) Dither		mA
Act 1 Cal Min		mA
Act 1 Cal Max		mA
Act #2 (LP) is 4-20mA?	YES	NO
Invert Driver Output ?	YES	NO
Use Act 2 Flt Shutdown	YES	NO
Act 2 (LP) Dither		mA
Act 2 Cal Min		mA
Act 2 Cal Max		mA

ANALOG INPUTS

Analog Input # 1 Function	Extr/Admission
Input 1 4mA Value	Units
Input 1 20mA Value	Units
Analog Input # 2 Function	
Input 2 4mA Value	Units
Input 2 20mA Value	Units
Analog Input # 3 Function	
Input 3 4mA Value	Units
Input 3 20mA Value	Units
Analog Input # 4 Function	
Input 4 4mA Value	Units
Input 4 20mA Value	Units
Analog Input # 5 Function	
Input 5 4mA Value	Units
Input 5 20mA Value	Units
Analog Input # 6 Function	
Input 6 4mA Value	Units
Input 6 20mA Value	Units

CONTACT INPUTS

Contact Input 1 Function
Contact Input 2 Function
Contact Input 3 Function
Contact Input 4 Function
Contact Input 5 Function
Contact Input 6 Function
Contact Input 7 Function
Contact Input 8 Function
Contact Input 9 Function
Contact Input 10 Fctn
Contact Input 11 Fctn
Contact Input 12 Fctn

FUNCTION KEYS

F3 Key Performs		
Blink when not Active?	YES	NO
F4 Key Performs		
Blink when not Active?	YES	NO

AUXILIARY CONTROL

Use Auxiliary Control ?	YES _____	NO _____
Lost Aux Input Shutdown?	YES _____	NO _____
Use KW Input ?	YES _____	NO _____
Invert Aux ?	YES _____	NO _____
Min Aux Setpt		Units
Max Aux Setpt		Units
Aux Setpt Rate units/sec		Units / SEC
Use Aux Enable?	YES _____	NO _____
Setpt Initial Value		Units
Aux Droop		%
Aux PID Prop Gain		%
Aux PID Integral Gain		rps
Aux Derivative Ratio		%
Tiebrkr Open Aux Disable	YES _____	NO _____
Genbrkr Open Aux Disable	YES _____	NO _____
Use Remote Aux Setting	YES _____	NO _____
Remote Aux Max Rate		Units / SEC
Aux Units of Measure		

CASCADE CONTROL

Use Cascade Control?	YES _____	NO _____
Invert Cascade ?	YES _____	NO _____
Min Cascade Setpt		Units
Max Cascade Setpt		Units
Casc Setpt Rate (/sec)		Units/SEC
Use Setpoint Tracking ?	YES _____	NO _____
Setpt Initial Value		Units
Speed Setpt Lower Limit		RPM
Speed Setpt Upper Limit		RPM
Max Speed Rate(RPM/sec)		RPM/Sec
Cascade Droop		%
Casc PID Prop Gain		%
Casc PID Integral Gain		rps
Casc Derivative Ratio		%
Use Remote Casc Setting	YES _____	NO _____
Remote Casc Max Rate		Units/SEC
Casc Units of Measure		

READOUTS

Analog Readout 1 Is	
Readout 1 4mA Value	Units
Readout 1 20mA Value	Units
Analog Readout 2 Is	
Readout 2 4mA Value	Units
Readout 2 20mA Value	Units
Analog Readout 3 Is	
Readout 3 4mA Value	Units
Readout 3 20mA Value	Units
Analog Readout 4 Is	
Readout 4 4mA Value	Units
Readout 4 20mA Value	Units
Analog Readout 5 Is	
Readout 5 4mA Value	Units
Readout 5 20mA Value	Units
Analog Readout 6 Is	
Readout 6 4mA Value	Units
Readout 6 20mA Value	Units

RELAYS

Use Relay #1?	YES _____	NO _____
Relay # 1 is Level Switch?	YES _____	NO _____
Relay 1 Is Level Sw For		
Relay 1 ON Level		Units
Relay 1 OFF Level		Units
Relay 1 Energizes On		
Use Relay # 2?	YES _____	NO _____
Relay # 2 is Level Switch?	YES _____	NO _____
Relay 2 Is Level Sw For		
Relay 2 On Level		Units
Relay 2 Off Level		Units
Relay 2 Energizes On		
Use Relay # 3?	YES _____	NO _____
Relay # 3 is Level Switch?	YES _____	NO _____
Rly 3 Is Level Sw For		
Relay 3 On Level		Units
Relay 3 Off Level		Units
Relay 3 Energizes On		
Use Relay # 4?	YES _____	NO _____
Relay # 4 is Level Switch?	YES _____	NO _____
Rly 4 Is Level Sw For		
Relay 4 On Level		Units
Relay 4 Off Level		Units
Relay 4 Energizes On		
Use Relay # 5?	YES _____	NO _____
Relay # 5 is Level Switch?	YES _____	NO _____
Rly 5 Is Level Sw For		
Relay 5 On Level		Units
Relay 5 Off Level		Units
Relay 5 Energizes On		
Use Relay # 6?	YES _____	NO _____
Relay # 6 is Level Switch?	YES _____	NO _____
Rly 6 Is Level Sw For		
Relay 6 On Level		Units
Relay 6 Off Level		Units
Relay 6 Energizes On		

COMMUNICATIONS

Use Communications ?	YES _____	NO _____
Use Modbus Port 1?	YES _____	NO _____
Mode Ascii=1 Rtu=2		
ModBus Device #		
Port#1 Driver		
Port#1 Baud Rate		
Port#1 Stop Bits		
Port#1 Parity		
Use Modbus Port 2?	YES _____	NO _____
Mode: Ascii=1 Rtu=2		
ModBus Device#		
Port#2 Driver		
Port#2 Baud Rate		
Port#2 Stop Bits		
Port#2 Parity		

Revision History

Changes in Revision E—
- Changed field wiring requirement (pages vi, 2, 24)

We appreciate your comments about the content of our publications.

Send comments to: **icinfo@woodward.com**

Please reference publication **85018V1E**.

B85018V1:E

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