WOODWARD

Product Manual 26347V1
(Revision L, 4/2014)
Original Instructions

505 Enhanced Digital Control for Steam Turbines (with Redundancy)

8923-1704 (Marine LVDC); 9907-1181, 9907-1182, 9907-1183

Manual 26347 consists of 2 volumes (26347V1 & 26347V2).

Volume 1—Installation and Operation

General Precautions

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

Practice all plant and safety instructions and precautions.

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

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:

www.woodward.com/publications

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Proper Use

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

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Revisions—Changes in this publication since the last revision are indicated by a black line alongside the text.

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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

Battery Charging Device

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

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Regulatory Compliance

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

EMC Directive: Declared to 2004/108/EC COUNCIL DIRECTIVE of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

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
T3A at 60 °C Ambient (NEMA 4X or similar enclosure provided)
T3B at 65 °C Ambient (NEMA 4X or similar enclosure omitted)
For use in Canada and the United States per UL File E156028

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.

Marine Compliance (24 V Version Only)

Det Norske Veritas (DNV): Certified for Marine Applications, Temperature Class B, Humidity Class B, Vibration Class A, EMC Class A, and Enclosure Class B per DNV Rules for Ships, Pt. 4, Ch. 9, Control and Monitoring Systems.

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
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.

A fixed wiring installation is required.

Grounding is required by the input PE Terminal.

A switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach for the operator and is clearly marked as the disconnecting device for the equipment.

⚠WARNING

Ensure that power has been disconnected prior to opening the control or replacing the input power fuse.

⚠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.

⚠WARNING

Do not use any test points on the power supply or control boards unless the area is known to be non-hazardous.

⚠AVERTISSEMENT

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 describes the Woodward 505 Digital Governor for steam turbines with single or split-range actuators. English versions are 9907-1181, 9907-1182, and 9907-1183. 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 505 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.

The 505E Digital Governor for extraction steam turbines has its own manual.

Part Number Options

Part Number	Power
8923-1704	Marine LVDC (18–32 Vdc)
9907-1181	HVAC (180–264 Vac)
9907-1182	AC/DC (88–132 Vac or 90–150 Vdc)
9907-1183	LVDC (18–32 Vdc)

Optional Bulkhead Mounting Box (NEMA 4X) P/N 8923-439

IMPORTANT

Part numbers 9907-825, 9907-826, and 9907-827 are inactive and have been replaced by part number 9907-1181, 9907-1182, and 9907-1183.

Part Numbers 9907-1181, 9907-1182, and 9907-1183 incorporate new features such as Pressure Compensation, more robust redundant operation, improvements to the "In-Control" selection logic, and other product enhancements. These units should not be used with other part numbers.

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
8923-1704	NEW	8923-1704
9907-1119	B	9907-1119B
9907-1120	B	9907-1120B
9907-1121	B	9907-1121B
9907-1181	NEW	9907-1181
9907-1182	NEW	9907-1182
9907-1183	NEW	9907-1183

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.

The 505s are 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.

The Marine Type approved version is installed with the Woodward-supplied NEMA enclosure with a power line filter. Power wires to the line filter must be segregated from the wires from the line filter to the 505. In addition, the field wiring must be installed with an additional shield layer which is grounded to the enclosure. The additional shielding is beyond the standard shielding described elsewhere in the manual, and it may be made from solid or flexible metal conduit, armored cabling, or a cable with an overall shield.

Controller Overview

General Description

The 505 controller is designed to control single or dual (split range) actuator steam turbines (extraction steam turbines require the 505E version). The 505 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 505 can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

The 505 control has three PID controllers; the Speed/load PID controller, the Auxiliary PID controller, and the Cascade PID controller. Depending on the configuration of the 505, these PIDs interact differently with each other. Please refer to the Block diagrams listed later in this chapter to fully understand PID relationships.

The 505 drives one or two steam turbine throttle valves to control one turbine parameter at a time, and if desired, limit turbine operation based on other parameters. The one controlled parameter is typically speed (or load), however, the 505 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 of this manual for details on applications.

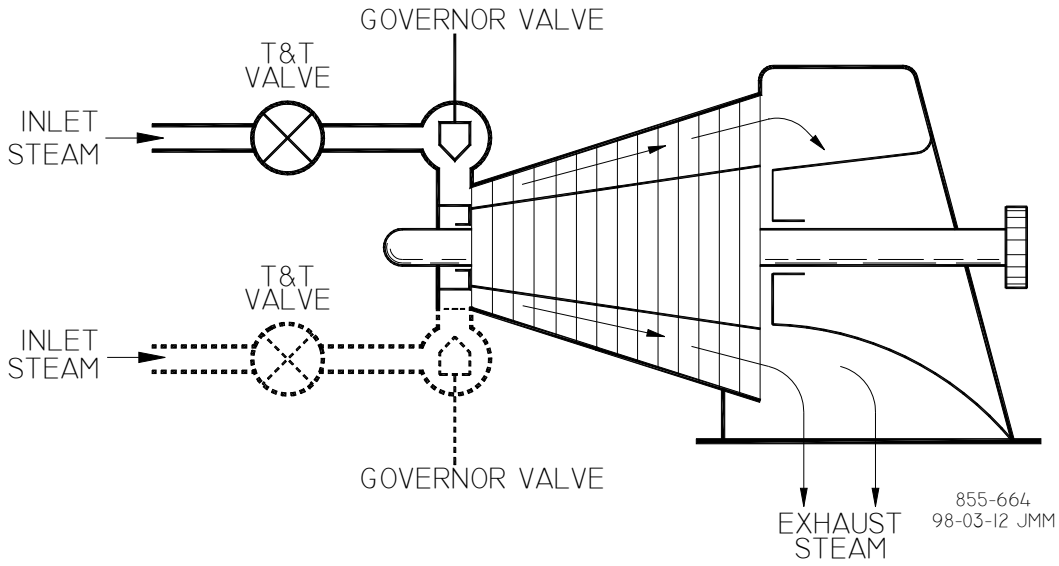

Figure 1-1. Typical Single or Dual Inlet Steam Turbine

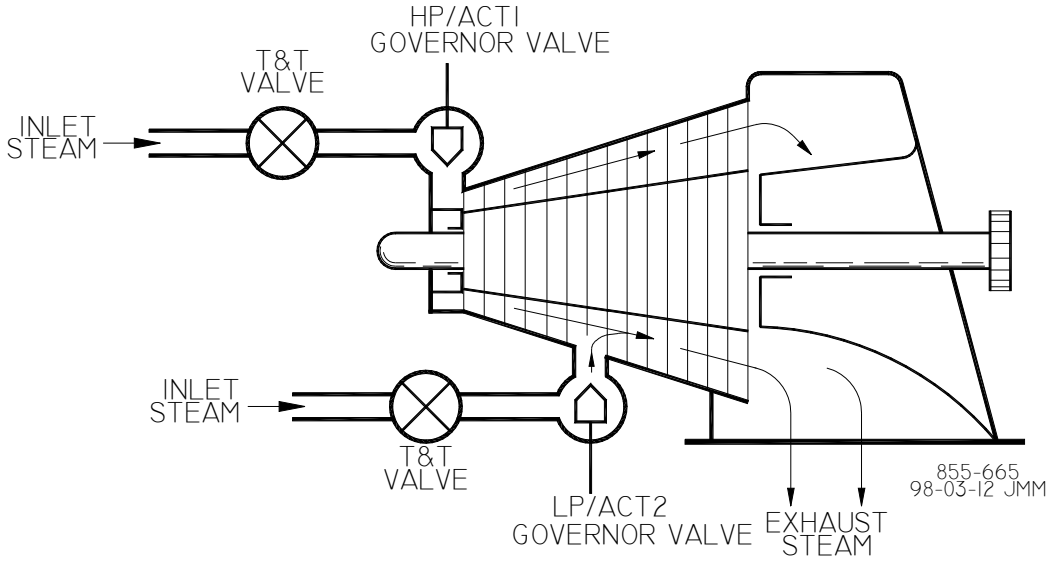

Figure 1-2. Split Range or Admission Type of Turbine Configuration

Operator Control Panel

The 505 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 505's front panel. This OCP is used to configure the 505, 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 set point values from the same screen.

Communications

The 505 control can communicate directly with plant Distributed Control Systems and/or Human Machine Interface (HMI) 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 505 and a plant DCS can also be performed through hardwired connections. Since all 505 PID set points can be controlled through analog input signals, interface resolution and control is not sacrificed.

*—Modbus is a trademark of Schneider Automation Inc.

In redundant control applications, one of these ports (Port #1) is dedicated for unit-to-unit communications. In this case, Port #1 is not available for DCS or HMI Modbus communications.

Additional Features

The 505 also provides the following features: First-Out Trip indication (10 total trip inputs), External Alarm indication (9 in total), 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 Load sharing between units (with an EGCP-3 control), Feed-forward loop, Acceleration protection, Remote droop, Frequency dead-band.

Using the 505

The 505 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, on-line adjustments can be made using the Service Mode (see Volume 2).

Functional Block Diagrams

Overviews of possible 505 configurations are shown in Figures 1-4 through 1-6. Use these block diagrams to match the control features to the site-specific application requirements. Figure 1-3 lists symbols and their respective explanations. The Cascade and auxiliary PIDs are optional controllers, and are shown in the following diagrams for PID relationship purposes only.

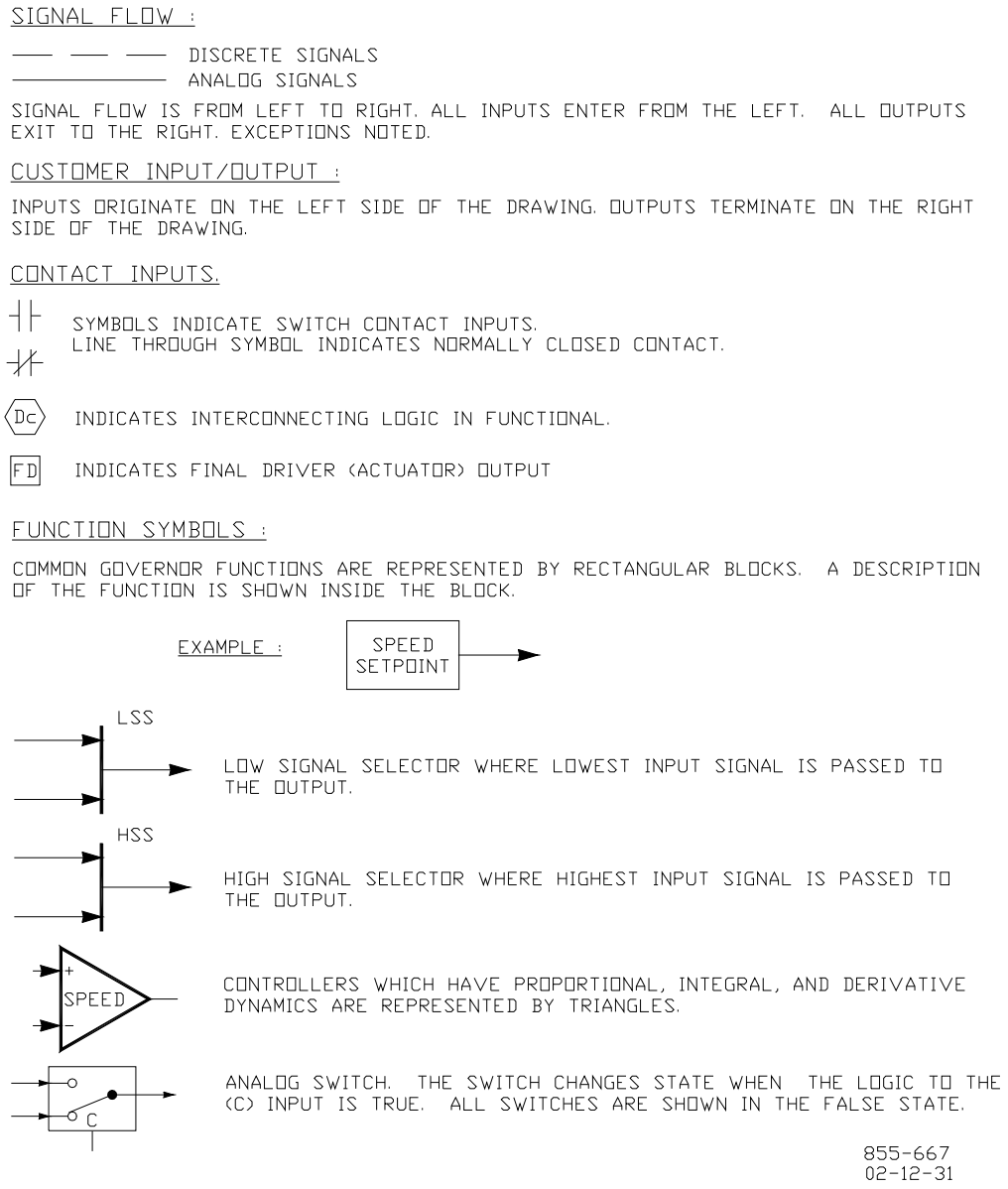

Figure 1-3. Explanation of Symbols

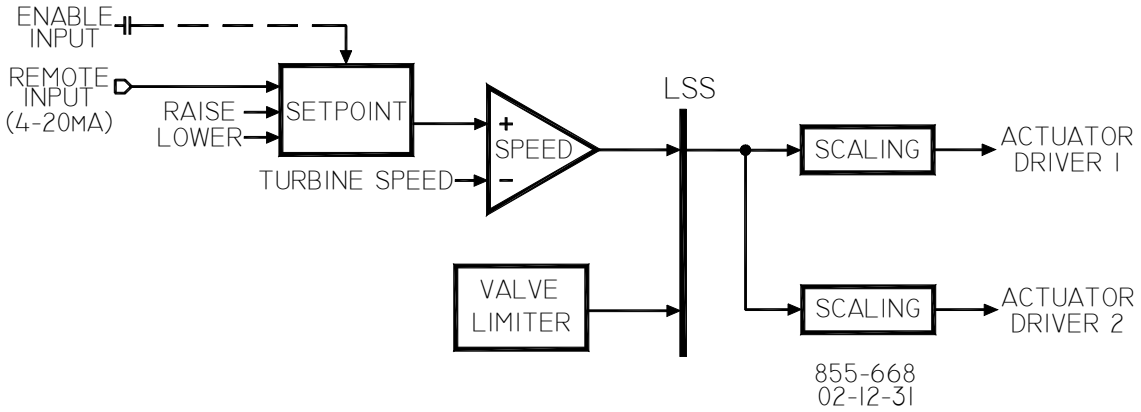

Figure 1-4. Single or Split-Range Turbine Configurations
(Speed PID with Remote Set Point)

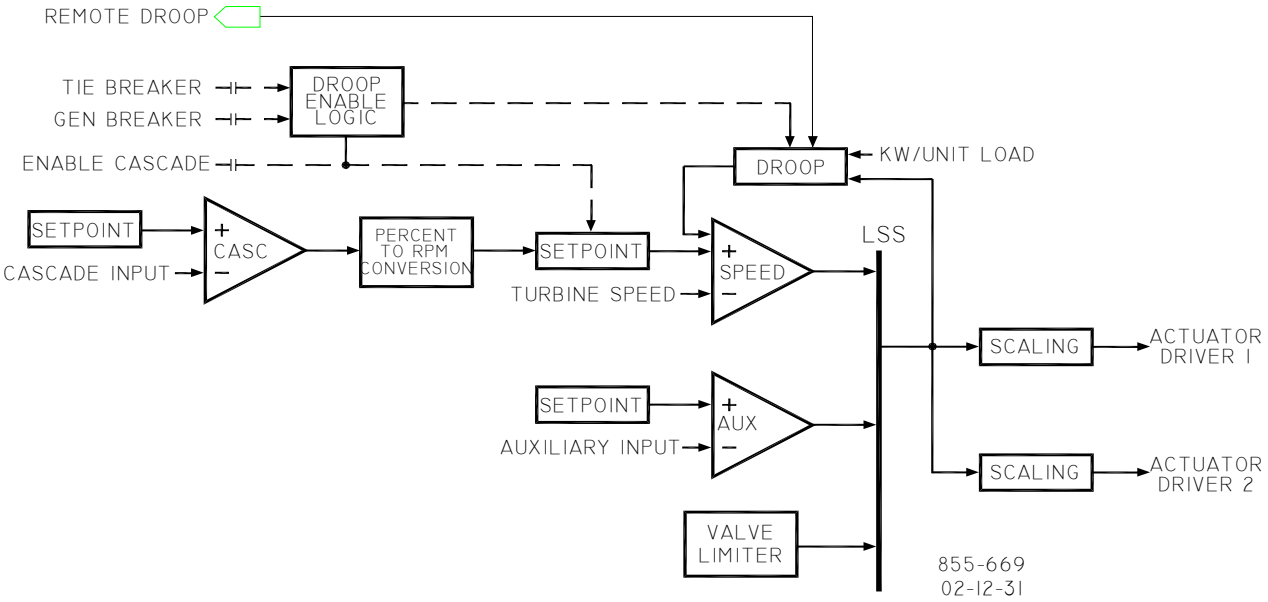

Figure 1-5. Single or Split-Range Turbine Configurations
(Auxiliary PID Configured as a Limiter)

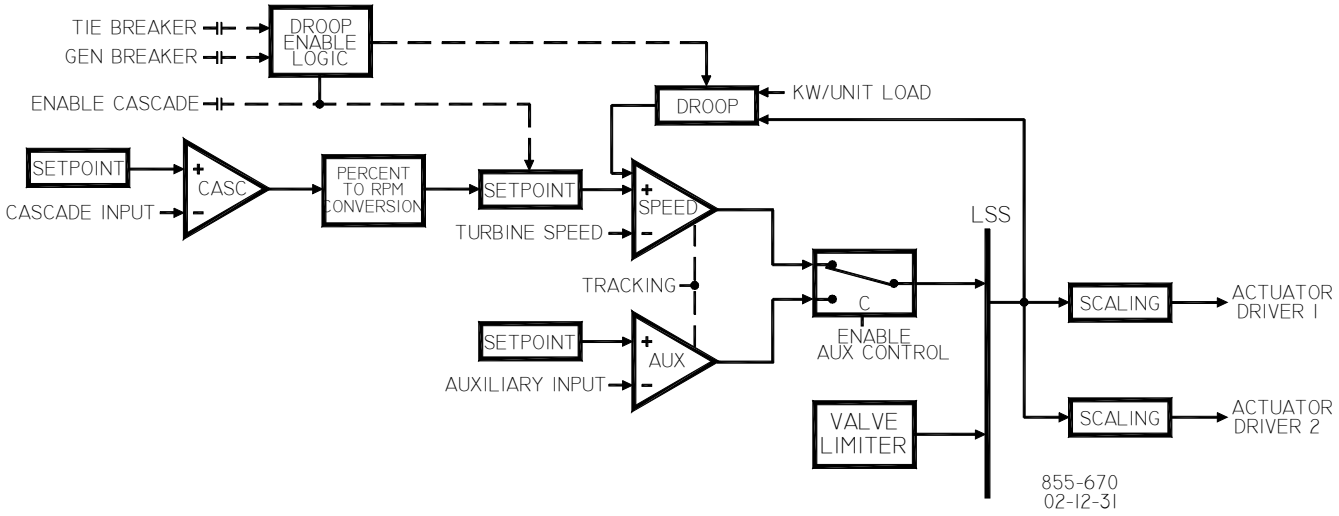

Figure 1-6. Single or Split-Range Turbine Configurations
(Auxiliary PID Configured as a Controller)

505 Inputs and Outputs

Control Inputs

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

Six programmable analog inputs can be configured as one of the following input functions: auxiliary PID input, remote auxiliary set point, cascade PID input, remote cascade set point, kW (load) input, remote speed set point, synchronizing input, load sharing input, both synchronizing and load sharing input, inlet header pressure, I/H converter pressure, compressor feed-forward input, remote droop input. The unit's sixth analog input is fully isolated and should be used when interfacing to self-powered signals that are not isolated.

Sixteen contact inputs are available. Four are dedicated for shutdown, reset, raise speed set point, and lower speed set point. Another two contact inputs must be dedicated for generator breaker and utility tie-breaker if the control is used in a generator application. Another input is dedicated to a discrete health signal between 505 units that are configured for redundant operation. The rest of the additional contact inputs (9-12 dependent on options selected) are available for configuration to function as various controller discrete input functions. See discrete input functional lists within this manual.

Four function keys are located on the front panel of the control with the F1 and F2 keys dedicated to "alarm display" and "overspeed test enable" functions respectively. If the unit is configured for Redundant operation then the F3 key is dedicated to displaying which unit is In-Control (light annunciated) and allows the user to "transfer" control from this 505 to the other 505. The F4 key (and F3 if not configured for redundancy) can be configured to enable or disable various functions of the control.

Control Outputs

Two 4–20 mA or 20–160 mA configurable actuator outputs with linearization curves are available for use. Actuator 1 can be configured to use inlet pressure compensation. Optionally the second actuator output can be used as an extra readout if not used as an actuator output.

Eight Form-C relay contact outputs, with six configurable relays, and two dedicated relay for shutdown and alarm indication are available for use. If the unit is configured for redundant operation, then a third relay is dedicated to the health status interconnection of the two units.

Control Interfaces

Two Modbus ports are available for HMI, plant DCS or redundant (unit-to-unit) control interfaces. The port protocol can be either ASCII or RTU and the communications can be RS-232, RS-422, or RS-485. For redundant operation, port 1 must be configured as a dedicated RS-422 Modbus link between the two units.

A third computer (PC) port is used for unit program down loading and as a debug port.

Redundant Control Applications

Optionally two 505 controllers can be applied together and configured to function in a redundant manner to increase overall system reliability and availability. In such configurations, one 505 functions as the In-Control unit and controls all aspects of the turbine system. The second 505 functions as a Tracking unit and tracks the In-Control 505's operating parameters to ensure a smooth transfer if the In-Control 505 fails. Transfer of control is initiated under the following conditions:

- In-Control 505 failure (CPU or internal problem)
- Loss of power to the In-Control 505
- Loss of all speed probes to the In-Control 505
- In-Control 505 actuator output failure detected
- A manual "Select In-Control Unit" command is given to the Tracking unit

IMPORTANT **Actuator output failures must be configured as shutdowns to ensure proper transfer of control between redundant 505 controllers.**

Although both the In-Control and Tracking units can be setup to monitor the same application parameters and drive into the same actuator coil, optionally the units can be programmed differently and forced to transfer control, allowing on-line system changes to be performed. Unit-to-unit tracking options can be configured as desired to ensure smooth transfers after unit program changes have been verified.

⚠WARNING **Exercise extreme caution when making program/configuration changes in the secondary 505 while operating in redundant operation. The transfer of control to this unit from the In-Control unit may have undesirable results.**

When configured for redundant applications the 505 can be configured to drive single coil actuators, dual coil actuators, or parallel actuators (Woodward redundant CPC skid). See the redundant control configuration section of this manual to understand all redundant application options.

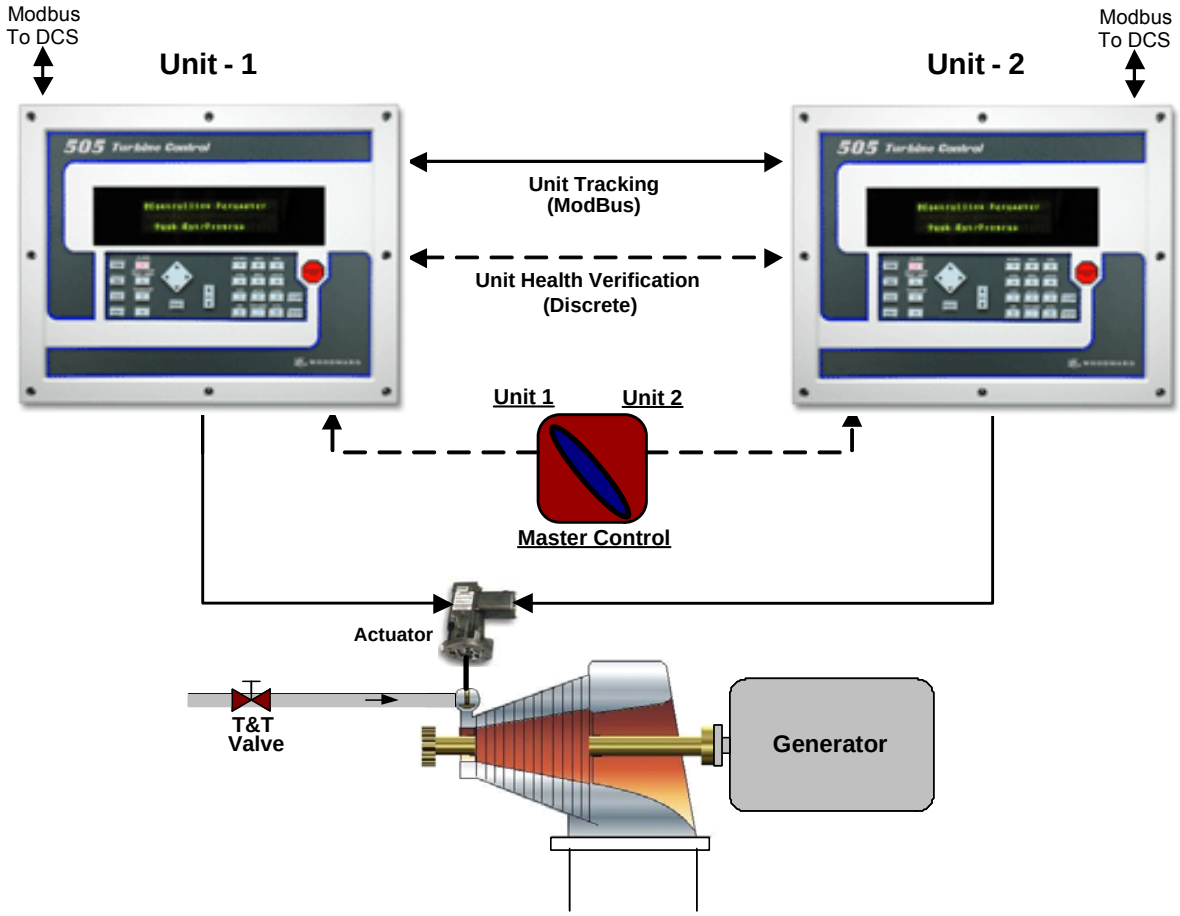

Figure 1-7. Typical Redundant 505 Application Configuration

Keypad and Display

The 505's service panel consists of a 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 troubleshooting parameters in plain English. Also, there are 30 keys available to provide complete control from the front of the 505. No additional control panels are required to operate the turbine, every turbine control function can be performed from the 505's front panel.

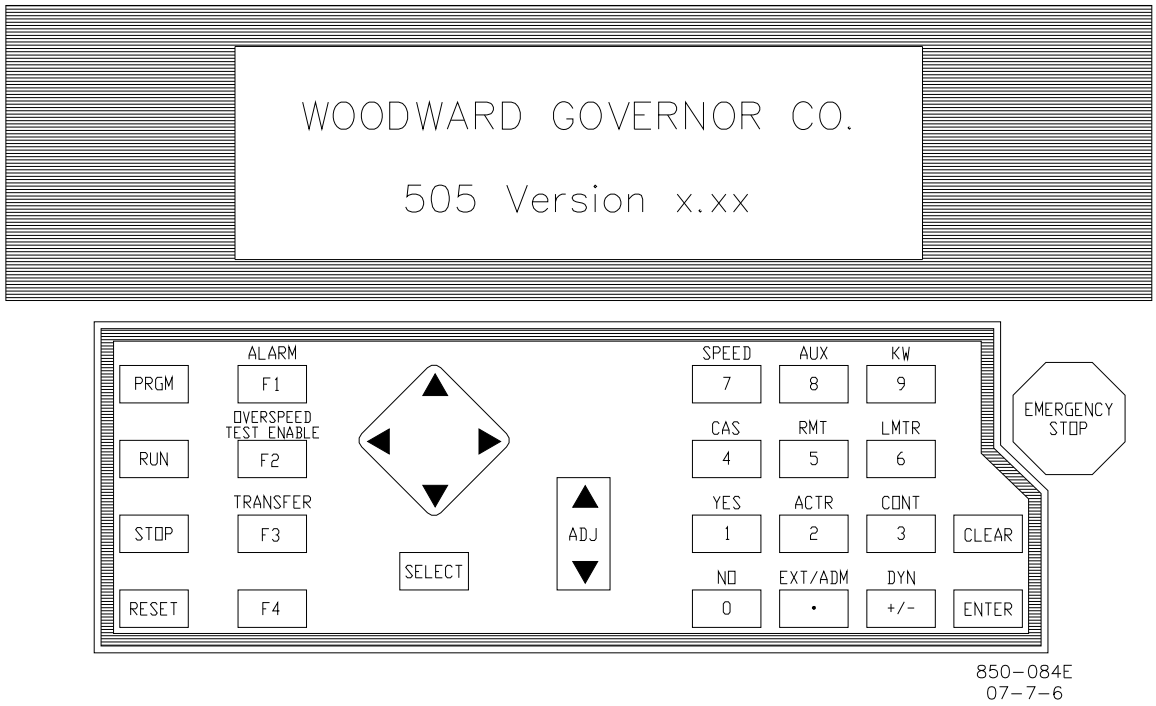

Figure 1-8. 505 Keypad and Display

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 505 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 variable per screen the "select key" and @ sign's position are irrelevant.

ADJ (adjust):
In the Run Mode, "ADJ▲" moves any adjustable parameter up (larger) and "ADJ▼" 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 from the (CONTROLLING PARAMETER/PUSH RUN or PRGM) state.
In redundant operation of two 505s, the system will only respond to this command being entered from the keypad on the In-Control unit.

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').
In redundant operation of two 505s, the system will only respond to this command being entered from the keypad on the In-Control unit.

RESET:
Resets/clears Run Mode alarms and shutdown conditions. 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).Use the Scroll down arrow to display the control's last trip cause, highest speed reached, local/remote status (if used), and select Unit-to-Unit transfer (redundant applications only).

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

5/RMT (remote):
Enters 5 or displays the remote speed set point and feed-forward control information (Run Mode).

6/LMTR (valve limiter):
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, droop, frequency or inlet header pressure information (Run Mode).

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

ENTER:
Enters new values in the Program Mode, and allows the "direct entry" of specific set point 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.

• (DECIMAL KEY)
Enters decimal point in number being entered from front panel.

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 set point to test either the electrical or mechanical overspeed trip.
In redundant operation of two 505s, the system will only respond to this command being entered from the keypad on the In-Control unit.

TRANSFER (F3):
If the 505 is configured for Redundant operation, this key will annunciate (illuminate) which unit is In Control. This key will also act as the command key to TRANSFER control over to the Tracking Unit, unless the user configures a discrete input as the Transfer command. If the 505 is not configured for Redundant operation, then this key is a programmable function key for enabling or disabling other programmable control functions.

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

EMERGENCY SHUTDOWN BUTTON:
This is an Emergency Shutdown command for the control. (Large red octagonal button on the front of the enclosure)
In redundant operation of two 505s, the system will only respond to this command being entered from the keypad on the In-Control unit.

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 505 into a system. Hardware dimensions, ratings, and jumper configurations are given to allow a customer to mount, wire, and configure the 505 package to a specific application.

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

Mechanical Data and Hardware Installation

The 505'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.

If so labeled on the enclosure, the 505 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.

The 505s are suitable for use in European Zone 2, Group II environments per compliance with EN60079-15, Electrical apparatus for explosive atmospheres – Type of protection 'n'

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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.

The Marine Type approved version is installed with the Woodward-supplied NEMA enclosure with a power line filter. Power wires to the line filter must be segregated from the wires from the line filter to the 505. In addition, the field wiring must be installed with an additional shield layer which is grounded to the enclosure. The additional shielding is beyond the standard shielding described elsewhere in the manual, and it may be made from solid or flexible metal conduit, armored cabling, or a cable with an overall shield.

Enclosures

Figure 2-1 shows the 505 controller layout and mounting pattern. The 505 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 505 package, once properly installed within a NEMA 4X panel or cabinet meets NEMA 4X ratings. A gasket is attached to the rear side of the package's bezel to properly seal the 505's face-plate to a panel. All field wiring connects to the 505 through removable terminal blocks located on the 505's back side.

An optional NEMA-4X enclosure is available to allow the 505 to be bulkhead mounted (Figure 2-2). The 505 digital control mounts on the front door of the 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") 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 505 package must be mounted to allow sufficient room for wiring access. Eight front panel screws permit secure mounting. The standard 505 weighs approximately 4 kg (9 lb), and has an operating range of –25 to +65 °C 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 ambient air temperature.

505 Hardware Jumpers

To allow the 505 the flexibility of interfacing with different types of speed probes, transducers, and communication cables, user changeable jumpers are used. These jumpers are accessed by removing the 505's back cover and are located on the exposed I/O module. Refer to Table 2-1 for jumper options and Figure 2-4 for jumper locations. Each set of jumpers is 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.

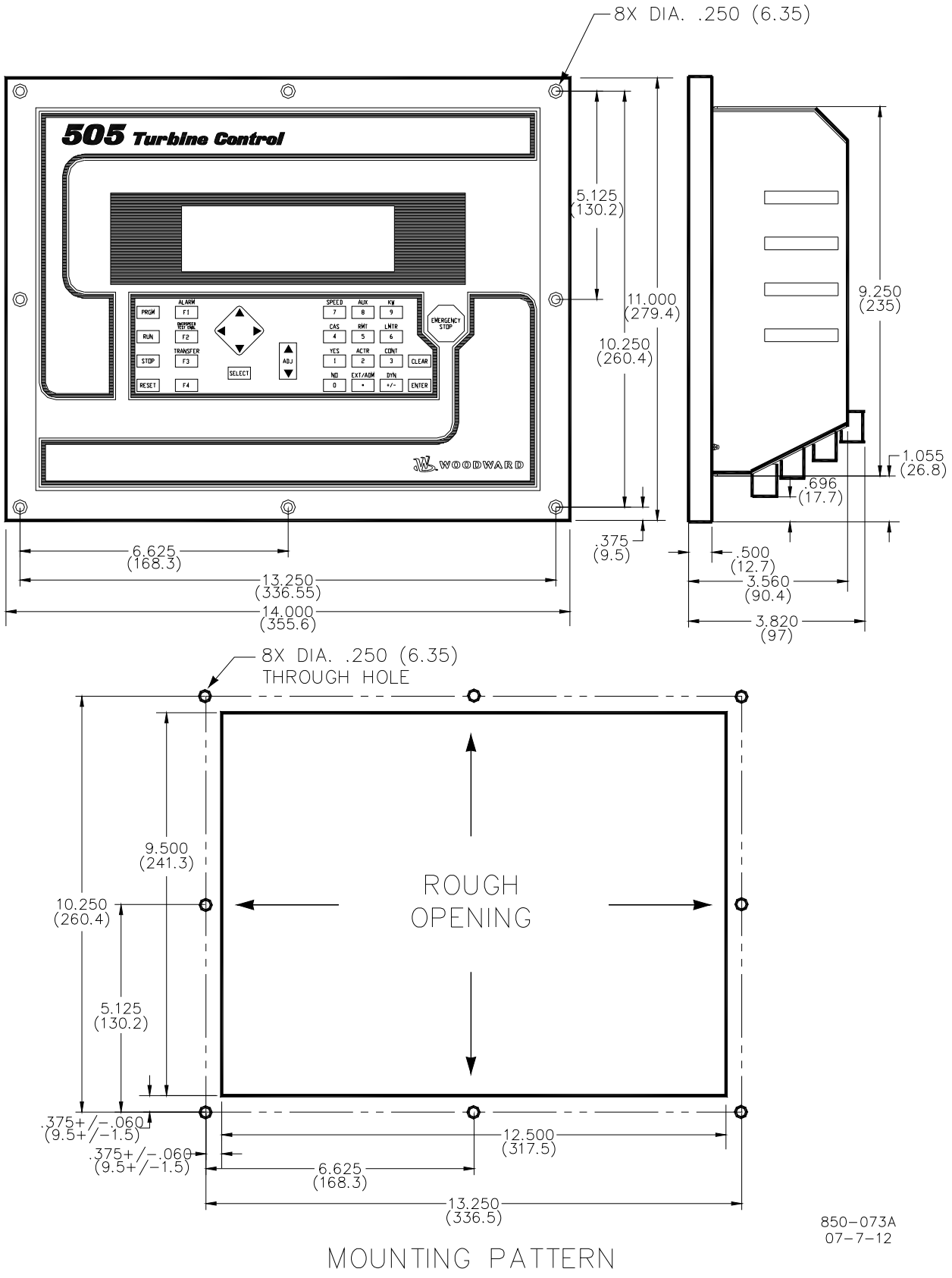
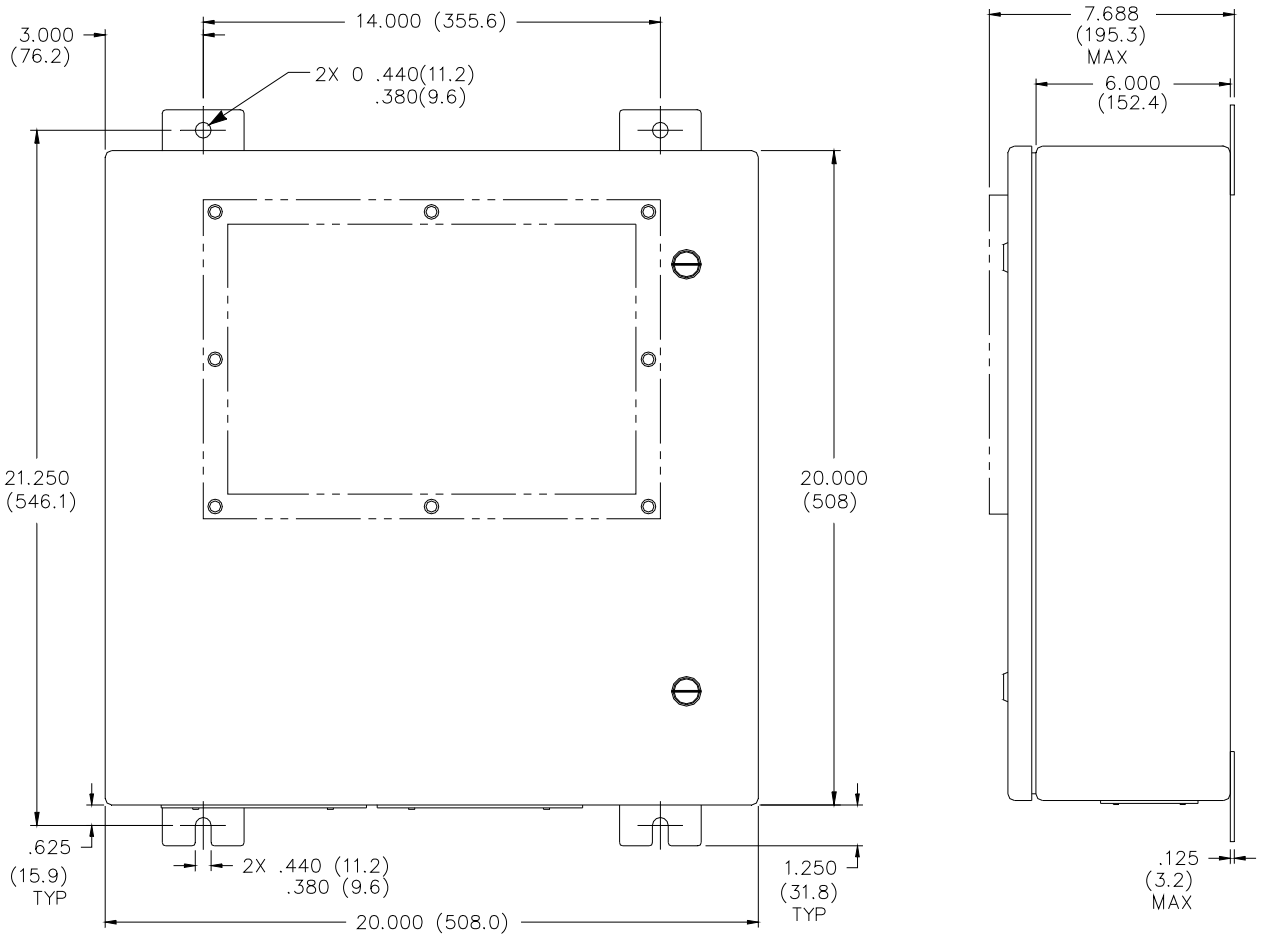
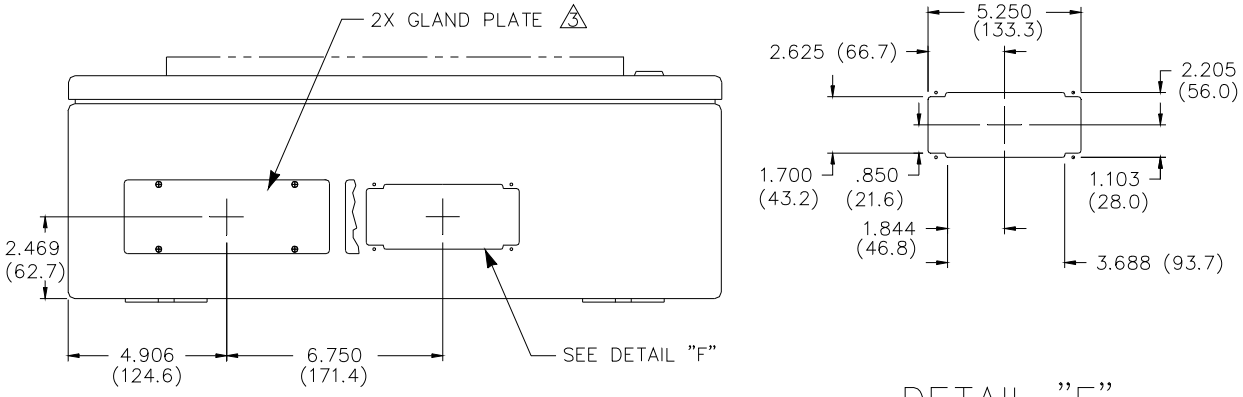


Figure 2-1. 505 Control Layout (Standard Enclosure)





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. 505 Bulkhead-Mounted Enclosure

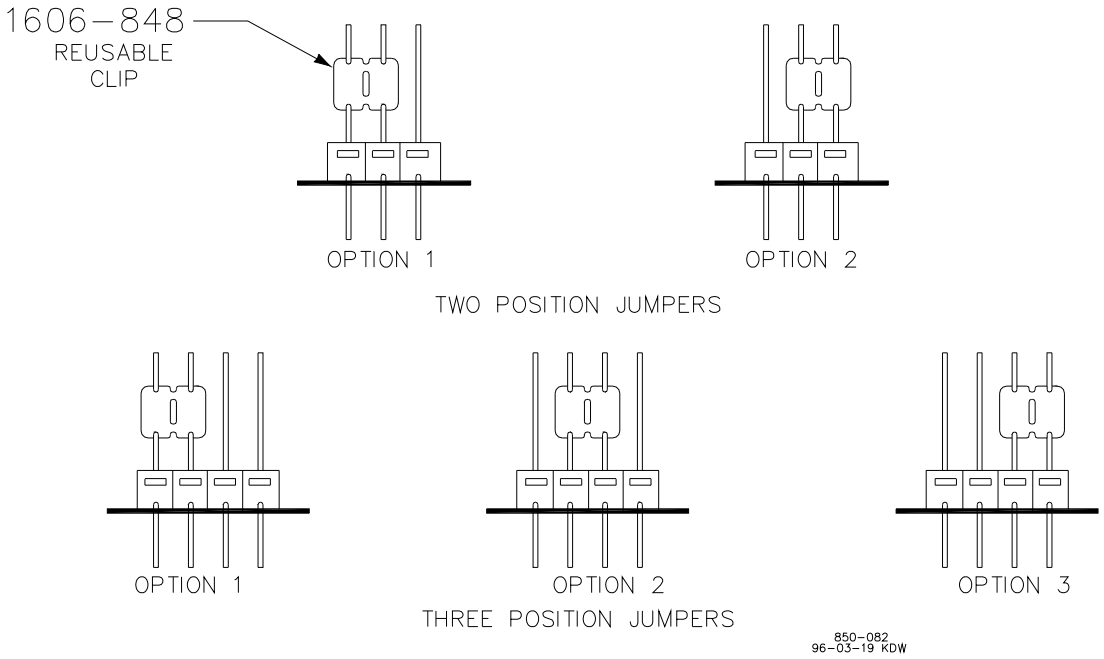


Figure 2-3. Jumper Options

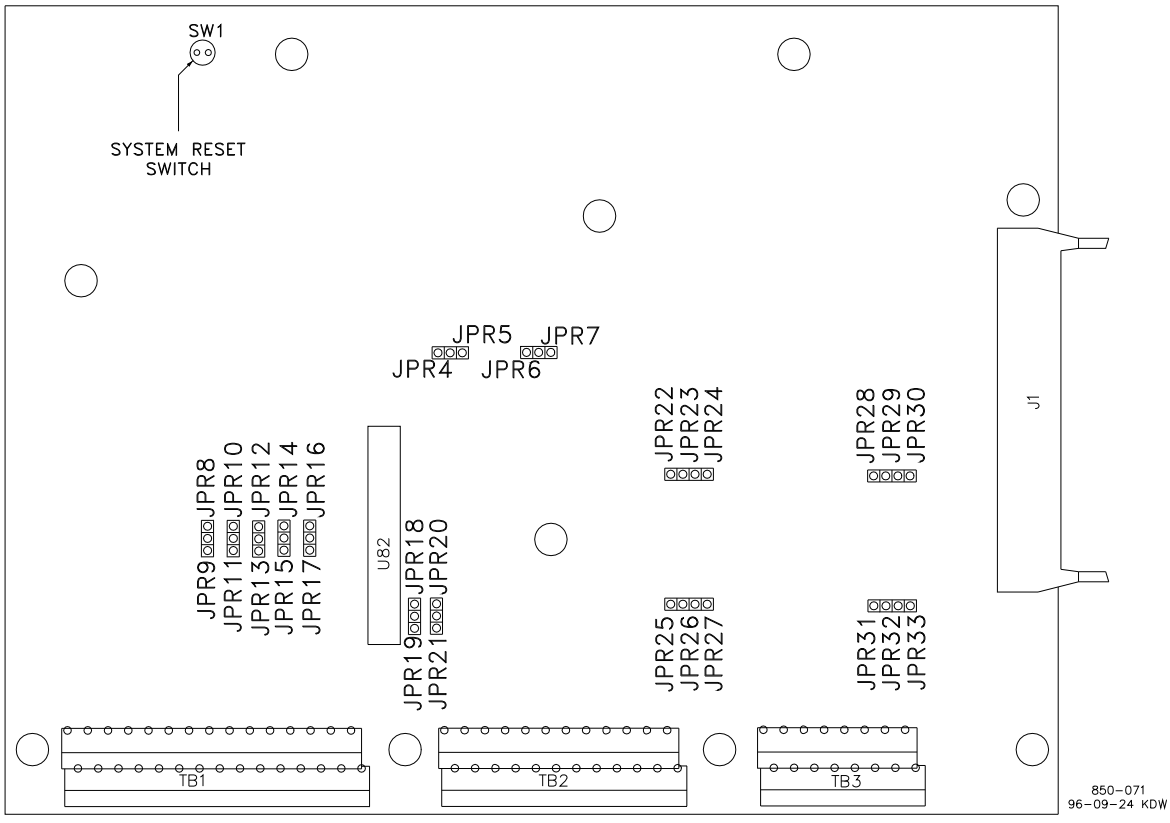


Figure 2-4. Jumper Locations

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
ANALOG INPUT #1-LOOP POWERED-(2—WIRE)	JPR10
ANALOG INPUT #1-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 RS-485/RS-422 RECEIVE TERMINATION	JPR22, JPR25
COMM PORT #1 RS-422 TRANSMIT TERMINATION	JPR24, JPR27
COMM PORT #2 NO TERMINATIONS	JPR29, JPR32 *
COMM PORT #2 RS-485/RS-422 RECEIVE TERMINATION	JPR28, JPR31
COMM PORT #2 RS-422 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.

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 chapter.

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

All inputs and outputs to the 505 are made through “CageClamp” terminal blocks on the bottom of the 505 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 Cage-Clamp style blocks. The Cage-Clamp’s internal spring can be actuated by using a standard 3 mm (1/8”) flat blade screwdriver, or a snap-on thumb lever (Figure 2-5). Two snap-on thumb levers are provided with the 505 unit. The 505 terminal blocks accept wires from 0.08–2.5 mm² (27–12 AWG) wire. Two 0.8 mm² (18 AWG) or three 0.5 mm² (20 AWG) wires can be easily installed in each terminal.

The 505 control's terminal blocks are designed to be removed by hand. After 505 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.

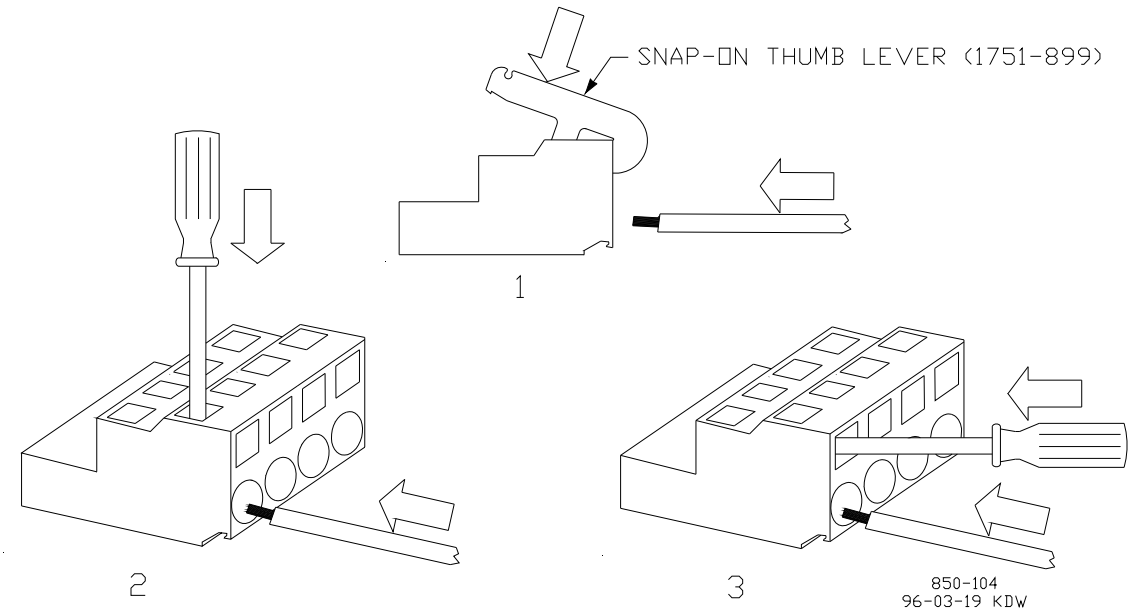


Figure 2-5. CageClamp Terminal Blocks

Power Supplies

The 505 control is available with three different input power source selections. The part number of the 505 depends on the rating of the input power source it can accept. The input power source rating on each unit can be identified by the back-panel sticker or the 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 505'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 505's input circuitry. All fuses are rated as slow-blow type fuses. These fuses are accessed by taking the 505'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 505 and the 505's internal fuse sizes are listed as follows:

18–32 Vdc	(6.25 A internal fuse, 77 VA maximum draw)
88–132 Vac @ 47–63 Hz or 90–150 Vdc	(2.5 A internal fuse, 143 VA maximum draw)
180–264 Vac @ 47–63 Hz	(1.5 A internal fuse, 180 VA maximum draw)

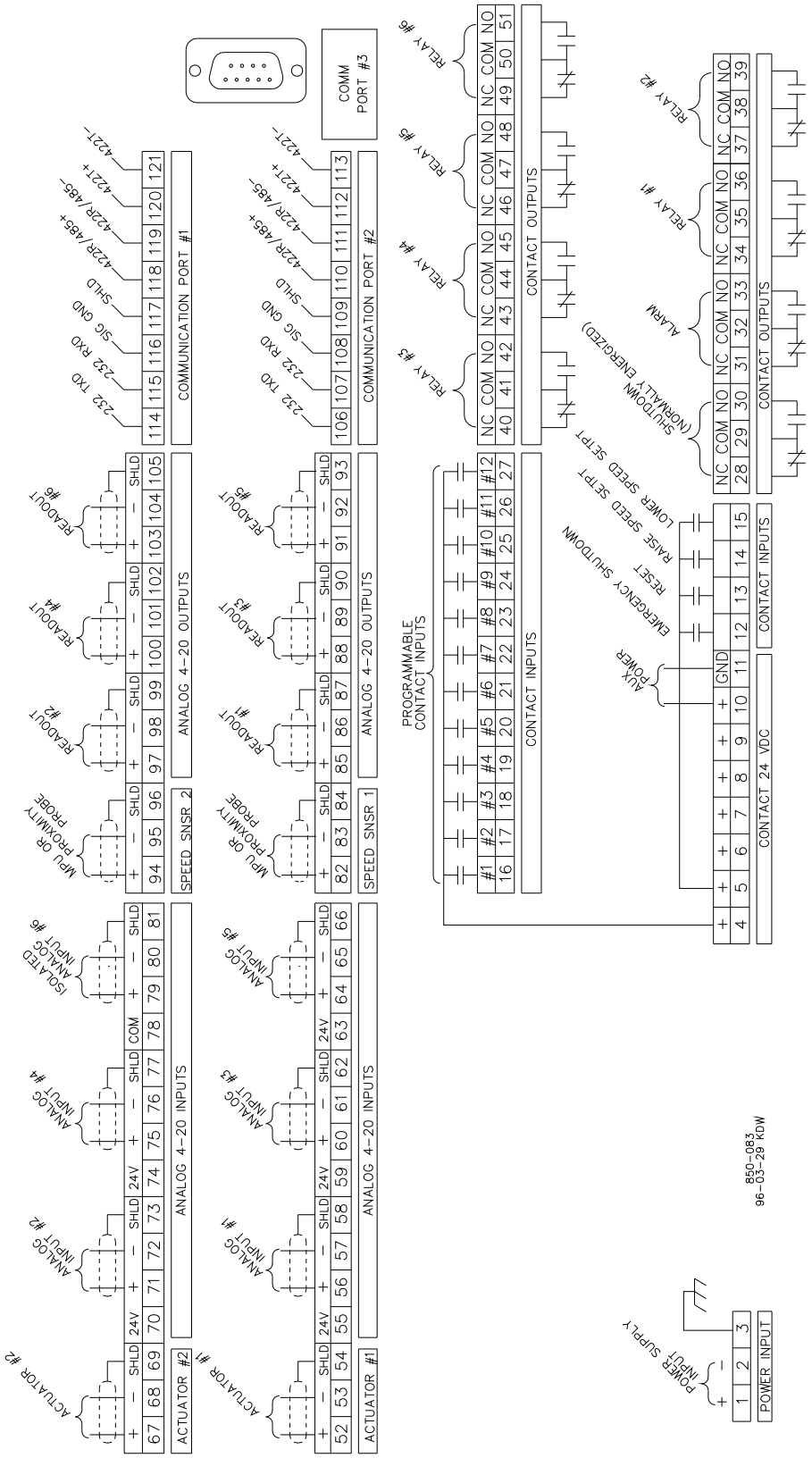


Figure 2-6. Control Wiring Diagram

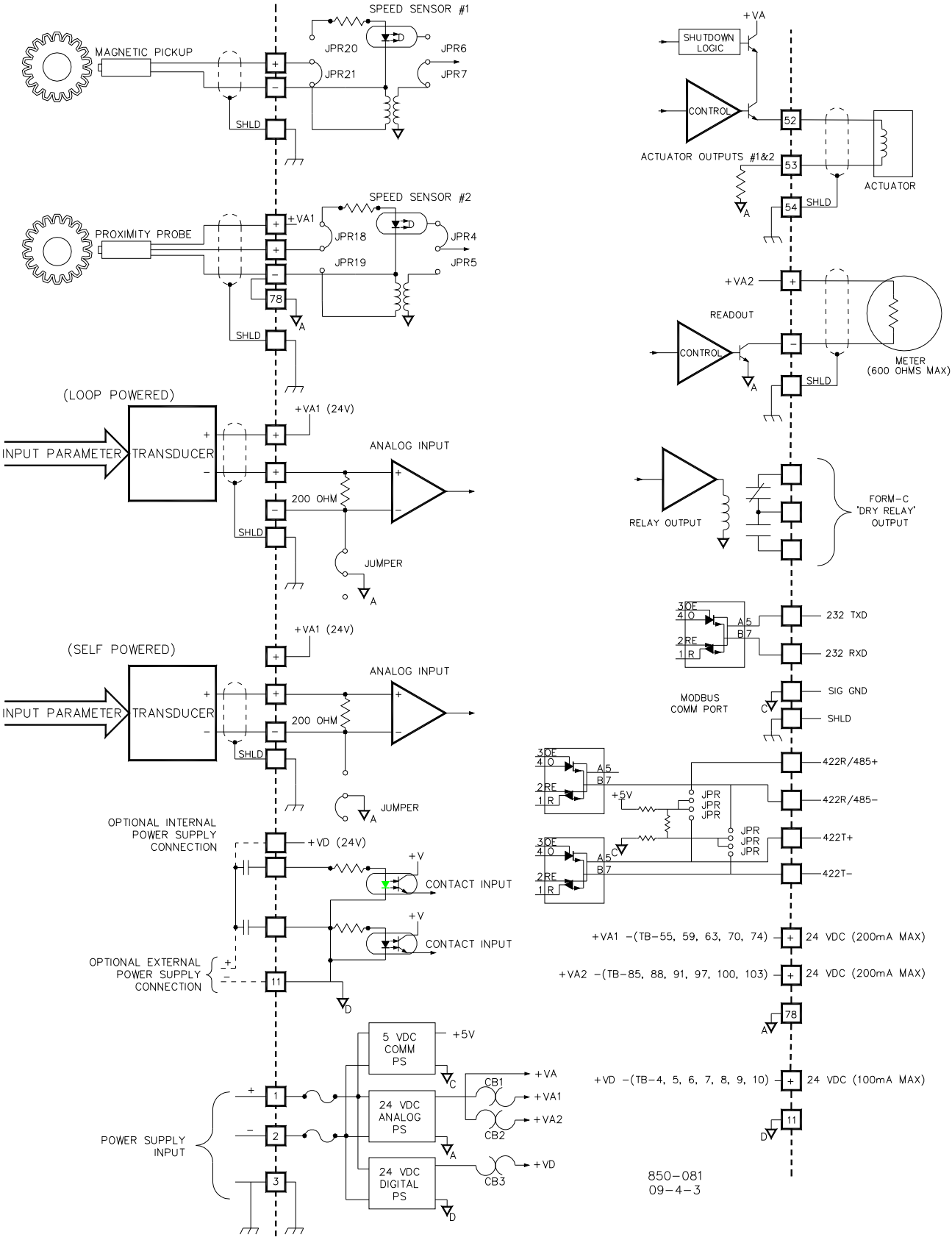


Figure 2-7. Representative 505 I/O Schematic

Each 505 requires a power source capable of a certain output voltage and current. In most cases this power rating is stated in Volt-Amps (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 505's VA requirement.

The 505's power supply holdup times are determined by the 505 power supply and input power used. The below times are based on worse case conditions (88 Vac with a possible range of 88–132 Vac when power is lost). These holdup times should be used when the 505 is powered by an Uninterruptible Power Source (UPS) to evaluate if the UPS's switchover time is quick enough avoid a system trip. A UPS's switchover 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

A 24 V power supply is available, within the 505, 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 505 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 505'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 505 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 505'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.

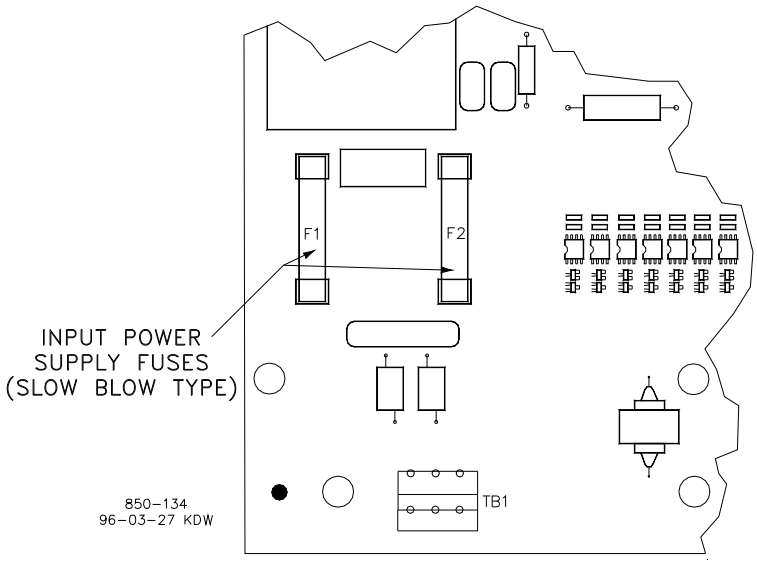


Figure 2-8. Fuse location

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.

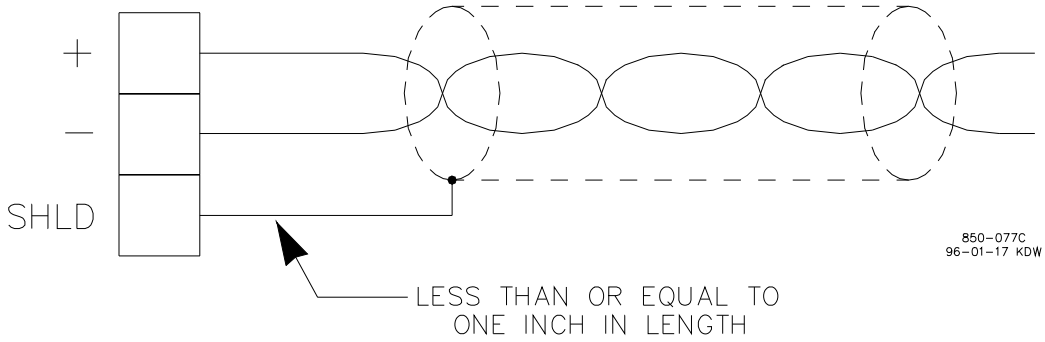


Figure 2-9. Shielded Wire Connections

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 start-up 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 505 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 0.25 to 1.02 mm (0.010 to 0.040") 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. By being able to sense turbine speed down to this level, the 505 can be programmed to turn on or off a turbine turning gear, via a relay output. 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 (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 505 can be programmed to sense only one speed input signal. However, it is recommended that the 505 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 505 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 505 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 V to recognize a closure command. See Figures 2-6 and 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 505's internal power output breaker (CB5) 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.

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

- External Emergency Shutdown
- External Reset
- Raise Speed Set Point
- Lower Speed Set Point

Before starting, the External Emergency Shutdown contact must have an external switch 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 set point 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 fifty-three programmable functions. If the 505 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.

If the unit is configured for redundant operation (two 505's), then discrete (contact) input #1 is dedicated as the health status from the other unit.

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 start-up 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.

All six analog inputs are programmable, and 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 a 505 current output 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. Optionally, if Actuator Driver #2 is not being utilized to drive an actuator, it can be programmed to function as a 4–20 mA driver to display one of the values listed below. The 505’s analog output connections are displayed in Figure 2-7. All 505 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

Two actuator outputs are available and programmable to interface with Woodward Governor Company actuators (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). Each actuator output can be optionally configured to use a variable dither signal to reduce actuator sticking conditions.

Each actuator driver senses the drive current to allow over- and under-current shutdowns. The 505 can be configured to use one or two actuators. If only one actuator is used and programmed, it must be wired to actuator #1's output terminals. If two actuators are used they can be programmed to operate in a staggered or parallel mode. If the "Actuator #2 Offset" percentage is set to 50% then actuator #2 will begin opening when actuator #1 reaches 50%. The control will continue to open both valves to 100% with a position difference of 50%. To operate two actuators in parallel, set "Actuator #2's Offset" adjustment to zero. This will force both actuators to operate at the same level or in parallel.

Optionally, the actuator #1 driver can compensate for variations in the inlet pressure. If configured, the pressure compensation schedule and action on failure of the pressure transmitter can be entered through Service Mode (see Service Mode adjustments in volume 2).

The inlet pressure compensation feature is used to adjust the control response based on variations in the inlet header pressure. Inlet pressure compensation is enabled in Configure Mode. To use this feature, an analog input must be configured as inlet header pressure. The compensation factor is determined by a user-defined curve. The X values of the curve points are inlet pressures in engineering units. The Y values of the curve points are compensation factors. By default, all Y values are set to 1.0. When the inlet pressure drives the compensation factor to a value greater than 1.0, the control response is faster. When the inlet pressure drives the compensation factor to a value less than 1.0, the control response is slower and the maximum valve position is reduced. Once the PID gains have been tuned at the rated inlet pressure, the inlet pressure compensation curve points can be set for other inlet pressures.

IMPORTANT

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

Optionally, if actuator #2 driver is not used as an actuator output driver it can be used as a 4–20 mA current output to drive a meter or DCS input. Refer to Chapter 4 of this manual for a complete list of programmable analog output options.

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 505. 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 505'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:

- Alarm relay—energizes for any alarm condition
- Shutdown relay—de-energizes for any shutdown 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.

If the unit is configured for redundant operation (two 505's), discrete output relay #1 is dedicated as the health status to the other unit.

Serial Communications

There are three serial communications ports on the 505. 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 505'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.

If the unit is configured for redundant operation (two 505's), communications port 1 is dedicated as the Modbus communication interconnection to the other unit. It must be set up for RS-422, 38400, N, 8, 1, and one unit must be configured as the Master and the second unit configured as the Slave.

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

NOTICE

Jumper settings must be set correctly whenever the 505 uses RS-422 or RS-485 communications.

IMPORTANT

Communications may still function properly as long as the total length of the communications cable is less than 1000 feet (305 meters).

Modbus Wiring

The 505 control can communicate to two devices via RS-232, RS-422, RS-485 using an ASCII or RTU Modbus transmission protocol. The 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 505 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..

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 505 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 505 control has termination resistors built-in. See the jumper option chart (Table 2-1) to connect the termination resistor.

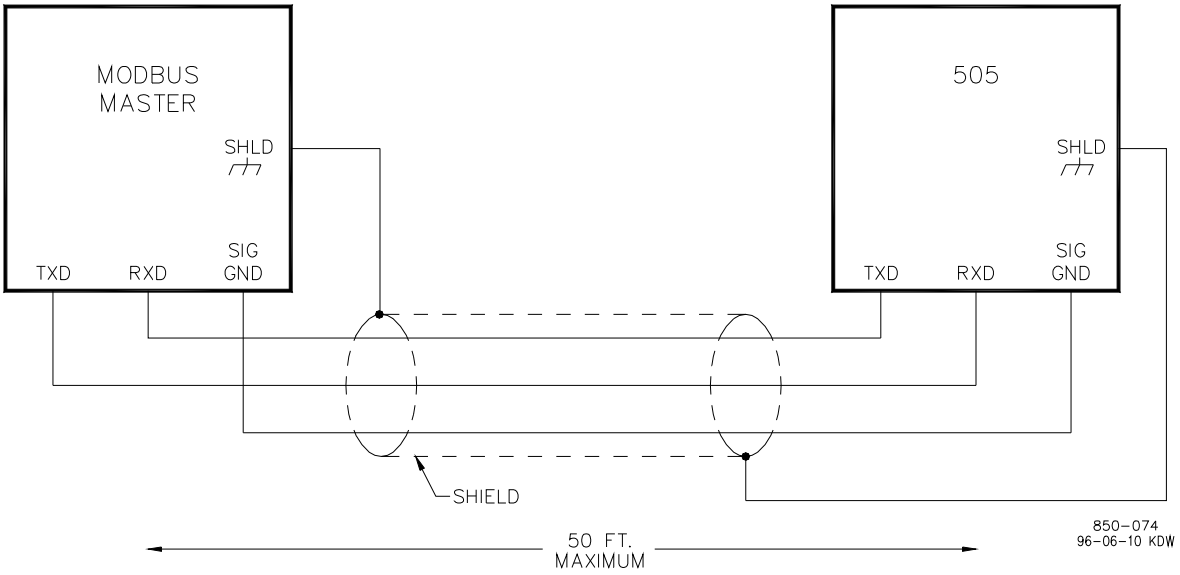


Figure 2-10. Typical RS-232 Communications

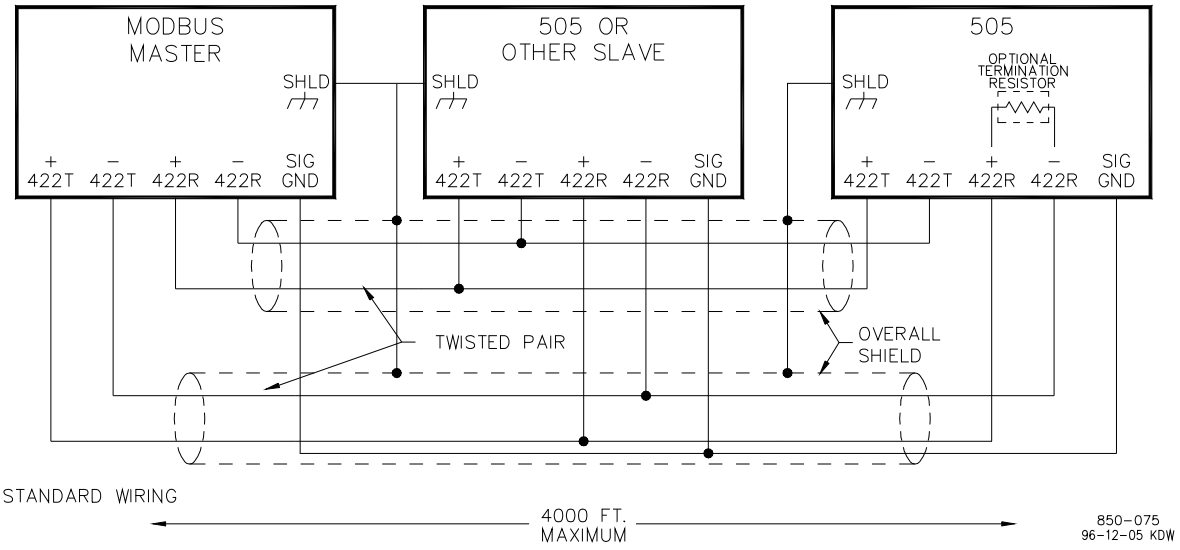


Figure 2-11. Typical RS-422 Communications

RS-485 Wiring

RS-485 communications can also accommodate transmission distances of up to a distance of 4000 feet. The 505 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 505 control has termination resistors built-in. See the jumper option chart (Table 2-1) to connect the termination resistor.

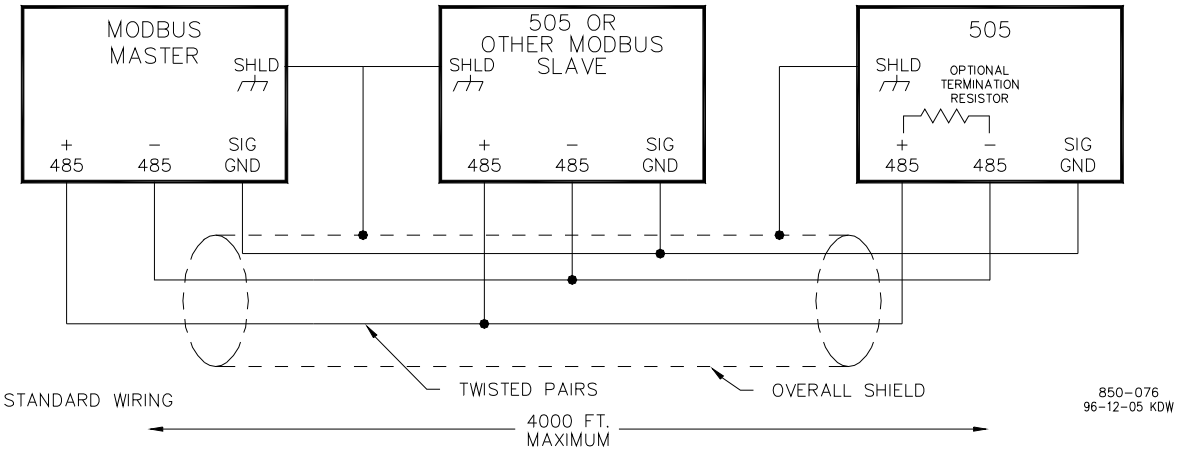


Figure 2-12. Typical RS-485 Communications

Communications Grounding and Shielding

All three 505 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 2-13.

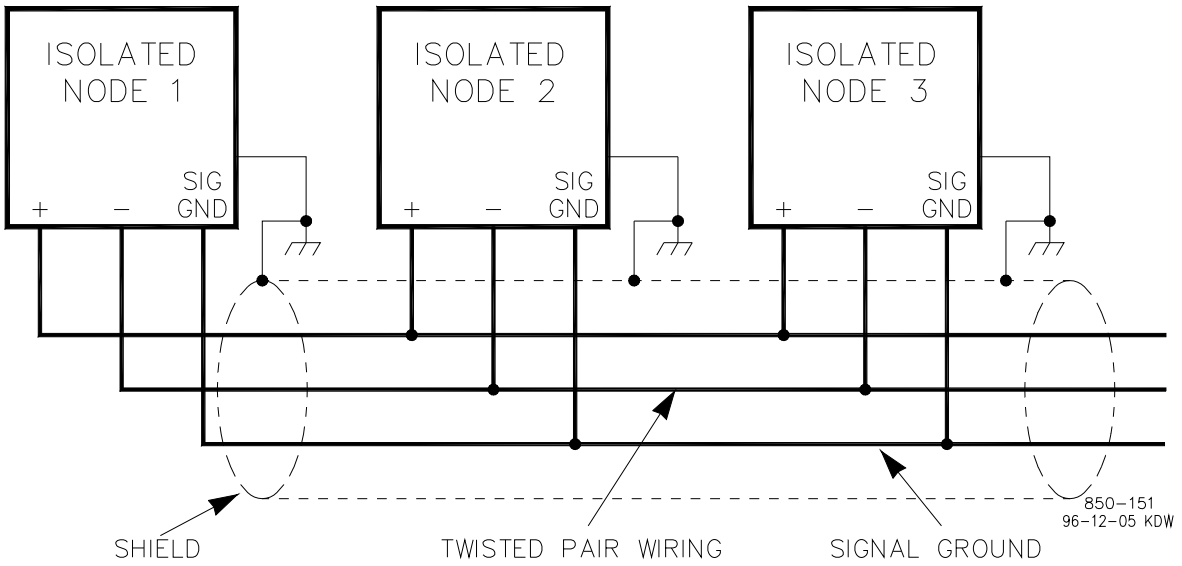


Figure 2-13. Preferred Multipoint Wiring with a Separate Signal Ground Wire

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 2-14. 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.

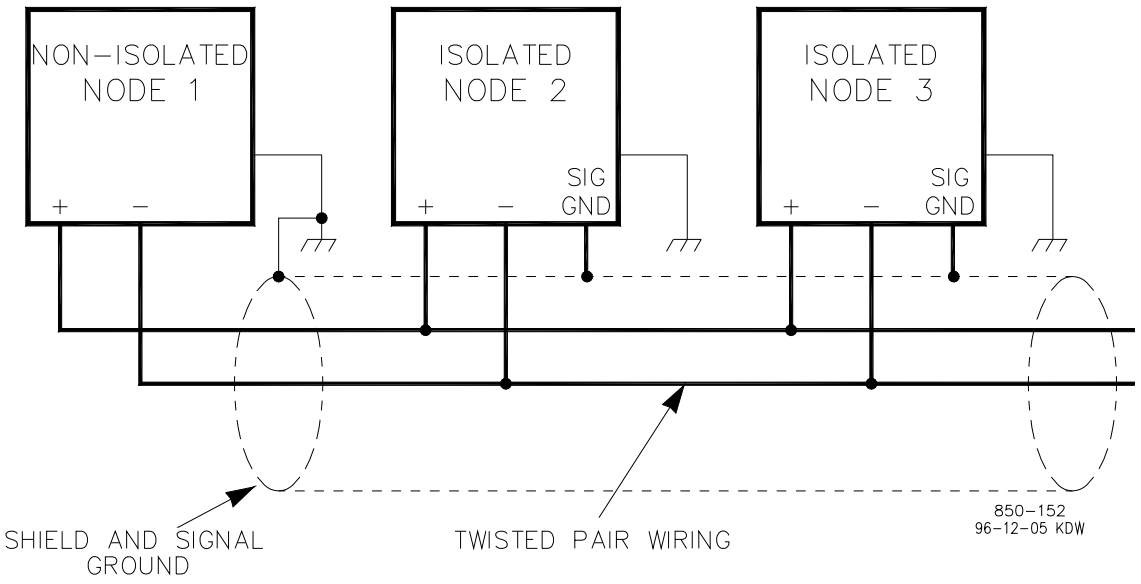


Figure 2-14. Alternate Multipoint Wiring without a Separate Signal Ground Wire

Redundant Application Installations

When configured for redundant applications, the 505 controller is designed to operate correctly utilizing with the below displayed diagrams. To ensure proper unit-to-unit communication and tracking operation, the following unit-to-unit signals must be connected:

- Unit 1 Modbus Port 1 connected to Unit 2 Modbus Port 1 via RS-422 communications
- Unit 1 505 “Unit OK” relay output (# 1) connected to Unit 2 505 “Other Unit OK” contact input (# 1)
- Unit 2 505 “Unit OK” relay output (# 1) connected to Unit 1 505 “Other Unit OK” contact input (# 1)

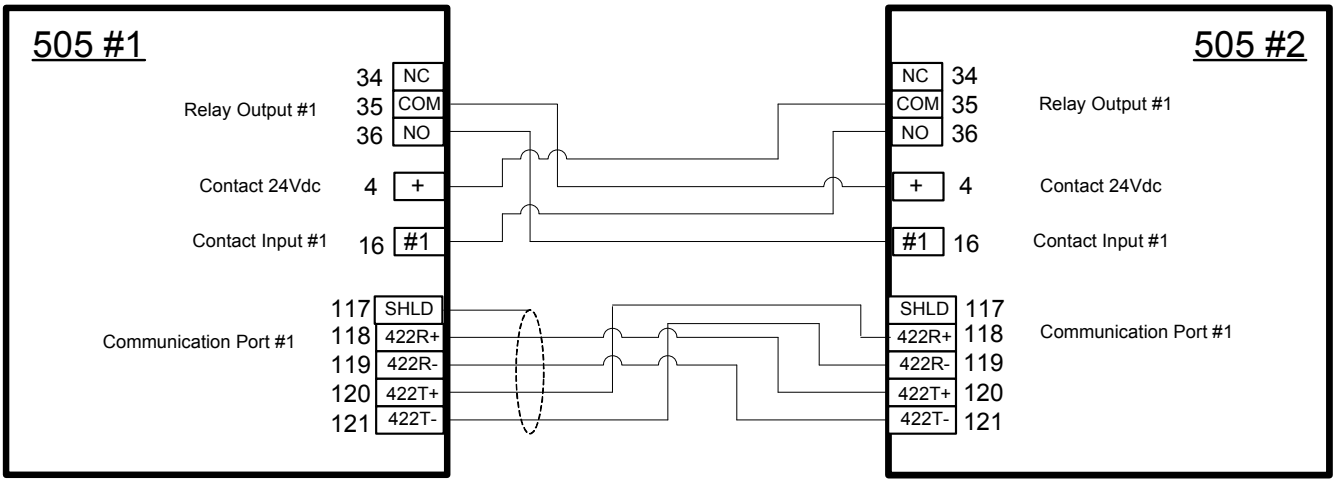


Figure 2-15a. Redundant Interface Connections

Site installations should consider what level of control system redundancy is desired, in addition to the use of redundant 505 controllers. In some cases, all I/O signals will be brought into both 505s; in other cases, one 505 may be a backup unit that is designed to keep the turbine running (in speed control) upon the failure or fault detection of the primary unit. Most installations will utilize a combination of these configurations.

For example: A unit using Aux or Cascade control may simplify wiring by only wiring these signals to the primary unit, realizing that if conditions exist that force the control to switch to the secondary unit, that these control loops will not be available.

The following is a step-by-step procedure that covers the redundant portion of the installation and configuration:

1. Connect Unit 1 Modbus Port 1 to Unit 2 Modbus Port 2 using RS-422 (see the 'Redundant Interface Connections' figure above).
2. Connect Unit 1 Relay Output #1 to Unit 2 Contact Input #1 (see the 'Redundant Interface Connections' figure above).
3. Connect Unit 2 Relay Output #1 to Unit 1 Contact Input #1 (see the 'Redundant Interface Connections' figure above).
4. In the Program Mode under "Operating Parameters"
   a. Set "Redundant 505 to 'YES'.
   b. Set "Master 505" to 'YES' in one 505 and 'NO' in the other 505.
   c. It is recommended to set "Track Cascade Status", "Track Auxiliary Status", and "Track Remote Status" to 'YES'.
5. Under "Contact Inputs", set "Redundant 505" to 'YES'.
6. Under "Relays", set "Redundant 505" to 'YES'.
7. Under "Function Keys", set "Redundant 505" to 'YES'.
8. Under "Communications"
   a. Set "Use Communications" to 'YES'.
   b. Set "Use Modbus Port 1" to 'YES'.
   c. Set "Mode" to '2'.
   d. Set "Modbus Device #" to '1'.
   e. Set "Port # 1 Driver" to '2'.
   f. Set "Port # 1 Baud Rate" to '10'.
   g. Set "Port # 1 Stop Bits" to '1'.
   h. Set "Port # 1 Parity" to '1'.
9. See the following sections for redundant I/O wiring options.

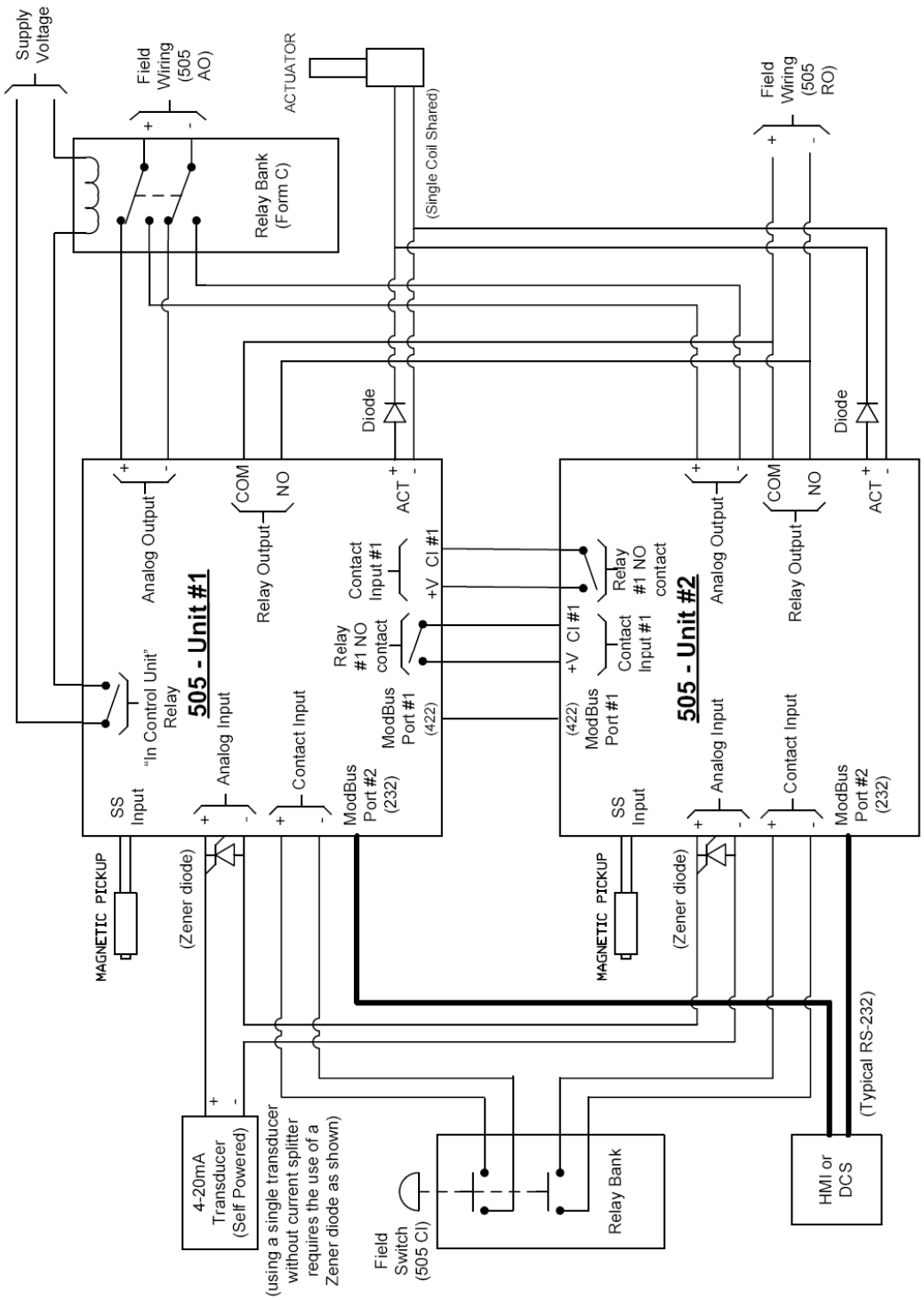


Figure 2-15b. Typical Redundant Diagram

Speed Inputs

It is recommended that separate speed sensors be utilized for each 505 controller to increase system availability and simplify unit replacement. As is displayed in the installation section of this manual, alternatively, both units can be configured to share one or both MPUs.

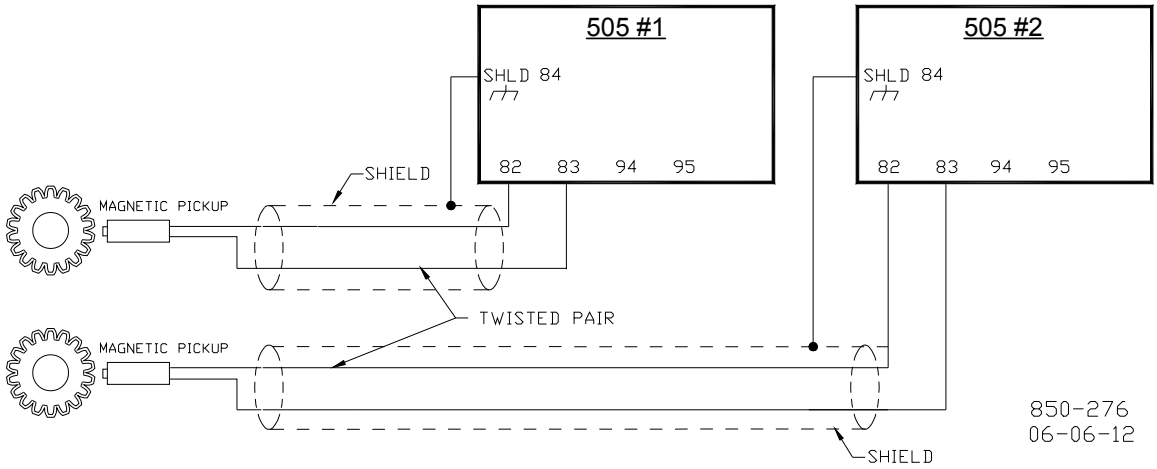


Figure 2-15c. Optional Speed MPU Input Diagram – Different Probes

The above installation depicts individual MPU for each 505 in redundant configuration. The second input on both the 505 can be driven in the same manner utilizing separate MPU or a common MPU as desired.

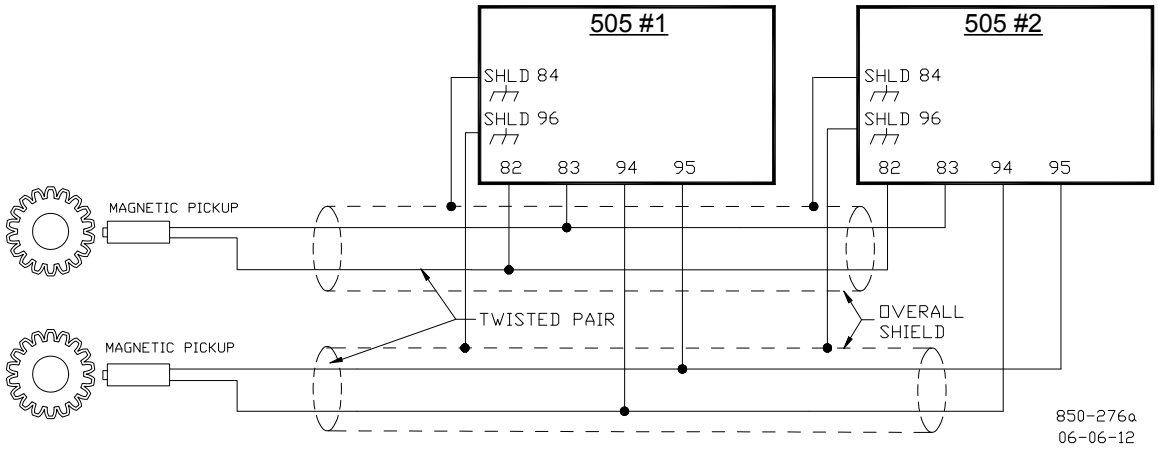


Figure 2-15d. Recommended Speed MPU Input Diagram – Common Probes

One MPU can be utilized to drive one speed sensor input channel on both the 505s as shown in the figure. The identical scheme can be implemented to drive other speed input on both the 505s using another MPU. MPU chosen for common use must have enough burden to drive both the 505s which otherwise may result in improper sensing of speed. Shielding should be connected to both the 505s.

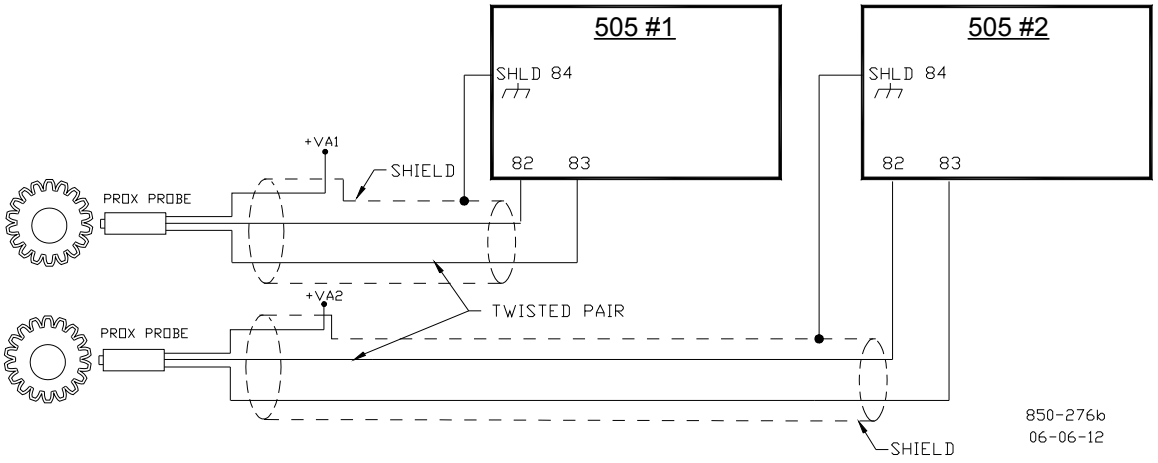


Figure 2-15e. Recommended Proximity Probe Input Diagram – Different Probes

The installation recommends the wiring scheme if Proximity probes are used as speed sensors. Active power should be taken from the respective 505 to drive the probes in order to avoid any grounding problem.

Contact Inputs

It is recommended that any contact input circuit of the same function be driven from the same device (pushbutton, relay, etc.) but utilize isolated circuits.

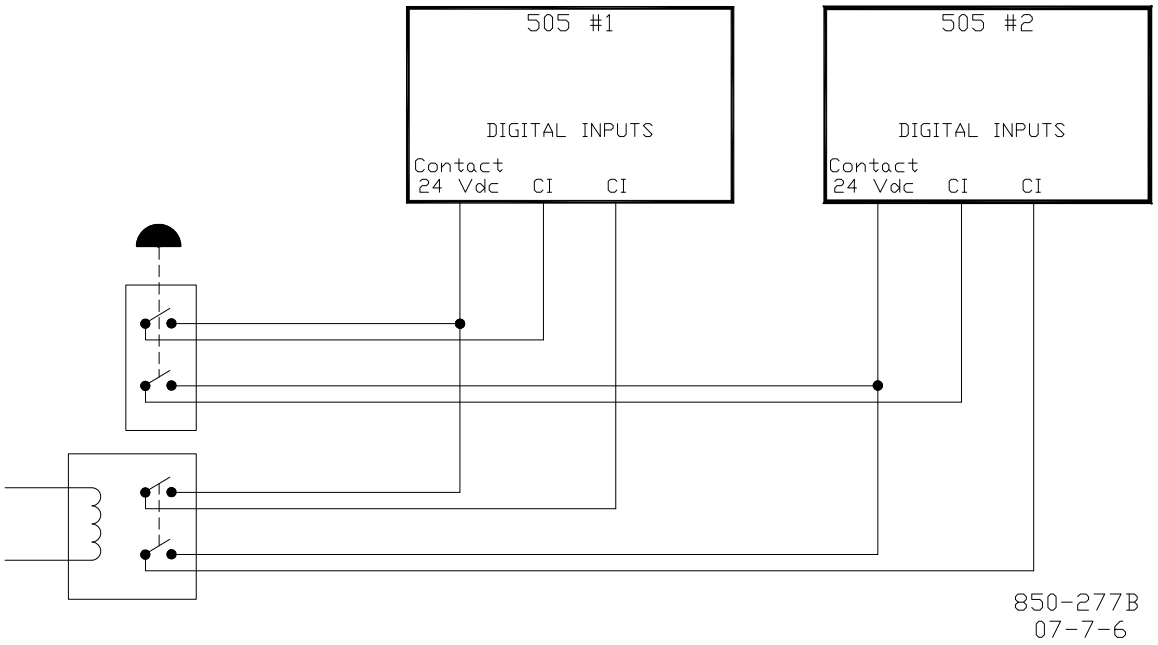


Figure 2-15f. Recommended Contact Input Diagram – Using Multiplier

The above diagram recommends wiring scheme if a multiplier is used to have the same discrete input in both the 505s. Multipliers should be powered using an external source.

A common DPDT switch can be used to get the same discrete input in both the 505s (In-control and Tracking) provided it must have isolated circuits. Each discrete input (“Other Unit OK”) provides a hardwire link to ensure the healthiness of the other unit. If any of the devices go out of order, relay #1 (“Unit OK”) changes state so that each unit knows the state of the other 505.

WARNING

Any external trip input that is intended to trip the entire system must be wired to both 505’s. For example, the main trip loop should be wired to the “Shutdown” or Trip Contact Input on both Unit 1 and Unit 2.

If the external trip contact inputs are programmed individually rather than joining them in series, it will require each of the external trip inputs to be connected individually to each 505 using multiplier circuits. Both 505s can be programmed to accept up to 10 external trip contacts ranging from External trip 2 to External trip 10. When received by the In-Control unit, the first 8 of these will trip the turbine. The last two External trips (9 and 10) are unique in that they will issue a Shutdown to this 505 and force a Transfer to the Tracking 505. These inputs are designed as Emergency Transfer commands from the user or from an ancillary device such as a redundant CPC skid.

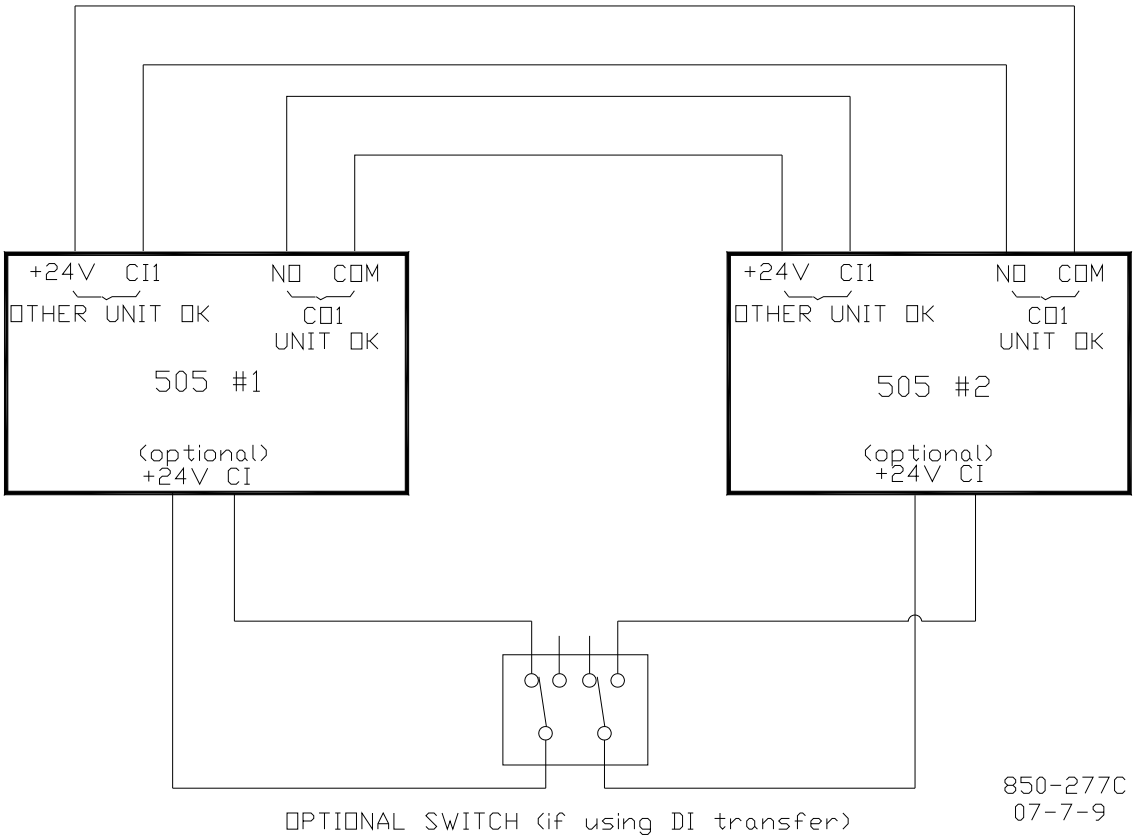


Figure 2-15g. Redundant Contact Input Diagram – DPDT Switches

Analog Inputs

We recommend that separate input transducers be utilized for each 505 controller to increase system availability and simplify unit replacement. If multiple transducers are not available, a transducer splitter should be installed to allow both units to be configured to share one or all input transducers. Signals that are intended to be configured to trip the turbine upon loss of signal require special attention to wiring details to ensure that nuisance trips do not occur and that on-line replacement of a 505 unit (if desired) can be accomplished (no opening of the current loops).

The following diagrams display the recommended redundant analog input wiring configurations:

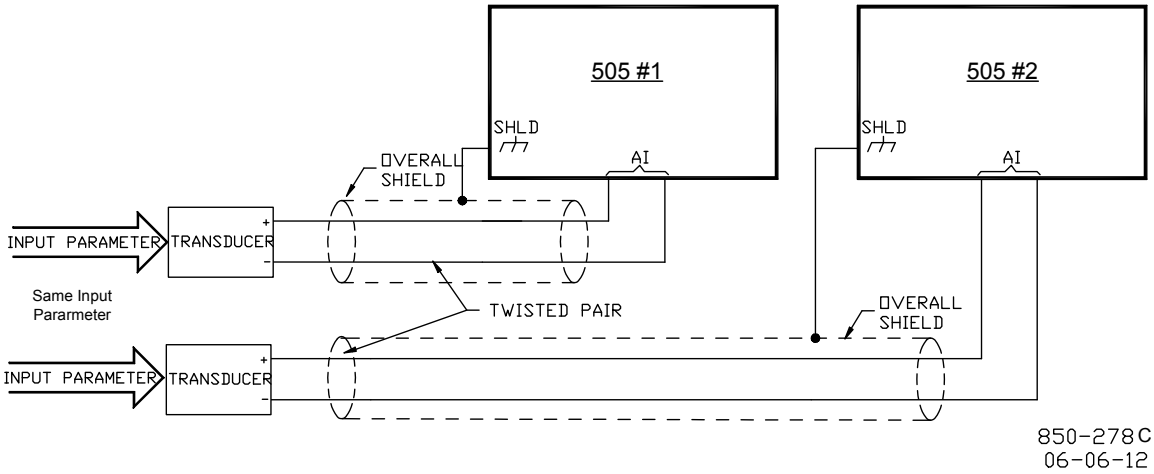


Figure 2-15h. Two Transducers with One Transducer for each 505 Unit

Separate transducer can be used to provide analog input signal into each 505 as shown in the diagram.

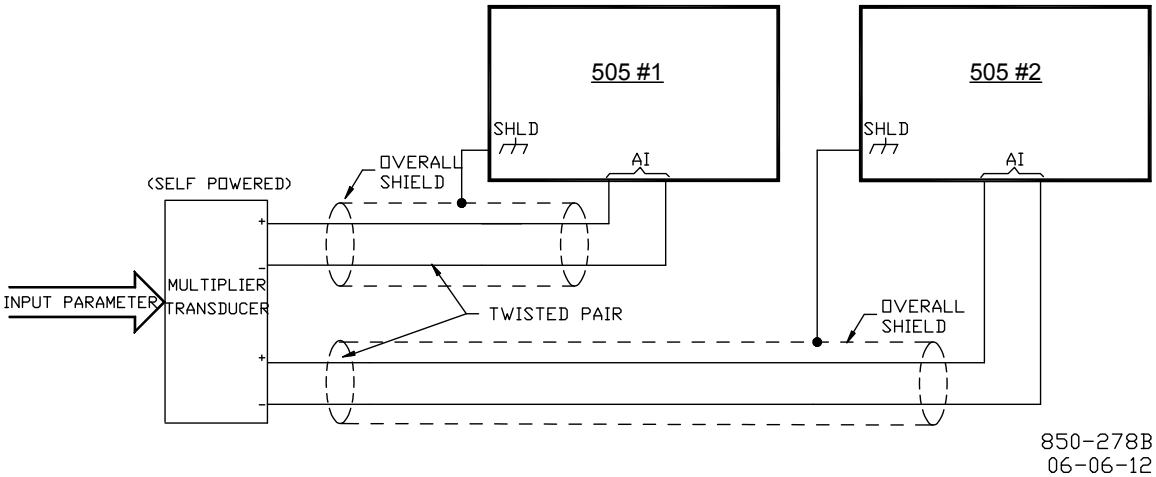


Figure 2-15i. One Transducer Using a Current Splitting/Isolation Device

Analog input multiplier/splitter can be used to provide the same signal in both the 505s. The above diagram depicts a scheme of an analog input multiplier circuitry (transducer splitter) to be used for both 505s.

IMPORTANT

If only one transducer is used, a Zener diode should be placed across the Analog Input terminals to prevent breaking the current loop in the event that a 505 is removed (online replacement). Specifications are as follows:

- **5 V < Vzener < 10 V (at 20 mA, 15 V minimum transducer power supply)**

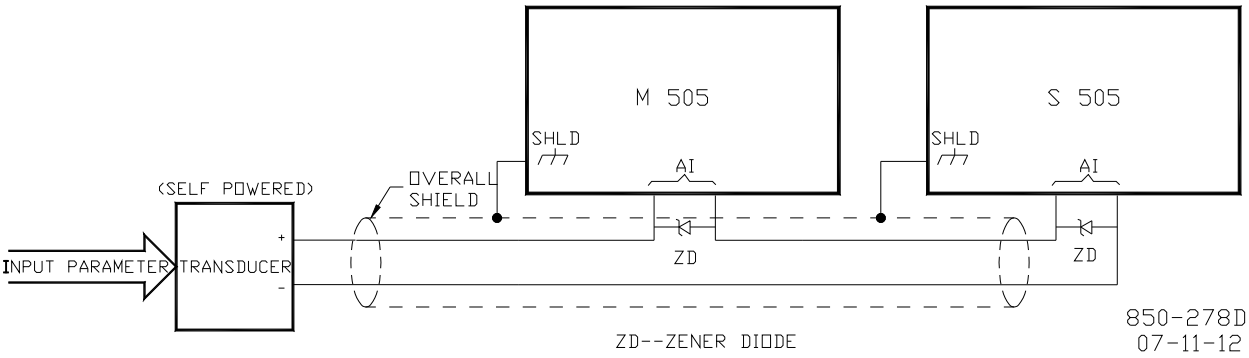


Figure 2-15j. One Transducer Driving Both 505 Inputs

One transducer can be utilized to drive both the circuits, provided it has burden strong enough to drive both the device. If this method is selected, a Zener diode as shown in the drawing should be connected across input terminals to simplify unit replacement and maintaining continuity all the time.

Actuator Outputs

When applied in redundant applications, the 505 can be configured to drive single coil actuators, dual coil actuators or two parallel actuators. Special attention to wiring details should be taken to ensure that nuisance trips do not occur and that on-line replacement of a 505 unit (if desired) can be accomplished (no opening of the actuator current loops).

IMPORTANT

Actuator output failures must be configured as shutdowns to ensure proper transfer of control between redundant 505 controllers.

When configured for Parallel Actuator applications both 505s output the same milliamp signal (when calibrated the same).

When configured for “Single-Shared Coil” applications, the Tracking 505 outputs a trickle current (equal to ½ of the Minimum current – for example 2 mA or 10 mA) to verify circuit health, and the In-control 505 outputs the required current (plus ½ of the minimum current 2–18 mA or 10–190 mA) to drive the coil from 0 to 100%. In this arrangement, diodes must be installed in series with the direction of current (as shown in Figure 2-15k) to prevent an unpowered 505 from ‘sinking’ current intended for the actuator.

IMPORTANT

When using Single Coil Shared for the actuator configuration, a diode should be used to prevent reverse current flow in the event that one 505 experiences a power loss. Specifications are as follows:

- **Reverse Voltage rating exceeding 24 V**
- **Max forward current from 505 is 200 mA**

NOTICE

The Actuator 2 output should not be used in redundant configurations. Use of this output can result in erratic speed control when actuator output failures are detected.

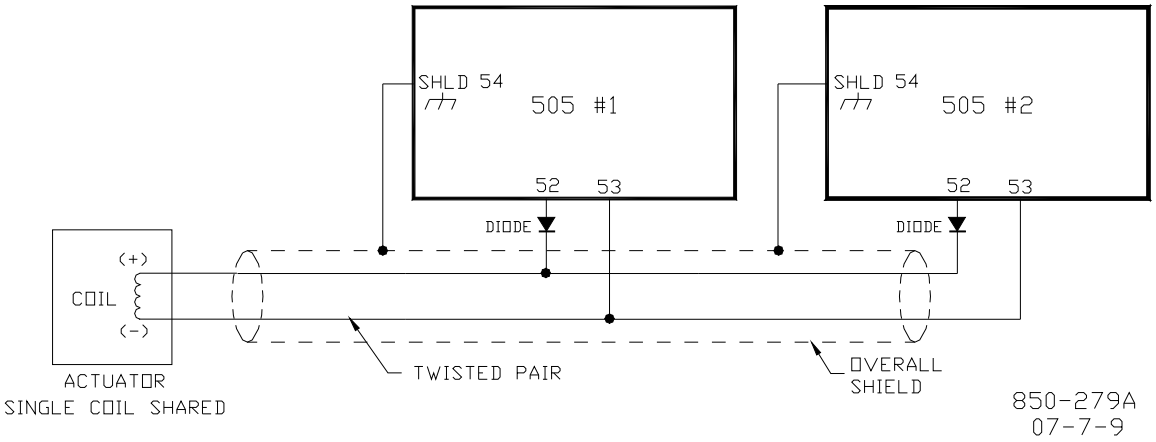


Figure 2-15k. Single Shared Coil Applications

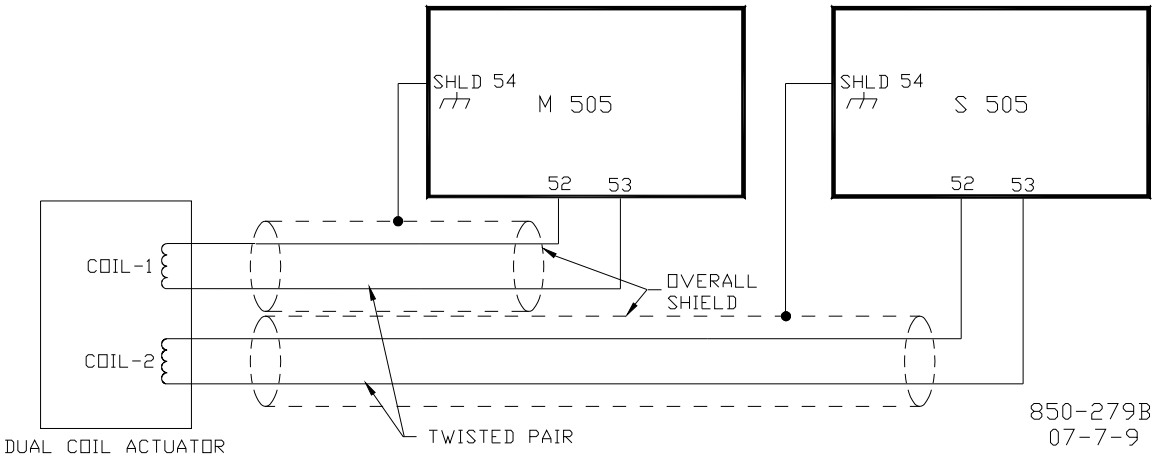


Figure 2-15l. Dual Coil Applications

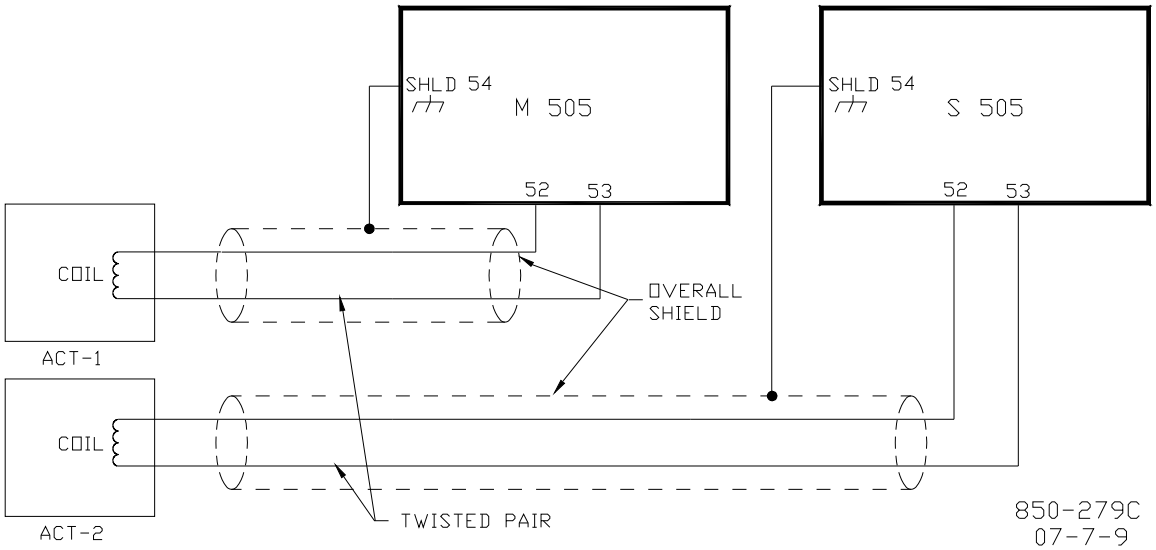


Figure 2-15m. Parallel Actuator Applications

Analog Outputs

We recommend that all 505 analog readouts be isolated from each other. If you desire to have only one set of Analog Output signals from both 505's, it is possible to use relays to switch to the Analog Output signals from the 505 that is in control. One way to do this is by using the "In-Control" Relay Output to activate a relay bank. This will switch a bank of relays depending on whether unit 1 or 2 is in control. When the "In-Control" Relay Output on unit 1 is closed, the unit 1 analog outputs will be connected to the field wiring. When it is open, the unit 2 analog outputs will be connected to the field wiring. This type of logic may also be performed using PLC's, a DCS computer, etc.

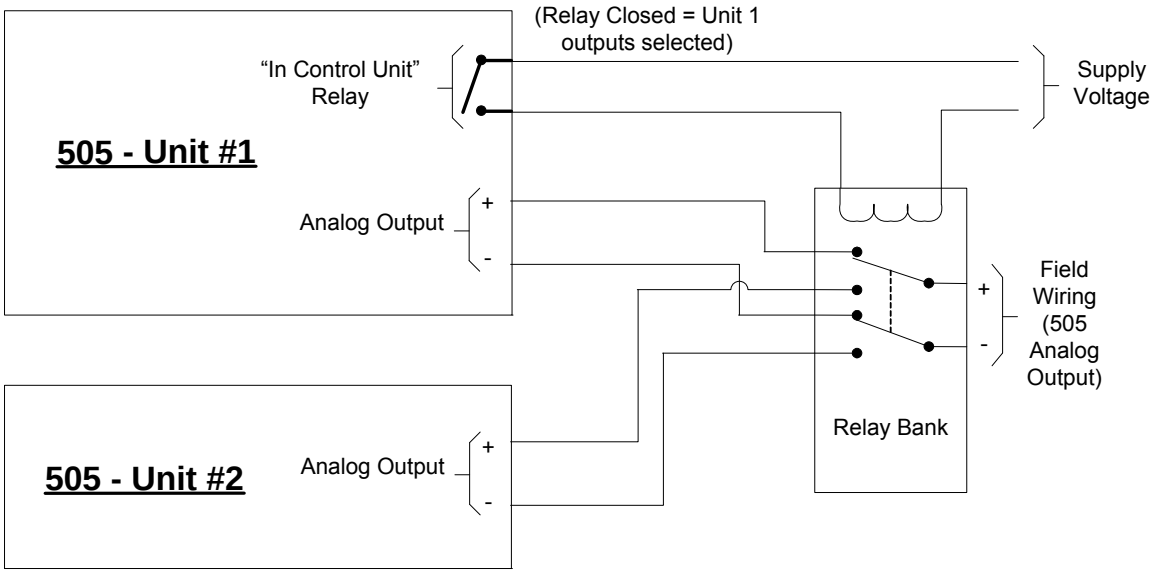


Figure 2-15n. Analog Output Switching Diagram

IMPORTANT

Using relays to switch between Unit 1 and Unit 2, Analog Outputs can interrupt the analog signal for the switch time of the relay when a transfer of control occurs. At the instant that the relays toggle, the current detected in the field may drop to 0 mA, resulting from an open circuit while the relays are transitioning.

Relay Outputs

The "Shutdown" or Trip Relay Outputs must be wired in parallel to avoid tripping the Trip Loop if only one 505 is shut down. This is the recommended method for a Trip Loop that uses positive logic where Energized = Closed = "Not Shutdown" (wired to the N.O. relay contact). Other Relay Outputs can be wired in parallel as long as they are also using positive logic (Energized = Closed = TRUE). With the exception of Trip/Shutdown logic, this type of logic may also be implemented using PLC's, a DCS computer, etc. Special considerations must be made if using a Trip Loop with "Energize-to-trip" (close loop to trip) logic.

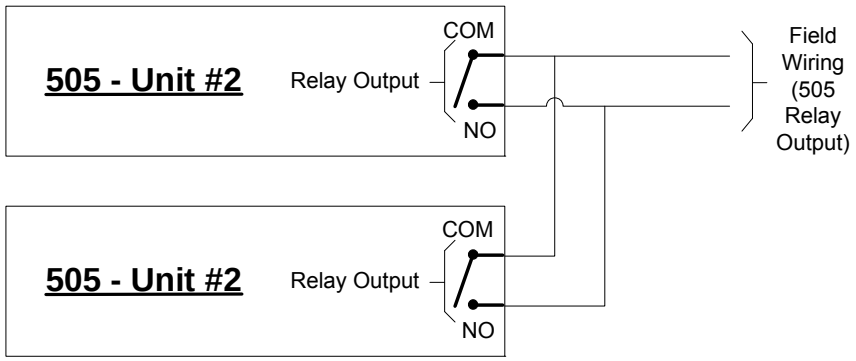


Figure 2-15o. Relay Outputs (positive logic)

WARNING

If a Trip command is only given to the Unit 1 "In Control" 505, there may be up to a 350 ms delay between the time the Shutdown Relay Output on Unit 1 indicates a shutdown and the time the Shutdown Relay Output on Unit 2 indicates a Shutdown.

Any Trip command intended to trip the system should be issued to both 505's (Contact Input Trip wired to both Unit 1 and Unit 2).

An alternative method for wiring Relay Outputs would be to use relays or a relay bank driven by the "In Control" Relay Output status (identical to the optional method for Analog Output wiring). This method may also be implemented using PLC's or a DCS computer. It should not be used for the Trip Loop or any other Trip/Shutdown logic.

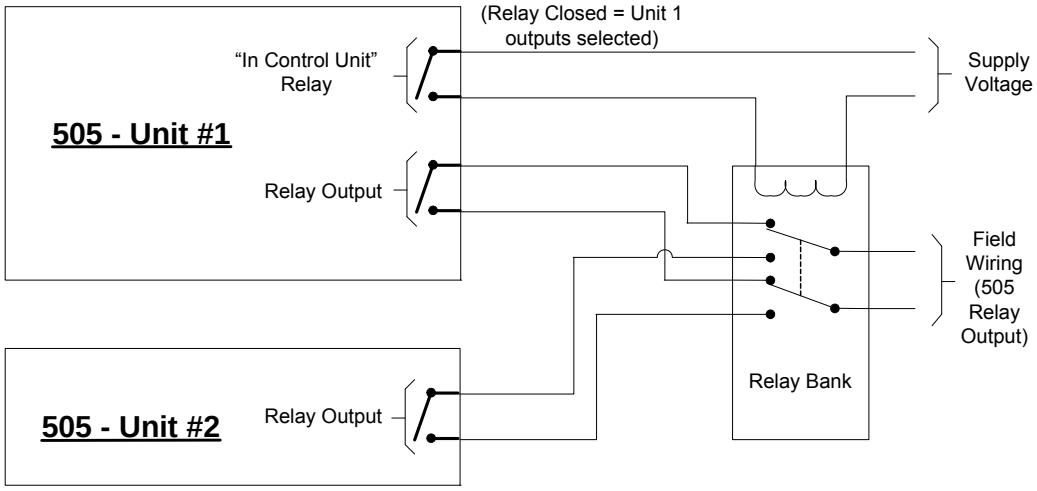


Figure 2-15p. Relay Output Switching Diagram

IMPORTANT

Using relays to switch between Unit 1 and Unit 2, Relay Outputs can interrupt the signal for the switch time of the relay when a transfer of control occurs. At the instant that the relays toggle, the voltage detected in the field may drop to 0 V, resulting from an open circuit while the relays are transitioning.

Serial Communications

Port#1 on the 505s can be configured to operate between Master & Slave. Port#2 can be configured to operate with DCS/HMI. The installation shown recommends port#1 configuration over RS-422 to get the communication link between Master & Slave.

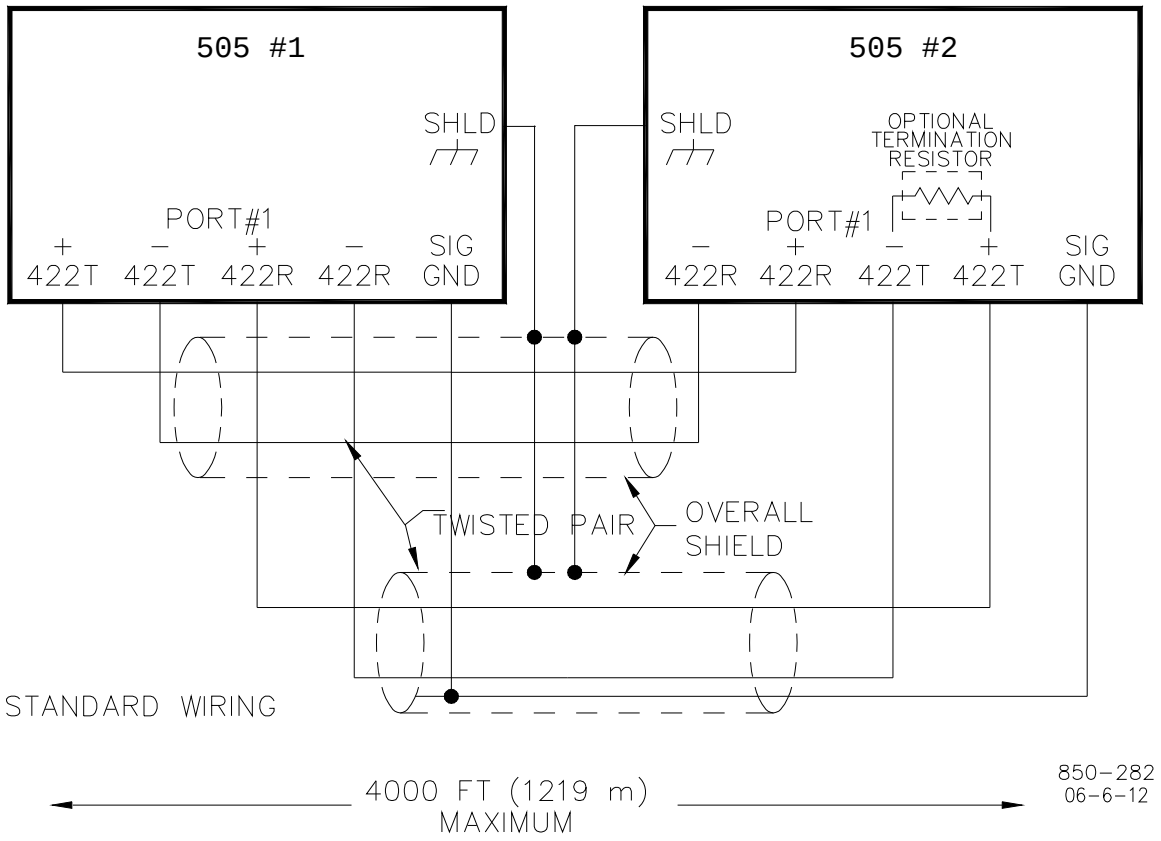


Figure 2-15q. Typical RS-422 Communications Between Master and Slave

Chapter 3.
505 Control Description

Introduction

The 505 has three PID controllers; the speed/load PID controller, the Auxiliary PID controller, and the Cascade PID controller. Depending on the configuration of the 505, these PIDs interact differently with each other. Please refer to the Block diagrams listed earlier in this manual to fully understand PID relationships.

Turbine Start Modes

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

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

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

Start Permissive

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

Zero Speed Signal Override

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

Manual Speed Override

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

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

Automatic Speed Override

If the Manual Speed Override option is not programmed, the Automatic Speed Override logic is used by the 505 to override the loss-of-speed signal shutdown logic during a turbine start-up. With the Automatic Override logic, the loss-of-speed signal failure is 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 timed limit is available on the automatic speed override function. The timed speed override timer deactivates the loss-of-speed override logic after the programmed time expires. If programmed, this timer starts counting down once a '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 505's Service mode.

Turbine Start Mode Procedures

Manual Start Mode

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

1. Issue a RESET command (to reset all alarms and shutdowns)
2. Issue a RUN command (verify T&T valve is closed before issuing)
   - At this point the 505 will ramp open the governor valve to its maximum position at the 'Valve Limiter Rate'.
   - The speed set point will ramp from zero to the minimum controlling speed setting at the 'Rate To Min' rate.
3. Open Trip & Throttle valve at a controlled rate
   - When turbine speed increases to the minimum controlling speed, the 505's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
4. Open Trip & Throttle valve to 100%
   - Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'Auto Start Sequence', if programmed, begins controlling.

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

⚠WARNING

The trip-and-throttle valve must be closed before pushing the 'RUN' key in Manual Start mode. If a 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.

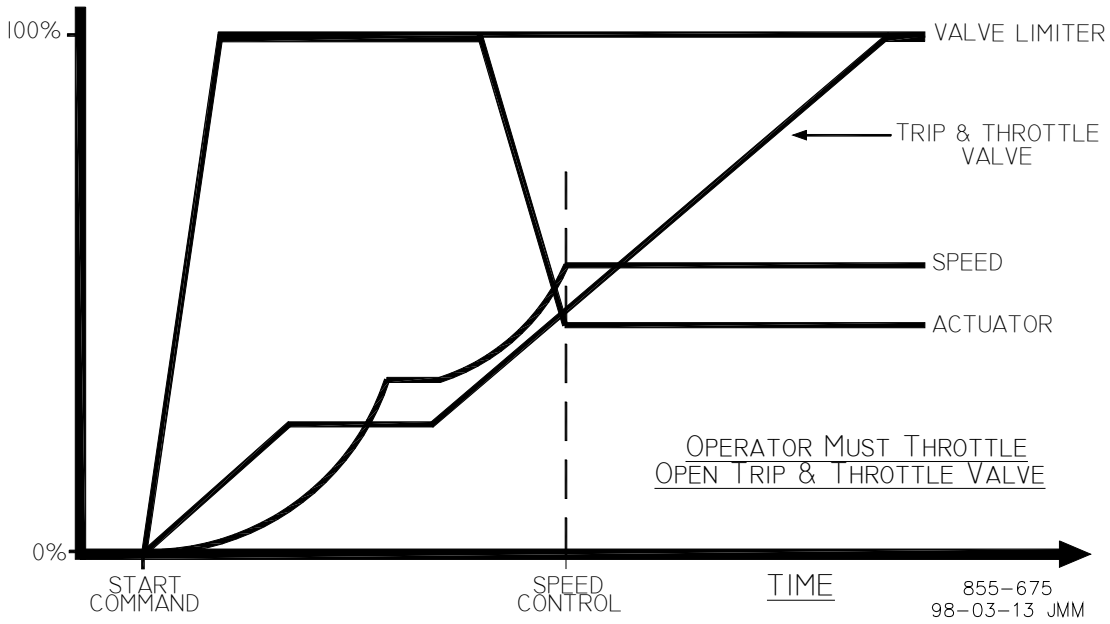


Figure 3-1. Manual Start Mode Example

Semiautomatic Start Mode

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

1. Issue a RESET command (to reset all alarms and shutdowns)
2. Open the Trip & Throttle valve (verify that the turbine does not accelerate)
3. Issue a RUN command
   - At this point the speed set point will ramp from zero to the minimum controlling speed setting at the 'Rate to Min' rate.
4. Raise the 505's VALVE LIMITER at a controlled rate.
   - When turbine speed increases to the minimum controlling speed, the 505's Speed PID will take control of turbine speed by controlling turbine inlet valve position.
5. Raise the 505's VALVE LIMITER to 100%.
   - Speed remains controlled at the minimum controlling point until action is taken by the operator or the 'AUTO START SEQUENCE', if programmed, begins controlling.

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

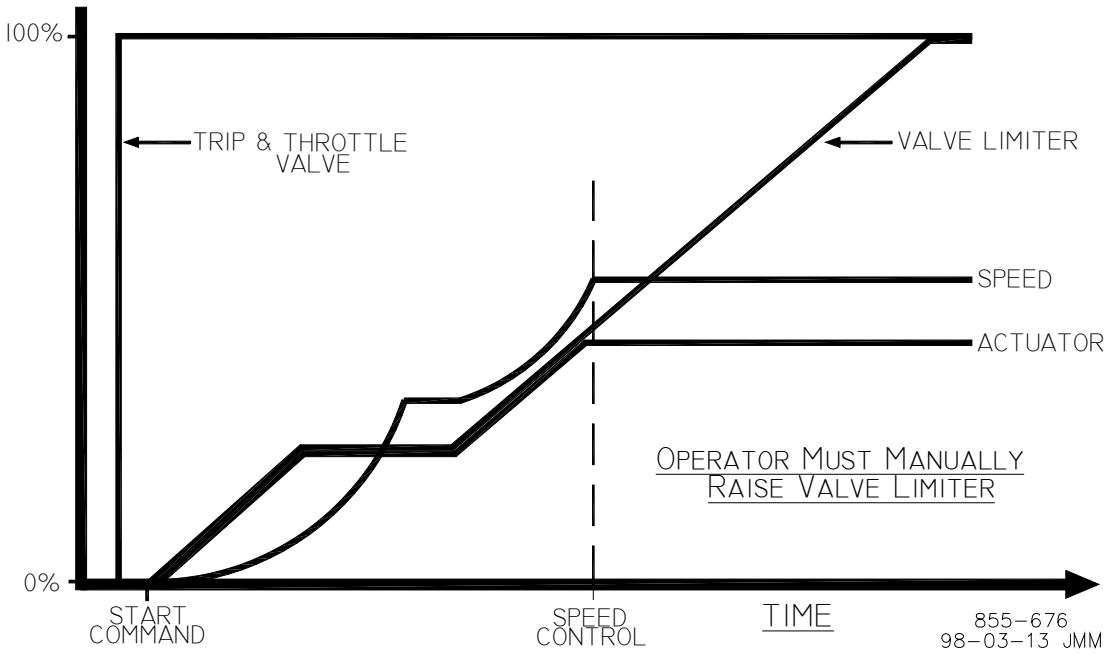


Figure 3-2. Semiautomatic Start mode Example

Automatic Start Mode

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

1. Issue a RESET command (to reset all alarms and shutdowns)
2. Open the Trip & Throttle valve (verify that the turbine does not accelerate)

3. Issue a RUN command
   - At this point the 505 will ramp open the governor valve to its “HP Max at Start” setting at the ‘Valve Limiter Rate’ setting.
   - The speed set point will ramp from zero to the minimum controlling speed setting at the ‘Rate to MIN’ rate.
   - When turbine speed increases and matches the ramping speed set point, the 505’s Speed PID will take control of turbine speed by controlling turbine inlet valve position.
   - Speed remains controlled at the minimum controlling point until action is taken by the operator or the ‘Auto Start Sequence’, if programmed, begins controlling.
   - Once the Speed PID begins controlling turbine speed, the HP Limiter will automatically ramp to the ‘Vlv Lmtr Max Limt’.

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

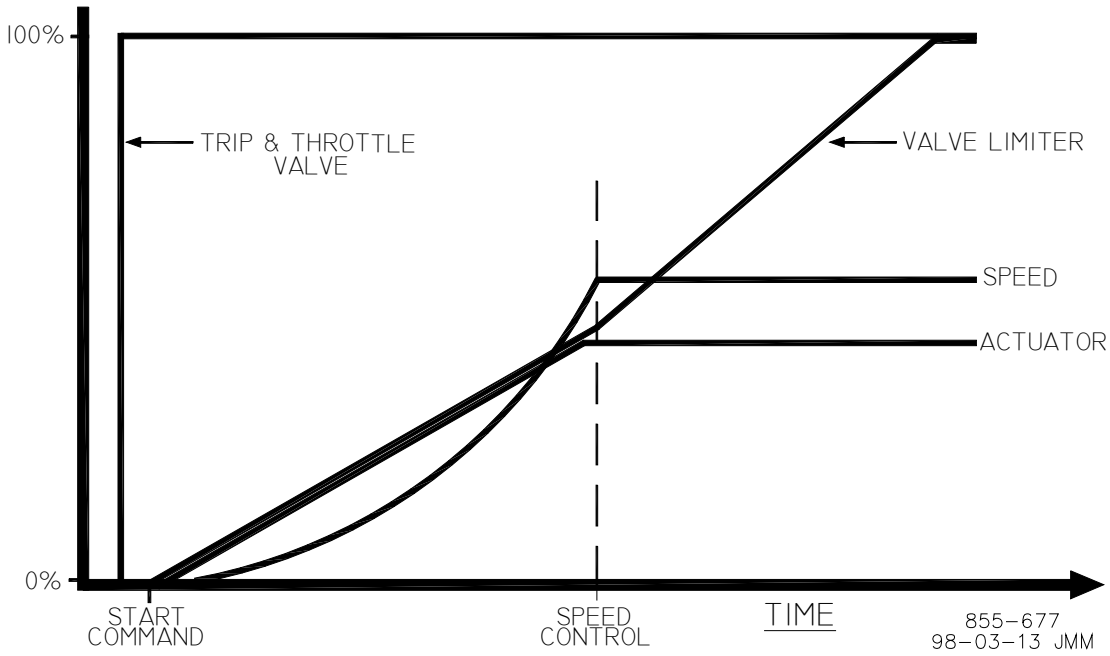


Figure 3-3. Automatic Start Mode Example

Critical Speed Avoidance

In many turbines, it is desirable to avoid certain speeds or speed ranges (or pass through them as quickly as possible) due to excessive turbine vibration or other factors. During programming, two critical speed ranges may be configured. These bands may be any speed ranges that is less than the minimum governor speed setting. Within a critical speed range, the 505 moves the speed set point at the critical speed rate programmed and does not allow the speed set point to stop within the critical speed avoidance band. If the turbine is accelerating through a critical avoidance band and excessively high vibrations are experienced, selecting the speed set point lower command will bring the unit back to the lower limit of the band.

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

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

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

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

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

No Idle Programmed

If neither, the Idle/Rated or Auto Start Sequence functions are programmed, the speed set point will ramp from zero to the minimum governor set point at the 'Rate To Min' setting rate. Critical speed bands cannot be programmed with this configuration.

Idle/Rated

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

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

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

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

Ramp to Rated Feature

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

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

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

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

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

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

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

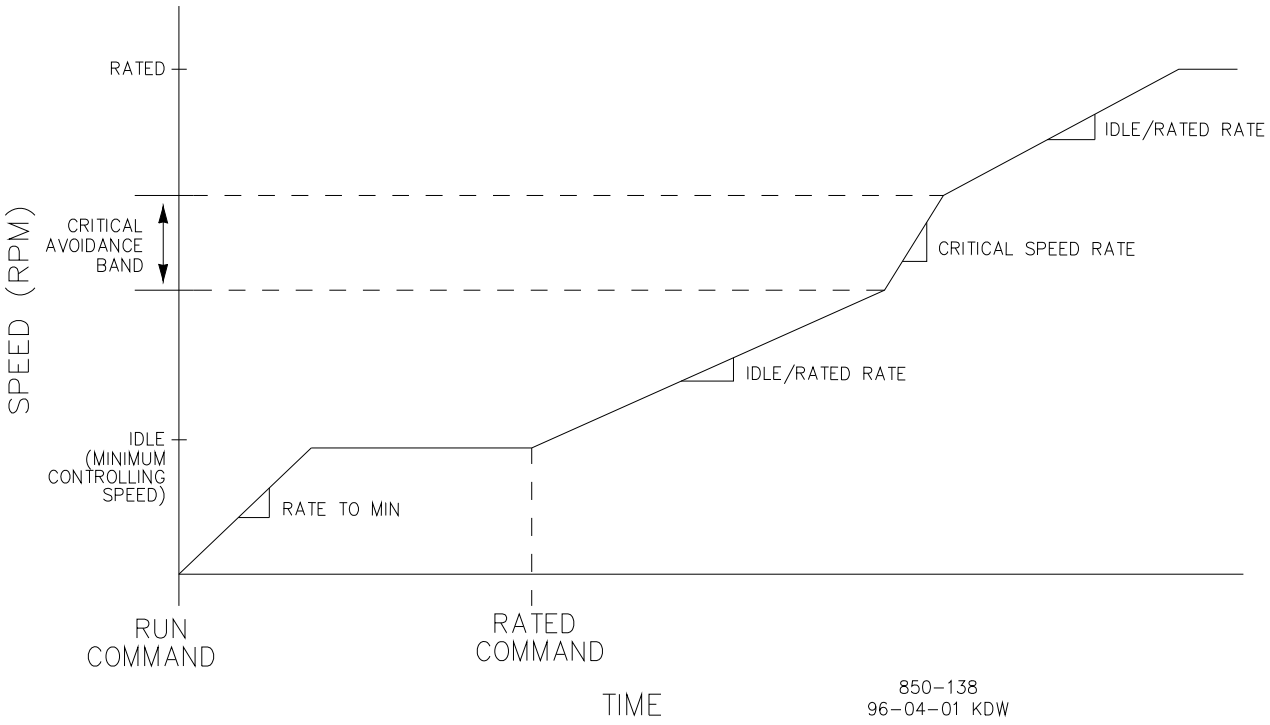


Figure 3-4. Idle/Rated Start

Automatic Start Sequence

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

The 505 can be configured to utilize an Automatic Start Sequence to start the turbine. This sequencing logic allows the 505 to perform a complete controlled system start-up from zero speed to rated speed. With this function, the turbine's starting ramp rates and idle speed hold times depend on the length of time the unit was shutdown. 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 set point to a low idle set point, holds at this setting for the set duration, ramps the speed set point to the Idle-2 setting, holds at this setting for a the set duration, ramps the speed set point to Idle-3 setting, holds at this setting for the set duration, then finally ramps the speed set point to the programmed rated turbine speed setting. All ramp rates and hold times are programmable for both hot start and cold start conditions. The control differentiates between hot and cold starts by using a "Hours-Since-Trip" timer or a contact input. When using the "Hours-Since-Trip" timer, the timer starts when a shutdown has been executed and turbine speed has decreased below the low idle speed setting.

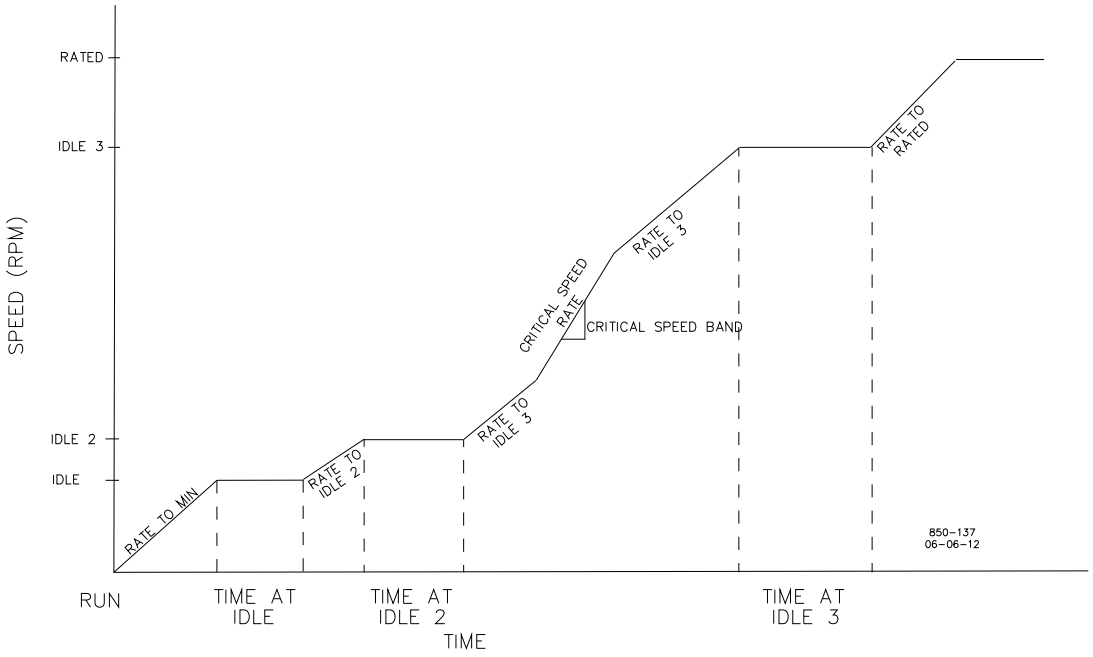


Figure 3-5. Automatic Start Sequence

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	MINIMUM
LOW IDLE DELAY (HOT)	=	10	MINIMUM
USE IDLE2	=	*TRUE	
RATE TO IDLE2 (COLD)	=	5	RPM/S
RATE TO IDLE2 (HOT)	=	15	RPM/S
IDLE2 SETPT	=	1500	RPM
USE IDLE3	=	*TRUE	
RATE TO IDLE3 (COLD)	=	5	RPM/S
RATE TO IDLE3 (HOT)	=	15	RPM/S
IDLE3 SETPT	=	2000	RPM
IDLE3 DELAY TIME (COLD)	=	30	MINIMUM
IDLE3 DELAY TIME (HOT)	=	20	MINIMUM
RATE TO RATED (COLD)	=	10	RPM/S
RATE TO RATED (HOT)	=	20	RPM/S
RATED SETPT	=	3400	RPM

If the unit was tripped for 12 hours, the control would interpolate between the hot and cold parameters and use the following rates and delays (viewed in the Service Mode, see Volume 2):

LOW IDLE DELAY	=	20	MINIMUM
RATE TO IDLE2	=	10	RPM/S
IDLE2 DELAY	=	10	MINIMUM
RATE TO IDLE3	=	10	RPM/S
IDLE3 DELAY	=	10	MINIMUM
RATE TO RATED	=	15	RPM/S
RST Timer Level	=	3500	RPM
Hot RST Timer (min)	=	10	MINUTES

Based on the example's configuration and trip time, the Speed Set Point would ramp to 1000 rpm at the rate to minimum setting and hold for 20 minutes (turbine speed must also be at or above 1000 rpm), move to 1500 rpm at 10 rpm/s and hold there for 10 minutes, move to 2000 rpm at 10 rpm/s and hold there for 10 minutes and lastly, move to 3400 rpm at 15 rpm/s. At 3400 rpm, the sequence would be completed.

- However, speed reference must be above the HOT RESET LEVEL during more than HOT RESET DELAY, to fully use the HOT parameter
- If the unit was tripped for 2 hours or less and restarted, the control would use the hot start parameters. If the unit was tripped for 22 hours or longer and restarted, the control would use the cold start parameters.

IMPORTANT

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

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

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

NOTICE

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

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

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

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

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

Speed Control Overview

The speed control receives a turbine speed signal from one or two magnetic pickups or proximity probes. The 'MPU Gear Ratio' and the 'Teeth Seen By MPU' settings are configured to allow the 505 to calculate actual turbine speed. 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 Speed PID (proportional, integral, derivative control amplifier) then compares this signal to the its set point to generate an output signal to the governor valve actuator (through a low signal select bus).

IMPORTANT

The 505 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).

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

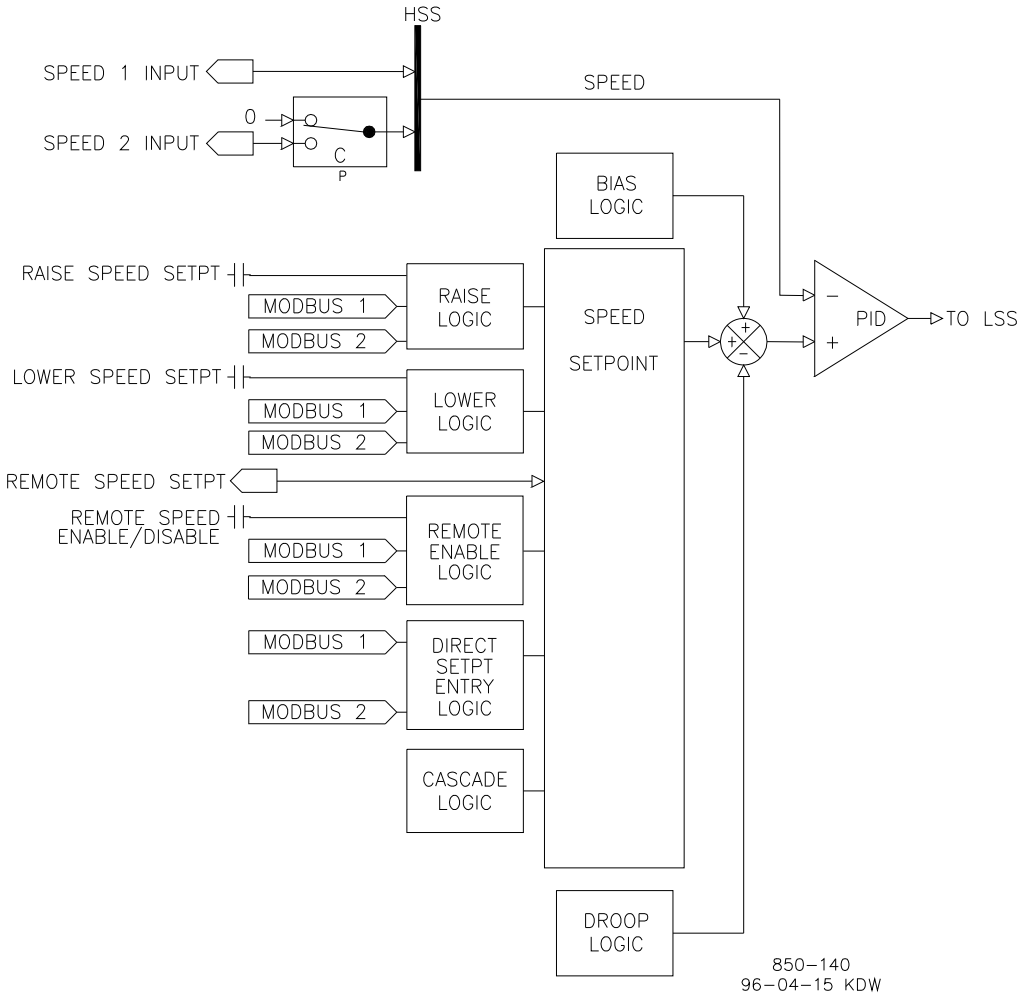


Figure 3-6. Speed Control Functional Diagram

Speed PID Operational Modes

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

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

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

Speed Control

While in the Speed Control mode, the Speed PID will control a turbine at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). With this configuration, no form of droop or second controlling parameter is used by the PID for stability or control. Refer to Figure 3-6.

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

Frequency Control

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

The Speed PID operates in the Frequency control mode when the generator breaker is closed and the utility tie breaker is open. In the Frequency control mode, the unit will operate at the same speed or frequency regardless of the load it is supplying (up to the unit's load capability). Refer to Figure 3-7.

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

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

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

Unit Load Control

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

Giving the Speed PID two parameters to control allows it to control unit load and act as a stabilizing effect for any change in bus frequency. With this configuration, when bus frequency decreases or increases, unit load increases and decreases respectively, based on the unit's droop setting. The net effect is a more stable bus. See Figure 3-8 for a frequency and load relationship diagram.

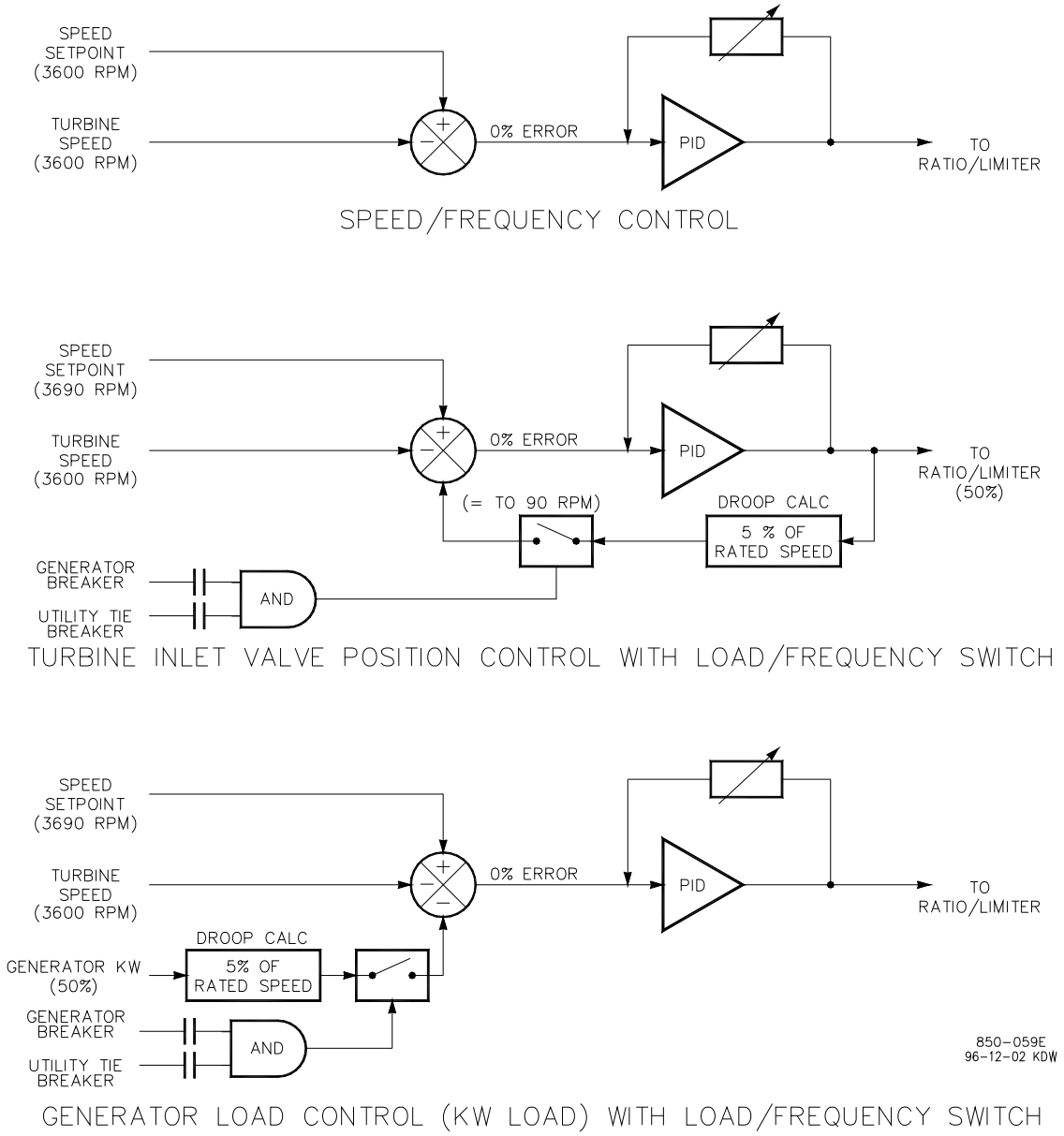


Figure 3-7. Speed PID Control Modes

The term “droop” was derived from an isolated unit’s speed reaction to an increase in load when another parameter (unit load) is fed back to a Speed PID’s summing junction. The Droop term, as used throughout this manual refers to a PID’s second controlling parameter. A second parameter representing unit load is fed back into the 505’s Speed PID to allow it to control two parameters; speed when operating in an isolated mode, and unit load when paralleled to an infinite bus. See Figure 3-8.

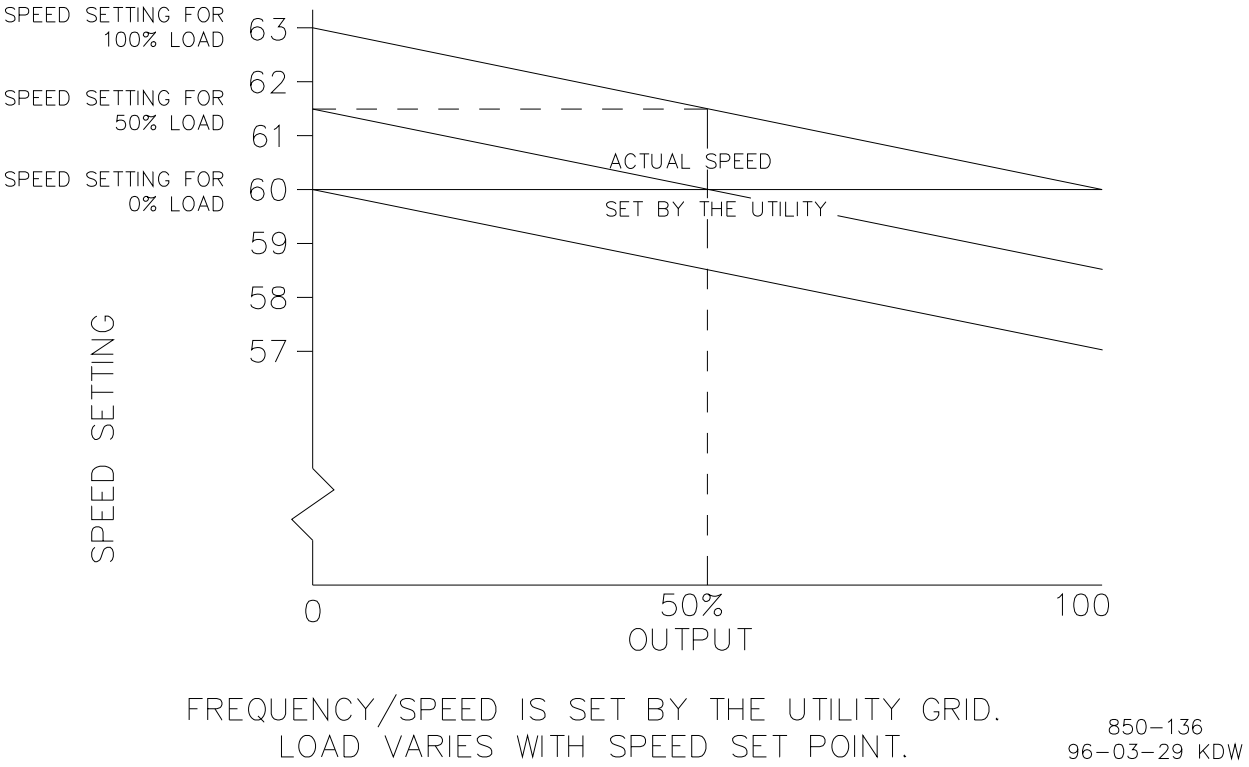


Figure 3-8. Frequency and Unit Load Relationship

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

DROOP % x (gen load or valve position-%) x Rated Speed = Speed Set Point change in rpm

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

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

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

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

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

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

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

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

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

However, in an application where turbine inlet or exhaust pressures are not at rated levels when the generator breaker is closed, the considered zero load level will be incorrect when system pressures do reach rated levels. With this type of application it is recommended that the Minimum Load set point not be used. To disable the use of the Minimum Load Set Point, configure the 'Use Min Load' setting (under the Service mode's 'BREAKER LOGIC' header) to 'No'.

Speed Set Point

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

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

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

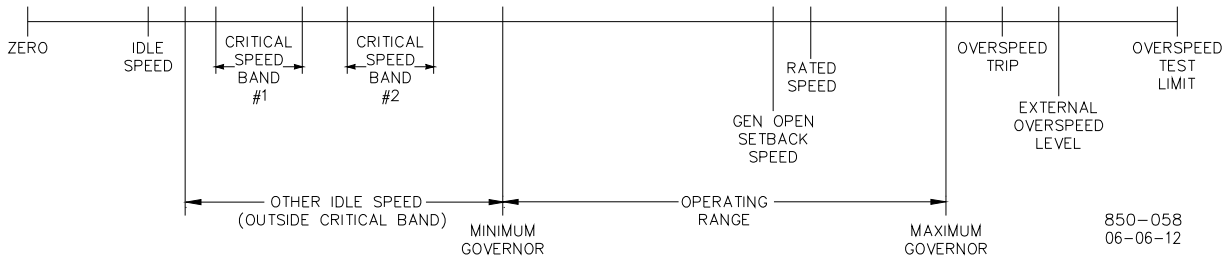


Figure 3-9. Speed Relationships

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

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

The speed set point may be set to a specific level, by directly entering a set point value through the 505 keypad or Modbus communications. To “enter” a specific set point from the 505 keypad, press the SPEED key to view the speed control screen, press the ENTER key, enter the set point level desired, then press the ENTER key again. If a valid number was entered, the setting will be accepted and the Speed set point will ramp to the “entered” set point level. If an invalid number is “entered” the setting will not be accepted and the 505’s screen will momentarily display a value out-of-range message. When a valid set point value is entered, the set point will ramp at the speed set point slow rate to the newly entered set point value. This ‘Entered’ rate is tunable through the Service mode.

When using the ENTER key from the front panel keypad, the 505 checks the validity of the new entered set point. The speed set point must be below the maximum governor setting and above the idle setting and not within a critical speed avoidance band. Once the speed set point is above the minimum governor setting, the set point cannot be lowered below minimum governor. Also, if the unit is driving a generator and the unit is on-line, the speed set point cannot be set below the minimum load setting. The minimum load setting is defaulted to 5 rpm above the isochronous speed set point (changeable in the Service Mode).

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

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

When configured for generator applications a Minimum Load set point is used by the 505 to reduce the chance of reverse powering a unit upon closing the generator breaker. With the utility tie breaker closed, when a generator breaker closed indication is received, the Speed set point is stepped to the Minimum Load setting. The Minimum Load setting is defaulted to 3% (changeable in the Service Mode). To disable the use of the Minimum Load Set Point, configure the 'Use Min Load' setting (under the Service mode's 'BREAKER LOGIC' header) to 'No'.

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

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

Frequency Arm/Disarm

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

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

To use this feature, the program's 'Use Freq Arm/Disarm' setting 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, health, and running status, an operator may select which unit is designated as the plant Frequency control unit if or when the plant-to-utility tie breaker opens. Frequency control can be Armed at any time, but it will only go into control when the generator breaker is closed and the utility tie breaker is open.

NOTICE

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

If the ‘Use Freq Arm/Disarm’ setting 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.

Speed Control Dual Dynamics

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

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

When not configured for a generator application, the 505 uses the programmed ‘Min Governor Speed Set Point’ setting to determine which set of dynamic values are used by the Speed PID. The Speed PID’s off-line dynamics are selected when turbine speed is below the ‘Min Governor Speed Set Point’ setting. The Speed PID’s on-line dynamics are selected when turbine speed is above the ‘Min Governor Speed Set Point’ setting. (see Table 3-1).

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

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

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

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

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

*The contact input option has priority, when programmed.

Table 3-1. On-Line/Off-Line Dynamics Selection

Remote Speed Set Point

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

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

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

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

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

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

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

Remote Speed Set Point Status Messages

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

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

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

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

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

Synchronization

Automatic generator synchronization can be performed through a Woodward EGCP-3. The EGCP-3 connects to a 505 analog input to bias the 505's speed set point directly to vary generator speed, frequency and phase. Optionally the EGCP-3 can interface with the unit voltage regulator to match system voltage across a generator breaker.

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

The EGCP-3 can be used as a synchronizer only or as a synchronizer and load control. When the EGCP-3 is used as a synchronizer only, the 505 must be configured to accept the EGCP-3'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 505'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 EGCP-3 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 EGCP-3 sync mode and 505 analog input at the same time.

To configure the 505 to utilize an EGCP-3 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 EGCP-3'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 26194 for more information on applying the EGCP-3.

When programming a Function Key (F3 or F4), instead of a contact input, to enable the 505's analog Synchronizing input, a 505 relay output can also be programmed to select an EGCP-3's synchronizing mode. To configure the 505 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 505 is programmed to use the EGCP-3 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:

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

Synchronizing/Load Sharing

The 505 is capable of using an analog input to accept a load sharing signal from Woodward's EGCP-3. This input in conjunction with the EGCP-3 allows the control to isochronously load share with any other system using an EGCP-3. The 505's internal summing junction adds this signal with the speed/load PID's reference. In addition to load sharing, the EGCP-3 input to the 505 can be used to synchronize the unit to either the plant bus or to the utility.

An EGCP-3 with VAR/Power Factor control, allows all units with EGCP-3s to reactive load share as well as real power load share. The EGCP-3 senses unit load through generator PTs & CTs and system load through the EGCP-3 LON network (a combination of all units on the network). The EGCP-3 uses a digital Echelon Network (LON) to communicate with other EGCP-3s on the same bus.

When used as a synchronizer and load control, the EGCP-3 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 EGCP-3 through the Sync/Load Share input or by the 505's internal speed/load set point. The Utility Tie Breaker Contact is used to select unit load control through the EGCP-3 or through the 505's internal load set point. When the 505's internal load control is selected (utility tie contact closed), the Speed PID set point is used to control unit load. Optionally the Cascade or Auxiliary control modes may be used to set unit load based on another system parameter.

The EGCP-3 interfaces to the 505 via its Speed Bias signal. To configure the 505 to utilize an EGCP-3 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 EGCP-3'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 505's synchronizing and load sharing operating modes (See Table 3-2).

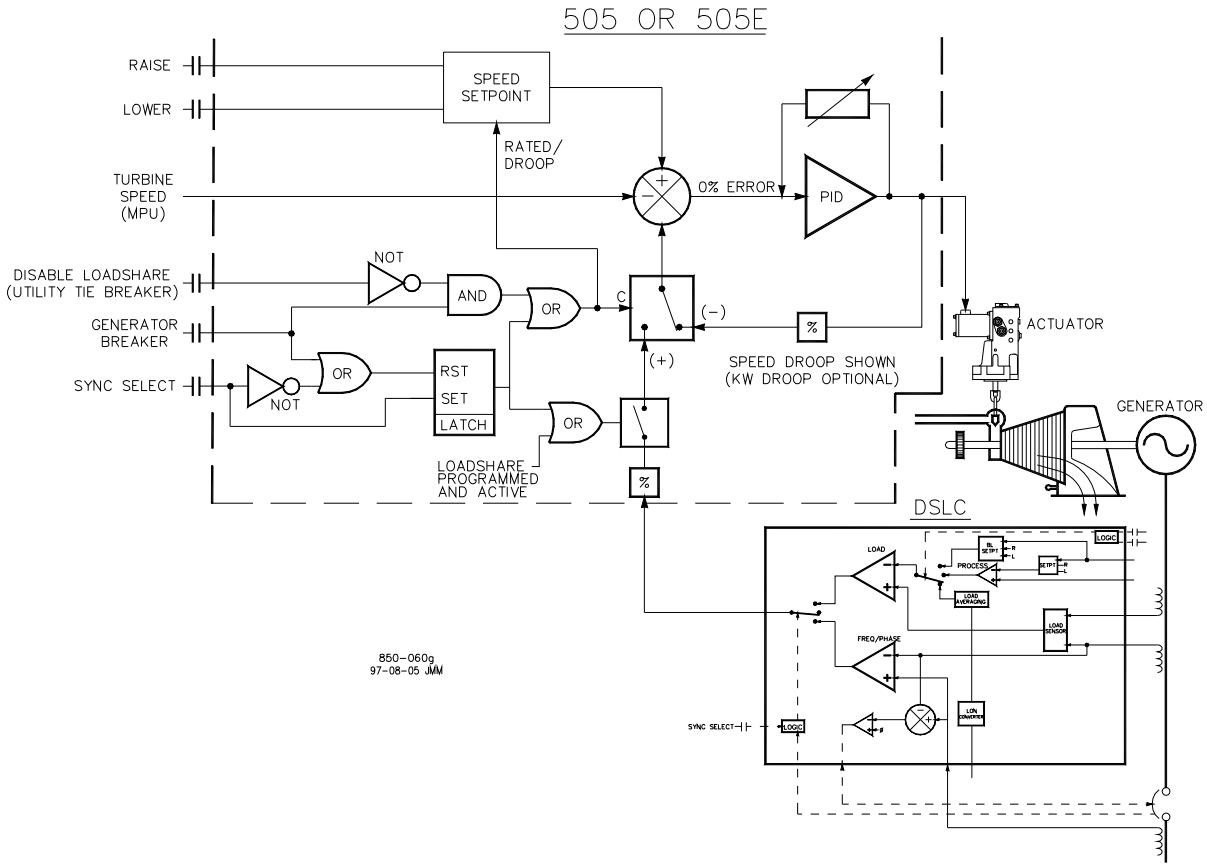


Figure 3-10. Load Sharing Logic

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

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

The 'Sync/Ld Share Enable' contact input option is used to enable the Sync/Load Share analog input before the generator breaker is closed. Optionally a Function Key (F3 or F4) can be programmed to enable the 505's Sync/Load Share analog input instead of an external contact. This discrete enable/disable function is ignored after the generator breaker is closed, and must be reselected after the generator breaker opens. Typically a double pole single throw (DPST) switch is used on a site's synchronizer control panel to select automatic synchronizing by enabling both the EGCP-3 sync mode and 505 analog input at the same time.

Tie Breaker Contact Status	Gen Breaker Contact Status	Sync/Ld Share Enable Contact	Speed Control Mode	Cascade or Auxiliary (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

Table 3-2. Load Sharing Logic

When programming a Function Key (F3 or F4) instead of a contact input to enable the 505's analog Sync/Load Share input, a 505 relay output, can be also be programmed to select an EGCP-3's synchronizing mode. To configure the 505 for this functionality, program the 'Sync/Ld Share Enable' function to a 'FX KEY PERFORMS' setting, and the 'Sync/Ld Share Enabled' function to a 'RELAY X ENERGIZES ON' setting.

When the 505 is programmed to use the EGCP-3 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:

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

Load Rejection

The Load Rejection logic provides two different methods for preventing an overspeed when a load rejection occurs. Once activated, to avoid multiple and repetitive actions, this logic is disarmed and will automatically be re-armed after 60 seconds. If acceleration detection is configured, the following two forms of protection apply:

Protection1—At Generator Breaker Opening:
When the Generator Breaker is opened, this logic sets the demand to a "no load" demand, which is the demand/valve position recorded when the Gen Breaker was closed. The demand is held at this value for 100 ms.

Protection 2—Pre-acting Acceleration Detection:

This protection triggers the load rejection logic when the following conditions are true:

- The Gen Breaker is closed.
- Start-up has been completed.
- Turbine speed is above the configured “Max Speed on Load” value.
- Turbine acceleration is above the configured “Max Accel on Load” value.

These conditions may occur if the Tie Breaker is opened. Due to possible delays in the breaker position feedback, it can also be used for pre-acting acceleration detection (when the Gen Breaker has been opened but the signal status has not yet changed). This feature can detect the acceleration caused by the loss of load and act ahead of time by lowering the demand, basically closing the valve and preventing an overspeed trip.

This function can also be configured to be triggered by detection of the Tie breaker opening.

As in Protection 1, when the logic is triggered it sets the demand to a “no load” demand, which is the demand/valve position recorded when the Gen Breaker was closed. The demand is held at this value for up to 300 ms.

Feed-Forward Input

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

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

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

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

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

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

Emergency Loop

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

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

Direct Action

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

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

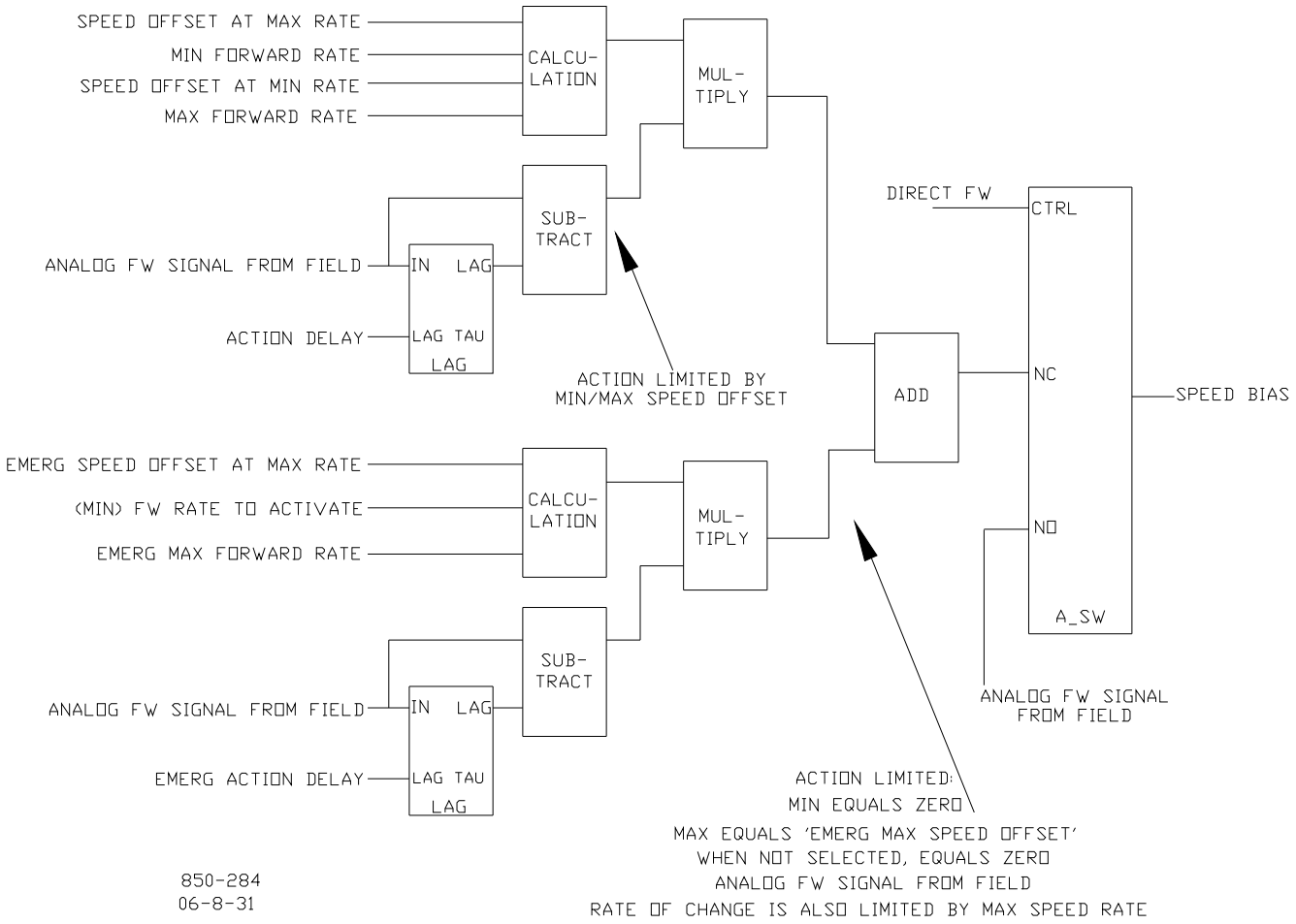


Figure 3-11. Typical Anti-surge Valve and Speed Feed-Forward Logic Trend

Cascade Control

The Cascade control can be configured to control any system process, related to or affected by turbine speed or load. Typically this controller is configured and used as a turbine inlet, or exhaust pressure controller.

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

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

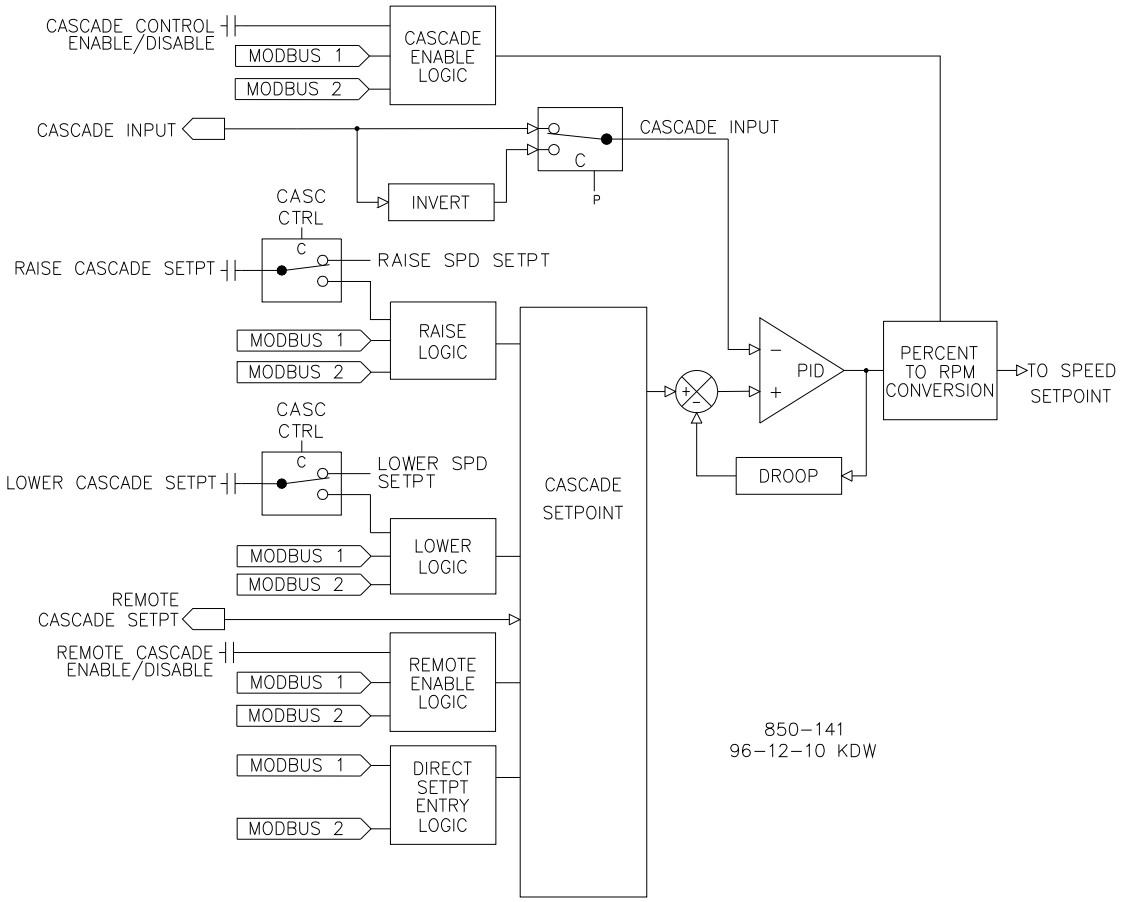


Figure 3-12. Cascade Functional Diagram

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

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

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

Cascade Control Status Messages

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

Cascade control is automatically disabled on a shutdown condition, and must be re-enabled after a successful system start-up. Cascade control is disabled if Remote Speed Set Point is used and enabled. Should another parameter on the LSS bus take control of governor valve position from the Speed PID, Cascade control will stay active, and begin controlling again when the Speed PID is the lowest parameter on the LSS bus again.

If Cascade control is desired in a 505 redundant configuration, both controls should receive the same related inputs. The Modbus link between the In-Control unit and the Tracking unit track whether or not Cascade is enabled and track the current speed reference operating point. The other information, such as cascade input signal and remote cascade set point, will not be passed through this link. If the backup 505 unit is not configured for Cascade control, it will revert to speed control authority.

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

Cascade Dynamics

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

Cascade Set Point

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

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

IMPORTANT

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

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

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

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

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

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

Cascade Set Point Tracking

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

Cascade Set Point with No Tracking

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

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

Cascade Droop

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

> PID OUTPUT % x 'CASCADE DROOP %' x 'MAX CASC SET POINT' x 0.0001
>
> Where the 'CASCADE DROOP %' and 'MAX CASC SET POINT' values are set in the Program Mode and the 'PID output %' is determined by the Cascade demand.
>
> Example: 25% x 5% x 600 psi x 0.0001 = 7.5 psi

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

Invert Cascade

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

Remote Cascade Set Point

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

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

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

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

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

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

Remote Cascade Enable Logic

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

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

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

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

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

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

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

Auxiliary Control

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

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

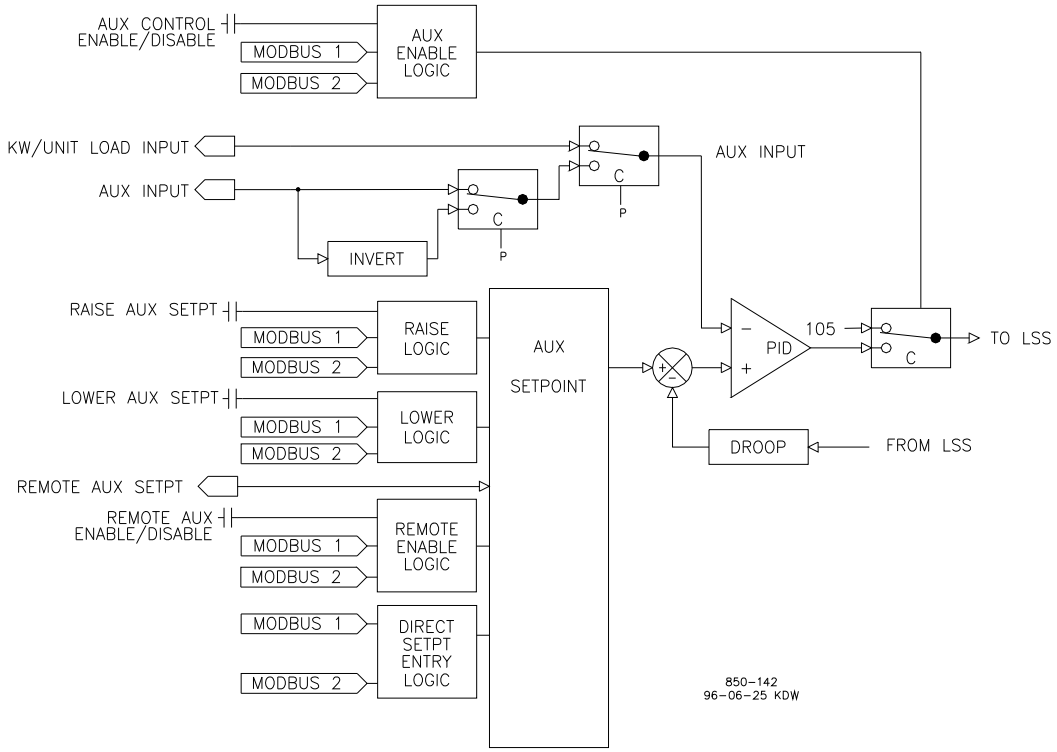


Figure 3-13. Aux Control Overview

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 turbine speed/load based on any auxiliary parameter which is directly related. 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 set point. The Aux set point initializes to the programmed ‘Setpt Initial Value’ setting on a power-up-reset. This set point may be adjusted at any time and will remain at a setting (running or shutdown), provided a power-up-reset did not occur.

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

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

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

To configure the Auxiliary controller to function as a controller, 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 (505 front panel screen messages):

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

For generator applications, Auxiliary control can be configured to be disabled when the generator and/or utility tie breakers are open. Program settings ‘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 505 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 505 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.

If Auxiliary control is desired in a 505 redundant configuration, both controls should receive the same related inputs. The Modbus link between the In-Control unit and the Tracking unit track whether or not Auxiliary is enabled and track the current speed reference operating point. The other information, such as auxiliary input signal and remote auxiliary set point, will not be passed through this link. If the backup 505 unit is not configured for Auxiliary control, it will revert to speed control authority.

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 ‘AUXILIARY DROOP %’ x ‘MAX AUX SET POINT’ x 0.0001

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

Where the ‘AUXILIARY DROOP %’ and ‘MAX AUX SET POINT’ 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 inlet control valve position is required to increase the Auxiliary process signal, program the ‘INVERT AUX INPUT’ setting to ‘YES’. An example of this control action would be when the Auxiliary PID is configured to control turbine inlet steam pressure. To increase turbine inlet steam pressure, inlet control valve position must be decreased.

Auxiliary Set Point

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

The Auxiliary set point range must be defined in the program mode. Program settings ‘Min Aux Set Point’ and ‘Max Aux Set Point’ define the range of the Auxiliary set point and control.

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

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

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

When a valid set point value is entered, the set point will ramp at the Auxiliary Set Point Rate to the newly entered set point 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 Set Point

Remote Aux Set Point

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

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

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

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

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

Remote Auxiliary Enable Logic

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

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

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

- 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 this is the normal operation mode. If 'Disable' is selected, both control modes are disabled.

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

If no external contact 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 Set Point parameters are available through the Modbus links. See Chapter 6 for a complete listing of Modbus parameters.

Valve Limiter

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

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

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

The shortest length of time a set point will move for an accepted raise or lower command is 40 milliseconds (120 milliseconds for a Modbus command). If the Valve limiter slow rate is programmed for 10 %/s, the smallest increment it will move is 0.4 % (.2 % for a Modbus command).

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

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

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

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

Emergency Shutdown

When an Emergency Shutdown condition occurs, the actuator output signal is stepped to zero milliamps, the Shutdown relay de-energizes, and the shutdown cause (first shutdown condition sensed) is displayed on the 505's front panel. 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 eight Emergency Shutdown inputs (contact inputs) can be programmed to allow the 505 to indicate the cause of an emergency shutdown. By wiring trip conditions directly into the 505, instead of a trip string, the 505 can pass a trip signal directly to its output relay (to trip the T&T valve), and also indicate the first trip condition sensed. The 505's total throughput time is 20 milliseconds (worse case). All trip conditions are indicated through the 505's front panel, and Modbus communications.

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

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

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

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

Controlled Shutdown

The Controlled Shutdown function is used to stop the turbine in a controlled manner, as opposed to an Emergency Trip. When a STOP command (controlled shutdown) is issued, the following sequence is performed:

1. Cascade and Auxiliary(if not a limiter) PID controllers are disabled
2. The Speed Set Point is ramped to min load set point at normal rate (only for generator application).
3. When at min load (only for generator application), the controller will wait until the generator breaker opens (only if Ctrl SD & Reverse Pwr ?= False). If a relay output is configured as "generator open pulse (2s)", then this relay will temporarily energize for 2 seconds.
4. The Speed Set Point is ramped to its low idle level.
5. Once the speed set point has reached its low idle point, the HP valve limiter is then ramped to zero percent at a controlled rate. At this point if the "Control Stop & Trip" setting is configured to "no" the control will then wait for a Start command to restart the turbine. However, if the "Control Stop & Trip" setting is configured to "yes" the control will then execute a turbine shutdown.

IMPORTANT

For redundant configurations, the "Control Stop & Trip" setting should be configured to "yes". This will shut down the "Tracking" unit at the end of the controlled shutdown. If the "Control Stop & Trip" setting is configured as "no", the "Tracking" unit will trip on an MPU failure as the Unit rolls down.

NOTICE

For Redundant configurations of units with Software P/N: 5418-2629 Rev. A and earlier:

If the "Control Stop & Trip" is configured as "yes", at the end of the Normal Shutdown, control will Transfer to the "Tracking" unit and the shutdown must be completed on that unit.

With the control in the run mode and the turbine turning, when the 505's "STOP" key is pressed, the control will display a message prompting the operator to verify the command (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 505'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 505 front panel, a programmed contact input or either Modbus communication link. Verification is not required, if a controlled shutdown command is initiated by a programmed contact input or Modbus communication link.

The controlled shutdown sequence can be aborted at any time. During a controlled shutdown sequence, by pressing the STOP key, the 505 will display a '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 trip, generator breaker open trip, and tie breaker open trip commands are overridden when a controlled shutdown is initiated.

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

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

Overspeed Test Function

The 505's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505's internal overspeed trip logic and any external overspeed trip device's settings and logic. An Overspeed Test will allow the control's speed set point to be increased above the normal maximum governor limit. This test can be performed from the front panel of the control or with external contacts. This test is not permissible through the Modbus.

An overspeed test is allowed only under the following conditions:

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

In redundant 505 configurations, the second unit should be healthy and in "Tracking" mode during this test. If the unit is shut down, it will trip the turbine on overspeed since the overspeed protection logic in the 505 is always active.

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 505's front panel OSPD key.

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

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

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

When Local mode is selected, the 505 is defaulted to be operable from its front panel only. This mode disables all contact inputs and Modbus commands, with exceptions noted 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)
External trip 6 Contact In	(active at all times, if programmed)
External trip 7 Contact In	(active at all times, if programmed)
External trip 8 Contact In	(active at all times, if programmed)
External trip 9 Contact In	(active at all times, if programmed)
External trip 10 Contact In	(active at all times, if programmed)
External alarm 1 Contact In	(active at all times, if programmed)
External alarm 2 Contact In	(active at all times, if programmed)
External alarm 3 Contact In	(active at all times, if programmed)
External alarm 4 Contact In	(active at all times, if programmed)
External alarm 5 Contact In	(active at all times, if programmed)
External alarm 6 Contact In	(active at all times, if programmed)
External alarm 7 Contact In	(active at all times, if programmed)
External alarm 8 Contact In	(active at all times, if programmed)
External alarm 9 Contact In	(active at all times, if programmed)
Override MPU Fault Contact In	(active at all times, if programmed)
Frequency Arm/Disarm	(active at all times, if programmed)
Generator breaker Contact In	(active at all times, if programmed)
Utility tie breaker Contact In	(active at all times, if programmed)
Start permissive Contact In	(active at all times, if programmed)

Switched dynamics Contact In	(active at all times, if programmed)
Select In-Control Unit Contact In	(active at all times, if programmed)
Local/Remote Contact In	(active at all times, if programmed)
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 505 can be operated through its front panel, contact inputs, and/or all Modbus commands.

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

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

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

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

Function Keys

In the redundant 505 configuration, Function key F3 will be defaulted to be the TRANSFER button to allow the transfer of control from the In-Control Unit to the Tracking Unit. This button will also be illuminated on the 505 that is In-Control. If the 505 is NOT configured for redundant operation, the F3 key is available for the optional functions discussed below.

Function keys, F3 & F4 are located on the 505's front panel, and can be programmed independently to function as a control panel switch. These keys allow functions to be enabled and disabled from the 505'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 Set Point Enable
Halt Continue Auto Start Seq	Auxiliary Enable
Remote Speed Set Point Enable	Remote Auxiliary Set Point Enable
Sync Enable	Relay Output
Frequency Control Arm/Disarm	Transfer Demand (only for Master)
	Feed-forward enable (only for Master)

A two step process is required to enable or disable any function. Pressing a programmed function key will cause the 505'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 505's Remote Speed Set Point, 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 Set Point function and the message will change to (Push No to Disable/Rmt Spd Setpt In Control).

Relays

The 505 has eight relay outputs available. Two of these relays are dedicated; one for a system shutdown command from the 505 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 505's Service mode, to toggle on and off repeatedly when an alarm conditions has occurred. With this configuration if a reset command is given and the alarm condition still exists, the relay will stop toggling and stay energized. The relay will start toggling again, upon a new alarm condition. This option can be used to inform the operator when another alarm condition has occurred.

If redundant operation is configured with two 505s, the third relay output is dedicated as a healthy/tracking indication from each unit to discrete input 5 of the other unit.

Any of the other five or six relays can be programmed to function as a level switch or mode indication. When programmed as a level switch the relay will change state when the selected parameter reaches the programmed level (energizes when value is higher the programmed level). The following is a list of the 505's relay options for level indication:

Speed	Aux Set Point
Speed Set Point	Actuator Demand
KW Input	Actuator 1 Demand
Sync/Load Share Input	Actuator 2 Demand
Cascade Input	Valve Limiter
Casc Set Point	Inlet Header Pressure
Aux Input	

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
- Trip Relay (additional trip relay output)
- Alarm Condition (energized)
- 505 Control Status OK
- Overspeed Trip
- Overspeed Test Enabled
- Speed PID in Control
- Remote Speed Setpt Enabled
- Remote Speed Setpt Active
- Underspeed Switch
- Auto Start Sequence Halted
- On-Line PID Dynamics Mode
- Local Control Mode
- Frequency Control Armed
- Frequency Control
- Modbus Command
- Track Inhibited
- Unit OK
- Reset Pulse (2 sec)
- Feed-Forward Active
- Sync Enabled
- Sync or Load Share Enabled
- Alarm Condition (de-energized)
- Load Share Control Enabled
- Casc Control Enabled
- Cascade Control Active
- Remote Casc Setpt Enabled
- Remote Casc Setpt Active
- Aux Control Enabled
- Aux Control Active
- Auxiliary PID in Control
- Remote Aux Setpt Enabled
- Remote Aux Setpt Active
- Valve Limiter in Control
- F3 Key Selected
- F4 Key Selected
- In Control Unit
- Backup Unit (Tracking)
- Open Generator CMD
- Feed-Forward Enabled

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 505 initiated trip by setting the ‘Ext trips in Trip Relay’ option to NO. Using this option, 505 trip annunciation will only occur if the 505 tripped the turbine and not annunciate when the other external devices 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 505 Control Status OK relay is normally energized, and will only de-energize if unit inlet power is lost, the 505’s CPU fails, or the 505 is in the program mode.

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

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

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

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

When the (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 505's F3 and F4 function keys to be used as panel switches to select and/or enable system related functions (synchronizers).

When the Modbus Command function is programmed, the assigned relay energizes when the respective Modbus command "Turn On Modbus Relay X" is issued, then de-energizes when the respective Modbus command "Turn Off Modbus Relay X" is issued. This feature allows a 505 relay to be driven directly from Modbus to control a system related function (synchronizing). In addition, the assigned relay can be momentarily energized using the Modbus command "Momentarily Energize Modbus Relay X" is issued (voltage raise/lower commands). Refer to Chapter 6 of this manual for more information on Modbus commands.

In a redundant configuration, the In-Control and Backup unit relays can be used to indicate which unit is controlling the turbine.

Redundant Configuration Operation

When configured for redundant applications, the two 505s work as a redundant Master/Slave configuration. In this configuration, one 505 functions as the master controller (In Control Unit) and controls all aspects of the turbine system, and the second 505 functions as a slave controller (Tracking Unit) and tracks the master 505. If the In Control 505 fails for any of the configured reasons, such as any turbine-related I/O signal loss or a user-defined input only wired to this unit, operation is smoothly transferred to the Tracking 505 controller. If the In Control 505 is tripped by the Emergency Stop button or a user programmed External shutdown, the turbine will trip.

⚠WARNING

If a Trip command is only given to the Unit 1 "In Control" 505, there may be up to a 350 ms delay between the time the Shutdown Relay Output on Unit 1 indicates a shutdown and the time the Shutdown Relay Output on Unit 2 indicates a Shutdown.

Any Trip command intended to trip the system should be issued to both 505's (Contact Input Trip wired to both Unit 1 and Unit 2).

Although both units can be set up to monitor the same application parameters and drive into the same actuator coil, optionally the units can be programmed differently and forced to transfer upon command, allowing on-line system changes to be performed. Unit-to-unit tracking options can be configured as desired to ensure smooth transfers after unit program changes have been verified.

⚠WARNING

Exercise extreme caution when making program/configuration changes in the secondary 505 while operating in redundant operation. The transfer of control to this unit from the In-Control unit may have undesirable results.

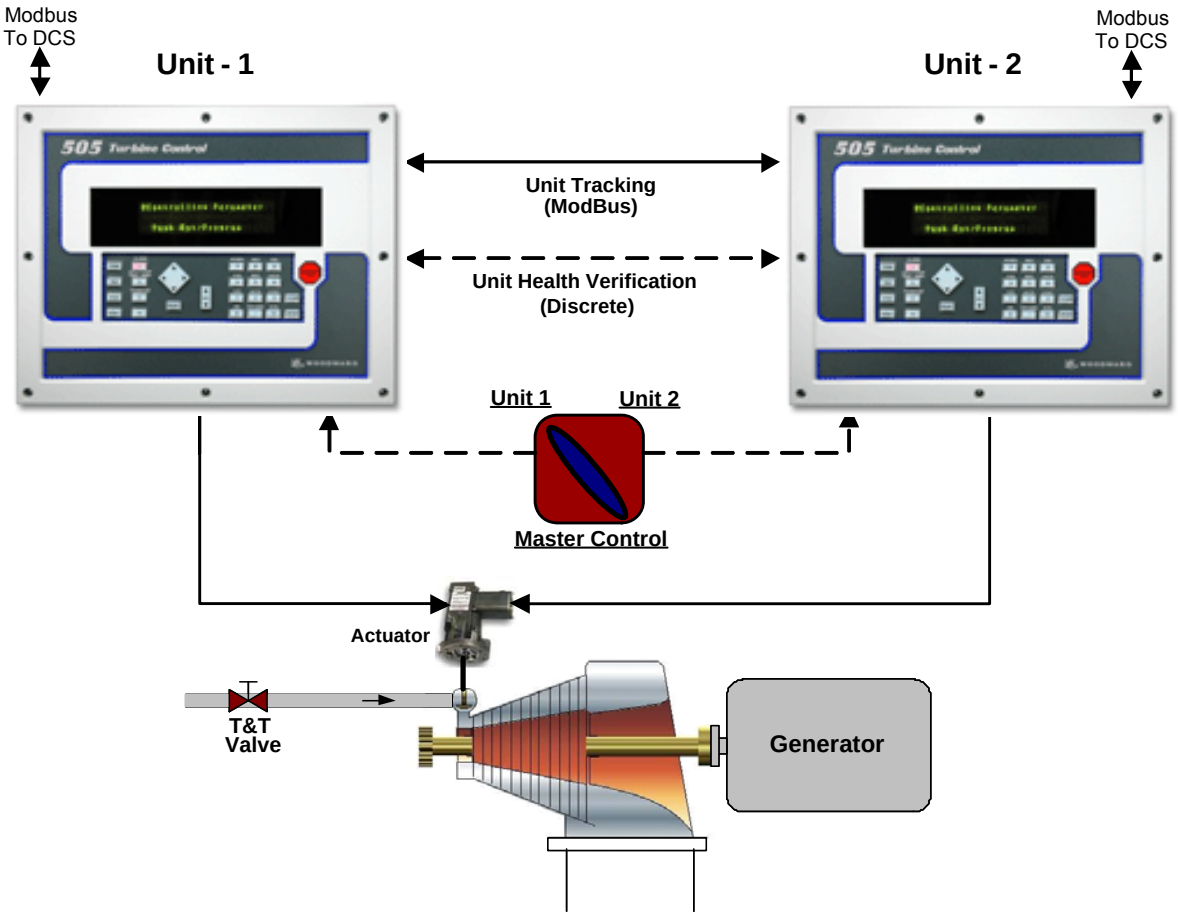


Figure 3-14. Redundant 505 Configuration Diagram

When configured for redundant applications the 505 can be configured to drive single coil actuators, dual coil actuators, or parallel actuators (CPC skid).

For redundant applications, the following basic configuration setup is required:

1. One 505 must be programmed as the Modbus Master
2. One 505 must be programmed as the Modbus Slave
3. Serial Port-1 of both the 505s must be connected via an RS-422 communications cable with Baud Rate = 38400, 1 Stop bit, No Parity Driver = 2 for RS-422.
4. Both 505's "Other Unit OK" contact inputs (BI 05 = Config Contact Input #1) must be connected to the other 505's "Unit-OK" relay output (BO 03 = Config Relay Output #1).

The In Control Unit

When used in a redundant configuration, the 505 is designed for the In Control 505 to be in control of all turbine parameters during normal operation, with the Tracking unit tracking the In Control 505's control state and main level parameters.

The In-Control and Tracking 505s use both the 'Unit-OK' discrete interface and the Unit-to-Unit serial communications interface to establish if the other unit is healthy and to decide which unit should be in control. The system initially defaults to the first unit that is given a Reset command after power up initialization as the unit being In-Control. If at any time the 'Unit-OK' discrete interface is lost from the other unit then this unit takes control. If at any time the unit-to-unit serial communications interface fails, the units will continue to operate with whichever unit was In-Control when the fault occurred, and no transfer to the other unit will be allowed until these links are re-established. Refer to Table 3-3 for information on which controller will control depending on the different system states. Table 3-4 shows the respective actuator current outputs from each unit – depending on the system state.

Unit #1 Status	Unit #2 Status	Unit-to-Unit Tracking	Selected In-Control Unit	System State
OK	OK	OK	Unit 1	Unit #1 Controlling
OK	OK	OK	Unit 2	Unit #2 Controlling
OK	OK	Fault	Unit 1 or Unit 2	Selected In-Control unit Controlling
OK	Fault	OK	Unit 1 or Unit 2	Unit #1 Controlling
Fault	OK	OK	Unit 1 or Unit 2	Unit #2 Controlling
OK	Fault	Fault	Unit 1	Unit #1 Controlling
OK	Fault	Fault	Unit 2	Shutdown
Fault	OK	Fault	Unit 1	Shutdown
Fault	OK	Fault	Unit 2	Unit #2 Controlling
Fault	Fault	OK	Unit 1 or Unit 2	Shutdown

Table 3-3. System Control Decision Matrix

In-Control Unit OK	Tracking Unit OK	Tracking Unit Status	Actuator Output Current
Yes	Yes	Tracking	In Control = Valve Demand + ½ of the Min Act current Tracking = ½ of the Min Act current
Yes	No	Shutdown	In Control = Valve Demand + full Min Act current Tracking = Zero Act current
No / SD	Yes	Takes Control	Tracking = Valve Demand + full Min Act current In Control = Zero Act current
No	No	Trip Turbine	In Control = Zero Act current Tracking = Zero Act current

Table 3-4. Actuator Output Current Matrix

Transferring Between Units

Transfer of control from one unit to the other will be initiated under the following conditions:

- In-Control 505 failure (CPU or internal problem)
- Loss of power to the In-Control 505
- Loss of all speed probes to the In-Control 505
- In-Control 505 actuator output failure detected
- A manual user command "Select In-Control Unit" is received
- Either of the 2 configurable External SD / XFER inputs

IMPORTANT **Actuator output failures must be configured as shutdowns to ensure proper transfer of control between redundant 505 controllers.**

When using the 'Select In-Control Unit' command to transfer between units, the In Control 505 uses both the 'Unit-OK' discrete interface and the Unit-to-Unit serial communications interface to establish if it is safe to transfer unit control from one unit to the other before transferring control.

Unit-to-unit transfer control commands can be issued from the 505 front panel or an external contact command. During the configuration of the control the user must decide how they want to issue the unit-to-unit transfer command.

Option 1) The default is for this to be done via the 505 keypad using the F3 function key. If the unit is configured for redundancy, then the F3 key is automatically configured for this function. The **F3 key will be illuminated on the unit that is In-Control** and this key will allow the user to transfer control from this unit to the other unit. With the Communication interface and discrete links healthy, the control should transfer from unit to unit in less than 100 ms. If the Communication interface link between the units is faulted, then the Transfer will be disabled, but the user will have the option of overriding this condition if needed (in case the other unit is not functional).

Option 2) If desired the user can configure the transfer to be done via a contact input selector switch. In this case the user should use a selector switch that insures only 1 of the units receives a True from this contact input. With the Communication interface and discrete links healthy, the control should transfer from unit to unit within 100 ms. If the Communication interface link between the units is faulted, this will force the unit receiving this True input to take control (there is no additional Override command).

When applying 505s in redundant configurations, there is no automatic sharing of tuned program information between the two units, thus each unit must be programmed identically if it is desired that both units function the same when controlling the unit. We recommend that any change to a 505's calibration be documented such that the replaced unit can be calibrated the same before it is put in service. Optionally Woodward's Control Assistant software program can be used on a computer connected to a 505 to upload and download all programmed configuration values to and from each unit. Refer to manual 26045 and Appendix D for information on utilizing Woodward's optional Control Assistant program with the 505.

Command Given	System State
Run Command given to In Control Unit	Turbine Starts
Run Command given to Tracking Unit	No Start Allowed
Reset Command given to In Control Unit	Reset accepted & sent to Tracking unit
Reset Command given to Tracking Unit	Reset accepted only in Tracking unit
Critical Trip Command to In Control Unit (ESD, OSPD or User programmed external ESD trips)	Turbine Trips
Any Trip Command given to Tracking Unit	Shuts down Tracking unit - Ready for Programming
Function Enable/Disable Command given to In Control	Enable/Disable Command Performed
Function Enable/Disable Command given to Tracking Unit	Command Not Performed

Table 3-5. Operational Commands Matrix

If a unit-to-unit transfer occurs during start-up, the speed set point will be halted, and the 'Ramp-to-Rated' or 'Continue Sequence' commands must be re-issued to the unit in control.

If the HP valve limiter did not reach its maximum limit before a unit-to-unit transfer occurred, it will be stopped and must be raised to its maximum limit by an operator.

Function Commands

The Cascade and Auxiliary control mode states, as well as the use of Remote Speed set point, are tracked to allow full system control transfers, however it is recommended that Enable/Disable commands be given to both controllers as the same time. The actual analog signals and set points of these control loops are not tracked between units, only the Enabled or Disabled state, therefore each unit will need parallel signal inputs to maintain relatively bumpless transfers of these processes.

NOTICE

With redundant 505 applications, the unit that is in control of the turbine is the only unit that will respond to "Emergency trip" commands, 'Run' commands, or any function enable/disable commands. The unit that is not in control of the turbine will ignore all commands, and will only shut off its trickle current if it is issued an 'Emergency Trip' or other Shutdown command.

On-Line Unit Replacement

When used in a redundant configuration, the 505 is designed such that either unit can be removed and replaced while the other healthy 505 continues to control and operate the turbine on-line. If this is desired, give careful consideration as to which relay output and actuator output connections are made to the end devices.

Unit Replacement Procedure:

1. Transfer turbine control to desired unit.
2. Verify that all unit analog calibration values are documented.
3. Shut down the Tracking unit with local 505 panel ESD.
4. Remove power to unit being replaced.
5. Carefully remove all plug-in terminal blocks from 505.
6. Replace respective 505 with another unit.
7. Apply power to the new unit.
8. Program the new unit with the identical or desired functionality.
9. If any of the 505's analog inputs, analog outputs, or actuator driver calibration values were changed from that of the 505's factory default values, we recommend that the new unit be calibrated to the same values or tunable list from the In Control unit loaded into this unit.

⚠WARNING

Do not calibrate the Tracking unit's actuator output when connected to the operating actuator's coil.

10. Install all unit terminal blocks into new unit.

11. Issue a ‘Reset’ command. At this point the new 505 will reset related faults or alarms and if they clear, will enter Tracking mode and output a trickle current (equal to half of the minimum actuator current) to verify actuator circuit continuity.
12. Transfer control to new unit if desired.
13. Issue a ‘Reset’ command to clear all redundant mode alarms.

Unit Recovery after a Failure

Upon a failure of either unit, full control is switched over to the healthy unit in a period of approximately 50 milliseconds. At this point, the failure can be corrected, unit program changed, etc., and the failed unit can be brought back in service via the following procedure.

Unit Recovery Procedure:
1. Investigate the root cause of the In Control unit Shutdown/Failure.
2. Once corrected, issue a ‘Reset’ command on the failed unit. At this point, the failed 505 will reset related faults or alarms, and if they clear, will enter Tracking mode and output a trickle current to verify actuator circuit continuity.
3. Transfer turbine control to desired unit.

The analog outputs of both the 505s should be used to drive two separate display channel/readouts.

Chapter 4.
Configuration Procedures

Program Architecture

The 505 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 5 for RUN Mode information). The Program Mode is used to configure the 505 for the specific application and set all operating parameters. The Run Mode is the normal turbine operation mode and is used to view operating parameters and run the turbine.

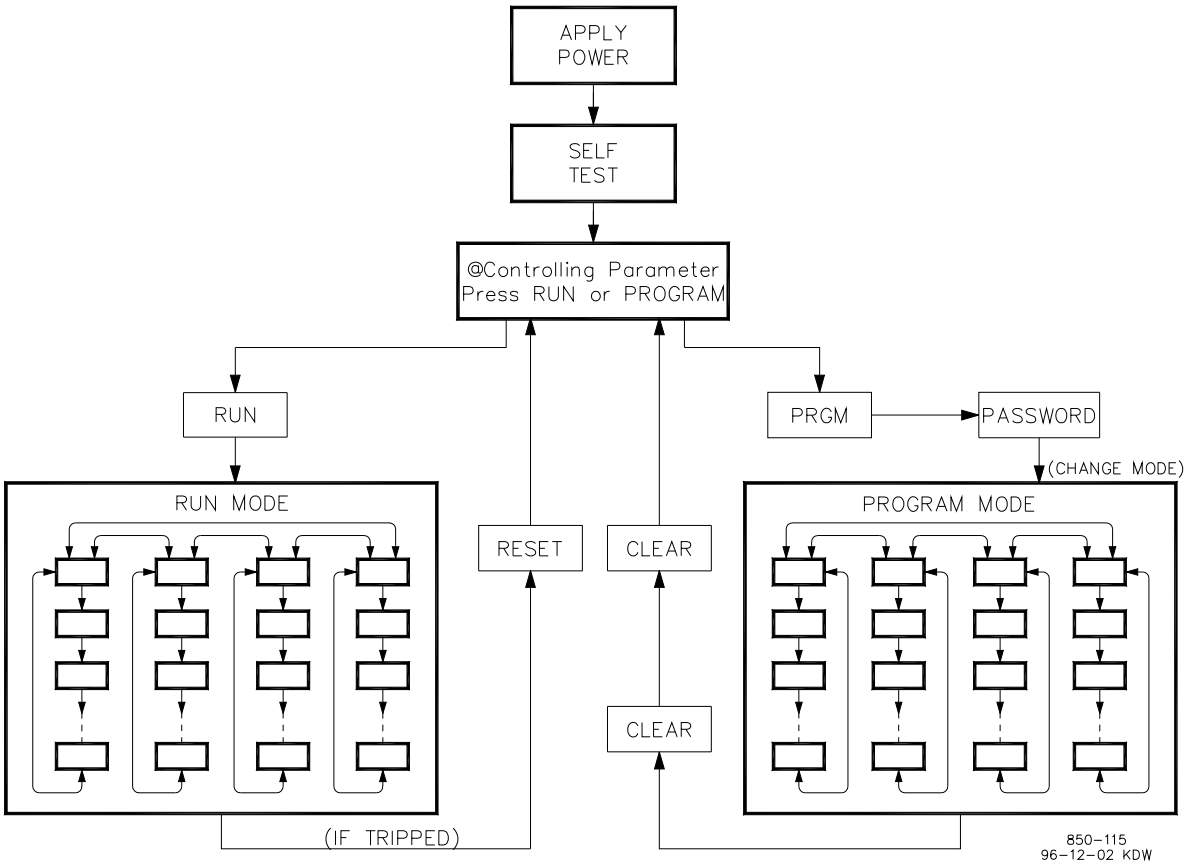


Figure 4-1. Basic Program Architecture

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.

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 set point value.

Programming the 505

Before the 505 can be used to operate any turbine, it must be configured with a valid program. A handy 505 Program Mode Worksheet is provided in Appendix A 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 505 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.

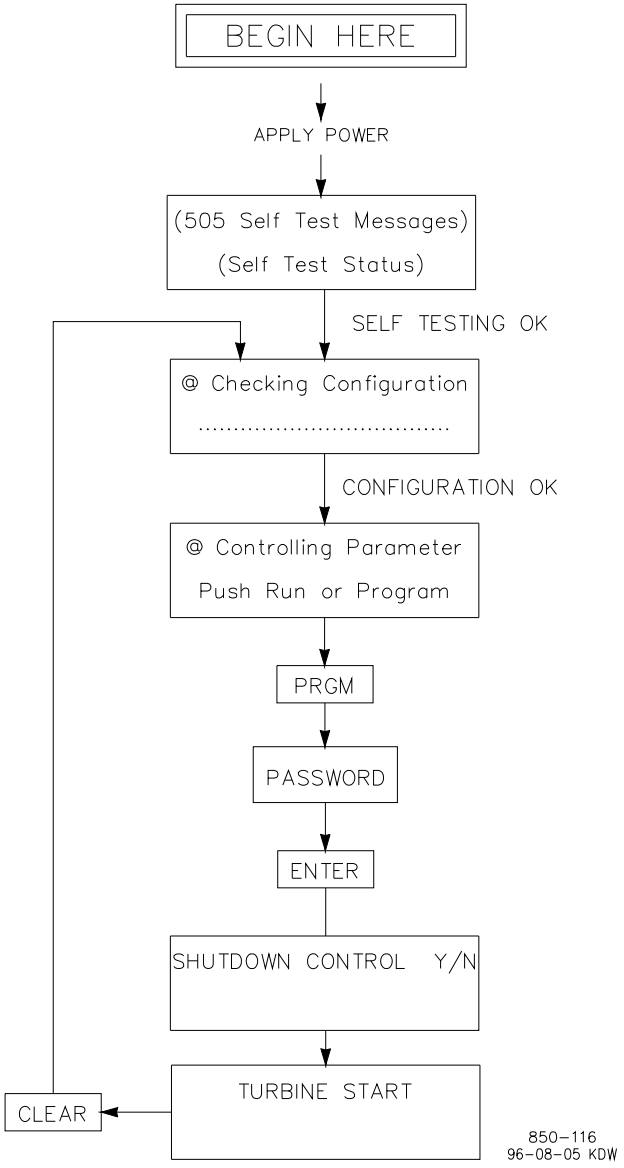


Figure 4-2. Initial 505 Program Mode Entry

The 505 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 505 keypad the SHUTDOWN CONTROL Y/N prompt will appear. If YES is pressed the 505 will issue a shutdown and the program mode will be accessed. If NO is pressed the 505 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 505 control. If power is removed from the 505 all saved values will return once power is restored. No batteries or back up power is required.

NOTICE

The field-configured portion of the 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 505. Figure 4-3 illustrates the 505 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.

Program Blocks

Figure 4-3 shows the 13 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 seven 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 Set Point Values–	to configure speed set points, overspeed trip set point, remote speed setting control and critical speed avoidance bands;
Operating Parameters–	to configure the unit for generator application, redundant operation, feed-forward and to use the local/remote function;
Driver Configuration–	to configure driver outputs, pressure compensation, and, if not using driver 2, to use driver 2 for a 4–20 mA readout;
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 pressure, temperature control information;
Readouts–	to configure analog readout options;
Relays–	to configure relay options;
Communications–	to configure Modbus communication options.

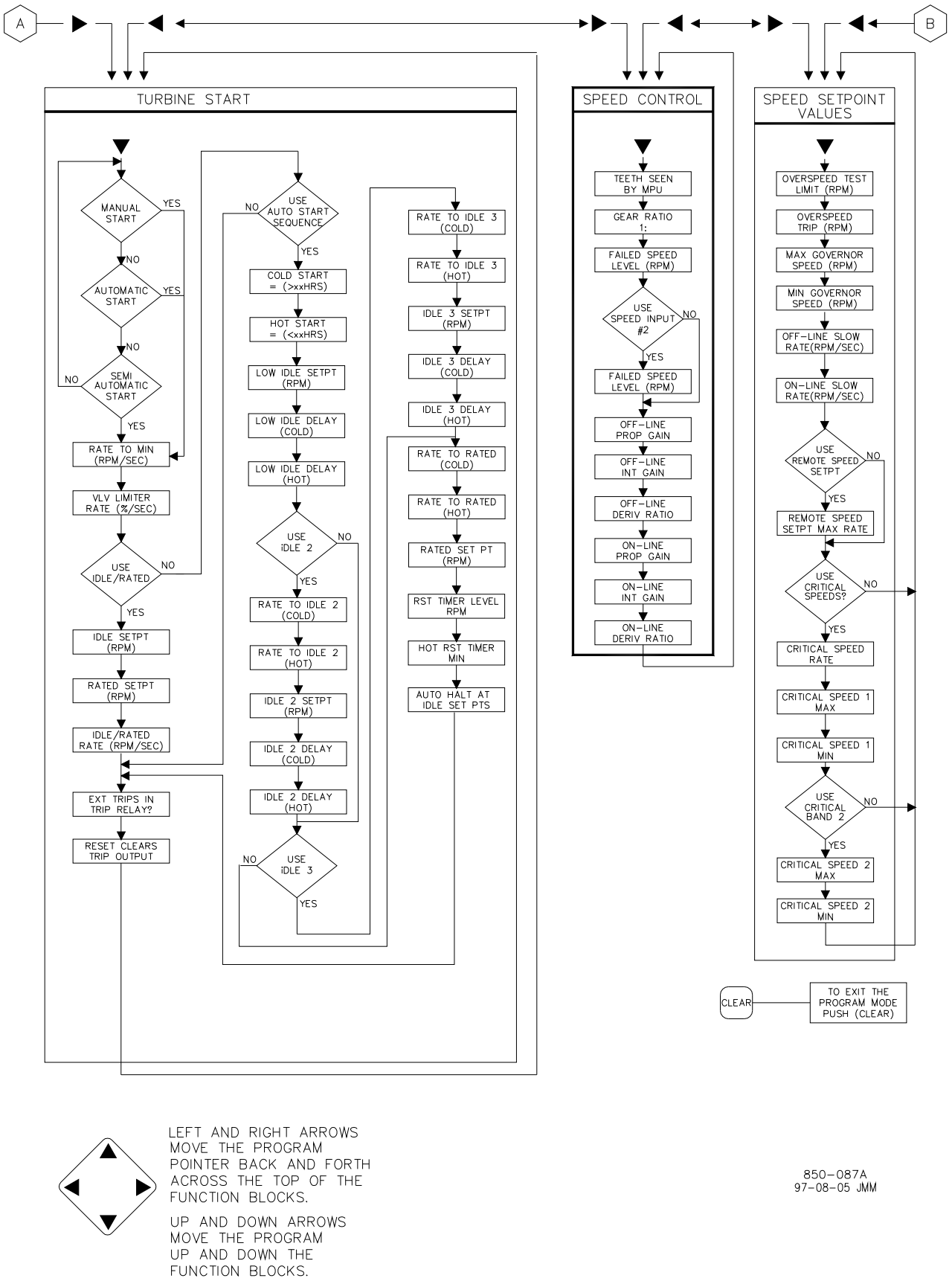


Figure 4-3a. Program Mode Blocks

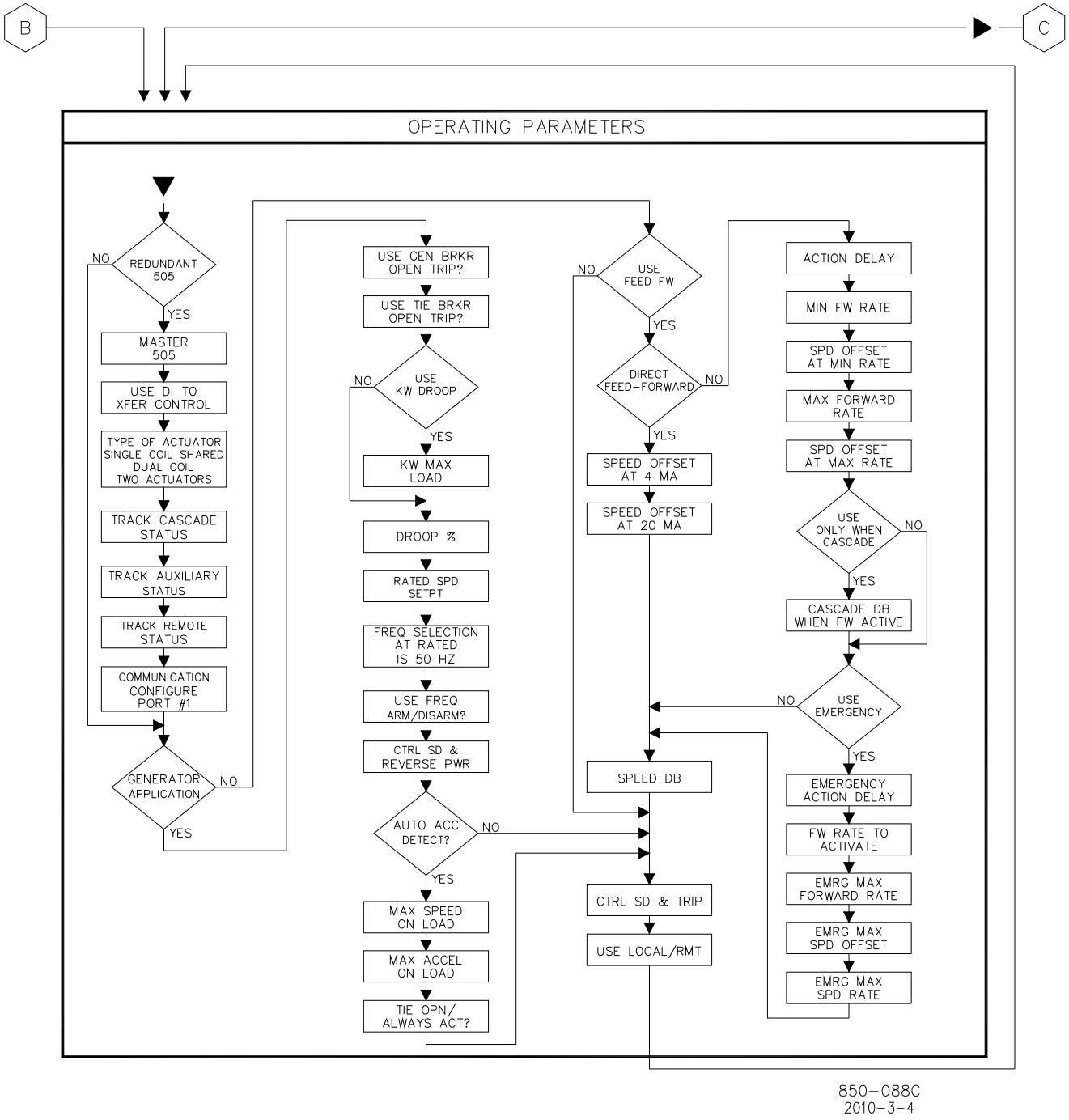


Figure 4-3b. Program Mode Blocks

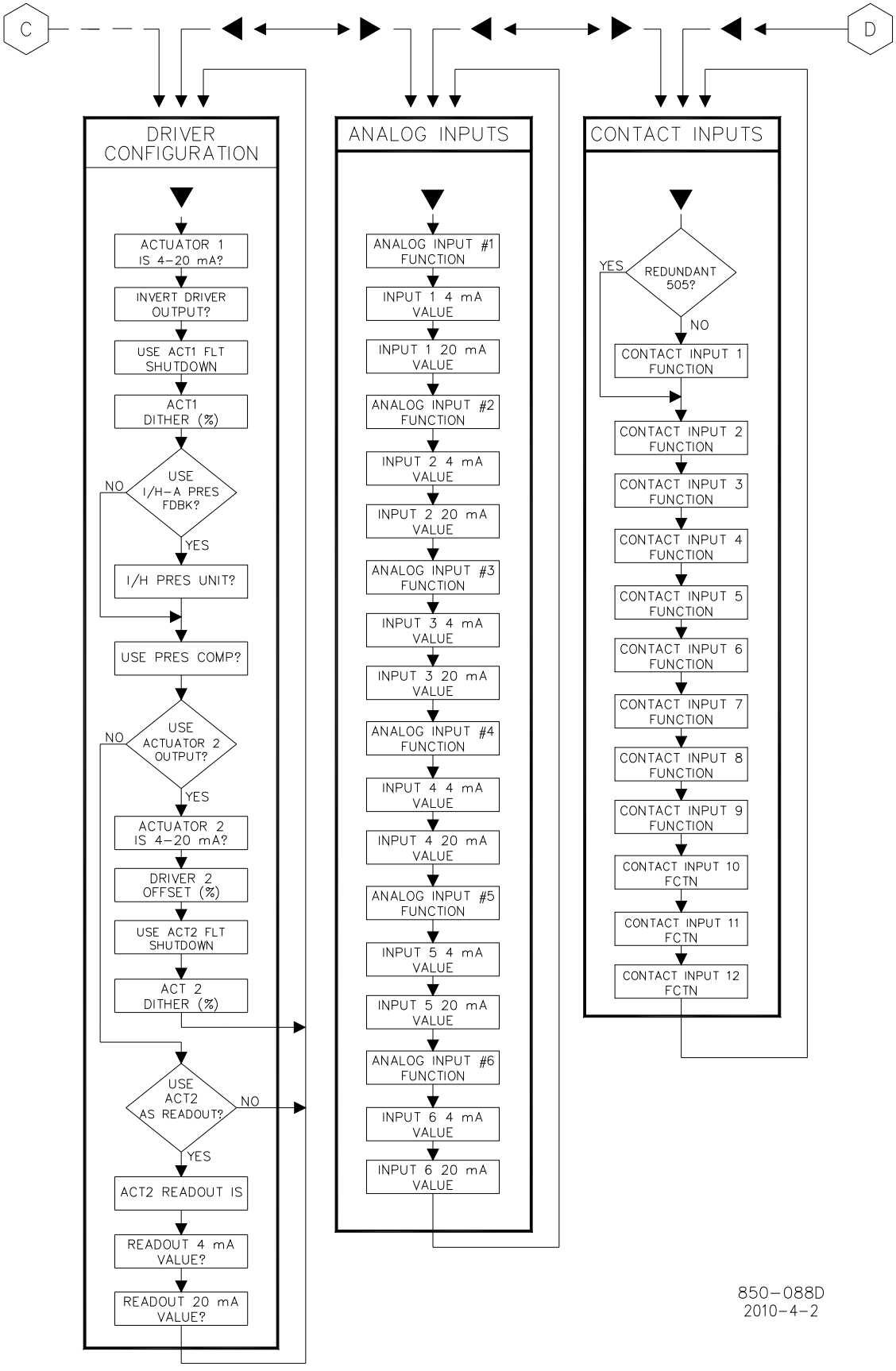


Figure 4-3c. Program Mode Blocks

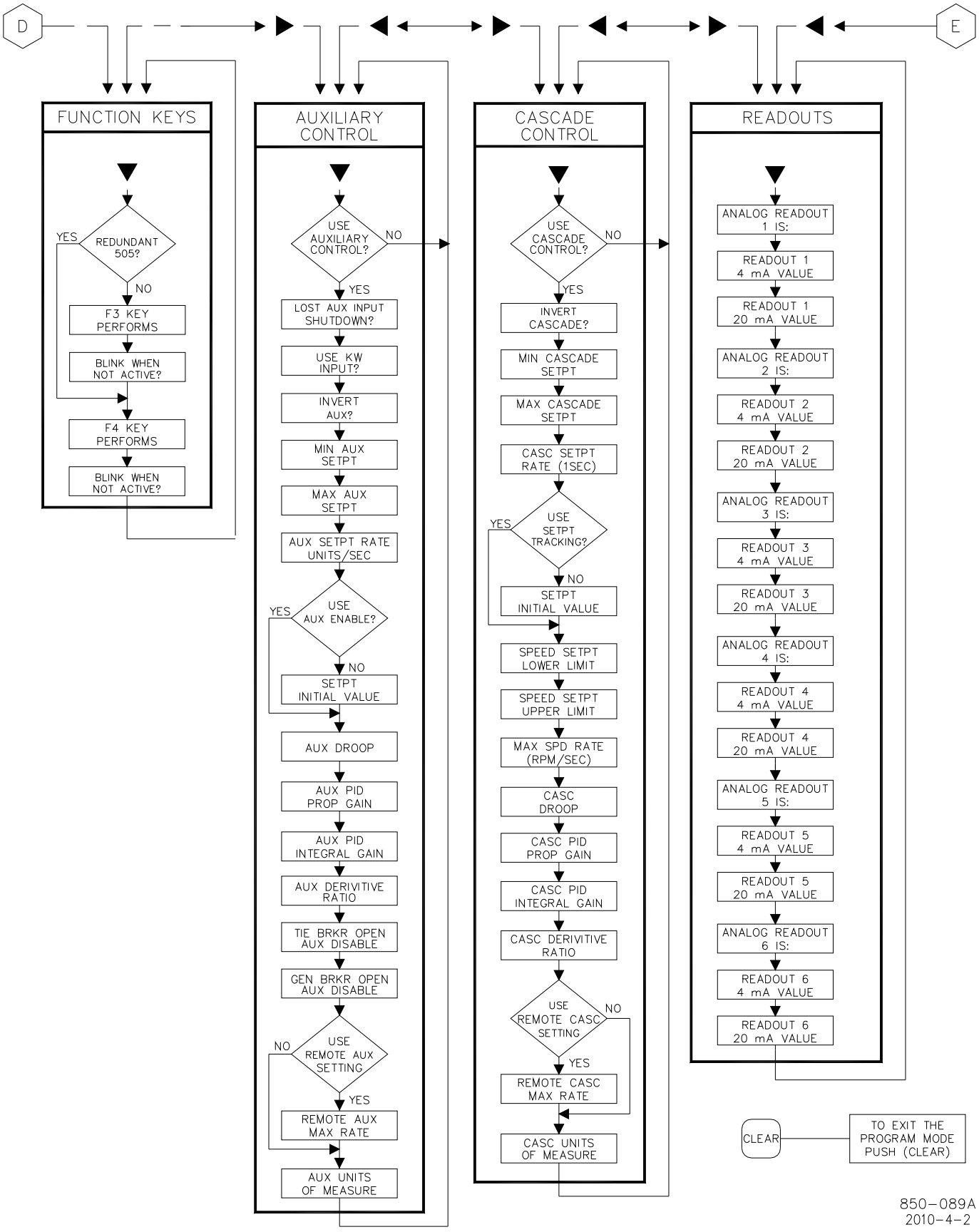


Figure 4-3d. Program Mode Blocks

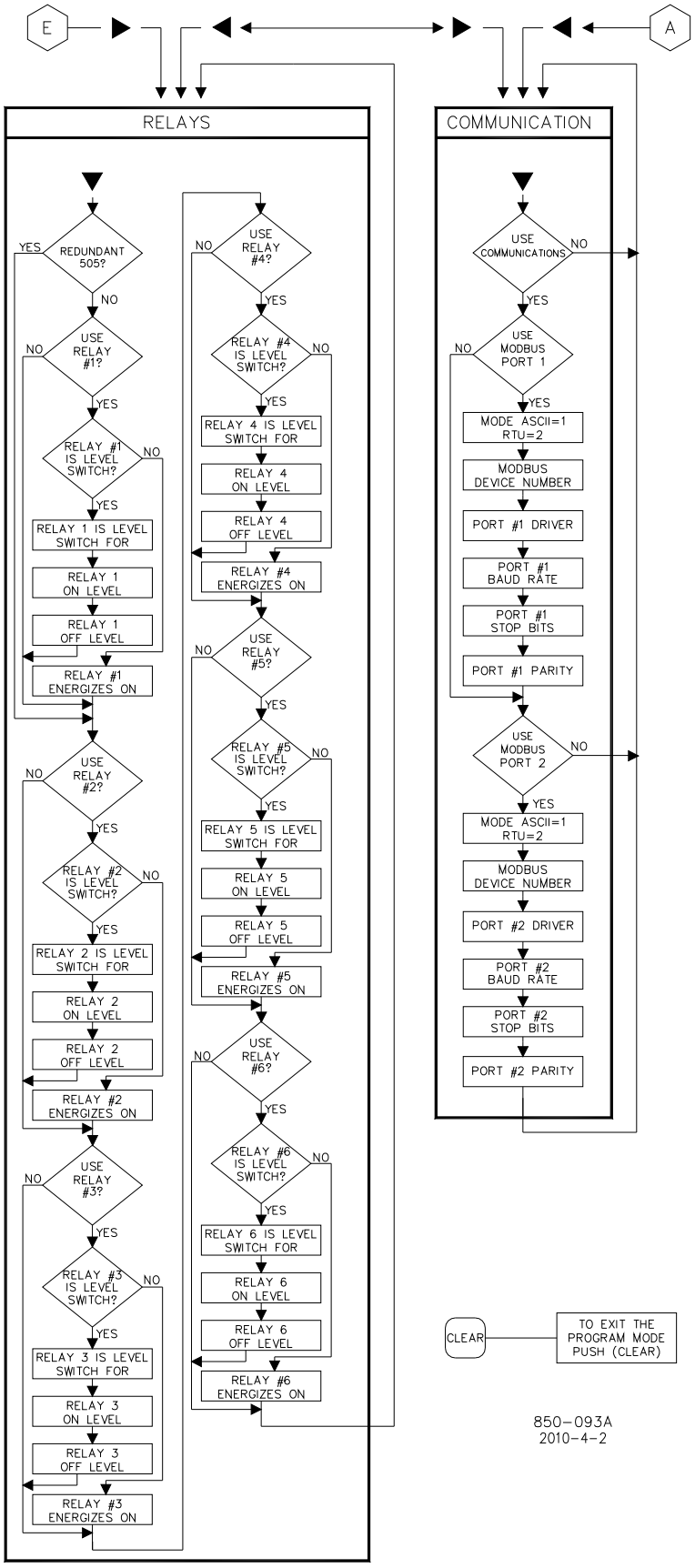


Figure 4-3e. Program Mode Blocks

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 505 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 Appendix A of this manual that should be completed/filled-in and used as a guide for your particular application. This worksheet can also be used for future reference to document your application program.

Turbine Start 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 actuator(s) automatically move to max position. Lastly, the operator slowly opens the trip-throttle valve until the governor takes control.

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

Select YES followed by the ENTER key to configure an automatic start mode. When configured for an automatic start mode, the 505 controls the turbine speed from zero up to the minimum control speed. The Automatic Start Sequence would be: Operator opens the T&T valve, then push RUN. The valve limiter opens automatically until the governor takes control.

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

Select YES followed by the ENTER key to configure a semiautomatic start mode. When configured, the 505 valve limiter must be manually opened by the operator, slowly, to open the control valve and bring the turbine speed from zero up to the minimum control speed. The Semi-automatic Start Sequence would be: Open the T&T valve, then push RUN. The valve limiter must then be raised by the operator until governor takes control.

(One of the three start modes must be selected before the unit will run.)

RATE TO MIN (rpm/s) **dflt= 10.0 (0.01, 2000)**

Enter the speed set point acceleration rate to minimum followed by the ENTER key. This is the rate the set point moves from zero to the lowest controlling speed on a start command (assuming the turbine is at zero speed). The minimum controlling speed will be either ‘idle’ if idle/rated is used or ‘low idle’ if the auto start sequence is used. If neither of these start-up features is used, the min speed will be the minimum governor speed set point.

VALVE LIMITER RATE (%/s) **dflt= 5.0 (0.1, 25)**

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

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 set point when Rated is selected through keypad, Modbus or external switch.

IDLE SETPT (rpm) **dflt= 1000 (0.0, 20000)**

Enter the Idle Speed set point desired followed by the ENTER key. This is the lowest speed control set point when using the Idle/Rated function.

RATED SETPT (rpm) **dflt= 3600 (0.0, 20000)**

Enter the Rated Speed set point desired followed by the ENTER key. This is the speed control set point that the unit accelerates to when using the Idle/Rated function.

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

IDLE/RATED SETPT RATE (rpm/s) **dflt= 5.0 (0.01, 2000)**

Enter the Idle/Rated rate (rpm/second) followed by ENTER. This is the at which the speed set point moves between Idle and Rated speed set points 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 505 automatically accelerates the speed set point to a programmable low idle speed and holds for a programmable time then ramps to a programmable high idle speed and holds for a programmable time then ramps to programmable rated speed set point. The start sequence can be actuated or halted through the keypad, Modbus or external switch.

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 set point will remain at this setting until the low idle delay/hold time has expired.

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

Enter the cold start hold time desired at low idle 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/seconds, that the turbine will wait/hold at the low idle speed when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold delays to determine the low idle hold time.

Use IDLE2? **dflt= True**

When TRUE, the speed reference will ramp to idle2 level when timer is passed.

When FALSE is selected, the speed reference will go to rated speed.

RATE TO IDLE2—COLD (rpm/s) **dflt= 5.0 (0.01, 500)**

Enter the cold start rate to idle2 followed by ENTER. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a cold start is determined.

RATE TO IDLE2—HOT (rpm/s) **dflt= 5.0 (0.01, 500)**

Enter the hot start rate to idle2 followed by ENTER. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to idle2 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 idle2 set point.

IDLE2 SETPT (rpm) **dflt= 1100 (0.0, 20000)**

Enter the idle2 Speed Setting followed by the ENTER key. This is the second hold speed when using the automatic start sequence. The speed set point will remain at this setting until the idle2 Delay/hold time has expired. (Must be greater than the 'Low Idle' Setting)

IDLE2 DELAY TIME—COLD (MINUTES) **dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at idle2 followed by ENTER. This is the programmable time, in minutes, that the turbine will wait/hold at the idle2 speed when a cold start is determined.

IDLE2 DELAY TIME—HOT (MINUTES) **dflt= 1.0 (0.0, 500)**

Enter the hot start hold time desired at idle2 followed by ENTER. This is the programmable time, in minutes, that the turbine will wait/hold at the idle2 speed when a hot start is determined. If the turbine has been shutdown for longer than the Hot time but shorter than the Cold time, the control will interpolate between the Hot and Cold delays to determine the hi idle hold time.

Use IDLE3? **dflt= True**

When TRUE, the speed reference will ramp to idle3 level when timer is passed.

When FALSE is selected, the speed reference will go to RATED speed.

RATE TO IDLE3—COLD (rpm/s) **dflt= 5.0 (0.01, 500)**

Enter the cold start rate to idle3 followed by ENTER. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to high idle when a cold start is determined.

RATE TO IDLE3—HOT (rpm/s) **dflt= 5.0 (0.01, 500)**

Enter the hot start rate to idle3 followed by ENTER. This is the programmable rate, in rpm per second, that the speed set point will accelerate at when moving to idle3 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 idle3 set point.

IDLE3 SETPT (rpm) **dflt= 1200 (0.0, 20000)**

Enter the idle3 Speed Setting followed by the ENTER key. This is the third hold speed when using the automatic start sequence. The speed set point will remain at this setting until the idle3 Delay/hold time has expired. (Must be greater than the ' Idle2' Setting)

IDLE3 DELAY TIME—COLD (MINUTES) **dflt= 1.0 (0.0, 500)**

Enter the cold start hold time desired at idle3 followed by ENTER. This is the programmable time, in minutes, that the turbine will wait/hold at the idle3 speed when a cold start is determined.

IDLE3 DELAY TIME—HOT (MINUTES) **dflt= 1.0 (0.0, 500)**

Enter the hot start hold time desired at idle3 followed by ENTER. This is the programmable time, in minutes, that the turbine will wait/hold at the idle3 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 idle3 hold time.

RATE TO RATED SETPT—COLD (rpm/s) **dflt= 5.0 (0.01, 500)**

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

RATE TO RATED SETPT—HOT (rpm/s) **dflt= 5.0 (0.01, 500)**

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

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

RATED SETPT (rpm) **dflt= 3000 (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 set point is reached, the start sequence is complete.

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

RST Timer Level (rpm) **dflt= 3000 (0.0, 20000)**

Enter the RST Timer Level setting followed by the ENTER key. This is the speed setting which is used to determine that the turbine has reached its HOT level. Speed must be above this level for five seconds to trigger the Hot RST Timer.

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

Hot RST Timer (min) **dflt= 0 (0.0, 200)**

Enter the reset LEVEL Setting followed by the ENTER key. This is the time needed, when RST Timer level is reached, to transfer the start-up parameters from fully COLD to fully HOT

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 set points. This feature would result in the unit automatically stopping/halting at the low idle set point and at the high idle set point. Also, if the unit is started and the speed is above the low idle set point, the sequence will be halted. Select NO to allow the control to perform its automatic start sequence routine without interruption.

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 505—typically due to one of the external trip inputs. Once reset, the unit will be 'Ready to Start' as soon as all external trip inputs are closed. When NO, the trip relay output will be de-energized on a 505 trip and will not energize until all trips have cleared and a 'Reset' command is given.

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, 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 505 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 505 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 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 5%.

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% .

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 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 0.5%.

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 Set Point 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 set point the control will increase to when overspeed testing the unit. The set point can only be raised to this level when the overspeed test function is being performed.

OVERSPEED TRIP LEVEL (rpm) **dflt= 1000 (0.0, 20000)**

Set the 505's overspeed trip level (in rpm) followed by the ENTER key. This is the governor overspeed trip set point only and is not to be used as ultimate overspeed protection.

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

MAX GOVERNOR SPEED SET POINT (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 SET POINT (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)

OFF-LINE SLOW RATE (rpm/s) **dflt= 5.0 (0.01, 100)**

Enter the speed set point slow rate in rpm per second followed by the ENTER key. This is the rate of speed change for normal operation when turbine is Off-line.

ON-LINE SLOW RATE (rpm/s) **dflt= 5.0 (0.01, 100)**

Enter the speed set point slow rate in rpm per second followed by the ENTER key. This is the rate of speed change for normal operation when turbine is On-line.

USE REMOTE SPEED SET POINT ? **dflt= NO (Yes/No)**

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

RMT SPEED SETPT MAX RATE (rpm/s) **dflt= 50.0 (0.01, 500)**

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

USE CRITICAL SPEEDS ? **dflt= NO (Yes/No)**

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 set point cannot be stopped. These bands are used to protect the turbine and driven device from speeds that have inherently high vibration.

(Must program either 'Idle/Rated' or 'Auto Start Sequence' to use critical speed avoidance. The lowest critical speed min must be greater than idle or low idle.)

CRITICAL SPEED RATE (rpm/s) **dflt= 50.0 (0.1, 2000)**

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

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.

REDUNDANT 505? **dflt= NO (Yes/No)**

Select YES followed by the ENTER key if the controller is going to be redundant with another 505

MASTER 505? **dflt= NO (Yes/No)**

Select YES followed by the ENTER key if the controller is going to be the Modbus MASTER unit. (One and only 1 of the units can be the Master)

(Next is for redundant configuration only)

USE DI TO XFER CONTROL? **dflt= NO (Yes/No)**

Select YES followed by the ENTER key if the controller is going to use a discrete input as the signal to select the In-Control unit. If this is left as NO then Transfer of Control will be via the F3 TRANSFER key on the keypad.

TYPE OF ACTUATOR? **dflt= Single Coil Shared**

Select the type of actuator for output 1 by using the ADJ arrows. Options for Single Coil Shared, Dual Coil, and Two Actuators are available.

TRACK CASCADE STATUS? **dflt= Yes (Yes/No)**

Select YES followed by the ENTER key if the controller is going to request Cascade enable during the control transfer (if configured).
If NO is selected, the operator will have manually enable cascade after transfer.

TRACK AUX STATUS? **dflt= Yes (Yes/No)**

Select YES followed by the ENTER key if the controller is going to request Auxiliary enable during the control transfer (if configured).
If NO is selected, the operator will have manually enable Auxiliary controller after transfer.

TRACK REMOTE STATUS? **dflt= Yes (Yes/No)**

Select YES followed by the ENTER key if the controller is going to request Remote enable during the control transfer (if configured).
If NO is selected, the operator will have manually enable Remote controller after transfer.

COMMUNICATION **Configure Port #1!**

This is a prompt only to notify the user that for Redundant operation they must configure Port 1 in the Configuration Communications menu.

(End of redundant menus)

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 set point will instantly reset to the 'Gen Open Set Point' which is defaulted to 50 rpm below rated speed.

USE TIE BREAKER OPEN TRIP? **dflt= NO (Yes/No)**

Select YES 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 set point will instantly reset to the speed last seen by the unit and move to the 'Rated Speed Set Point' and an alarm is issued. If NO and the generator breaker is open, there is only an alarm when the utility tie breaker opens.

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.

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%.

RATED SPEED SET POINT (rpm) **dflt= 3600 (0.0, 20000)**

Set the generator's rated speed set point 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)*

FREQUENCY SELECTION **dflt 50 Hz(50 Hz, 60 Hz)**

Set the generator's frequency at rated speed set point followed by the ENTER key.

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 LOAD SHARING)

CTRL SD & REVERSE PWR? **dflt = No (Yes/No)**

Set to YES if reverse power is allowed during a controlled shutdown. Set to NO if a controlled SD should ramp the speed reference to "min load" speed and wait for the Generator Breaker Open signal before continuing the shutdown.

AUTO ACCEL DETECT? **dflt = No (Yes/No)**

Set to YES if using the pre-acting acceleration feature, followed by the ENTER. This parameter enables acceleration detection logic that will help the 505 prevent an overspeed trip when load rejection occurs. The demand is driven to a "no load" value, as described under "Load Rejection" in this manual, when the Gen Breaker is opened or if the Gen Breaker is closed but an acceleration and speed above the configured values are detected, or if configured, when the Tie Breaker is opened.

MAX SPD on LOAD? **dflt = 3600 (250, 20000)**

Set the maximum speed when the unit is loaded (on-line). This value must be between Rated and Max Governor. This value determines the speed above which the load rejection logic is enabled as long as the generator breaker is closed.

MAX ACCEL on LOAD? (rpm/s) **dflt = 200(10, 2000)**

Set maximum possible acceleration when the unit is loaded (on-line), followed by the ENTER key. If turbine acceleration above this parameter is detected and turbine speed is above the "Max Spd Unload" value, then the load rejection logic is triggered.

TIE OPN/ALWAYS ACT? **dflt = No (Yes/No)**

Set to YES if using the Tie breaker opening to enable the load rejection logic followed by the ENTER.

USE FEED-FORWARD? **dflt = No (Yes/No)**

Set to YES if using the feed-forward loop followed by the ENTER.

The feed-forward loop allows an analog input representing the anti-surge valve demand to offset (bias) the 505's speed reference in order to assist the anti-surge controller. This bias then slowly decreases back to 0 rpm offset in the configured feed-forward action delay.

DIRECT FEED-FORWARD? **dflt = No (Yes/No)**

Set to YES if using the feed-forward loop as direct command followed by the ENTER.

If YES is selected, the feed-forward speed bias will be directly proportional to the 4–20 mA signal. The speed bias, when using direct feed-forward, does not slowly reduce over time. This feature proportionally affects the speed reference.

ACTION DELAY? (s) **dflt = 180 (0,1000)**

Only when 'Direct feed-forward?' = NO. Set the minimum response time (lag) needed to remove the effect of the feed-forward loop. After a feed-forward event, when the speed reference is biased by the feed-forward loop, this parameter determines how long it takes (minimum) for the offset to ramp back to 0 rpm (no speed reference offset). Essentially it is the duration of the feed-forward action.

MIN FORWARD RATE (%/s) **dflt = -100(-100,-1)**

Set the minimum effective rate (negative value) of the feed-forward signal, when decreasing, followed by the ENTER. This sets the highest level of response for the feed-forward loop based on the 4-20 mA signal's rate of decrease.

SPD OFFSET AT MIN RATE (rpm) **dflt =-100(-1000,0)**

Set the speed offset at the Min Forward Rate (%/s) followed by the ENTER. This sets the largest negative offset that can be provided by the feed-forward loop. It is the amount the speed reference will be biased (RPM) when the Analog Input decreases by the "Min Forward Rate".

MAX FORWARD RATE (%/s) **dflt = 100(1,100)**

Set the maximum effective rate (positive value) of the feed-forward signal, when increasing, followed by the ENTER. This sets the highest level of response for the feed-forward loop based on the 4-20 mA signal's rate of increase.

SPD OFFSET AT MAX RATE (rpm) **dflt = 100 (0,2000)**

Set the speed offset at the Max Forward Rate (%/s) followed by the ENTER. This sets the largest positive offset that can be provided by the feed-forward loop. It is the amount the speed reference will be biased (RPM) when the Analog Input increases by the "Max Forward Rate".

USE ONLY WHEN CASCADE? **dflt = Yes (Yes/No)**

Set to YES if the feed-forward loop can only be enabled when cascade is enabled, followed by the ENTER. If set to NO, then Feed-Forward can be enabled in both speed or cascade control.

CASC DB WHEN FW ACTIVE? **dflt = 0.1 (0,50)**

Set the cascade dead band when Feed-Forward is enabled, followed by the ENTER. This value directly sets the DB input on the Cascade PID.

USE EMERGENCY? **dflt = No (Yes/No)**

Only when 'Direct feed-forward?' = NO. Set to YES if using the feed-forward emergency loop followed by the ENTER. This loop can be configured to provide a larger feed-forward response. For example, when the compressor is extremely close to a surge condition and the anti-surge valve demand moves at a greater rate, this can be detected by this loop and a larger offset than the normal feed-forward response can be introduced. This response can also have a much shorter duration so that it does not cause problems for the anti-surge controller rather than help it. The Emergency Feed-Forward Loop effects overlap the normal Feed-Forward Loop; they are not summed. The Emergency Feed-Forward Loop acts only in the positive direction.

EMERGENCY ACTION DELAY (s) **dflt = 10 (2,100)**

Set the response time (lag) needed to remove the effect of the emergency feed-forward loop. After an emergency feed-forward event, when the speed reference is biased by the emergency feed-forward loop, this parameter determines how long it takes for the emergency offset to ramp back to 0 rpm (no speed reference offset). Essentially it is the duration of the emergency feed-forward action. After this time expires, only the normal Feed-Forward will be in effect until its Action Delay time expires.

FW RATE TO ACTIVATE (%/s) **dflt = 10(2,100)**

Set the minimum required rate of increase (%/s) to activate the emergency loop, followed by the ENTER. This is the rate at which the Feed-Forward analog input has to increase in order to trigger the Emergency Feed-Forward action.

EMRG MAX FORWARD RATE (%/s) **dflt = 100 (7,100)**

Set the maximum effective rate (positive direction) of the feed-forward analog input, when increasing, followed by the ENTER. This sets the highest level of response for the Emergency Feed-Forward Loop based on the 4-20 mA signal's rate of increase. Must be greater than 'FW RATE TO ACTIVATE'.

EMRG MAX SPD OFFSET **dflt = 300 (0,2000)**

Set the speed bias at "Emerg Max Forward Rate", followed by the ENTER. When the Emergency Feed-Forward action is triggered, this parameter defines the maximum speed offset that will be applied by the Emergency Feed-Forward Loop when the analog input increases at the "Erg Max Forward Rate".

EMRG MAX SPEED RATE (rpm/s) **dflt = 500 (0,2000)**

Set the max speed bias rate when Emergency Feed-Forward is activated, followed by the ENTER. This limits how fast the emergency action can change the speed offset and, hence, limits how fast the speed reference is increased when the Emergency Feed-Forward Loop is activated.

SPEED OFFSET AT 4 mA (rpm) **dflt = -100 (-1000,0)**

Only when direct action is selected, set the speed bias applied when the Feed-Forward Analog Input is at 4 mA, followed by ENTER. The range of the values configured for the speed offset at 4 mA and 20 mA determines the amount that speed reference is changed when the Feed-Forward Analog Input current changes. If the analog input current is increased/decreased by 25% while Direct Feed-Forward is enabled, for example, then the speed reference will be increased/decreased by 25% of the range between 'Speed Offset at 4 mA' and 'Speed Offset at 20 mA'.

SPEED OFFSET AT 20 mA (rpm) **dflt = 100 (0,2000)**

Only when direct action is selected, set the speed bias applied when the Feed-Forward Analog Input is at 20 mA, followed by ENTER. The range of the values configured for the speed offset at 4 mA and 20 mA determines the amount that speed reference is changed when the Feed-Forward Analog Input current changes. If the analog input current is increased/decreased by 25% while Direct Feed-Forward is enabled, for example, then the speed reference will be increased/decreased by 25% of the range between 'Speed Offset at 4 mA' and 'Speed Offset at 20 mA'.

SPEED [Feed-Forward] DB (rpm) **dflt = 0.1 (0.1,100)**

Set the dead band for the Feed-Forward speed bias, followed by the ENTER. This setting is needed if the Feed-Forward Analog Input signal is noisy.

(end of FW)

CTRL SD & TRIP ? **dflt= No(Yes/No)**

Set to YES if when controlled SD is completed, the unit must be Tripped, followed by the ENTER. If set to NO, the unit will remain in a stopped but reset state after a controlled shutdown.

IMPORTANT

For Redundant configurations, the "Control Stop & Trip" setting should be configured to "yes". This will shut down the "Tracking" unit at the end of the controlled shutdown. If the "Control Stop & Trip" setting is configured as "no", the "Tracking" unit will trip on an MPU failure as the Unit rolls down.

For Redundant configurations of units with Software P/N: 5418-2629 Rev. A and earlier: If the "Control Stop & Trip" is configured as "yes", at the end of the Normal Shutdown, control will Transfer to the "Tracking" unit and the shutdown must be completed on that unit.

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.

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 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 output(s) followed by the ENTER key. This is normally set to NO

When Set to YES, unless contact input #1 or front panel SD input are used, the actuator output will go to 20 mA at SD

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 505 will issue a shutdown if Actuator 1 has a fault. If NO, an actuator fault alarm will be issued when a fault is detected. An actuator fault will be determined if the current drops below or goes above the failure levels, basically checking for an open or a short circuit in the actuator wires/coil.

ACTUATOR 1 DITHER (%) dflt= 0.0 (0.0, 10)

Enter the dither percentage 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.

USE I/H-A PRES FDBK ? dflt= No (Yes/No)

Select YES followed by ENTER if the actuator pressure feedback is sent back to the control.

I/H PRES UNIT ?

Select the Unit using Adjust up/dw followed by ENTER.
(BarG, kpaG, Psig, atm, none)

USE PRESS COMP ? dflt= NO (Yes/No)

Select YES followed by ENTER to enable actuator 1 inlet pressure compensation. NO disables this function

USE ACTUATOR NUMBER 2? dflt= NO (Yes/No)

Select YES followed by ENTER if using both Actuator outputs (Act 1 & Act 2). If NO skip to ‘Use Actuator 2 as a Readout’.

ACTUATOR 2 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.

ACTUATOR 2 OFFSET (%) dflt= 0.0 (0.0, 100)

Enter the percentage actuator #1 is opened when actuator #2 begins to open followed by the ENTER key. Enter 0.0 if both actuators open together.

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 505 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 DITHER (%) dflt= 0.0 (0.0, 10)

Enter the dither percentage 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.

USE ACTUATOR 2 AS A READOUT? dflt= NO (Yes/No)

Select YES followed by ENTER to use the actuator output as an additional readout. When set to NO, the actuator #2 output is not used for anything. This option is available for customers who do not need two actuator drivers and would like an additional readout.

ACTUATOR 2 READOUT IS: (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 ACTUATOR 2 READOUT

Actual Speed	Rmt Cascade Setpt
Speed Set Point	Auxiliary Input
Remote Speed Setpt	Auxiliary Set Point
Sync/Load Share Input	Rmt Auxiliary Setpt
KW Input	Valve Limiter Set Point
Cascade Input	Actuator 1 Readout
Cascade Set Point	Inlet Header Press Input

(The function that the readout uses must be programmed or an error message will occur. For example, to use the Cascade Set Point readout, the 'Use Cascade' function must be programmed)

READOUT 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 20 mA VALUE (UNITS) dflt= 0.0 (-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)

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 505) 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 **(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

Remote Speed Setpt	Remote Cascade Setpt
Synchronizing Input	Auxiliary Input
Sync/Load Share Input	Remote Aux Setpt
KW/Unit Load Input	Inlet Header Press Input
Cascade Input	(Not Used)
IH-A pressure	Feed-forward Input
Remote Droop	

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 Inputs # 2 through # 6 are entered following the same rules as described for Analog Input # 1.

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.

In Redundant 505 configurations, it is important to connect all External Turbine Trip commands to both units. The last two TRIPS (External Trip 9 and 10) are unique in that they will trip the control to which they are connected but attempt to Transfer control to the tracking unit. If the same external trip is connected to both controls, it will trip the turbine just like the first eight.

REDUNDANT 505? **dflt= NO (Yes/No)**

Select YES followed by the ENTER key if the controller is going to be redundant with another 505, it will configure Contact Input 1 for Other Unit OK and skip the function options for Contact Input 1

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.

CONTACT INPUT OPTIONS

(Not Used)
Generator Breaker
Utility Tie Breaker
Overspeed Test
External Run
Start Permissive
Idle/Rated
Halt/Continue Auto Start Sequence
Override MPU Fault
Select On-Line Dynamics
Local/Remote
Remote Speed Setpt Enable
Sync Enable
Freq Control Arm/Disarm
Casc Setpt Raise
Casc Setpt Lower
Casc Control Enable
Remote Casc Setpt Enable
Aux Setpt Raise
Aux Setpt Lower
Aux Control Enable
Remote Aux Setpt Enable
Valve Limiter Open
Valve Limiter Close
External Trip 2
External Trip 3
External Trip 4
External Trip 5
Controlled Shutdown
External Trip 7
External Trip 8
External SD/XFER 9
External SD/XFER 10
External Alarm 1
External Alarm 2
External Alarm 3
External Alarm 4
External Alarm 5
External Alarm 6
External Alarm 7
External Alarm 8
External Alarm 9
Select In-Control Unit
Monitor Only (no function)
I/H-Act1 Flt
I/H-Act2 Flt
Monitor Only (no function)
External Trip 6
Speed Forward Enable
Instant Min Gov Speed
Select Hot Start

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

IMPORTANT

The I/H-Act1 and I/H-Act2 Flt Contact Input options can be configured to provide more protection in case of an actuator failure. These can be used as the input for a Woodward CPC fault relay output, for example. When configured, this input will produce an alarm in the 505 when it is operating as a standalone unit or a Shutdown/Transfer condition if the unit is configured as a redundant 505.

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 / TRANSFER
*If the unit is configured for redundancy, then the F3 key is automatically configured for as a TRANSFER command. The **F3 key will be illuminated on the unit that is In-Control** and this key will allow the user to transfer control from this unit to the other unit. With the Communication interface link healthy, the control should transfer almost bumplessly from unit to unit. If the Communication interface link between the units is faulted, then the Transfer will be disabled, but the user will have the option of overriding this condition if needed (in case the other unit is not functional).*

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.
(Not Used)
Local/Remote
Idle/Rated
Halt/Continue Auto Start Sequence
Remote Speed Setpt Enable
Sync Enable
Freq Arm/Disarm
Transfer In-Control Unit (F3 Only)
Casc Control Enable
Remote Casc Setpt Enable
Aux Control Enable
Remote Aux Setpt Enable
Energize Relay Output
Feed-forward 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 IN CNTRL? **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 set point. An example where the invert would be YES is for turbine inlet pressure control.

MIN AUX SET POINT (UNITS) **dflt= 0.0 (-20000, 20000)**

Set the min AUX set point followed by ENTER. This value is the minimum set point value that the auxiliary set point can be decreased/lowered to (lower limit of AUX set point).

MAX AUX SET POINT (UNITS) **dflt= 100 (-20000, 20000)**

Set the max AUX set point followed by ENTER. This value is the maximum set point value that the auxiliary set point can be increased/raised to (upper limit of AUX set point).

(Must be greater than the 'Min Aux Setpt' Setting)

AUX SET POINT RATE (UNITS/s) **dflt= 5.0 (0.01, 1000)**

Set the AUX set point rate followed by ENTER. This value is the rate (in units per second) at which AUX set point 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 set point, the Aux PID controller would decrease and take control of the valve until the KW level decreases below the maximum kW(Aux) setting. Alternatively, if the Aux enable is used, the Aux set point tracks the Aux input. When enabled, the Aux PID takes control of the valve and the speed set point tracks the speed/load of the unit for bumpless transfer between modes.

SETPT INITIAL VALUE (UNITS) **dflt= 0.0 (-20000, 20000)**

Set the set point initialization value followed by ENTER. When not using the Aux Enable function, this is the value that the auxiliary set point initializes to upon power- up or exiting the program mode.

(Must be less than or equal to the 'Max Aux Set Point' 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%.

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 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 3%.

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 set point to be adjusted from an analog input. *(Must program a 'remote auxiliary set point' analog input)*

REMOTE AUX MAX RATE (UNITS/s) **dflt= 5.0 (0.1, 1000)**

Enter the maximum rate at which the remote input will move the aux set point 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 valve needs to open when the input exceeds the set point. An example where the invert would be YES is for turbine inlet pressure control.

MIN CASCADE SET POINT (UNITS) **dflt= 0.0 (-20000, 20000)**

Set the minimum cascade set point followed by ENTER. This value is the minimum set point value that the cascade set point can be decreased/lowered to (lower limit of cascade set point).

MAX CASCADE SET POINT (UNITS) **dflt= 100 (-20000, 20000)**

Set the maximum cascade set point followed by ENTER. This value is the maximum set point value that the cascade set point can be increased/raised to (upper limit of cascade set point).

(Must be greater than the 'Min Cascade Setpt' Setting)

CASC SETPT RATE (UNITS/s) **dflt= 5.0 (0.01, 1000)**

Set the cascade set point rate followed by ENTER. This value is the rate (in units per second) at which cascade set point moves when adjusted.

USE SET POINT TRACKING? **dflt= NO (Yes/No)**

Select YES or NO followed by ENTER. If YES, the cascade set point tracks the cascade input to provide bumpless transfer to cascade control when it is enabled. If NO, the cascade set point remains at the last position except on power-up or exiting the program mode.

SETPT INITIAL VALUE (UNITS) **dflt= 100.0 (-20000, 20000)**

Set the set point initialization value followed by ENTER. When not using the Set Point Tracking function, this is the value that the cascade set point initializes to upon power-up or exiting the program mode.

(Must be less than or equal to the 'Max Cascade Setpt' Setting)

SPEED SET POINT LOWER LIMIT (rpm) **dflt= 3605 (0.0, 20000)**

Set the minimum speed set point that the cascade controller can lower the speed set point to 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 SET POINT UPPER LIMIT (rpm) **dflt= 3780 (0.0, 20000)**

Set the maximum speed set point that cascade controller can raise the speed set point to followed by the ENTER key.

(Must be less than or equal to the 'Maximum Governor Speed Setpt' Setting)

MAX SPEED SET POINT RATE (rpm/s) **dflt= 20 (0.1, 100)**

Set the maximum rate at which the cascade control can vary the speed set point 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%.

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 5%.

CASCADE PID INTEGRAL GAIN (%) **dflt= 0.3 (0.001, 50.0)**

Enter the cascade PID integral 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 0.3%.

CASCADE PID DERIVATIVE RATIO (%) **dflt= 100 (0.01, 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 set point to be adjusted from an analog input.

(Must program a 'remote cascade set point' analog input

RMT CASCADE MAX RATE (UNITS/s) **dflt= 5.0 (0.1, 1000)**

Enter the maximum rate at which the remote input will move the cascade set point 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 Set Point 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

Actual Speed	Rmt Auxiliary Setpt
Speed Set Point	Valve Limiter Set Point
Remote Speed Setpt	Actuator Demand Readout
Load Share Input	Actuator 1 Readout
Sync Input	Actuator 2 Readout
KW Input	Act 1 Valve Demand
Cascade Input	Act 2 Valve Demand
Cascade Set Point	Inlet Header Press Input
Rmt Cascade Setpt	IH-A press Readout
Auxiliary Input	(Not Used)
Auxiliary Set Point	

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.

If the unit is configured for redundancy, Relay #1 is automatically configured as the Redundant Link Relay between the two controls.

REDUNDANT 505? dflt= NO (Yes/No)

Select YES followed by the ENTER key if the controller is going to be redundant with another 505, it will configure Relay #1 for Unit OK and skip the function options for Relay #1

USE RELAY # 1? **dflt= NO (Yes/No)**

Press Set to 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.

LIST OF OPTIONS FOR LEVEL SWITCH

Actual Speed Level	Aux Set Point Level
Speed Set Point Level	Valve Limiter Level
KW Input Level	Actuator Demand (hand valve)
Sync/Load Share Level	Act 1 Output Level
Cascade Input Level	Act 2 Output Level
Cascade Set Point Level	Inlet Header Press Level
Aux Input Level Switch	

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 desired hysteresis 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	Sync Enabled
Trip Relay (additional trip relay output)	Sync or Load Share Enabled
Alarm Condition (energized)	Alarm Condition (de-energized)
NOT USED	Load Share Control Enabled
505 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	Valve Limiter in Control
Frequency Control Armed	F3 Key Selected
Frequency Control	F4 Key Selected
Modbus Selected	In-Control Unit
Redundant Link Relay	Backup Unit (Tracking)
Other Unit Failed	Unit OK (No SD)
Reset Pulse (2 sec)	Open Generator CMD
Feed-Forward Active	Feed-Forward Enabled

Relay outputs # 2 through # 6 are entered following the same rules as described for Relay output # 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 505. 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.

IMPORTANT

For Redundant functionality – YES must be selected and Port 1 must be configured as follows:

ASCII	**Not applicable – set by 505 software**
Modbus Device	**1 (Slave 1)**
Port Driver	**2 (RS-422)**
Baud Rate	**10 (38400)**
Stop Bits	**1 (One)**
Parity	**1 (None)**

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.

MODE: 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.

PORT1 BAUD RATE **dflt= 10 (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	

PORT 1 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.

PORT 1 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

Once the programming steps have been completed, the Program Mode can be exited (refer to Figure 4-4 Exiting the Program Mode). To exit the Program mode the “CLEAR’ key is pressed twice. This initiates the 505 to save the configuration and to begin a Configuration Check procedure. If there are no errors in the programming, the 505 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.

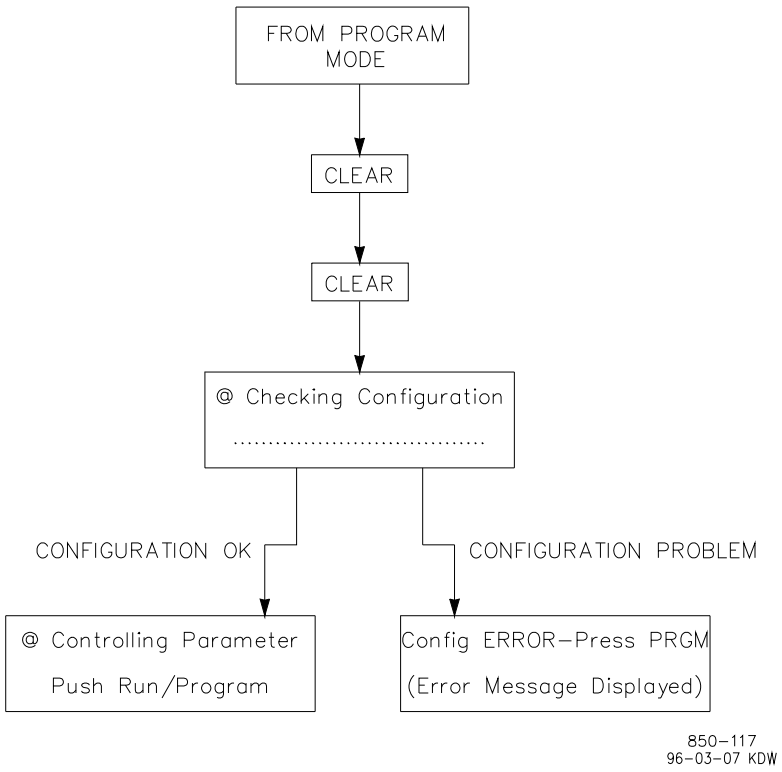


Figure 4-4. Exiting the Program Mode

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 505's hardware/speed sensing circuitry. The frequency input of the speed sensor must be less than this value. The gear the speed sensor is mounted on may need to be changed to one with less teeth, this will decrease the frequency seen by the speed probes.

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 set point 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 set point (when using idle/rated) or the low idle set point (when using the auto start sequence) was programmed within a critical speed avoidance band.

Hi Idle set in Critical—The hi idle speed set point (when using the auto start sequence) was programmed within a critical speed avoidance band.

Idle Program Errors

Idle Setpt > Min Gov—The Idle Speed set point was programmed at a higher speed than the minimum governor speed set point.

Rated Speed > Max Gov—The Rated Speed set point was programmed at a higher speed than the maximum governor speed set point.

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.

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 Set Point Enable but Remote Cascade Set Point 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 Set Point but Remote Cascade Set Point was not programmed under the Cascade Program Block.

No Rmt Speed Input Prgm—The remote speed set point control function was programmed but no remote speed set point 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 set point control function was programmed but no remote cascade set point 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 set point control function was programmed but no remote auxiliary set point 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 Set Point Enabled but Remote Cascade Set Point 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 Set Point Enabled but Remote Cascade Set Point 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 Set Point Enabled but Remote Cascade Set Point 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 Set Point but Cascade Control was not programmed under the Cascade Program Block.

Driver 2 Readout Err—The Actuator/Driver 2 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, driver 2 is programmed for Cascade Set Point but Cascade Control was not programmed under the Cascade Program Block.

Valve/Actuator Calibration & Test

Before initial operation or after a turbine overhaul where any actuator or valve travel may have been affected, the below Valve Calibration procedure should be followed to insure that the 505 is correctly calibrated to the turbine control valve(s). When calibration is complete, 0 to 100% actuator position as displayed by the 505 must equal 0 to 100% actual valve travel.

After a valid 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 overtravel at the minimum stop is achieved (1%). This assures that each valve can fully close to completely shut off the steam flow to the turbine.

Driver Limits	**20–160 mA Range**	**4–20 mA Range**
Overcurrent	217 mA	26 mA
Undercurrent	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 505 to valve resolution.

Figures 4-5 and 4-6 graphically show the steps available to stroke the actuator output(s). The stroking option is only available when the 505 control is in a shutdown state. Also, the screens displayed varies with the number of actuators programmed.

In Redundant operation, it is important to only calibrate one 505 actuator at a time and have the other unit shut down while following this procedure.

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 actuator and valves from 0 to 100% after the minimum and maximum positions have been adjusted. This allows both the actuator and valve to be tested for binding, play, resolution, linearity, and repeatability. 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.

Press any available Run Mode key to exit the STROKE ACTUATORS mode. For example, pressing the SPEED key will disable the stroking function and display the 'speed' information. To return to the STROKE ACTUATORS mode, the ACT key must be selected again and the keystrokes to enter this mode must be repeated. As a safety precaution, if the turbine speed ever exceeds 1000 rpm, the STROKE ACTUATORS mode is disabled.

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

(for single actuator output configuration)

⚠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 505's Emergency shutdown contact input must be closed or jumpered throughout this procedure (or the 505's actuator current output will go to ZERO current).
2. Execute a system RESET command (Press the 505 "Reset" key).
3. Press the 505's front panel "Emergency Shutdown" button.
4. Press the 'ACT' key then the SCROLL DOWN key until the "Stroke Actuators—Dsbled, 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 "Stroke to Min—Enabled, Min Curr Adjust * 20.000" message).
6. Press the "YES" key to enable this mode or the "Scroll Down Arrow" to step to the mode desired. (Refer to Figure 4-5).
   6a. **Stroke 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. **Stroke 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 Valve XXX.XX**—Press the ADJ UP, ADJ DOWN keys from this screen to move the 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, enter 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 505 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 505. If variables are tuned or changed but not stored in EEPROM by pressing the CLEAR key twice, then those changes will be lost if power is removed from the control or if the control receives a CPU reset.**

Calibration/Stroking Procedure

(for dual actuator output configuration)

⚠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 505's Emergency shutdown contact input must be closed or jumpered throughout this procedure (or the 505's actuator current output will go to ZERO current.
2. Execute a system RESET command (Press the 505 "Reset" key).
3. Press the 505'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 "Act #1 to Min—Enabld, Min Curr Adjust * 20.000" message).

6. Press the “YES” key to enable this mode or the “Scroll Down Arrow” to step to the mode desired. (Refer to Figure 4-6).
   6a. **Act #1 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. **Act #1 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 Valve XXX.XX**—Press the ADJ UP, ADJ DOWN keys from this screen to move the 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, enter 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 505 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. Similarly, for Act #2:
   7a. Act #2 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.

7b. Act #2 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.

7c. Manually Adjust—Enabld, Stroke Valve XXX.XX — Press the ADJ UP, ADJ DOWN keys from this screen to move the 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, enter 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 505 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.

8. Press the CLEAR key twice to permanently save any minimum or maximum actuator settings into the 505. If variables are tuned or changed but not stored in EEPROM by pressing the CLEAR key 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.

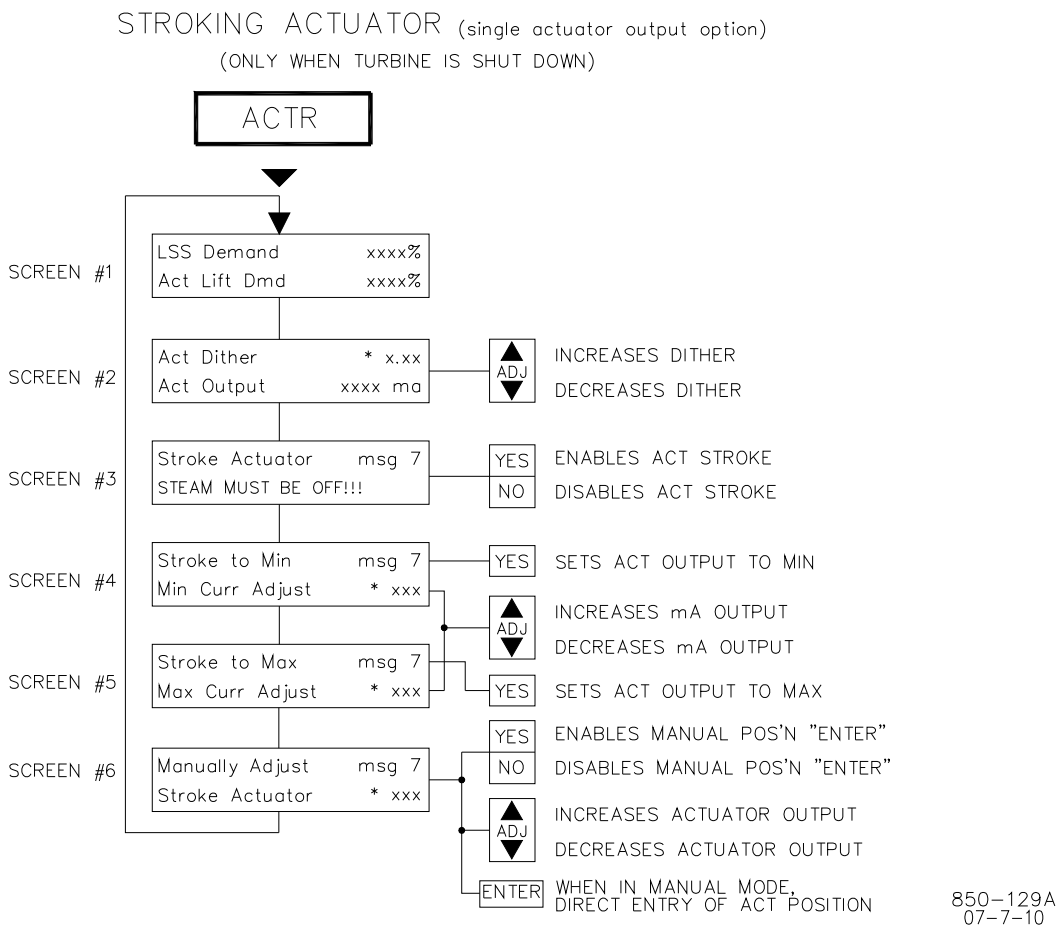
Pressing any available Run Mode key will exit the STROKE ACTUATORS/VALVE mode. Exiting the STROKE ACTUATORS/VALVE mode by a RUN MODE key will not permanently save any calibration changes.

NOTICE

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

Stroke Actuator Messages

Message 7	Meaning
Dsbld	Stroke actuators function is disabled
Enabld	Stroke actuators function is enabled
At Min	Actuator output is set to the minimum value (0%)
At Min	Actuator output is set to the maximum value (100%)
Manual	Actuator output is in manual mode

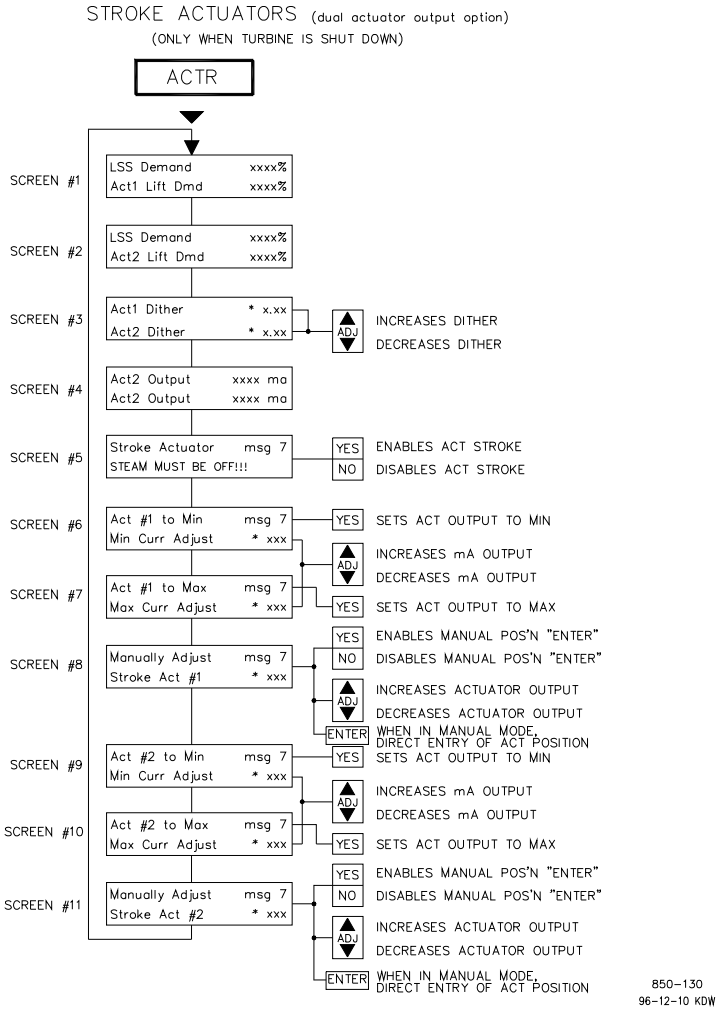


Screen 3 shown only when the unit is shut down.
Screens 4, 5, & 6 shown only when Stroke Actuator is set to YES.

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.

Figure 4-5. Stroke Actuator



Screen 5 shown only when the unit is shut down.
Screens 6–11 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.

Figure 4-6. Stroking Dual Actuators

Chapter 5.
505 Operation

Run Mode Architecture

The 505 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 505's normal operating architecture is divided into two sections: the Run Mode and the Program Mode. The Program Mode is used to configure the 505 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. A Service Mode is also available to make additional on-line adjustments while the unit is running. See Volume 2 for information on the Service Mode.

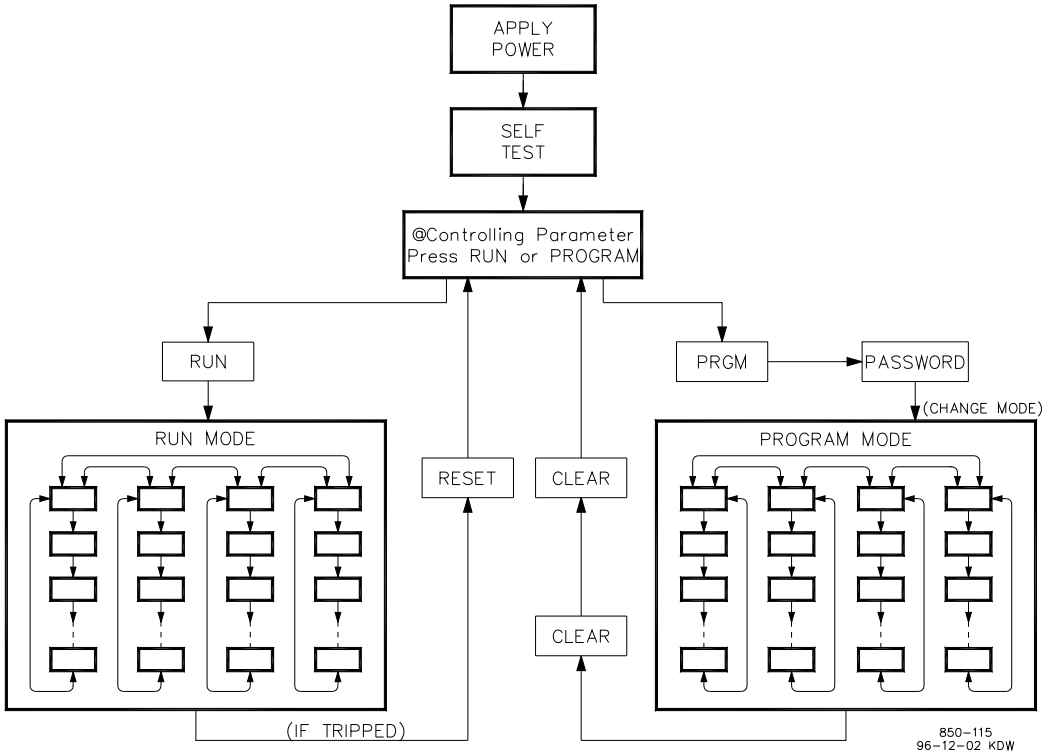


Figure 5-1. Basic Program Architecture

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 505'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.

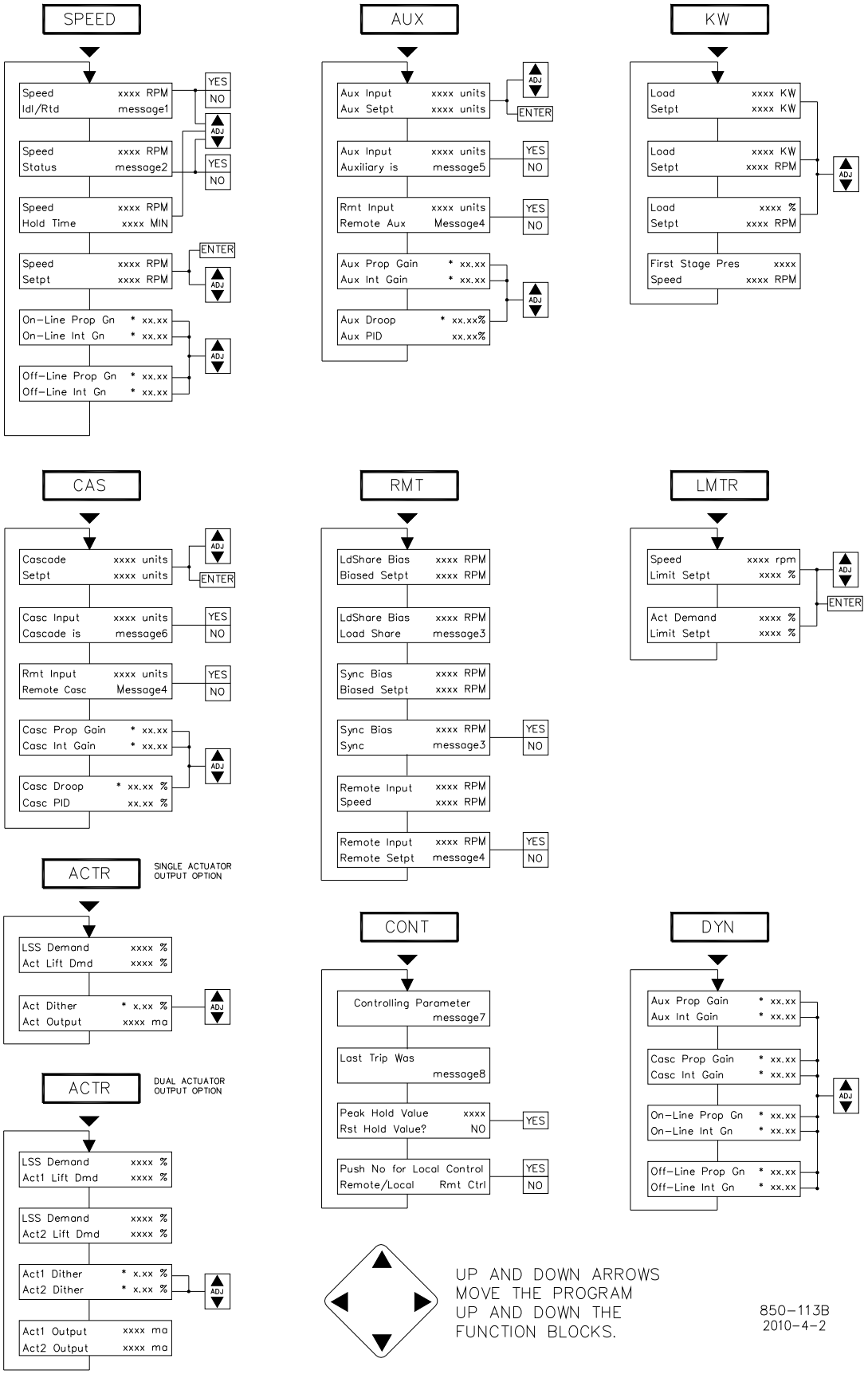


Figure 5-2a. Overview of Run Mode

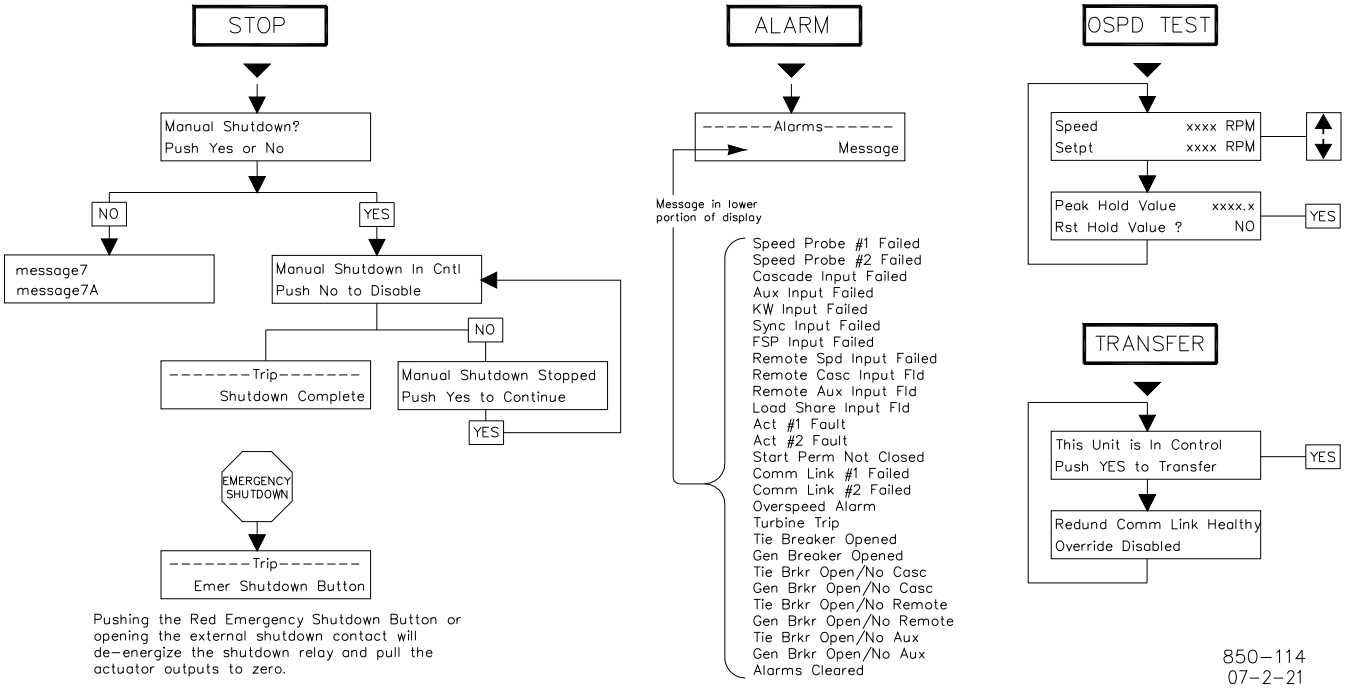


Figure 5-2b. Overview of Run Mode

Trip Messages
Message 8
External Trip Input
Emrg Shutdown Button
Overspeed
All Speed Probes Failed
Actuator 1 failed
Actuator 2 failed
Aux Input Failed
External Trip 2
External Trip 3
External Trip 4
External Trip 5
External Trip 6
External Trip 7
External Trip 8
External Trip 9
External Trip 10
Comm Link #1 Trip
Comm Link #2 Trip
KW Input Failed
Util Tie Brkr Opened
Gen Brkr Opened
Power Up Shutdown
Shutdown Complete
HP Ramp Max/No Spd
* All 505R Links Failed
Trip from Other 505
IHA DI Fault
IHB DI Fault
*—This trip occurs only when a unit is in the tracking mode.

Idle/Rated Messages

Message 1
Stopped
Speed/Off-Line
Mvg to Idle
At Idle Spd
In Crit Band
Mvg to Rated
At Rated Spd
Rated Inhibited
Idle Inhibited
Back to Idle

Auto Start Messages
Message 2
Disabled
Halted
Mvg Low Idle
At Low Idle
Mvg Idle2
At High Idle2
Mvg Idle3
At Idle3
In Crit Band
Mvg to Rated
Completed

Controlling Parameter Messages
Message 7
Shutdown
Controlled Shutdown
Max Actuator
Valve Limiter
Remote Auxiliary
Auxiliary Control
Configuration Error
Start Perm Not Met
Ready to Start
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
In Tracking Mode

F3 Transfer Control (if Redundant)
This Unit is In-Control
This Unit is Tracking
This Unit is Shut down
Transfer Disabled
Transfer Only via DI
Push YES to Transfer
Override Disabled
Failed Link Override ON
Push YES to Override
Rednd Comm Link Healthy
Rednd Comm Link Failed

Aux Messages (if using aux as a limiter)
Message 5
Inhibited FLT: Track Mode Forced
Enabled
Enabled w/Rmt Setpt
Active w/Rmt Setpt
Active/Not Lmting
Control w/Rmt Setpt
In Control

Control Messages
Message 3
Disabled
Inhibited
Enabled
In Control

Remote Messages
Message 4
Disabled
Inhibited
Enabled
Active
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

Units Options (for Aux/Casc
(none)
psi
kPa
MW
KW
degF
degC
t/h
k#/hr
#/hr
kg/cm²
bar
atm

Aux Messages (if using aux enable)
Message 5
Disabled
Inhibited
Enabled
Active/Not in Ctrl
Active w/Rmt Setpt
In Control
Remote Control

Table 5-1. Overview of Run Mode

Keypad and Display

The 505 is a field configurable steam turbine control and operator control panel (OCP) integrated into one package. The 505'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 505, 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 505'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 505's Overspeed Test function cannot be performed through a Modbus link.

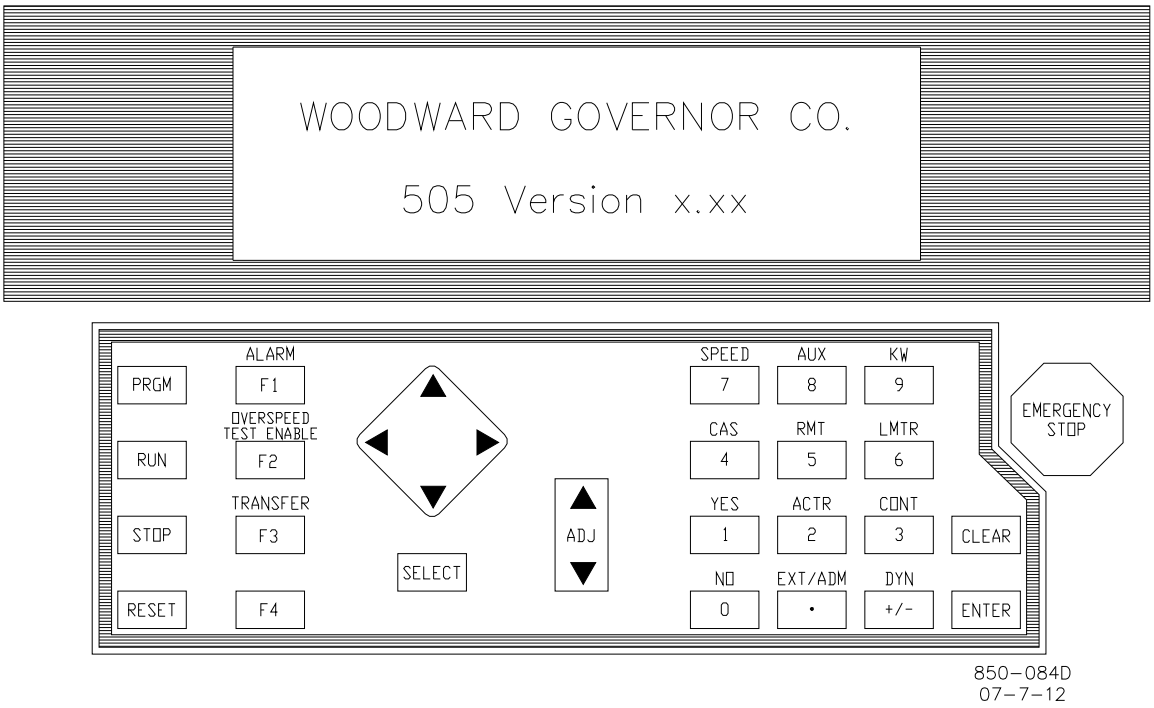


Figure 5-3. 505 Keypad and Display

Run Mode Front Panel Keys

For a detailed description of each 505 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 505's service 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 set point is displayed and the set point 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 set point is shown on the display and the set point 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, and DYN keys are always active.
- The PRGM, RUN, STOP, RESET, and ALARM keys are always active.
- If Configured for Redundant operation, F3 TRANSFER indicates the unit that is In-Control and activates a transfer to the other unit.
- 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.

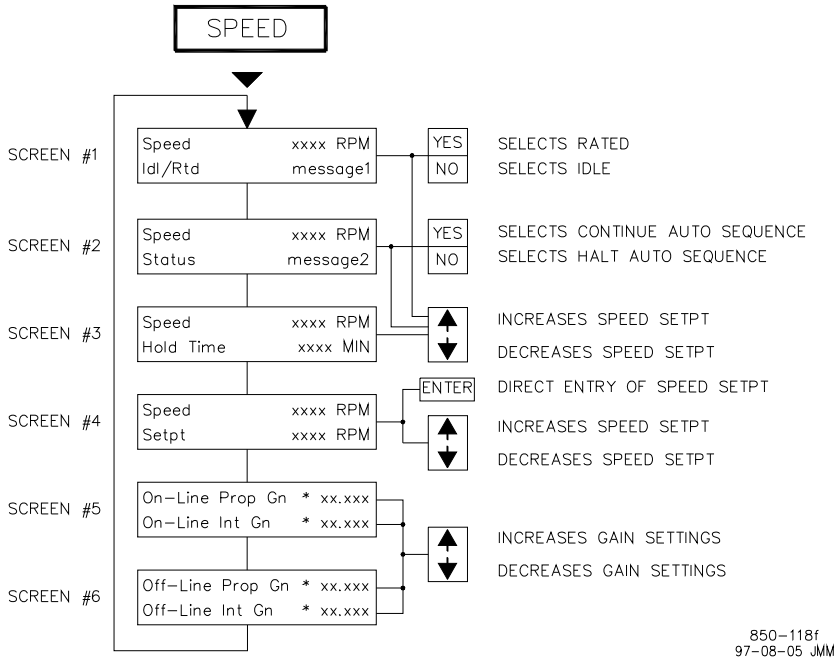
The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

1. Press the RESET key to clear all alarms and trips. If the 505's RESET CLEARS TRIP setting is programmed "YES", the 505's shutdown relay will reset or energize upon pressing the RESET key after a shutdown. If the RESET CLEARS TRIP OUTPUT setting is programmed "NO", the 505's shutdown relay will reset or energize upon pressing the Reset key ONLY after all trip conditions are cleared.
2. Press the 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 semi-auto 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 505's speed set point will move to minimum governor speed unless an idle speed is programmed. The Idle/Rated or Auto Start Sequence functions must be programmed for the turbine to control at idle speed. An operator at this time may vary turbine speed through the 505's keypad, external switches or communication links.

The 'Run' and 'Reset' commands can be selected from the 505'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.



- 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 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 start-up, refer to Chapter 3. When a RUN command is issued, the 505 automatically displays the SPEED screen and shows the Idle/Rated status. The speed set point 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 Modbus communications.

When the speed set point is ramping to the Rated Set Point 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 set point 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 Idl/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 set point will ramp to the Idle Speed setting upon start-up. However, the Idle Speed setting can be re-selected, when conditions allow, (see Chapter 3) by pressing the front panel NO key from the Idl/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 set point 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 set point ramping to the Rated Speed setting and opening the contact stops the speed set point 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 Idl/Rtd screen (screen 1) or select Go To Rated from Modbus communications.

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	Speed Setpt is moving through 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 Set Point and Rated Speed Set Point analog values are also available.

Auto Start Sequence

When a RUN command is issued, the 505 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 set point 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	Speed 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 Set Point, Low Idle Delay Time, Time Remaining at Low Idle, Low Idle to High Idle Rate, High Idle Speed Set Point, High Idle Delay Time, Time Remaining at High Idle, High Idle to Rated Rate, Rated Speed Set Point, Run Time (hours), and Hours Since Trip analog values are also available providing comprehensive sequence information.

Direct Set Point Entry

The Speed set point 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 set point that can be entered. The Speed set point must be below the maximum governor setting and above the idle setting. Also, if the unit is driving a generator and the unit is on-line, the speed set point cannot be set below the minimum load setting (tunable in the Service Mode).

The Speed set point 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 set point 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 set point and the Modbus Entered Speed set point are available over the communication link to provide feedback for directly entered Modbus values.

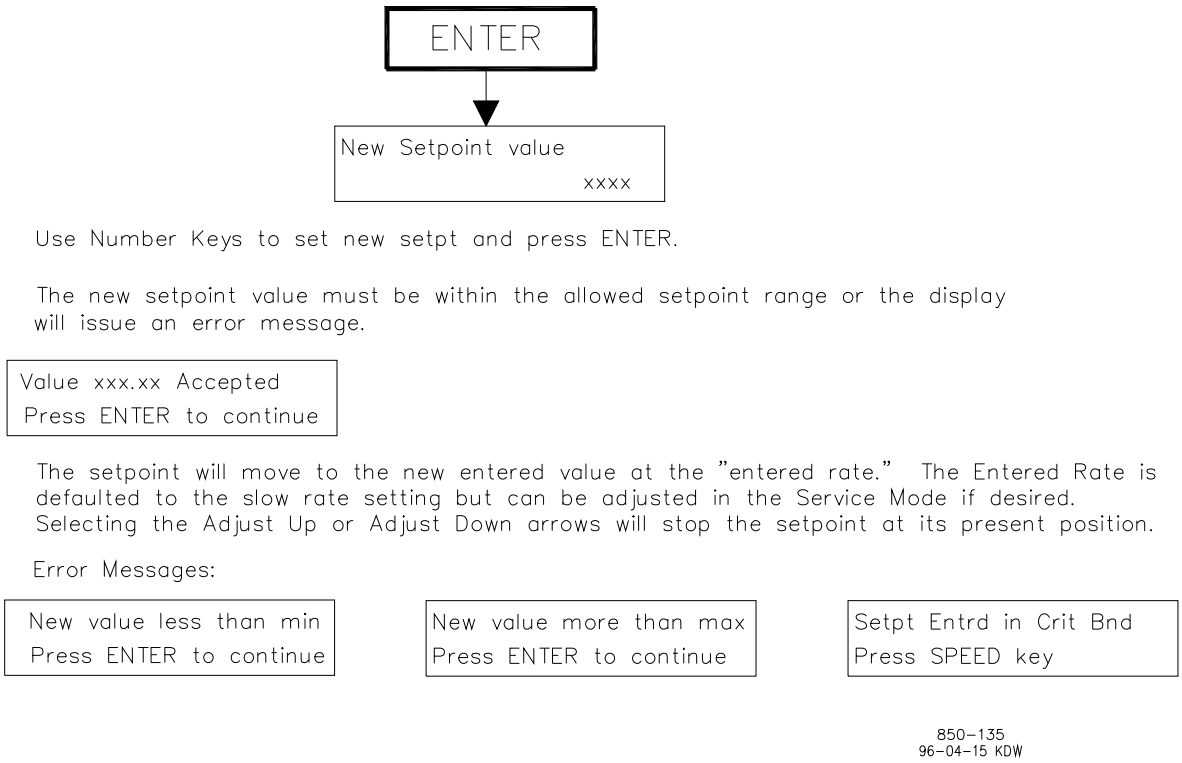


Figure 5-5. Direct Set Point Entry

Speed Control

Once the turbine is in speed control at minimum governor speed or rated speed, the speed set point can be adjusted with the ADJUST UP or DOWN front panel keys from the Speed screen (screen 4), Speed Set Point Raise or Lower contact inputs, or commands through a Modbus link. In addition the set point can be directly entered using the ENTER key from a Set Point display or through the communication links (see Direct Set Point 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 Set Point, 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 505's Overspeed Test function allows an operator to increase turbine speed above its rated operating range to periodically test turbine electrical and/or mechanical overspeed protection logic and circuitry. This includes the 505's internal overspeed trip logic and any external overspeed trip device's settings and logic. Figure 5-6 shows the screens that are displayed when the 'OSPD' key is pressed. These will only be displayed when the speed set point 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.

In redundant 505 configurations, the second unit should be healthy and in "Tracking" mode during this test. If the unit is shut down, it will trip the turbine on overspeed since the overspeed protection logic in the 505 is always active. If desired, the set point in the tracking unit can be raised to ensure that the In Control unit would have tripped the turbine.

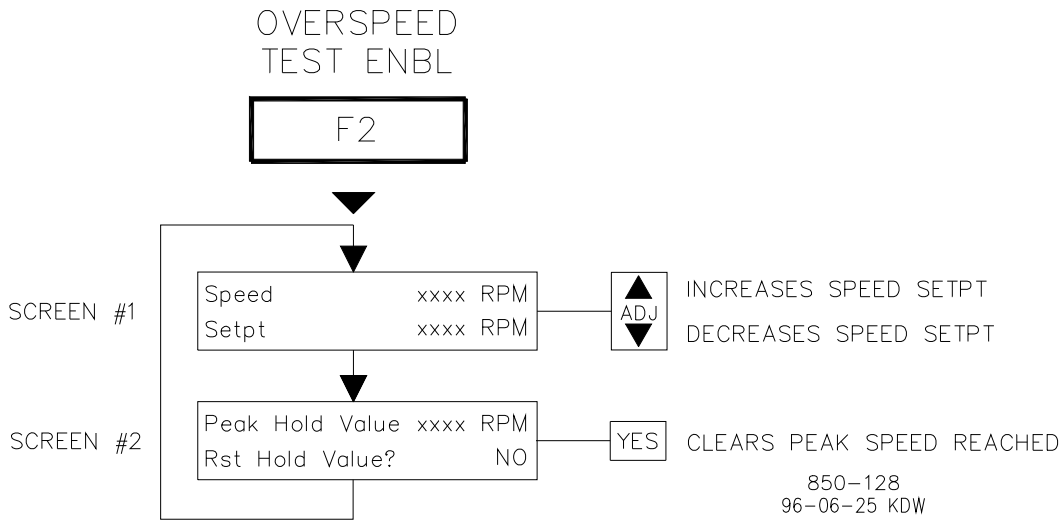


Figure 5-6. Overspeed Test Enable Key Screens

Overspeed Test Procedure

(from the 505's Service Panel)

- Raise the Speed Set Point to the maximum governor setting.
- If desired, clear the 'Highest Speed Reached' value, to record the highest speed reached during this overspeed test. (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 Set Point to be raised for testing. The Overspeed Test Enable LED in the OSPD key will turn ON when the set point is raised above the maximum governor setting.

  If the OSPD key is released, the speed set point will move back to the maximum governor setting.
- Once turbine speed reaches the 505'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 Set Point can be raised up to the 505's OVERSPEED TEST LIMIT setting, by not releasing the OSPD key and continuing to adjust the 505's Speed Set Point. The Overspeed Test LED will blink at a faster rate when the OVERSPEED TEST LIMIT is reached, indicating the maximum speed set point 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 505's service panel. When the conditions outlined in the above procedure are met, closing this contact allows the Speed set point to be increased up to the "Overspeed Test limit" setting. The testing procedure is similar to using the OSPD key. An Overspeed Test Enabled relay can be programmed to provide the same status feedback as the front panel Overspeed Test LED.

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

Transfer Key Screens (Redundant Only)

In redundant mode, the F3 key illuminates to indicate the unit that is currently in control of the turbine. Pressing this key will enter the Control Status / Transfer screens that allow the user to transfer control from one unit to another. If the Communication link between the two 505s is failed, this screen will allow the user to override this condition (if desired) and transfer to the other unit.

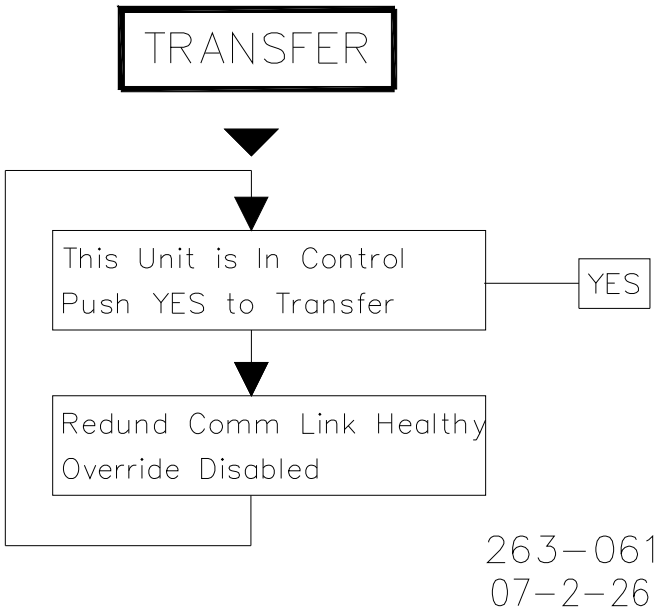


Figure 5-7. Redundant Transfer Key Screens

F3 Transfer Control Messages:

Unit Status Message

This Unit is In-Control, Tracking or Shutdown	Shows the current status of this 505 Control

Transfer Options Message

Transfer Disabled	Transfer to other unit Inhibited (Link problem or SD)
Transfer Only via DI	Configured to only Transfer from Discrete Input
Push YES to Transfer	Transfer control of turbine to tracking unit

Unit-to-Unit Modbus Link Status Message

Rednd Comm Link Healthy	Indicates the redundant Modbus link is healthy
Rednd Comm Link Failed	Indicates the redundant Modbus link is failed

Transfer Override Options

Override Disabled	No Override available, unit is Shutdown
Push YES to Override	If link is failed, user can override and transfer
Failed Link Override ON	Indicates that Override is ON

F3 and F4 Keys

The F-key (F3 [if not redundant] & 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
- Idle/Rated
- Halt/Continue Auto Start Sequence
- Remote Speed Setpt Enable
- Sync Enable
- Freq Arm/Disarm
- Casc Control Enable
- Remote Casc Setpt Enable
- Aux Control Enable
- Remote Aux Setpt Enable
- Energize Relay Output
- Transfer In-Control Unit (F3 Only)

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 5-8 shows the screens that appear when the LMTR key is pressed. These screens are always active and always displayed. During normal operation the Valve Limiter setting is at 100% and not limiting.

Typically, the only time this parameter is adjusted is during a start sequence or to troubleshoot system dynamics problems. The actuator demand and the limiter set point can be viewed from screen 2. To manually position the governor valve with the Valve Limiter set point, the limiter set point must be decreased below the 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 valve limiter can be adjusted with the ADJUST UP or DOWN front panel keys from any Limiter screen, Valve Limiter Raise or Lower contact inputs (if programmed), or commands through a Modbus link. In addition the set point can be directly entered using the ENTER key from any Limiter screen.

The following valve limiter indications are available through the Modbus links: Valve Limiter at Min, Valve Limiter at Max, and Valve Limiter In Control of actuator output. In addition to these indications the Valve Limiter Set Point, Actuator LSS, Actuator #1 Output and Actuator #2 Output analog values are also available.

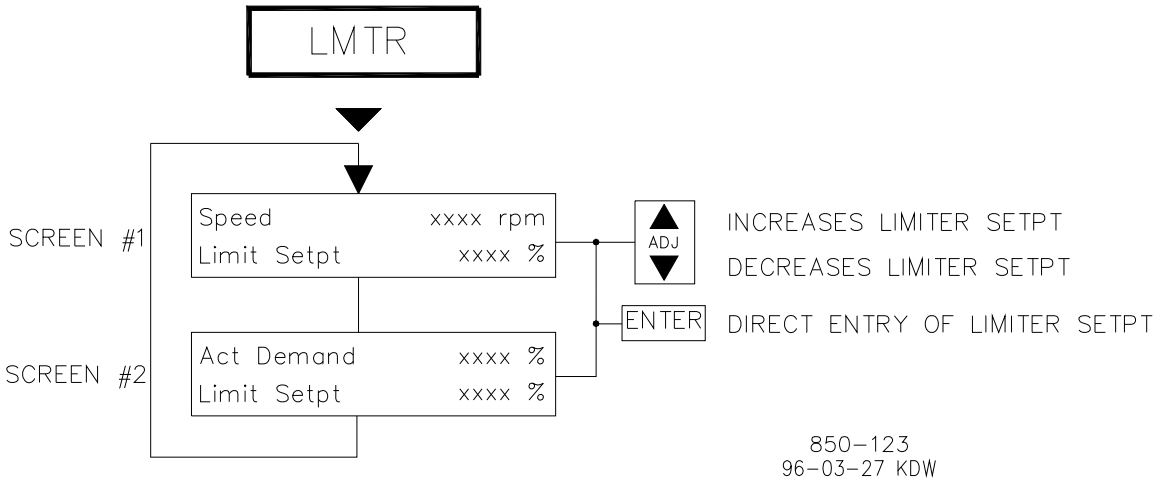
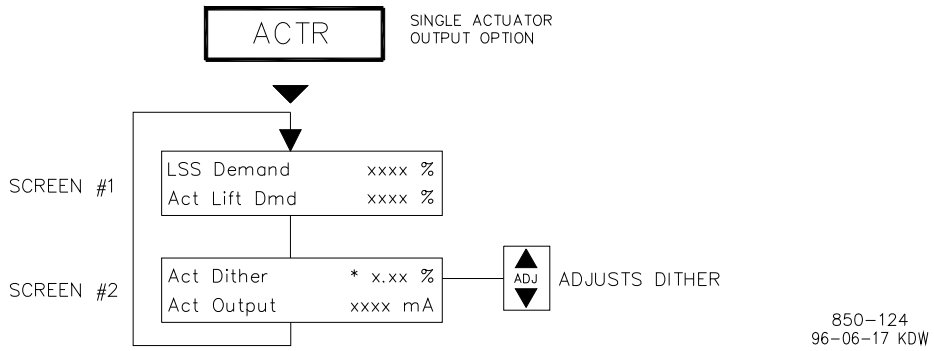


Figure 5-8. LMTR Key Screens

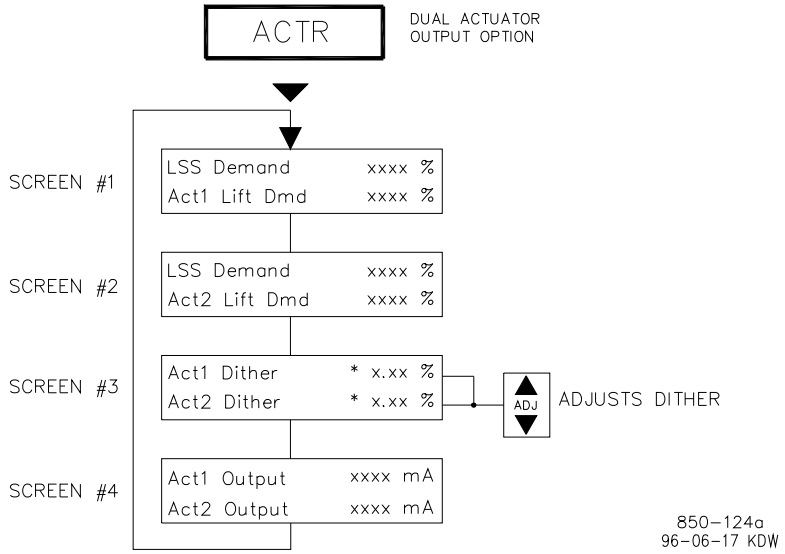
Actuator (ACTR) Key Screens

Figure 5-9 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 dual actuator output option displays both actuator output demand values as well as the LSS demand. If the Actuator #2 offset is zero, all of these values will be the same. If the offset is not zero, the LSS will display the total lift demand for both outputs. The LSS will be zero when Actuator #1 is zero and reach 100% when Actuator #2 reaches 100%. The communications links will display the Actuator LSS, Actuator #1 Demand, Actuator #2 Demand values as well as the actual Actuator Output Current for both actuators in milliamps.



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.



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 5-9. ACTR Key Screens

Control (CONT) Key Screens

Figure 5-10 shows the screens that appear when the CONT key is pressed. The CONT key allows operators to monitor what 505 parameter (PID or limiter) is controlling governor valve position (screen 1). From screen 2 the cause of the last turbine shutdown can be viewed and from screen 3 the highest turbine speed reached can be viewed and cleared, if desired.

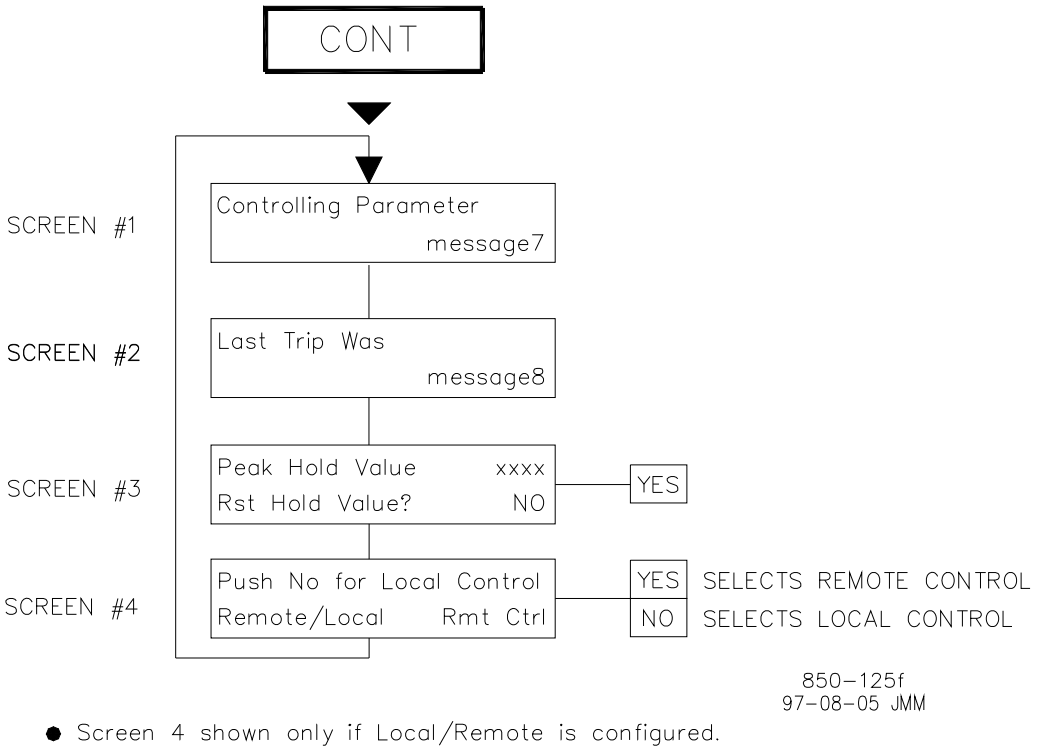


Figure 5-10. CONT Key Screens

Table 5-4 shows a complete listing of all possible controlling parameters and their meanings.

Message 7	Meaning
Shutdown	Control is tripped
Controlled Shutdown	A controlled shutdown is being executed
Start Perm Not Met	The start permissive contact input is not closed
Max Actuator	The actuator output is at its maximum position
Valve Limiter	The Valve Limiter is in control of the actuator output
Ready to Start	The unit's start permissives are OK and the unit is ready to start
Manual Start	The 505 is running and in the Manual start mode
Auto Start	The 505 is running and in the Automatic start mode
Semi Auto Start	The 505 is running and in the Semi-automatic start mode
Idle/Rated Start	The 505 is running and in the Idle/Rated sequence mode
Auto Start Sequence	The 505 is running and in the Automatic Start Sequence mode
Remote/Speed	Speed PID is in control, the Speed Set Point is in remote control
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 is in control with the gen. breaker closed and tie breaker open
Synchronizing	Speed PID is in control with the Synch. analog input biasing its set point
Load Share/Speed	Speed PID is in control with Sync/Ld Share analog input biasing its set point
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 control
Cascade/Speed	Casc & Speed PIDs are in control
Rmt Cascade/Speed	Casc & Speed PIDs are in control, and Casc Setpt is in remote control
Configuration Error	The 505 program has been configured incorrectly
In Tracking Mode	This unit is tracking the In-Control unit (Redundant only)

Table 5-4. Controlling Parameter Messages

For a complete listing of Shutdown/Trip causes, refer to the Trips section later in this chapter.

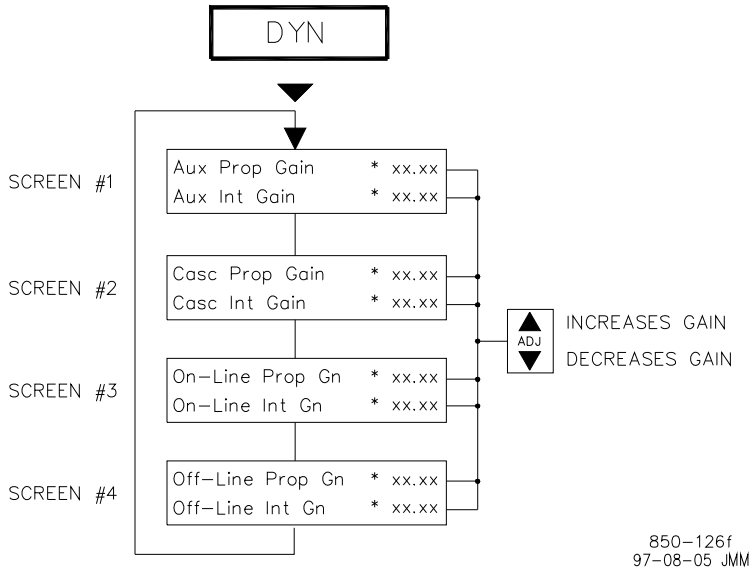
The Controlling Parameter and Highest Speed Reached values are also available through the Modbus links.

Dynamics (DYN) Key Screens

Figure 5-11 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 505's Service panel only, they cannot be adjusted remotely.



- Screen displayed varies with the parameter "in control" of 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 5-11. DYN Key Screens

Stop Key Screens

Figure 5-12 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'.

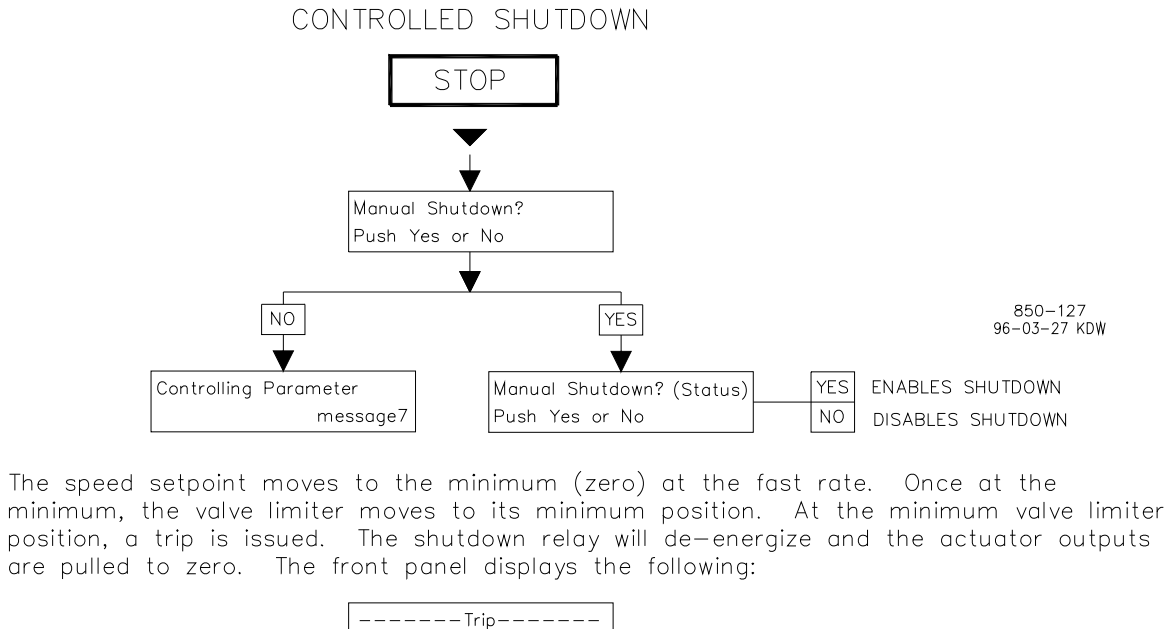
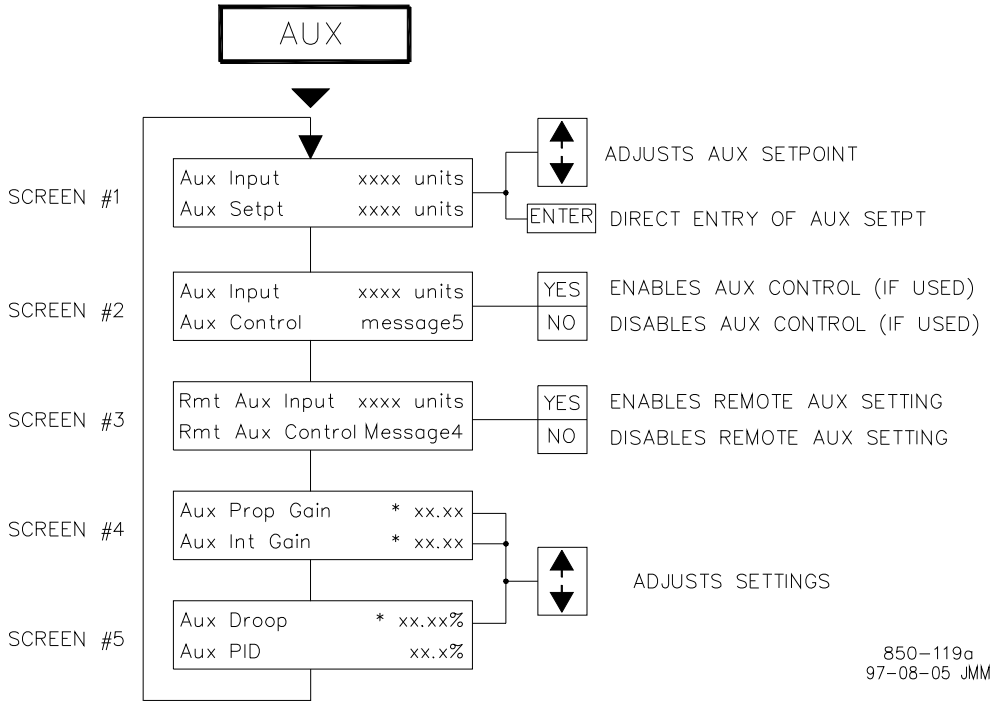


Figure 5-12. STOP Key Screens

Auxiliary (Aux) Key Screens

For this key to be active, the Auxiliary function must be programmed. Figure 5-13 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 Set Point is programmed, screen 3 will appear. The Auxiliary PID dynamics and droop level (if required) can be adjusted from these screens.



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 5-13. 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 set point tracks the Auxiliary analog input to accommodate bumpless transfers between control modes. As a result, the Auxiliary set point cannot be changed until the Auxiliary PID is enabled. Once enabled, the Auxiliary set point can be changed by pressing the ADJUST UP or DOWN from the front panel Aux Setpt screen (screen 1), closing a Aux Setpt Raise/Lower contact input, or selecting Aux Set Point Raise or Lower from either Modbus communications link. In addition, the Auxiliary set point can be directly set to a value by pressing the front panel ENTER key from the Auxiliary Set Point screen or by "Entering" a new Auxiliary Set Point 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 5-5). Auxiliary control is also disabled if Cascade control is enabled, or Remote Speed Set Point 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 5-5. 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 set point 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 Set Point Raise/Lower contact inputs, or selecting Auxiliary Set Point Raise or Lower from either Modbus communications link. In addition, the Auxiliary set point 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 5-6. 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 5-6. 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 Set Point, 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'.

Remote Aux Set Point

The Remote Auxiliary Set Point function is used to allow the Auxiliary set point 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 Set Point Enable/Disable contact (if programmed), or selecting Remote Aux Enable from either Modbus communications link.

Remote Auxiliary Set Point 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 5-7 for all possible Remote Aux control messages.

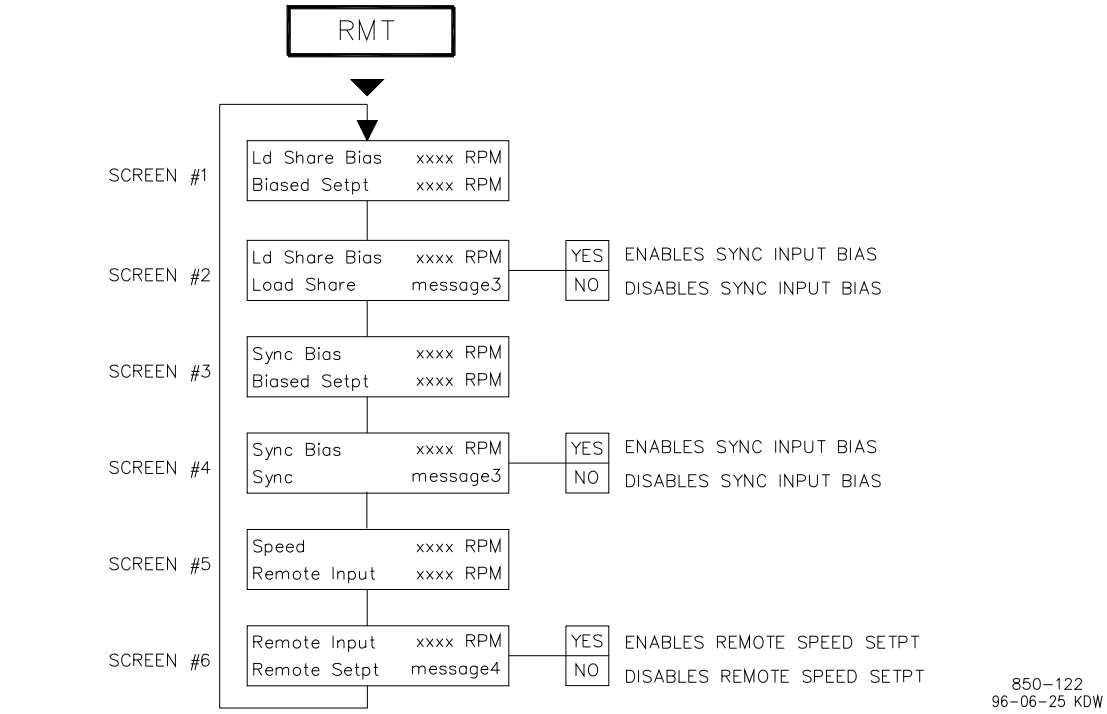
Message 4	**Meaning**
Disabled	Remote Aux Set Point is not selected
Inhibited	Remote Aux Set Point is inhibited and cannot be enabled
Enabled	Remote Aux Set Point is enabled but not in control of the Setpt
Active	Remote Aux Set Point is in control, Aux PID is not controlling the actuator
In Control	Remote Aux Set Point is in control, Aux PID is controlling the actuator

Table 5-7. 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 Set Point is also available.
Relay indications can be programmed to indicate Remote Aux Control Active and Remote Aux Control Enabled status'.

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 5-14 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 Set Point input is programmed.



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 5-14. RMT Key Screens

Remote Speed Set Point

The Speed PID set point can be remotely set by an analog input, if programmed. This Remote Speed Set Point input can be enabled by pressing the front panel YES key from the Remote Speed Status screen (screen 6), closing the Remote Speed Set Point Enable/Disable contact (if programmed), or selecting Enable Remote Speed Setpt Control from either Modbus communications link (see Table 5-8).

Remote Speed Set Point 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 5-8. 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'.

Synchronizing and/or Load Sharing

The Synchronizing feature allows an analog input to bias the speed set point when using an EGCP-3 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 a "F" key, or selecting Sync Enable from either Modbus communications link.

The Synchronizing & Load Sharing feature allows an analog input to bias the speed set point when using an EGCP-3 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 a "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 5-9 lists the possible synchronizing/load sharing control messages.

Message 3	Meaning
Disabled	Function is in disabled mode
Inhibited	Function is inhibited and cannot be enabled
Enabled	Function is enabled but not in control of the Setpt
In Control	Function is in control of the actuator output

Table 5-9. Control Messages

The following synchronizing and load sharing control indications are available through the Modbus links: Generator Breaker Status, Utility Tie Breaker Status, Frequency Control, Sync is Enabled, Sync or Load Share is In Control, Sync or Load Share is Inhibited, and the Sync/Load Share Input Failed Alarm. In addition to these indications, Sync/Load Share Input analog value is also available.

Relay indications can be programmed to indicate Sync Enabled, Sync/Load Share Enabled, Load Share Control and Frequency Control status'.

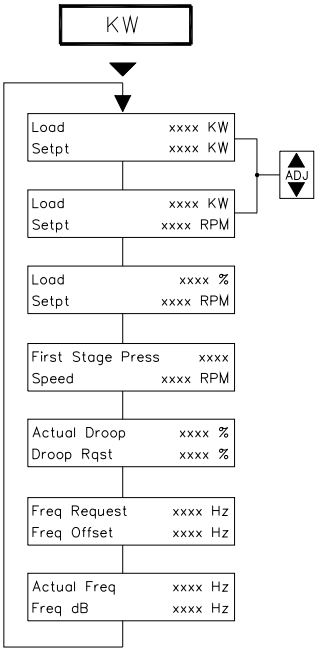
Unit Load (KW) Key Screens

This key is active if the unit is programmed for a generator application or if an inlet header pressure analog input is configured. Figure 5-15 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 an inlet header 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 Load Set Point. This value and units change depending on the droop mode the 505 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 Set Point 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 Set Point Raise/Lower contact inputs or selecting Speed Set Point Raise or Lower commands from either Modbus communications link. In addition, the Load set point can be directly set to a value by pressing the ENTER key from the SPEED screen and entering a speed set point value, or Entering a new Speed/Load Set Point through either Modbus communications link.



- 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 5-15. KW Key Screens

Cascade (CAS) Key Screens

For this key to be active, the Cascade function must be programmed. Figure 5-16 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 Set Point 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 Set Point 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 set point and Speed PID, Cascade will only be "In Control" when the Speed PID is "In Control" of the actuator output. See Table 5-10 for all possible cascade control messages.

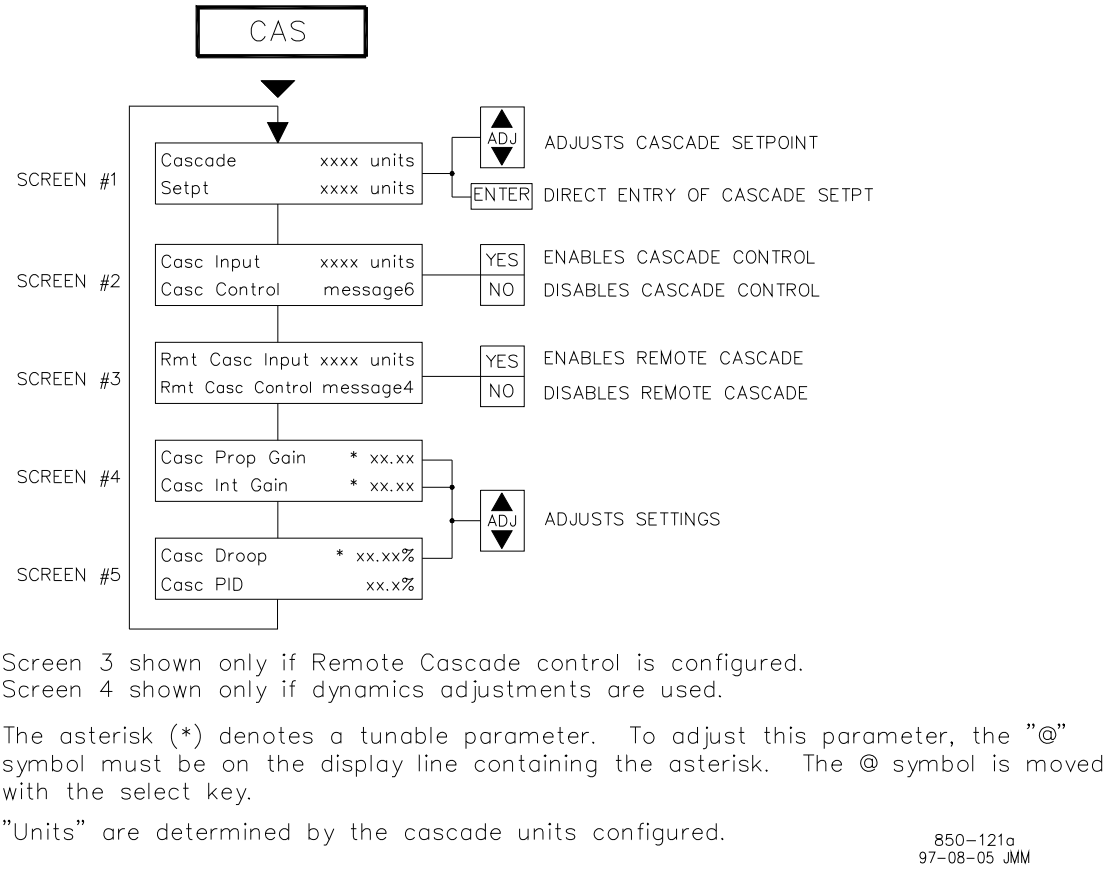


Figure 5-16. CAS Key Screens

The Cascade set point 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 set point cannot be changed until Cascade control is enabled.

The Cascade set point can be changed by pressing the ADJUST UP or DOWN keys from the Cascade set point screen (screen 1), closing a Cascade Setpt Raise/Lower contact input, or selecting Cascade Set Point Raise or Lower commands from either Modbus communications link. In addition, the Cascade set point 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 set point will be adjusted. If either contact is closed and the cascade control is not active, the Speed set point will be adjusted. The advantage of this feature is that only one set of raise/lower switches is required to adjust either set point.

The Cascade set point 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 5	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 5-10. 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 Set Point, 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 Set Point

The Cascade control set point can be remotely positioned by an analog input (if programmed). The Remote Cascade Set Point input can be enabled by pressing the front panel YES key from the Remote Cascade Status screen (screen 3), closing the Remote Cascade Set Point Enable/Disable contact (if programmed), or selecting Remote Cascade Enable from either Modbus communications link. Remote Cascade Set Point 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 5-11 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 5-11. 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 Set Point is also available.

Relay indications can be programmed to indicate Remote Cascade Control Active and Remote Cascade Control Enabled status'.

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 5-12 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.

Figure 5-17. ALARM Screen

Alarm Messages	Meaning
Speed Probe #1 Failed	Speed probe #1 failure—(< Failed Speed Level or 1 Vrms)
Speed Probe #2 Failed	Speed probe #2 failure—(< Failed Speed Level or 1 Vrms)
Cascade Input Fld	Cascade analog input failure detected (> 22 mA or < 2 mA)
Aux Input Fld	Auxiliary analog input failure detected (> 22 mA or < 2 mA)
KW Input Failed	KW analog input failure detected (> 22 mA or < 2 mA)
Sync Input Failed	Sync analog input failure detected (> 22 mA or < 2 mA)
Inlet Press Input Fld	Inlet Header Pressure analog input failure detected (> 22 mA or < 2 mA)
Remote Spd Input Failed	Remote Speed Setpt analog input failure (> 22 mA or < 2 mA)
Remote Casc Input Fld	Remote Cascade Setpt analog input failure (> 22 mA or < 2 mA)
Remote Aux Input Fld	Remote Aux Setpt analog input failure (> 22 mA or < 2 mA)
Load Share Input Fld	Load Share analog input failure detected (> 22 mA or < 2 mA)
Act #1 Fault	Actuator #1 fault detected (an open or short circuit was sensed)
Act #2 Fault	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 is tripped alarm indication
Overspeed	Turbine overspeed alarm
Tie Breaker Opened	Utility Tie breaker was opened after it was closed
Gen Breaker Opened	Generator breaker was opened after it was closed
Tie Brkr Open/No Casc	Utility Tie breaker was opened when Cascade was active
Gen Brkr Open/No Casc	Generator breaker was opened when Cascade was active
Tie Brkr Open/No Remote	Util. Tie breaker was opened when Remote Spd Setpt was active
Gen Brkr Open/No Remote	Generator breaker was opened when Remote Spd Setpt was active
Tie Brkr Open/No Aux	Utility Tie breaker was opened when Auxiliary was active
Gen Brkr Open/No Aux	Generator breaker was opened when Auxiliary was active
Stuck in Critical Band	Turbine is stagnating within critical speed window
External Alarm #1 - #9	Customer configured external alarms (up to 9 available)
IH-Act1 Fault	Fault indication from current-to-hydraulic Actuator 1 (CPC)
IH-Act2 Fault	Fault indication from current-to-hydraulic Actuator 2 (CPC)
IH-A Press Fault	Fault indication from hydraulic pressure unit
Feed-forward_flt	Feed-Forward analog input failure detected (> 22 mA or < 2 mA)
Remote Droop Flt	Remote Droop Setting analog input failure detected (> 22 mA or < 2 mA)
Hardware Flt COM1	505 H/W fault on Communication Port #1
Alarms Cleared	All alarms are cleared—no alarms are present

Table 5-12. 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 505 Common Alarm, in addition to the dedicated Alarm Relay output.

Trips

Figure 6-17 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 5-13 lists all the potential trip conditions and their cause.

Figure 5-18. TRIP Screen

Message 6	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
External Trip 6	External Trip #6 contact input was opened
External Trip 7	External Trip #7 contact input was opened
External Trip 8	External Trip #8 contact input was opened
External Trip 9	External Trip #9 contact input was opened
External Trip 10	External Trip #10 contact input was opened
Emer Shutdown Button	Emergency Shutdown on the 505 front panel was pressed
Overspeed	Turbine overspeed was sensed
All Speed Probes Failed	Loss of all speed probes was sensed
Actuator #1 Fault	Actuator #1 fault detected (an open or short circuit was sensed)
Actuator #2 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
KW Input Failed	KW 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	505 lost power and CPU was reset or the Program mode was exited
HP Ramp at Max/No Spd	HP Valve Limiter ramp is at Max but no speed is detected
IHA Discrete Input Fault	Contact input from IH system (A side CPC) faulted
IHB Discrete Input Fault	Contact input from IH system (B side CPC) faulted
Trip from Other Unit	Trip initiated from other 505 unit (Redundant mode only)
All 505R Links Failed	This unit Shutdown because it is the tracking unit and all redundant interface links have failed (Redundant mode only)
Shutdown Complete	Controlled shutdown was performed and completed

Table 5-13. Trip Messages

Each individual trip condition is available through the Modbus links to monitor the control status. A common trip indication is also provided.

Relay indications can be programmed to indicate a 505 Shutdown Condition (energizes for a shutdown condition) or a Trip Relay (de-energizes for a shutdown/trip), in addition to the dedicated Emergency Trip Relay output.

Speed, Cascade, and Auxiliary 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 (SPEED, CAS, & AUX). The Derivative term adjustments are made in the Service Mode—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 and Auxiliary controls are PID controllers. The response of each control loop can be adjusted by selecting the dynamics mode as described above. Proportional gain, integral gain (stability), and DR (derivative ratio) are the adjustable and interacting parameters used to match the response of the control loop with the response of the system. They correspond to the P (proportional), I (integral), and D (derivative) terms, and are displayed by the 505 as follows:

P = Proportional gain (%)
I = Integral gain (%)
D = Derivative (determined by DR and I)

If an older type 505 is being replaced by a new 505, the " P & D " terms will be the same, however, the " I " term should be reduced by a factor of 10 from the old 505'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 gain for best control at steady state. If system response is not known a typical starting value is 5%. If the integral gain is set too high the control may hunt or oscillate at 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, and valve linkage gain, transducer gain, internal turbine gains, and the 505's adjustable gains. If the accumulated mechanical gain (actuators, valves, valve linkage, etc.) is very high, the 505's gain must be very low to be added to the system gain required for system stability.

In cases where a small change in the 505's output results in a large speed or load change (high mechanical gain) it may not be possible to take the 505's gains low enough to reach stable operation. In those cases the mechanical interface (actuator, linkage, servo, valve rack) design and/or calibration should be reviewed and changed to achieve a gain of one where 0–100% 505 output corresponds to 0–100% valve travel.

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 (DR) variables. There are three cases that determine when the dynamics switch between On-Line and Off-Line:

- A “Select On-Line Dynamics” contact input is programmed
- Unit is driving a generator
- Unit is driving a mechanical drive (not a generator)

If a contact input is programmed to “Select On-Line Dynamics”, it has priority regardless of the driven device. When the contact is closed, On-Line dynamics are selected; when open, Off-Line dynamics are selected.

If the unit is driving a generator and no “Select On-Line Dynamics” contact input is programmed, the Speed Off-Line dynamics are used by the Speed PID when the generator or utility tie breaker contacts are open. The speed On-Line dynamics are used by the speed PID when the generator and utility tie breaker contacts are closed. If the speed dynamics select contact is programmed, the generator and utility tie contacts do not 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 Droop

The Cascade and Auxiliary controllers can be programmed to use droop for control loop stability. If the parameter being controlled (Cascade or Auxiliary) is also being controlled by another device (letdown station, boiler, or other turbine), droop is typically required for control loop stability. If required, no less than 5% droop is recommend for stable operation.

Tuning Derivative

The value of the Derivative Ratio (DR) term can range from 0.01 to 100. If unsure of the correct value, set the Speed control's DR term to 5% and the Aux & Cascade controllers' DR terms to 100%. In order to simplify adjustment of the dynamics, adjusting the integral gain value sets both the I and D terms of the PID controller. The DR term establishes the degree of effect the integral gain value has on the "D" term, and changes the configuration of a controller from input rate sensitive (input dominant) to feedback rate sensitive (feedback dominant) and vice versa.

Another possible use of the DR adjustment is to reconfigure the controller from a PID to a PI controller. This is done by adjusting the DR term to its upper or lower limits, depending on whether an input or feedback dominant controller is desired.

- A DR setting of 1 to 100 selects feedback dominant mode.
- A DR setting of .01 to 1 selects input dominant mode.
- A DR setting of .01 or 100 selects a PI only controller, input and feedback dominant respectively.

The change from one of these configurations to the other may have no effect during normal operation, however, it can cause great differences in response when the governor is coming into control. (at start-up, during a full load change, or during transfer of control from another channel).

An input dominant controller is more sensitive to the change-of-rate of its input (Speed, Cascade in or Auxiliary in), and can therefore prevent overshoot of the set point better than a feedback dominant controller. Although this response is desirable during a start-up or full load rejections, it can cause excessive control motions in some systems where a smooth transition response is desired.

A controller configured as feedback dominant is more sensitive to the change-of-rate of its feedback (LSS). A feedback dominant controller has the ability to limit the rate of change of the LSS bus when a controller is near its set point but is not yet in control. This limiting of the LSS bus allows a feedback dominant controller to make smoother control transitions than an input dominant controller.

Tuning Example

If the system is unstable, make sure the governor is the cause. This can be checked by closing the valve limiter until it has control of the actuator output. If the governor is causing the oscillation, time the oscillation cycle time. A rule-of-thumb is, if the system's oscillation cycle time is less than 1 second reduce the Proportional gain term. A rule-of-thumb is, if the system's oscillation cycle time is greater the 1 second reduce the Integral gain term (proportional gain may need to be increased also).

On an initial start-up with the 505, all PID dynamic gain terms will require adjustment to match the respective PID's response to that of its control loop. There are multiple dynamic tuning methods available that can be used with the 505's PIDs to assist in determining the gain terms that provide optimum control loop response times (Ziegler Nichols, etc.).

Figure 5-19 shows the typical response to a load change when the dynamics are optimally adjusted.

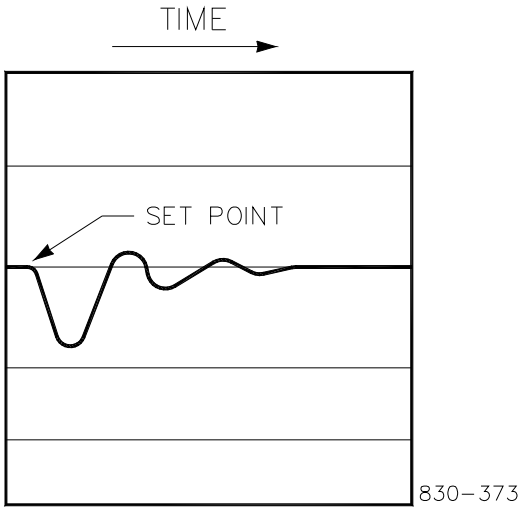


Figure 5-19. Typical Response to Load Change

IMPORTANT **For additional information on PID settings, refer to Volume 2.**

Chapter 6. Communications

Modbus Communications

The 505 control can communicate with plant distributed control systems and/or CRT based operator control panels through two Modbus communication ports. These ports support RS-232, RS-422, 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.

In redundant configurations, Communication Port 1 is consumed by the Modbus interface link between the two 505s. Communication Port 2 on each control can be configured as Modbus ports to provide two operator interface links into the system. Note that the "Tracking" unit does not always provide the same information and command capability as the "In Control" unit via Modbus, so the Mod 2 links cannot be considered fully functional until that 505 becomes the "In Control" unit. Most information is still available, as long as the unit is healthy and tracking, so Comm Port 2 could certainly be used as a connection to monitor some operational data.

Monitor Only

The two Modbus communication ports, as defaulted from the factory, are not programmed. Although these ports are not programmed they continue to update all information to all registers. This allows the 505 to be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, and to the 505's defaulted protocol settings (parity, stop bits, etc.), this device can be used to monitor all the 505's controlling parameters, modes, etc. without affecting control.

To use a 505 port to only monitor 505 parameters and operational modes or not use the port at all (Boolean and analog write commands are ignored), program the port's 'Use Modbus Port' setting to 'NO'.

Monitor and Control

Once a Modbus port is configured within the 505's Program Mode, the 505 will accept RUN mode commands from an external network master device (DCS, etc.). This allows a Modbus compatible device to monitor and perform all 505 RUN mode parameters and commands except for the Overspeed Test enable, On- Line/Off-Line Dynamics select, and Override Failed Speed Signal commands.

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 505 Modbus port to monitor and operate the 505 through, program the port's 'Use Modbus Port' setting to 'YES'.

Modbus Communication

The 505 control supports two Modbus transmission modes. A mode defines the individual units of information within a message and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in the following table.

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).

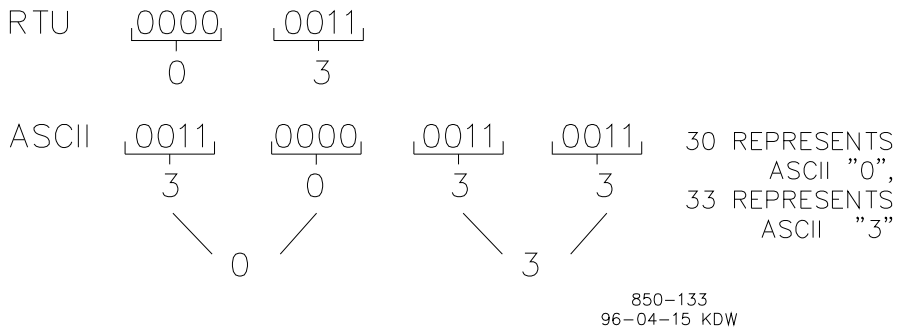


Figure 6-1. ASCII/RTU Representation of 3

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 505 control is programmed to function as a slave unit only. As a slave unit, the 505 will only respond to a transaction request by a master device. The 505 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 (505s or other customer devices) can be connected to one Master device on a single network. The control address is programmed under the 505'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 (Subfunction 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

Error Code	Error Message	Code Sent To Master	Description
0	No Error	0	No Error
1	Bad Modbus function	1	The specified function is not supported for this control.
2	Bad Modbus data address	2	The Modbus value addressed is not valid for this control.
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid.
9	Bad Modbus checksum	None	Message checksum did not match.
10	Bad Modbus message	None	Message could not be decoded.
N/A	Lost Modbus link	None	No messages received for the configured time-out period

Table 6-3. Modbus Error Codes

Port Adjustments

Before the 505 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	RS-232, RS-422, or RS-485

505 Control Modbus Addresses

The Modbus communication ports in the 505 control are programmed for unique Modbus addresses. A complete listing of these addresses for your application is located at the end of this section in the manual. The Modbus address listing consists of Boolean Writes, Boolean Reads, Analog Reads, and Analog Writes. The Boolean reads and writes are also referred to as input and holding coils. The analog reads and writes are also referred to as input registers and holding registers.

All values that can be addressed by Modbus are considered to be discrete and numeric. The discrete values are a 1 bit binary, on or off value and the numerics are 16 bit values. Discrete values are sometimes referred to as coils or digitals and numerics are referred to as registers or analogs. All read/write registers are interpreted by the 505 as signed 16 bit integer values. Since Modbus can only handle integers, values that require a decimal point in the Modbus Master Device are multiplied by a scaling constant before being sent by 505. See Tables 6-7 and 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 505 control. An example of a Boolean write value would be raise or lower commands. A logical true denoted by the value 1 will cause the command listed in the description to be executed. For example, if a 1 is written to address 0:0010 and this corresponded to a speed raise command, the manual speed set point will increase until a 0 is written to address 0:0010. The 505 control supports function codes 1, 5, and 15. These correspond to reading selected holding coils, writing to a single holding coil, and writing to multiple holding coils, respectively. The holding coils available are listed in Table 6-5.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writable to, the 505 control. An example of an Boolean read value would be a turbine trip status indication. The input coil will have the value 1 if the statement in the description column is true and a 0 if false. The `1:' term in the address identifies an input coil. The 505 control supports Modbus function code 2, which involves reading selected input coils. The input coils available are listed in Table 6-6.

Analog Reads (Input Registers)

Input registers are analog values that are readable from, but not writable to, the 505 control. An example of an analog read value would be turbine speed. The values of the input registers are stored internal to the control as floating point numbers representing engineering units (kPa or rpm). The values that are transmitted are integer values ranging from -32767 to +32767. Since Modbus can only handle integers, values that have a decimal point are multiplied by a constant before being sent by Modbus. For example, these input registers may be listed as the Modbus value `x100' or `x10' under the description heading to denote the value is multiplied by a scaling constant. This will allow transmission of decimal parts of a unit if this is necessary for better resolution.

See the 505 Service mode for defaulted communication constants and ranges. The 505 control supports Modbus function code 4, which involves reading selected input registers. The input registers available are listed in Table 6-7.

Analog Writes (Holding Registers)

Holding registers are analog values that are writable to the 505 control. These values can also be read from by a device performing error checking. An example of an analog write value would be a direct speed set point value as opposed to raise and lower commands. The value of the holding registers are also stored in the control as numbers representing engineering units (psi or rpm). The 505 control supports Modbus function codes 3, 6, and 16. These correspond to reading selected holding registers, writing to a single holding register, and writing to multiple holding registers, respectively. The holding registers available are listed in Table 6-8.

The following tables give the address and description of all Boolean and analog, reads and writes:

Addr	Description	Addr	Description
0.0001	Emergency Shutdown	0.0041	Spare
0.0002	Emergency Shutdown Acknowledge	0.0042	Modbus Alarm Acknowledge
0.0003	Controlled Shutdown	0:0043	Turn On Relay 1
0.0004	Abort Controlled Shutdown	0:0044	Turn Off Relay 1
0.0005	System Reset	0:0045	Turn On Relay 2
0.0006	Start / Run	0:0046	Turn Off Relay 2
0.0007	Manual Open VLV Limiter	0:0047	Turn On Relay 3
0.0008	Manual Close VLV Limiter	0:0048	Turn Off Relay 3
0.0009	Lower Speed Set Point	0:0049	Turn On Relay 4
0.0010	Raise Speed Set Point	0:0050	Turn Off Relay 4
0.0011	Go To Rated (Idle / Rated)	0:0051	Turn On Relay 5
0.0012	Go To Idle (Idle / Rated)	0:0052	Turn Off Relay 5
0.0013	Halt Auto Start Seq	0:0053	Turn On Relay 6
0.0014	Continue Auto Start Seq	0:0054	Turn Off Relay 6
0.0015	Enable Remote Speed Set Point Control	0:0055	
0.0016	Disable Remote Speed Set Point Control	0:0056	
0.0017	Go To Modbus Entered Speed Setpt	0:0057	
0.0018	Spare	0:0058	
0.0019	Arm Frequency Control	0:0059	
0.0020	Disarm Frequency Control	0:0060	
0.0021	Sync Enable	0:0061	
0.0022	Sync Disable	0:0062	
0.0023	Enable Cascade Control	0:0063	
0.0024	Disable Cascade Control	0:0064	
0.0025	Lower Cascade Set Point	0:0065	
0.0026	Raise Cascade Set Point	0:0066	
0.0027	Enable Remote Cascade Set Point Control	0:0067	
0.0028	Disable Remote Cascade Set Point Control	0:0068	
0.0029	Go to Modbus Entered Cascade Setpt	0:0069	
0.0030	Spare	0:0070	* Enable Droop Set Point change
0.0031	Enable Aux Control	0:0071	* Disable Droop Set Point change
0.0032	Disable Aux Control	0:0072	* Enable Speed Forwarding
0.0033	Lower Aux Set Point	0:0073	* Disable Speed Forwarding
0.0034	Raise Aux Set Point	0:0074	
0.0035	Enable Remote Aux Set Point Control	0:0075	Momentarily Energize Relay 1
0.0036	Disable Remote Aux Set Point Control	0:0076	Momentarily Energize Relay 2
0.0037	Go To Modbus Entered Auxiliary Setpt	0:0077	Momentarily Energize Relay 3
0.0038	Spare	0:0078	Momentarily Energize Relay 4
0.0039	Select Remote Ctrl (Remote/Local)	0:0079	Momentarily Energize Relay 5
0.0040	Select Local Ctrl (Remote/Local)	0:0080	Momentarily Energize Relay 6

Table 6-5. Boolean Write Addresses

Addr	Description	Addr	Description
1:0001	Alarm - MPU #1 Failed	1:0060	* Trip - External Trip 6
1:0002	Alarm - MPU #2 Failed	1:0061	* Trip - External Trip 7
1:0003	Alarm - Cascade Input Failed	1:0062	* Trip - External Trip 8
1:0004	Alarm - Aux Input Failed	1:0063	* Trip - External Trip 9
1:0005	Alarm - KW Input Failed	1:0064	Shutdown Exists (Trip Indication)
1:0006	Alarm - Sync Input Failed	1:0065	Modbus-1 ESD Acknowledge Enable
1:0007	Alarm - Inlet Header Press Input Failed	1:0066	Moving to Min Set Point
1:0008	Alarm - Remote Speed Input Failed	1:0067	Ramping to Idle (Idle / Rated)
1:0009	Alarm - Remote Cascade Input Failed	1:0068	Idle / Rated at Idle
1:0010	Alarm - Remote Aux Input Failed	1:0069	Ramping to Rated (Idle / Rated)
1:0011	Alarm - Loadshare Input Failed	1:0070	at rated
1:0012	Alarm - Actuator #1 Failed	1:0071	Auto Seq - Setpt at Lo Idle
1:0013	Alarm - Actuator #2 Failed	1:0072	Auto Seq - Ramp to idle 2
1:0014	Alarm - Start Permissive Not Met	1:0073	Auto Seq - Setpt at Idle 2
1:0015	Alarm - Communication Link #1 Failed	1:0074	Auto Seq - Ramp to rated
1:0016	Alarm - Communication Link #2 Failed	1:0075	Auto Seq - at rated
1:0017	Alarm - Generator Breaker Open	1:0076	Speed PID In Control
1:0018	Alarm - Turbine Trip	1:0077	Speed Sensor 1 Failed Override ON
1:0019	Alarm - Tie Breaker Open	1:0078	Speed Sensor 2 Failed Override ON
1:0020	Alarm - Overspeed Alarm	1:0079	Overspeed Test Permissive
1:0021	Alarm - Tie Breaker Open / No Aux	1:0080	Overspeed Test In progress
1:0022	Alarm - Gen Breaker Open / No Aux	1:0081	Speed At or above Min Gov
1:0023	Alarm - Tie Breaker Open / No Casc	1:0082	Turbine In Critical Speed Band
1:0024	Alarm - Gen Breaker Open / No Casc	1:0083	Remote Speed Setpt Is Enabled
1:0025	Alarm - Tie Breaker Open / No Remote	1:0084	Remote Speed Setpt Is Active
1:0026	Alarm - Gen Breaker Open / No Remote	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 - spare E	1:0087	* Spare E
1:0029	Alarm - spare E	1:0088	* Auto Seq - at idle 3
1:0030	Alarm - spare E	1:0089	Spare
1:0031	Alarm - spare E	1:0090	Generator Breaker Closed
1:0032	* Alarm - ext 1	1:0091	Utility Tie Breaker Closed
1:0033	* Alarm - ext 2	1:0092	Synchronizing Rate Selected
1:0034	* Alarm - ext 3	1:0093	Synchronizing Is Enabled
1:0035	* Alarm - ext 4	1:0094	Sync or Load Share Is In Control
1:0036	* Alarm - ext 5	1:0095	Sync / Load Share Is Inhibited
1:0037	* Alarm - ext 6	1:0096	Spare
1:0038	CTC Alarm latch	1:0097	Frequency Control Armed
1:0039	Modbus-1 Alarm Acknowledge	1:0098	Frequency Control
1:0040	Alarm Exists (Common Alarm Indication)	1:0099	* Reset
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 Fault	1:0104	Rmt Cascade Is Enabled
1:0046	Trip - Actuator # 2 Fault	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	* IH Configured
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	Trip - 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	* Spare E	1:0118	Rmt Aux Is Inhibited

1:0119	* Startup Complete	1:0171	Contact In 9 Closed
1:0120	* Spare E	1:0172	Contact In 10 Closed
1:0121	* Spare E	1:0173	Contact In 11 Closed
1:0122	* Spare E	1:0174	Contact In 12 Closed
1:0123	* Spare E	1:0175	Aux Limiter Configured
1:0124	* Spare E	1:0176	Sync Function Configured
1:0125	* Spare E	1:0177	Modbus-1 ESD Control Configured
1:0126	* Spare E	1:0178	Manual Start Configured
1:0127	* Spare E	1:0179	Auto Start Configured
1:0128	* Spare E	1:0180	Semi-Auto Start Configured
1:0129	* Spare E	1:0181	Idle/Rated Start Configured
1:0130	* Spare E	1:0182	Auto Start Sequence Configured
1:0131	* Spare E	1:0183	Inlet Header Pressure Configured
1:0132	* Auto seq: ramp to Idle3	1:0184	Remote Control Configured
1:0133	* Spare E	1:0185	Loadsharing Configured
1:0134	* Spare E	1:0186	Actuator 2 Configured
1:0135	* Spare E	1:0187	Gen Set Configured
1:0136	* Spare E	1:0188	Cascade Control Configured
1:0137	VLV Limiter Is Open	1:0189	Remote Cascade Configured
1:0138	VLV Limiter Is Closed	1:0190	Aux Control Configured
1:0139	VLV Limiter In Control	1:0191	Remote Aux Configured
1:0140	Remote/Local Remote Selected	1:0192	Enables Mod1 in local
1:0141	MODBUS 1 Active	1:0193	Start Permissive Configured
1:0142	Start Permissive	1:0194	Frequency Arm/Disarm Configured
1:0143	* Spare E	1:0195	Frequency Control Configured
1:0144	* Spare E	1:0196	MPU 2 Configured
1:0145	* Spare E	1:0197	Local/Remote Configured
1:0146	* Spare E	1:0198	Local Trip Enabled
1:0147	* Spare E	1:0199	Casc Tracking Configured
1:0148	* Spare E	1:0200	KW Signal OK
1:0149	* Spare E	1:0201	* Spare E
1:0150	* Spare E	1:0202	* Spare E
1:0151	Shutdown Relay Energized	1:0203	* Spare E
1:0152	Alarm Relay Energized	1:0204	* Spare E
1:0153	Relay 1 Energized	1:0205	* Spare E
1:0154	Relay 2 Energized	1:0206	* Spare E
1:0155	Relay 3 Energized	1:0207	* TRUE = NEW 505 R
1:0156	Relay 4 Energized	1:0208	FALSE = 505, TRUE = 505E
1:0157	Relay 5 Energized	1:0209	* Alarm - ext 7
1:0158	Relay 6 Energized	1:0210	* Alarm - ext 8
1:0159	ESD Contact Input Closed	1:0211	* Alarm - ext 9
1:0160	Reset Contact Input Closed	1:0212	* Alarm - IH-act1 flt
1:0161	Raise Speed Contact Input Closed	1:0213	* Alarm - IH-act2 flt
1:0162	Lower Speed Contact Input Closed	1:0214	* Tunable ALM
1:0163	Contact In 1 Closed	1:0215	* IH-A Pressure Input Failed
1:0164	Contact In 2 Closed	1:0216	* AI FW Fault
1:0165	Contact In 3 Closed	1:0217	* Remote Droop fault
1:0166	Contact In 4 Closed	1:0218	* Hwr com1 fault
1:0167	Contact In 5 Closed	1:0219	* Spare
1:0168	Contact In 6 Closed	1:0220	* Spare
1:0169	Contact In 7 Closed	1:0221	* Spare
1:0170	Contact In 8 Closed	1:0222	* Trip - External Trip 10
1:0223	* SD HP max	1:0234	* Modbus-2 ESD Acknowledge Enable
1:0224	* Trip from other 505R Unit	1:0235	* Modbus 2 Active
1:0225	* IHA DI Fault	1:0236	* Modbus 2 ESD-2 control Configured
1:0226	* IHB DI Fault	1:0237	* Modbus-2 Alarm Acknowledge
1:0227	* All 505R Links Failed	1:0238	* Modbus-2 ESD Configured
1:0228	* Tunable SD	1:0239	* Tracking Unit Available

1:0229	Modbus 1 ESD Configured	1:0240	* Spare
1:0230	* Tracking other 505R		
1:0231	* Redundant Configured		
1:0232	* Master 505 Configured		
1:0233	Controlled Stop In Progress		

Table 6-6. Boolean Read Addresses

Analog Reads:

Addr	Description	Units	Multiplier
3:0001	Control Parameter	none	none
3:0002	Speed Sensor #1 Input (rpm)	rpm	none
3:0003	Speed Sensor #2 Input (rpm)	rpm	none
3:0004	Actual Turbine Speed (rpm)	rpm	none
3:0005	Actual Speed (%) x 100	%	100
3:0006	Speed Set Point (%) x 100	%	100
3:0007	Speed Set Point (rpm)	rpm	none
3:0008	Speed Droop Set Point (rpm)	rpm	none
3:0009	Speed Droop (%) x 100	%	100
3:0010	Speed PID Output (%)	%	100
3:0011	Min Governor Speed Set Point (rpm)	rpm	none
3:0012	Highest Speed reached	rpm	none
3:0013	Idle / Rated - Idle Speed (rpm)	rpm	none
3:0014	Idle / Rated - Rated Speed (rpm)	rpm	none
3:0015	Auto Seq - Low Idle Speed Setpt (rpm)	rpm	none
3:0016	Auto Seq-Lo Idle Dly Time (MIN) X 100	min	100
3:0017	Auto Seq-Time Left Lo Idle (MIN) X 100	min	100
3:0018	Auto Seq-Low to High Idle Rate rpm/s	rpm/s	none
3:0019	Auto Seq - High Idle Speed Setpt (rpm)	rpm	none
3:0020	Auto Seq-Hi Idle Dly Time (MIN) X 100	min	100
3:0021	Auto Seq-Time Left Hi Idle(MIN) X 100	min	100
3:0022	Auto Seq-Time ramp to Rated (rpm/s)	rpm/s	none
3:0023	Auto Seq- Rated speed stpt (rpm)	rpm	none
3:0024	Auto Seq-run hours	hrs	none
3:0025	Auto Seq-Hours Since trip	hrs	none
3:0026	Cascade Set Point (Scaled)	Casc units	cascade scale factor
3:0027	Cascade PID Output (%) x 100	%	100
3:0028	Cascade Input (%)	%	100
3:0029	Cascade Set Point (%)	%	100
3:0030	Cascade Scale Factor	none	none
3:0031	Cascade Input (Scaled)	Casc units	cascade scale factor
3:0032	Remote Cascade Input (Scaled)	Casc units	cascade scale factor
3:0033	Aux Set Point (Scaled)	aux units	aux scale factor
3:0034	Aux PID Output (%) x 100	%	100
3:0035	Aux Input (%)	%	100
3:0036	Aux Set Point (%)	%	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 Set Point Input	rpm	none
3:0041	Inlet Pressure Scale Factor	none	none
3:0042	Inlet Pressure Input (Scaled)	IP units	IP 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	VLV Limiter Output x 100	%	100
3:0048	LSS Demand (%) x100	%	100
3:0049	Actuator 1Demand (%) x100	%	100

3:0050	Actuator 2 Demand (%) x100	%	100
3:0051	* Spare E		
3:0052	* Spare E		
3:0053	* Spare E		
3:0054	* Spare E		
3:0055	* Spare E		
3:0056	* Spare E		
3:0057	* Spare E		
3:0058	* Spare E		
3:0059	* Spare		
3:0060	Modbus1 Entered Speed Set Point (fdbk)	rpm	none
3:0061	Mod1 Entered Cascade Set Point (fdbk)	Casc units	Casc scale factor
3:0062	Mod#1 Entered Aux Set Point (fdbk)	Aux units	Aux scale factor
3:0063	* Spare E		
3:0064	* Spare E		
3:0065	* Spare E		
3:0066	* Spare E		
3:0067	* Spare E		
3:0068	* Spare E		
3:0069	* Spare E		
3:0070	* Spare E		
3:0071	* Spare E		
3:0072	Analog Input 1 (percent x 100)	%	100
3:0073	Analog Input 2 (percent x 100)	%	100
3:0074	Analog Input 3 (percent x 100)	%	100
3:0075	Analog Input 4 (percent x 100)	%	100
3:0076	Analog Input 5 (percent x 100)	%	100
3:0077	Analog Input 6 (percent x 100)	%	100
3:0078	Analog Output 1 (mA x 100)	mA	100
3:0079	Analog Output 2 (mA x 100)	mA	100
3:0080	Analog Output 3 (mA x 100)	mA	100
3:0081	Analog Output 4 (mA x 100)	mA	100
3:0082	Analog Output 5 (mA x 100)	mA	100
3:0083	Analog Output 6 (mA x 100)	mA	100
3:0084	Actuator #1 Output (mA x 100)	mA	100
3:0085	Actuator #2 Output (mA x 100)	mA	100
3:0086	Last Trip	none	none
3:0087	KW Units (3=MW 4=KW)	none	none
3:0088	Analog Input 1 Configuration	none	none
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 6 Configuration	none	none
3:0106	Contact Configuration Select 1	none	none
3:0107	Contact Configuration Select 2	none	none
3:0108	Contact Configuration Select 3	none	none
3:0109	Contact Configuration Select 4	none	none
3:0110	Contact Configuration Select 5	none	none

3:0111	Contact Configuration Select 6	none	none
3:0112	Contact Configuration Select 7	none	none
3:0113	Contact Configuration Select 8	none	none
3:0114	Contact Configuration Select 9	none	none
3:0115	Contact Configuration Select 10	none	none
3:0116	Contact Configuration Select 11	none	none
3:0117	Contact Configuration Select 12	none	none
3:0118	Aux Units Configured	none	none
3:0119	Cascade Units Configured	none	none
3:0120	* Spare E	none	none
3:0121	* S/W PN54182629	none	none
3:0122	*S/W Revision	none	none
3:0123	* Auto Seq-Time ramp to HH idle(rpm/s)	none	none
3:0124	* Auto Seq-HHi Idle speed rpm	none	none
3:0125	* Auto Seq-HH Idle Dly Time (MIN)X 100	none	none
3:0126	* Auto Seq-Time Left HH Idle(MIN) X100	none	none
3:0127	* Max Governor Speed	rpm	none
3:0128	* IH-A Press (Unit)	none	IH scale factor
3:0129	* IH Scale Factor	none	none
3:0130	* IH Press Units Configured	none	none
3:0131	* Modbus 2 Entered Speed Set Point	rpm	none
3:0132	* Modbus 2 Entered Cascade Set Point	Casc units	Casc scale factor
3:0133	* Modbus 2 Entered Aux Set Point	Aux units	Aux scale factor
3:0134	* Feed-Forward Input	rpm	none
3:0135	* Actuator Driver Type	none	none
3:0136	* Droop Setting	%	100
3:0137	* Autostart seq rate to Low idle	rpm/s	none
3:0138	* Autostart seq CF Cold rte to H idle	rpm/s	none
3:0139	* Autostart seq CF Hot rate to H idle	rpm/s	none
3:0140	* Autostart seq CF Cold rte to HH idle	rpm/s	none
3:0141	* Autostart seq CF Hot rate to HH idle	rpm/s	none
3:0142	* Autostart seq CF Cold rate to rated	rpm/s	none
3:0143	* Autostart seq CF Hot rate to rated	rpm/s	none
3:0144	Speed Derivative signal	rpm/s	1
3:0145	Speed Accel Rate (%/s of Overspeed Limit x10)	%/s	X10

Table 6-7. Analog Read Addresses

*—Denotes differences between 505 and 505 Enhanced.

Analog Writes:

Addr	Description	Units	Multiplier
4:0001	Modbus Entered Speed Set Point	rpm	none
4:0002	Modbus Entered Casc Set Point	Casc units	Casc scale factor
4:0003	Modbus Entered Aux Set Point	Aux units	Aux scale factor
4:0004	* Spare E		
4:0005	* Modbus Droop demand (x100)	%	x0.01
4:0006	Spare		
4:0007	Spare		
4:0008	Spare		

Table 6-8. Analog Write Addresses

Last Turbine Trip Cause

The cause of the last turbine trip (address 3:0086) is an integer that represents the following cause:

Value	Description
1.	External Trip Input
2.	Emergency Shutdown Button (front panel push-button)
3.	Overspeed Trip
4.	All Speed Probes Failed
5.	Act #1 Fault
6.	Act #2 Fault
7.	Aux or KW Input Failed
8.	External Trip 2
9.	External Trip 3
10.	Comm Link #1 Trip
11.	Comm Link #2 Trip
12.	(Not Used)
13.	Utility Tie Breaker Opened
14.	Generator Breaker Opened
15.	Power up Shutdown
16.	Manual (controlled) Shutdown
17.	External Trip 4
18.	External Trip 5
19.	(Not Used)
20.	External Trip 6
21.	External Trip 7
22.	External Trip 8
23.	External Trip/XFER 9
24.	External Trip/XFER 10
25.	HP Valve Limiter at Max w/ No Speed Detected
26.	Trip from Other Unit (Redundant Only)
27.	IHA Discrete Input Fault
28.	IHB Discrete Input Fault
29.	All 505R Links Failed (Redundant Only)
30.	(Not Used)

Table 6-9. Last Turbine Trip Cause

505 Controlling Parameters

The controlling parameter status of the 505 uses an Analog Read register (3:0001) to identify the parameters that are in control. This variable follows what is displayed on the controlling parameter screen, under the ‘CONT’ key. The variable gives the current status of the control and is defined in the following table.

Value	Description	Value	Description
1.	Speed/Off—Line	13.	Manual Start
2.	Speed/On—Line	14.	Ready to Start
3.	Remote/Speed	15.	Start Perm Not Met
4.	Cascade/Speed	16.	Configuration Error
5.	Remote Cascade/Speed	17.	Auxiliary
6.	Frequency/Speed	18.	Remote Auxiliary
7.	Load Share/Speed	19.	Valve Limiter
8.	Synchronizing	20.	Max Actuator
9.	Auto Start Sequence	21.	Spare for future use
10.	Idle/Rated Start	22.	Controlled Shutdown
11.	Semi Auto Start	23.	Shutdown
12.	Auto Start		

Table 6-10. 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.

Value	Description
1.	Remote Speed Setpt
2.	Synchronizing Input
3.	Sync/Load Share Input
4.	KW/Unit Load Input
5.	Cascade Input
6.	Remote Cascade Setpt
7.	Auxiliary Input
8.	Remote Aux Setpt
9.	Inlet Header Press Input
10.	I/H-A Pressure Input
11.	Speed Feed-Forward
12.	Remote Droop
13.	(Not Used)

Table 6-11. 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.

Value	Description
1.	Actual Speed
2.	Speed Set Point
3.	Remote Speed Setpt
4.	Load Share Input
5.	Sync Input
6.	KW Input
7.	Cascade Input
8.	Cascade Set Point
9.	Rmt Cascade Setpt
10.	Auxiliary Input
11.	Auxiliary Set Point
12.	Rmt Auxiliary Setpt
13.	Valve Limiter Set Point
14.	Actuator Demand Readout
15.	Actuator 1 Readout
16.	Actuator 2 Readout
17.	Inlet Header Press Input
18.	I/H-A Pressure Readout
19.	(Not Used)

Table 6-12. 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.

IMPORTANT **If the control is configured as redundant, relay 1 is reserved for redundant status function regardless of configuration value.**

Value	Description
Relay Configured As Level Switch	
1.	Speed Level Switch
2.	Speed Set Point Level Switch
3.	KW Level Switch
4.	Load Share Level Switch
5.	Cascade Level Switch
6.	Cascade Set Point Level Switch
7.	Aux Level Switch
8.	Aux Set Point Level Switch
9.	Actuator Demand Level Switch
10.	Act 1 Demand Level Switch
11.	Act 2 Demand Level Switch
12.	Valve Limiter Level Switch
13.	Inlet Header Pressure Level Switch

Relay Configured to Indicate State

Value	Description	Value	Description
21.	Shutdown Indication	42.	Rmt Casc Setpt Active
22.	Trip Relay	43.	Aux Control Enabled
23.	Alarm Energized	44.	Aux Control Active
24.	Control Status O.K.	45.	Aux PID in Control
25.	Overspeed Trip	46.	Rmt Aux Setpt Enabled
26.	Overspeed Test Enabled	47.	Rmt Aux Setpt Active
27.	Speed PID in Control	48.	Valve Limiter in Control
28.	Rmt Spd Setpt Enabled	49.	F3 Key Selected
29.	Rmt Spd Setpt Active	50.	F4 Key Selected
30.	Underspeed Switch	51.	Modbus Selected
31.	Auto Start Seq Halted	52.	NOT USED
32.	On-Line PID Selected	53.	Alarm De-energized
33.	Local Control Mode	54.	Backup Unit (Tracking)
34.	Frequency Ctrl Armed	55.	Redundant Link Relay
35.	Frequency Control	56.	In Control Unit
36.	Sync Enabled	57.	Other Unit Failed
37.	Sync or Ld Share Active	58.	Unit OK (No SD)
38.	Load Share Control	59.	Open Generator CMD
39.	Casc Control Enabled	60.	Reset Pulse (2 sec)
40.	Cascade Control Active	61.	Feed-Forward Enabled
41.	Rmt Casc Setpt Enabled	62.	Feed-Forward Active

Table 6-13. 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.

IMPORTANT **If the control is configured as redundant, contact input 1 is reserved for redundant status function regardless of configuration value.**

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.	N/A
14.	Freq. Control Arm/Disarm
15.	Casc Setpt Raise
16.	Casc Setpt Lower
17.	Casc Control Enable
18.	Remote Casc Setpt Enable
19.	Aux Setpt Raise
20.	Aux Setpt Lower
21.	Aux Control Enable
22.	Remote Aux Setpt Enable
23.	Valve Limiter Open
24.	Valve Limiter Close
25.	External Trip 2
26.	External Trip 3
27.	External Trip 4
28.	External Trip 5
29.	Controlled Shutdown
30.	External Trip 7
31.	External Trip 8
32.	External Trip/XFER 9
33.	External Trip/XFER 10
34.	External Alarm 1
35.	External Alarm 2
36.	External Alarm 3
37.	External Alarm 4
38.	External Alarm 5
39.	External Alarm 6
40.	External Alarm 7
41.	External Alarm 8
42.	External Alarm 9
43.	Select In-Control Unit
44.	Monitor Only (no function)
45.	I/HA Act1 Fault
46.	I/HB Act2 Fault
47.	Monitor Only (no function)
48.	External Trip 6
49.	Speed Forward Enable
50.	Instant Min Gov Speed
51.	Select Hot Start
52.	NOT USED

Table 6-14. 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.

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 6-15. Units Configuration

Specific Address Information

Entering Set Point from Modbus

- The set point for the Speed, Cascade and Auxiliary can be entered from the Modbus. When the set point is entered for any of these functions the set point will not move to the entered set point instantly, but the set point will move towards the entered set point at the entered rate defined for the function in the program mode. This functions the same as entering the set point from the front panel of the control.
- There is feedback provided to let the operator know what value was entered. This value will not change until a new value is entered from the Modbus. The addresses, 3:0060-:0062, are for speed, cascade, and auxiliary respectively. When the a new value is entered from the Modbus, the set point will move to the new value. If the entered set point that is the same as the feedback, the operator can use a go to the set point command instead of entering the set point again. This command needs to be used when the set point to be entered is the same as the feedback.

Modbus Scale Factors

Modbus has two limitations:
- only integers can be sent across
- the value is limited between -32767 and 32767

These limitations can be overcome by scaling the value before it is sent across the Modbus. The default scale factor for the analog values is 1. The scale factor can be changed in the service mode between 1 and 100. The following input and set point values that are sent across the Modbus have independent scale factors: Casc (3:0030), Aux (3:0037), FSP (3:0041), KW (3:0045), and Sync/Load Share (3:0043). These scaled parameters and their scale factor are available through the Modbus. Values that require a decimal point must be multiplied by the scale factor (10 or 100) prior to being sent across the Modbus. The value sent must then be divided by the scale factor in the Master.

The Scale Factor adjusts all associated analog reads and writes accordingly. For example, the Cascade Scale Factor adjusts the cascade input and set point analog read values as well as the Entered Setpt analog write value.

For example, if the Cascade set point of 60.15 needs to be sent across the Modbus and have two decimal places, the Cascade Scale Factor would be set to 100 in the Service Mode. This will change the value so that the decimal places can be sent across the Modbus communications link (60.15 * 100 = 6015). After the value is sent across the Modbus, it must be rescaled in the Master to the original value (6015/100 = 60.15). A Directly Entered Cascade Set Point (4:0002) of 61.5 would be sent across the link as 6150 and the 505 automatically divides the value by the Casc Scale Factor and uses the value of 61.5 as the set point desired.

Modbus Percentage

Some of the analog read addresses have percentages sent across. The formula used in the percentage calculation is (actual/max) * 100). The percentage is multiplied by 100 before being sent across the Modbus to provide up to 2 decimal places, if desired.

Modbus Emergency Shutdown

Two different types of shutdown commands (emergency and controlled) can be issued through Modbus. The Emergency Shutdown command instantly takes the speed set point and actuator current to zero. Optionally the 505 can be configured to ignore this Emergency Shutdown command if it is desired to not allow the unit to be tripped through Modbus.

To avoid an inadvertent trip, the emergency shutdown command from Modbus can be configured to require a two step process before a shutdown command is issued. When the shutdown is a two step process Boolean write address 0001 starts the shutdown process. An “ESD ACKN ENABLE” feedback (1:0065) is given and an acknowledge on address 0002 has to be given within five seconds for the control to issue a shutdown command.

See Volume 2 for Service mode tunables.

For More Modbus Information

Detailed information on the Modbus protocol is presented in “Reference Guide PI-MBUS-300” published by AEC Corp./Modicon Inc., formerly Gould Inc. To implement your own source code, you must register with Modicon. Registration includes purchasing document PI-MBUS-303 and signing a non-disclosure agreement. You can register to use Modbus at your nearest Modicon field office. To find the office nearest you, contact Modicon Technical Support at 1-800-468- 5342.

Chapter 7.
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

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Turbine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

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 A.
505 Program Mode Worksheets

Governor Serial Number _____

Application _____ Date _____

For details on individual settings, refer to Chapter 4.

TURBINE START

Manual Start	YES	NO	
Automatic Start	YES	NO	
Semiautomatic Start	YES	NO	
Rate to Min (rpm/s)			rpm/s
Valve Lmtr Rate (%/s)			%/s
Use Idle/Rated?	YES	NO	
Idle Setpt (rpm)			rpm
Rated Setpt (rpm)			rpm
Idle/Rtd Rate (rpm/s)			rpm/s
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
Use Idle 2	YES	NO	
Rate to Idle 2 (Cold)			rpm/s
Rate to Idle 2 (Hot)			rpm/s
Idle 2 Setpt (rpm)			rpm
Idle 2 Delay (Cold)			MIN
Idle 2 Delay (Hot)			MIN
Use Idle 3	YES	NO	
Rate to Idle 3 (Cold)			rpm/s
Rate to Idle 3 (Hot)			rpm/s
Idle 3 Setpt (rpm)			rpm
Idle 3 Delay (Cold)			MIN
Idle 3 Delay (Hot)			MIN
Rate to Rated (Cold)			rpm/s
Rate to Rated (Hot)			rpm/s
Rated Setpt (rpm)			rpm
RST Timer Level (rpm)			rpm
Hot RST Timer (min)			min
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 SET POINT VALUES

Overspeed Test Lmt (rpm)			rpm
Overspeed Trip (rpm)			rpm
Max Governor Speed (rpm)			rpm
Min Governor Speed (rpm)			rpm
Off-line Slow Rate (rpm/s)			rpm/s
On-line Slow Rate (rpm/s)			rpm/s
Use Remote Speed Setpt ?	YES	NO	
Rmt Spd Setpt Max Rate			rpm/s
Use Critical Speeds?	YES	NO	
Critical Speed Rate			rpm/s
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

Redundant 505	YES	NO	
Master 505	YES	NO	
Use DI to XFER Control	YES	NO	
Type of Actuator Single Coil shared			
Dual Coil / Two Actuator			
Track Cascade Status	YES	NO	
Track Auxiliary Status	YES	NO	
Track Remote Status?	YES	NO	
Communication – Configure Port 1/ Use Port-1			
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
Freq at rated is 50/60 Hz			
Use Freq Arm/Disarm ?	YES	NO	
Ctrl Stop & Rev Pwr	YES	NO	
Auto Acceleration detect	YES	NO	
Max Spd on Load			rpm
Max Accel on Load			rpm/s
TieOpn/Always act?	YES	NO	
Use Feed-Forward	YES	NO	
Direct Feed-Forward	YES	NO	
Action Delay			
Min Forward Rate			
Spd offset at Min Rate			
Max Forward Rate			
Speed offset at Max Rate			
Use Only when Cascade	YES	NO	
Cascade DB when FW active			
Use Emergency	YES	NO	
Emergency Action Delay			
FW Rate to activate			
Emrg Max Forward Rate			
Emrg Max Speed Offset			
Emrg Max Speed Rate	YES	NO	
Speed Offset at 4 mA			rpm
Speed Offset at 20 mA			rpm
Speed DB			
CTRL Stop & Trip	YES	NO	
Use Local/Remote	YES	NO	

DRIVER CONFIGURATION

Act#1 is 4–20 mA?	YES	NO	
Invert Driver Output?	YES	NO	
Use Act 1 Flt Shutdown	YES	NO	
Act#1 Dither			
Use I/H-A Press FDBK	YES	NO	
I/H Press Unit			
Use Press Comp?	YES	NO	
Use Actuator#2?	YES	NO	
Act#2 is 4–20 mA	YES	NO	
Act#2 Offset?			%
Use Act 2 Flt Shutdown	YES	NO	
Act#2 Dither(%)			
Use Act#2 as Readout?	YES	NO	
Act#2 Readout is:			
Readout 4 mA Value			Units
Readout 20 mA Value			Units

ANALOG INPUTS

Analog Input # 1 Function	
Input 1 4 mA Value	Units
Input 1 20 mA Value	Units
Analog Input # 2 Function	
Input 2 4 mA Value	Units
Input 2 20 mA Value	Units
Analog Input # 3 Function	
Input 3 4 mA Value	Units
Input 3 20 mA Value	Units
Analog Input # 4 Function	
Input 4 4 mA Value	Units
Input 4 20 mA Value	Units
Analog Input # 5 Function	
Input 5 4 mA Value	Units
Input 5 20 mA Value	Units
Analog Input # 6 Function	
Input 6 4 mA Value	Units
Input 6 20 mA Value	Units

CONTACT INPUTS

Redundant 505?	YES	NO
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

Redundant 505?	YES	NO
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/s		Units/s
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/s
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 (/s)		Units/s
Use Set Point Tracking ?	YES	NO
Setpt Initial Value		Units
Speed Setpt Lower Limit		rpm
Speed Setpt Upper Limit		rpm
Max Speed Rate(rpm/s)		rpm/s
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/s
Casc Units of Measure		

READOUTS

Analog Readout 1 Is	
Readout 1 4 mA Value	Units
Readout 1 20 mA Value	Units
Analog Readout 2 Is	
Readout 2 4 mA Value	Units
Readout 2 20 mA Value	Units
Analog Readout 3 Is	
Readout 3 4 mA Value	Units
Readout 3 20 mA Value	Units
Analog Readout 4 Is	
Readout 4 4 mA Value	Units
Readout 4 20 mA Value	Units
Analog Readout 5 Is	
Readout 5 4 mA Value	Units
Readout 5 20 mA Value	Units
Analog Readout 6 Is	
Readout 6 4 mA Value	Units
Readout 6 20 mA Value	Units

RELAYS

Redundant 505?	YES	NO	
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			

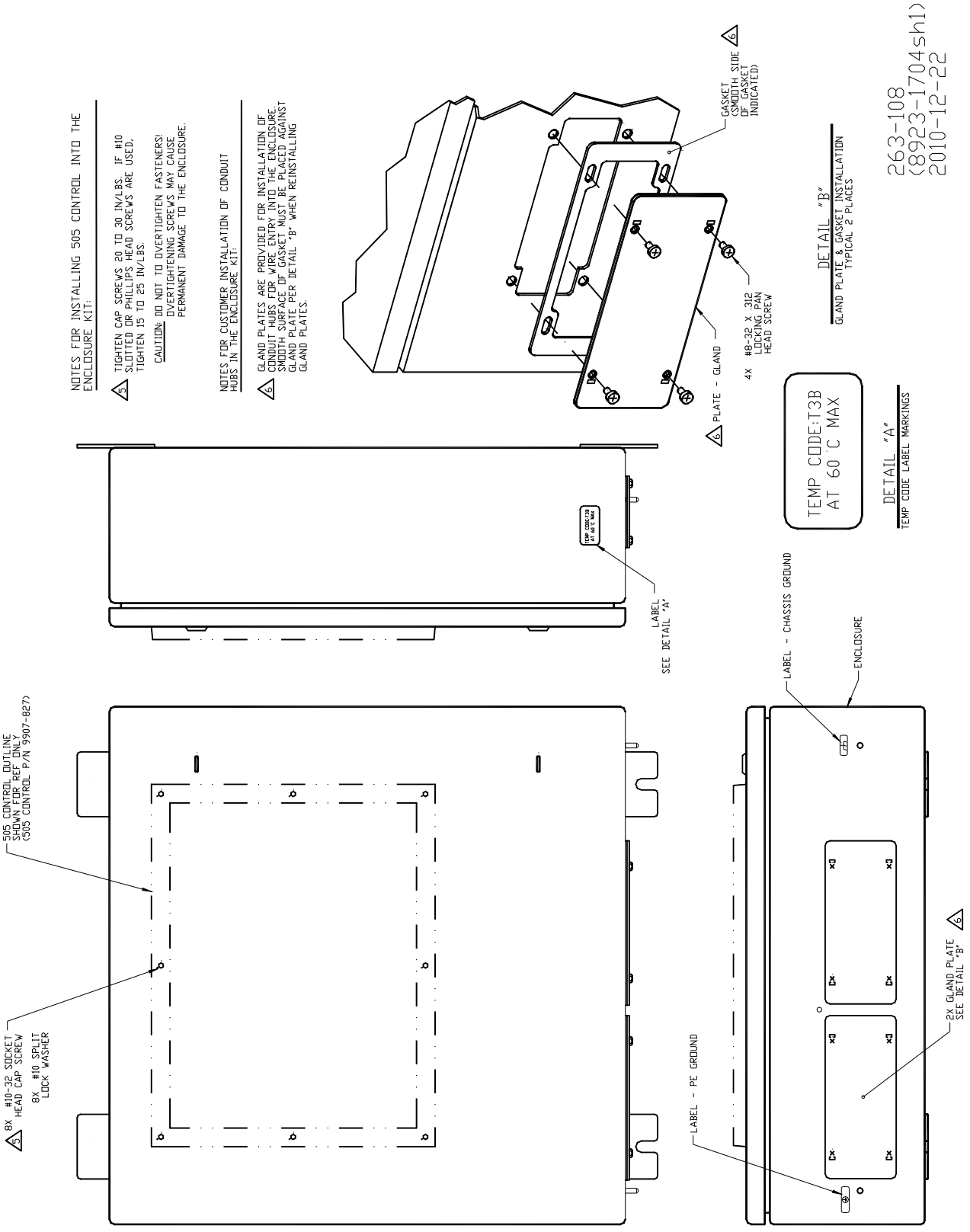
COMMUNICATIONS

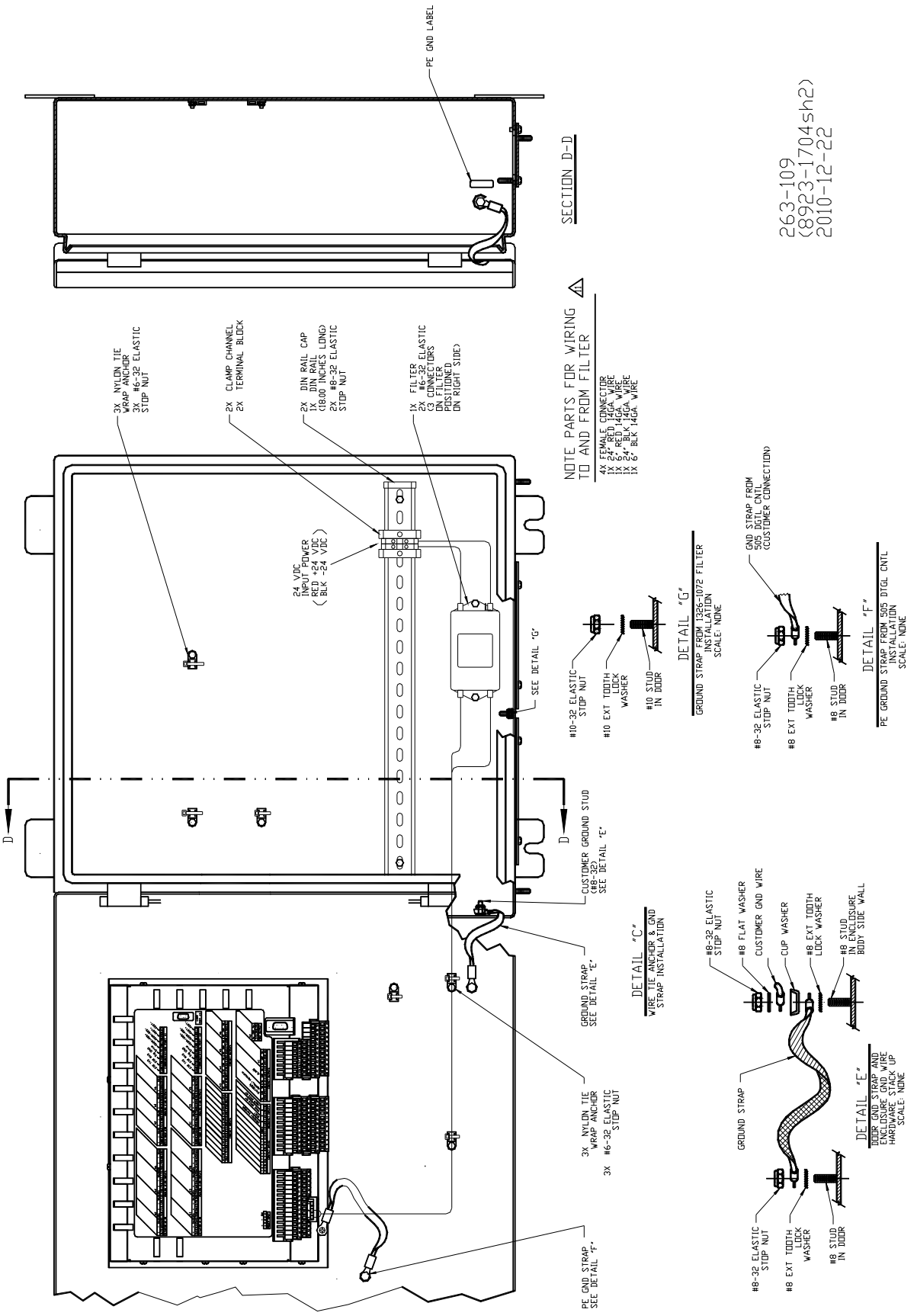
Use Communications ?	YES	NO
Use Modbus Port 1?	YES	NO
Mode Ascii=1 Rtu=2		
Modbus Device #		
Port #1 Driver		
Port #1 Baud Rate		
Port #1 Stop Bits		
Port #1 Parity		
Use Modbus Port 2?	YES	NO
Mode Ascii=1 Rtu=2		
Modbus Device #		
Port #2 Driver		
Port #2 Baud Rate		
Port #2 Stop Bits		
Port #2Parity		

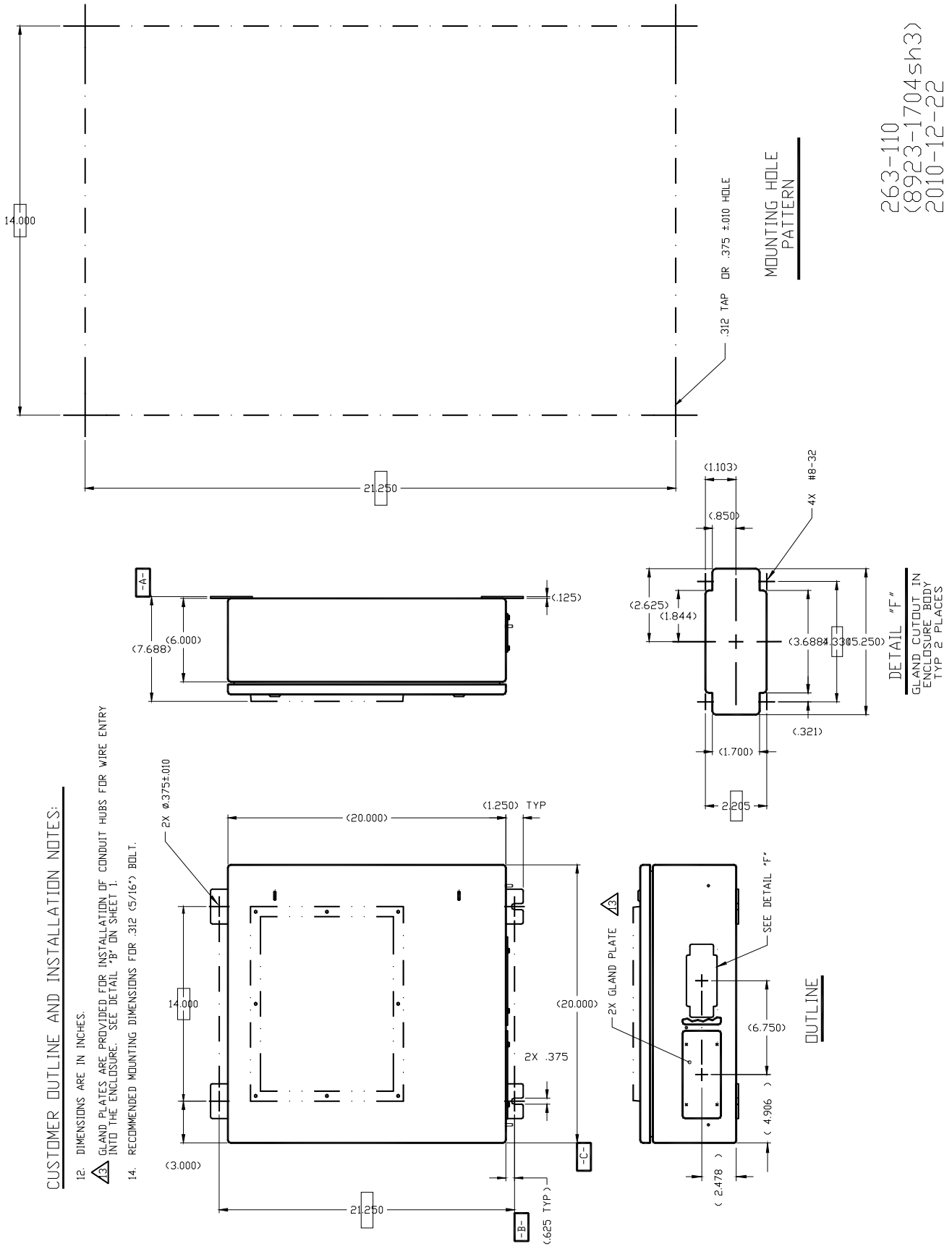
When Actuator Outputs have been (In Service) Calibrated and Stroked, record values here.

	Default	505 Unit #1	505 Unit #2
Actuator # 1 mA at Minimum Position	*4.00		
Actuator # 1 mA at Maximum Position	*20.00		
Actuator # 1 Dither (%)	*0.00		
Actuator # 2 mA at Minimum Position	*4.00		
Actuator # 2 mA at Maximum Position	*20.00		
Actuator # 2 Dither (%)	*0.00		

Appendix B.
505 Marine 8923-1704




PE GND LABEL
SECTION D-D
263-109
(8923-1704sh2)
2010-12-22
NOTE PARTS FOR WIRING TO AND FROM FILTER
4X FEMALE CONNECTOR
1X 24" RED 14GA WIRE
1X 24" BLK 14GA WIRE
1X 6" BLK 14GA WIRE
3X NYLON TIE WRAP ANCHOR
3X #6-32 ELASTIC STOP NUT
2X CLAMP CHANNEL
2X TERMINAL BLOCK
2X DIN RAIL CAP
1X DIN RAIL (18.00 INCHES LONG)
2X #8-32 ELASTIC STOP NUT
1X FILTER
2X #6-32 ELASTIC
(3 CONNECTORS ON FILTER POSITIONED ON RIGHT SIDE)
24 VDC INPUT POWER
RED +24 VDC
BLK -24 VDC
SEE DETAIL "G"
CUSTOMER GROUND STUD (#8-32) SEE DETAIL "E"
GROUND STRAP SEE DETAIL "E"
3X NYLON TIE WRAP ANCHOR
3X #6-32 ELASTIC STOP NUT
PE GND STRAP SEE DETAIL "F"
DETAIL "C"
WIRE TIE ANCHOR & GND STRAP INSTALLATION
#10-32 ELASTIC STOP NUT
#10 EXT TOOTH LOCK WASHER
#10 STUD IN DOOR
DETAIL "G"
GROUND STRAP FROM 1326-1072 FILTER INSTALLATION
SCALE: NONE
GND STRAP FROM 505 DTGL CNTL (CUSTOMER CONNECTION)
#8-32 ELASTIC STOP NUT
#8 EXT TOOTH LOCK WASHER
#8 STUD IN DOOR
DETAIL "F"
PE GROUNDD STRAP FROM 505 DTGL CNTL INSTALLATION
SCALE: NONE
#8-32 ELASTIC STOP NUT
#8 FLAT WASHER
CUSTOMER GND WIRE
CUP WASHER
#8 EXT TOOTH LOCK WASHER
#8 STUD IN ENCLOSURE BODY SIDE WALL
GROUND STRAP
#8-32 ELASTIC STOP NUT
#8 EXT TOOTH LOCK WASHER
#8 STUD IN DOOR
DETAIL "E"
DOOR GND STRAP AND ENCLOSURE GND WIRE HARDWARE STACK UP
SCALE: NONE


263-110
(8923-1704 sh 3)
2010-12-22
MOUNTING HOLE PATTERN
14.000
21.250
.312 TAP OR .375 ±.010 HOLE
DETAIL "F"
GLAND CUTOUT IN ENCLOSURE BODY TYP 2 PLACES
(1.103)
(.850)
4X #8-32
(2.625)
(1.844)
(3.688)
(4.330)
(5.250)
(.321)
(1.700)
2.205
-A-
(.125)
(7.688)
(6.000)
2X ø.375±.010
(20.000)
(1.250) TYP
14.000
(20.000)
2X .375
(3.000)
21.250
-B-
(.625 TYP)
-C-
2X GLAND PLATE
SEE DETAIL "F"
(6.750)
(4.906)
(2.478)
OUTLINE
CUSTOMER OUTLINE AND INSTALLATION NOTES:
12. DIMENSIONS ARE IN INCHES.
13 GLAND PLATES ARE PROVIDED FOR INSTALLATION OF CONDUIT HUBS FOR WIRE ENTRY INTO THE ENCLOSURE. SEE DETAIL "B" ON SHEET 1.
14. RECOMMENDED MOUNTING DIMENSIONS FOR .312 (5/16") BOLT.

Revision History

Changes in Revision L—

- Added recommendation to not use Actuator 2 in redundant configurations
- Removed notes related to the auto-reset function for failed sync / load share inputs
- Updated Table 6-14 (Contact Input Configurations)
- Added description of inlet pressure compensation feature
- Clarified ASCII/RTU setting for the Modbus link between redundant 505s
- Removed PID tuning formulas
- Added description of the instant min gov feature
- Clarified condtions for initiating the transition from the cold start condition to the hot start condition

Changes in Revision K—

- Updated Regulatory Compliance information (page viii)

Changes in Revision J—

- Added information about wiring and disconnecting power

Changes in Revision H—

- Changed field wiring requirement

Declarations

DECLARATION OF CONFORMITY

Manufacturer's Name: WOODWARD GOVERNOR COMPANY (WGC)

Manufacturer's Address: 1000 E. Drake Rd.
Fort Collins, CO, USA, 80525

Model Name(s)/Number(s): 505 Control: 18-32 Vdc (9907-164 and similar)
505E Control: 18-32 Vdc (9907-167 and similar)
505H Control: 18-32 Vdc (9907-117 and similar)

Conformance to Directive(s): 2004/108/EC COUNCIL DIRECTIVE of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

94/9/EC 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

Marking(s): Ⓔx Category 3, Group II G, Ex nA II T3

Applicable Standards: EN61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments
EN61000-6-4, 2007: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments
EN60079-0, 2004: Electrical apparatus for explosive gas atmospheres – Part 0: General requirements
EN60079-15, 2005: Electrical apparatus for explosive gas atmospheres – Part 15: Type of protection 'n'

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

Suhail Horan
Signature

Suhail Horan
Full Name

Quality Manager
Position

Fort Collins, CO, USA
Place

27-APR-2010
Date

5-09-1183 Rev 16, 22-Jan-2009 00134-04-EU-02-01

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26347V1L.

B26347V1:L

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