



## **505 Digital Governor for Steam Turbines with Single or Split-Range Actuators**

**9907-162, 9907-163, 9907-164**  
**Volume 2**

Manual 85017 consists of 2 volumes (85017V1 & 85017V2).

**Installation and Operation Manual**



### General Precautions

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

Practice all plant and safety instructions and precautions.

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



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



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# Warnings and Notices

## Important Definitions



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

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

### **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 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

**ATEX – Potentially Explosive Atmospheres Directive:** Declared to 94/9/EEC COUNCIL DIRECTIVE of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.  
EEx nA II T3 X

**C-Tick (ACA/RSM):** Declared to Australian Radiocommunications Act of 1992 and the New Zealand Radiocommunications Act of 1989.

## 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

## General Installation and Operating Notes and Warnings

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

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

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

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

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

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

 **WARNING**

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

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

 **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.**



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# Introduction

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Manual 85017 Volume 2 is a dual purpose manual. It includes application-specific notes and 505 specific Service mode information.

The first part of this volume gives users an idea of the 505 Digital Control's capabilities, and how to apply them to a system. Typical applications are schematically shown and their functionality explained. Programming and Start/Run mode notes are given for each application to assist application programmers in configuring the 505 for their application.

The second part of this volume includes 505 program modes not covered in Volume 1 of this manual (Service, Debug, SYS\_INFO, OPSYS Faults), PID dynamic setting specifics, and Hardware rating information.

# Chapter 1.

## Peripheral Devices

### Overview

This chapter provides a brief explanation of peripheral devices, that can be used with the 505. By understanding the functionality of a peripheral device, a better understanding of the overall control configuration can be achieved.

All the devices covered in this section are manufactured or supported by the Woodward Governor Company. Peripheral devices manufactured by other companies can be used with the 505 to perform the functions detailed bellow, however, the compatibility of them to the 505 and the application should be verified before system operation.

### 505 HMI Software

Woodward offers two different HMI software packages, OpView™ and 505View, which allow an operator to remotely view operating inputs, adjust control setpoints, issue Run mode commands, and monitor/troubleshoot the turbine control. Both HMI packages are self-configuring which eliminates all field engineering—they automatically configure their screens to match the control's programmed application.

The OpView is comprised of an industrialized NEMA 4 touchscreen hardware package bundles together with a Woodward developed software interface program. The 505View is a unbundled Intellution-based software package that runs on a pc (hardware can be optionally purchased). Both HMI packages are pre-configured to communicate via Modbus® \* protocol with either a 505 or 505E Woodward steam turbine control and offer the following features:

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

- Automatic Screen Generation based on control configuration
- Security with multiple User Levels
- Remote Access Capability<sup>1</sup>
- Real-Time and Historical Trending<sup>2</sup>
- Alarm/Trip Status Indication
- Alarm/Trip Log with Time Tagging and First-Out Indication
- I/O and System Troubleshooting
- Graphic System Control screens
- Event Status Logging and History<sup>3</sup>

#### Notes:

1 505View only

2 OpView has Real-Time Trending only; 505View has both

3 OpView has Logging only; 505View has Logging and History

By connecting the OpView or 505View to either 505 Modbus port, it automatically configures its screens to match the 505's programmed application. If the 505 is not configured to accept Modbus commands, the HMI functions as a system monitor only. If the 505 is configured to accept Modbus commands, all 505 Run Mode operations can be monitored and performed through it (start, stop, mode enable/disable, setpoint raise/lower). For safety purposes, the Overspeed test function can not be performed through the HMI. See Volume 1, Chapter 7 of this manual for more information on programming Modbus ports.

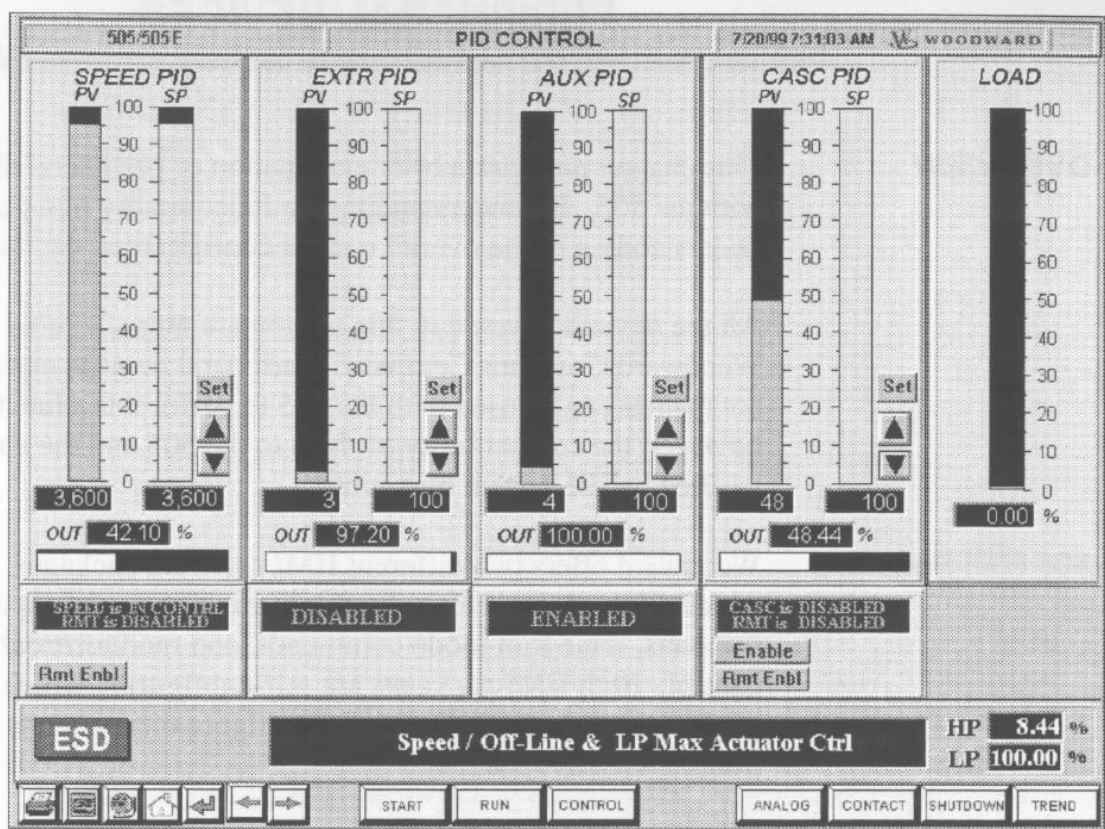


Figure 1-1. 505 HMI Software

User-friendly touch screens allow operators to view and control multiple modes of operation and setpoints from one screen. Ten different screens are available to allow operators the flexibility of viewing. These screens display the following information:

- Controlling parameter information
- Complete starting sequences
- Turbine and/or Generator information
- Speed, Extr/Adm, Aux, Casc, & Limiter information
- Analog Input and Output levels
- Contact Input and Relay Output states
- Alarm and Shutdown Log

The OpView or 505View can interface with the 505 through serial RS-232, RS-422, or RS-485 communications. By using RS-422 or RS-485 communications, the HMI can be located up to 1220 m (4000 ft) from the 505 digital control.

### Digital Remote Final Driver

A Digital Remote Final Driver (DRFD) is used to interface the 505 digital control to existing valve operators or Woodward actuators that are integrating in action or are not compatible with the 505.

The 505's actuator outputs have the capability of driving a 4–20 mA or 20–160 mA (200 mA max) proportional signal into an actuator coil. These 505 actuator output signals represent a demand signal equal to desired valve position (proportional). If the application's actuator or servo assembly requires a different drive signal, or control action (integrating with a null setting), a Digital Remote Final Driver or equivalent device must be used.

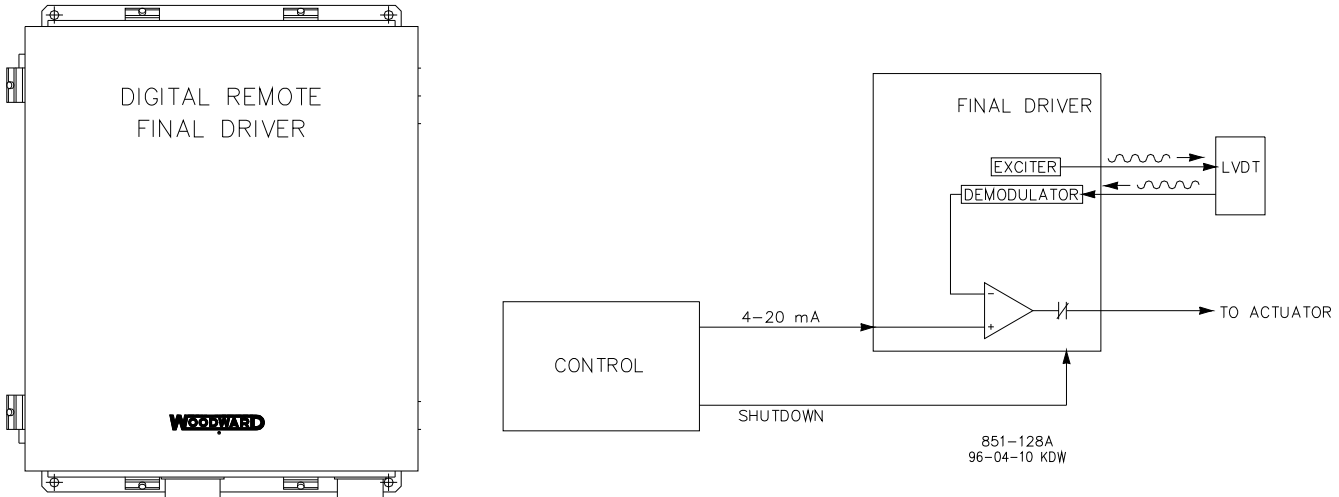


Figure 1-2. Digital Remote Final Driver

Woodward Digital Remote Final Drivers accept a 4–20 mA actuator-drive signal proportional to desired valve position, and position a servo assembly accordingly. Integrating or proportional type DRFDs are available depending on the servo assembly being interfaced to. Woodward DRFDs have the capability of driving unipolar or bipolar actuator demand signals, up to 0–400 mA or +400 mA respectively.

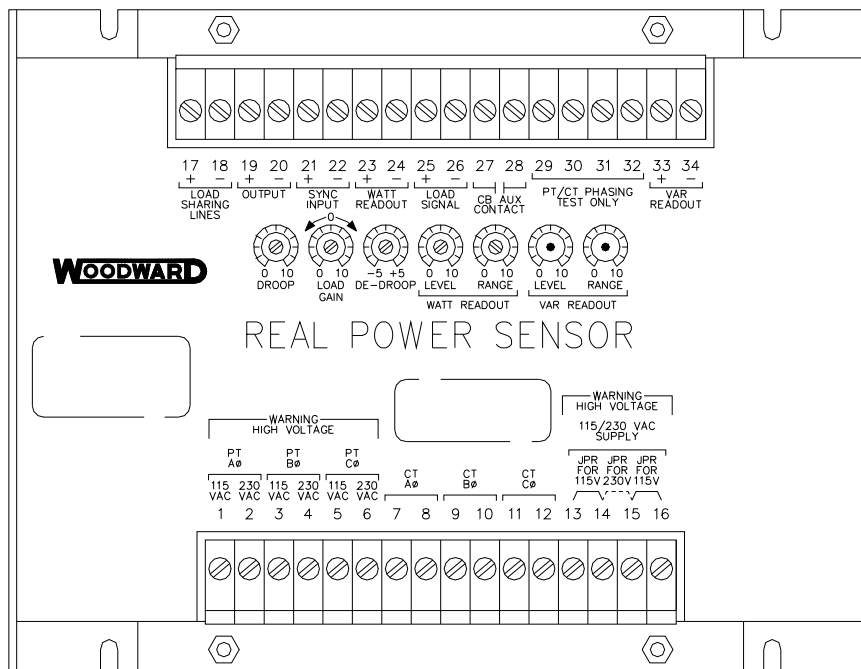
The Digital Remote Final Driver is housed in a NEMA-4X enclosure with a hinged cover and consists of driver and power supply modules. The driver module uses plug-in jumpers and an alphanumeric display to facilitate field configuration and calibration.

Proportional type DRFDs can provide an output drive signal of up to 400 mA, to be compatible with existing servo assemblies. This drive signal is proportional to the 4–20 mA input signal received from the 505 digital control.

Integrating type DRFDs sense actual valve position (through, LVDTs, RVDTs, MLDTs, or dc position feedback devices), compare this signal to the input position demand signal from the 505, and output a drive signal to position a servo assembly accordingly. See Figure 1-2.

## Real Power Sensor

A Real Power Sensor is used to sense the real power being produced by a generator, or flowing through a tie line. Woodward Real Power Sensors sense three phase volts, three phase amps, compare each phase's voltage to current relationship, and develop a 4–20 mA output proportional to real power.



820-015 F1

96-04-11 KDW

Figure 1-3. Real Power Sensor

Woodward manufactures two types of Real Power Sensors. The first type of RPS is designed to sense power flow in one direction only (0 to +5 A CT current only), and output a proportional 4–20 mA signal. This type of RPS was designed for and should be used to sense generator power output. Many different real power sensors of this type exist. Some of the optional RPS features include VAR sensing, Loadsharing, 0–1 A CT current sensing, and multiple combinations of these. Please consult a Woodward certified distributor or a Woodward factory for the recommended RPS for your application.

The second type of RPS manufactured by Woodward is designed to sense power flow through a bus-to-bus tie line. This RPS (8272-726) senses –5 A to +5 A CT current to allow its output to represent power flow in both directions. This RPS provides a 4–20 mA power indication output signal where 12 mA represents 0 power flow. It is recommended that this RPS be used to sense power flow through a tie line only. This RPS or equivalent is required to sense plant Import and Export power.

Woodward Real Power Sensors have terminals labeled “Output” and terminals labeled “KW Readout”. The “KW Readout” terminals provide a 4–20 mA signal proportional to real power which is used by and compatible with the 505 control. Thus the RPS terminals labeled “Output” are designed and typically compatible only to Woodward’s 2301 type of control.

Woodward manufactured Real Power Sensors have a 2.5 Hz Low pass filter (400 ms lag time) on their output to filter out the high frequency noise typically created in a switch gear type environment. Thus if another vendor’s watt transducer is used, verification that it has similar filtering criteria should be performed before it is applied with the 505. For more information on Woodward Real Power Sensors, please refer to Woodward manual 82018.

## Digital Synchronizer and Load Control (DSLCTM)

The Woodward DSLCTM control is a microprocessor based generator load control designed for use on three-phase ac generators with Woodward speed controls and automatic voltage regulators. The DSLC is a synchronizer, a load control, a dead bus closing system, a VAR/PF control, and a process control, integrated into one package.

The 505 can be programmed to use the DSLC as a synchronizer only, or as a synchronizer and load control. The DSLC provides either phase match or slip frequency synchronizing, and ties into the unit automatic voltage regulator to match voltages before paralleling. It interfaces with the 505 via a Speed bias signal to control generator frequency and phase. When configured to use the DSLC as a synchronizer only, the 505 must be programmed to receive the DSLC Speed Bias signal through an analog input and have this input enabled through a contact input or function key.

The DSLC communicates over a LAN using a digital Echelon network with other system DSLCs to enable it to perform safe deadbus closings. Because the DSLC performs all synchronizing functions simultaneously, synchronization typically takes only a few seconds.

When used as a synchronizer and load control, the DSLC performs automatic synchronization, and controls unit load based on the DSLCs mode of operation. The DSLC can be in a base-load, loadsharing, remote load setting, or Process control mode, depending on configuration and system conditions.

The DSLC's baseload mode of operation allows an operator to set the unit to a specified load. A proportional or integrating control action can be used with this mode of operation. The integrating mode of operation can be used with systems tying to an unstable grid to allow the unit to control at a constant load and not vary based on grid frequency.

The DSLC's loadsharing mode is used to share load with any other units using a DSLC and tied to the same isolated bus. This mode is used in conjunction with a Master Synchronizer & Load Control when paralleled to a utility to allow the MSLC to control plant frequency or load depending on its state of operation.

The DSLC's remote load setting mode allows load to be set by a remote 4–20 mA signal. The DSLC's Process control mode allows any process directly related to generator load to be controlled.

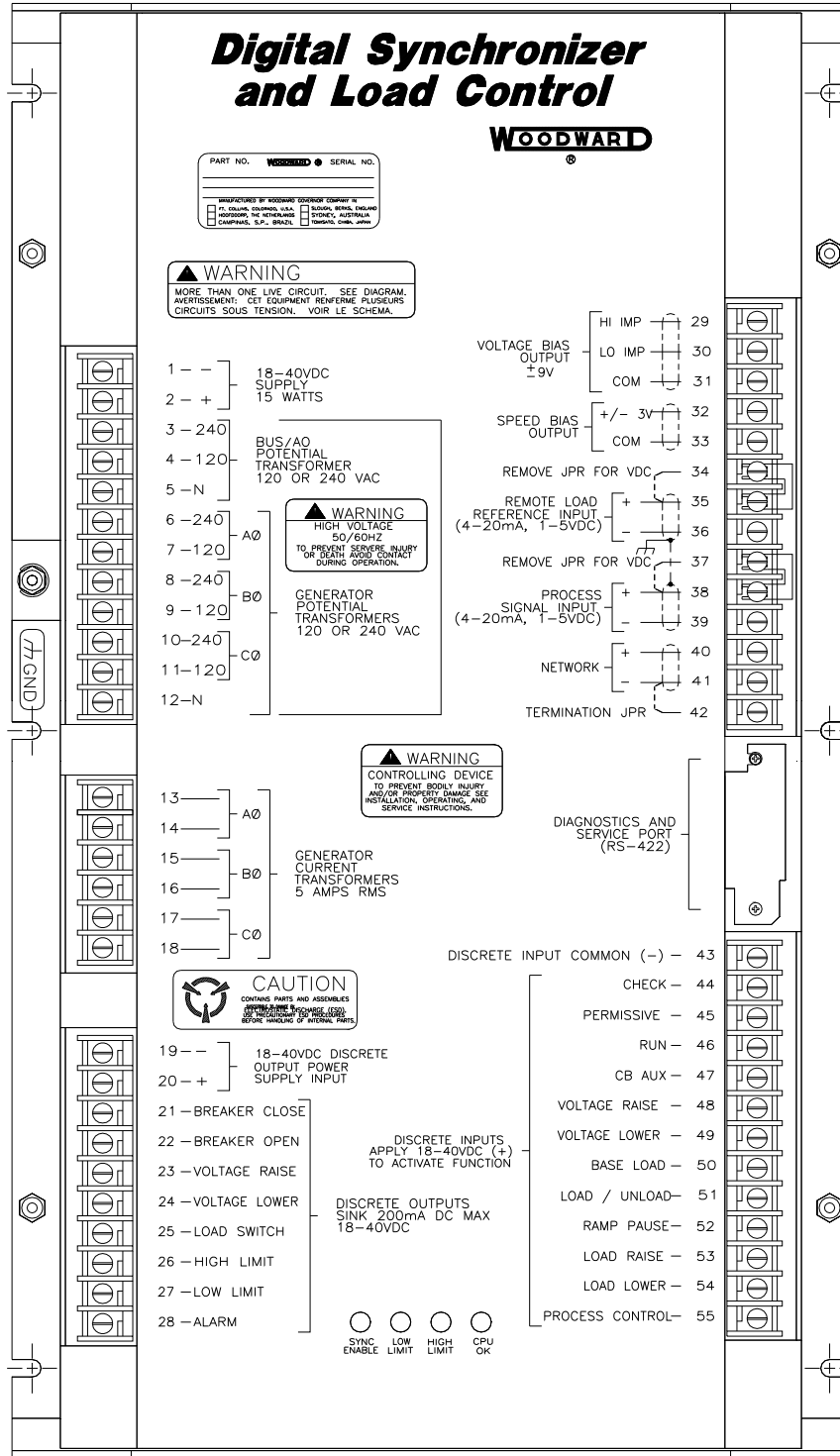
When using the DSLC as both a synchronizer and load control, the 505 control must be programmed to receive the DSLC Speed Bias signal through an analog input and have this input enabled through a contact input or function key.

After synchronization, unit load can be controlled by the DSLC (through the 505 Sync/Ld input) or by the 505's internal speed/load setpoint. When the Sync/Ld Share input is programmed, the position of the Utility Tie Breaker Contact selects unit load control through the DSLC or through the 505's internal load setpoint.

The DSLC interfaces to the 505 via a Speed Bias signal. From the many different types of DSLCs manufactured by Woodward only a few have a Speed Bias output (1–5 Vdc) compatible with the 505 control. The 505's isolated analog #6 input is the only analog input that is directly compatible with the DSLC. Thus the DSLC's speed bias output should only be connected to the # 6 analog input. The DSLC's speed bias output is designed to drive into the 505's low impedance input.



Once the generator is synchronized the DSLC soft-loads the unit to the load setting determined by the mode of operation (base load, loadsharing, Process control). When commanded the DSLC can also soft-unload the unit and issue a breaker-open command at a set power level.



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 93-11-17 RAM

Figure 1-4a. Digital Synchronizer and Load Control

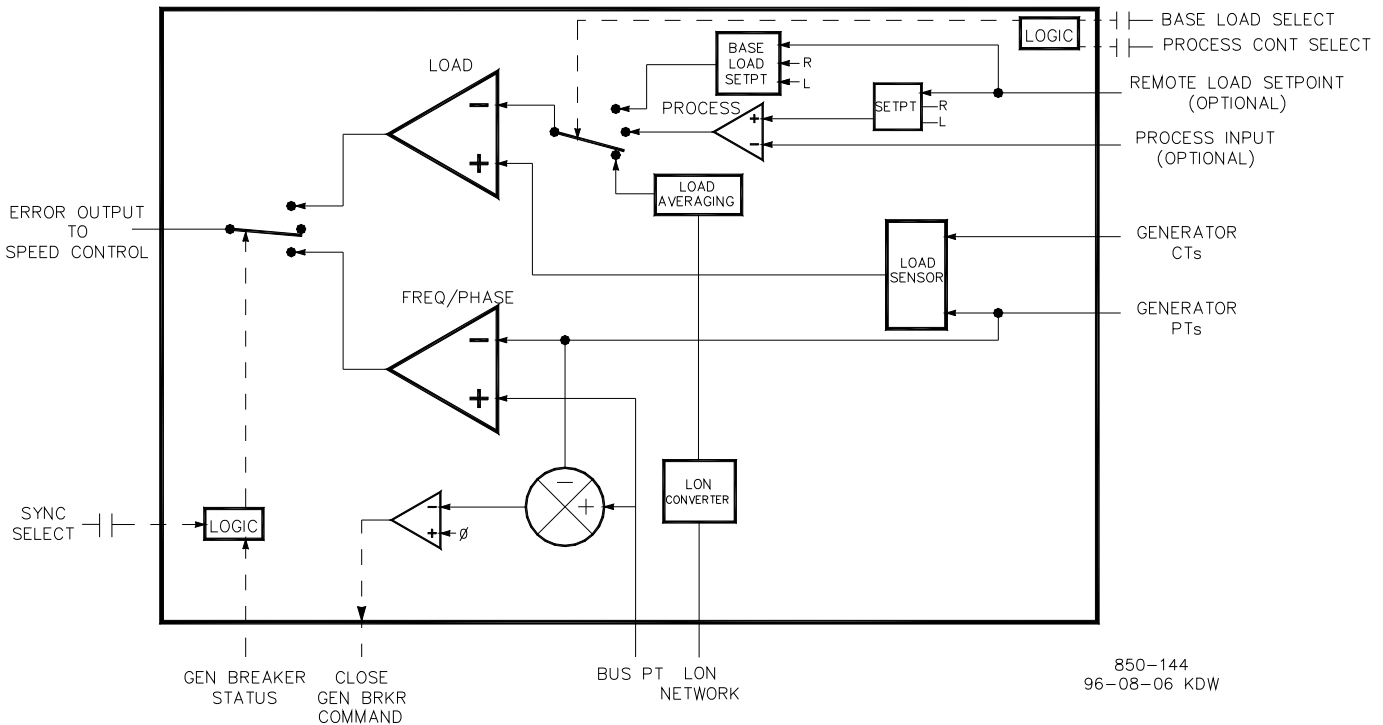


Figure 1-4b. Digital Synchronizer and Load Control Functional Diagram

### Installation Notes

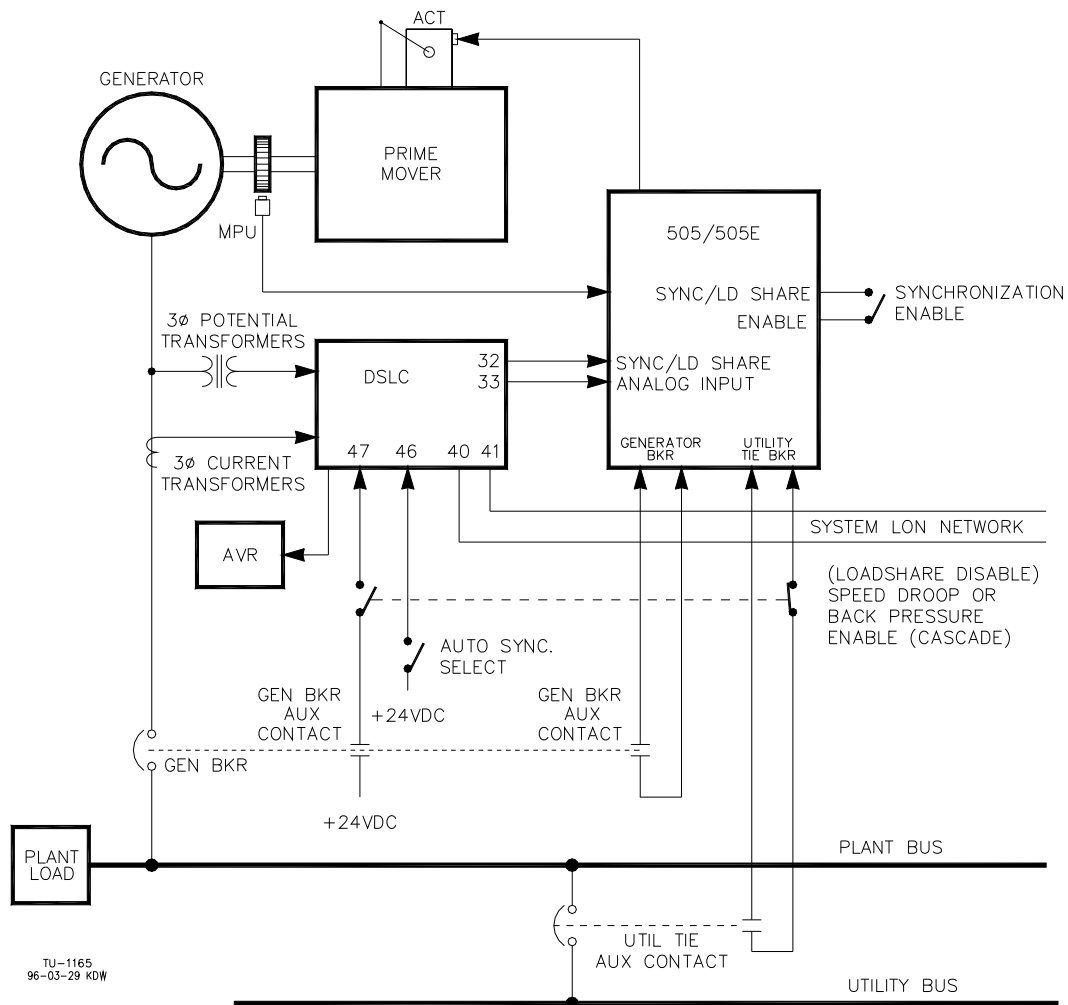
A Hand-held Programmer (9905-292) is required and used by the DSLC to configure and calibrate it to the site specific application.

The DSLC requires a power source of +24 Vdc @ 1 A. The 505 power supplies can not supply this much power, thus an external power supply may be required.

The DSLC can interface with the unit Automatic Voltage Regulator through contacts or a +9 volt bias signal.

For more information on Woodward's Digital Synchronizer & Load Control, please refer to Woodward manual 02007.





TU-1165  
96-03-29 KDW

Figure 1-5. DSLC Interface Wiring

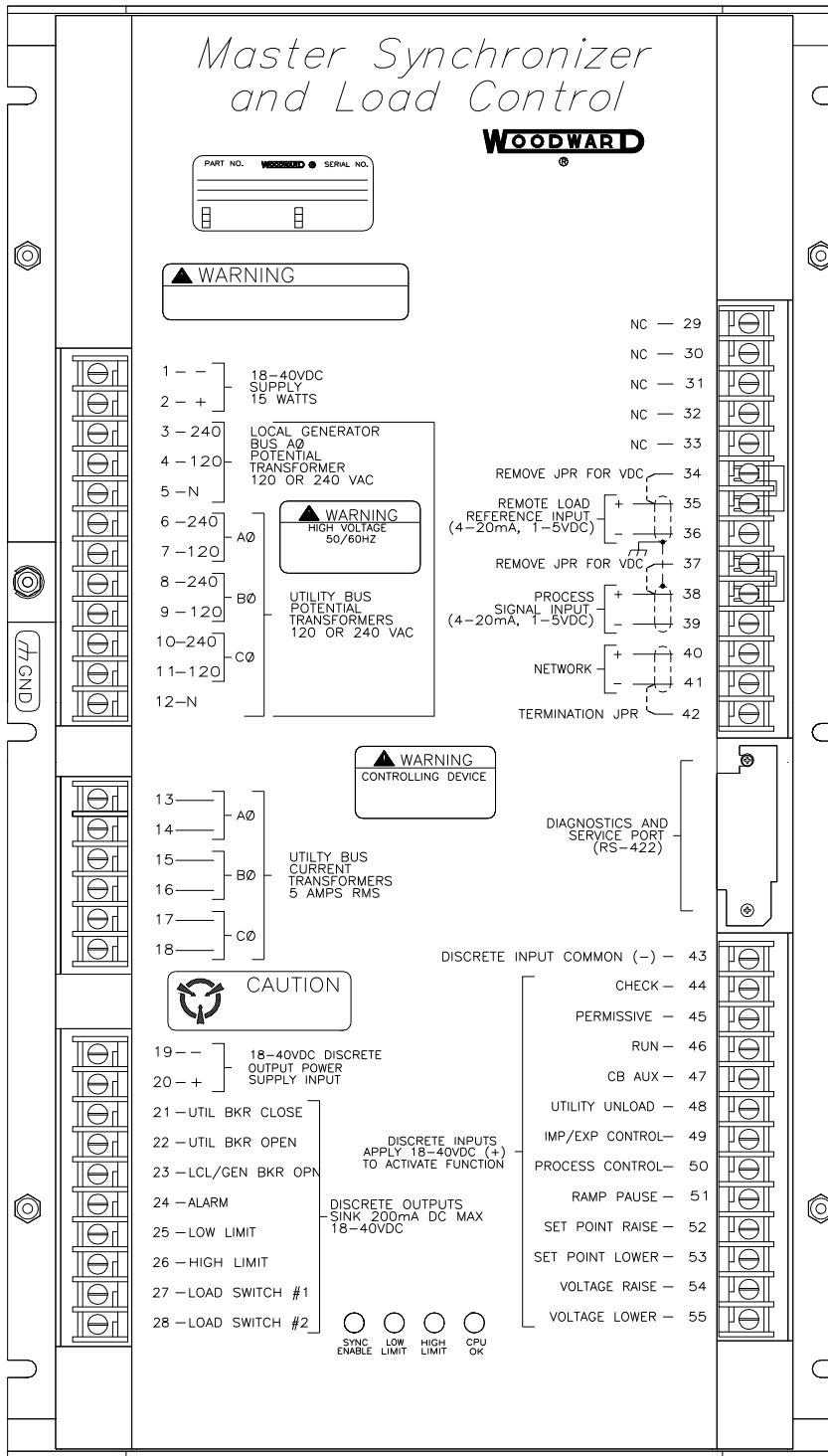
## Master Synchronizer and Load Control (MSLC)

The Woodward MSLC is a microprocessor based plant load control designed for use in three-phase electric power generation sites equipped with Woodward DSLCs which operate in parallel with the utility. The MSLC is a tie-line synchronizer, a plant import/export load control, reactive load control (power factor), and a master process control integrated into one package.

Used as a synchronizer, the MSLC provides phase (or slip frequency) and voltage match synchronizing of the local plant bus to a main power grid. It communicates over a LAN using a digital Echelon network with system DSLCs to control plant frequency, phase, and voltage to perform automatic plant synchronization.

After the utility tie breaker is closed manually or by the MSLC, the MSLC then controls plant load to a baseload setting, remote load setting, import/export demand setting, or process control demand setting. If programmed, reactive tie line power can also be controlled by the MSLC through each DSLC interfacing to each unit's automatic voltage regulator.

The MSLC's baseload mode of operation allows an operator to set the plant to a specified load. A proportional or integrating control action can be used with this mode of operation. The integrating mode of operation can be used with systems tying to an unstable grid to allow the plant to control at a constant load and not vary based on grid frequency.



020-060  
98-08-10 skw

Figure 1-6a. Master Synchronizer and Load Control

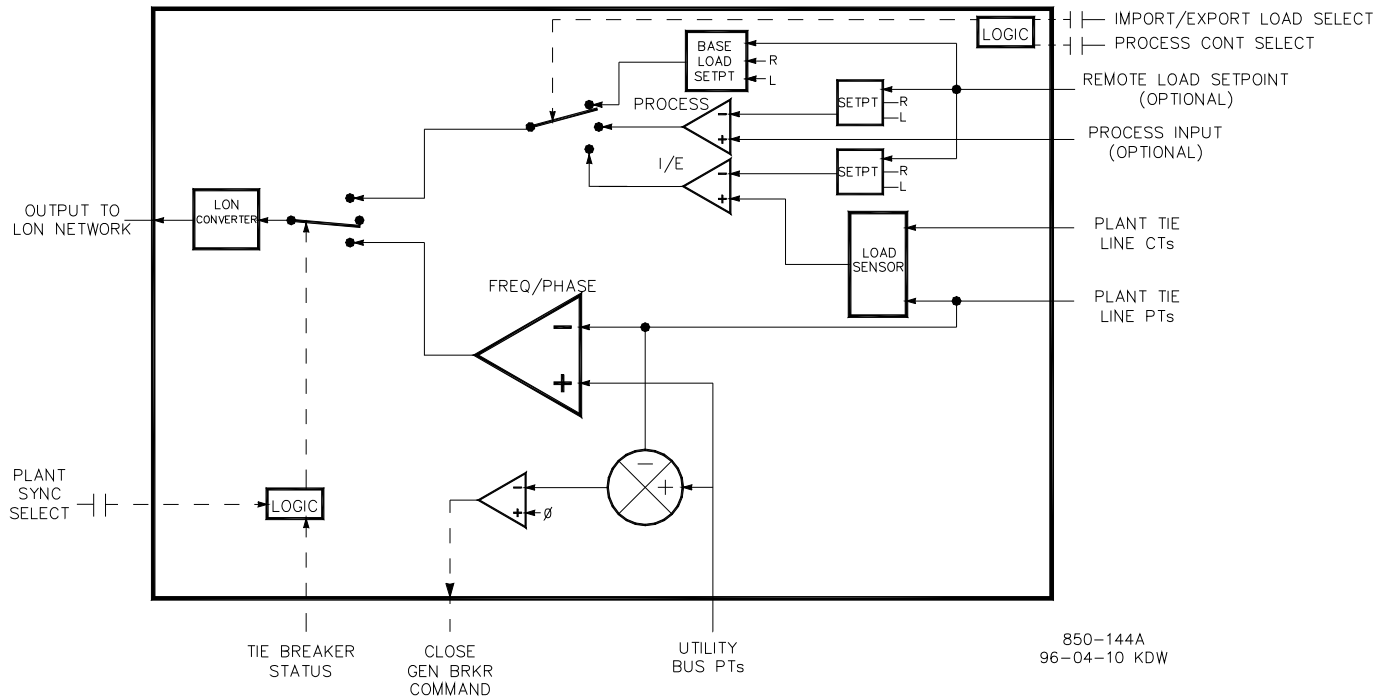


Figure 1-6b. Master Synchronizer and Load Control Functional Diagram

The MSLC's remote load setting mode allows plant load to be set by a remote 4–20 mA signal.

The MSLC's import/export control mode, when enabled senses plant-to-utility tie line power flow and controls this flow based on a import/export setpoint.

The MSLC's process control mode allows any process directly related to plant load to be controlled.

Once the plant-to-utility tie breaker is closed the MSLC soft-loads the plant to a load setting determined by the mode of operation (base load, import/export, Process control). When commanded the MSLC can also soft-unload the plant and issue a plant-to-utility tie breaker open command at a set power level.

When using the MSLC as both a synchronizer and load control, the system DSLCs must be in their Loadsharing mode to enable the MSLC to control them. The MSLC is only active when synchronizing a plant bus to a utility bus, or when the utility tie breaker is closed to control tie line power (real & reactive). Once the utility tie breaker opens, the MSLC becomes disabled and does not effect DSLC load sharing control. Because the MSLC/DSLc network only allows one master controller at a time, only one MSLC at a time can be utilized to control plant load.

For more information on Woodward's Master Synchronizer & Load Control and how to apply it, please refer to Woodward manual 02022.

#### Installation Notes

A Hand-held Programmer (9905-292) is required and used by the MSLC to configure and calibrate it to the site specific application.

The MSLC requires a power source of +24 Vdc @ 1 A. The 505 power supplies can not supply this much power, thus an external power supply may be required.

## Chapter 2. Application Notes

### Overview

This chapter is provided to give users an idea of the 505 Digital Control's capabilities, and how to apply them to a system. Typical applications are schematically shown and their functionality explained. Programming and Start/Run mode notes are given for each application to assist application programmers in configuring the 505 for their application. Basic peripheral device connections are shown in each application drawing to allow an understanding of how these devices interface to the 505 and expand system capabilities.

### Speed/Load PID

The Speed PID can control and limit:

- Unit Speed/Frequency
- Unit Load

The 505's Speed PID can be used to control unit speed/frequency when isolated and unit load when paralleled to an infinite bus (utility). The Speed PID can be programmed to sense unit load via its actuator output signal or a 4–20 mA analog input signal from a generator power sensor. When programmed to sense and control generator load via a analog input true unit load is sensed and controlled. By using the generator load signal to control from, any turbine inlet or exhaust pressure variation is sensed and compensated for, thus providing true load control.

A combination of the Speed PID and its setpoint limits allow this PID to limit unit load. When used as a unit load limiter, it is recommended that the 505 be configured to sense and control only true generator load. If applying the 505 system to a soft grid (utility frequency varies greatly) it is recommended that unit load limiting be performed by the Auxiliary PID not the Speed PID.

### Auxiliary PID

The 505's Auxiliary PID can be programmed to control or limit:

- Turbine Inlet Steam Pressure
- Turbine Inlet Steam Flow
- Turbine Exhaust Steam pressure
- Turbine Exhaust Steam Flow
- Generator Power output
- Plant or Tie line Import/Export Power
- Process Temperature
- Compressor Suction pressure
- Compressor Suction Flow
- Compressor Discharge pressure
- Compressor Discharge Flow
- Any process parameter related to unit load, inlet pressure/flow, or exhaust pressure/flow (depending on configuration)

The 505's Auxiliary PID can be used as a limiter or controller (enabled/disabled on command). When programmed as a limiter this PID's output is Low Signal Selected with the Speed PID's output. This configuration allows the Auxiliary PID to limit the unit's load based on the parameter being sensed.

When the Auxiliary PID is configured as a controller, it must be enabled and disabled by commands given through the 505's front panel, contact input, or Modbus communications. With this configuration when the Aux PID is enabled the Speed PID is disabled and tracks the Auxiliary PID's output.

To control or limit any of the listed parameters, the 505 must be programmed to accept an Auxiliary analog input signal representing that parameter's level. The exception to this rule is when controlling or limiting generator load, the Auxiliary PID can be programmed to use and share the KW/Unit load input with the Speed PID.

## Cascade PID

The 505's Cascade PID can be programmed to control:

- Turbine Inlet Steam Pressure
- Turbine Inlet Steam Flow
- Turbine Exhaust Steam pressure
- Turbine Exhaust Steam Flow
- Generator Power output
- Plant or Tie line Import/Export Power
- Process Temperature
- Compressor Suction pressure
- Compressor Suction Flow
- Compressor Discharge pressure
- Compressor Discharge Flow
- Any process parameter related to unit load, inlet pressure, or exhaust pressure (depending on the configuration)

The 505's Cascade PID can be used to control any of the listed parameters. This PID must be enabled and disabled by commands given through the 505's front panel, contact input, or Modbus communications.

The Cascade PID is cascaded with the Speed PID to vary unit speed/load. By directly positioning the Speed PID's setpoint, the Cascade PID can vary unit speed/load to control its input parameter. This configuration allows for bumpless transfers between the two control modes (Speed/Load and Cascade).

## Example Applications

The example applications in this chapter do not show every possible control configuration or combination. However, these examples can also be used as a reference to apply any of the controlling combinations or parameters not listed or shown. To apply a desired control parameter or combination not shown, refer to one or more of the typical application configurations that are shown and resemble the control configuration desired, then substitute the shown control parameters with the required control parameters.

To apply a desired control parameter or combination not shown, refer to one or more of the typical application configurations that are shown and resemble the control configuration desired, then substitute the shown control parameters with the required control parameters.

Example—To configure the 505 to perform a Turbine Exhaust pressure limiting function use Example 1, the “Pump or Compressor Discharge Pressure Control with Turbine Inlet Pressure Limiting” application for reference. With this example substitute exhaust pressure for inlet pressure and disregard any program settings specified to control pump or compressor discharge pressure.

The examples shown in this chapter are summarized as follows:

- Example 1: Pump or Compressor Discharge Pressure Control with Inlet Pressure Limiting
- Example 2: Inlet Pressure Control with Auto Synchronizing and Generator Power Limiting
- Example 3: Exhaust Pressure Control with Plant Import/Export Power Limiting
- Example 4: Plant Import/Export Power Control with DRFD Servo Interface
- Example 5: Inlet Pressure Control with Isochronous Load Share Control in Island Mode
- Example 6: Plant Import/Export Power Control with Isochronous Load Share Control in Island Mode
- Example 7: Induction Generator Control

The features and functionality shown in each example are summarized in table 2-1.

APPLICATION		EXAMPLES						
		1	2	3	4	5	6	7
Turbine Type	Mechanical Drive	X						
	Synchronous Gen. Drive		X	X	X	X	X	
	Induction Gen. Drive							X
Control Channels	Auxiliary Limiting	X	X	X		X		
	Auxiliary Control				X			
	Cascade Control	X	X	X			X	X
	Synchronizing		X	X	X	X	X	
	Loadsharing					X	X	
	Frequency Control				X	X		
Control Modes	Inlet Pressure Control		X			X		
	Min Inlet Pres. Limiting	X						
	KW / Load Control						X	
	KW / Load Limiting		X			X		
	Import/Export Load Cntrl				X		X	
	Import/Export Load Limtg			X				
Devices	Dig. Sync Ld Share (DSLCL)		X	X	X	X	X	
	Mstr Sync Ld Share (MSLC)						X	
	Real Power Sensor (RPS)		X	X	X	X		
	Dig. Rmt Final Dvr (DRFD)				X			

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Table 2-1. Example Summary

## Example 1–Pump or Compressor Discharge Pressure Control with Turbine Inlet Pressure Limiting

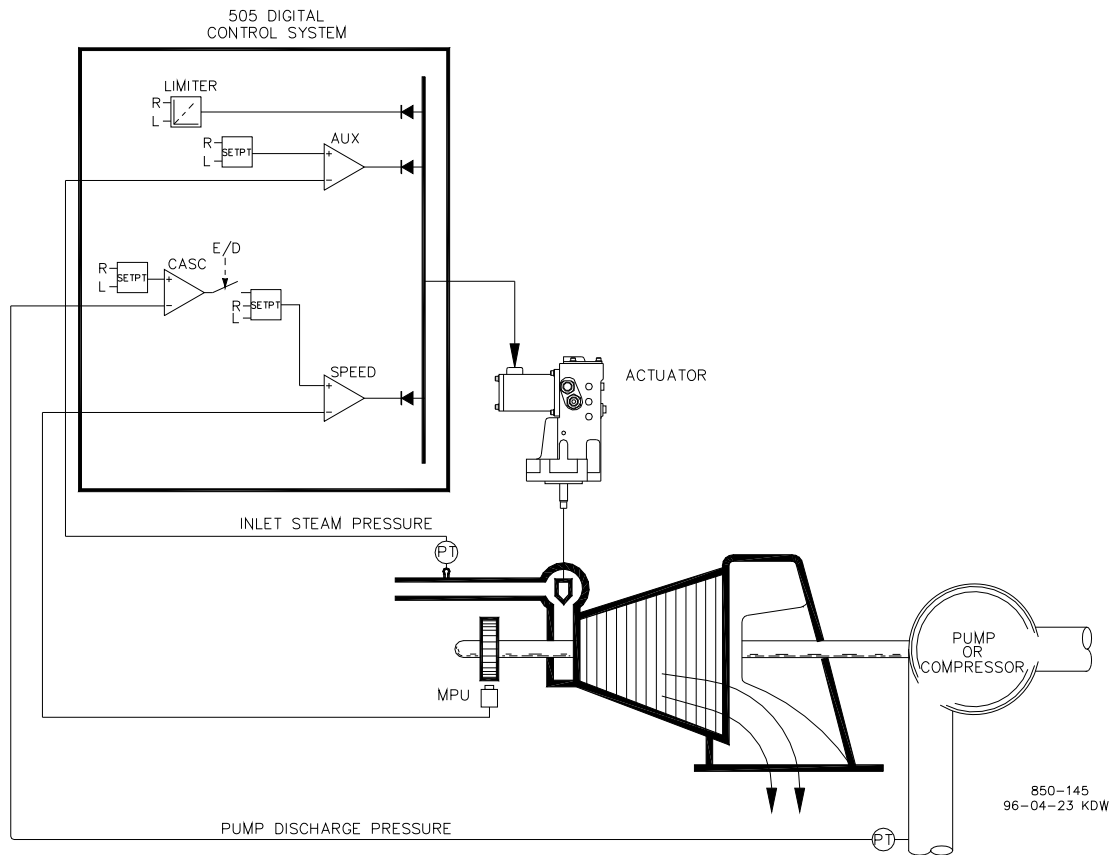


Figure 2-1. Pump or Compressor Discharge Pressure Control with Turbine Inlet Pressure Limiting

This is an example of a typical pump or compressor application. With this application the 505 is configured to normally control pump/compressor discharge pressure, and limit governor valve position based on low turbine inlet steam pressure. Both the Auxiliary and Cascade modes were used for this example application. Other applications may or may not use all the functionality shown in Figure 2-1 and described below.

With this application pump/compressor discharge pressure control is performed within the 505 through the Cascade controller. Because the discharge pressure being controlled, typically affects many other plant processes, a plant Distributed Control System (DCS) may be used to monitor plant process conditions and set the Cascade setpoint position. This can be performed through Modbus communications, discrete raise and lower commands, or with a Analog setpoint signal.

For this application a limiting type of control function was required to help preserve inlet header pressure in case of system header problems. Because the Auxiliary PID is the only controller that has this capability, it is used to sense turbine inlet pressure and limit governor valve position, based on a low inlet pressure setting.

If a plant Distributed Control System is used to sense and control a process by positioning the load of multiple pumps or compressors (loadsharing), the DCS may interface directly to the 505 Speed PID setpoint through a programmed Remote Speed Setpoint analog input. This allows a DCS to monitor and compensate for plant and system conditions by directly changing the speed of multiple pumps or compressors simultaneously.

All 505 PID controller setpoints (Speed, Auxiliary, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes is provided as a reference for application programmers to follow when configuring the 505 to achieve any of the control and limiting actions shown in figure 2-1:

## 505 Configuration Notes for Example 1

### Operating Param:

This is not a Generator application. (Generator Application? No)

### Cascade Control:

The Cascade control loop was configured to receive a pump/compressor discharge pressure signal through Analog input #1. (Analog Input #1 Function: Cascade Input)

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR10 installed.

The 505 was configured to accept a contact from a panel mounted switch to externally enable and disable discharge pressure control. (Contact Input 1 Function: Casc Control Enable)

Pump/compressor discharge pressure is directly proportional to turbine inlet valve position, thus input inversion is not required. (Invert Cascade Input? No)

With this application, Setpoint Tracking is not used because the system's pressure setpoint never changes. (Use Setpoint Tracking? No)

To protect the generator from being reverse powered by the Cascade PID, the 'Speed Setpoint Lower Limit' value was set to 3% above synchronous speed or 3605.4 rpm (5.4 rpm if rated speed is 3600 rpm and using 5% droop). The 505 will automatically limit the Speed Setpoint Lower Limit to a minimum of 3% (min load). If it is desired to allow the Cascade PID to lower load below this setting, the Service mode's (Cascade Control Settings, Use Min Load) setting must be set to "No".

In this case, because the Cascade PID is not sharing control of discharge pressure with another control, Droop is not needed. (Cascade Droop = 0%)

### Auxiliary Control:

The Auxiliary control loop was configured to receive a turbine inlet header pressure signal through Analog input #2. (Analog Input #2 Function: Auxiliary Input)

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR8 installed.



The Auxiliary Input was inverted to allow the correct control action. To increase turbine inlet header pressure, the governor valve must decrease. This is considered an indirect action and requires the input to be inverted. (Invert Aux Input? YES)

The Auxiliary PID was programmed to perform as a limiter. (Use Aux Enable? No)

Because the Auxiliary PID is used only as a limiter and is not sharing control of inlet pressure with another control, Droop is not needed. (Aux Droop = 0%)

#### Trips:

In this example the turbine can be tripped by several devices, one of these devices is the 505 control. To provide feedback to the 505 control that the turbine is tripped, a contact from the trip string is wired into the External Emergency Shutdown input (TB12). With this application, the 'governor trip' annunciation should only occur if the 505 tripped the turbine and not annunciate when the other external devices shuts down the unit (Turbine Start: Ext Trips in Trip Relay ?–No.)

Because the Shutdown relay is used in the trip string to shut down the turbine should the 505 initiate a trip, additional relays are required for annunciating any turbine trip and annunciating a 505 initiated trip. Relay #3 was programmed to annunciate any turbine trip as follows: (Relays: Use Relay #3–Yes ; Relay #3 is a Level Switch?–No ; Relay #3 Energizes on–Shutdown Condition) Relay #4 was programmed to indicate a 505 initiated trip as follows: (Relays: Use Relay #4–Yes ; Relay #4 is a Level Switch?–No ; Relay #4 Energizes on–Trip Relay) Note that Relay #4 de-energizes on a trip condition (excluding external trip inputs) and Relay #3 energizes on a trip (shutdown) condition.

## Starting and Run Mode Notes for Example 1

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position or an operator can give a raise command to manually increase turbine speed.

After the unit has been started and is controlling at a minimum/desired speed position, Cascade control (pump/compressor discharge pressure) can be enabled through contacts, Modbus commands, or the 505 service panel. When Cascade control is enabled, if actual discharge pressure does not match the setpoint, the control will automatically ramp turbine speed at the 'SPEED SETPOINT SLOW RATE' setting until the pump/compressor discharge pressure does match the setpoint.

With this application the Auxiliary control is used as a limiter, thus it does not need to be enabled. If turbine inlet pressure decreases below the Auxiliary setpoint at any time the Auxiliary PID will take control of the governor valve and lower it to help preserve inlet header pressure.

See the Service mode section of this manual, for information on related tunable values and rates.

**Example 2–Inlet Pressure Control with Automatic Synchronizing & Generator Power Limiting**

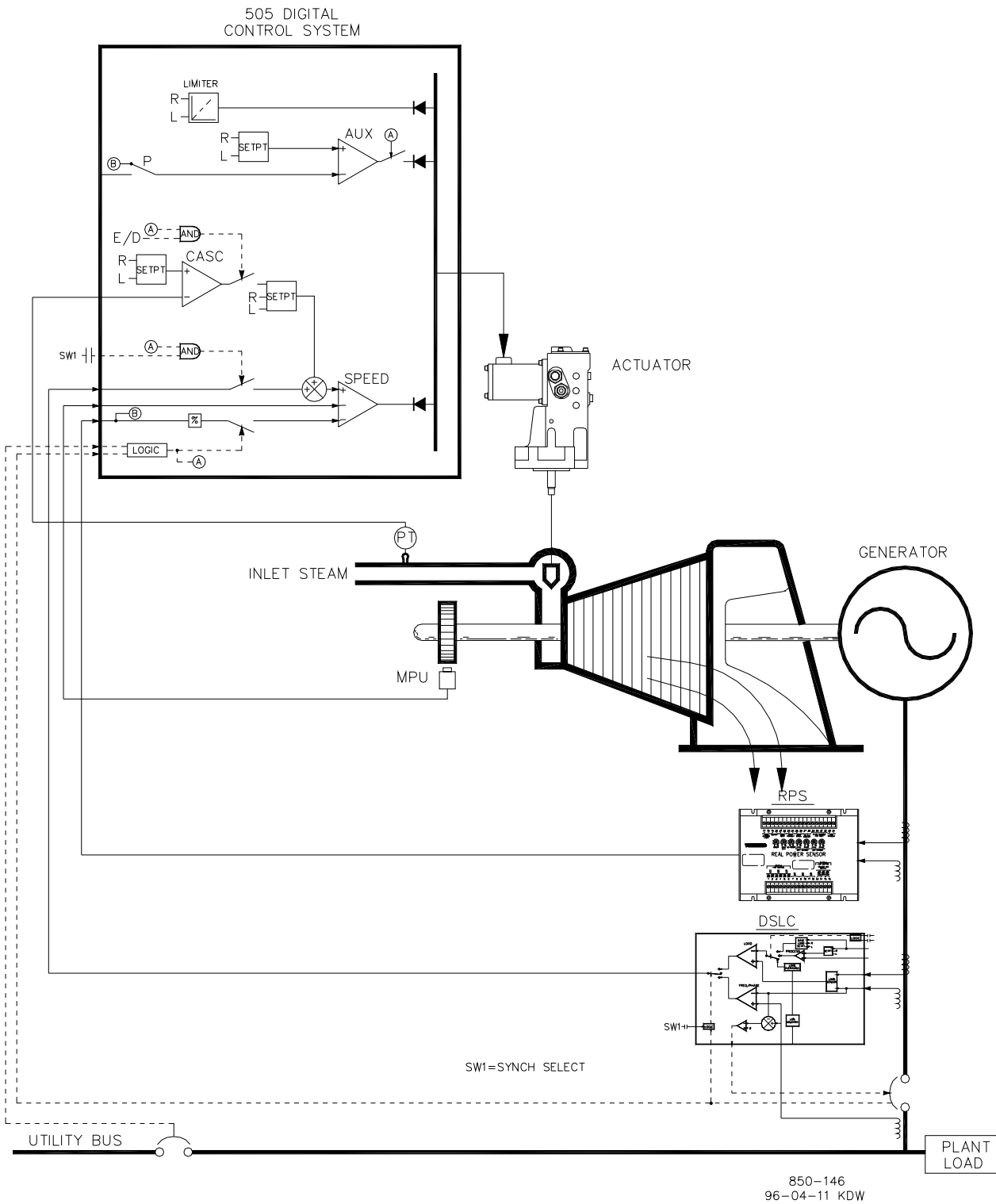


Figure 2-2. Inlet Pressure Control with Automatic Synchronizing & Generator Power Limiting

This is an example of a typical turbine generator application where plant process steam (turbine inlet header pressure) is desired to be controlled at a single pressure. With this type of application, turbine load varies based on the plant process steam demand. Both the Auxiliary and Cascade modes were used for this example application. Other applications may or may not utilize all the functionality shown in Figure 2-2 and described below.

With this application turbine inlet header pressure control is performed within the 505 through the Cascade PID controller. This is an ideal controller for this type of function because it can be enabled and disabled as desired by a system operator. This gives a system operator full authority of when to transfer process pressure control to or from a letdown station or turbine bypass valve.

As shown in Figure 2-2 generator load is being sensed with a Woodward Real Power Sensor and supplied to the 505's KW/unit load input. This allows generator load to be set and controlled by the Speed PID when paralleled to the utility during unit start-up and shutdown.

During normal operation unit load is determined by the Cascade PID controlling inlet header pressure. Because turbine load may vary greatly with this application, a limiter is used to protect the generator from being over powered. This protection is performed by the Auxiliary PID configured as a limiter. By configuring the Auxiliary PID as a limiter and to use the generator load input as the PID's controlling parameter, the maximum load the generator can operate at can be limited.

This application uses a DSLC for synchronization only. Because the DSLC interfaces to the 505 through an analog signal, a 505 analog input must be programmed. The 505's Analog Input #6 is the only analog input directly compatible with the DSLC, thus it is required that this input be programmed to receive the DSLC's Speed Bias signal. When a Synchronizing input/function is programmed, the input can be enabled, through a contact input, function key, Modbus command, or the 505 service panel. As shown in Figure 2-2 a panel mounted (DPST) switch is used with this application to select automatic synchronization in both the DSLC and 505.

All 505 PID controller setpoints (Speed, Auxiliary, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes are provided as a reference for application programmers to follow when programming the 505 to achieve any of the control and limiting actions shown in Figure 2-2.

## 505 Configuration Notes for Example 2

### OPERATING PARAM:

This is a Generator application. (Generator Application? Yes)

Generator and Utility Tie breaker contact inputs are required to be programmed when a generator application is selected. (Contact Input #1 Function: Generator Breaker), (Contact Input #2 Function: Utility Tie Breaker).

The 505 was configured to sense the Real Power Sensor's generator load signal through Analog input #1. (Analog Input #1 Function: KW/Unit Load Input)

Because the Real Power Sensor's 'KW readout' is self powered, the 505 back cover was removed and JPR11 installed.

Generator load control (when paralleled to the utility) is controlled through the Speed PID and programmed by selecting KW Droop. (Use kW Droop? Yes) For good response and load adjustment resolution, Droop was set to 5% of rated speed. (Droop = 5 %)

It was desired to switch to Frequency control at all times, if the plant became isolated from the Utility bus. (Use Freq Arm/Disarm? No)

#### CASCADE CONTROL:

The Cascade control loop was configured to receive an inlet header pressure signal through Analog input #2. (Analog Input #2 Function: Cascade Input)

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR8 installed.

The 505 was configured to accept a contact from a panel mounted switch to externally enable and disable inlet header pressure control. (Contact Input #3 Function: Casc Control Enable)

The Cascade Input was inverted to allow the correct control action. To increase turbine inlet header pressure, the governor valve position must decrease. This is considered an indirect action and requires the input to be inverted. (Invert Cascade Input? Yes)

With this application, Setpoint Tracking is not used because the system's pressure setpoint never changes, thus system start-up is simpler. (Use Setpoint Tracking? No)

To protect the generator from being reverse powered by the Cascade PID, the 'Speed Setpoint Lower Limit' value was set to 5 rpm above synchronous speed.

In this case, because the Cascade PID, during normal operation, is not sharing control of inlet header pressure with another controller, Droop is not needed. (Cascade Droop = 0%)

#### AUXILIARY CONTROL:

The Auxiliary control loop was configured to receive a generator load signal through the KW/Unit Load input, also being used for KW Droop. (Use KW Input? Yes)

Unit load is directly proportional to turbine inlet valve position, thus no input inversion is required. (Invert Aux Input? No)

The Auxiliary PID was programmed to perform as a load limiter. (Use Aux Enable? No)

In this case, because the Auxiliary PID is used only as a limiter, and is not sharing control of generator load with another control, Droop is not needed. (Aux Droop = 0%)

With this application, it was desirable to only enable the Auxiliary PID if paralleled to the utility. (Tiebkr Open Aux Dsbl? Yes), (Genbkr Open Aux Dsbl? Yes)

**AUTO SYNCHRONIZING:**

The 505's Analog input #6 was programmed to receive the DSLC's speed bias signal for automatic synchronization (Analog Input #6 Function: Synchronizing Input) With this configuration, the analog input's range is defaulted to provide a certain gain factor for best performance, thus the input's 4 mA and 20 mA program settings are not used and do not require programming.

A contact input was programmed to enable the Synchronizing analog input (Contact Input #4 Function: Synch Enable).

**Starting and Run Mode Notes For Example 2**

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position. Alternatively an operator can give a manual raise command to increase turbine speed as desired.

After the unit has been started and is controlling at a rated speed position, the turbine generator can be synchronized manually, or automatically. The system operator can select automatic synchronization through the Auto-Synch select switch (switch SW1 in Figure 2-2). When this switch is closed the 505's Synchronizing input is enabled and the DSLC's automatic synchronizing function is selected.

When the plant-to-utility tie-line breaker is closed, and the unit generator breaker closes, the 505 steps the speed/load setpoint up to a minimum load level to reduce the chance of reverse powering or motoring the generator. This minimum load level is based on the speed/load setpoint and is defaulted to a "3% 5 rpm" step change of the speed/load setpoint. The defaulted value is adjustable through the 505's Service mode (Breaker Logic–Min Load Bias = 5 ).

After synchronization the 505's load setpoint can be positioned through raise and lower Speed/Load setpoint contacts, a programmed 4–20 mA input, Modbus commands, or the 505 service panel. This load control mode may be used to slowly increase turbine load, and take control away from a letdown station or turbine bypass valve.

Cascade control (turbine exhaust pressure) can be enabled at any time after the Utility Tie breaker and Generator breakers are closed, through a contact input, Modbus command or the 505 service panel. With this configuration, when Cascade control is enabled, if actual inlet header pressure does not match setpoint, the control will increase generator load at the 'SPEED SETPOINT SLOW RATE' setting until the inlet header pressure matches setpoint.

With this application the Auxiliary control is programmed to be used as a limiter, and be automatically enabled when both the Utility Tie and Generator breakers are closed. When paralleled to the utility, if inlet header pressure demand, and/or other system conditions try to force the generator to operate above its load limit setting, the Auxiliary PID will take control of the governor valve to limit generator load. Once system conditions demand unit load below that of the Auxiliary setpoint, the Cascade/Speed PIDs will again take control of generator load.

### Example 3—Exhaust Pressure Control with Generator Power Limiting and Plant Import/Export Limiting

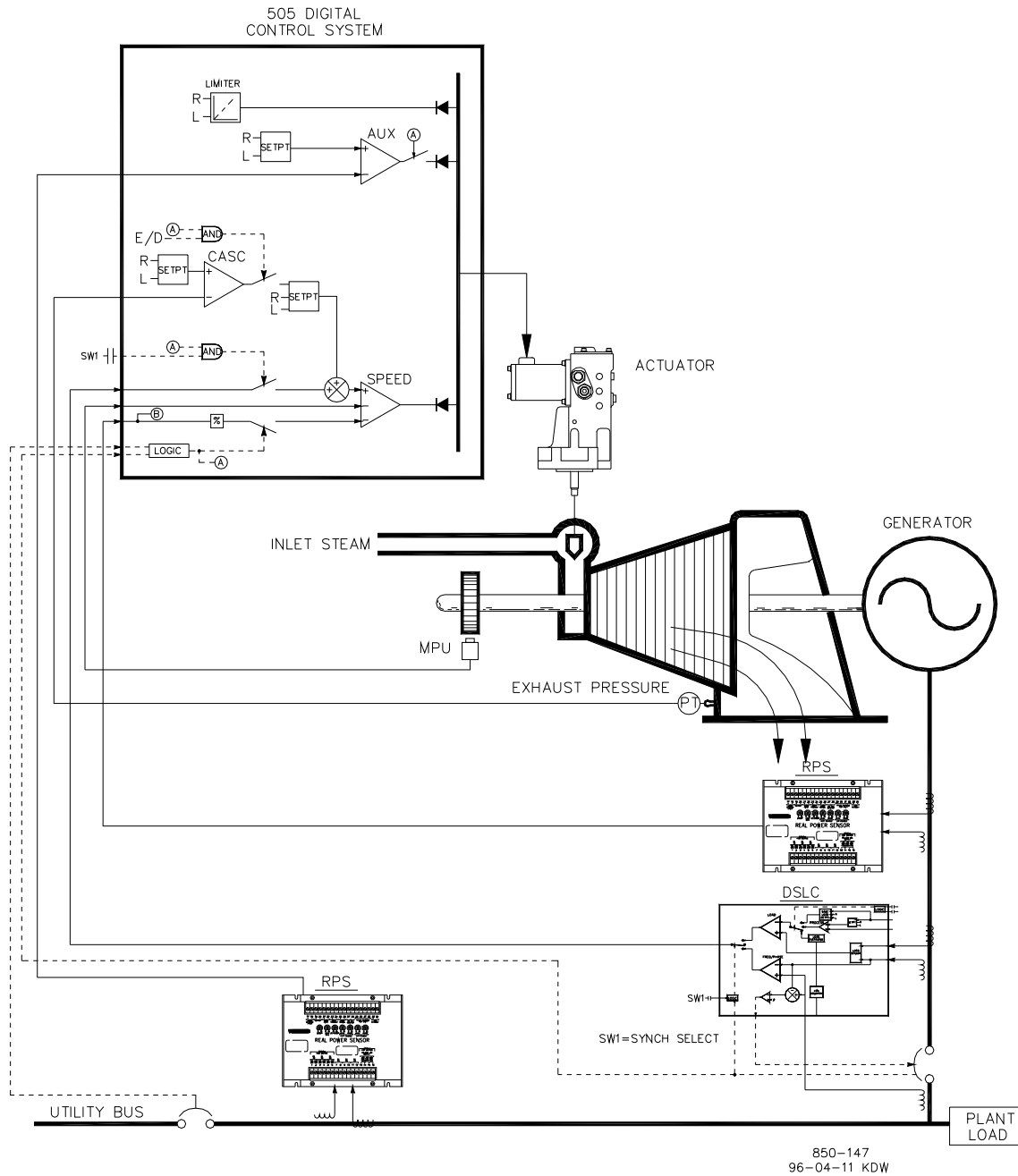


Figure 2-3. Exhaust Pressure Control with Generator Power Limiting and Plant Import/Export Limiting

This is an example of a typical turbine generator application where plant process steam (turbine exhaust pressure) is desired to be controlled at a single pressure level. With this type of application, turbine load varies based on the plant process steam demand. Both the Auxiliary and Cascade modes were used for this example application. Other applications may or may not utilize all the functionality shown in Figure 2-3 and described below.

With this application turbine exhaust pressure control is performed within the 505 through the Cascade PID controller. This is an ideal controller for this type of function because it can be enabled and disabled as desired by a system operator. This gives a system operator full authority of when to transfer process pressure control to or from a letdown station or turbine bypass valve.

Because turbine load may vary greatly with this application, a limiter is used to protect the generator from being over powered. In order to limit generator load, the 505 control must be able to sense generator load. As shown in Figure 2-3 generator load is being sensed with a Woodward Real Power Sensor and supplied to the 505's KW droop input. With this application generator over-load protection is performed by a combination of the Speed PID and the Speed Setpoint Maximum limit. By programming the Speed Setpoint Maximum limit to that of rated speed plus the % droop value at 100% load, the speed setpoint cannot be taken over 100% load and the Speed PID will limit generator load to 100%.

For this application a limiting type of control function was required to limit the plant export power to zero. The plant does not get reimbursed for any power exported, and it is more economical to make power than purchase it from the utility, thus a zero plant import/export power level is desired. Because the Auxiliary PID is the only 505 controller that has this limiting capability, it was used to sense tie line power and limit turbine/generator output, based on a zero export limit setting.

A second Real Power Sensor #8272-726 was used with this application to sense utility tie line power. This RPS is special, in that it senses  $-5$  A to  $+5$  A CT current to allow its output to represent power flow in both the import and export directions. With this RPS 12 mA represents zero power flow. Because of this feature the RPS #8272-726 can not, be used with the 505 to sense generator load/ power. Please check with a Woodward certified distributor or factory for the correct RPS to use as a generator load sensor.

This application uses a DSLC for synchronization only. Because the DSLC interfaces to the 505 through an analog signal, a 505 analog input must be programmed. The 505's Analog Input #6 is the only analog input directly compatible with the DSLC, thus it is required that this input be programmed to receive the DSLC's Speed Bias signal. When a synchronizing input/function is programmed, the input can be enabled, through a contact input, function key, Modbus command, or the 505 service panel. As shown in Figure 2-3 a panel mounted (DPST) switch is used with this application to select automatic synchronization in both the DSLC and 505.

All 505 PID controller setpoints (Speed, Auxiliary, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes are provided as a reference for application programmers to follow when programming the 505 to achieve the control and limiting actions shown in Figure 2-3.

## 505 Configuration Notes for Example 3

### OPERATING PARAM:

This is a Generator application. (Generator Application? Yes)

Generator and Utility Tie breaker contact inputs are required to be programmed when a generator application is selected. (Contact Input #1 Function: Generator Breaker) (Contact Input #2 Function: Utility Tie Breaker)

The 505 was configured to sense a Real Power Sensor's generator load signal through Analog input #1. (Analog Input #1 Function: KW/Unit Load Input)

Because the RPS's KW readout is self powered, the 505 back cover was removed and JPR11 installed.

Generator load (when paralleled to the utility) is controlled by the Speed PID and programmed by selecting the KW/Unit load input. (Use KW Droop? YES) For good response and load adjustment resolution, Droop was set to 5% of rated speed. (Droop = 5 %)

It was desired to switch to Frequency control at all times, if the plant became isolated from the Utility bus. (Use Freq Arm/Disarm? No)

### CASCADE CONTROL:

The Cascade control loop was configured to receive an exhaust header pressure signal through Analog input #2. (Analog Input #2 Function: Cascade Input)

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR8 installed.

The Function Key F3 was programmed to allow an operator to easily enable and disable Cascade control. (F3 Key Performs: Casc Control Enable).

Exhaust header pressure is directly proportional to turbine inlet valve position, thus no input inversion is required. (Invert Cascade Input? No)

With this application, Setpoint Tracking is used to allow the 505's Cascade control, when disabled, to track exhaust header pressure being controlled by a letdown station. (Use Setpoint Tracking? Yes)

To protect the generator from being reverse powered by the Cascade PID, the 'Speed Setpoint Lower Limit' value was set to 5 rpm above synchronous speed.

In this case, because the Cascade PID, during normal operation, is not sharing control of exhaust header pressure with another control, Droop is not needed. (Cascade Droop = 0%)

### GEN LOAD LIMITING:

To limit generator load to 100% the Speed setpoint's maximum limit was set at the 100% load setting. 5% Droop was programmed for this application. (Max Governor Speed Setpoint = Rated speed x 1.05)



**AUXILIARY CONTROL:**

The Auxiliary control loop was configured to receive a utility tie line power signal through Analog input #3. (Analog Input #3 Function: Auxiliary Input) the minimum analog input value was programmed for import power based on the tie line power level at -5 A CT current (Input #3 4 mA Value =-XXXX). the maximum analog input value was programmed for export power based on the tie line power level at +5 A CT current (Input #3 20 mA Value = +XXXX).

Because the RPS's KW readout is self powered, the 505 back cover was removed and JPR15 installed.

The utility-tie Real Power Sensor's CT inputs were wired to allow the RPS's 4 mA value to represent full import power and the RPS's 20 mA value to represent full export power. Because this signal is directly proportional to turbine inlet valve position, no input inversion is required. (Invert Aux Input? No)

The Auxiliary PID was programmed to perform as a limiter. (Use Aux Enable? No)

In this case, because the Auxiliary PID is used as a limiter, and is not sharing control of inlet pressure with another control, Droop is not needed. (Aux Droop = 0%)

With this application, it was desirable to only enable the Auxiliary PID if paralleled to the utility. (Tiebkr Open Aux Dsbl? Yes), (Genbkr Open Aux Dsbl? Yes)

**AUTO SYNCHRONIZING:**

The 505's Analog input #6 was programmed to receive the DSLC's speed bias signal for automatic synchronization (Analog Input #6 Function: Synchronizing Input). With this configuration, the analog input's range is defaulted to a certain gain value, for best performance, thus the input's 4 mA and 20 mA settings are not used and do not require programming.

A contact input was programmed to enable the Synchronizing analog input (Contact Input #4 Function: Synch Enable).

**Starting and Run Mode Notes for Example 3**

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position. Alternatively, an operator can give a manual raise command to increase turbine speed as desired.

After the unit has been started and is controlling at a rated speed position, the turbine generator can be synchronized manually, or automatically. The system operator can select automatic synchronization through the Auto-Synch select switch ( SW1 in Figure 2-3 ). When this switch is closed the 505's Synchronizing input is enabled and the DSLC's automatic synchronizing function selected.

When the plant to utility tie line/breaker is closed, and the unit generator breaker closes, the 505 steps the speed/load setpoint up to a minimum load level to reduce the chance of reverse powering or motoring the generator. This minimum load level is based on the speed/load setpoint and is defaulted to 3%. The defaulted value is adjustable through the 505's Service mode (Breaker Logic–Min Load Bias = 5).

After synchronization the 505's load setpoint can be positioned through raise and lower speed/load setpoint contacts, a programmed 4–20 mA input, Modbus commands, or the 505 service panel.

Cascade control (turbine exhaust pressure) can be enabled at any time after the utility tie breaker and generator breaker input contacts are closed. Cascade control can be enabled through a programmed contact, Modbus command, or the 505 service panel. Exhaust pressure control can be transferred from a letdown station or turbine bypass valve in one of the following ways; enabling Cascade control, and backing down the letdown station's setpoint, or slowly increasing turbine load with the Speed PID's setpoint, to allow the letdown station to close, then enable Cascade control.

After exhaust pressure control has been transferred to the 505's Cascade PID, the letdown station or turbine bypass valve must be closed or in a manual control mode. This will stop the two controllers (505 Cascade PID and system letdown station) from fighting for control of one parameter and causing system instability.

With this application the Auxiliary control is programmed to be used as a limiter and be automatically enabled when both the utility tie and generator breakers are closed. When paralleled to the utility this 505 and RPS combination allows the plant to import power from the utility, but not export power. If the utility-to-plant tie line power reaches a zero import/export level the Auxiliary PID will begin limiting generator output, until plant conditions require power to be imported again.

Optionally the Auxiliary PID's setpoint can be varied to limit plant power to a different import or export power level as required.

### **Example 4–Plant Import/ Export Control with DRFD Servo Interface**

This is an example of a typical turbine generator application where plant import/export control is desired when paralleled with the utility, and frequency control when isolated from the utility. With this type of application, when paralleled to the utility, turbine load varies based on the plant power demand. Other applications may or may not use all the functionality shown in Figure 2-4 and described below.

With this application, plant import/export control is performed within the 505 through the Auxiliary PID controller. Optionally the Cascade PID controller could have been used instead. For this application the Auxiliary PID is configured to be enabled and disabled on command, instead of performing a limiting action. This gives a system operator full authority of when to enable or disable plant import/export control.

When programmed for this type of control action, the Speed PID is disabled when the Auxiliary PID is enabled, and can only limit the 505's valve output signal if unit load reaches 100%. Also, the Auxiliary setpoint automatically tracks the PID's input value when not in-control.

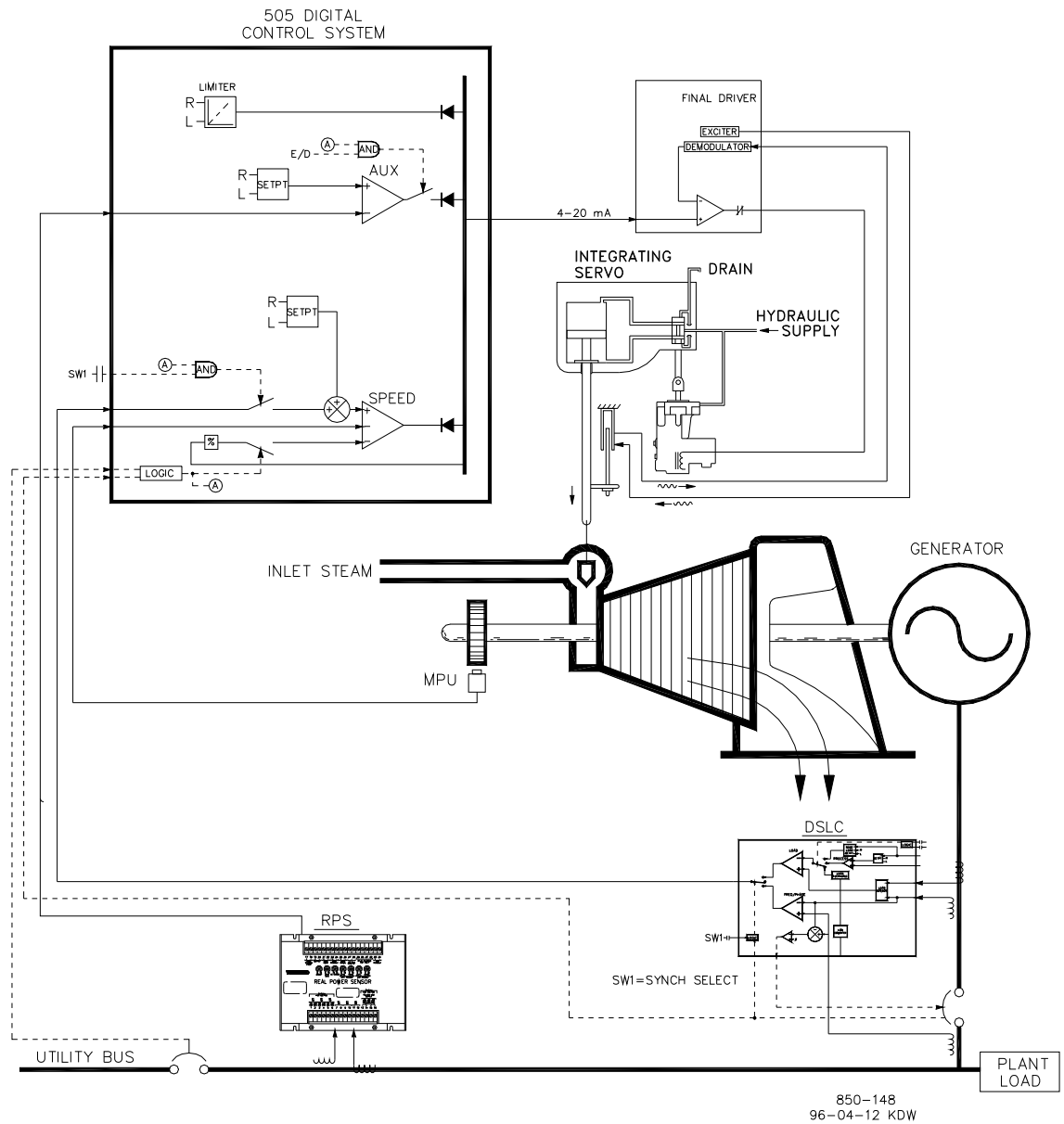


Figure 2-4. Plant Import/Export Control with DRFD Servo Interface

A Real Power Sensor #8272-726 was used with this application to sense utility tie line power flow. This RPS is special, in that it senses  $-5$  A to  $+5$  A CT current to allow its output to represent power flow in both the import and export directions. With this RPS 12 mA represents zero power flow. Because of this feature the RPS #8272-726 can not, be used with the 505 to sense generator load/power.

To save buying a second Real Power Sensor, with this application, unit load is sensed through turbine inlet valve position (505 LSS bus), not a generator load signal. Optionally, another Real Power Sensor could be used with this application to sense generator power, and allow true unit load to be sensed, controlled, and limited. With this configuration, when the generator is paralleled to the utility, the Speed PID controls governor valve position, instead of generator power. Thus 100% governor valve position is considered 100% unit load, no matter if system conditions are at rated or not.

This application uses a DSLC for synchronization only. Because the DSLC interfaces to the 505 through an analog signal, a 505 analog input must be programmed. The 505's Analog Input #6 is the only analog input directly compatible with the DSLC, thus it is required that this input be programmed to receive the DSLC's Speed Bias signal. When a synchronizing input/function is programmed, the input can be enabled, through a contact input, function key, Modbus command, or the 505 service panel. As shown in Figure 2-4 a panel mounted (DPST) switch is used with this application to select automatic synchronization in both the DSLC and 505.

With this application the existing servo assembly had an actuator which required +50 mA for pilot valve positioning, and a LVDT mounted to the valve rack to feedback actual rack position. Because the 505 does not have a bipolar drive circuit, and cannot perform closed loop servo position control, a Woodward Digital Remote Final Driver (DRFD) was used to interface with the existing servo actuator. The integrating type of DRFD used, accepts a 4–20 mA valve demand signal from the 505, monitors actual valve position (through, LVDTs, MLDTs, or other dc position feedback devices), compares the two signals, and outputs a drive signal to the servo assemblies actuator accordingly. The DRFD interfaces directly with an LVDT, (providing excitation, and demodulation) thus no external converter was required or used.

All 505 PID controller setpoints (Speed, Auxiliary, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes are provided as a reference for application programmers to follow when programming the 505 to achieve any control and limiting actions shown in Figure 2-4.

## 505 Configuration Notes for Example 4

### OPERATING PARAM:

This is a Generator application. (Generator Application? Yes)

Generator and Utility Tie breaker contact inputs are required to be programmed when a generator application is selected. (Contact Input #1 Function: Generator Breaker), (Contact Input #2 Function: Utility Tie Breaker)

Because no RPS was used to sense unit load, turbine inlet steam valve position, when paralleled to the utility, is controlled by the Speed PID and programmed by not selecting KW Droop. (Use KW Droop? No) For good response and load adjustment resolution, Droop was set to 5% of rated speed. (Droop = 5 %)

It was desired to switch to Frequency control at all times, if the plant became isolated from the Utility bus. (Use Freq Arm/Disarm? No)

### DRIVER CONFIGURATION:

Because the Digital Remote Final Driver used to interface with the servo assembly only accepts a 4–20 mA valve demand signal, the 505 was configured to output a 4–20 mA valve demand signal. (Actuator Is 4–20 mA? Yes)

Dither is a low frequency ac current modulated on to the 505's dc actuator-drive current to reduce stiction in linear type actuators. Because the 505's actuator output is connected to the DRFD, dither was not required or used with this application. (Actuator #1 Dither = 0.0%)

#### AUXILIARY CONTROL:

The Auxiliary control loop was configured to receive a utility tie line power signal through Analog input #3. (Analog Input #3 Function: Auxiliary Input) the minimum analog input value was programmed for import power based on the tie line power level at -5 A CT current (Input #3 4 mA Value =-XXXX). the maximum analog input value was programmed for export power based on the tie line power level at +5 A CT current. (Input #3 20 mA Value = +XXXX).

Because the RPS's KW readout is self powered, the 505 back cover was removed and JPR15 installed.

The 505 was configured to accept a contact from a plant distributed control system to enable and disable import/export control. (Contact Input #3 Function: Aux Control Enable)

The utility-tie Real Power Sensor's CT inputs were wired to allow the RPS's 4 mA value to represent full import power and the RPS's 20 mA value to represent full export power. Because this signal is directly proportional to turbine inlet valve position, no input inversion is required. (Invert Aux Input? No)

The Auxiliary PID was programmed to be enabled and disabled on command. (Use Aux Enable? Yes)

In this case, because the Auxiliary PID is the sole import/export controller, Droop is not needed. (Aux Droop = 0%)

With this application, it was desirable to only allow the Auxiliary PID to be enabled if paralleled to the utility. (Tiebkr Open Aux Dsbl? Yes), (Genbkr Open Aux Dsbl? Yes)

#### AUTO SYNCHRONIZING:

The 505's Analog input #6 was programmed to receive the DSLC's speed bias signal for automatic synchronization (Analog Input #6 Function: Synchronizing Input). With this configuration, the analog input's range is defaulted to a certain gain value, for best performance, thus input's 4 mA and 20 mA settings are not used and do not require programming.

A contact input was programmed to enable the Synchronizing analog input. (Contact Input #4 Function: Sync Enable)

## Starting and Run Mode Notes for Example 4

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position. Alternatively, an operator can give a manual raise command to increase turbine speed as desired.

After the unit has been started and is controlling at a rated speed position, the turbine generator can be synchronized manually, or automatically. The system operator can select automatic synchronization through the Auto-Synch select switch ( SW1 in Figure 2-4 ). When this switch is closed the 505's Synchronizing input is enabled and the DSLC's automatic synchronizing function selected.

The DSLC provides either phase matching or slip frequency synchronizing, and ties into the unit automatic voltage regulator to match voltages before paralleling. It communicates over a LAN using a digital Echelon network with other plant DSLCs to perform safe dead bus closing.

When the plant-to-utility tie line/breaker is closed, and the unit generator breaker closes, the 505 steps the speed/load setpoint up to a minimum load level to reduce the chance of reverse powering or motoring the generator. This minimum load level is based on the speed/load setpoint and is to 3%. The defaulted value is adjustable through the 505's Service mode (Breaker Logic–Min Load Bias = 5).

After synchronization the 505's load setpoint can be positioned through raise and lower speed/load setpoint contacts, a programmed 4–20 mA input, Modbus commands, or the 505 service panel.

With this configuration, Import/Export control (Auxiliary PID) can be enabled at any time after the utility tie breaker and generator breaker input contacts are closed. Auxiliary control can be enabled through the programmed contact, a Modbus command, or the 505 service panel. Because the Auxiliary Setpoint tracks plant Import/Export power before being enabled, the transfer to Auxiliary control is bumpless. Once enabled, the Auxiliary PID's setpoint can then be positioned to the desired import or export level.

Because of the 505's configuration, this unit will automatically switch to Frequency control, upon the opening of the plant-to-utility tie breaker.

### **Example 5–Inlet Pressure Control with Isochronous Loadsharing Control in Island Mode**

For this application, it is desired to control Inlet Pressure when paralleled to the utility, and Frequency while loadsharing with three other units, when isolated from the utility. With this type of application, when paralleled to the utility, load varies based on plant process steam demand, and when isolated load varies based on plant power demand. Other applications may or may not utilize all the functionality shown in Figure 2-5 and described below.

With this application, turbine inlet header pressure control is performed within the 505 through the Cascade PID controller. This is an ideal controller for this type of function because it can be enabled and disabled as desired by a system operator. This gives a system operator full authority of when to transfer process pressure control to or from a letdown station or turbine bypass valve.

To save buying a Real Power Sensor, for this application, unit load is sensed through turbine inlet valve position (505 LSS bus), not a generator load signal. Optionally, another Real Power Sensor could be used with this application to sense generator power, and allow true unit load to be sensed and controlled. With this configuration, 100% governor valve position, is considered to be 100% unit load, no matter what system conditions are.

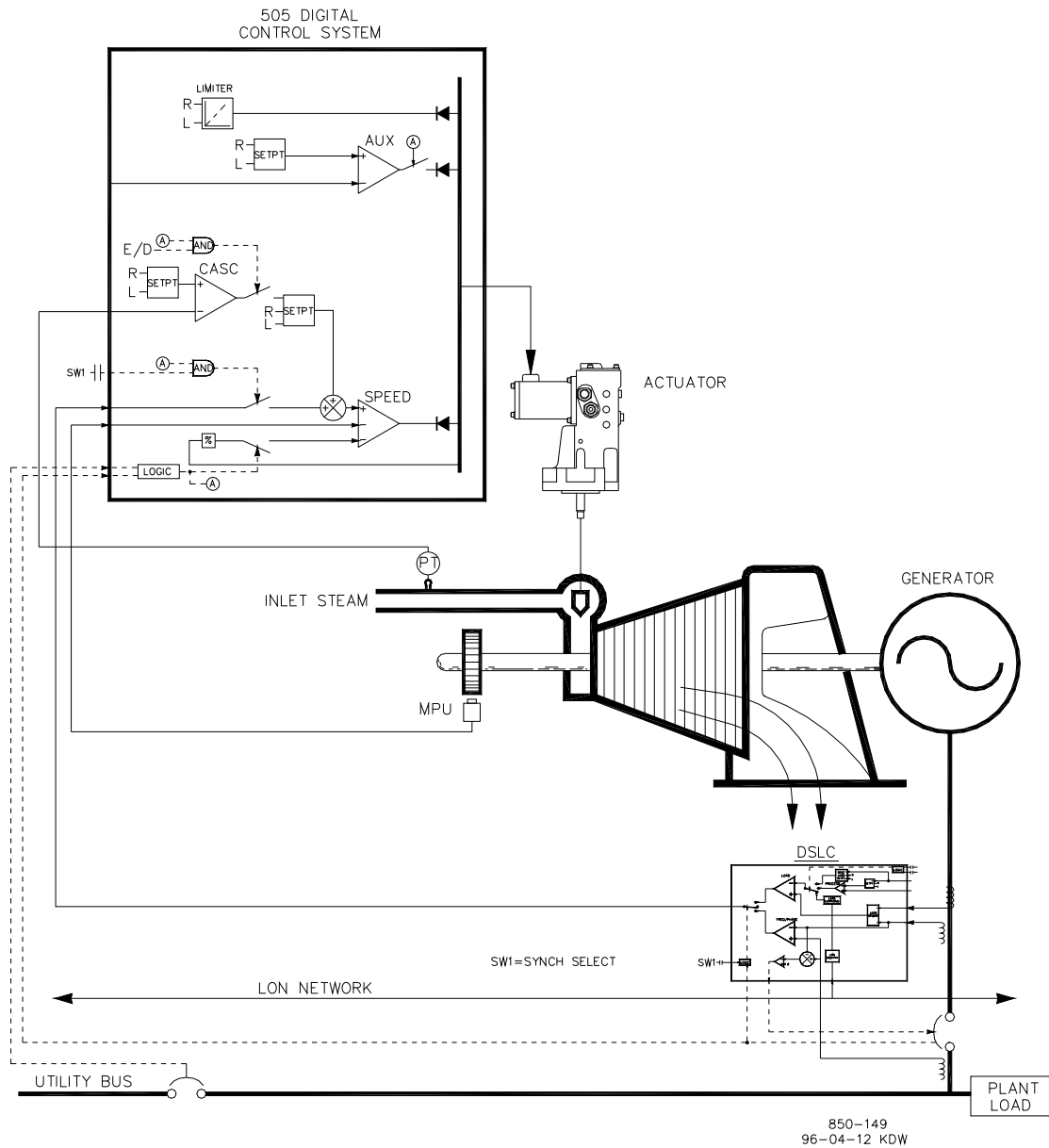


Figure 2-5. Inlet Pressure Control with Isochronous Loadsharing Control in Island Mode

This application uses a DSLC for synchronization and isochronous loadsharing. With this configuration, the DSLC is disabled when the generator is paralleled to the utility, and enabled when isolated from the utility. When the unit is paralleled to the utility, the DSLC is disabled and the 505's internal load setpoint or Cascade PID (plant import/export power) is used to control/set unit load. When the plant becomes isolated from the utility, (utility tie breaker opens), the DSLC is enabled, Cascade control is disabled, and the 505 is switched to a Frequency control/loadsharing mode.

A DSLC can only interface to a 505 through an analog input signal. The 505's Analog Input #6 is the only analog input directly compatible with the DSLC, thus it is required that this input be programmed to receive the DSLC's Speed Bias signal. When a Sync/LD Share analog input is programmed, the input is automatically enabled if the generator breaker input is closed and the utility tie breaker input is open.



Before the generator breaker is closed, the Synch/Ld Share input can be enabled, to allow automatic synchronization by the DSLC. This synchronizing function/ input can be enabled, through a contact input, function key, Modbus command, or the 505 service panel. As shown in Figure 2-5 a panel mounted (DPST) switch is used with this application to select automatic synchronization in both the DSLC and 505.

All 505 PID controller setpoints (Speed, Auxiliary, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes are provided as a reference for application programmers to follow when programming the 505 to achieve any control and limiting actions shown in Figure 2-5.

## 505 Programming Notes for Example 5

### OPERATING PARAM:

This is a Generator application. (Generator Application? Yes)

Generator and Utility Tie breaker contact inputs are required to be programmed when a generator application is selected. (Contact Input #1 Function: Generator Breaker), (Contact Input #2 Function: Utility Tie Breaker)

Because no RPS was used to sense unit load, turbine inlet steam valve position, when paralleled to the utility, is controlled by the Speed PID and programmed by not selecting KW Droop. (Use KW Droop? No) For good response and load adjustment resolution, Droop was set to 5% of rated speed. (Droop = 5 %)

It was desired to switch to Frequency control at all times, if the plant became isolated from the Utility bus. (Use Freq Arm/Disarm? No)

### CASCADE CONTROL:

The Cascade control loop was configured to receive an inlet header pressure signal through Analog input #2. (Analog Input #2 Function: Cascade Input).

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR8 was installed.

The 505 was configured to accept a contact from a panel mounted switch to externally enable and disable inlet header pressure control. (Contact Input #3 Function: Casc Control Enable)

The Cascade Input was inverted to allow the correct control action. To increase turbine inlet header pressure, the governor valve must decrease. This is considered an indirect action and requires the input to be inverted. (Invert Cascade Input? Yes)

With this application, Setpoint Tracking is not used because the desired system pressure level never changes, thus system start-up is simpler. (Use Setpoint Tracking? No)

To protect the generator from being reverse powered by the Cascade PID, the 'Speed Setpoint Lower Limit' value was set to 5 rpm above synchronous speed.



In this case, because the Cascade PID is sharing control of inlet header pressure with the boiler control, Droop was set at 5%. This allows the Cascade PID to assist the boiler control with inlet header pressure control, without having the two fight over the same parameter. (Cascade Droop = 5%).

#### SYNCH/LD SHARING:

The 505's Analog Input #6 was programmed to receive the DSLC's speed bias signal for automatic synchronization, and load sharing. (Analog Input #6 Function: Synch/Load Share Input) With this configuration, the analog input's range is defaulted to a certain gain value, for best performance, thus input's 4 mA and 20 mA settings are not used and do not require programming.

A contact input was programmed to enable the Synch/Load Share analog input to allow synchronization through the DSLC before the generator breaker is closed. (Contact Input #4 Function: Synch/Ld Share Enable).

### Starting and Run Mode Notes for Example 5

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position. Alternatively, an operator can give a manual raise command to increase turbine speed as desired.

When the unit has been started and is controlling at a rated speed position, the turbine generator can be synchronized manually, or automatically. The system operator can select automatic synchronization through the Auto-Synch select switch ( SW1 in Figure 2-5 ). When this switch is closed the 505's Synch/Load Sharing input is enabled and the DSLC's automatic synchronizing function is selected.

After synchronization, generator load is determined by the mode of operation selected, (the position of the utility tie breaker contact input). If the utility tie breaker contact is closed, generator load is determined by the 505's internal load setpoint, or when enabled, inlet header pressure control (Cascade control). If the utility tie breaker contact is open generator load is determined by the DSLC. The DSLC can be configured to operate in several different load control modes. For this application the DSLC is only used for isochronous loadsharing, when the plant is isolated from the utility.

In this plant four generating units use DSLCs, and upon the plant-to-utility tie breaker opening they all switch to Frequency control and communicate with each other via a digital LON network to share load. Thus plant frequency is controlled by all units, and plant load is shared proportionally by all four units. With this configuration plant frequency will be the average frequency of all units. The 505, has a feature that resets its frequency setpoint to the 'RATED SPEED SETPOINT' setting upon the utility tie breaker opening, thus assuring that all units will be at synchronous speed. A DSLC's Frequency Trimmer function may be programmed to hold frequency within  $\pm 0.1\%$  of the desired frequency.

Inlet header pressure (Cascade control) can be enabled any time after the utility tie and generator breaker contacts are closed. Cascade control can be enabled through a programmed contact, a Modbus command, or the 505's service panel.

### Example 6—Import/Export Control or Exhaust Pressure Control with Isoch Load Sharing in Island Mode

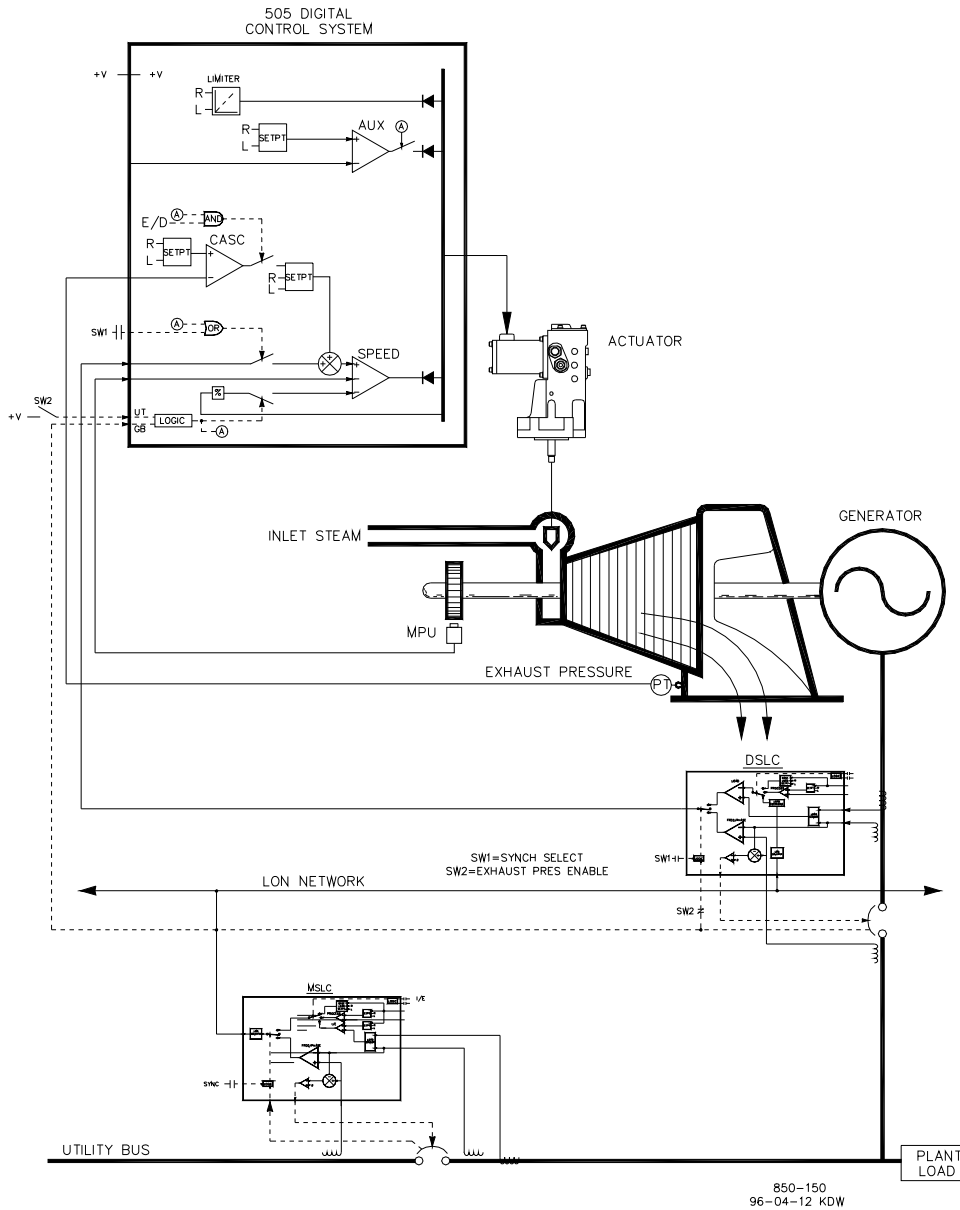


Figure 2-6. Import/Export Control or Exhaust Pressure Control with Isoch Load Sharing in Island Mode

This application utilizes multiple turbine generators, and requires that all units have the capability to control different plant parameters depending on the status and health of each unit. Normal operation is to have one unit control plant process steam (turbine exhaust pressure) and the other units be controlled based on plant import/export demand. Other applications may or may not utilize all the functionality shown in Figure 2-6 and described below.

For this application one unit at a time, based on system, health is used to control plant process steam. The other units are used to control a plant export power level of 5 MW. Because the plant is contractually obligated to provide this level of power to the utility, and because it is more economical to make power than purchase it from the utility, a 5 MW plant export power level is desired.

Each unit control panel has a mode selection switch which allows an operator to place a unit in one of three different modes of operation. The three modes of operation are Manual load (used to manually load and unload a unit), Plant Process Steam control (turbine exhaust pressure), and Loadsharing (used for plant import/export control or unit loadsharing).

When a unit is switched to a Manual load control mode, its 505's internal load setpoint determines unit load. This allows an operator to manually load or unload a unit to a set level if desired.

With this application when a unit is switched to the Plant Process control mode, turbine exhaust pressure control is performed within the 505 through the Cascade PID controller. This is an ideal controller for this type of function because it can be enabled and disabled as desired by a system operator. This gives a system operator full authority of when to transfer process pressure control to or from a letdown station or turbine bypass valve.

To save buying a Real Power Sensor, turbine inlet valve position (505 LSS bus) is used to sense unit load, not a generator load signal. With this configuration, 100% governor valve position, is considered to be 100% unit load, no matter what the system conditions. Thus unit overload protection is only performed by limiting the 505's output to 100%. Optionally, a Real Power Sensor could be used with this application to sense generator power, and allow true unit load to be sensed, controlled and limited.

This application uses Woodward DSLCs and a MSLC to allow all units to communicate, share plant load, and control plant export power. The DSLC is used on each unit, for synchronization and loadsharing. One Master Synchronizer & Load Control is used for plant synchronization and import/export power control. When a unit is in the Loadsharing mode, the MSLC determines its load with the plant-to-utility tie line is closed, and the DSLC's loadsharing circuitry when the plant-to-utility tie line is open. The MSLC, when enabled, sets the load setpoint of each unit DSLC (in the Loadsharing mode) to control a plant export level. When the plant-to-utility tie breaker is open, the MSLC is disabled, and each unit communicates with the other units in the Loadsharing mode via the DSLC's LON network to share plant load.

A DSLC interfaces to a 505 through an analog input signal. The 505's Analog Input #6 is the only analog input directly compatible with the DSLC, thus it is required that this input be programmed to receive the DSLC's Speed Bias signal. When a Sync/LD Share analog input is programmed, the input is automatically enabled if the generator breaker input is closed and the utility tie breaker input is open.

Before the generator breaker is closed, the 505's Sync/Ld Share analog input can be enabled, to allow automatic synchronization by the DSLC. This synchronizing function/input can be enabled, through a contact input, function key, Modbus command, or the 505 service panel. As shown in Figure 2-6 a panel mounted (DPST) switch is used, with this application, to select automatic synchronization in both the DSLC and 505.

All 505 PID controller setpoints (Speed, Cascade) may be changed through programmed raise and lower contacts, programmed 4–20 mA inputs, Modbus commands, or the 505 service panel.

The following list of notes are provided as a reference for application programmers to follow when programming the 505 to achieve any control and limiting actions shown in Figure 2-6.

## 505 Configuration Notes for Example 6

### OPERATING PARAM:

This is a Generator application. (Generator Application? Yes)

Generator and Utility Tie breaker contact inputs are required to be programmed when a generator application is selected. (Contact Input #1 Function: Generator Breaker), (Contact Input #2 Fncion: Utility Tie Breaker).

Generator load is limited by the Speed PID sensing governor valve position through its LSS bus, and programmed by not selecting KW Droop. (Use KW Droop? No)

For good response and load adjustment resolution, Droop (LSS bus position) was set to 5% of rated speed. (Droop = 5 %)

It was desired to switch to Frequency/Loadsharing control at all times, if the plant becomes isolated from the Utility bus. (Use Freq Arm/Disarm? No)

### CASCADE CONTROL:

The Cascade control loop was configured to receive an exhaust header pressure signal through Analog input #1. (Analog Input #1 Function: Cascade Input)

Because a two wire, loop powered transducer is used to interface with this signal, the 505 back cover was removed and JPR10 installed.

A contact input was programmed to allow an operator to easily enable and disable Cascade control via a control panel switch. (Contact Input #3 Function: Casc Control Enable).

Exhaust header pressure is directly proportional to turbine inlet valve position, thus no input inversion is required. (Invert Cascade Input? No)

With this application, Setpoint Tracking is used to allow the 505's Cascade control, when disabled, to track exhaust header pressure being controlled by a letdown station. (Use Setpoint Tracking? Yes)

To protect the generator from being reverse powered by the Cascade PID, the 'Speed Setpoint Lower Limit' value was set to 5 rpm above synchronous speed.

In this case, because the Cascade PID, during normal operation, is not sharing control of the exhaust header pressure with another control, Droop is not needed. (Cascade Droop = 0%)

**GEN LOAD LIMITING:**

To limit generator load to 100% the Speed setpoint maximum limit was set at the 100% load setting. 5% Droop was programmed for this application. (Max Governor Speed Setpoint = Rated Speed X 1.05)

**SYNC & LOAD SHARING:**

The 505's Analog input #6 was programmed to receive the DSLC's speed bias signal for automatic synchronization and loadsharing (Analog Input #6 Function: Sync/Load Share input). or best performance, the analog input's range is defaulted to a certain gain value, thus the input's 4 mA and 20 mA settings are not used and do not require programming.

A contact input is programmed to enable the Sync/Load Share analog input before the generator breaker is closed to enable synchronizing through the DSLC (Contact Input #4 Function: Sync/Ld Share Enable).

**Starting and Run Mode Notes for Example 6**

Starting and ramping to an idle or minimum speed position can be performed automatically, semi-automatically, or manually. After the unit is started, the Idle/ Rated or Auto Start Sequence functions, if programmed, can be used to assist ramping the control to a rated speed position. Alternatively, an operator can give a manual raise command to increase turbine speed as desired.

After the unit has been started and is controlling at a rated speed position, the turbine generator can be synchronized manually, or automatically. The system operator can select automatic synchronization through the Auto-Synch select switch ( SW1 in Figure 2-6 ). When this switch is closed the 505's Synchronizing input is enabled and the DSLC's automatic synchronizing function selected.

With this configuration the mode of operation the system operates in is dependent on SW2's position. When SW2 is not selecting the Loadsharing mode, and the generator breaker is closed, unit load is set by the 505's internal Speed/load setpoint, or the Cascade PID if enabled. Upon the generator breaker closing, the 505 steps the speed/load setpoint up to a minimum load level to reduce the chance of reverse powering or motoring the generator. This minimum load level is based on the speed/load setpoint and is defaulted to 3%. The defaulted value is adjustable through the 505's Service mode (Breaker Logic–Min Load Bias = 5).

After synchronization the 505's load setpoint can be positioned through raise and lower speed/load setpoint contacts, a programmed 4–20 mA input, Modbus commands, or the 505 service panel.

Cascade control (turbine exhaust pressure) can be enabled at any time after the utility tie breaker and generator breaker input contacts are closed. The Cascade control can be enabled through a programmed contact, Modbus command, or the 505 service panel.

When SW2 is switched to select Loadsharing, the DSLC bumplessly ramps load to match the MSLC's load setpoint, or to a load setting determined by the DSLC's loadsharing circuitry, depending on utility-to-tie breaker position. The MSLC can be used to set all the units in the Loadsharing mode to a base load setting, or vary their load based on a plant import/export demand setting.

With this application, during normal operation, one unit is switched to control plant process steam and the other units are switched to the loadsharing mode and are loaded based on the MSLC plant load demand. If the plant should become isolated from the utility, the MSLC will become disabled and all units in the loadsharing mode will share plant load. When desired the MSLC can be enabled to re-synchronize the plant bus to the utility bus and close the plant-to-utility tie breaker. After synchronization the MSLC will either ramp plant power to a 5 MW export power level, or ramp plant load to a base load setting, depending on the mode of operation selected.

Woodward DSLCs can interface directly with a unit's automatic voltage regulator. This allows units with DSLCs to share reactive power as well as real power. This configuration also allows the MSLC to control plant power factor when the utility tie breaker is closed.

### Example 7—Induction Generator Applications

When the 505 is configured for induction generator applications, typically there are only two differences in the programming of the 505 verses programming for synchronous generator applications.

The induction generator's slip frequency must be taken into account. This is achieved by compensating for the slip frequency with the 505's maximum Speed Setpoint setting. The 'MAX GOVERNOR SPEED SETPOINT' setting must be equal to synchronous speed plus the droop percentage plus the full load slip frequency percentage.

1. MAX GOVERNOR SPEED SETPOINT = SYNC SPEED + (SYNC SPEED \* DROOP) + MAX SLIP rpm.
2. The USE TIE BREAKER OPEN TRIP setting must be set to "Yes" if a synchronous generator is not sharing the same plant bus. This will cause the generator to trip when the utility tie breaker opens.

## Chapter 3. Operator Interface

### Introduction

Interface to the control may be performed through the 505's service panel (located on the front of the control), remote switch contacts, analog inputs, meter readouts, relays, or a Modbus communications line to an operator interface device.

### Keypad and Display

The control's service panel consists of a keypad and LED display (two lines, 24 characters each) located on the front of the control.

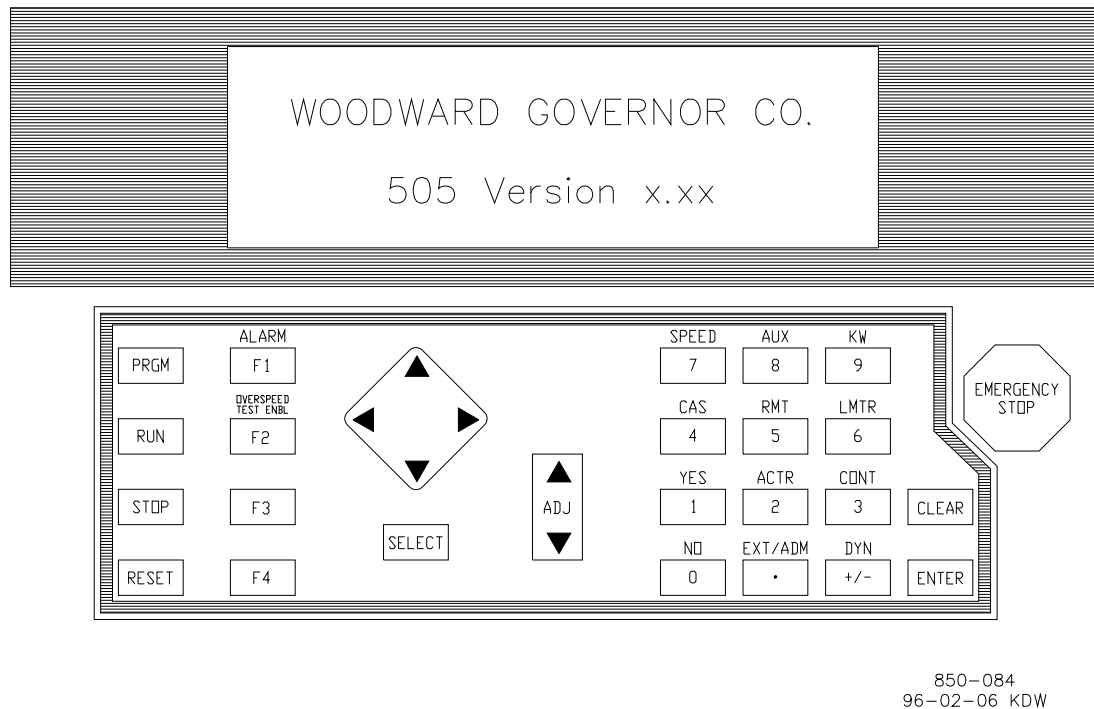


Figure 3-1. 505 Keypad and Display

The system operator uses the service panel to communicate with the 505 system. The service panel can be used only occasionally to communicate with the system, or it can continuously monitor a value for the operator to view.

The Service Panel, shown in Figure 3-1, includes the 30 key keypad and the split screen display. An overview of the software and information arrangement scheme for the Service Panel is shown in Figure 3-2.

## Service Panel Modes

The 505 Service Panel operates in several access modes, each of which has a different purpose. These modes are: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS, and SYS\_INFO. See Figure 3-2 , Software Structure Overview.

The SERVICE mode can be used while the turbine is running. The SERVICE mode permits displaying the value of any SERVICE mode block, and changing the value of any of those blocks that are tunable. Entry into the SERVICE mode requires a password.

The CONFIGURE mode is also referred to as the PROGRAM mode and is used to set up the parameters for a specific application prior to operation of the unit. The turbine must be shut down (and the password entered correctly) to change any CONFIGURE values. If the control is not shutdown, pressing the PRGM key will allow viewing of CONFIGURE, but will not permit any changes to be made.

The DEBUG mode is used to troubleshoot a system during development and is not intended for general use. It should be used only by properly trained Woodward personnel or when expressly authorized by Woodward Governor Company. Entry into the DEBUG mode requires a password.

The OS\_FAULTS mode displays any operating system faults or alarms that have occurred, and permits resetting (clearing) the list of detected alarms. Entry into the OS\_FAULTS mode requires a password.

The SYS\_INFO mode is used to display system information, change passwords, or download a configuration file into the control.

## Using the Service Mode

Information that can be displayed by the SERVICE mode and CONFIGURE mode is all arranged in the same way. There are three tiers or levels: modes, headers, and blocks. The modes each have a number of headers under them and each header usually has many blocks under it. The DEBUG mode, the OS\_FAULTS mode, and the SYS\_INFO use different arrangements and will be described later.

### Top Level/Root System Block

This is normally the first block to appear on the display after power up, but may be overwritten by the application program. To get to the Root System block at any time push the CLEAR key once or sometimes twice depending where the user is in the programmable service. The block looks like this:



Pressing the scroll \_ key takes the system to the first level, the mode level.



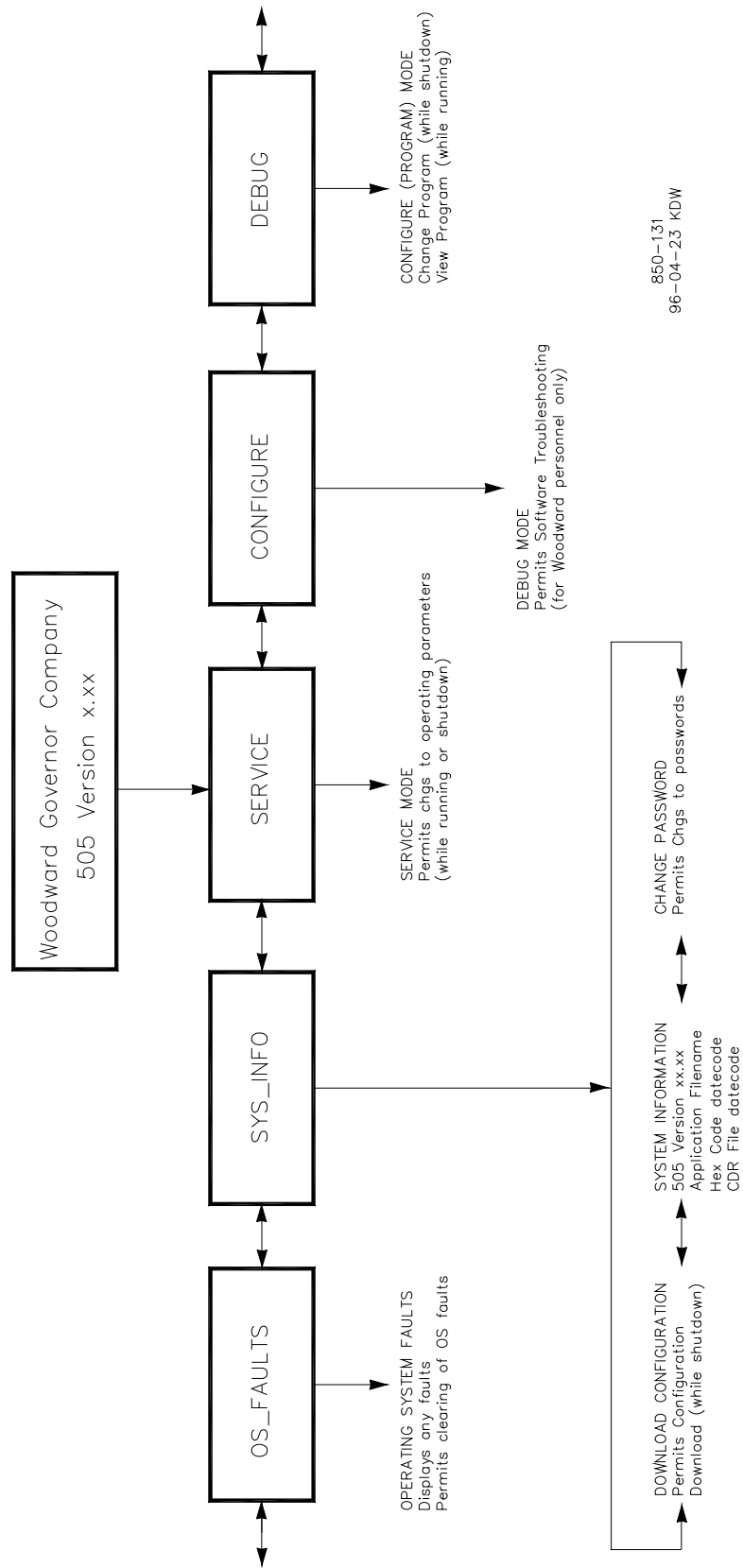


Figure 3-2. Software Structure Overview

### Select Mode Level

This first level (below the Top Level/Root System block) contains the five different programmable service mode blocks. The five mode blocks are arranged within the first level as shown in Figure 3-3. Scroll left (◀) or right (▶) to display each mode.

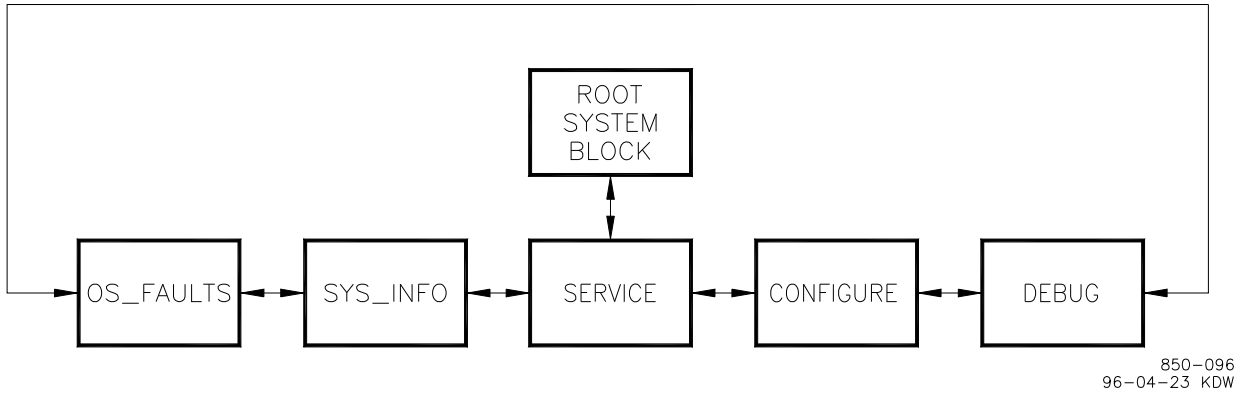


Figure 3-3. The Select Mode Level

**IMPORTANT** When entering the mode level, the **SERVICE** mode will always be the one displayed first in the mode-level message.

### Header Level

The second level is the header level. This level contains the programmable service header blocks as shown in Figure 3-4. Scroll left (◀) or right (▶) to get to each header. Press CLEAR to get back to the Select Mode Level. Scroll down (▼) to get to any block under a header.

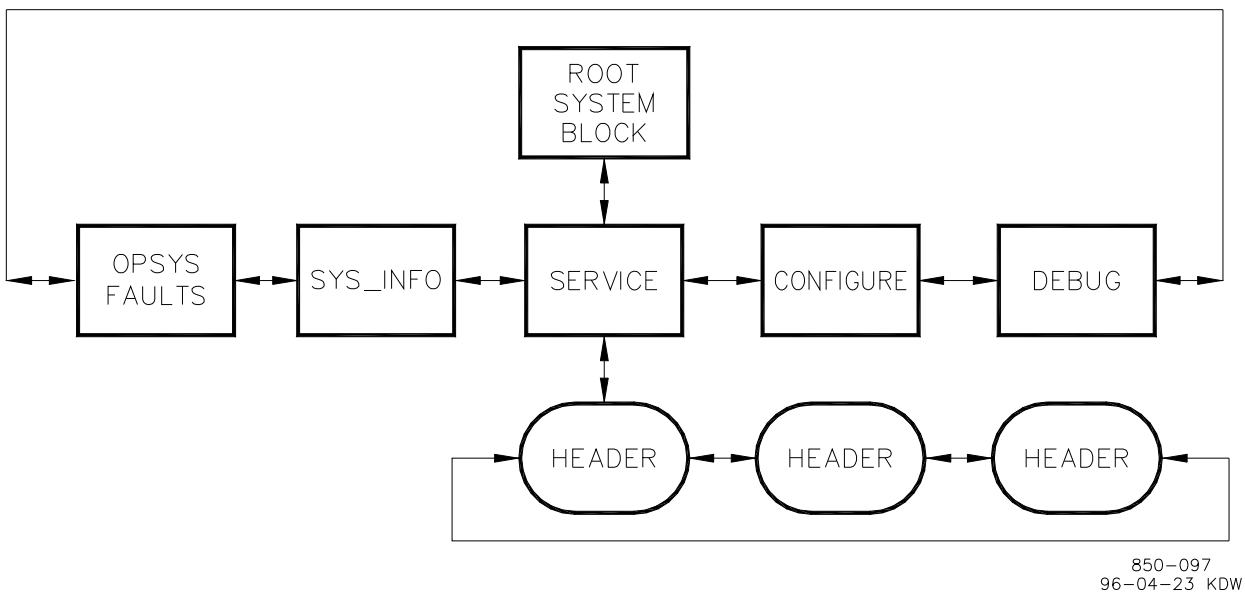


Figure 3-4. Header Level

## Block Level

The third level, the block level, is shown in Figure 3-5. The programmable service blocks containing the values to be monitored or changed are found at this level. Scroll down (▼) or up (▲) to get to a different block. Push CLEAR to get back to the header level.

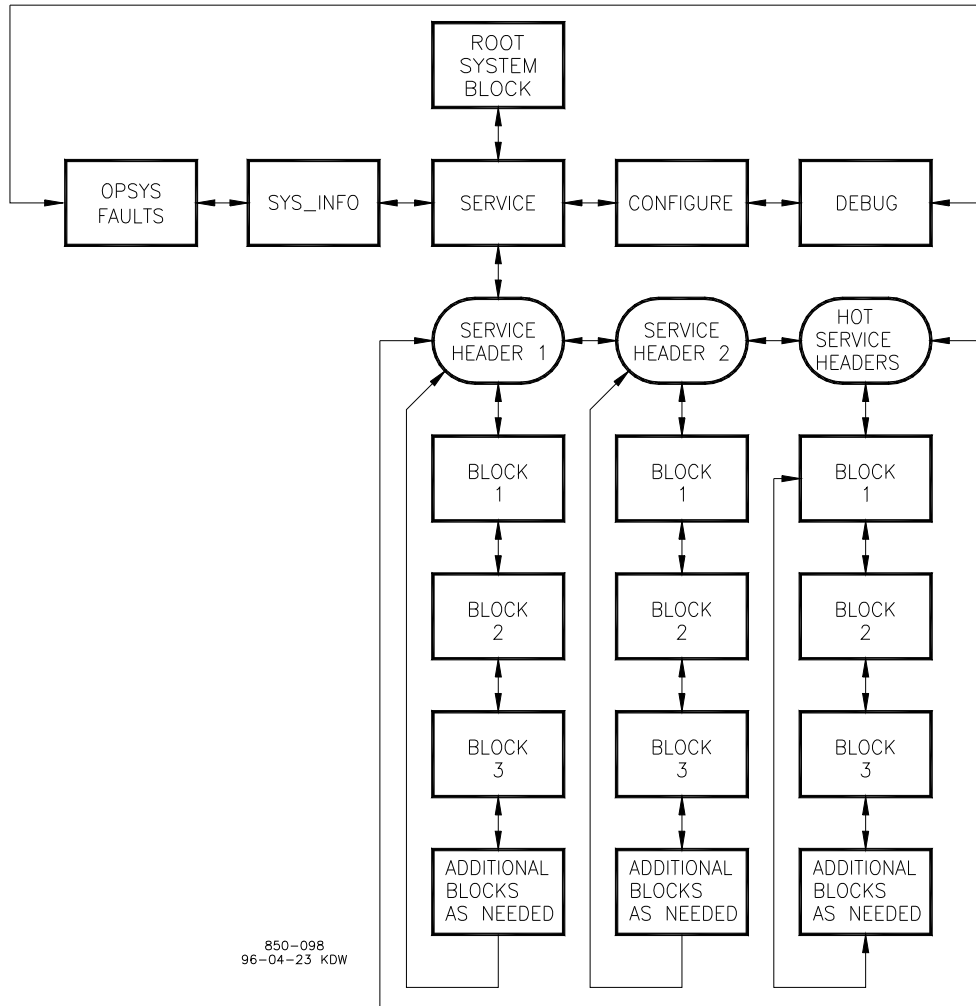


Figure 3-5. Block Level

## Service Mode

The SERVICE mode can be used while the engine/turbine is running or shut down. The SERVICE mode permits displaying the value of any SERVICE mode block, and changing the value of any of those blocks that are tunable. Entry into the SERVICE mode requires a password.

In the SERVICE mode, the value displayed for a block can be changed by using either the ADJ \_ or ADJ \_ keys. The value can be changed if it is a tunable variable; in this case there will be a \* before the value.

This mode can also be used to make direct numeric entries. However, because this mode is intended to be used while the turbine is running, the Service Panel will accept the entry of numeric values for a block only if the proposed change is very small. The block value proposed for entry must be within 1 percent of the current displayed value of that block, unless that current displayed value is between  $-0.1$  and  $+0.1$ . If the current displayed value is between  $-0.1$  and  $+0.1$ , the system will accept any entry between  $-0.1$  and  $+0.1$ .

To make direct numeric entries, first bring the displayed value to within 1% of the value to be entered. Press the ENTER key. Press the numerical keys to input the value and press ENTER again.

If the value entered is less than the value displayed by more than 1% or greater than the value displayed by more than 1%, an appropriate message will be displayed indicating the value entered is too large or too small.

When using the SERVICE mode, refer to the Service Mode worksheet in Appendix B.

## Entering the Service Mode

1. At the select mode level, the following message will appear on the display.

```
Push < or > for new mode
Press ENTER for MMMMMMMM
```

(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS or SYS\_INFO)

2. Press the scroll right (▶) key until the message indicates the SERVICE mode (unless it already does).
3. Press the ENTER key. The following message will be on the display.

```
Password SERVICE
```

### **IMPORTANT**

**For password information see Appendix C at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.**

4. Enter the password on the numeric keys, then press the ENTER key. The display will show a SERVICE mode header. An example is shown below.

```
@SERVICE HEADER
XXXXXXXXXXXXXXXXXXXXX
```

**IMPORTANT**

The headers and blocks are assigned their names by the application programmer; this is only an example.

5. The @ indicates which half of the split screen display that key entry will affect. Use the SELECT key to select either the top or bottom of the split screen display. (The Xs indicate another header or block which is being shown on the bottom half of the split screen display.)
6. Use the scroll right (▶) or scroll left (◀) key to select the desired SERVICE mode header.
7. Use the scroll up (▲) key or scroll down (▼) key to select the desired SERVICE mode block. A message similar to the one below will be displayed.

```
@On-Line rop Gn      *5.000
  On-Line Int Gn      *5.000
```

(The \* indicates this block contains a tunable variable).

8. Use the ADJ \_ or ADJ \_ keys to increase or decrease the value of the block being displayed. If a faster rate of change is desired simply hold the key down and the rate of change will increase after two seconds and again after six seconds. If a slower rate of change is desired, repeatedly release the key after holding one second then press again.

**IMPORTANT**

This mode can also be used to make direct numeric entries. However, because this mode is intended to be used while the engine/turbine is running, the Service Panel will accept the entry of numeric values for a block, only if the proposed change is very small. The block value proposed for entry must be within 1 percent of the current displayed value of that block, unless that current displayed value is between -0.1 and +0.1. If the current displayed value is between -0.1 and +0.1, the system will accept any entry between -0.1 and +0.1.

9. When setting the value of the block has been completed, either go to another block or exit out of the mode.
  - To scroll to another block under the same header, use the scroll down (▼) or scroll up (▲) keys.
  - To go back to the same header, press the CLEAR key.
  - From header level, to go to a block under a different header, scroll to the new header by using the scroll right (▶) or scroll left (◀) key, then scroll to the new block by using the scroll down (▼) or scroll up (▲) key.

- To exit the mode, use the CLEAR key to get back to the header. Then press CLEAR again to get back to the Top Level/Root block. The values of all variables that were changed will then be stored in EEPROM.

**IMPORTANT**

If the display will not be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the screen to save power and prolong the life of the display.

**Exiting Modes**

When leaving the SERVICE mode or the CONFIGURE mode and returning to the Root level (by pressing CLEAR), the values of all variables that were changed (while in SERVICE mode or CONFIGURE mode) are stored in EEPROM.

**WARNING**

If variables are tuned or changed but not stored in EEPROM by pressing CLEAR to return to the root level, then those changes will be lost if power is removed from the control or if the control is reset.

**IMPORTANT**

When the display is showing the Top Level/Root block (shown below) the display will turn off if approximately 5 minutes elapse without a key being pressed. If the unit is powered up but the display is blank, press the CLEAR, scroll down (▼), PRGM, or any hot key to turn the display on. This will turn the display block on.

**Configure Mode**

The CONFIGURE mode is used to set a system up for a specific application, before actual operation of that system starts. The engine/turbine must be shut down when using the CONFIGURE mode, and numeric entries of any value (within the allowed range for that block) may be made.

Entry into the CONFIGURE mode requires a password. If the control is not shutdown, pressing the PRGM key will allow viewing of CONFIGURE, but will not permit changing the value of a block.

The structure of the CONFIGURE mode is identical to that of the SERVICE mode (see Figure 3-5).

**NOTICE**

Entry into the CONFIGURE mode will cause an automatic shutdown of all control outputs. The control will prompt "SHUTDOWN CONTROL? Y/N". Entering YES will cause all milliamps outputs will go to zero and all relays will de-energize. Entering NO will abort the shutdown.

When using the CONFIGURE mode, refer to CONFIGURE/PROGRAM MODE worksheet in Appendix A of Volume 1.

Since configuring a control or viewing how a control is configured is such a commonly used mode the PRGM (program) key has been designed to take the user directly to step 4 below from anywhere in programmable service except DEBUG, OS\_FAULTS, or SYS\_INFO. The CONFIGURE mode can also be reached like the other modes by following the steps below.

1. At the mode level the following message will appear on the display.

```
Push < or > for new mode
Press ENTER for MMMMMMMM
```

(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS or SYS\_INFO)

2. Press the scroll right (▶) or scroll left (◀) key until the message indicates the CONFIGURE mode.
3. Press the ENTER key. The following message will be on the display.

```
Password CONFIGURE
```

For password information see Appendix C at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.

4. Enter the password on the numeric keys, then press the ENTER key. The system will display the following message.

```
SHUTDOWN CONTROL? Y/N
```

If the NO key is pressed, the system will return to the mode level. If the YES key is pressed, the system will enter the CONFIGURE mode; all control outputs will shut off. The display will show a CONFIGURE mode header. An example is shown below.

```
CONFIGURATION HEADER
```

**IMPORTANT**

The headers and blocks are assigned their names by the application programmer; this is only an example. The CONFIGURE mode does not use the split-screen as does SERVICE, and DEBUG mode. In the CONFIGURE mode the prompt is displayed on the top line and the variable to be configured is displayed on the second line.

5. Use the scroll right (▶) or scroll left (◀) key to select the desired CONFIGURE mode header.
6. Use the scroll down (▼) key or scroll up (▲) key to select the desired CONFIGURE mode block.
7. Enter the desired value on the numeric keys and press the ENTER key.
8. When setting the value of the block has been completed, either go to another block or exit out of the mode.
  - To scroll to another block under the same header, use the scroll down (▼) or scroll up (▲) keys.
  - To go back to the header, press the CLEAR key.
  - From header level, to go to a block under a different header, scroll to the new header by using the scroll right (▶) or scroll left (◀) key, then scroll to the new block by using the scroll down (▼) or scroll up (▲) key.
  - To exit the mode, use the CLEAR key to get back to the header. Then press CLEAR again to get back to the Top Level/Root block. The values of all variables that were changed will then be stored in EEPROM.

**IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

## DEBUG Mode

The DEBUG mode is used to troubleshoot a system during development and is not intended for general use. It should be used only by properly trained Woodward personnel or when expressly authorized by Woodward Governor Company. Entry into the DEBUG mode requires a password.

**IMPORTANT**

For password information see Appendix C at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.

**WARNING**

The DEBUG mode is intended for use only by authorized and trained personnel to maintain and troubleshoot the system. Use of the DEBUG mode by untrained or unauthorized personnel could result in inadvertently changing critical system values; changing critical system values could cause equipment damage or personnel injury or death. Do not permit unauthorized personnel to use the DEBUG mode.



The information in the DEBUG mode is arranged as shown in Figure 3-6. Scroll down to go from a MOE category to a MOE block; scroll up or down to go to another MOE block. Scroll left or right to go from a MOE block to a field of that MOE block, or from one field to another field of the same MOE block.

All tunable values that are used in SERVICE or CONFIGURE modes will not show up in DEBUG mode. Any value that is tunable but is not used in SERVICE mode or CONFIGURE mode will appear as a tunable, and can be tuned, in DEBUG mode.

When exiting the DEBUG mode, all tunable values that have been changed will be stored in EEPROM memory.

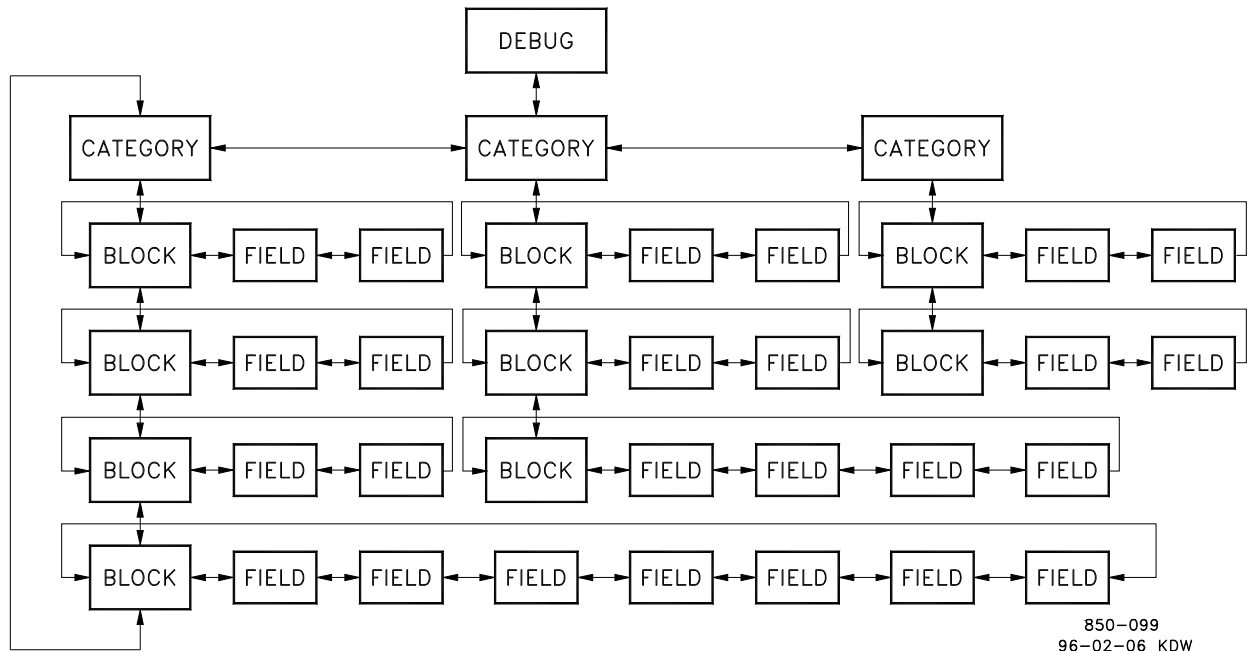


Figure 3-6. Debug Information Arrangement

Pressing the '.' key while in the DEBUG mode will switch the display to the SERVICE mode; pressing the '.' key again will switch the display back to the DEBUG mode.

## OS\_FAULTS Mode

The OS\_FAULTS mode displays all operating system faults or alarms that have occurred since the last Faults Reset operation. It also permits resetting (clearing) the alarm list.

The OS\_FAULTS mode headers are:

- Faults Detected—Displays faults detected since the last power down.
- Alarms Detected—Displays alarms detected since the last time the alarm list was cleared.
- Clear Alarms Detected—Clears the alarm list.

The information in the OS\_FAULTS mode is arranged as shown in Figure 3-7.

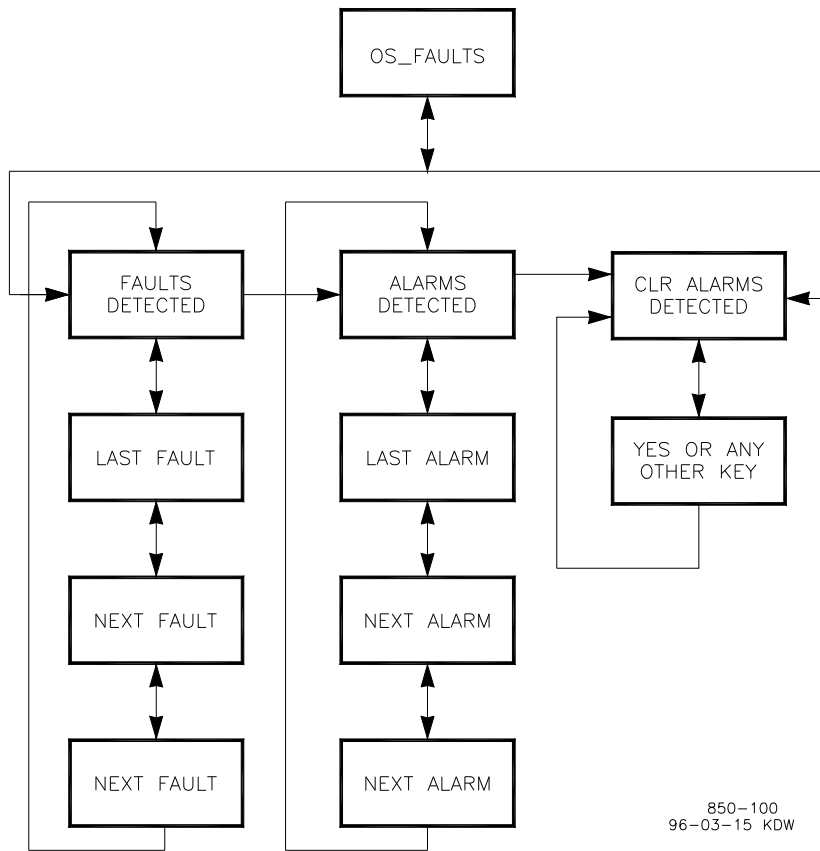


Figure 3-7. OS\_FAULTS Mode Information Arrangement

1. To Enter the OS\_FAULTS mode:

The following message will be displayed when the system is at the select mode level.

Push < or > for new mode  
Press ENTER for MMMMMMM

(MMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS or SYS\_INFO)

2. Press the scroll left (◀) or scroll right (▶) key until the message indicates the OS\_FAULTS mode.
3. Press the ENTER key. The following message will be on the display.

Password OS\_FAULTS

**IMPORTANT**

For password information see Appendix C at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.

4. Enter the password on the numeric keys and press the ENTER key. The header shown below will be displayed.



CONFIGURATION HEADER

5. Use the scroll left (◀) or scroll right (▶) key to select the desired OS\_FAULTS mode header. The header will display as shown below.



Faults Detected

or



Alarms Detected

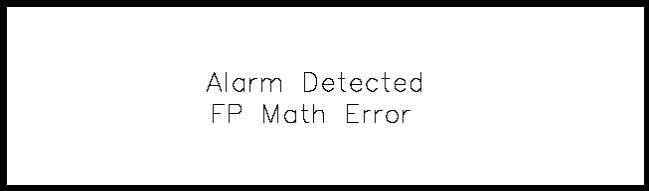
or



Clear Alarms Detected

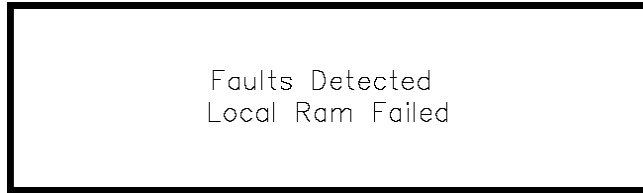
**Faults Detected Header**

1. While the Faults Detected header is displaying, use the scroll down (▼) key or scroll up (▲) key to display the faults detected under it. A message describing the most recent fault detected will display under the header message, as shown below.



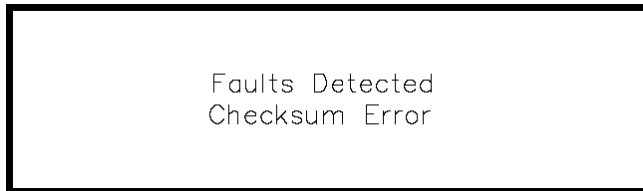
Alarm Detected  
FP Math Error

2. Press scroll down (▼) to see the next fault detected. Each time scroll down (▼) or scroll up (▲) is pressed, another fault detected under this header will display. An example is shown below.



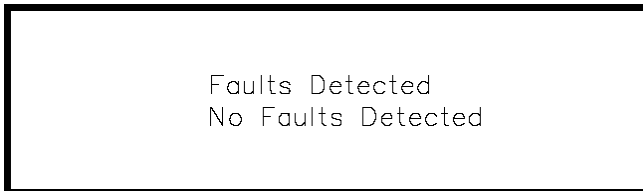
Faults Detected  
Local Ram Failed

If no faults have been detected, the following message will display for one second.



Faults Detected  
Checksum Error

After one second, only the header message will display.



Faults Detected  
No Faults Detected

3. From a displaying fault message, to go back to the Faults Detected header, press the CLEAR key.
4. To go from the Faults Detected header to the Top Level/Root display, press the CLEAR key again.

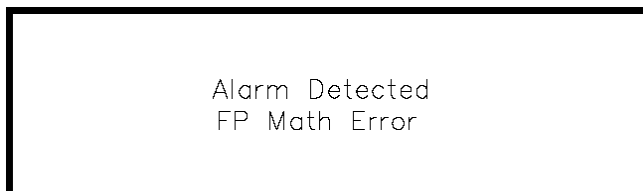
**IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

The meanings of the fault messages generated by the 505 System are shown in Chapter 7.

**Alarms Detected Header**

1. While the Alarms Detected header is displaying, use the scroll down (▼) key to display the alarms detected under it. A message describing the most recent alarm detected will display under the header message, as shown below.



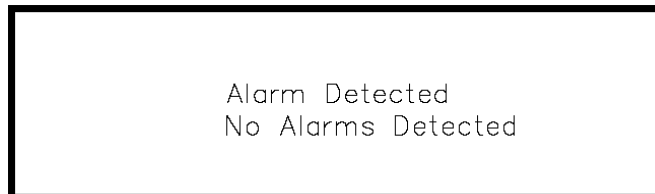
Alarm Detected  
FP Math Error

2. Press scroll down (▼) to see the next alarm detected. Each time scroll down (▼) or scroll up (▲) is pressed, another detected alarm will display. An example is shown below.



Alarm Detected  
System Alarm #18

If no faults have been detected, the following message will display for one second.



Alarm Detected  
No Alarms Detected

After one second, only the header message will display.

3. From a displaying alarm message, to go back to the Alarms Detected header, press the CLEAR key.
4. To go from the Alarms Detected header to the Top Level/Root display, press the CLEAR key.

**IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

The meanings of the alarm messages generated by the 505 System are shown in Chapter 7.

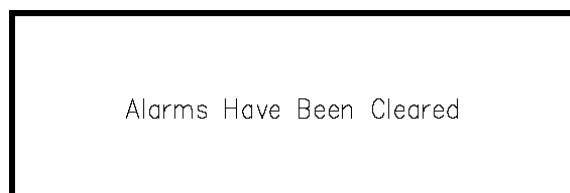
**Clear Alarms Detected Header**

1. To clear the alarm list, while the Clear Alarms Detected header is displaying, press the scroll down (▼) key. The following message will be displayed.



Clear All Alarms? Y/N

2. To clear the alarm list, press Y (for Yes). The alarm list will be cleared. The following message will appear for one second.



Alarms Have Been Cleared

If any other key is pressed, the display will return to the header level and only the following message will appear.



3. To go from the Clear Alarms Detected header to the Top Level/Root display, press the CLEAR key.

**IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

### SYS\_INFO Mode

The SYS\_INFO mode displays information about the system. It also permits changing passwords for the different modes and loading a configuration file from a personal computer.

The SYS\_INFO mode headers are:

- System Information—Displays software version and information about the application program.
- Change Password—Allows user to change all the system passwords for the various modes.
- Download Configuration—Allows the user to download a configuration file from a personal computer.

The information in the SYS\_INFO mode is arranged as shown in Figure 3-8.

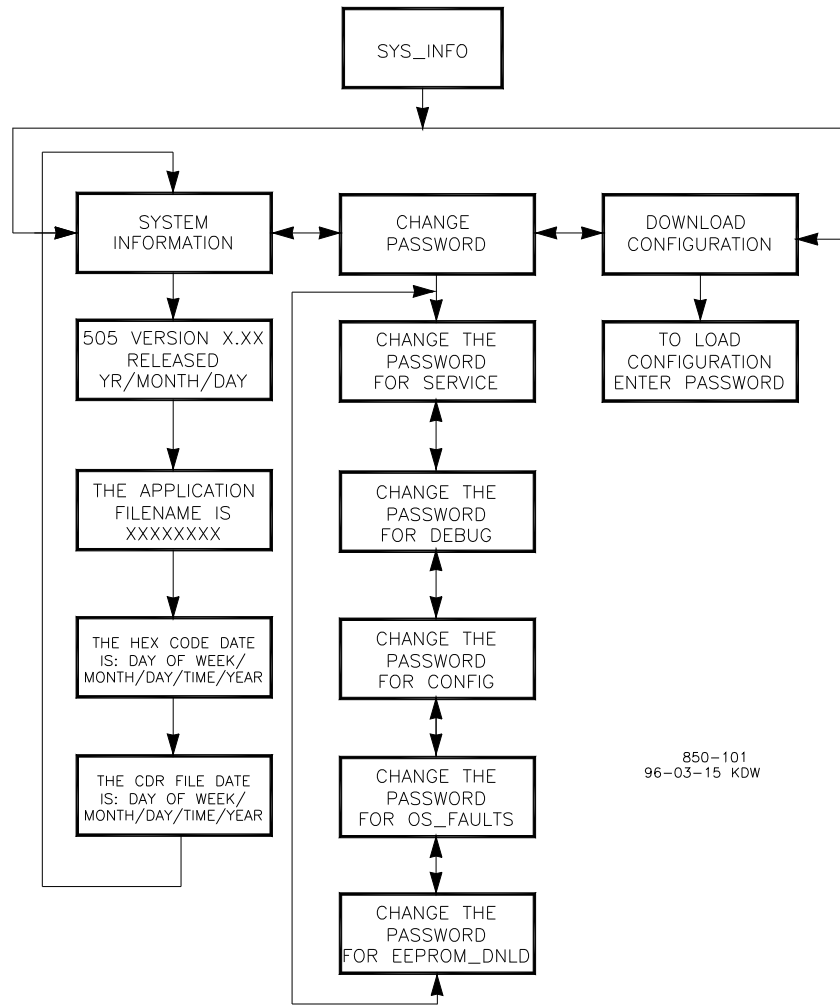


Figure 3-8. SYS\_INFO Mode Information Arrangement

To enter the SYS\_INFO mode:

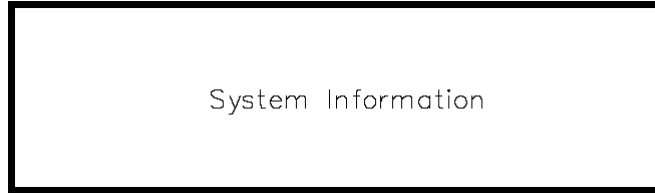
1. The following message will be displayed when the system is at the select mode level.

Push < or > for new mode  
Press ENTER for MMMMMMM

(MMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS or SYS\_INFO)

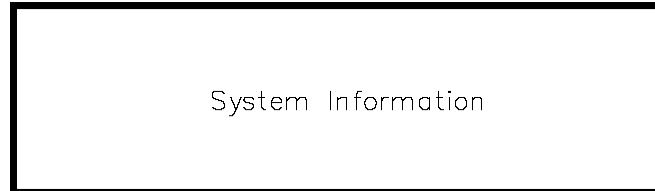
2. Press the scroll left (◀) or scroll right (▶) key until the message indicates the SYS\_INFO mode.

3. Press the ENTER key. The header shown below will be displayed.



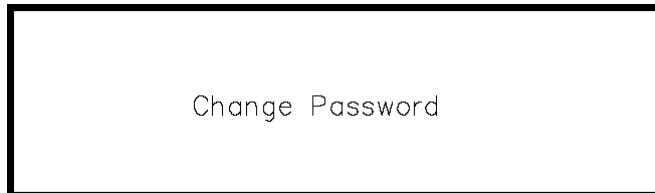
System Information

4. Use the scroll left (◀) or scroll right (▶) key to select the desired SYS\_INFO mode header. The header will display as shown below.



System Information

or



Change Password

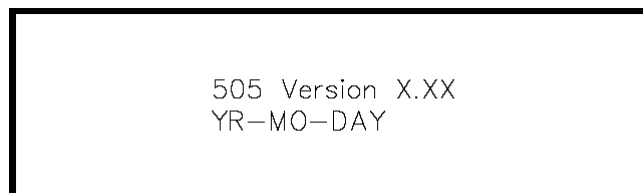
or



Download Configuration

#### System Information Header

1. While the System Information header is displaying, use the scroll down (▼) key to display the system information under it. A message will display as shown below.



505 Version X.XX  
YR-MO-DAY

This is information about the version being used.



- Continue to Press scroll down (▼) to see more system information. The messages will appear as shown below.

The Application Filename is:  
XXXXXXXX

The Hex Code date is:  
Day of Week/Month/Day/Time/Year

The CDR file date is:  
Day of Week/Month/Day/Time/Year

- From a system information message, to go back to the System Information header, press the CLEAR key.
- To go from the System Information header to the Top Level/Root display, press the CLEAR key.

### **IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

### Change Password Header

### **! WARNING**

If any password is changed and that new password is forgotten or lost, the user will be locked out of that mode or function forever. It is suggested that changed passwords be documented and kept in a secure place so that authorized personnel have access to them.

- While the Change Password header is displaying, use the scroll down (▼) key or scroll up (▲) key to enter the Change Password blocks. The following message will be displayed:

Push ENTER to change the  
Password for MMMMMMMM

(MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS\_FAULTS, or EEPROM\_DNLD)

2. Press scroll left (◀) or scroll right (▶) to see the next passworded mode or function. Push ENTER when the desired mode or function is displayed. Carefully follow the instructions displayed on the screen.
3. From a change password message, to go back to the Change Password header, press the CLEAR key.
4. To go from the Change Password header to the Top Level/Root display, press the CLEAR key again.

**IMPORTANT**

If the display is not going to be used for a while, it is a good idea to return to the Top Level/Root display and permit the system to blank the display to save power and prolong its life.

**Download Configuration Header**

*The Download function is to be used only by Woodward certified technicians.*

1. While the Download Configuration header is displaying, use the scroll down (▼) key to enter this function. A message will display as shown below.

Push ENTER to change the  
Password for MMMMMMMM

**IMPORTANT**

For password information, see Appendix D at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.


2. Enter the password on the numeric keys, then press the ENTER key. The system will display the following message.

**NOTICE**

Entry into the SYS\_INFO/Download configuration mode while the engine/turbine is running will cause an automatic shutdown of the engine/turbine with resulting process stoppage. The control will prompt "SHUTDOWN CONTROL? Y/N". Entering YES will shutdown the engine/turbine. All milliamps outputs will go to zero and all relays will de-energize. Entering NO will abort the shutdown.

SHUTDOWN CONTROL? Y/N

3. If the NO key is pressed the system will return to the Download Configuration header. If the YES key is pressed, the system will display the following message.



Ready for CNF Download  
Push CLEAR for run mode

4. Push CLEAR to abort the configuration download, else download the configuration as described in Chapter 6 under Transferring Configuration Files. Then push the CLEAR key to begin running the control with the new configuration parameters.

# Chapter 4.

## Service Mode Procedures

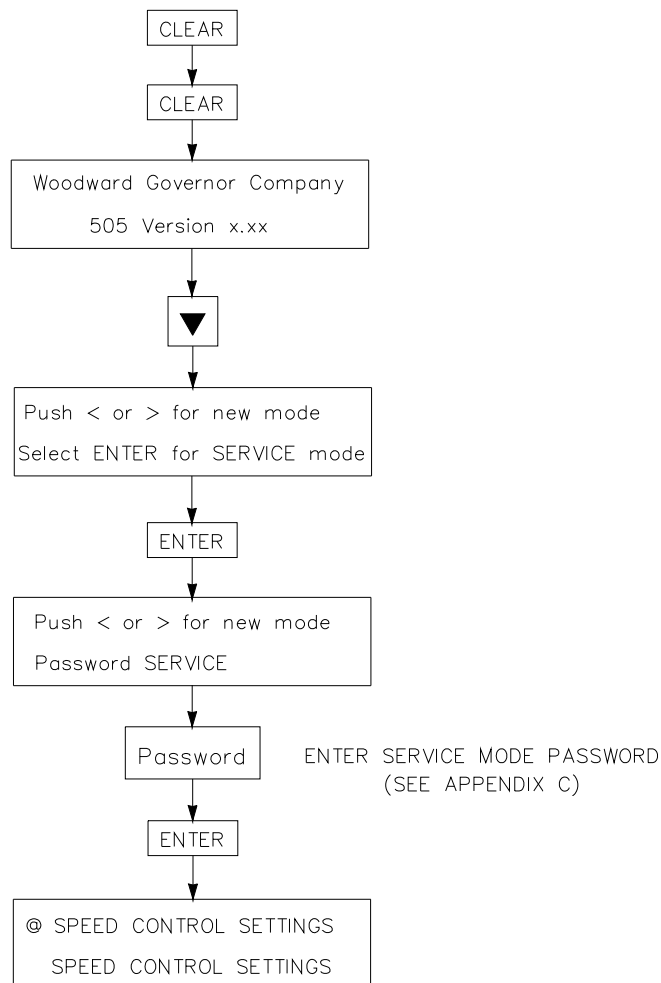
### Overview

The service mode of the 505 control has the same easy to follow format as the program mode. The service mode can be used to customize the control to be more application specific. The parameters that are tuned in the service mode may affect system performance, caution is advised.

The service mode of the 505 can be accessed at any time the control is powered up. The turbine doesn't need to be shutdown. This will allow tuning while the turbine is on-line. Figure 4-1 illustrates the steps to enter the service mode.

The service mode is password protected. The password is required to protect against both intentional and inadvertent program changes. The password can be changed if desired, refer to Appendix C of this manual for information on changing passwords.

Steps to enter the service mode:



Service mode entry completed.

850-153  
96-12-06 KDW

Figure 4-1. Service Mode Entry

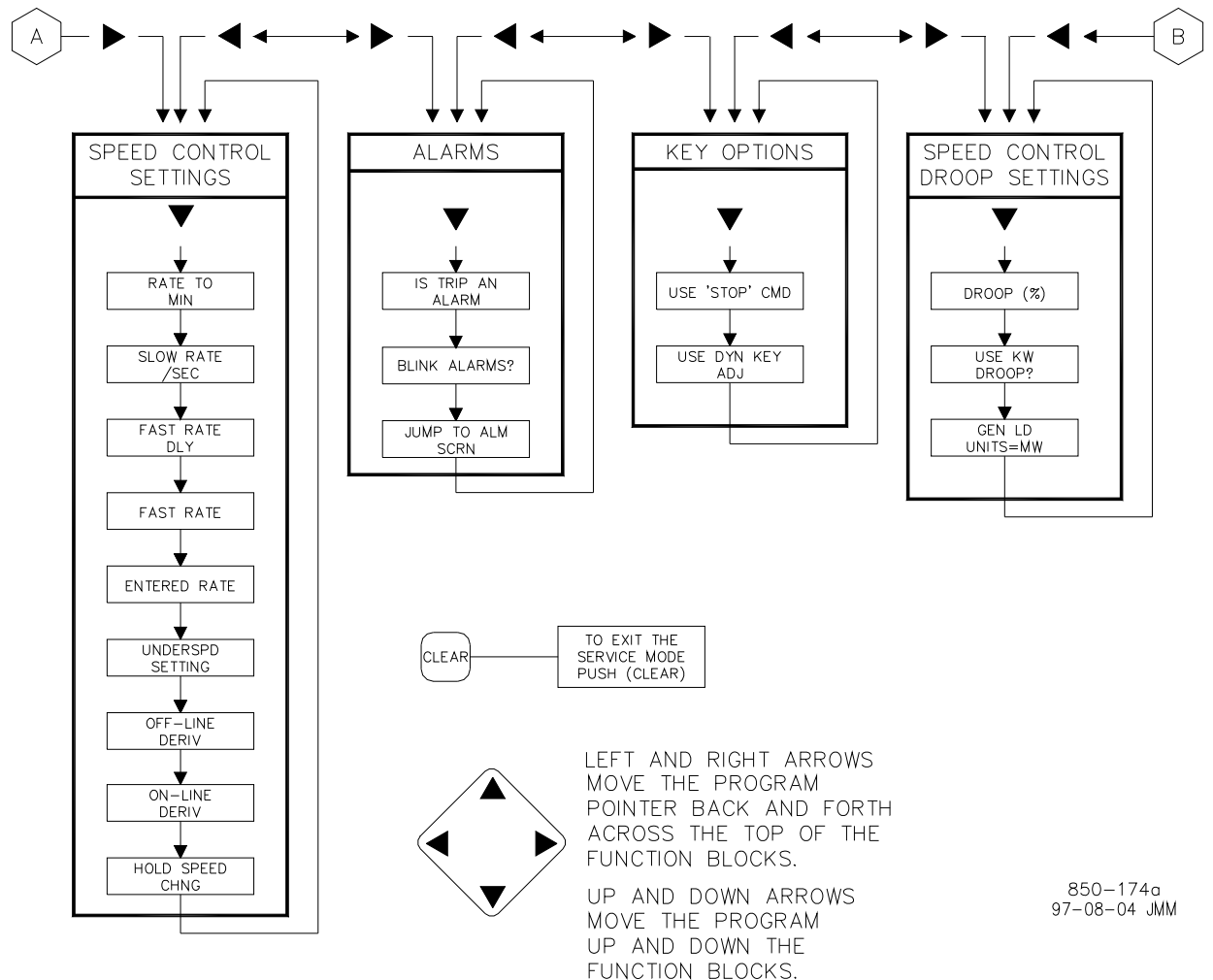
# The 505 Service Mode

## Using Service Menus

Once the Service Mode has been entered with the password, any of service value that has a \* before it can be adjusted. A work sheet is provided at the end of this manual, to document any changes for future reference. Figure 4-2 illustrates the 505 service menus and the questions/options available under each block.

The arrow keys (STEP LEFT, STEP RIGHT) allow you to move right or left across the tops of the function the Service mode columns. The STEP UP and STEP DOWN keys allow you to move up or down the columns.

Not all of the service headers listed below will appear at all times. Only the headers that are necessary for the application will appear. Some of the headers will not appear unless the turbine is shutdown.



850-174a  
97-08-04 JMM

Figure 4-2a. Service Mode Blocks

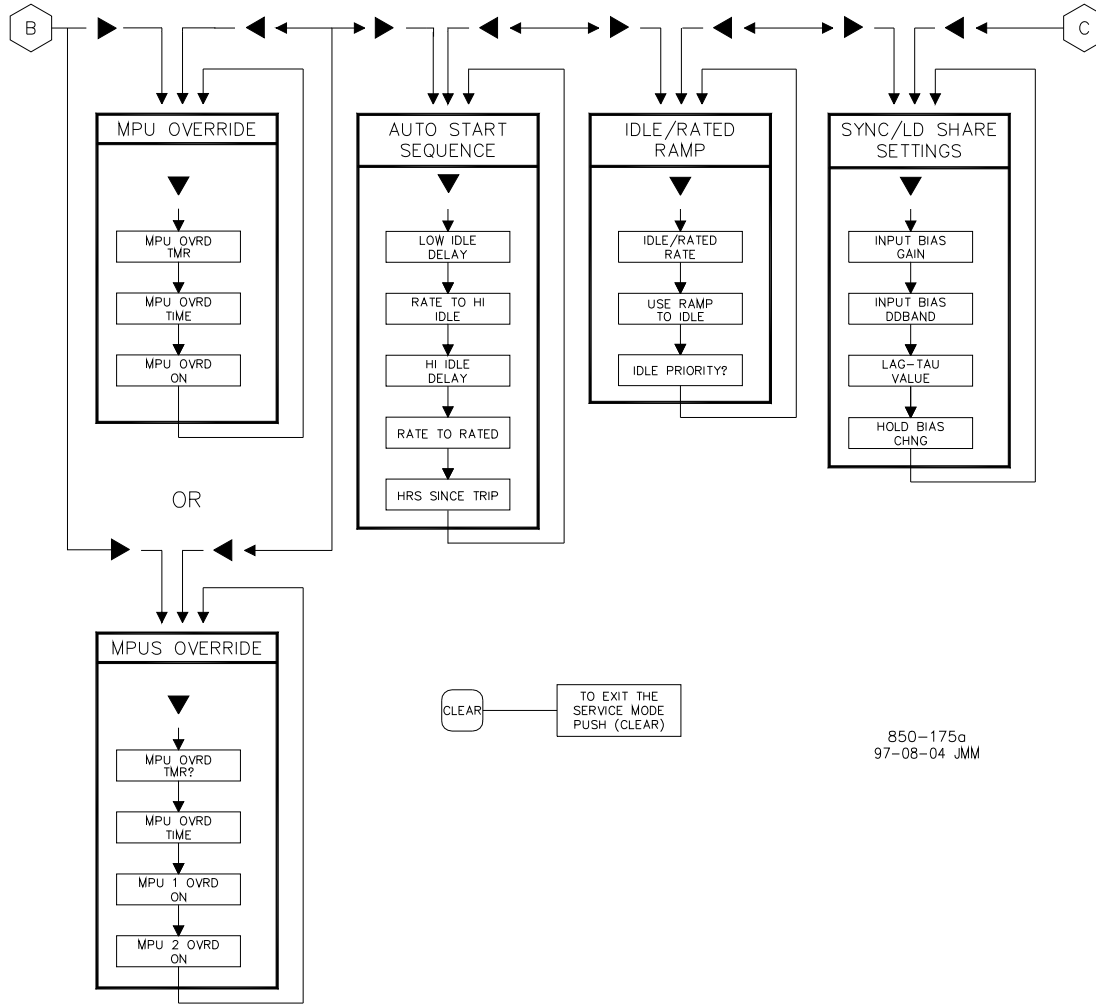


Figure 4-2b. Service Mode Blocks

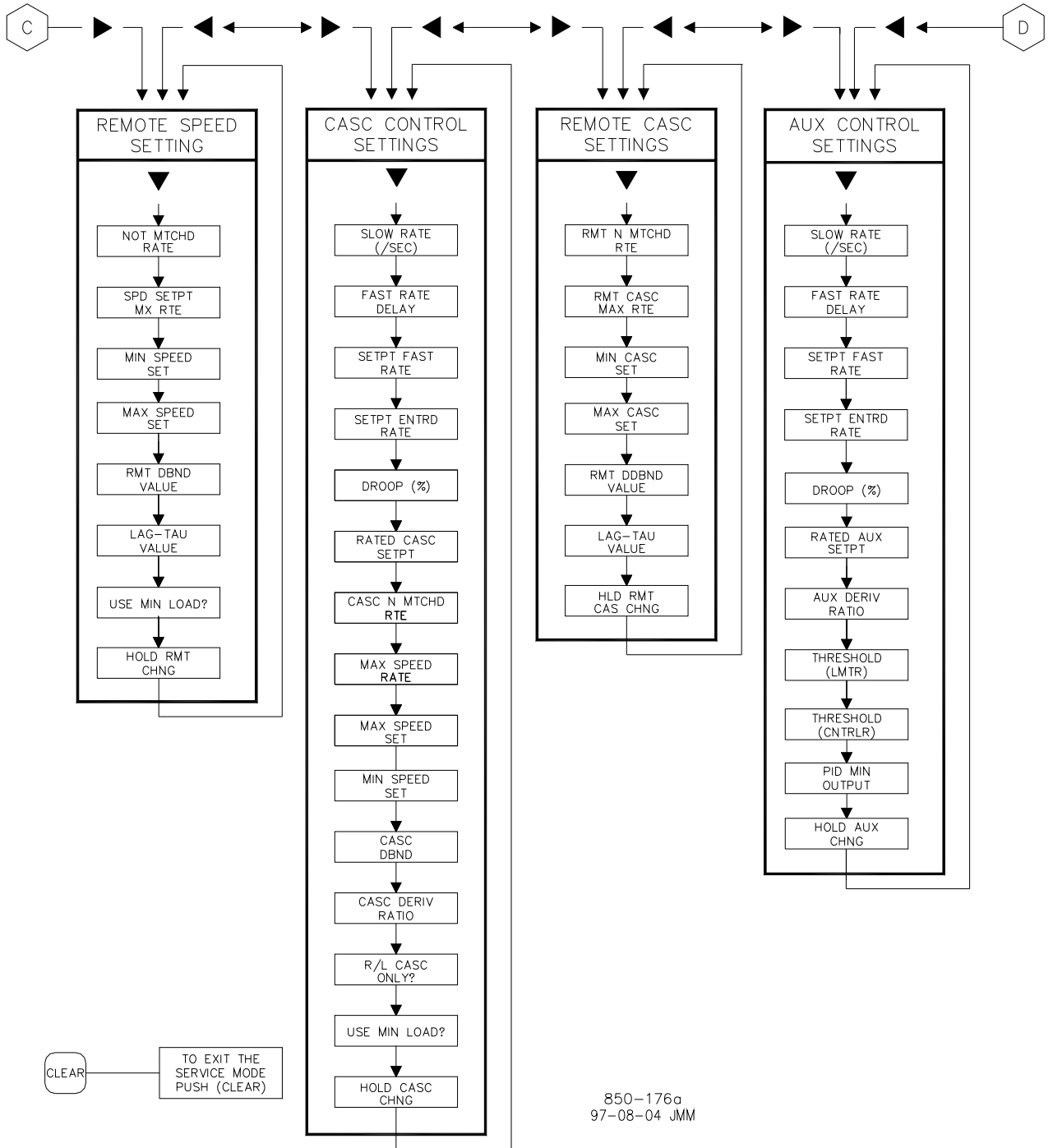


Figure 4-2c. Service Mode Blocks

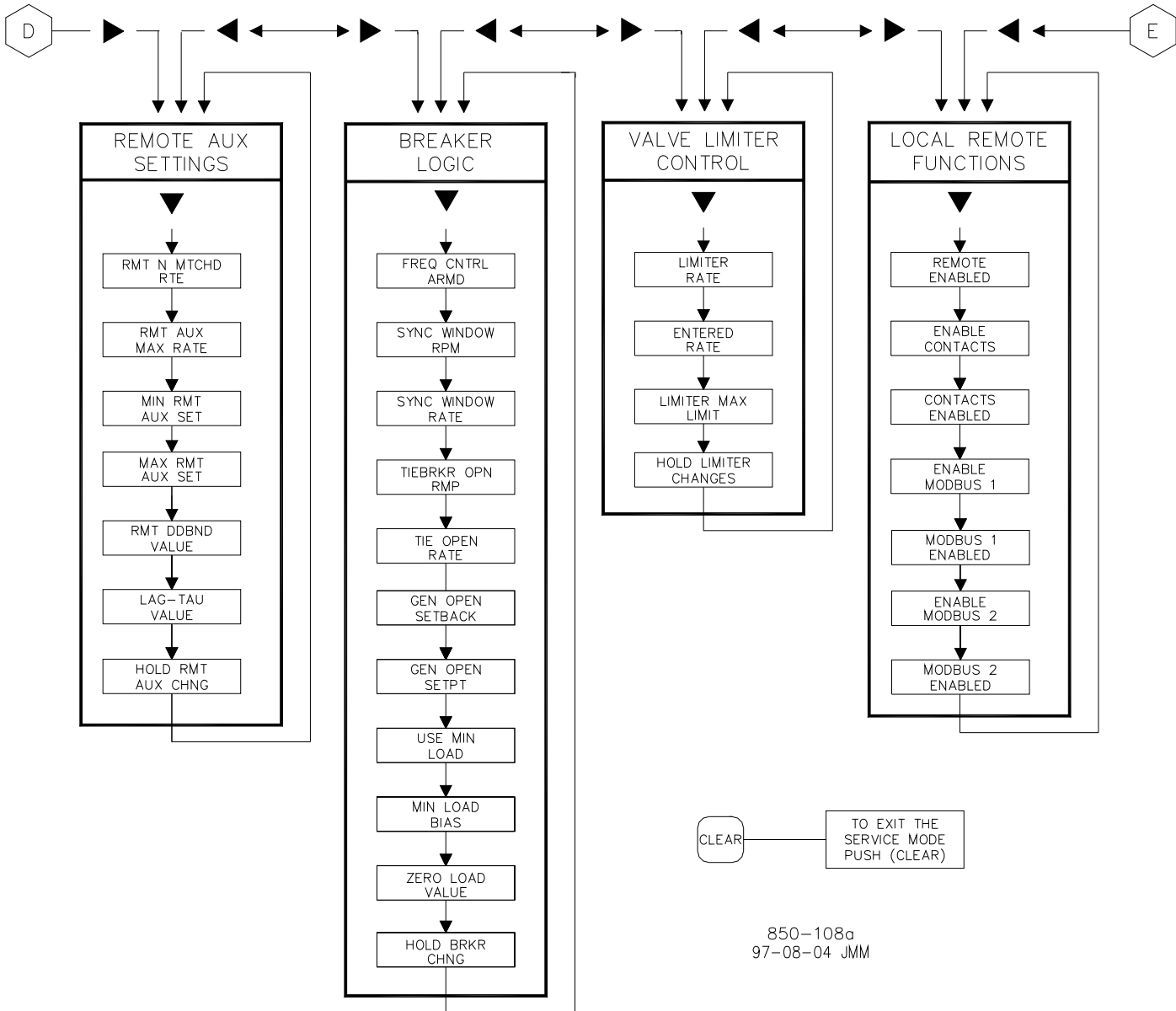


Figure 4-2d. Service Mode Blocks



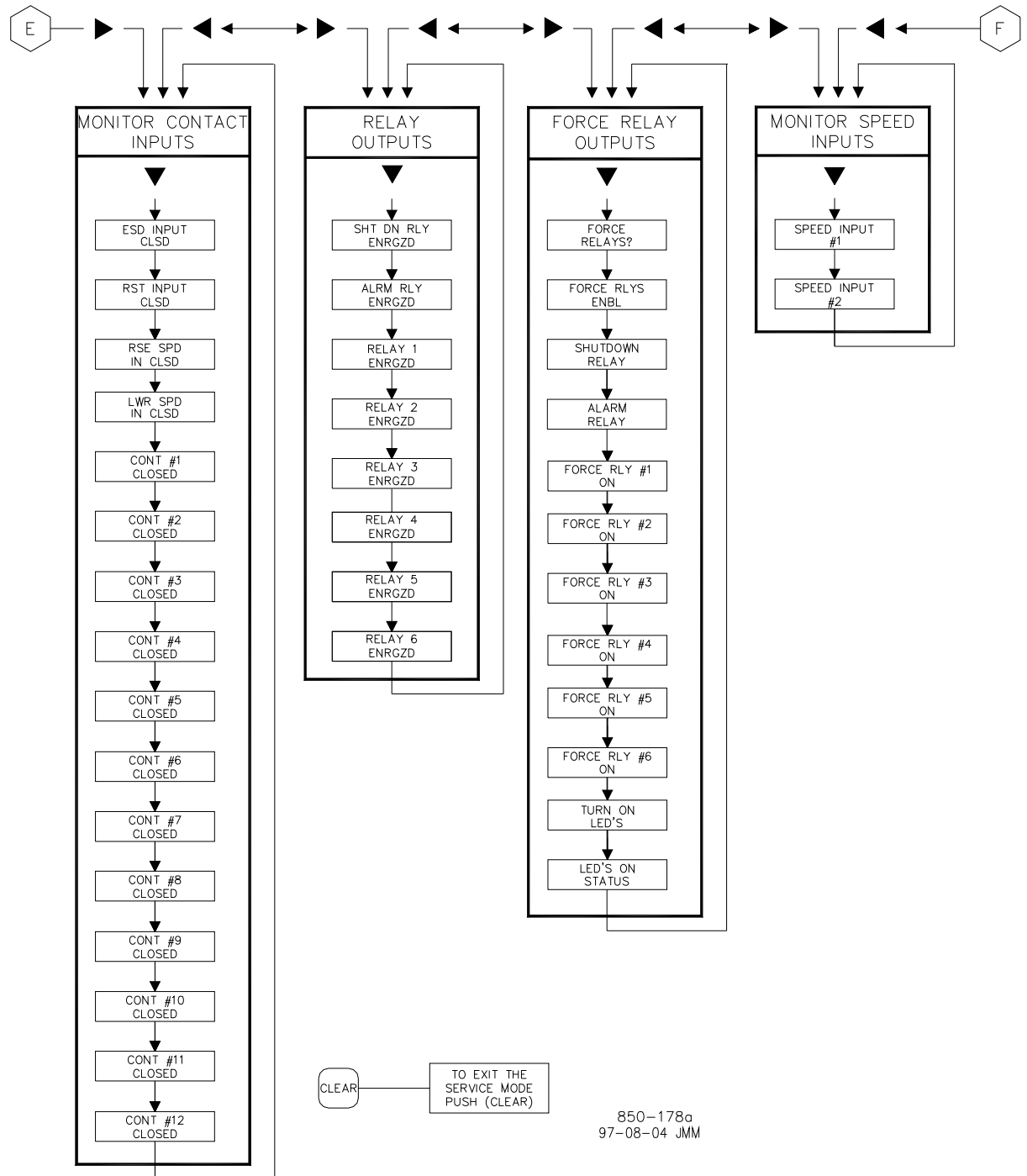


Figure 4-2e. Service Mode Blocks

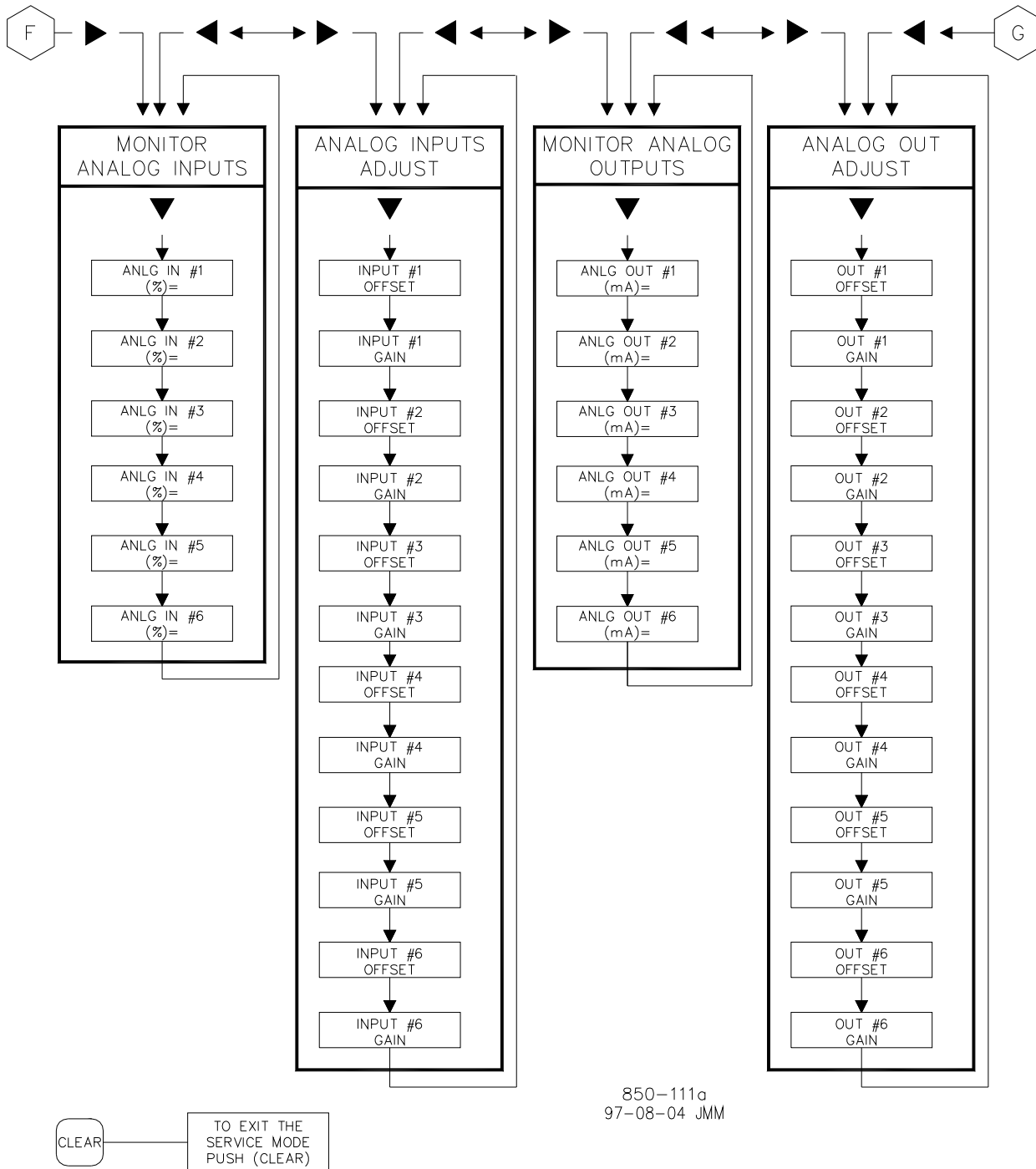
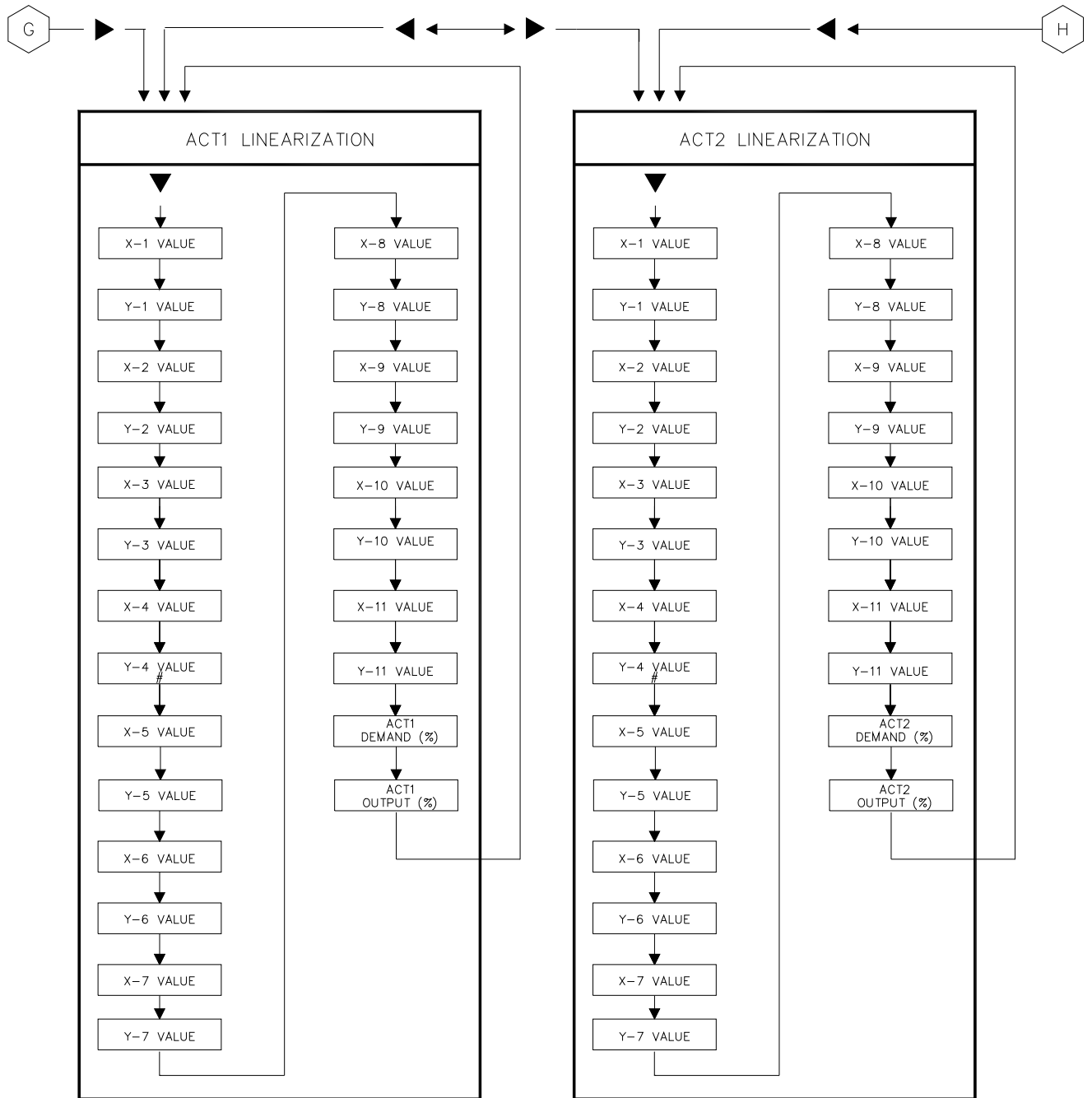


Figure 4-2f. Service Mode Blocks



850-196  
97-08-04 JMM

Figure 4-2g. Service Mode Blocks

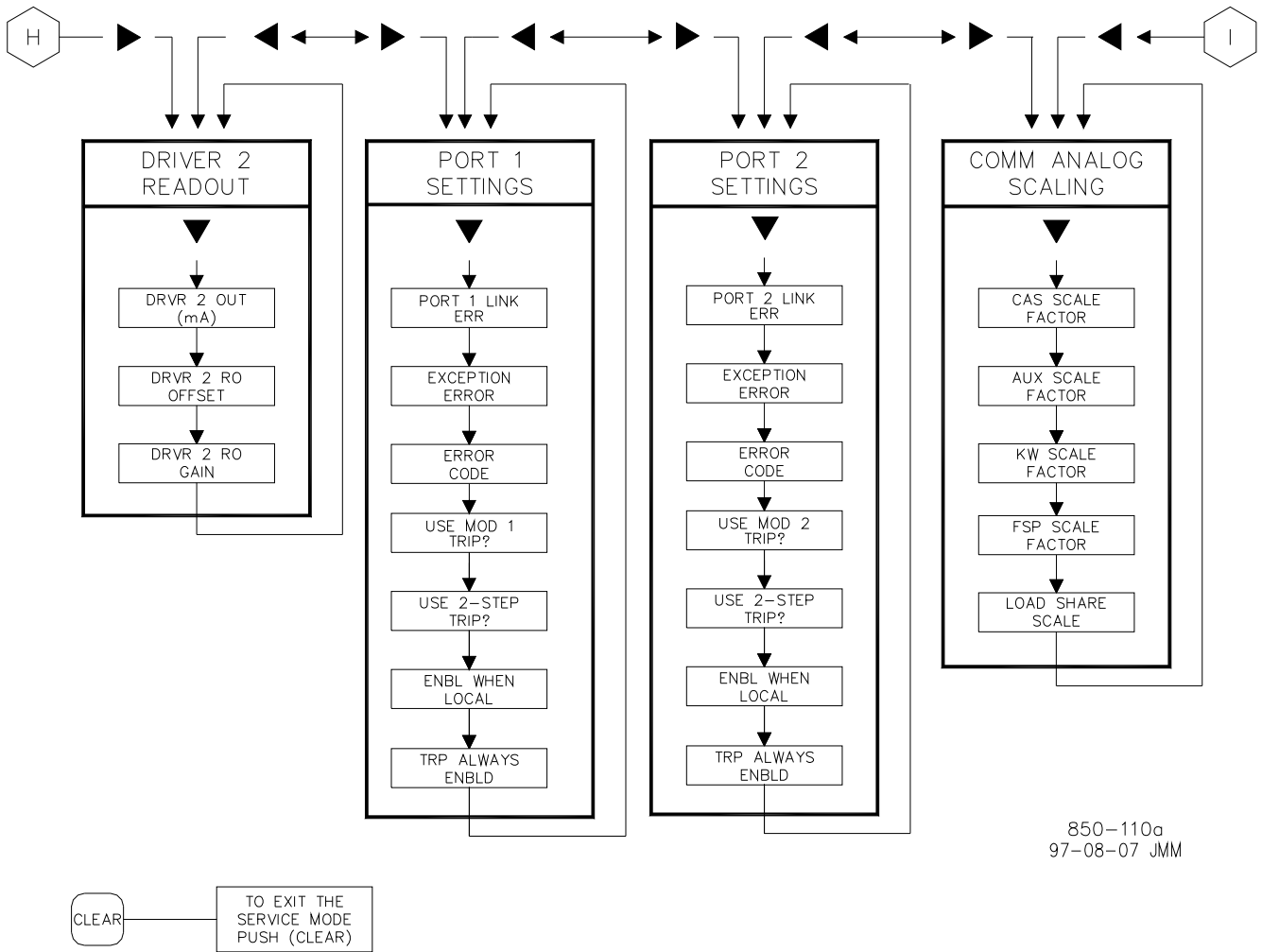


Figure 4-2h. Service Mode Blocks

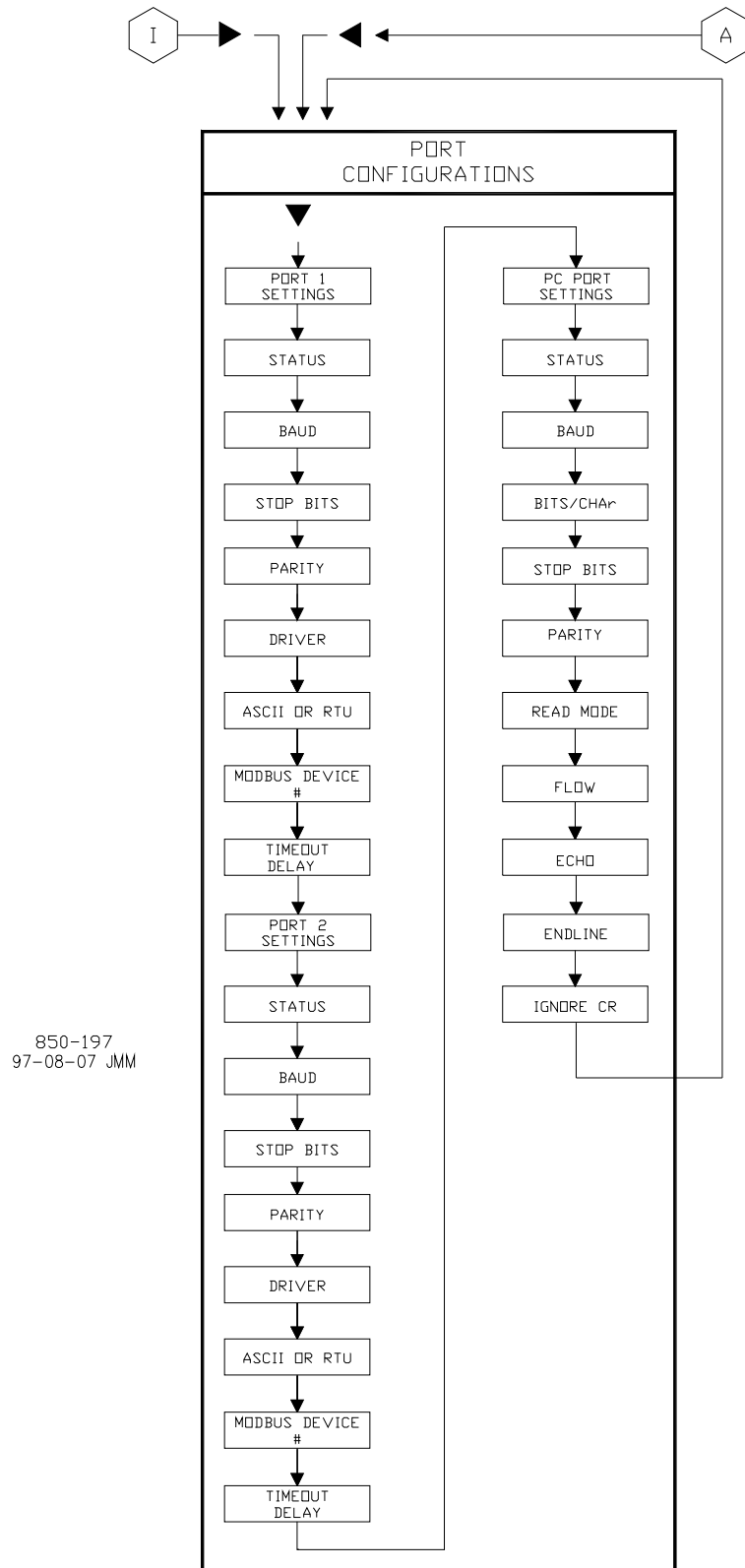


Figure 4-2i. Service Mode Blocks

## Service Mode Blocks

Figure 4-2 shows the 29 service columns/blocks. The actual blocks that appear will vary with the program configuration. To enter the Service Mode, use the procedure described above. To use the Service mode, simply step through the blocks as described above and change the control features for your application. The first twelve service columns will appear for every installation. The remaining seventeen columns contain optional features which can be selected if desired. The 29 columns and their basic functions are described in detail below.

### Service Blocks

Speed Control Settings—monitor or change the program or default settings of; rate to min; setpoint slow rate; delay for the fast rate; setpoint fast rate; speed setpoint entered rate; underspeed setting; on-line and off-line derivative;

Alarm Settings—monitor or change the program or default settings of; is trip an alarm indication; blink alarm relay; jump to alarm screen;

Key Options—allow or disable controlled stop and dynamics adjustments;

MPU Override Settings—monitor or change program or default settings of; MPU override timer; MPU override time; MPU (s) override timer is on;

Valve Limiter Settings—monitor or change program or default settings of; valve limiter rate; entered rate; limiter max limit;

Monitor Contact Inputs—monitor the status of the contact inputs;

Monitor Relay Outputs—monitor the status of the relay outputs;

Force Relay Outputs—forcing of the relays, between de-energized and energized state, when the turbine is shutdown;

Monitor Speed Inputs—monitors the speed input (s)

Monitor Analog Inputs—monitor the status of the analog inputs;

Analog Input Adjustments—offset and gain adjustments to the analog inputs;

Monitor Analog Outputs—monitor the status of the analog outputs;

Valve Linearization—provides actuator 1 and actuator 2 output linearization adjustments;

Port Configurations—change or view the default settings of baud rate, stop bits, parity, driver, communications mode, device number, time out delay for port.

### Optional Service Blocks

Speed Control Droop Settings—change the program or default settings of; droop percentage; use KW droop; select gen load units;

Auto Start Sequence Settings—monitor the status of; low idle delay; rate to hi idle; hi idle delay; rate to rated; hrs since trip;

Idle/Rated Ramp Settings—change the program or default settings of; idle rated rate; use ramp to idle; idle priority;

Sync/Load Share Settings—change the program or default settings of; input bias gain; input bias deadband; lag-tau value;

Remote Speed Settings—change the program or default settings of; not matched rate; speed setpt max rate; min speed setpt; max speed setpt; rmt deadband value; lag-tau value;

Cascade Control Settings—change the program or default settings of; slow rate; fast rate delay; setpt fast rate; setpt entered rate; droop %; rated casc setpt; casc not matched rate; max speed rate; max speed setting; min speed setting; casc deadband; casc derivative ratio;

Remote Cascade Settings—change the program or default settings of; rmt not matched rate; rmt casc max rate; min rmt casc setting; max rmt casc setting; rmt deadband value; lag-tau value;

Auxiliary Control Settings—change the program or default settings of; slow rate; fast rate delay; setpt fast rate; setpt entered rate; droop % ; rated aux setpt; aux derivative ratio; aux threshold;

Remote Auxiliary Settings—change the program or default settings of; rmt not matched rate; rmt aux max rate; min rmt aux setting; max rmt aux setting; rmt deadband value; lag-tau value;

Breaker Logic Values—change the program or default settings of; freq cntrl armed; sync window rpm; sync window rate; tiebrkr open ramp; tie open rate; gen open setback; gen open setpt; use min load; min load bias;

Local/Remote Functions—monitor or change the program or default settings of; remote ennobled; enable contacts; contacts enabled; enable Modbus 1; Modbus 1 enabled; enable Modbus 2; Modbus 2 enabled;

Driver 2 Readout—monitor the current output of actuator 2 when configured for readout; offset and gain adjustments of actuator 2 when configured for Readout;

Port 1 Settings—monitor or change the program or default settings of; port 1 link error; exception error, error code; use Modbus 1 trip; use 2-step trip; enabled when local; trip always enabled;

Port 2 Settings—monitor or change the program or default settings of; port 2 link error; exception error, error code; use Modbus 2 trip; use 2-step trip; enabled when local; trip always enabled;

Communication Analog Scaling Settings—change the default settings of; cascade scale factor; auxiliary scale factor; kW scale factor; fsp scale factor; ld shr scale factor;

Each of the service blocks are described in detail below. Figure 4-2 can be referred to for a graphical service mode block reference. Pressing the down arrow key will step through the column and back to the top of the column, use the left or right arrow keys to select the next column to change/check.

All service program questions will display on the left side of the line the @ symbol is on, all entries made will be displayed on the right side of the same line. At the beginning of each column the control will display the header, pushing the down arrow will access the column. The line the @ symbol is on will be affected, the other line of the display will not change, use the SELECT button to move the @ symbol to the other line of the display so another parameter can be displayed. This gives the operator the flexibility in the service mode to display or tune two different values by using the SELECT button .

The service blocks contain information detailing each question and/or 505 program service 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 service mode worksheet in the appendix of this manual that should be completed and filled-in and used as a guide the site specific application. This worksheet can also be used for future reference to document your application program.

## Service Mode Worksheet Parameters

### Speed Control Settings

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

- RATE TO MIN ( RPM/SEC ) dflt= xxx (0.01, 2000)  
 Adjusts the rate the setpoint moves from zero to the minimum controlling speed when the unit is started. The minimum controlling speed will be either 'idle' if idle/rated is used or 'low idle' if the auto start sequence is used. If neither of these startup features is used, the min speed will be the minimum governor speed setpoint. This value is set in the program mode.
- SETPPOINT SLOW RATE (RPM/SEC) dflt= xxx (0.01, 100)  
 Normal speed setpoint rate of change. This value is set in the program mode.
- FAST RATE DELAY (SEC) dflt= 3.0 (0, 100)  
 Delay, in seconds, before the 'Setpt Fast Rate' is selected.
- SETPPT FAST RATE (RPM/SEC) dflt= xxx (0.01, 500)  
 This rate is defaulted to three times (3x) the 'Setpoint Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- SETPPT ENTERED RATE (RPM/SEC) dflt= xxx (0.01, 100)  
 This is the rate that the Speed setpoint will move when setpoint is entered from the front panel of the control or from the communication links. This rate is defaulted to the Speed setpoint slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- UNDERSPEED SETTING (RPM) dflt= xxx (0.0, 20000)  
 Only used if an underspeed relay is programmed. Speed setting for the underspeed indication. This rate is defaulted to 100 rpm below the 'Minimum Governor Speed Setpt'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.



- ON-LINE DERIVATIVE RATIO** dflt= xxx (0.01, 100)  
 Speed PID Derivative Ratio when in on-line mode. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to  $1.0/[(\text{Deriv Ratio}) * (\text{Integral Gain})]$ . This value is set in the program mode.
- OFF-LINE DERIVATIVE RATIO** dflt= xxx (0.01, 100)  
 Speed PID Derivative Ratio when in off-line mode. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to  $1.0/[(\text{Deriv Ratio}) * (\text{Integral Gain})]$ . This value is set in the program mode.
- HOLD SPEED CHANGES ?** dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Setpoint Fast Rate, the Entered Rate, and Underspeed settings. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

## Alarm Settings

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

- IS TRIP AN ALARM ?** dflt= YES (Yes/No)  
 When set to YES, any trip condition will also be annunciated as an alarm. When NO, a trip condition will not necessarily mean an alarm will be issued.
- BLINK ALARMS ?** dflt= NO (Yes/No)  
 Set to YES if want an indication if another alarm occurs when an alarm is already present. When set to YES, the alarm relay blinks when an alarm condition occurs until a reset command is issued. If the alarm still exists, the relay will stay energized, but will stop blinking until another alarm occurs. When NO, the alarm relay indicates an alarm continuously whenever an alarm condition exists.
- JUMP TO ALARMS SCREEN ?** dflt= NO (Yes/No)  
 When set to YES, the alarm (F1) menu automatically appears on the front panel display identifying the cause of the alarm at the time of the alarm. When NO, the alarm only shows up when the F1 key is pressed. Also disables the controlling parameter message from automatically appearing when all alarms are cleared.

## Key Options

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

- USE 'STOP' COMMAND ?** dflt= YES (Yes/No)  
 When set to YES, allows the Controlled Stop command to be used. When NO, the Controlled Stop feature is disabled from front panel, Modbus, and contact commands.
- USE DYNAMICS KEY ADJUSTMENTS ?** dflt= YES (Yes/No)  
 When set to YES, allows the dynamics of all PIDs to be adjusted. When NO, the DYN (dynamics) key and PID proportional and integral gain adjustments are no longer available.

## Speed Control Droop Settings (only if generator unit)

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

- DROOP (%) dflt= xxx (0.0, 10)  
 Speed/load control droop setting. This value is set in the program mode.
- USE KW DROOP ? dflt= YES (Yes/No)  
 When set to NO, the unit is forced to use speed demand/actuator position droop. This setting is only used and relevant if KW Droop was programmed.
- GEN LOAD UNITS = MW ? dflt= NO (Yes/No)  
 When set to NO the generator load units are 'KW'. When YES the units are set to 'MW' under the KW/9 key of the 505 front panel. This allows the 505 to display load units in terms of MW as opposed to KW.

## MPU Override

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

- USE MPU OVERRIDE TIMER ? dflt= NO (Yes/No)  
 When set to YES, the MPU override will go OFF when the MPU Override Time expires after a start is initiated. This provides a maximum time for speed to be sensed on startup before a loss of speed is detected.
- MPU OVERRIDE TIME (SEC) dflt= 600.0 (00, 600)  
 Sets the maximum time after a start is initiated for speed to be sensed above the failure level. Only valid if 'Use MPU Override Timer?' is YES.
- MPU #1 OVERRIDE ON STATUS (status indication only)  
 Indicates when the speed probe failure override is on.
- MPU #2 OVERRIDE ON STATUS (status indication only)  
 Indicates when the speed probe failure override is on. This status message only appears if the application is using two speed probes.

## Auto Start Sequence (only displayed if configured)

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

The following information is provided to display the information useful to the auto start sequence. It allows the operator to check all the times and rates that the 505 is using for the present start sequence.

- LOW IDLE DELAY (MIN) (status indication only)  
 Indicates the hold time any Low Idle, in minutes.
- RATE TO HI IDLE (RPM/SEC) (status indication only)  
 Indicates the acceleration rate, in rpm/sec; used by the control from Low Idle to High Idle.
- HI IDLE DELAY (MIN) (status indication only)  
 Indicates the hold time at High Idle, in minutes.
- RATE TO RATED (RPM/SEC) (status indication only)  
 Indicates the acceleration rate, in rpm/sec; used by the control from High Idle to Rated.

HOURS SINCE TRIP (HRS) (status indication only)  
 Indicates the number of hours the unit was tripped, as determined by the control.

### Idle/Rated Ramp (only displayed if configured)

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

IDLE/RATED RATE (RPM/SEC) dflt= xxx (0.01, 2000)  
 Rate at which the speed setpoint will ramp from idle to rated speed. This value is set in the program mode.

USE RAMP TO IDLE FUNCTION? dflt= YES (Yes/No)  
 Set to YES if want to return to idle speed with this function. If set to NO, the Idle/ Rated function acts as a 'Ramp to Rated' function and will not return to idle. When set to NO, closing the Idle/Rated contact accelerates the speed setpoint towards Rated and opening the contact stops the acceleration.

IDLE PRIORITY ? dflt= NO (Yes/No)  
 If YES, the setpoint will move to Idle whenever Idle is selected. If NO, the setpoint will move to Idle only if Remote Speed Setpoint is not enabled, Cascade control is not enabled, Auxiliary 'controller' is not enabled, and the Generator Breaker is open.

### Sync/Load Share Settings (Only Displayed If Configured)

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

INPUT BIAS GAIN (%) dflt= xxx (0.0, 100)  
 Affects the RPM bias the Sync/Load Sharing input has on the speed setting. This setting is defaulted to the Droop (%) value or 3%, whichever is higher. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

INPUT BIAS DEADBAND VALUE dflt= 0.0 (0.0, 100)  
 Load Share deadband in RPM.

LAG-TAU VALUE dflt= 0.0 (0.0, 10)  
 Load Sharing input lag setting.

HOLD BIAS CHANGES ? dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Load Share Gain (%). To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

### Remote Speed Settings (only displayed if configured)

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

- NOT MATCHED RATE** dflt= xxx (0.01, 200)  
Rate the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint. This rate is defaulted to the setpoint slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- SPEED SETPT MAX RATE** dflt= xxx (0.01, 500)  
Rate the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the remote input setting. This value is set in the program mode.
- MINIMUM SPEED SETTING** dflt= xxx (0.0, 20000)  
Minimum setting allowed by the remote input. This setting is defaulted to the Speed Setpoint Minimum Governor Speed Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)*
- MAXIMUM SPEED SETTING** dflt= xxx (0.0, 20000)  
Maximum setting allowed by the remote input. This setting is defaulted to the Speed Setpoint Maximum Governor Speed Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings and greater than Minimum Speed Setting)*
- REMOTE DEADBAND VALUE** dflt= 0.0 (0.0, 100)  
Remote speed setting deadband in RPM.
- REMOTE LAG-TAU VALUE** dflt= 0.0 (0.0, 10)  
Remote Setpoint input lag setting.
- USE MIN LOAD ?** dflt= YES (Yes/No)  
When set to YES, the speed setpoint cannot be lowered/decreased by the remote speed setpoint input below the rated/synchronous speed setpoint plus the 'Min Load Bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When NO, the remote speed setpoint can move the speed setpoint down to the higher of the minimum governor setting or the RSS 4 mA value.
- HOLD RMT CHANGES ?** dflt= NO (Yes/No)  
Set to YES to permanently Hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Speed Settings. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

### **Cascade Control (only displayed if configured)**

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

- SLOW RATE (UNITS/SEC)** dflt= xxx (0.01, 1000)  
Normal setpoint rate of change. This value is set in the program mode.
- FAST RATE DELAY (SEC)** dflt= 3.0 (0.0, 100)  
Delay, in seconds, before the 'Setpt Fast Rate' is selected.

- SETPT FAST RATE (UNITS/SEC) dflt= xxx (0.01, 5000)  
 This rate is defaulted to three times (3x) the setpoint 'Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- SETPT ENTERED RATE (UNITS/SEC) dflt= xxx (0.01, 1000)  
 This is the rate that the Cascade setpoint will move when setpoint is entered from the front panel of the control or from the communication links. This rate is defaulted to the Cascade setpoint slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- DROOP (%) dflt= xxx (0.0, 100)  
 Cascade control droop setting. This value is set in the program mode.
- RATED CASC SETPT dflt= xxx (-20000, 20000)  
 This setting is only used to determine the cascade control droop. This setpoint is defaulted to the cascade maximum setpoint limit. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Cascade Setpoint' and the 'Maximum Cascade Setpoint' settings)*
- CASC NOT MATCHED RATE dflt= xxx (0.01, 1000)  
 This rate is defaulted to the 'Speed Setpoint Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- MAX SPEED SETPT RATE dflt= xxx (0.1, 100)  
 The maximum rate at which the cascade control can vary the speed setpoint. This value is set in the program mode.
- MAXIMUM SPEED SETTING dflt= xxx (0.0, 20000)  
 This setting is defaulted to the maximum speed setpoint value set in the program mode. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)*
- MINIMUM SPEED SETTING dflt= xxx (0.0, 20000)  
 This setting is defaulted to the minimum speed setpoint value set in the program mode. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Governor Speed' and the 'Maximum Governor Speed' settings)*
- CASC PID INT DEADBAND dflt= 0.1 (0.0, 50)  
 Cascade PID controller integrator deadband setting in percent.
- CASC PID DERIV RATIO dflt= xxx (0.01, 100)  
 Cascade PID controller derivative ratio setting. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to 1.0/[(Deriv Ratio)\*(Integral Gain)]. This value is set in the program mode.
- RAISE /LOWER CASCADE SETPOINT ONLY ? dflt= NO (Yes/No)  
 When set to NO, the cascade raise/lower commands will adjust the speed setpoint when cascade control is disabled and adjust the cascade setpoint when cascade control is enabled. When YES, the cascade raise/lower commands adjust the cascade setpoint only.

- USE MIN LOAD ? dflt= YES (Yes/No)  
 When set to YES, the speed setpoint cannot be lowered/decreased by the cascade control PID below the rated/synchronous speed setpoint plus the 'min load bias' setting. This is used to prevent a reverse power condition as well as allowing the plant to utilize a minimum load setting for the generator. When NO, the cascade control PID can move the speed setpoint down to the cascade minimum speed setting value.
- HOLD CASC CHANGES ? dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Fast Rate, Entered Rate, Rated Setpt, Casc Not Matched Rate, Maximum Speed Setting and Minimum Speed Setting. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

### Remote Casc Settings (only displayed if configured)

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

- REMOTE NOT MATCHED RATE dflt= xxx (0.01, 1000)  
 Rate the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint. This rate is defaulted to the 'Cascade Setpoint Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- RMT CASC SETPT MAX RATE dflt= xxx (0.01, 1000)  
 Rate the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the remote cascade input setting. This rate is set in the Program Mode.
- MINIMUM CASC SETTING dflt= xxx (-20000, 20000)  
 Minimum setting allowed by the remote input. This setting is defaulted to the Minimum Cascade Setpoint Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Cascade Setpoint' and the 'Maximum Cascade Setpoint' settings)*
- MAXIMUM CASC SETTING dflt= xxx (-20000, 20000)  
 Maximum setting allowed by the remote input. This setting is defaulted to the Maximum Cascade Setpoint Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Cascade Setpoint' and the 'Maximum Cascade Setpoint' settings)*
- REMOTE DEADBAND VALUE dflt= 0.0 (0.0, 500)  
 Remote cascade setting input deadband in engineering units.
- REMOTE LAG-TAU VALUE dflt= 0.0 (0.0, 10)  
 Remote Setpoint input lag setting.
- HOLD RMT CASC CHANGES ? dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Casc Settings. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.



## Aux Control Settings (only displayed if configured)

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

SLOW RATE (UNITS/SEC) dflt= xxx (0.01, 1000)

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

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

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

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

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

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

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

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

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

RATED AUX SETPT dflt= xxx (-20000, 20000)

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

*(Must be between the 'Minimum Auxiliary Setpoint' and the 'Maximum Auxiliary Setpoint' settings)*

AUX PID DERIV RATIO dflt= 100 (0.01, 100)

Aux PID controller derivative ratio setting. When this value is between 0.01 and 1.0, the derivative term is considered to be 'input dominant' and the derivative is equal to (Deriv Ratio)/(Integral Gain). When this value is between 1.0 and 100, the derivative term is considered to be 'feedback dominant' and the derivative is equal to 1.0/ [(Deriv Ratio)\*(Integral Gain)]. This value is set in the program mode.

AUX PID THRESHOLD (LIMITER) dflt= 100 (0.0, 110)

Aux PID threshold setting when aux is used as a limiter.

AUX PID THRESHOLD (CONTROLLER) dflt= 10 (0.0, 110)

Aux PID threshold setting when aux is used as a controller.

AUX PID MIN OUTPUT dflt= 0.00 (0.0, 50)

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

HOLD AUX CHANGES ? dflt= NO (Yes/No)

Set to YES to permanently Hold the changes made to the Setpoint Fast Rate, Entered Rate, and Rated Aux Setpoint. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

## Remote Aux Settings (only displayed if configured)

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

- REMOTE NOT MATCHED RATE dflt= xxx (0.01, 1000)  
 Rate the setpoint moves when remote is enabled and the remote input doesn't match the actual setpoint. This rate is defaulted to the 'Aux Setpoint Slow Rate'. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.
- RMT AUX SETPT MAX RATE dflt= xxx (0.01, 1000)  
 Rate the setpoint moves once the remote input and actual setpoint are matched. This is a maximum rate. Normally the setpoint will follow the remote input setting. This value is set in the program mode.
- MINIMUM AUX SETTING dflt= xxx (-20000, 20000)  
 Minimum setting allowed by the remote input. This setting is defaulted to the Aux Setpoint Minimum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Auxiliary Setpoint' and the 'Maximum Auxiliary Setpoint' settings)*
- MAXIMUM AUX SETTING dflt= xxx (-20000, 20000)  
 Maximum setting allowed by the remote input. This setting is defaulted to the Aux Setpoint Maximum Value. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Auxiliary Setpoint' and the 'Maximum Auxiliary Setpoint' settings)*
- REMOTE DEADBAND VALUE dflt= 0.0 (0.0, 500)  
 Remote aux setting input deadband in engineering units.
- REMOTE LAG-TAU VALUE dflt= 0.0 (0.0, 10)  
 Remote Setpoint input lag setting.
- HOLD RMT AUX CHANGES ? dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Remote Not Matched Rate and the Maximum and Minimum Aux Settings. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

## Breaker Logic (only displayed if a generator)

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

- FREQ CONTROL ARMED (status indication only)  
 SYNC WINDOW (RPM) dflt= 10.0 (0.0, 200)  
 A setpoint window, in rpm, that the setpoint moves at a slower rate to accommodate synchronizing to the bus. This rate is only active while within this window and the generator breaker is open.
- SYNC WINDOW RATE (RPM/SEC) dflt= 2.0 (0.1, 100)  
 The rate the speed setpoint moves at when within the 'Sync Window' and the generator breaker is open. This is normally slower than the slow rate to accommodate synchronizing to the bus.



- TIEBRKR OPEN SYNC RAMP ? dflt= YES (Yes/No)  
 If NO, the speed setpoint is instantly set to the last utility bus speed setting and holds. When set to YES, the speed setpoint is instantly set to the last utility bus speed setting and moves to the synchronous (rated) speed setpoint after the utility tie breaker opens and the generator breaker is still closed.
- TIEBRKR OPEN RATE (RPM/SEC) dflt= 1.0 (0.1, 20000)  
 Rate the setpoint moves to rated speed after the utility tie breaker opens (only used if 'Tiebrkr Open Sync Ramp' is YES).
- GEN BRKR OPEN SETBACK ? dflt= YES (Yes/No)  
 When set to YES, the speed setpoint is instantly set to the 'Gen Breaker Open Setpt' when the generator breaker opens.
- GEN BRKR OPEN SETPT (RPM) dflt= xxx (0.0, 20000)  
 This setpoint is defaulted to 50 rpm below the synchronous (rated) speed setpoint (only used if 'Gen Breaker Open Setback' is YES). This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.  
*(Must be between the 'Minimum Governor' and 'Rated Speed Setpt' settings)*
- USE MIN LOAD ? dflt= YES (Yes/No)  
 When set to YES, the speed setpoint automatically increases to the rated/synchronous speed setpoint plus the 'Min Load Bias' setting when the generator breaker is closed and the unit is on-line (the utility tie breaker is closed). When NO, no automatic setpoint action occurs.
- MIN LOAD BIAS (RPM) dflt= xxx (0.0, 500)  
 This value is the rpm bias above rated speed and the default is calculated as 3% of full load. This is the value the speed setpoint will increase to upon the generator breaker closure (when the utility tie is closed).
- ZERO LOAD VALUE (%) dflt= xxx (0.0, 100)  
 This value is automatically sampled and held at the actuator/load demand value when the generator breaker is closed. When the steam conditions are not at rated conditions when the breaker is closed, this value can be adjusted to a more reasonable value (2–10%). Every time the generator breaker closes, this value is re-sampled.
- HOLD BREAKER CHANGES ? dflt= NO (Yes/No)  
 Set to YES to permanently Hold the changes made to the Gen Breaker Open Setpoint and Min Load Bias. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

## Valve Limiter

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

- LIMITER RATE (%/SEC) dflt= xxx (0.1, 25)  
 The rate at which the valve limiter will move when a raise or lower command is given from the contact inputs or the Modbus connections. This rate is set in the program mode.
- LIMITER ENTERED RATE (%/SEC) dflt= xxx (0.1, 100)  
 This is the rate the valve limiter will move at when a new position is entered from the front panel of the control. This rate is defaulted to the slow rate. This value can be changed to a new value, however, the HOLD CHANGES prompt must be set to YES to retain the change. If not, the value will return to the default on the next initialization.

- LIMITER MAX LIMIT (%) dflt= 100.0 (0, 101)  
 Valve Limiter Maximum setting. Normally set to 100%, but this can be set lower to provide a maximum valve lift setting.
- HOLD LIMITER CHANGES ? dflt= NO (Yes/No)  
 Set to YES to Hold the changes made to the Entered Rate. To permanently save these changes into the 505, set to YES and select the 'CLEAR' key twice.

### Local/Remote Functions (only displayed if configured)

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

Normally the Local/Remote function will disable all inputs except the front panel commands when Local is selected. The following questions can customize this feature by allowing the Contacts, Modbus 1, and/or Modbus 2 to be active also when local is selected.

- REMOTE MODE ENABLED ? (status indication only)  
 Indicates when the Remote mode is enabled. When the indication is NO, remote control is disabled and local control only is selected.
- ENABLE CONTACTS ? dflt= NO (Yes/No)  
 When set to YES, the contacts are always active regardless of the Local/Remote selection. When set to NO, the contact inputs are disabled when the local mode is selected.
- CONTACTS ENABLED ? (status indication only)  
 Indicates the status of the Contact input commands. When the indication is NO, local control is selected and remote control from the contact inputs is disabled.
- ENABLE MODBUS 1 ? dflt= NO (Yes/No)  
 When set to YES, the Modbus #1 commands are always active regardless of the Local/Remote selection. When set to NO, the Modbus #1 commands are disabled when the local mode is selected.
- MODBUS 1 ENABLED ? (status indication only)  
 Indicates the status of the Modbus #1 commands. When the indication is NO, local control is selected and remote control from the Modbus #1 inputs is disabled.
- ENABLE MODBUS 2 ? dflt= NO (Yes/No)  
 When set to YES, the Modbus #2 commands are always active regardless of the Local/Remote selection. When set to NO, the Modbus #2 commands are disabled when the local mode is selected.
- MODBUS 2 ENABLED ? (status indication only)  
 Indicates the status of the Modbus #2 commands. When the indication is NO, local control is selected and remote control from the Modbus #2 inputs is disabled.

### Monitor Contact Inputs

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

This block monitors the status of the contact input and can be used when troubleshooting or for initial wiring checkout procedures. Normally will be closed or YES unless the unit is tripped and then it will be open or NO.

EMERGENCY SHUTDOWN CLOSED ?	(status indication only)
RESET INPUT CLOSED ?	(status indication only)
RAISE SPEED INPUT CLOSED ?	(status indication only)
LOWER SPEED INPUT CLOSED ?	(status indication only)
CONT IN #1 CLOSED ?	(status indication only)
CONT IN #2 CLOSED ?	(status indication only)
CONT IN #3 CLOSED ?	(status indication only)
CONT IN #4 CLOSED ?	(status indication only)
CONT IN #5 CLOSED ?	(status indication only)
CONT IN #6 CLOSED ?	(status indication only)
CONT IN #7 CLOSED ?	(status indication only)
CONT IN #8 CLOSED ?	(status indication only)
CONT IN #9 CLOSED ?	(status indication only)
CONT IN #10 CLOSED ?	(status indication only)
CONT IN #11 CLOSED ?	(status indication only)
CONT IN #12 CLOSED ?	(status indication only)

### Monitor Relay Outputs

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

SHUTDOWN RELAY ENERGIZED ?	(status indication only)
This block monitors the status of the relay output command and can be used when troubleshooting or for initial wiring checkout procedures when used with the 'Force Relay Outputs' function in the Service Mode. Normally will be energized or YES unless there is a shutdown condition and then it will be de-energized or NO.	
ALARM RELAY ENERGIZED ?	(status indication only)
This block monitors the status of the relay output command and can be used when troubleshooting or for initial wiring checkout procedures when used with the 'Force Relay Outputs' function in the Service Mode. Normally will be de-energized or NO unless there is an alarm condition and then it will be energized or YES.	
RELAY 1 ENERGIZED ?	(status indication only)
This block monitors the status of the relay output command and can be used when troubleshooting or for initial wiring checkout procedures when used with the 'Force Relay Outputs' function in the Service Mode. Normally will be de-energized or NO unless the relay function is issued and then it will be energized or YES.	
RELAY 2 ENERGIZED ?	(status indication only)
RELAY 3 ENERGIZED ?	(status indication only)
RELAY 4 ENERGIZED ?	(status indication only)
RELAY 5 ENERGIZED ?	(status indication only)
RELAY 6 ENERGIZED ?	(status indication only)

### Force Relay Outputs (only displayed if shut down)

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

FORCE RELAYS ?	dflt= NO (Yes/No)
Set to YES to allow testing of the relay outputs or associated external logic. Only active if the 'Force Relays Enabled' value is true (next display value- below). To be active, the unit must be shut down and the turbine speed less than 1000 rpm.	
FORCE RELAYS ENABLED ?	(status indication only)
FORCE SHUTDOWN RELAY ON ?	dflt= NO (Yes/No)
FORCE ALARM RELAY ON ?	dflt= NO (Yes/No)
FORCE RELAY #1 ON ?	dflt= NO (Yes/No)
FORCE RELAY #2 ON ?	dflt= NO (Yes/No)
FORCE RELAY #3 ON ?	dflt= NO (Yes/No)
FORCE RELAY #4 ON ?	dflt= NO (Yes/No)
FORCE RELAY #5 ON ?	dflt= NO (Yes/No)
FORCE RELAY #6 ON ?	dflt= NO (Yes/No)
TURN ON LEDs ?	dflt= NO (Yes/No)
When set to YES, turns on all front-panel LEDs to test them.	
LED ON STATUS ?	(status indication only)

### Monitor Speed Inputs

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

Used to monitor the speed inputs. The input is shown in RPM.

SPEED INPUT #1 =	(status indication only)
SPEED INPUT #2 =	(status indication only)

### Monitor Analog Inputs

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

Used to monitor the analog input. The input is shown in percent (%).

ANALOG IN #1 =	(status indication only)
ANALOG IN #2 =	(status indication only)
ANALOG IN #3 =	(status indication only)
ANALOG IN #4 =	(status indication only)
ANALOG IN #5 =	(status indication only)
ANALOG IN #6 =	(status indication only)

### Analog In Adjustments

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

Used to adjust the analog input. The offset units are in percent (%).

INPUT #1 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #1 GAIN?	dflt= 1.0 (0.00, 2.0)
INPUT #2 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #2 GAIN?	dflt= 1.0 (0.00, 2.0)
INPUT #3 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #3 GAIN?	dflt= 1.0 (0.00, 2.0)
INPUT #4 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #4 GAIN?	dflt= 1.0 (0.00, 2.0)
INPUT #5 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #5 GAIN?	dflt= 1.0 (0.00, 2.0)
INPUT #6 OFFSET?	dflt= 0.0 (-20, 20)
INPUT #6 GAIN?	dflt= 1.0 (0.00, 2.0)

## Monitor Analog Outputs

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

Indication of the milliamp signal demanded by the control. This is not actual milliamps.

ANALOG OUT #1 Demand (mA) =	(status indication only)
ANALOG OUT #2 Demand (mA) =	(status indication only)
ANALOG OUT #3 Demand (mA) =	(status indication only)
ANALOG OUT #4 Demand (mA) =	(status indication only)
ANALOG OUT #5 Demand (mA) =	(status indication only)
ANALOG OUT #6 Demand (mA) =	(status indication only)

## Analog Output Adjustments

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

Used to adjust the analog output. The offset units are milliamps (mA).

OUTPUT #1 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #1 GAIN?	dflt= 1.0 (0.00, 2.0)
OUTPUT #2 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #2 GAIN?	dflt= 1.0 (0.00, 2.0)
OUTPUT #3 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #3 GAIN?	dflt= 1.0 (0.00, 2.0)
OUTPUT #4 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #4 GAIN?	dflt= 1.0 (0.00, 2.0)
OUTPUT #5 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #5 GAIN?	dflt= 1.0 (0.00, 2.0)
OUTPUT #6 OFFSET?	dflt= 0.0 (-20, 20)
OUTPUT #6 GAIN?	dflt= 1.0 (0.00, 2.0)

## Act1 Linearization

When this header appears in the display, press the down arrow key to view or change this block or press the left or right arrow key to select another block to change. The actuator linearization settings can be checked or verified by using the actuator stroke feature when the unit is shut down.

X-1 VALUE	dflt= 0.0 (-5, 110)
Input point #1 of the actuator linearization curve, in percentage. ( <i>Must be less than the 'X-2 Value'</i> )	
Y-1 VALUE	dflt= 0.0 (-5, 110)
Output point #1 of the actuator linearization curve, in percentage.	
X-2 VALUE	dflt= 10.0 (-5, 110)
Input point #2 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-1 Value' and the 'X-3 Value' settings</i> )	
Y-2 VALUE	dflt= 10.0 (-5, 110)
Output point #2 of the actuator linearization curve, in percentage.	
X-3 VALUE	dflt= 20.0 (-5, 110)
Input point #3 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-2 Value' and the 'X-4 Value' settings</i> )	
Y-3 VALUE	dflt= 20.0 (-5, 110)
Output point #3 of the actuator linearization curve, in percentage.	
X-4 VALUE	dflt= 30.0 (-5, 110)
Input point #4 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-3 Value' and the 'X-5 Value' settings</i> )	
Y-4 VALUE	dflt= 30.0 (-5, 110)
Output point #4 of the actuator linearization curve, in percentage.	
X-5 VALUE	dflt= 40.0 (-5, 110)
Input point #5 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-4 Value' and the 'X-6 Value' settings</i> )	
Y-5 VALUE	dflt= 40.0 (-5, 110)
Output point #5 of the actuator linearization curve, in percentage.	
X-6 VALUE	dflt= 50.0 (-5, 110)
Input point #6 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-5 Value' and the 'X-7 Value' settings</i> )	
Y-6 VALUE	dflt= 50.0 (-5, 110)
Output point #6 of the actuator linearization curve, in percentage.	
X-7 VALUE	dflt= 60.0 (-5, 110)
Input point #7 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-6 Value' and the 'X-8 Value' settings</i> )	
Y-7 VALUE	dflt= 60.0 (-5, 110)
Output point #7 of the actuator linearization curve, in percentage.	
X-8 VALUE	dflt= 70.0 (-5, 110)
Input point #8 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-7 Value' and the 'X-9 Value' settings</i> )	
Y-8 VALUE	dflt= 70.0 (-5, 110)
Output point #8 of the actuator linearization curve, in percentage.	
X-9 VALUE	dflt= 80.0 (-5, 110)
Input point #9 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-8 Value' and the 'X-10 Value' settings</i> )	
Y-9 VALUE	dflt= 80.0 (-5, 110)
Output point #9 of the actuator linearization curve, in percentage.	
X-10 VALUE	dflt= 90.0 (-5, 110)
Input point #10 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-9 Value' and the 'X-11 Value' settings</i> )	
Y-10 VALUE	dflt= 90.0 (-5, 110)
Output point #10 of the actuator linearization curve, in percentage.	

X-11 VALUE	dflt= 100.0 (-5, 110)
Input point #11 of the actuator linearization curve, in percentage. ( <i>Must be greater than the 'X-10 Value'</i> )	
Y-11 VALUE	dflt= 100.0 (-5, 110)
Output point #11 of the actuator linearization curve, in percentage.	
ACT1 DEMAND (%) =	(status indication only)
Displays the actuator demand (%) before the linearization curve.	
ACT1 OUTPUT (%) =	(status indication only)
Displays the actuator demand (%) after the linearization curve.	

## ACT2 Linearization

When this header appears in the display, press the down arrow key to view or change this block or press the left or right arrow key to select another block to change. The actuator linearization settings can be checked or verified by using the actuator stroke feature when the unit is shut down.

X-1 VALUE	dflt= 0.0 (-5, 110)
Input point #1 of the actuator linearization curve, in percentage. ( <i>Must be less than the 'X-2 Value'</i> )	
Y-1 VALUE	dflt= 0.0 (-5, 110)
Output point #1 of the actuator linearization curve, in percentage.	
X-2 VALUE	dflt= 10.0 (-5, 110)
Input point #2 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-1 Value' and the 'X-3 Value' settings</i> )	
Y-2 VALUE	dflt= 10.0 (-5, 110)
Output point #2 of the actuator linearization curve, in percentage.	
X-3 VALUE	dflt= 20.0 (-5, 110)
Input point #3 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-2 Value' and the 'X-4 Value' settings</i> )	
Y-3 VALUE	dflt= 20.0 (-5, 110)
Output point #3 of the actuator linearization curve, in percentage.	
X-4 VALUE	dflt= 30.0 (-5, 110)
Input point #4 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-3 Value' and the 'X-5 Value' settings</i> )	
Y-4 VALUE	dflt= 30.0 (-5, 110)
Output point #4 of the actuator linearization curve, in percentage.	
X-5 VALUE	dflt= 40.0 (-5, 110)
Input point #5 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-4 Value' and the 'X-6 Value' settings</i> )	
Y-5 VALUE	dflt= 40.0 (-5, 110)
Output point #5 of the actuator linearization curve, in percentage.	
X-6 VALUE	dflt= 50.0 (-5, 110)
Input point #6 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-5 Value' and the 'X-7 Value' settings</i> )	
Y-6 VALUE	dflt= 50.0 (-5, 110)
Output point #6 of the actuator linearization curve, in percentage.	
X-7 VALUE	dflt= 60.0 (-5, 110)
Input point #7 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-6 Value' and the 'X-8 Value' settings</i> )	
Y-7 VALUE	dflt= 60.0 (-5, 110)
Output point #7 of the actuator linearization curve, in percentage.	
X-8 VALUE	dflt= 70.0 (-5, 110)
Input point #8 of the actuator linearization curve, in percentage. ( <i>Must be between the 'X-7 Value' and the 'X-9 Value' settings</i> )	
Y-8 VALUE	dflt= 70.0 (-5, 110)
Output point #8 of the actuator linearization curve, in percentage.	



X-9 VALUE	dflt= 80.0 (-5, 110)
Input point #9 of the actuator linearization curve, in percentage. (Must be between the 'X-8 Value' and the 'X-10 Value' settings)	
Y-9 VALUE	dflt= 80.0 (-5, 110)
Output point #9 of the actuator linearization curve, in percentage.	
X-10 VALUE	dflt= 90.0 (-5, 110)
Input point #10 of the actuator linearization curve, in percentage. (Must be between the 'X-9 Value' and the 'X-11 Value' settings)	
Y-10 VALUE	dflt= 90.0 (-5, 110)
Output point #10 of the actuator linearization curve, in percentage.	
X-11 VALUE	dflt= 100.0 (-5, 110)
Input point #11 of the actuator linearization curve, in percentage. (Must be greater than the 'X-10 Value')	
Y-11 VALUE	dflt= 100.0 (-5, 110)
Output point #11 of the actuator linearization curve, in percentage.	
ACT2 DEMAND (%) =	(status indication only)
Displays the actuator demand (%) before the linearization curve.	
ACT2 OUTPUT (%) =	(status indication only)
Displays the actuator demand (%) after the linearization curve.	

### Driver 2 Readout (only displayed if configured)

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

DRIVER 2 OUT (mA) =	(status indication only)
DRIVER 2 READOUT OFFSET?	dflt= 0.0 (-20, 20)
Used to adjust the analog output. The offset units are milliamps (mA).	
DRIVER 2 READOUT GAIN?	dflt= 1.0 (0.0, 2.0)

### Port 1 Settings (only displayed if configured)

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

PORT 1 LINK ERROR	(status indication only)
Displays a YES message if the port has a communication error. The `Time-out Delay` or port configuration may need to be adjusted under `PORT CONFIGURATIONS`.	
EXCEPTION ERROR	(status indication only)
Displays a YES message if the port has a exception error	
ERROR CODE	(status indication only)
Displays the error code related to the communication problem.	
0 = No Errors	1 = Illegal Function
2 = Illegal Data Address	3 = Illegal Data Value
9 = Checksum Error	10= Garbled Message
Press RESET to clear the port error.	
USE MODBUS 1 TRIP ?	dflt= YES (Yes/No)
Use trip command through the Modbus link from the Modbus device.	
USE 2-STEP TRIP ?	dflt= NO (Yes/No)
If using a Modbus Trip, is this a two-step trip. If YES, requires both the Trip command and the Trip Acknowledge command to go YES before a trip from the Modbus link will executed.	



ENABLED WHEN LOCAL IS SELECTED ? dfilt= NO (Yes/No)  
 If using Local/Remote only. If YES, allows commands from Modbus to be active even when LOCAL mode is selected. When NO, the Modbus commands are disabled when in LOCAL.

ALWAYS ENABLE MODBUS TRIP ? dfilt= NO (Yes/No)  
 If using Local/Remote only and if the Modbus is disabled on Local selection. If YES, the TRIP from the Modbus is still active event though all other Modbus commands are disabled. When NO, all Modbus commands are disabled when in LOCAL.

### Port 2 Settings (only displayed if configured)

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

PORT 2 LINK ERROR (status indication only)  
 Displays a YES message if the port has a communication error. The `Time-out Delay` or port configuration may need to be adjusted under `PORT CONFIGURATIONS`.

EXCEPTION ERROR (status indication only)  
 Displays a YES message if the port has a exception error

ERROR CODE (status indication only)  
 Displays the error code related to the communication problem.  
 0 = No Errors 1 = Illegal Function  
 2 = Illegal Data Address 3 = Illegal Data Value  
 9 = Checksum Error 10= Garbled Message  
 Press RESET to clear the port error.

USE MODBUS 2 TRIP ? dfilt= YES (Yes/No)  
 Use trip command through the Modbus link from the Modbus device.

USE 2-STEP TRIP ? dfilt= NO (Yes/No)  
 If using a Modbus Trip, is this a two-step trip. If YES, requires both the Trip command and the Trip Acknowledge command to go YES before a trip from the Modbus link will executed.

ENABLED WHEN LOCAL IS SELECTED ? dfilt= NO (Yes/No)  
 If using Local/Remote only. If YES, allows commands from Modbus to be active even when LOCAL mode is selected. When NO, the Modbus commands are disabled when in LOCAL.

ALWAYS ENABLE MODBUS TRIP ? dfilt= NO (Yes/No)  
 If using Local/Remote only and if the Modbus is disabled on Local selection. If YES, the TRIP from the Modbus is still active event though all other Modbus commands are disabled. When NO, all Modbus commands are disabled when in LOCAL.

### Comm Analog Scaling (if communications is used)

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

CASCADE SCALING FACTOR dfilt= 1.0 (1.0, 100)  
 Multiplier constant for all Cascade analog values sent over both Modbus links. When set to a value other than one (1.0), allows the Modbus device to scale inputs that are too small or to allow decimal places to be displayed.

AUX SCALING FACTOR	dflt= 1.0 (1.0, 100)
Multiplier constant for all Auxiliary analog values sent over both Modbus links. When set to a value other than one (1.0), allows the Modbus device to scale inputs that are too small or to allow decimal places to be displayed.	
KW SCALING FACTOR	dflt= 1.0 (1.0, 100)
Multiplier constant for all KW analog values sent over both Modbus links. When set to a value other than one (1.0), allows the Modbus device to scale inputs that are too small or to allow decimal places to be displayed.	
FSP SCALING FACTOR	dflt= 1.0 (1.0, 100)
Multiplier constant for all First Stage Pressure analog values sent over both Modbus links. When set to a value other than one (1.0), allows the Modbus device to scale inputs that are too small or to allow decimal places to be displayed.	
LOAD SHARE SCALING FACTOR	dflt= 1.0 (1.0, 100)
Multiplier constant for all Load Share analog values sent over both Modbus links. When set to a value other than one (1.0), allows the Modbus device to scale inputs that are too small or to allow decimal places to be displayed.	

## Port Configurations

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

### PORT 1 SETTINGS

STATUS	(status indication only)
Indicates a hardware communications problem.	
BAUD	dflt = scroll thru options
This value is set in the program mode	
STOP BITS	dflt = scroll thru options
This value is set in the program mode	
PARITY	dflt = scroll thru options
This value is set in the program mode	
DRIVER	dflt = scroll thru options
This value is set in the program mode	
ASCII OR RTU	dflt= xx (1, 2)
1 = ASCII 2 = RTU This value is set in the program mode.	
MODBUS DEVICE NUMBER	dflt= xx (1, 247)
Enter a number from 1 to 247. This value is set in the program mode.	
TIME-OUT DELAY (SEC)	dflt= 10.0 (0, 100)
Sets the delay for no communication on the Modbus link before the link is considered failed and issues an alarm.	

### PORT 2 SETTINGS

STATUS	(status indication only)
Indicates a hardware communications problem.	
BAUD	dflt = scroll thru options
This value is set in the program mode	
STOP BITS	dflt = scroll thru options
This value is set in the program mode	
PARITY	dflt = scroll thru options
This value is set in the program mode	
DRIVER	dflt = scroll thru options
This value is set in the program mode	
ASCII OR RTU	dflt= xx (1, 2)
1 = ASCII 2 = RTU This value is set in the program mode.	

MODBUS DEVICE NUMBER dflt= xx (1, 247)  
Enter a number from 1 to 247. This value is set in the program mode.  
TIME-OUT DELAY (SEC) dflt= 10.0 (0, 100)  
Sets the delay for no communication on the Modbus link before the link is considered failed and issues an alarm.

PC PORT SETTINGS

STATUS (status indication only)  
Indicates a hardware communications problem.  
BAUD dflt = scroll thru options  
BITS/CHAR dflt = scroll thru options  
STOP BITS dflt = scroll thru options  
PARITY dflt = scroll thru options  
READ MODE dflt = scroll thru options  
FLOW dflt = scroll thru options  
ECHO dflt = scroll thru options  
ENDLINE dflt = scroll thru options  
IGNORE CR dflt = scroll thru options

# Chapter 5.

## Understanding PID Settings

### Overview

The Speed, Cascade and Auxiliary controls utilize PID controllers. The response of each control loop can be adjusted for optimum response, however it is important to understand what a PID controller is and the effect each controller adjustment has on the controller response. Proportional gain, integral gain (stability), and DR (speed derivative ratio) are the adjustable and interacting parameters used to match the response of the control loop with the response of the system. They correspond to the P (proportional), I (integral), and D (derivative) terms, and are displayed by the 505 as follows:

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

### Proportional Control

Proportional response is directly proportional to a process change.

Analogy: Setting hand throttle to keep constant speed on straight and level.

Proportional control (using the same analogy) results in a certain speed as long as the car is not subjected to any load change such as a hill. If a throttle is set to any particular setting, the speed of the car will remain constant as long as the car remains straight and level. If the car goes up a hill, it will slow down. Of course, going down a hill the car would gain speed.

### Integral Control

Integral compensates for process and setpoint load changes.

Analogy: Cruise control maintains constant speed regardless of hills.

Integral, sometimes called reset, provides additional action to the original proportional response as long as the process variable remains away from the setpoint. Integral is a function of the magnitude and duration of the deviation. In this analogy the reset response would keep the car speed constant regardless of the terrain.

### Derivative

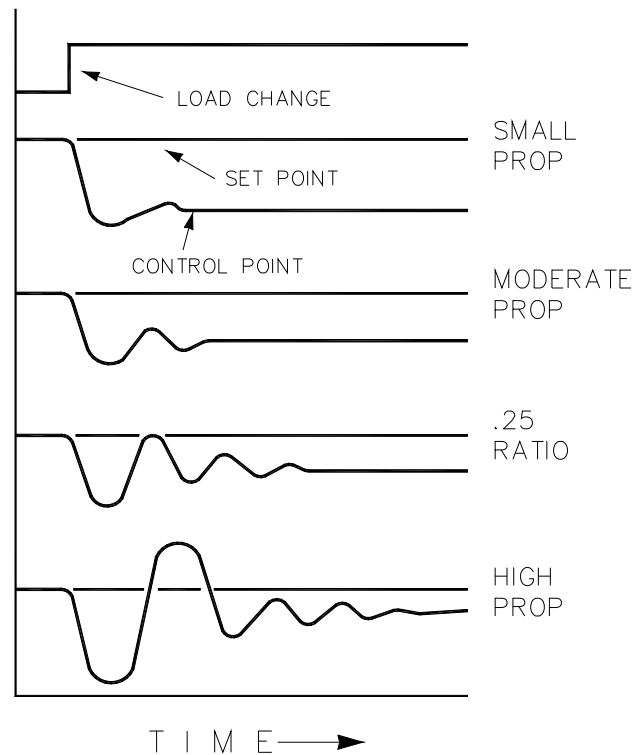
Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).

Analogy: Accelerating into high speed lane with merging traffic.

Derivative, sometimes called “preact” or “rate”, is very difficult to draw an accurate analogy to, because the action takes place only when the process changes and is directly related to the speed at which the process changes. Merging into high speed traffic of a freeway from an “on” ramp is no easy task and requires accelerated correction (temporary overcorrection) in both increasing and decreasing directions. The application of brakes to fall behind the car in the first continuous lane or passing gear to get ahead of the car in the first continuous lane is derivative action.

## Proportional Response

The amount of controller change is directly related to the process change and the Proportional gain setting on the controller; Controller output change is Proportional to the process change. If there is no process change, there is no change in output from the controller (or valve change) regardless of the deviation. This results in an undesired offset between the original desired Setpoint and the resulting drop in the Control Point.



830-360  
92-08-03 DAR

Figure 5-1. Proportional Gain Setting Effects

## Proportional Gain (effect of settings)

Figure 5-1 shows the effect of Proportional gain settings on control. Starting at the top of the graph a load change is introduced. With a small Proportional gain (meaning a large process change is required to produce full valve travel), stability is good but offset is very high. With a moderate gain setting (higher number setting) stability is still good—offset is still fairly high. With a high setting, offset is considerably smaller but the stability is poor. The 0.25 ratio effects a minimum area whereby the offset is reduced to a minimum while stability is in a decaying manner at 0.25% ratio. The decay ratio used (0.25%) means that if the second cycle is 1/4 of the first cycle, then each succeeding cycle will be 1/4 of the preceding cycle until the cycle is not visible.

Since Proportional gain is adjusted to produce (only) the proper stability of a process, do not continue increasing its effect to correct offset conditions. The amount of stability and offset is directly related to the setting of the Proportional setting. Stability is of course also affected by the stability of the process. In essence, the amount of output from the controller due to the Proportional setting is from the error. If there is no error, then there is no Proportional effect.

## Integral Response

Integral Gain as stated in the Woodward controls is repeats per minute (or Reset Rate). Therefore, a high amount of Integral gain (high number) would result in a large amount of Reset action. Conversely, a low Integral gain (low number) would result in a slower reset action.

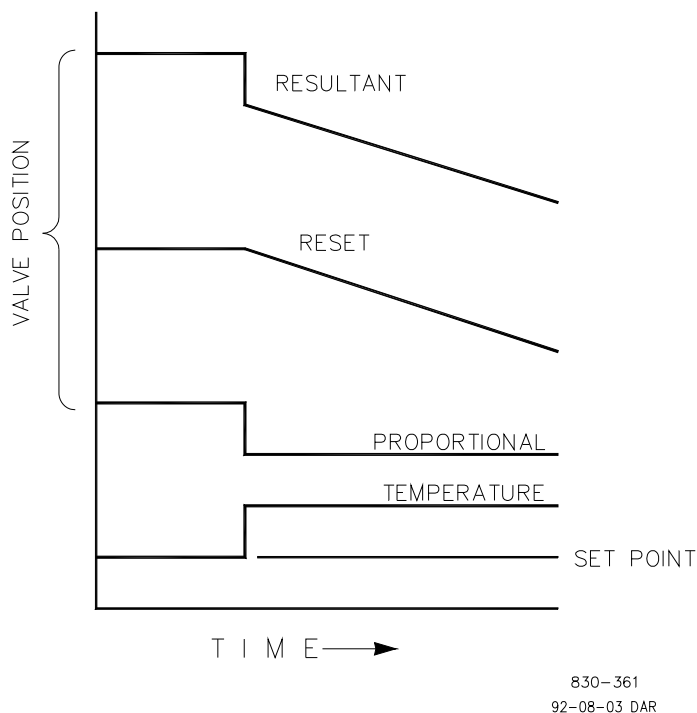


Figure 5-2. Open Loop Proportional and Integral Response

Integral response is provided to eliminate the offset that resulted from straight Proportional control. Figure 5-2 shows how the controller action is Proportional to the measurement change, but as we saw earlier, this results in offset. The Integral (or Reset) action is a function of both time and magnitude of the deviation. As long as an offset condition (due to load changes) exists, Integral action is taking place.

The amount of Integral action is a function of four things:

- The magnitude of the deviation
- The duration of the deviation
- The Proportional gain setting
- The Integral setting

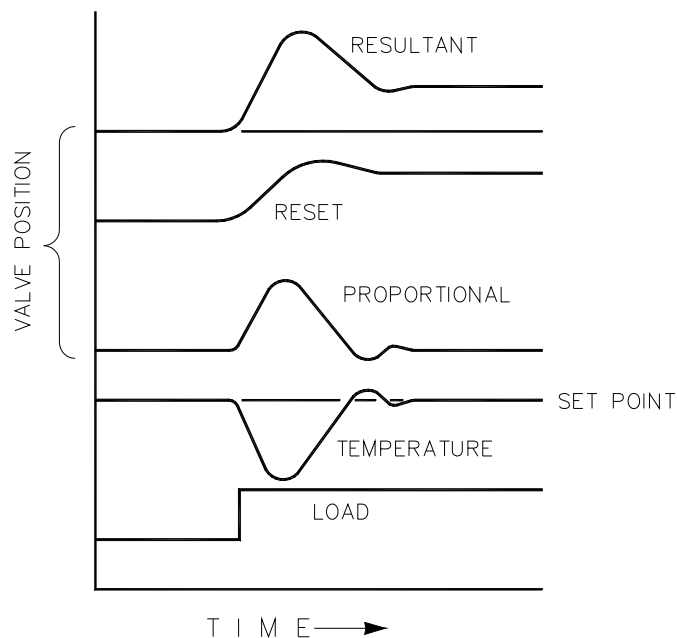
In this Open Loop figure (5-2), the Integral response is shown increasing due to the offset condition existing between the temperature and the setpoint. The resultant action is the top curve showing the step Proportional response that ends as soon as the measurement stops changing. Then the Integral (or reset) action is added to the Proportional action in an amount equal to the Integral of the deviation. In other words, Reset action continues (in either or both directions) as long as there is a difference (deviation) between the setpoint and the process measurement.

In this case, the deviation will never be eliminated (or even reduced) because the system is in Open Loop.

### Proportional + Integral (closed loop)

Figure 5-3 shows the closed loop effects of integral action. The bottom curve displays the load change. The next curve up shows the setpoint and the measured variable, temperature. With the load change the temperature droops or deviates from the setpoint.

The next highest curve is the Proportional action and follows the measured variable proportionately. The Integral curve adds to the Proportional curve resulting in a different valve position, thereby returning the process to the Setpoint.



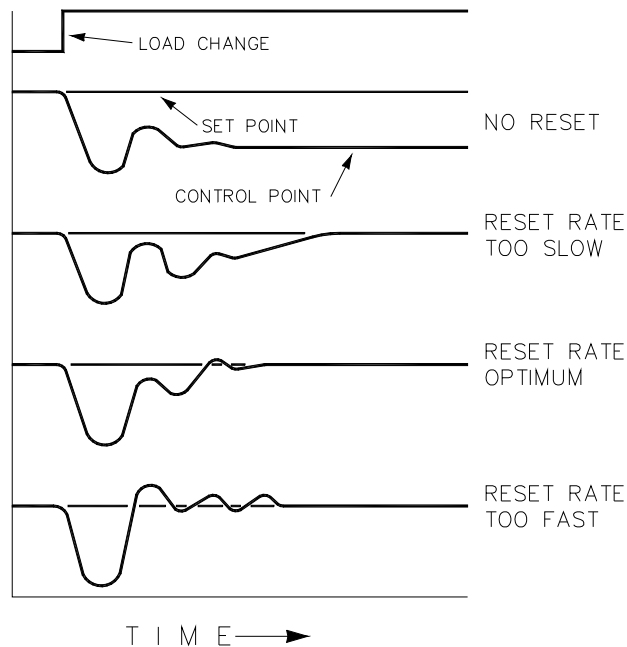
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Figure 5-3. Closed Loop Proportional and Integral Response

In Closed Loop, however (as opposed to Open Loop), as the measurement decays toward the Setpoint the Proportional action is taking place Proportionally to the measurement change, and the Integral action is decaying proportionately to the magnitude and duration of the deviation until the measurement reaches the setpoint at which time the Integral action is zero.

### Integral (effects of settings)

Figure 5-4 shows the effect of fast or slow Integral action. For a given load change an offset results with Proportional response only. Since recovery time (for a given load change) is important, the Integral setting should remove the offset in minimum time without adding additional cycling. If two cycles are added, then too much Integral Gain has been added. Of course, Proportional only must first establish the 1/4 decay ratio. If increased cycling occurs, the Integral must be turned off or the controller switched to “manual” if allowed to go too far. Ideally, the process should not continue to cycle after the setpoint has been reached as in the second curve from the bottom.



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Figure 5-4. Integral Gain (Reset) Setting Responses

### Derivative Response

In a process control loop the Derivative action is directly related to how fast the process changes (rate of change). If the process change is slow then the Derivative action is proportional to that rate of change. Derivative acts by advancing the Proportional action. Derivative acts at the start of the process change, when the process changes its rate and when the process stops its change.



Derivative action takes place at only three times:

- When the process starts to change
- When the rate of change takes place in the process
- When the process stops changing

The net result of Derivative action is to oppose any process change and combined with Proportional action to reduce stabilization time in returning the process to the setpoint after an upset. Derivative will not remove offset.

Woodward Derivative is split into two working domains, Input dominant and Feedback dominant. The allowed values for DR range from 0.01 to 100. The most common derivative is Feedback dominant, it is automatically selected with an Derivative Ratio (DR) from 1 to 100. The Input dominant domain is selected with DR values between 0.01 to 1.

Feedback dominant applies the derivative action to the integrator feedback term of the PID equation and is more stable than input dominant derivative. This will not take corrective action as early and it will be less noise sensitive. When tuning the derivative, the DR will be established in the 1 to 100 range because it is easier to tune and more forgiving of excessive values. Most PIDs will employ feedback dominant derivative.

Input dominant derivative applies the DR term before the integrator term of the PID equation. When the DR is less than 1, the derivative is input dominant and reacts very quickly to process upsets. This function is very adapted for PIDs that control the load parameter, such as load shaft turbine speed. Since the input dominant derivative is so sensitive, it should be reserved only for applications without high frequency noise.

Except for input dominant and feedback dominant features, the reciprocal of one domain will appear identical in the other domain. As an example, consider an DR of 5.0, the reciprocal being 1/5. That means that an DR of 5.0 will appear the same as DR of 0.200. The difference in response between these values of 5.0 and 0.2 is in the dominance feature.

If in doubt about the type of derivative to use, then set up for feedback dominant,  $1 < DR < 100$ .

## Proportional + Derivative (closed loop)

Figure 5-5 shows how Derivative acts to oppose a change in process in either direction. The dashed line shows the Derivative action going through zero to oppose the process deviation traveling toward zero. Notice offset still exists between the desired setpoint and the drooped control point that resulted from the load change. The top curve is the resultant controller output, Proportional plus Derivative.

If an upset (momentary) had occurred rather than a load change, there would be no offset.

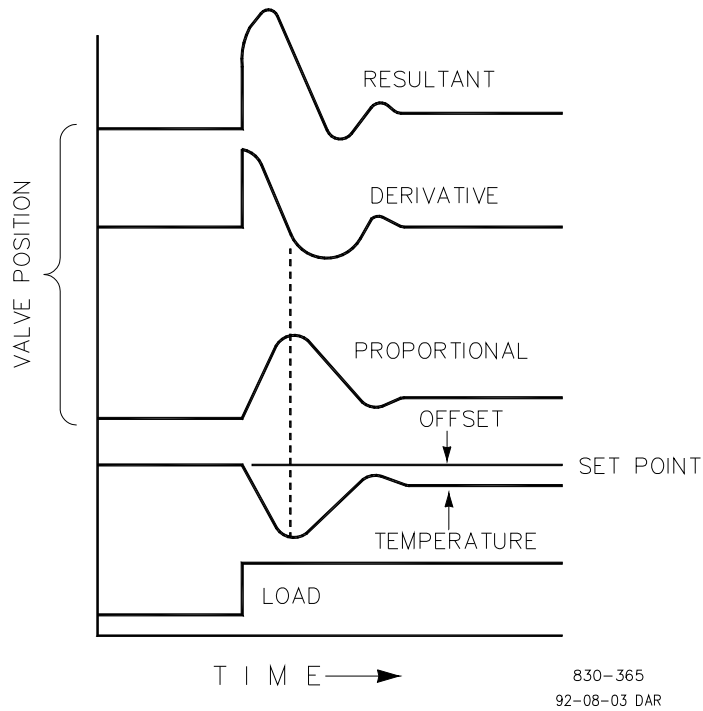


Figure 5-5. Closed Loop Proportional and Derivative Action

**Derivative (effects of settings)**

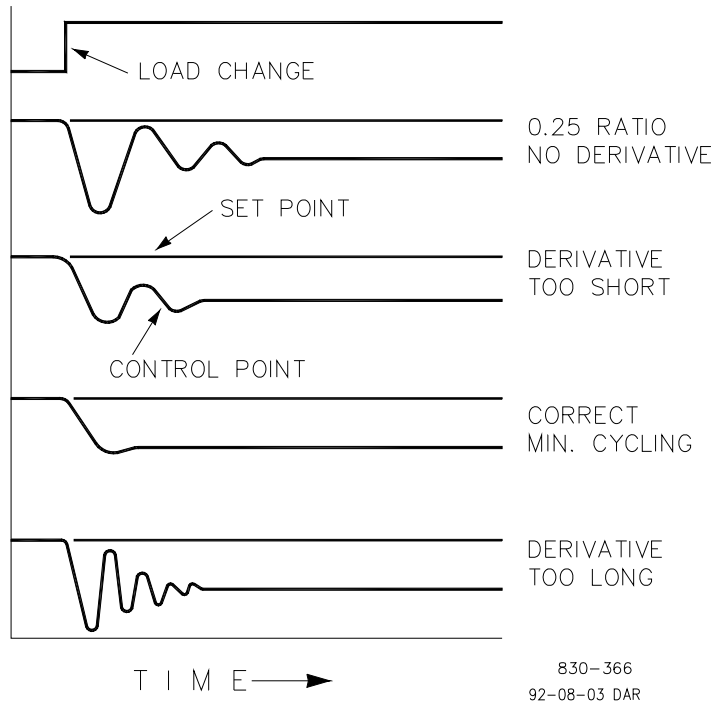


Figure 5-6. Derivative Setting Effects

Figure 5-6 shows the effect of different Derivative settings. The curves are relative since it depends on what type of control is desired in order to properly adjust Derivative time. For example, if minimum cycling is desired (as is shown here) then Derivative is added to the 1/4 decay cycle provided by Proportional until more than one cycle is removed and of course the 1/4 decay cycle is destroyed. However, in most cases it is desirable to retain the 1/4 decay cycle, in which case Derivative is added to the point of removing only one cycle from the 1/4 decay ratio then the gain is increased until the 1/4 decay ratio is restored.

In all the above curves, you will note offset exists since offset can only be eliminated by the addition of Integral (or Reset).

### Proportional + Integral + Derivative (closed loop)

Figure 5-7 shows the relationship of valve position to the interaction of the PID modes of control whenever a load change takes place in closed loop. As the temperature drops due to the load change, the proportional action moves the control valve proportionately to the measurement (temperature) change. The integral gain/reset adds to the proportional action as a result of the magnitude and time (duration) of the deviation. And the derivative temporarily over-corrects based on the speed at which the measurement moves in any direction. The resultant curve (at the top) shows a similar over-correction (in this case), but in addition the valve will stay at the new position required to keep the measurement at the setpoint.

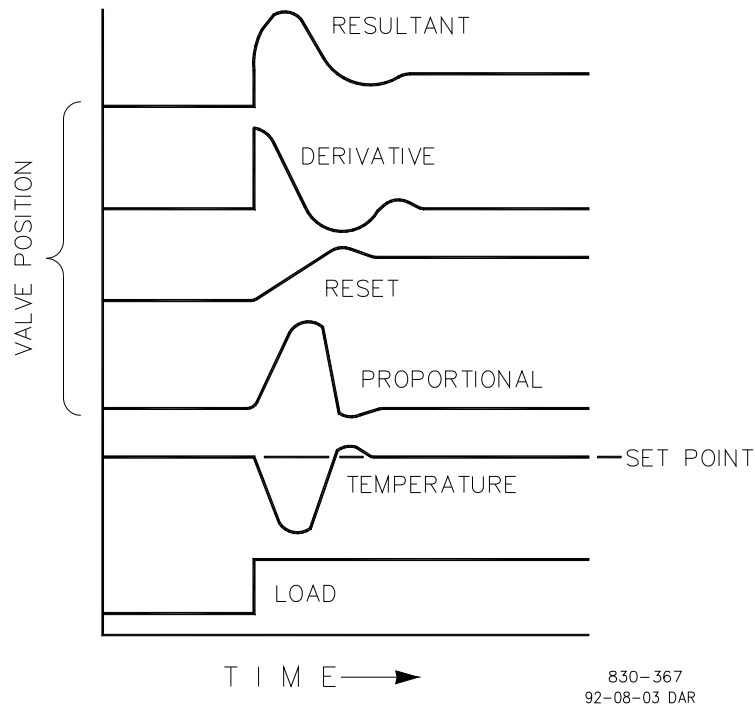


Figure 5-7. Closed Loop Proportional, Integral and Derivative Action

In summary, Derivative provides a temporary over-correction to compensate for long transfer lags and reduce stabilization time on process upsets (momentary disturbances).

## NOTICE

**Do not use if high frequency noise is normally in the measured variable or the main lag is dead time. After Proportional is set to 1/4 decay ratio and Derivative is adjusted to remove one cycle as well as decreasing the 1/4 decay ratio, then the Proportional gain can be increased to restore the 1/4 decay ratio.**

## Adding Derivative

The value of the Derivative Ratio (DR) term can range from 0.01 to 100. In order to simplify adjustment of the dynamics of the 505, 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. (i.e. at startup, during a full load change, or during transfer of control from another channel).

An input dominant controller is more sensitive to the change-of-rate of its input (i.e. Speed, Cascade in or Auxiliary in), and can therefore prevent overshoot of the setpoint better than a feedback dominant controller. Although this response is desirable during a startup or full load rejections, it can cause excessive control motions in some systems where a smooth transition response is desired.

A controller configured as feedback dominant is more sensitive to the change-of-rate of its feedback (LSS). A feedback dominant controller has the ability to limit the rate of change of the LSS bus when a controller is near its setpoint but is not yet in control. This limiting of the LSS bus allows a feedback dominant controller to make smoother control transitions than an input dominant controller.

## Controller Field Tuning General

The quality of regulation obtained from an automatic control system depends upon the adjustments that are made to the various controller modes. Best results are obtained when the adjustment (tuning) is done systematically. Prior training and experience in controller tuning are desirable for effective application of this procedure.

This procedure will lead to controller settings which will provide after a load change:

- Process control without sustained cycling
- Process recovery in a minimum time

Controller settings derived for given operating conditions are valid over a narrow range of load change. The settings made for one operating set of conditions may result in excessive cycling or highly damped response at some other operating condition. This procedure should be applied under the most difficult operating conditions to assure conservative settings over the normal operating range. It is good practice to keep the average of the setpoint changes near the normal setpoint of the process to avoid excessive departure from normal operating level.

After each setpoint change, allow sufficient time to observe the effect of the last adjustment (see Figure 5-8). It is wise to wait until approximately 90% of the change has been completed.

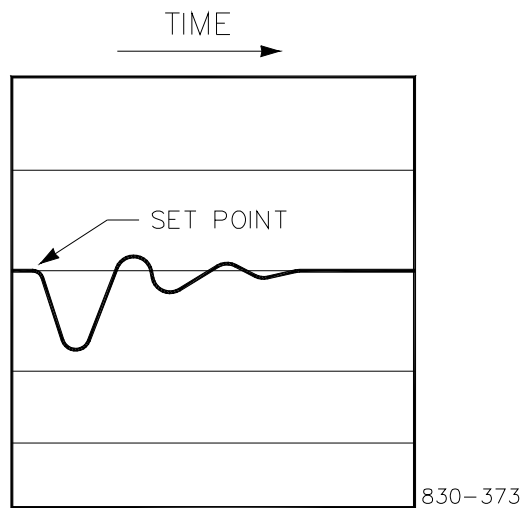


Figure 5-8. Typical Response to Load Change

### 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 startup 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.

The following method can be used to achieve PID gain values that are close to optimum:

1. Increase Derivative Ratio (SDR) to 100 (Service Mode adjustment)
2. Reduce integral gain to 0.01 (Run Mode adjustment)
3. Increase proportional gain until system just starts to oscillate (Run Mode). The optimum gain for this step is when the system just starts to oscillate and maintains a self-sustaining oscillation that does not increase or decrease in magnitude.
4. Record the control gain ( $K_c$ ) and oscillation period ( $T$ ) in seconds.
5. Set the dynamics as follows:
  - For PI control:  $G=P(I/s + 1)$ 
    - Set: Proportional gain =  $0.45 \cdot K_c$
    - Integral gain =  $1.2/T$
    - Derivative ratio = 100
  - For PID control :  $G=P(I/s + 1 + Ds)$ 
    - Set: Proportional gain =  $0.60 \cdot K_c$
    - Integral gain =  $2/T$
    - Deriv ratio =  $8/(T \cdot \text{Integral Gain})$  for fdbk dominant
    - =  $(T \cdot \text{Integral Gain})/8$  for input dominant

This method of tuning will get the gain settings close, they can be fine-tuned from this point.

## Chapter 6. Hardware/Operating System Faults

### General



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



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

### General

Most 505 problems which will be encountered are covered in the manual. Use the table of contents to locate the sections of the manual that may describe a specific problem. Refer to the CONTROLLING PARAM DISPLAYS and ALARM DISPLAYS sections of this manual for display descriptions and corrective actions. This troubleshooting section contains a few guidelines that Woodward field service technicians and engineers have suggested.

### Off-line Diagnostics

When the 505 control is powered up the microprocessor and other hardware is reset and the self-test begins. The first thing that the self-test does is turn off all five of the LED lamps. If these LEDs do not turn off this means that the microprocessor is not working and that the CPU module has failed. The self-test tests the RAM, system clock, LED display, EEPROM, communications memory, and application memory before beginning execution of the application program. If an error is found during the self-test it is annunciated on the front panel LED display. It also indicates the error by flashing the F1/Alarm LED a certain number of times repetitively for errors when the LED display may not be functioning. The table below shows the errors indicated by flashing LEDs:

LED Flashes	Error
1	RAM Test Failed
2	Unexpected Exception
3	Clock Interrupt Test Failed
4	Display Test Failed
5	EEPROM Test Failed
6	Communications Memory Test Failed
7	Flash Memory Test Failed

It is also possible to see the errors below on the front panel LED display. These errors could occur at anytime during the self-test or during execution of the application program. These indicate that an illegal reset condition has occurred.

“Reset caused by”  
“WATCHDOG TIMEOUT”

“Reset caused by”  
“HALT MONITOR”

“Reset caused by”  
“LOSS OF CLOCK”

“Reset caused by”  
“SOFTWARE RESET”

“Reset caused by”  
“TEST SUBMODULE RESET”

All the above errors indicate a problem with the CPU module except the “Display Test Failed” which indicates a problem with the display module.

## On-line Diagnostics

As soon as the application program starts running, the system will use a small portion of run time to continuously run the following on-line diagnostic tests.

<b>Test</b>	<b>Message On Failure</b>
Local Memory Test	This test gets a RAM location, saves the data from that location, then writes several different values to that location. It reads each value back, and checks it to be sure it is correct. It then restores the saved original data aback to the RAM and repeats the process at another location.
Application Memory Test	This test reads all flash memory, then calculates the sumcheck value and compares it to the sumcheck value previously calculated offline and stored in memory.
Task Overflow	This test checks the last eight locations in the task that has just completed to make sure that the values that were set up when the task was created have not changed. If they have, it indicates that the task has overflowed its memory, and destroyed memory in another task.

A failure of any one of the on-line tests results in the I/O lock being asserted and display of a message as shown in the following table. The message will be displayed on the Service Panel at the time the error occurs, and it also will go into the Fault Mode Buffer so that it can be displayed in the Fault Mode.

<b>Test</b>	<b>Message On Failure</b>
Local RAM	Local Ram Railed
Application Checksum	Checksum Error
During execution, an operating system task ran out of memory, or its memory was corrupted by a different task.	Task Overrun in Task XX



## Operation Errors and Faults

Certain other errors can also occur during system operation. If any of the below error messages appear:

- Disconnect all field wiring to the 505 control, except input power.
- Perform a power-up reset (for 30 seconds or more, temporarily remove input power, or press the “System Reset Switch”. See Volume 1, Figure 2-4 for location).

If the problem disappears, troubleshoot field wiring errors or check for and correct noise on the input power. If the problem does not disappear, replace the control.

### Operation Error Messages

System Error (#)

EEPROM Fault

Rate Group Slip (#)

EE Initialization Fault

Exception Error (#)

## Wiring Problems

Most 505 problems are caused by wiring problems. Carefully and thoroughly check all wiring connections at both ends. Be very careful when installing wires into the 505 control terminal blocks. Check all shields for proper grounding.

All inputs and outputs can be measured directly at the terminal strips. In addition, from the Service Mode, the LED display will show what the 505 measures. This comparison can be used to determine if the 505 is interpreting the input signal correctly. The Service Mode can be used to monitor and adjust analog inputs and outputs, monitor speed inputs, monitor and adjust actuator outputs, monitor contact inputs, and monitor and force relay outputs.

Contact inputs can be verified by measuring the voltage at the terminal blocks. The contact power supply voltage should measure approximately 24 Vdc from any contact (+) terminal to the contact GND terminal (11). If 24 Vdc is not the voltage measured, disconnect all wiring to the 505 except input power, then re-measure this power supply voltage. If 24 Vdc is not the voltage measured, check for wiring problems. If 24 Vdc is not measured across the contact input (+) and contact GND terminal (11) with input wiring disconnected, replace the 505.

The operation of a contact input to the 505 can be checked by verifying that the voltage from the contact input's (+) terminal measures 24 Vdc with respect to the contact input GND, terminal (11), when the external contact is closed.

Any 4–20 mA input or output can be checked by placing a milliamp meter in series with the input or output.

Refer to Volume 1 Chapter 3 for actuator wiring concerns or questions.

If the serial communications line is not working, check the wiring first. Then check the Program Mode entries for matching communications setup.

## Control Adjustments

If, while trying to adjust the Speed Setpoint in the Run Mode, the ADJ up and ADJ down keys will not work, check to make sure that CAS (cascade control) and RMT (remote control) are both disabled.

If the system's steam valve is unsteady or hunts, try manually positioning the steam valve by closing the valve limiter. If the steam valve is blocked in this manner and the actuator output is steady but the turbine still hunts, then the problem is outside the governor. If an actuator hunts, or appears sticky, it may need dither (especially TM type).

If the 505 control is not able to fully close or open the governor valves, check to make sure that the actuators are calibrated correctly, and valve linkage is correctly set.

If the 505 control is not able to control speed above or below a certain speed, the steam valve may not be adjusted correctly. Verify that the steam valve position is indeed in the position indicated by the 505 (by pressing the ACT key). If these positions do not match, correct the problem (actuator linkage, or current calibration).

If an overspeed condition is reached on start-up, verify that the governor valve is closed. Next verify that the governor valve is seated correctly by opening the T&T valve with the governor valve closed. If the T&T valve allows the turbine to turn, then the governor valve is not correctly seated.

## Other Operating Problems

If CAS or RMT will not work, check that the generator and tie breakers are both closed.

From the (MANUAL SHUTDOWN) (PUSH YES OR NO) display, you cannot initiate a shutdown.

If actual speed is less than the speed called for by the speed setpoint, check for droop (kW or speed). Droop causes the actual speed to be less than the speed reference.

# Appendix A.

## 505 Design Specifications

### Hardware Specifications

#### Package

Flush mount package

Approximate physical size of 11" x 14" x 4"

Environmental Category:

Lloyd's Type ENV2

NEMA: Type 4X or IEC 60529, IP 56

(applies only to front of flush mount package)

Optional bulkhead Enclosure (approximate size: 20" x 20" x 7")

#### Humidity

Lloyd's Test Specification No. 1, 1996, Humidity Test #1:

Two temperature cycles between 20 and 55 °C at 95% relative humidity within 48 hours

#### Operating Temperature

Without Enclosure (8923-439) = -25 to +65 °C, still air, no external heat loads.

Passes Lloyd's type ENV3 Dry Heat test

With Enclosure (8923-439) = -20 to +60 °C, still air, no external heat loads.

Passes Lloyd's type ENV3 Dry Heat test

#### Storage Temperature

-40 to +85 °C. For longest life, store near room temperature and limit the thermal cycle range.

#### Shock

US MIL-STD-810C, Figure 516.2-1 procedure 1b

(30 g 11 ms half-sine pulse)

#### Vibration

Lloyd's Test Specification No. 1, 1996, Vibration Test #1: 5-13.2 Hz, 1.0 mm;

13.2-100 Hz, 0.7 g

#### Pollution Resistance

##### Particulates:

IEC 664-1 Pollution Degree 2 (Normally only nonconductive pollution occurs. Temporary conductivity caused by condensation is to be expected.)

##### Gaseous Pollutants:

The polyacrylate conformal coating withstands NO<sub>2</sub>, CO<sub>2</sub>, SO<sub>2</sub>, and H<sub>2</sub>S gases per IEC 60068-2-60:1995 Part 2.60 Methods 1 and 4 (Flowing Mixed Gas Corrosion Test). It will withstand levels typical of telecommunications and computer installations as defined by Battelle Labs Class III (between IEC 60721-3-3 classification 3C1 and 3C2, light industrial to urban industrial, heavy traffic).

**Power Supply Specification****Insulation Resistance/HiPot**

24 Vdc power supply: 707 Vdc from power input to chassis

120 Vac/dc and 220 Vac version: 2200 Vdc from power input to chassis

**Power Inputs**

1. Low Voltage dc (18–32 Vdc)
  - input power fuse rating (F1 & F2)–6.25 A slow blow
  - Holdup Time = 14 milliseconds
2. ac/dc (90–150 Vdc or 88–132 Vac, 47–63 Hz)
  - input power fuse rating (F1 & F2)–2.5 A slow blow
  - Holdup Time = 30 milliseconds
3. High Voltage ac (180–264 Vac, 47–63 Hz)
  - input power fuse rating (F1 & F2)–1.5 A slow blow
  - Holdup Time = 58 milliseconds

**Power Outputs**

- Three 5 Vdc communications port isolated power supplies (100 mA max.)
- 5 Vdc digital power (2.5 A max.)
- 24 Vdc analog power (1.275 A max.)
- 15 Vdc analog power (150 mA max.)
- 15 Vdc analog power (150 mA max.)
- 24 Vdc isolated contact input power (100 mA max.)

**Microprocessor**

Motorola 68332 Microcontroller/20 MHz

**General I/O Specifications****Analog Inputs**

1. Six 4–20 mA inputs
  - a. One isolated input (input #6).
  - b. Five non-isolated differential inputs or may use 24 V provided with single common.
2. 16 Bit resolution over 0-25 mA full-scale range.
3. 200  $\Omega$  input impedance on all inputs.
4. Accuracy
  - a. Non-isolated input: 0.145% of full-scale input worst case @ 25° C ambient.
  - b. Isolated input: 0.186% of full-scale input worst case @ 25° C ambient.
5. Temperature drift.
  - a. Non-isolated inputs: 130ppm/°C worst case, 40ppm/°C root sum square.
  - b. Isolated input: 245ppm/°C worst case, 60ppm/°C root sum square.
6. Isolation
  - a. Non-isolated input: 2 M $\Omega$  to chassis.
  - b. Isolated input: infinite ohms to chassis.

**Speed Sensor Inputs**

1. Two channels, jumper selectable between MPU input and Proximity input.
2. MPU input.
  - a. Two isolated, independent channels.
  - b. 1–25 VRMS input voltage range.
  - c. 100–15000 Hz.
  - d. Input impedance of approximately 1.5 k $\Omega$

3. Proximity input.
  - a. Two isolated channels, independent channels.
  - b. 16–28 Vdc voltage range, at the input.
  - c. 0.5–15000 Hz.
  - d. Input impedance of approximately 7.1 k $\Omega$
4. Minimum of 12 bit resolution, 16 bit resolution at 100 Hz.
5. Speed range software selectable, 0-5000, 0–10000, or 0–15000.
6. Software filtering.
7. Accuracy is 0.027% worst case over temperature and time.

#### Actuator Drivers

1. Two channels, software selectable for 4–20 mA or 20–160 mA range.
2. Current readback on each channel, to detect over/under current.
3. Dither is software selectable (0–10 mA).
4. 45  $\Omega$  maximum load on the 20–160 mA version.
5. 360  $\Omega$  maximum load on the 4–20 mA version.
6. 10 bit resolution over 24 mA (4–20 mA range) or 196 mA (20–160 mA range) full scale range.
7. Temperature drift is 153ppm/ $^{\circ}$ C worst case and 143ppm/ $^{\circ}$ C root sum square.
8. Accuracy is 0.25% of full scale output worst case @ 25  $^{\circ}$ C ambient.

#### Analog Outputs

1. Six software configurable 4–20 mA outputs.
2. 600  $\Omega$  maximum load.
3. 10 bit resolution over 25 mA full scale range.
4. Temperature drift is 118ppm/ $^{\circ}$ C worst case and 100ppm/ $^{\circ}$ C root sum square.
5. Accuracy is 0.4% of 25 mA full scale output worst case @ 25 $^{\circ}$  C ambient

#### Relay Outputs

1. Eight software configurable relay outputs
2. One set of form C contacts provided for each relay output.
  - a. European ratings  
European ratings restrict use to applications with voltages not subject to the Low Voltage Directive (73/23/EEC).

Rated Voltage	Resistive	Inductive
28 Vdc	5 A	1 A

- b. UL Recognized Ratings

Rated Voltage	Resistive
28 Vdc	5 A
115 Vac	0.5 A

- c. Relay Manufacturer's Ratings

Rated Voltage	Resistive	Inductive
28 Vdc	5 A	1 A
115 Vac	0.5 A	0.3 A
125 Vdc	0.2 A	0.1 A

#### Discrete Inputs

1. 16 isolated discrete inputs.
2. Isolated +24 V power provided for discrete inputs.
3. 2.5 mA draw on each input when contact is closed.
4. 18–25 Vdc external contact power may be used instead of the 505's internal power supply.
5. Solid state relays may be used to drive any discrete input:
  - a. 505 Discrete Input Thresholds: <8 Vdc = "OFF", >15 Vdc = "ON"
  - b. 505 Discrete Input Impedance = 25 k $\Omega$ , at "ON" threshold

**Modbus Communications Ports**

1. Two isolated Modbus communications ports.
2. Supports RTU and ASCII protocol.
3. Baud rates to 57600.
4. Supports RS-232, RS-422, and RS-485 hardware.
5. Maximum network cable length is 1220 m/4000 ft (15 m/50 ft with RS-232).

**Personal Computer Communications Port**

1. One isolated PC communications port.
2. Supports RS-232 only.
3. Baud rates to 57600.
4. Maximum cable length is 15 m (50 ft).

**Built-In Operator Interface**

1. Two line x 24 character LED display.
2. 30 key multi-function keypad.
3. Emergency stop and overspeed test buttons.
4. Alarm and overspeed test LED indicators.

## Software Specifications

**Speed/Load Control**

NEMA D or better speed regulation.

**Nominal Software Execution Rate**

Speed/Load Control: 10 ms

Auxiliary Control: 20 ms

Cascade Control: 20 ms

Remote Speed Setpoint: 40 ms

Remote Aux Setpoint: 40 ms

Remote Cascade Setpoint: 40 ms

Sync/Load Share Control: 20 ms

Shutdowns: 10 ms

Alarms: 20 ms

Relays:

a. Trip Relay: 10 ms

b. Alarm Relay: 20 ms

c. Configurable Relays: 40 ms

Readouts: 40 ms

Contact Inputs:

a. External Trip & Configurable Inputs: 10 ms

b. Reset: 40 ms

c. Speed Raise & Lower: 20 ms

**IMPORTANT**

The “nominal rate” listed is the fastest update rate, the worst case response would be twice the nominal rate.

## Appendix B.

# 505 Service Mode Worksheet

Governor Serial Number \_\_\_\_\_

Application \_\_\_\_\_

Date \_\_\_\_\_

For details on individual settings, refer to Chapter 4.

**SPEED CONTROL SETTINGS**

Rate to Min =	RPM/SEC
Slow Rate /sec =	RPM/SEC
Fast Rate Dly =	SEC
Fast Rate =	RPM/SEC
Entered Rate =	RPM/SEC
Underspd Setting =	RPM
On-line Deriv Ratio =	%
Off-line Deriv Ratio =	%
Hold Speed Chng	Yes No

**ALARM SETTINGS**

Is Trip an Alarm	Yes	No
Blink Alarms	Yes	No
Jump to Alm Scrn	Yes	No

**KEY OPTIONS**

Use 'Stop' Cmd	Yes	No
Use Dyn Key Adj	Yes	No

**SPD CNTRL DROOP SETTINGS (if generator)**

Droop (%) =	%	
Use KW Droop?	Yes	No
Gen Load Units = MW	Yes	No

**MPU OVERRIDE**

Use MPU OvrD Tmr?	Yes	No
MPU OvrD Time =	Sec	
MPU #1 OvrD On	(Status Only)	
MPU #2 OvrD On	(Status Only)	

**AUTO START SEQUENCE (if configured)**

Low Idle Delay	(status only-MIN)
Rate To Hi Idle	(status only-RPM/SEC)
Hi Idle Delay	(status only-MIN)
Rate To Rated	(status only-RPM/SEC)
Hrs Since Trip	(status only-HRS)

**IDLE/RATED SETTINGS (if configured)**

Idle/Rated Rate =	RPM/SEC	
Use Ramp To Idle	Yes	No
Idle Priority?	Yes	No

**SYNC/LD SHARE SETTINGS (if configured)**

Input Bias Gain =	%	
Input Bias Dband =	RPM	
Lag-Tau Value =	%	
Hold Bias Chng	Yes	No

**REMOTE SPEED SETTINGS (if configured)**

Not Mtchd Rate =	RPM/SEC	
Spd Setpt Mx Rte =	RPM/SEC	
Min Speed Set =	RPM	
Max Speed Set =	RPM	
Rmt Dbnd Value =	RPM	
Lag-Tau Value =	%	
Use Min Load?	Yes	No
Hold Rmt Chng	Yes	No

**CASCADE CTRL SETTINGS (if configured)**

Slow Rate (/Sec) =	UNITS/SEC	
Fast Rate Delay =	SEC	
Setpt Fast Rate =	UNITS/SEC	
Septpt Entrd Rate =	UNITS/SEC	
Droop (%) =	%	
Rated Casc Setpt =	UNITS	
Casc N Mtchd Rte =	UNITS	
Max Speed Rate =	RPM/SEC	
Max Speed Set =	RPM	
Min Speed Set =	RPM	
Cascade Dbnd =	UNITS	
Casc Deriv Ratio =	%	
R/L Casc Only?	Yes	No
Use Min Load?	Yes	No
Hold Casc Chng	Yes	No

**REMOTE CASC SETTINGS (if configured)**

Rmt N Mtchd Rte =	UNITS/SEC	
Rmt Casc Max Rte =	UNITS/SEC	
Min Casc Set =	UNITS	
Max Casc Set =	UNITS	
Rmt Dbnd Value =	UNITS	
Lag-Tau Value =	SEC	
Hld Rmt Cas Chng	Yes	No

**AUX CONTROL SETTINGS (if configured)**

Slow Rate (/Sec) =	UNITS/SEC	
Fast Rate Delay =	SEC	
Setpt Fast Rate =	UNITS/SEC	
Setpt Entrd Rate =	UNITS/SEC	
Droop (%) =	%	
Rated Aux Setpt =	UNITS	
Aux Deriv Ratio =	%	
Aux Threshold =	%	
PID Min Output =	%	
Hold Aux Chng	Yes	No

**REMOTE AUX SETTINGS (if configured)**

Rmt N Mtchd Rte =	UNITS/SEC
Rmt Aux Max Rate =	UNITS/SEC
Min Rmt Aux Set =	UNITS
Max Aux Set =	UNITS
Rmt Dbnd Value =	UNITS
Lag-Tau Value =	%
Hold Rmt Aux Chng	Yes No

**BREAKER LOGIC (if generator)**

Freq Cntrl Armd	(status only)
Sync Window Rpm =	RPM
Sync Window Rate =	RPM/SEC
Tiebrkr Opn Rmp	Yes No
Tie Open Rate =	RPM/SEC
Gen Open Setback	Yes No
Gen Open Setpt =	RPM
Use Min Load	Yes No
Min Load Bias =	RPM
Zero Load Value =	%
Hold Brkr Chng	Yes No

**VALVE LIMITER SETTINGS**

Limiter Rate =	%/SEC
Entered Rate =	%/SEC
Limiter Max Limit =	%
Hold Limiter Chng	Yes No

**LOCAL/REMOTE FUNCTIONS (if configured)**

Remote Enabled	(status only)
Enable Contacts	Yes No
Contacts Enabled	(status only)
Enable Modbus 1	Yes No
Modbus 1 Enabled	(status only)
Enable Modbus 2	Yes No
Modbus 2 Enabled	(status only)

**MONITOR CONTACT INPUTS**

ESD Input Clsd	(status only)
Rst Input Clsd	(status only)
Rse Spd In Clsd	(status only)
Lwr Spd In Clsd	(status only)
Cont In #1 Closed	(status only)
Cont In #2 Closed	(status only)
Cont In #3 Closed	(status only)
Cont In #4 Closed	(status only)
Cont In #5 Closed	(status only)
Cont In #6 Closed	(status only)
Cont In #7 Closed	(status only)
Cont In #8 Closed	(status only)
Cont In #9 Closed	(status only)
Cont In #10 Closed	(status only)
Cont In #11 Closed	(status only)
Cont In #12 Closed	(status only)

**MONITOR RELAY OUTPUTS**

Sht Dn Rly Enrgzd	(status only)
Alrm Rly Enrgzd	(status only)
Relay 1 Enrgzd	(status only)
Relay 2 Enrgzd	(status only)
Relay 3 Enrgzd	(status only)
Relay 4 Enrgzd	(status only)
Relay 5 Enrgzd	(status only)
Relay 6 Enrgzd	(status only)

**FORCE RELAY OUTPUTS (if shut down)**

Force Relays ?	(troubleshooting only)
Force Rlys Enbl	(status only)
Shutdn Rly	(troubleshooting only)
Force Alarm Rly On?	(troubleshooting only)
Relay #1 On	(troubleshooting only)
Relay #2 On	(troubleshooting only)
Relay #3 On	(troubleshooting only)
Relay #4 On	(troubleshooting only)
Relay #5 On	(troubleshooting only)
Relay #6 On	(troubleshooting only)
Turn On LED's	(troubleshooting only)
LED's ON Status	(status only)

**MONITOR SPEED INPUTS**

Speed Input #1 =	(status only)
Speed Input #2 =	(status only)

**MONITOR ANALOG INPUTS**

Anlg In #1 (%) =	(status only)
Anlg In #2 (%) =	(status only)
Anlg In #3 (%) =	(status only)
Anlg In #4 (%) =	(status only)
Anlg In #5 (%) =	(status only)
Anlg In #6 (%) =	(status only)

**ANALOG IN ADJUSTMENTS**

Input #1 Offset =	
Input #1 Gain =	
Input #2 Offset =	
Input #2 Gain =	
Input #3 Offset =	
Input #3 Gain =	
Input #4 Offset =	
Input #4 Gain =	
Input #5 Offset =	
Input #5 Gain =	
Input #6 Offset =	
Input #6 Gain =	

**MONITOR ANALOG OUTPUTS**

Anlg Out # 1 (mA) =	(status only)
Anlg Out # 2 (mA) =	(status only)
Anlg Out # 3 (mA) =	(status only)
Anlg Out # 4 (mA) =	(status only)
Anlg Out # 5 (mA) =	(status only)
Anlg Out # 6 (mA) =	(status only)

**ANALOG OUTPUT ADJUSTMENTS**

Out #1 Offset =	
Out #1 Gain =	
Out #2 Offset =	
Out #2 Gain =	
Out #3 Offset =	
Out #3 Gain =	
Out #4 Offset =	
Out #4 Gain =	
Out #5 Offset =	
Out #5 Gain =	
Out #6 Offset =	
Out #6 Gain =	



**ACT1 LINEARIZATION**

X-1 Value =
Y-1 Value =
X-2 Value =
Y-2 Value =
X-3 Value =
Y-3 Value =
X-4 Value =
Y-4 Value =
X-5 Value =
Y-5 Value =
X-6 Value =
Y-6 Value =
X-7 Value =
Y-7 Value =
X-8 Value =
Y-8 Value =
X-9 Value =
Y-9 Value =
X-10 Value=
Y-10 Value=
X-11 Value =
Y-11 Value =

**ACT2 LINEARIZATION**

X-1 Value =
Y-1 Value =
X-2 Value =
Y-2 Value =
X-3 Value =
Y-3 Value =
X-4 Value =
Y-4 Value =
X-5 Value =
Y-5 Value =
X-6 Value =
Y-6 Value =
X-7 Value =
Y-7 Value =
X-8 Value =
Y-8 Value =
X-9 Value =
Y-9 Value =
X-10 Value=
Y-10 Value=
X-11 Value =
Y-11 Value =

**PORT 1 SETTINGS (if configured)**

Port 1 Link Error	(status only)
Exception Error	(status only)
Error Code	(status only)
Use Modbus 1 Trip?	Yes No
Use 2-Step Trip?	Yes No
Enbl When Local	Yes No
Trp Always Enbl	Yes No

**PORT 2 SETTINGS (if configured)**

Port 2 Link Err	(status only)
Exception Error	(status only)
Error Code	(status only)
Use Mod 2 Trip	Yes No
Use 2-Step Trp?	Yes No
Enbl When Local	Yes No
Trp Always Enbl	Yes No

**COMM ANALOG SCALING (if using Modbus)**

Cas Scale Factor =
Aux Scale Factor =
KW Scale Factor =
FSP Scale Factor =
Load Share Scale =

**PORT CONFIGURATIONS**

**PORT 1 SETTINGS**

STATUS	(status only)
BAUD =	
STOP BITS =	
PARITY =	
DRIVER =	
ASCII OR RTU =	
MODBUS DEVICE # =	
TIME OUT DELAY (SEC) =	

**PORT 2 SETTINGS**

STATUS	(status only)
TOP BITS =	
PARITY =	
DRIVER =	
ASCII OR RTU =	
MODBUS DEVICE # =	
TIME OUT DELAY (SEC) =	

**PC PORT SETTINGS**

STATUS	(status only)
BAUD =	
STOP BITS =	
PARITY =	
DRIVER =	

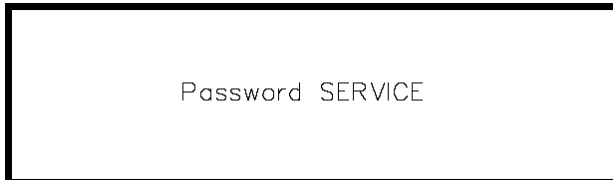
## Appendix C. Password Information

### General

The 505 Series control system requires a password to be entered before access can be given to the SERVICE, CONFIGURE, DEBUG, or OS\_FAULTS modes. The Download Configuration function also requires a password. These passwords are intended to help prevent unauthorized or untrained personnel from accessing these modes and possibly making changes that could cause damage to the turbine or associated process. If only certain people are to know these passwords, remove this appendix and keep it in a separate place, apart from the manual.

### Service Mode Password

When the display reads:

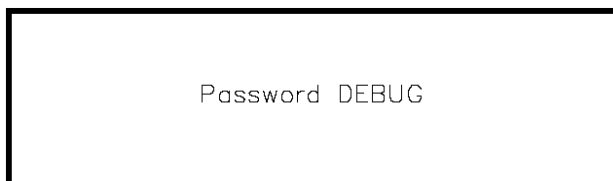


The password for your control is: 1 1 1 1

Press the keys on the 505 front panel in this sequence followed by ENTER to gain access to the SERVICE mode.

### Debug Mode Password

When the display reads:



The password for your control is: 1 1 1 2

Press the keys on the 505 front panel in this sequence followed by ENTER to gain access to the DEBUG Mode.

## Configure Mode Password

When the display reads:

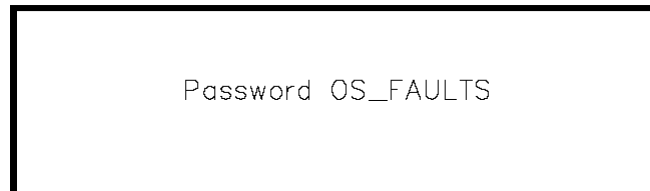


The password for your control is: 1 1 1 3

Press the keys on the 505 front panel in this sequence followed by ENTER to gain access to the CONFIGURE mode.

## OS\_FAULTS Mode Password

When the display reads:

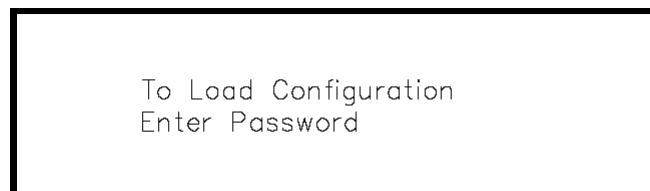


The password for your control is: 1 1 1 4

Press the keys on the 505 front panel in this sequence to gain access to the OS\_FAULTS mode.

## Download Configuration Function Password

When the display reads:



The password for your control is: 1 1 1 6

Press the keys on the 505 front panel in this sequence followed by ENTER to gain access to the Load Configuration function.

## Revision History

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### Changes in Revision F—

- Updated Regulatory Compliance information

### Changes in Revision E—

- Added UL requirement for field wiring to be stranded copper wire

# Declarations

## DECLARATION OF CONFORMITY

According to EN 45014

**Manufacturer's Name:** WOODWARD GOVERNOR COMPANY (WGC)  
Industrial Controls Group

**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)

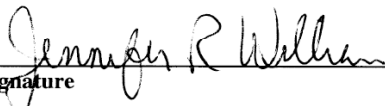
**Conformance to Directive(s):** 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

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

**Applicable Standards:** EN61000-6-2, 1999: EMC Generic Standards - Immunity for Industrial Environments  
EN50081-2, August 1993: EMC Generic Emissions Standard, Part 2: Industrial Environment  
EN50082-2, March 1995: EMC Generic Immunity Standard, Part 2: Industrial Environment  
EN 60079-15, 2003: Electrical apparatus for potentially explosive atmospheres - Type of protection 'n'

**We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).**

### MANUFACTURER

  
\_\_\_\_\_  
**Signature**

Jennifer Williams  
\_\_\_\_\_  
**Full Name**

Engineering Manager  
\_\_\_\_\_  
**Position**

WGC, Fort Collins, CO, USA  
\_\_\_\_\_  
**Place**

7-9-04  
\_\_\_\_\_  
**Date**

We appreciate your comments about the content of our publications.

Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)

Please reference publication **85017V2F**.



B85017V2:F



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