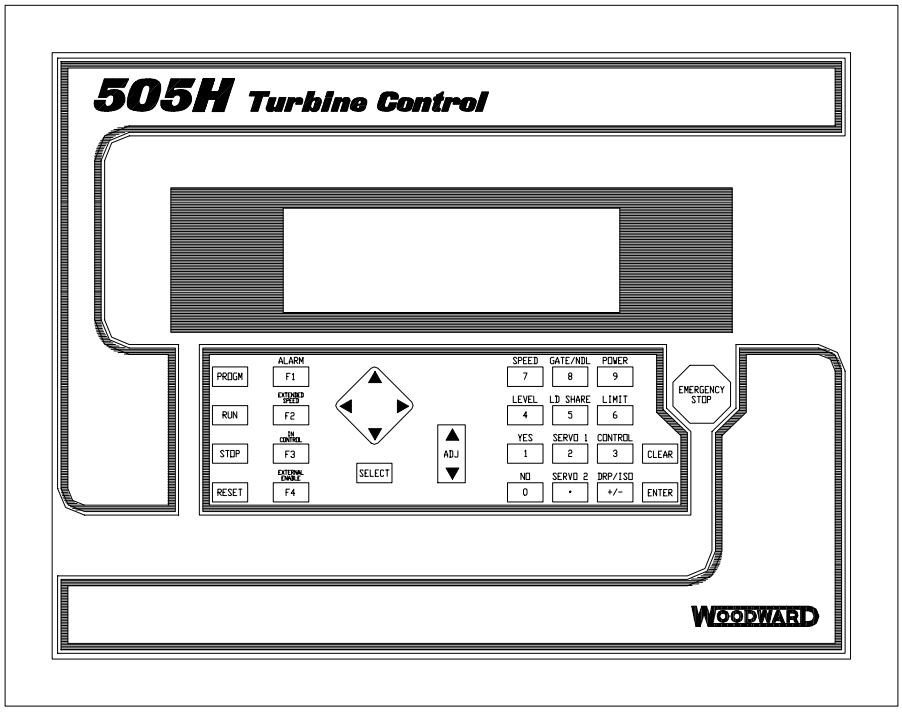
505H DIGITAL GOVERNOR FOR HYDRAULIC TURBINES



850-072H
96-05-15 KDW

Manual 85013B

WARNING

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.

The engine, turbine, or other type of prime mover should be equipped with an overspeed (overtemperature, or overpressure, where applicable) shutdown device(s), that operates totally independently of the prime mover control device(s) to protect against runaway or damage to the engine, turbine, or other type of prime mover with possible personal injury or loss of life should the mechanical-hydraulic governor(s) or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

CAUTION

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.

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.**

IMPORTANT DEFINITIONS

WARNING—indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION—indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment.

NOTE—provides other helpful information that does not fall under the warning or caution categories.

Revisions—Text changes are indicated by a black line alongside the text.

Contents

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Chapter 1
General Information

Introduction

This manual (85013) describes the Woodward 505H Digital Governor for fixed and adjustable blade hydroelectric turbines. English versions are 9907-117, 9907-118, and 9907-119. The option charts below show the differences between the part numbers. The manual gives the installation instructions, describes the control, and explains the configuration (programming) and operating procedures.

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

Manual 85013 describes the 505H Digital Governor for impulse-type hydroelectric turbines.

PART NUMBER	POWER
9907-117	LVDC (18-32 VDC)
9907-118	AC/DC (90-150 VDC), (88-132 VAC)
9907-119	HVAC (180-264 VAC)

Optional Bulkhead Mounting Box (NEMA 4x) P/N 1626-677

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 nonhazardous locations.

Field wiring must be 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 Class I, Division 2 (Zone 2) wiring methods and in accordance with the authority having jurisdiction.

⚠ **WARNING**
Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 (Zone 2).

⚠ **AVERTISSEMENT**
Risque d'explosion - La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.

⚠ **WARNING**
Explosion Hazard - Do not disconnect while circuit is live unless the area is known to be nonhazardous.

⚠ **AVERTISSEMENT**
Risque d'explosion - Ne pas debrancher tant que le circuit est sous tension, a moins qu'il ne s'agisse d'un emplacement non dangereux.

CAUTION
All test points on the power supply and control boards must not be used unless area is known to be non-hazardous.

ATTENTION
Ne pas utiliser les bornes d'essai du block d'alimentation et des cartes de commande a moins de se trouver dans un emplacement non dangereux.

Chapter 2
Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. 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.

3. Keep plastic, vinyl, and styrofoam materials (such as plastic or styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:

    - Do not touch any part of the PCB except the edges.

    - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.

    - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Chapter 3
Description

Introduction

The 505H Digital Governor is a microprocessor-based control designed to control fixed- or adjustable-blade hydroelectric turbines. A microprocessor-based digital control provides considerable flexibility in configuring the governor to the site-specific application requirements. The ability to configure the system in the field allows a single design to be used in many different control applications, and reduces both cost and delivery time.

The 505H control has two normal operating modes, the Program Mode and the Run Mode. The Program Mode is used to select the options needed to configure the control to your specific turbine application. Once the control has been configured, the Program Mode is typically never again used, unless turbine options change. Once configured, the Run Mode is used to operate the turbine from start-up through shutdown.

Inputs to the control are:

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

Six analog inputs are available. One is dedicated to gate position. The five remaining analog inputs are programmable. Chapters 4 and 5 give listings of the options available. The sixth analog input has isolation circuitry and should be used for a self-powered signal which is not isolated.

Sixteen contact inputs are available. Four are dedicated for shutdown, reset, raise setpoint, and lower setpoint. Another contact input must be dedicated for the generator breaker. The eleven remaining contact inputs are programmable. Chapters 4 and 5 give listings of the available options.

Four function keys on the front panel of the control. F1 is the alarm key. F2 is the extended speed key. F3 is for selecting the reference to place in control. F4 is to enable an external signal to control the reference.

Outputs from the control are:

Two actuator outputs; the second actuator output can be used as an extra readout if not used as an actuator output.

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

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

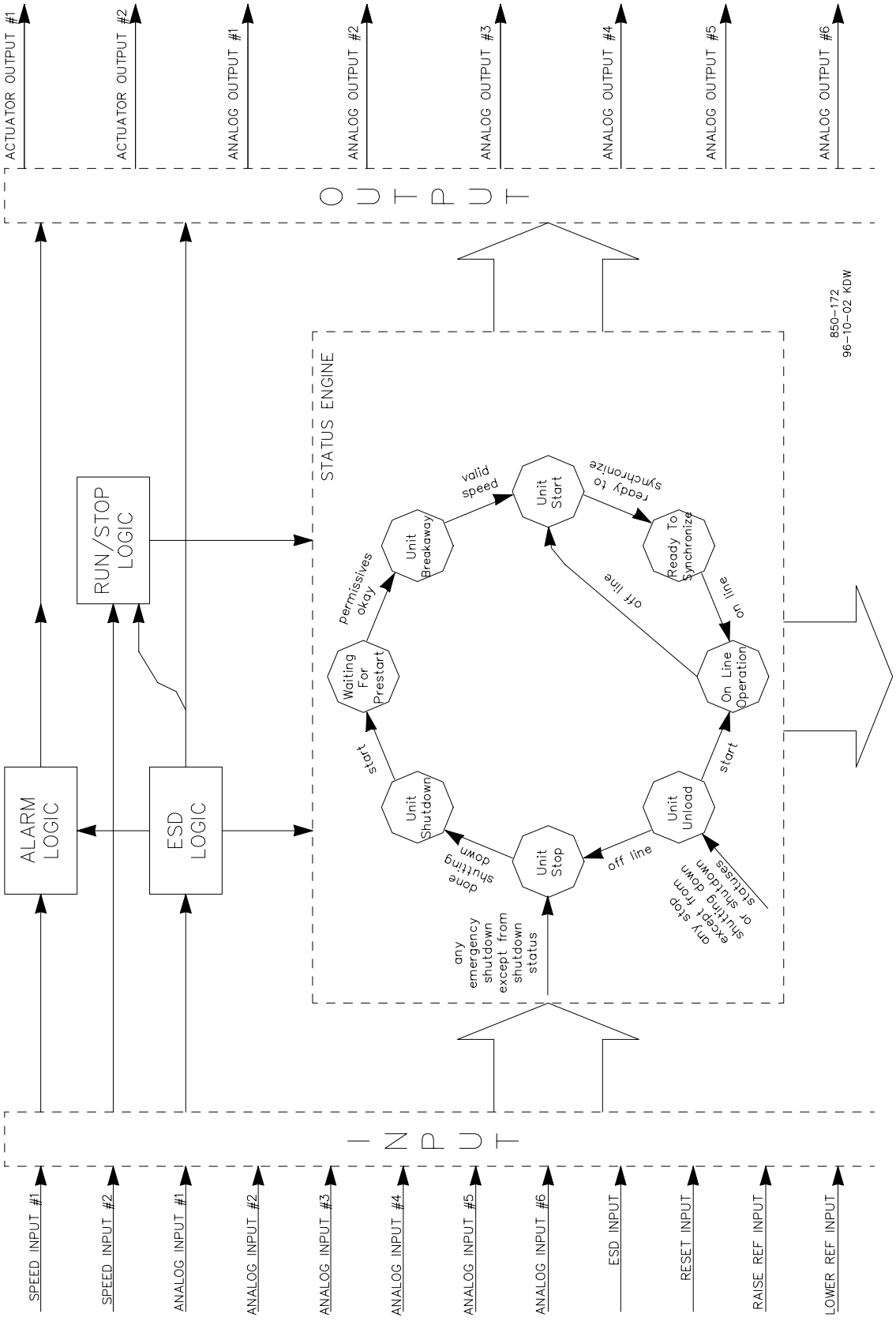

Figure 3-1. Overview of 505H Functionality

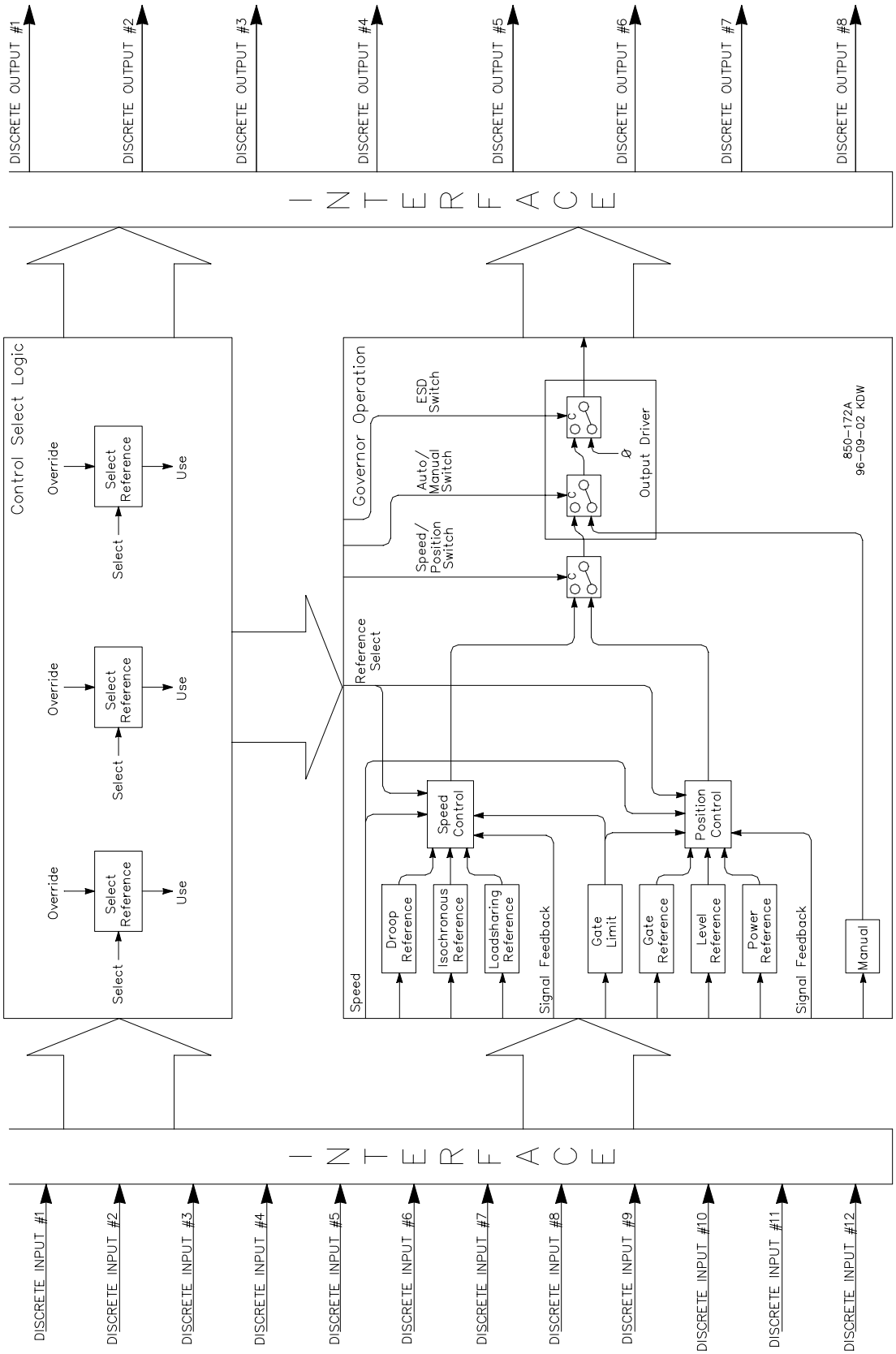

Figure 3-1. Overview of 505H Functionality

Serial Interfaces with the control are:

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

One computer (PC) port to be used for program configuration storage and modification.

An overview of the 505H functions is shown in Figure 3-1. Use this block diagram to match the control features to the site-specific application required.

CONTROL OVERVIEW

The 505H has six independent Governor References which are divided into two different sets of Controls. The Droop, Isochronous, and Loadsharing References are all associated with the Speed Control, while the Gate, Level, and Power References are associated with the Position Control. The outputs of these two Controls are limited at the PID by the gate limit. The selected output sets the actuator output current. Many of the Governor References have the option of an External Signal to determine the position setpoint. An integrated manual control is also provided to allow manual setting of the gate servomotor (and blade servomotor, if it exists). The manual control signal overrides the signals from either of the controllers. Additional features of the 505H include frequency control, isochronous loadsharing, brake circuit, creep detection, and small system detection. There are two serial communications ports which can be used to monitor and control the turbine using Modbus protocol.

SPEED CONTROL

Speed Control is the normal “small system”, or isolated operating condition for the 505H. The unit speed compared to the speed setpoint through a speed PID (proportional plus integral plus derivative) to generate a setpoint signal to the actuator(s). The primary Governor References in Speed Control are Droop, Isochronous, and Loadsharing. These are covered in detail in chapter 4.

POSITION CONTROL

Position Control is quite similar to Speed Control, except that primary setting device is a position setpoint, as opposed to a speed setpoint. In this case, the speed error signal is generated by the difference between the position setpoint and position. Position Control would typically be used in “large system”, or interconnected applications, as any deviation from normal speed will cause a position error. This position error may be the source of confusion under normal operating circumstances. The primary Governor References in Position Control are Gate, Level, and Power. These are covered in detail in chapter 4.

GATE LIMIT

The Gate Limit limits the gate setpoint signal to aid in starting or stopping the turbine. In addition, it can be used to determine a maximum gate opening during normal operation. The Gate Limit can be adjusted either up or down via the keypad, programmable contact inputs, or the Modbus interface.

The output of the Gate Limit is low-signal selected with the output of the Speed or Position Control. The control or limit asking for the lowest gate position will control the gate position. Thus, the Gate Limit limits the maximum gate position.

MANUAL CONTROL

Integrated Manual Control is available to manually position the gate servomotor. This operates equivalently to an external manual controlling device, in that the setpoint signal provided by either the Speed Control or Position Control is ignored, and only the Manual Control signal is used to determine the gate position.

KEYPAD AND DISPLAY

The 505H's service panel consists of a keypad and LED display located on the front of the control. The LED display has two, 24 character lines that can be used to display operating parameters and troubleshooting parameters in plain English. Also, there are 30 keys available to provide complete control from the front of the 505H. No additional control panels are required to operate the turbine, every turbine control function can be done from the 505H's front panel.

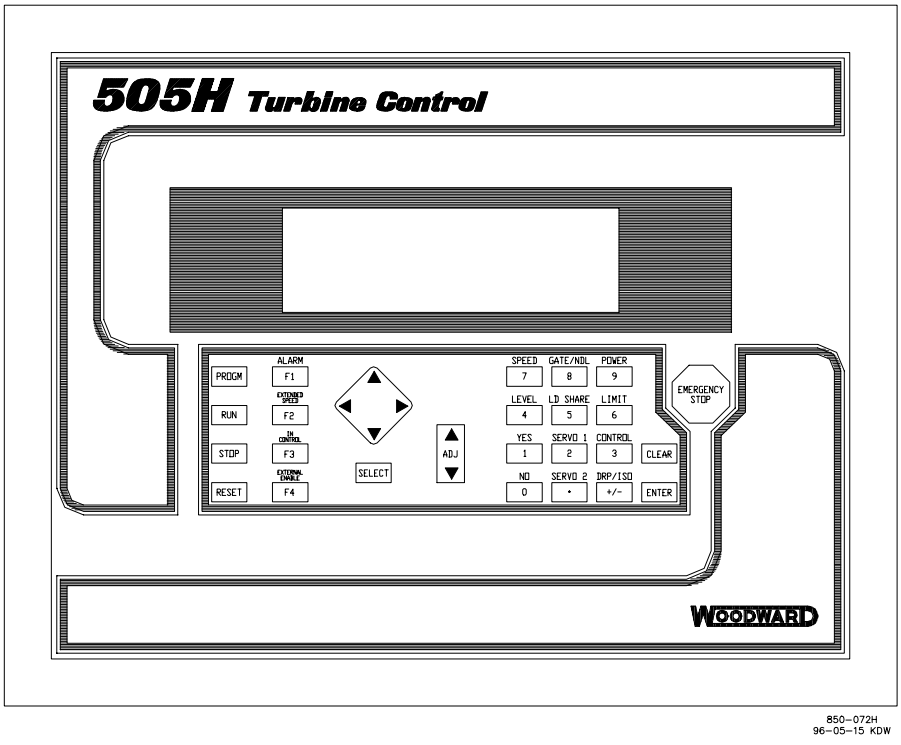

Figure 3-2. 505H Keypad and Display

A description of each key's function follows. Some descriptions refer to the function blocks contained in the programming (chapter 6), service (chapter 7), and operating flowcharts (chapter 8).

The < > (scroll left, right) moves the display left or right through the function blocks of the Program, Service, or Run Modes. The ∧ , ∨ (scroll up, down) moves the display up or down within a function block of the Program or Run Mode.

In the Run and Service Modes, ∧ , moves any adjustable parameter up (larger) or, ∨ moves any adjustable parameter down (smaller).

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

RUN Initiates a turbine run or start command from the (CONTROLLING PARAMETER/ RUN OR PROGRAM) state.

STOP Initiates a controlled turbine shutdown (Run Mode) once verification is given.

RESET Resets/clears Run Mode alarms and shutdowns. Pressing the key also returns the control to the (CONTROLLING PARAMETER / RUN OR PROGRAM) status after a shutdown.

NO
0 Enters 0/NO or disable.

SERVO2
. Enters decimal point or displays the blade position information (Run Mode).

DRP/ISO
+/- Changes the sign of the value being entered or displays the droop / isoch selection information.

YES
1 Enters 1 or answers YES to questions.

SERVO2
. Enters 2 or displays the gate position information (Run Mode).

CONTROL
3 Enters 3 or displays the parameter which is in control (Run Mode).

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

LD SHARE
5 Enters 5 or displays the loadsharing control information (Run Mode).

LIMIT
6 Enters 6 or displays the gate limit information (Run Mode).

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

GATE/NDL
8 Enters 8 or displays the gate set control information (Run Mode).

Enters 9 or displays the power control information (Run Mode).

Clears Program Mode and Run Mode entries and takes control out of its present mode.

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

Displays the reason for any alarm condition when the key's LED indicator is illuminated.

Enables the Extended Speed Range.

Programmable function key for enabling or disabling programmable control functions.

Programmable function key for enabling or disabling programmable control functions.

Large red octagonal button on the front of the enclosure. This is an emergency shutdown command for the control.

WATCHDOG TIMER/CPU FAULT CONTROL

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

Chapter 4
Installation Procedures

Introduction

This chapter provides instructions on how to mount and connect the 505H into a system. Hardware dimensions and jumper configurations are given to allow you to mount, wire, and configure the 505H package to a specific application. Electrical ratings, wiring requirements, and options are provided in appendix E.

MECHANICAL DATA AND HARDWARE INSTALLATION

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

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

Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.

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

WARNING
Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 (Zone 2).

AVERTISSEMENT
Risque d'explosion - La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.

WARNING
Explosion Hazard - Do not disconnect while circuit is live unless the area is known to be nonhazardous.

AVERTISSEMENT
Risque d'explosion - Ne pas debrancher tant que le circuit est sous tension, a moins qu'il ne s'agisse d'un emplacement non dangereux.

CAUTION
All test points on the power supply and control boards must not be used unless area is known to be non-hazardous.

ATTENTION
Ne pas utiliser les bornes d'essai du block d'alimentation et des cartes de commande a moins de se trouver dans un emplacement non dangereux.

Enclosures

Figure 4-1 shows 505H control layout and mounting pattern. The 505H is housed in a flush mount enclosure. This enclosure is designed for installation within a control room panel or cabinet, and, by itself, cannot be bulkhead-mounted. The 505H package, once properly installed within a NEMA4 panel or cabinet meets NEMA 4X ratings. All field wiring connects to the 505H through removable terminal blocks located on the 505H's back side.

An optional NEMA-4X enclosure is available to allow the 505H to be bulkhead mounted (Figure 4-2). The 505H digital control mounts on the front door of the optional enclosure. This allows for easy service access through the enclosure's front door. The size of the enclosure allows the control to accommodate an internal heat rise of 20° C (30° C for bulkhead mounted package). This bulkhead mounted enclosure has two removable gland plates attached to the bottom. You may cut appropriately sized conduit openings (up to 1.5") as required, in the removable gland plates for wiring access.

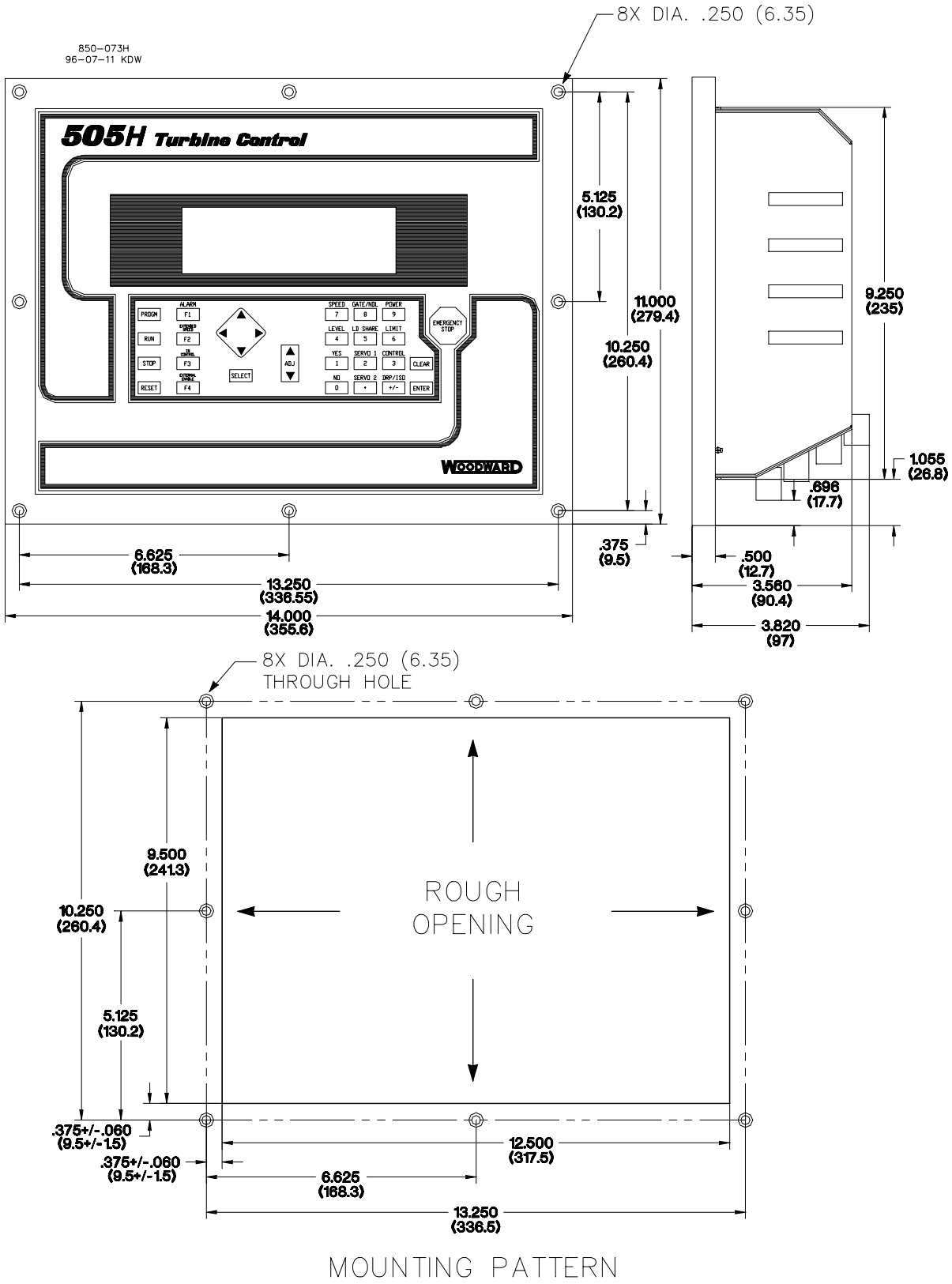

Figure 4-1. 505H Control Layout (Standard Enclosure)

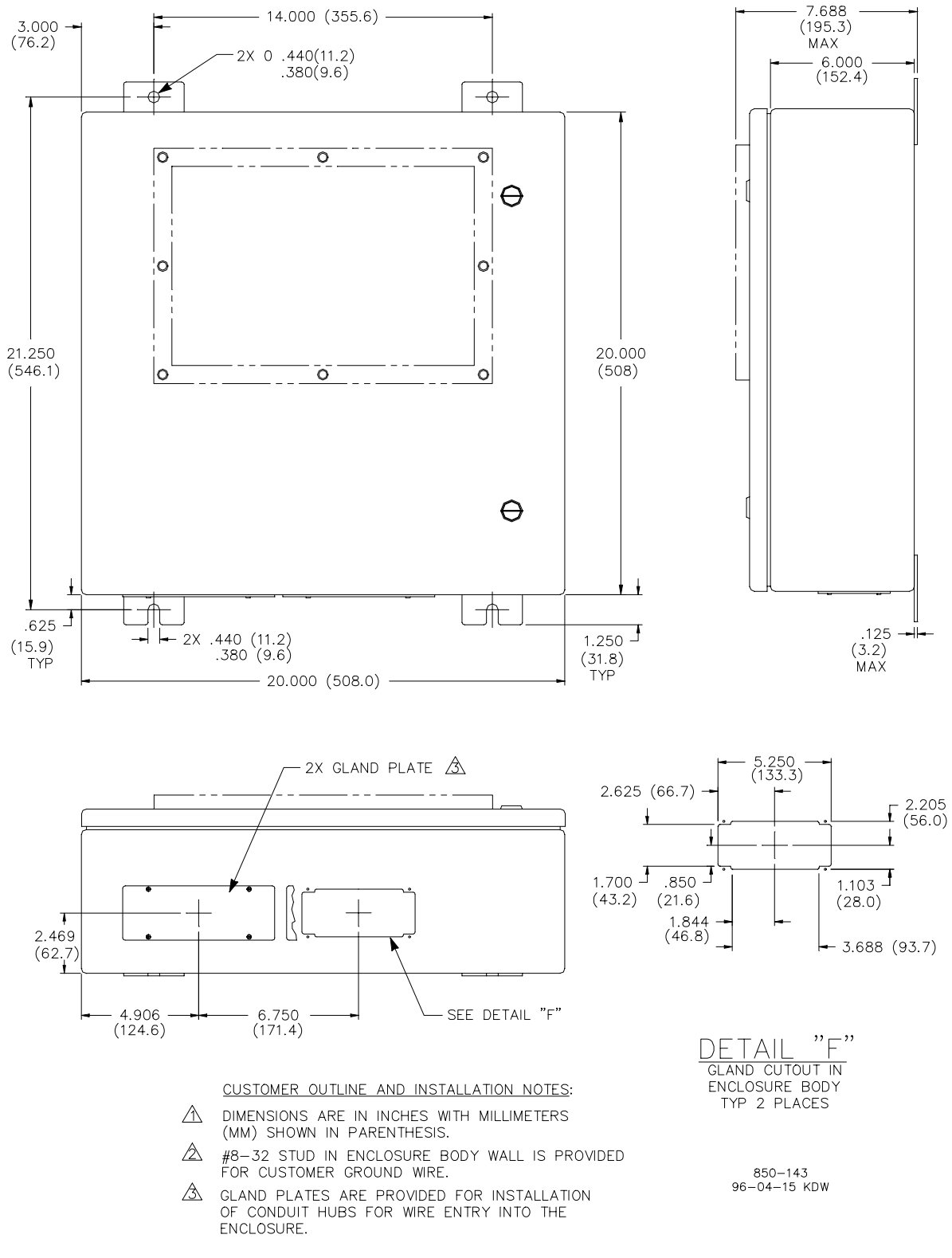

Figure 4-2. 505H Bulkhead-Mounted Enclosure

Mounting

The standard 505H enclosure must be mounted to allow sufficient room for wiring access. Eight front panel screws permit secure mounting. See Figure 4-1 for mounting dimensions. The optional enclosure permits the control to be bulkhead mounted. See Figure 4-2 for mounting dimensions. This enclosure weighs approximately 22 pounds, and has an operating range of -25° C to 60° C.

505H Hardware Jumpers

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

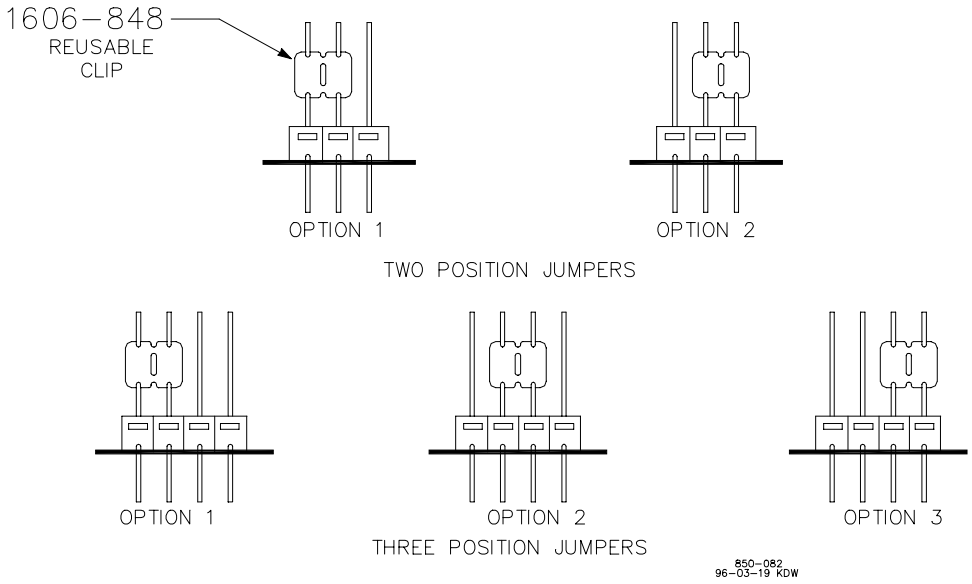

Figure 4-3. Jumper Options

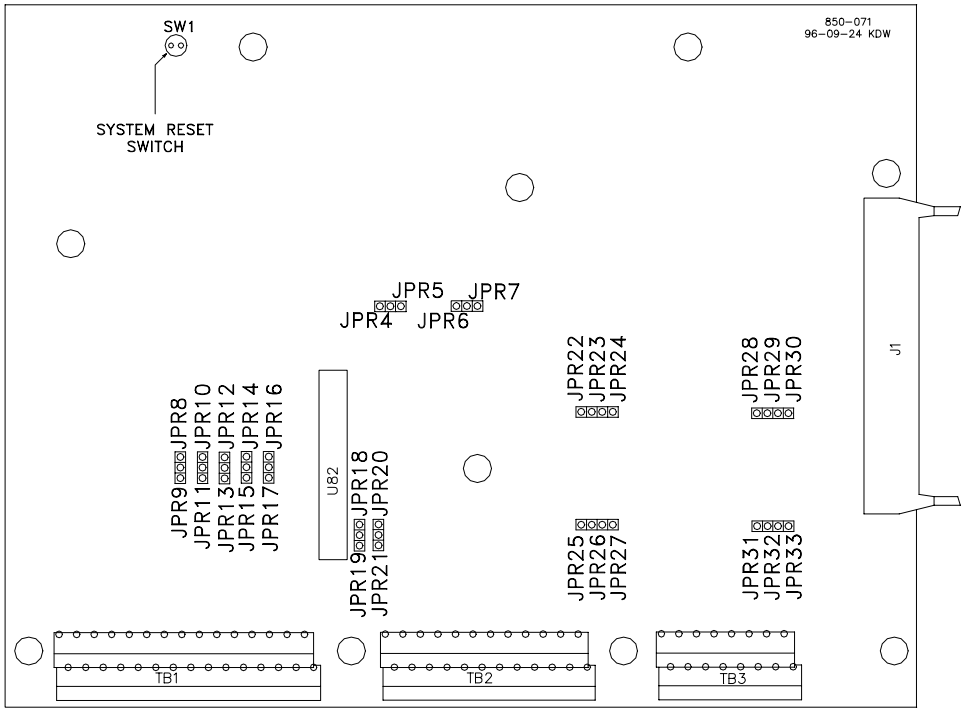

Figure 4-4. Jumper Locations

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

* = DEFAULT

Table 4-1. Jumper Options Chart

Electrical Connections

All inputs and outputs to the 505H are made via terminal blocks on the bottom of the 505H flush mount unit. For EMI reasons, it is recommended that all low-current wire (terminals 52 through 121) be separated from all high-current wire (terminals 1 through 51). Refer to Figure 4-7 for a representative I/O interface schematic, and appendix E for hardware specifications.

The terminal blocks are screwless "CageClamp" style blocks. The spring clamp can be actuated by using a standard 3mm or 1/8in flat bladed screwdriver or a snap-on thumb lever (Figure 4-5). Two snap-on thumb levers are provided with the 505H unit. The 505H terminal blocks accept wires from 0.08-2.5mm (27-12 AWG) wire. Two 18 AWG or three 20 AWG wires can be installed in each terminal.

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

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

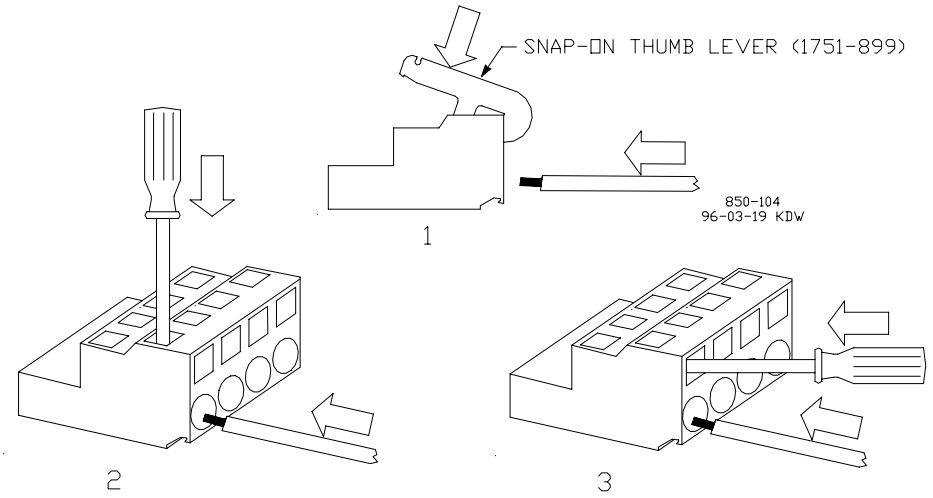

Figure 4-5. CageClamp Terminal Blocks

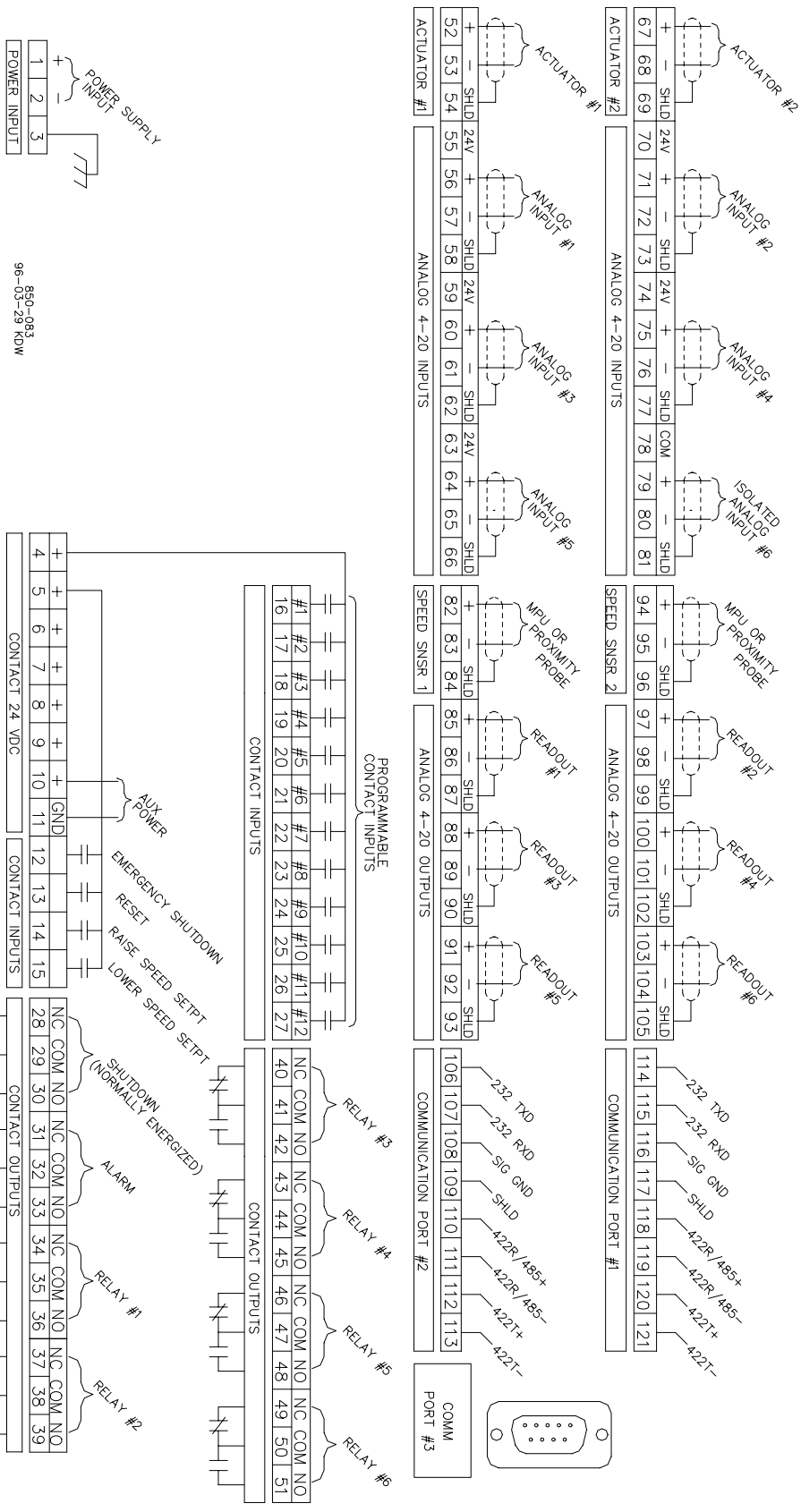

Figure 4-6. Control Wiring Diagram

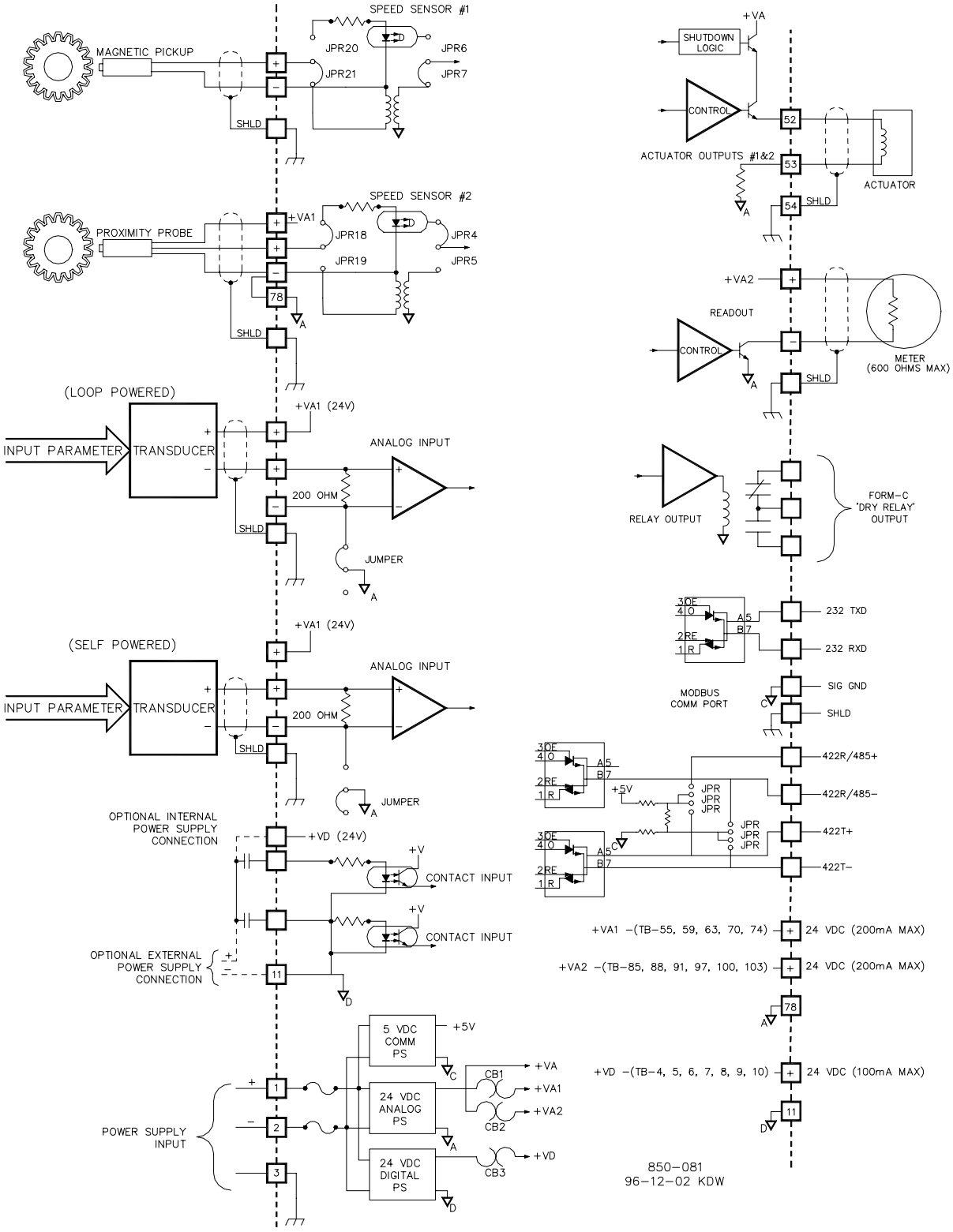

Figure 4-7. Representative 505H I/O Schematic

Power Supplies

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

Internal fuses, in series with each input power trace, are used to protect the 505H's input circuitry. All fuses are rated as slow-blow type fuses. These fuses are accessed by taking the 505H's back cover off and are located on its power supply module (bottom module). Refer to Figure 4-8 for fuse locations.

A power supply is built into the 505H to provide power to external transducers or devices. This supply is split into two breaker-protected power sources, each capable of providing 24VDC +/- 10% @ 200 mA. One power source is provided to power current inputs and auxiliary devices. Connections to this source can be made through terminals 55, 59, 63, 70, and 74. The second power source is provided to power current outputs and auxiliary devices. Connections to this source can be made through terminals 85, 88, 91, 97, 100, and 103. Terminal 78 is the 0VDC reference (common) for both power sources. Refer to Figure 4-7.

WARNING

Neither the total current draw through terminals 55, 59, 63, 70, and 74 nor the total current draw through terminals 85, 88, 91, 97, 100, and 103 can exceed 200mA or the 505H's internal power supply breakers (CB1 or CB2, respectively) will open resulting in a possible CPU reset and trip condition. All load must be removed from the specified terminals to allow the breaker to reset.

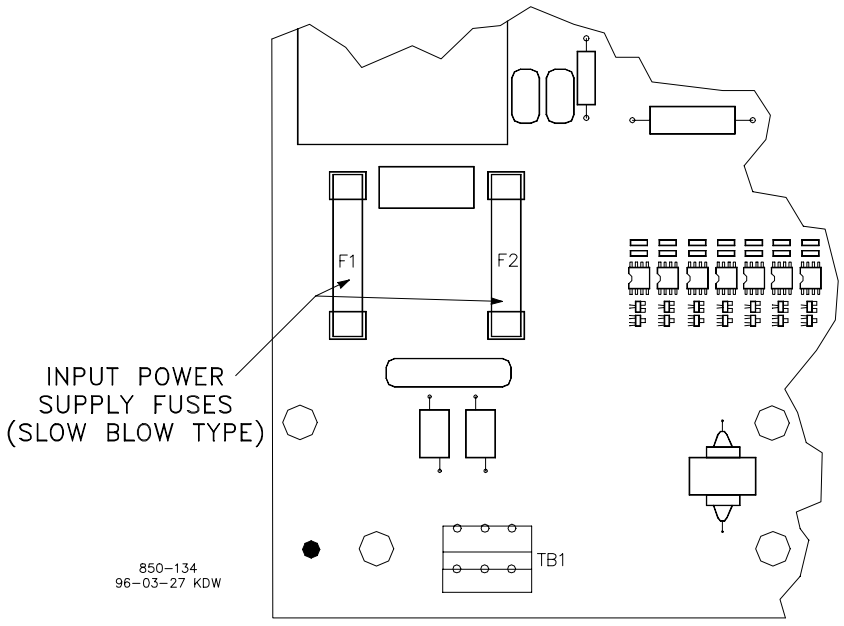

Figure 4-8. Fuse location

Shields & Grounding

An individual shield termination is provided at the terminal block for each of the speed sensor inputs, actuator outputs, analog inputs, analog outputs, and communications ports. All of these inputs should be wired using shielded, twisted-pair wiring. The shields should be connected to earth ground at all intermediate terminal blocks, as well as terminated at the control terminal block. The exposed wire length, beyond the shield, should be limited to one inch. Relay outputs, contact inputs, and power supply wiring do not normally require shielding, but can be shielded if desired. The input power ground terminal (terminal 3) should be wired to external ground. Refer to Figure 4-6.

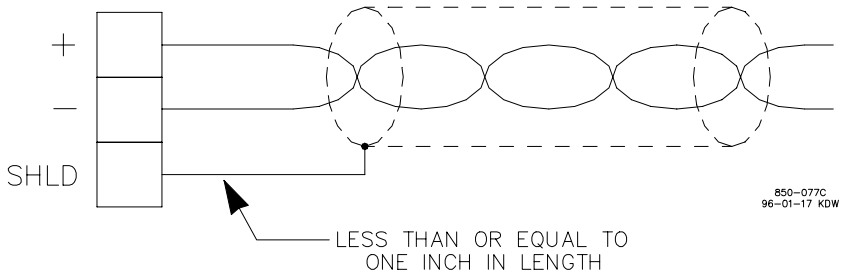

Figure 4-9. Shielded Wire Connections

Speed Sensor Inputs

To sense speed, the control accepts signals from one or two passive magnetic pickup units (MPUs) or active proximity probe inputs. Because of the differences between passive MPUs and active proximity probes, and the sensing circuits required for each type, jumpers are provided to allow field configuration of each speed input depending on the type of probe used. See Table 4-1 for jumper options, and Figure 4-4 for jumper locations. Verification of jumper location is recommended before system startup or operation. See appendix E for hardware specifications.

An application may use two of the same type of speed probes, or two different types of speed probes, i.e. one MPU and one proximity probe. The two 505H speed sensing inputs can be configured to accept different frequency values or the same frequency values. Thus if two speed probes are used which are sensing gear tooth passings off the same gear the programmed rated frequency value for each probe must be the same.

The 505H software has deadband filtering for each input that is configurable (see configure mode). If a proximity probe (ZVPU) is used in conjunction with a PT speed input, the speed sensing can be switched between inputs based on speed. The speed of switching between inputs is configurable (see configure mode – Speed Input SW Speed). Typically, speed input #1 is set up as a PT and input #2 is a ZVPU. On a start, the 505H will use the ZVPU. When the turbine speed reaches the "Speed Input SW Speed", it switches to speed input #1 (PT) as the controlling speed. If either speed signal is failed, the remaining input is used as the controlling speed and the unit does not shutdown.

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

NOTE
The maximum rated frequency that the speed signal input can accept is 10,000 Hz. This value is limited at the configuration stage.

Contact Inputs

Contacts must change state for a minimum of 120 milliseconds for the control to sense and register a change in state. All contact inputs accept dry contacts. Contact wetting voltage is available through terminals 4,5,6,7,8,9, and 10; or an external 18-26 VDC power source can be used. In this case terminal 11 (contact input common) must be connected to the external power source's common to establish a common reference point. See Figures 4-3 & 4-4 for wiring information, and Appendix E for input specifications.

Analog Inputs

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

Because inputs 1-5 are not fully isolated, care must be taken in their application and maintenance to avoid "ground-loop" type problems. If interfacing to a non-isolated device with one of these inputs, the use of a loop isolator is recommended to break any return current paths, which could result in erroneous readings.
Analog input #6 is a fully isolated input and is designed to be used with a non-isolated source such as a Distributed Control System (DCS). This input does not use or have jumpers for hardware configuration options. Refer to Figure 4-7, Option #1 for correct wiring configuration

NOTE
The 505H's input impedance for all analog inputs is 200 ohms.

Analog Outputs

Applications using the 505H current outputs must have the desired analog value assigned or configured to a specific output. There is a choice of six possible 4-20mA output drivers which can be used to display a parameter externally. The analog output connections for the 505H are shown in Figure 4-7.
.

NOTE
The 505H's analog outputs can drive into a maximum of 600 ohms.

Actuator Outputs

Two actuator outputs are available and programmable to interface with actuators requiring either 4-20mA or 20-160mA drive currents.

Each actuator output can be individually configured to interface with either type of actuator. Actuator drive current is selected in the Configure Mode. Maximum impedance for each 4-20mA actuator output driver is 360 ohms

(actuator impedance + wire resistance). Maximum impedance for each 20-160mA actuator output is 45 ohms (actuator impedance + wire resistance).

Each actuator driver senses the drive current to allow over- and under-current shutdowns. The 505H can be configured to use one or two actuators. Actuator #1 is dedicated to the actuator driving the hydraulics for the gate servomotor. Actuator #2 is dedicated to the actuator driving the hydraulics for the blade servomotor.

Relay Outputs

There are eight relay outputs available from the 505H. All relay contacts are Form C type contacts. The output ratings are given in appendix E. Before installation verify that the 505H's relay contacts meet the power requirements of the circuit with which it is being interfaced. Interposing relays are required, in cases where the interfaced circuit demands relay contacts with a higher power rating. If interposing relays are required, it is recommended that interposing relays with inductive kick-back protection be used. Improper connection could cause serious equipment damage.

Serial Communications

There are three serial communications ports on the 505H. Figures 4-12, 13, and 14, show the communications port connections for ports #1, #2, and #3. Ports one and two are for Modbus communications and can be configured for RS-232, RS-422, or RS-485 communications. These communication lines are connected to ports one and two though terminal blocks located on the back of the 505H. RS-422 and RS-485 communication lines can function up to a length of 4000 feet Refer to Chapter 8 for a list of all the commands and parameters available through ports one and two.

The third port, an RS-232 port, uses a 9-pin Sub-D connector to interface to, and is dedicated for communication with a computer for uploading and downloading unit configuration values. See Figure 4-10. An RS-232 line is limited to approximately 50 feet in length. See Figure 4-11 for the RS-232 protocol.

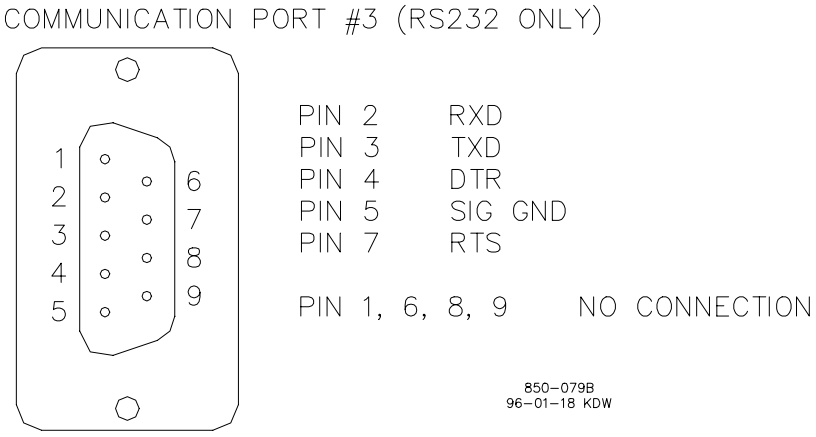

Figure 4-10. Communications Port #3 Connections

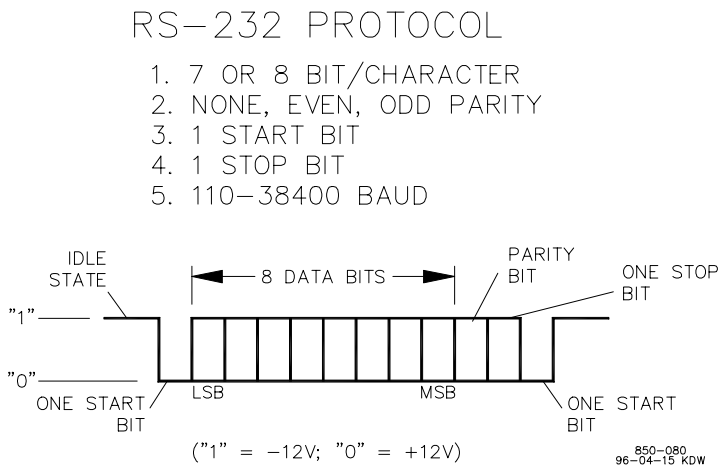

Figure 4-11. RS-232 Protocol

Modbus Port Wiring

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

RS-232 Wiring. A RS-232 link is limited to a distance of 50 feet. The 505H control utilizes terminal blocks 114-117 and 106-109 for RS-232 connections. Figure 4-12 shows typical RS-232 communications connection. The transmit data (TXD), receive data (RXD), and signal ground (SIG GND) must be properly connected as shown. In addition the shield (SHLD) should be connected in at least one location..

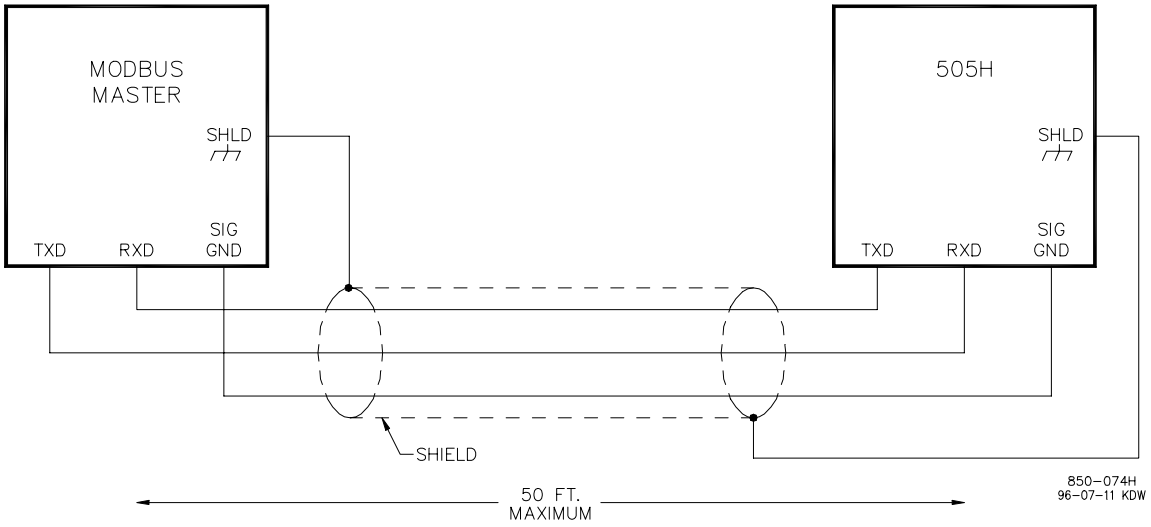

Figure 4-12. Typical RS-232 Communications

RS-422 Wiring. An advantage of RS-422 is that it uses a differential voltage and can accommodate much longer transmission distances. A RS-422 link can communicate up to a distance of 4000 feet. The 505H control utilizes terminal blocks 108-113 and 116-121 for RS-422 connections. Figure 4-13 shows a typical RS-422 communications connection. The transmit data pairs (422T+ and 422T-), receive data pairs (422R+ and 422R-), and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505H control has termination resistors built-in. See the jumper option chart (Table 4-1) to connect the termination resistor.

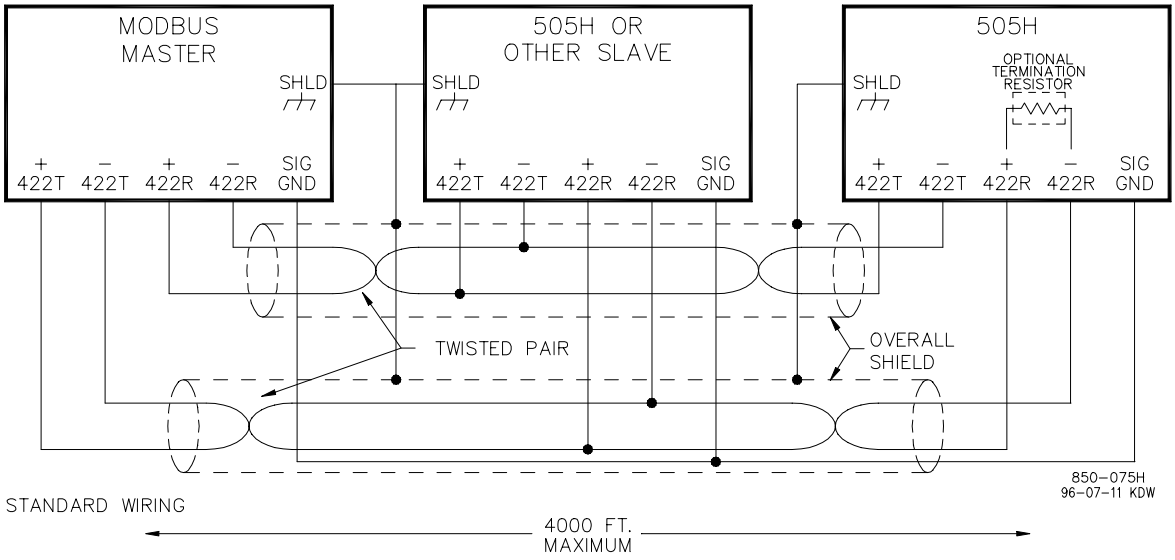

Figure 4-13. Typical RS-422 Communications

RS-485 Wiring. RS-485 can also accommodate transmission distances of up to a distance of 4000 feet. The 505H control utilizes terminal blocks 108-111 and 116-119 for RS-485 connections. Figure 4-14 shows a typical RS-485 communications connection. The data lines (422R+/485+ and 422R-/485-) and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the Modbus network chain, and only the last unit, should have it's receiver terminated with a resistor. The 505H control has termination resistors built-in. See the jumper option chart (Table 4-1) to connect the termination resistor.

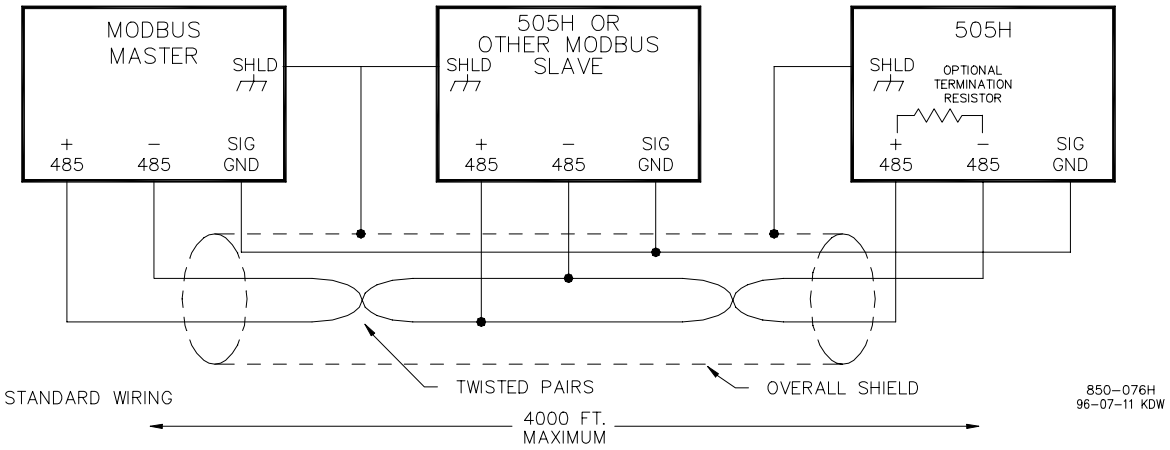

Figure 4-14. Typical RS-485 Communications

COMMUNICATIONS GROUNDING AND SHIELDING

All three 505H communications ports are fully isolated from earth ground. The RS-422 and RS-485 specifications state that a ground wire is needed if there is no other ground path between units. the preferred method to do this for isolated ports is to include a separate wire in the ground cable that connects the circuit grounds together. Connect the shield to earth ground in at least one location, see Figure 4-15.

Non-isolated nodes may not have a signal ground available. If signal ground is not available, use the alternate wiring scheme as shown in Figure 4-16. The alternate way is to connect all circuit grounds of isolated nodes to the shield, and then connect the shield to earth ground at a non-isolated mode.

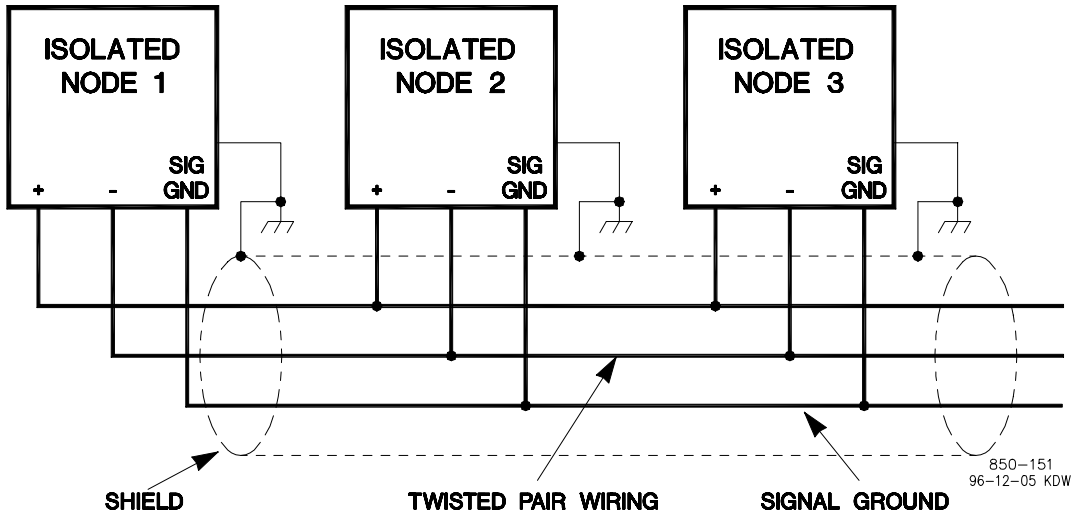

Figure 4-15. Preferred Multipoint Wiring Using Shielded Twisted-Pair Cable with a Separate Signal Ground Wire

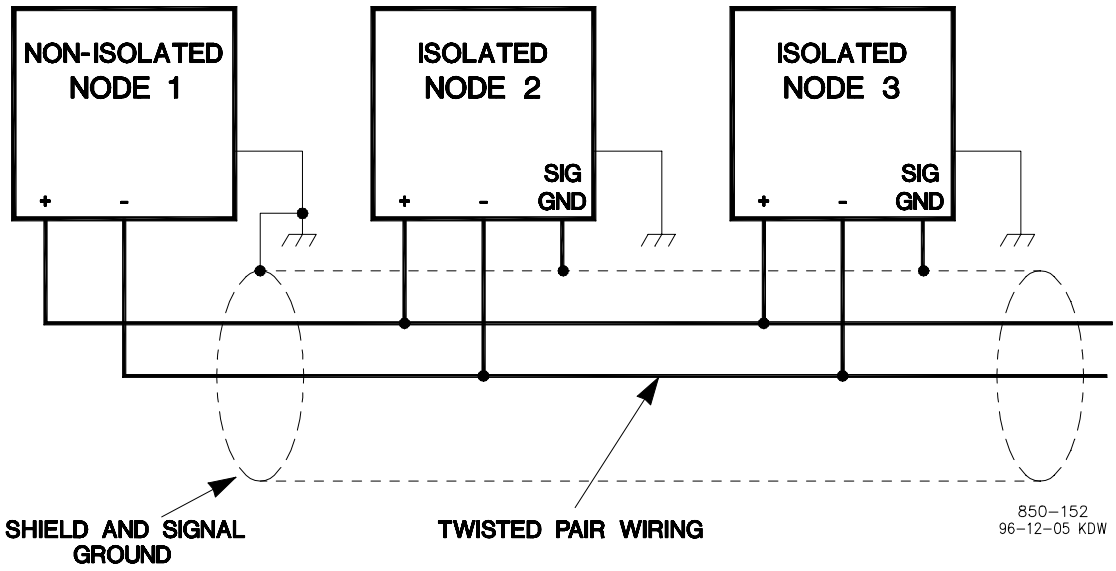

Figure 4-16. Alternate Multipoint Wiring Using Shielded Twisted-Pair Cable Without a Separate Signal Ground Wire

Chapter 5
505H Control Description

Introduction

The 505H is a very modular control. The functional block diagram (Figure 3-1) is drawn to show the modular design of the control. We will now break out the modular blocks and describe them first, at a conceptual level; followed by a detailed description of features unique to the different areas.

INPUT INTERFACE

The input interface is perhaps one of the most layered modules in the control. This is because several of the inputs can come from any of three different sources, and inputs from different sources can control three different sections of the 505H. This portion is covered under the Control Input section.

There are also some additional inputs which can come from only one source, but also control certain events within the control. These are covered in the Signal Input section.

Also covered within this section is the Speed Sensor. There is some additional logic on top of the speed sensing algorithm which may dictate that it be given a category of its own. But for the sake of simplicity, we will include it in the Input Interface. The speed signal feeds several parts of the control, as is shown with the Input Interface.

Control Input

The control input, as depicted in Figure 5-1, is the input used to control a given section of the 505H. As was mentioned above, this input can be one of three signals: a keypad input, a contact input, or the Modbus input.

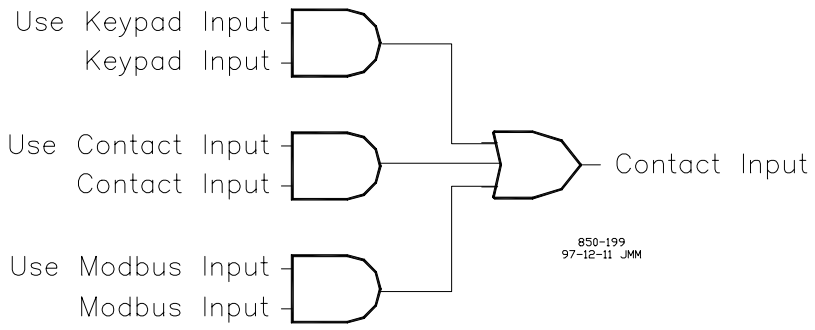

Figure 5-1. 505H Control Input

Keypad Input. The keypad input is a control signal received from the keypad. This includes the Start key, the Stop key, the F1 through F4 keys, along with the Reset key. In general, based on the current information displayed on the screen, certain functions will cause certain events to occur within the 505H. Chapter 7 presents a detailed discussion of the control of various events within the 505H.

Contact Input. The contact input is a control signal received from one of the discrete input terminals on the back of the 505H. Configuration of the contact inputs is performed in the Program Mode (see Chapter 6). The contact inputs are determined via a series of multiplexers, as there are more control input signal available than there are discrete inputs. Care must be taken that to not overutilize the control, thus falling short of the required number of control inputs to operate your unit as desired. Examples of the available contact inputs which fall under the control input category are given in Table 5-1.

Enable/Disable External SP	Selects/Switches Setpoint Control from External Analog Value to Keypad or Contact Inputs
Droop Ref Enable	Select Droop Reference as the input to the Speed Control.
Gate Limit Lower	Lower/decrease the Gate Limit.
Gate Limit Raise	Raise/increase the Gate Limit.
Gate Ref Enable	Select Gate Reference as the input to the Position Control.
Isoch Ref Enable	Select Isochronous Reference as the input to the Speed Control.
Level Ref Enable	Select Level Reference as the input to the Position Control.
Loadsharing Enable	Select Loadsharing Reference as the input to the Speed Control.
Manual Control Enable	Select gate Manual Control.
Power Ref Enable	Select Power Reference as the input to the Position Control
Run/Stop (Maintained)	Maintained run/stop input to the Run/Stop Logic.
Start (Momentary)	Momentary start input to the Run/Stop Logic.
Stop (Momentary)	Momentary stop input to the Run/Stop Logic.

Table 5-1. Control Contact Inputs

Modbus Input. The Modbus input is a control signal received from one of the two Modbus ports. Both Modbus ports operate in parallel, meaning that the last signal received is the signal which determines the actual course of action for the control. All Modbus inputs are converted to pulses, and all control inputs from the Modbus port are both positive and negative edge triggered.

If speed deadband is enabled and Modbus priority is selected, then speed deadband can be adjusted over Modbus.

Control Interface. The control source, as depicted in Figure 5-2, is the actual source of the control input. As was mentioned above, there are three different sections of the 505H which can be controlled from three different sources: the start/stop logic, the auto/ manual logic, and the operating logic.

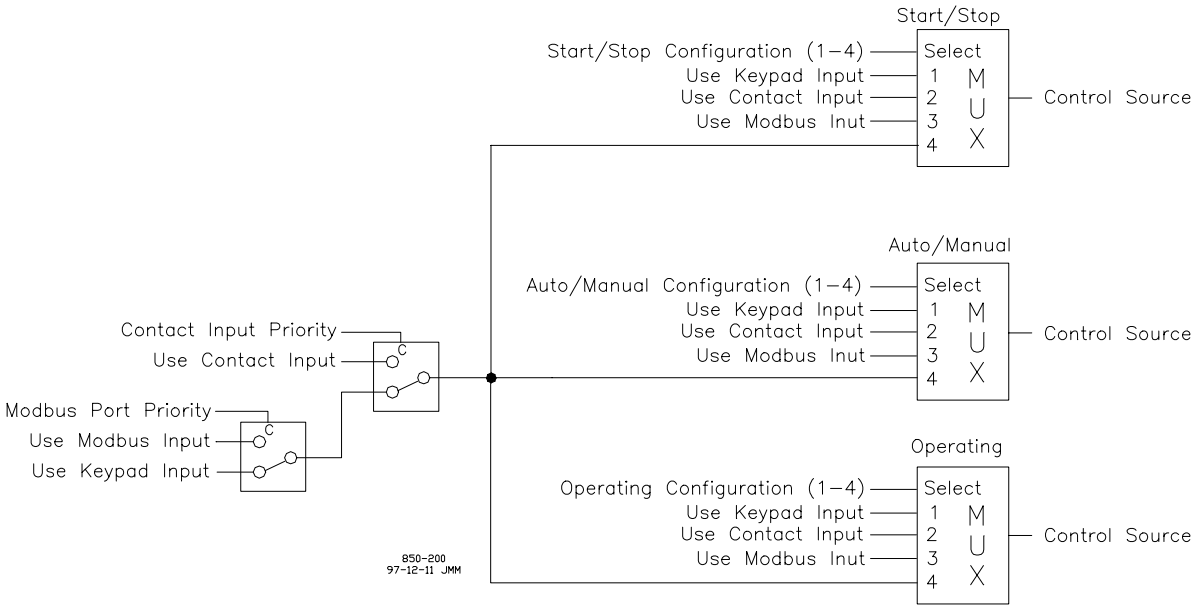

Figure 5-2. 505H Control Source

The Start/Stop Logic is the logic involved in starting and stopping the unit. The Auto/Manual Logic is the logic involved in selecting and operating the integrated manual gate control. However, Blade Manual Control selection can only be performed via the keypad. The Operating Logic is the logic involved in normal operation of the unit. This includes Governor Reference selection, raising and lowering of the setpoints, etc. The configuration for each of the control sources is done in the Program Mode. Selection of the Priority Select Lines necessitates that you configure your contact input signal(s) for Contact Input Priority and/or Modbus Port Priority. Omitting this configuration will result in your using strictly the keypad input to control the unit.

The load sharing analog input, used for synchronization, is disabled when Contact Input Priority is selected ("Use Contact Input" DI is True).

Signal Input

Signal inputs are limited to special contact inputs which serve unique purposes within the control, along with all of the analog inputs. These signals are always available to the control and always cause some event within the control.

Contact Input. Table 5-2 gives a list of all of the contact inputs which fall under the category of signal inputs. The signals are listed as they appear on the front screen of the 505H during Program Mode.

Blade Lock Enable	Lock the blades at their current location. See Blade Control.
Blade Tilt Enable	Position the blades at a preprogrammed position. See Blade Control.
Contact Input Priority	Select contact inputs for 505H via the Control Interface.
Creep Input #1	Input #1 for the Creep Detection logic.
Creep Input #2	Input #2 for the Creep Detection logic.
Generator Breaker	Contact indicating the generator breaker is closed. See Status Engine.
Modbus(R) Port Priority	Select Modbus port for 505H control via the Control Interface.
Position Control Select	Select Position Control for Governor Operation in the on-line statuses.
Start Permissive	External start permissive (from gate lock, etc.). See Status Engine.

Table 5-2. Signal Contact Inputs

Analog Input. Table 5-3 gives a list of all of the analog inputs available within the 505H. The signals are listed as they appear on the front screen of the 505H during Program Mode. All analog inputs are considered valid within the default range of 2-22 mA. The min and max values on the analog inputs are tunable from Debug. The signal failure will occur any time the input value is detected to be above or below the min or max value. A delay time on the signal latch can be tuned from Debug. The analog input signals also have signal filtering that can be adjusted from Debug (refer to Debug in Chapter 10). Offset and gain adjustments are available for all analog inputs. See Appendix B for more information.

Blade Position Signal	Position Feedback used by Blade Control.
Ext Blade Manual Setpoint	External Signal for the blade Manual Control.
Ext Gate Manual Setpoint	External Signal for the gate Manual Control.
External Gate Setpoint	External Signal for the Gate Reference.
External Level Setpoint	External Signal for the Level Reference.
External Power Setpoint	External Signal for the Power Reference.
External Speed Setpoint	External Signal for the Droop Reference.
Forebay Level Signal	Forebay input used by either the Level Reference or Blade Control.
Gate Position Signal	Gate Position feedback signal used by most of the Governor References in the Droop Logic.
Loadsharing Signal	External Signal for the Loadsharing Reference.
Net Head Signal	Net head signal used by Blade Control.
Power Level Signal	Power input used by the Power Reference.
Tailbay Level Signal	Tailrace input used by either the Level Reference or Blade Control.

Table 5-3. Analog Inputs

Speed Sensor

The Speed Sensor takes a speed input from one of two sources (MPU or PPU) and converts it into a usable signal within the control. If you notice, several of the Program Mode values are set in terms of percentage of rated speed. This is because the Governor Operation is performed based on percentage of rated speed.

The Speed Sensor receives a signal from the external device, and using the rated frequency, is able to determine the percentage of rated speed of the turbine. In the event that the speed detected by one of the speed inputs drops below 4% speed or goes above 200% speed, a speed signal failure is generated by the control. In the event that all used speed input channels have failed, an Emergency Shutdown is issued due to a Speed Sensor Failure.

The underfrequency condition (less than 4% of rated speed) is disabled during the Unit Shutdown, Unit Stop, and Waiting For Prestart statuses (see Status Engine). It is also disabled when the Wide Speed Range is enabled. Also, there is a adjustable delay called Fail Time #X (Chapter 6) which is used to determine how long after attaining the Unit Breakaway status before a speed signal must be detected.

OUTPUT INTERFACE

The output interface describes what signals are available and where they are available. In general, both the front display of the 505H and Modbus port are capable of displaying all of the necessary information all of the time. The only sections of the output interface which is of any consequence are the Analog Readout and Relay Output sections. These pertain to the hardwired signal outputs from the 505H.

In either case, the number of outputs provided is fewer than the number of available options. Thus, your application must not require more output signals than are available from the 505H. Any Analog Readout or relay output can be brought out to any or all of the analog outputs or discrete outputs, respectively. Thus, you can have up to six independent unit speed indications, if desired. Tables 5-4 and 5-5 list options for the relay outputs and analog readouts, respectively.

Relay Output

There are two dedicated and six configurable relay outputs available on the 505H. The two dedicated relay outputs are Alarm and ESD (normally energized) signals. Table 5-4 lists all of the signals which can be configured to be sent to any of the configurable relay outputs. The Alarm and ESD (normally energized) signals can be programmed to be used on the configurable relay outputs, also.

Gate Ref In Control	Signal indicating Gate Reference is presently controlling the unit.
Isoch Ref In Control	Signal indicating Isochronous Reference is presently controlling the unit.
Level Ref In Control	Signal indicating Level Reference is presently controlling the unit.
Loadsharing In Control	Signal indicating Loadsharing Reference is presently controlling the unit.
Manual Ref. In Control	Signal indicating the unit is presently in gate Manual Control.
Overspeed Trip	Signal indicating the unit speed has exceeded the Overspeed Trip speed.
Power Ref In Control	Signal indicating Power Reference is presently controlling the unit.
Reset	Signal indicating the Reset Logic has been activated.
Shutdown Indication	Signal indicating the unit has attained the Unit Shutdown status. See Status Engine.
Synchronizer Enable	Signal Indicating the 505H is Ready To Synchronize. See Status Engine.
Waiting For Prestart	Signal indicating the 505H is Waiting For Prestart. See Status Engine.

Table 5-4. Relay Output Options

Analog Readout

Table 5-5 gives a list of all of the Analog Readouts available within the 505H. The signals are listed as they appear on the front screen of the 505H during Program Mode. All Analog Readouts are limited to 4-20mA. Offset and gain adjustments are available for all Analog Readouts. See Appendix B for more information.

Blade Position	Readout of the blade position.
Forebay Level	Readout of the forebay level.
Gate Limit	Readout of the gate limit.
Gate Position	Readout of the gate position.
Gate Setpoint	Readout of the gate setpoint.
Level Setpoint	Readout of the level setpoint.
Power Level	Readout of the power output.
Power Setpoint	Readout of the power setpoint.
Speed Setpoint	Readout of the speed setpoint.
Tailbay Level	Readout of the tailbay level.
Unit Speed	Readout of the unit speed.

Table 5-5. Analog Readout Options

ALARM LOGIC

The unit alarms are captured in a first-in, first-out manner. All alarms are latched in. To clear any alarms which are no longer present, issue a reset command to the 505H. Table 5-6 gives a list of all of the potential alarms within the 505H, along with the cause. The alarms are listed as they appear on the front screen of the 505H when an alarm occurs.

Blade Driver Failed	The blade Output Driver signal failed.
Blade Manual Sig Failed	The Analog Input programmed for External Blade Manual Setpoint failed.
Blade Manual Trouble	The Governor Reference used for blade Manual Control detected an alarm.
Blade Position Failed	The Analog Input programmed for Blade Position Signal failed.
Comm Link #1 Failed	Modbus communications link #1 failed - timeout error. See Chapter 6.
Comm Link #2 Failed	Modbus communications link #2 failed -timeout error. See Chapter 6.
Droop Reference Trouble	The Governor Reference used for Droop Reference detected an alarm.
Emergency Shutdown	The ESD Logic detected an Emergency Shutdown condition.
Forebay Signal Failed	The Analog Input programmed for Forebay Level Signal failed.
Gate Reference Trouble	The Governor Reference used for Gate Reference detected an alarm.
Gate Driver Failed	The gate Output Driver signal failed.
Gate Limit Trouble	The Governor Reference used for Gate Limit detected an alarm.
Gate Manual Sig Failed	The Analog Input programmed for External Gate Manual Setpoint failed.
Gate Manual Trouble	The Governor Reference used for gate Manual Control detected an alarm.
Gate Position Failed	The Analog Input programmed for Gate Position Signal failed.
Gate Setpoint Failed	The Analog Input programmed for External Gate Setpoint failed.
Gate Tracking Error	Gate Position Demand and Gate Position Feedback difference exceeds a configurable tolerance.
Isoch Reference Trouble	The Governor Reference used for Isochronous Reference detected an alarm.
Level Reference Trouble	The Governor Reference used for Level Reference detected an alarm.
Level Setpoint Failed	The Analog Input programmed for External Level Setpoint signal failed.
Loadshare Signal Failed	The Analog Input programmed for Loadsharing Signal failed.
Loadsharing Trouble	The Governor Reference used for Loadsharing Reference detected an alarm.
Net Head Signal Failed	The net head signal failed. See Appendix A.
Overspeed Trip	The unit speed exceeded the Overspeed Trip speed.

Power Reference Trouble	The Governor Reference used for Power Reference detected an alarm.
Power Setpoint Failed	The Analog Input programmed for External Power Setpoint.
Power Signal Failed	The Analog Input programmed for Power Level Signal failed.
Speed Sensor #1 Failed	Speed Input #1 of the Speed Sensor failed.
Speed Sensor #2 Failed	Speed Input #2 of the Speed Sensor failed.
Speed Setpoint Failed	The Analog Input programmed for External Speed Setpoint failed.
Tailbay Signal Failed	The Analog Input programmed for Tailbay Level Signal failed.

Table 5-6. Alarm Message

GATE TRACKING ERROR

This alarm occurs when the Gate Position Demand and Gate Position Feedback difference exceeds a configurable tolerance. The default error difference is 4%. The difference value is tunable from Debug.

RUN/STOP LOGIC

The Run/Stop Logic translates your signals into the 505H's starting and stopping the unit. Certain safeguards are put into here to insure that the unit cannot start unless it is properly configured, along with preventing a unit start while the 505H is in calibration mode. If there is any emergency shutdown condition with the 505H, the unit also automatically shuts down.

Via the keypad, the run and stop commands are generated with the run and stop keys, respectively. Likewise, through the Modbus port, there are addresses dedicated to the run and stop commands. The contact inputs, however, offer a little more flexibility. You can either program the control to use a maintained contact input indicative of the run and stop commands { Run/Stop (maintained)} or you can program two independent contacts { Start (momentary) and Stop (momentary)} to provide momentary start and stop signals to the control.

ESD LOGIC

The ESD Logic looks at various parameters throughout the 505H, and if one of these parameters meets the emergency shutdown requirement, an emergency shutdown is issued. Table 5-7 gives a list of the parameters which are monitored to determine an emergency shutdown condition. Four of these conditions are determined by external inputs, while the remaining are determined by internal conditions within the 505H. The external contact input and pushbutton emergency stop are always active. The two communication link emergency shutdowns are active only if the respective communications port is selected to be used. The emergency shutdown indications are captured in a first-in, last-out manner. All emergency shutdown conditions are latched in. To reset the ESSD relay, clear all shutdown conditions to the 505H, then issue a reset command. If the 505H's ESD relay has to be reset first, before external shutdowns can be cleared, configure the 505H for "Reset Clears Trip Output" (see Configuration Chapter 6).

Blade Driver Failure	The blade Output Driver signal failed.
Blade Signal Failure	The Blade Position Signal failed. See Analog Input.
Comm Link #1 Emer SD	The Emergency Shutdown was issued via Modbus port #1.
Comm Link #2 Emer SD	The Emergency Shutdown was issued via Modbus port #2.
External Emergency SD	The ESD contact input opened.
Gate Driver Failure	The gate Output Driver signal failed.
Gate Signal Failure	The Gate Position Signal failed. See Analog Input.
Overspeed Trip	The unit speed exceeded the Overspeed Trip speed.
Prestart Timer Expired	A start permissive was not received within the specified time. See Status Engine.
Pushbutton Emergency SD	The emergency shutdown pushbutton was pressed.
Speed Sensor Failure	The speed signal failed. See Speed Sensor.

Table 5-7. Emergency Shutdown Messages

STATUS ENGINE

The Status Engine is perhaps the heart of the system. The status engine gives an indication of the present status of the control, along with what options will allow the unit to proceed to a different status. Figure 5-3 shows the flowchart representative of the status engine built into the 505H, along with the signals which will cause a transition from one status to another.

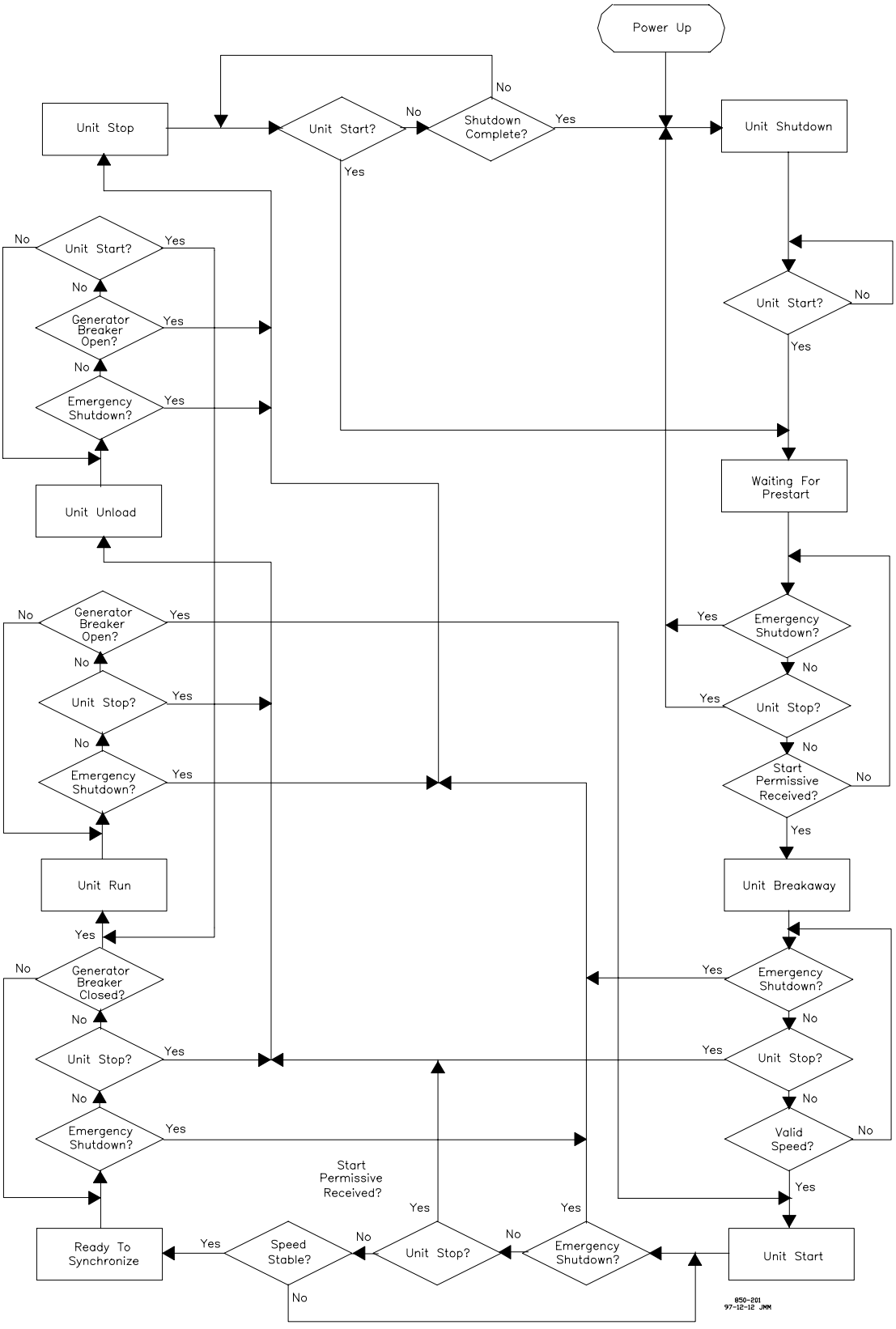

Figure 5-3. Status Engine

Unit shutdown

This is the power-up status of the 505H. The Unit Shutdown status tells the 505H that the gates are closed and the unit is at deadstop. Although this may not necessarily be the case, this is always assumed to be a safe status to bring the 505H into on power-up. If the unit is operating under manual control, it may be necessary to reissue a start command along with other commands to get the 505H status in line with the actual status of the unit. From the Unit Shutdown status, a Start Command will cause a transition to the Waiting For Prestart status.

Waiting For Prestart

After the unit has received a Start Command, the unit proceeds to the Waiting For Prestart status. In this status, the unit will, if configured to Use Start Permissive (Chapter 6), look for the Start Permissive to energize. If an Emergency Shutdown or Stop Command is received before the Start Permissive, the unit will revert to the Unit Shutdown status. If the 505H does not receive the Start Permissive within the Prestart Timeout (Chapter 6) period, an emergency shutdown is internally generated within the 505H, causing a transition to the Unit Shutdown status. If the 505H is not configured to use a Start Permissive, the Start Permissive is internally maintained, causing an immediate transition to the Unit Breakaway status.

Unit Breakaway

The Unit Breakaway status describes the time between when the gates initially open until the unit attains 10% speed. On Unit Breakaway, the Gate Limit is increased to the Breakaway Gate Limit (Chapters 6 and 7), and the 505H attempts to increase the speed to the speed setpoint (presently 20% per the Override Command Matrix). If the 505H does not receive a valid speed signal within the Speed Sensor Fail Time (Chapter 6), an Emergency Shutdown is internally generated within the 505H. An Emergency Shutdown at this point causes the unit to go into the Unit Stop status, while a Stop Command causes the unit to go into a Unit Unload status. See Manual Start.

Unit Start

The Unit Start status describes the period from when the unit has attained 10% speed until the unit is controlling at 100% speed. During this period, the turbine is ramped up to 100% speed at the Unit Acceleration Rate (Chapters 6 and 7), the Gate Limit is set to the Starting Gate Limit (Chapters 6 and 7). An Emergency Shutdown causes the unit to go into the Unit Stop status, while a Stop Command causes the unit to go into a Unit Unload status. See Manual Start.

Ready to Synchronize

The Ready To Synchronize status is a determination by the 505H that it has brought the unit up to a Stable Speed so that is can be synchronized to the bus. The 505H makes the determination by one of two methods. If the 505H is set up to Use Speed Window (Chapter 6), the unit speed must remain between the Low Speed Limit (Chapter 6) and High Speed Limit (Chapter 6) for the period of time specified in Time In Window (Chapter 6). If the 505H is not set up to Use Speed Window, the speed must remain above the Sync Enable Speed (Program) for the period of time specified in Time Above Speed (Chapter 6). From here,

indication of Generator Breaker closure causes a transition to the On Line Operation status, an Emergency Shutdown causes a transition to the Unit Stop status, and a Stop Command causes a transition to the Unit Unload status.

On Line Operation

The On Line Operation status is the normal status for unit power generation. This is the status which allows unit to control power, level, gate position, etc. This status can only be attained through a Generator Breaker closure, indicating the importance of the Generator Breaker in conjunction with the 505H. From here, an Emergency Shutdown causes a transition to the Unit Stop status, a Stop Command causes a transition to the Unit Unload status, and indication of Generator Breaker opening causes a transition to the Unit Start Status.

Unit Unload

The Unit Unload status is a special status incorporated into the 505H to allow controlled unloading of the unit. Unit Unload is identified by the following characteristics: a Stop Command is issued to the unit and the Generator Breaker is closed. In this status, the 505H forces the Governor Reference into either Droop Reference (if in Speed Control) or Gate Reference (if in Position Control) and forces the corresponding reference to ramp at the programmed Unloading Rate to the Unloading Setpoint (see the Override Command Matrix). Either an Emergency Shutdown or Generator Breaker Opening causes a transition to the Unit Stop status. Issuing a Start Command brings the 505H back to the On Line Operation status.

Unit Stop

The Unit Stop status brings all systems to a stop. The Gate Limit is set to zero, forcing the machine to coast to a stop. If a Start Command is issued while in this status, a transition to the Waiting For Prestart status occurs. We go to the Waiting For Prestart status to insure that all permissives are valid before trying to restart the unit. Once a Shutdown Complete is determined by the 505H, a transition to the Unit Shutdown status occurs. The Shutdown Complete is determined by the unit speed remaining below 20% and the gate position remaining below 2% for the Shutdown Time Delay (Chapters 6 and 7).

CONTROL SELECT LOGIC

Selection Process

As was noted under the Input Interface section, the Control Source for the 505H can be one of three locations: the keypad, contact inputs, or the Modbus port(s). Both the keypad and Modbus port inputs are assumed to be momentary Control Signals, while the contact inputs are assumed to be maintained Control Signals. If a momentary Control Signal is given, all other selections are disabled. In the case of a maintained contact, however, selection of multiple Governor References causes the one with the highest priority to be In Control. Figures 5-4 and 5-5 give simplified logic diagrams of these two interfaces. Here, the SET input forces OUT to true, causing Use Governor Reference #X to be true; while the RST input forces OUT to false, causing Use Governor Reference #X to be false.

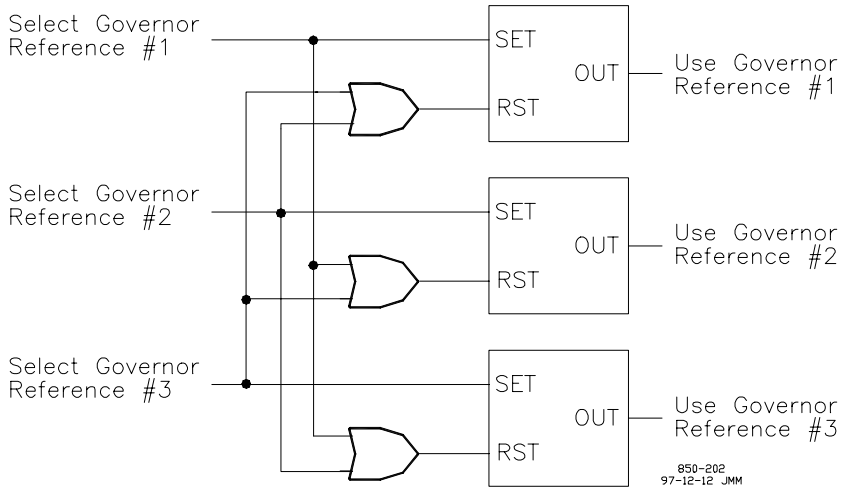

Figure 5-4. Momentary Control Signal Interface

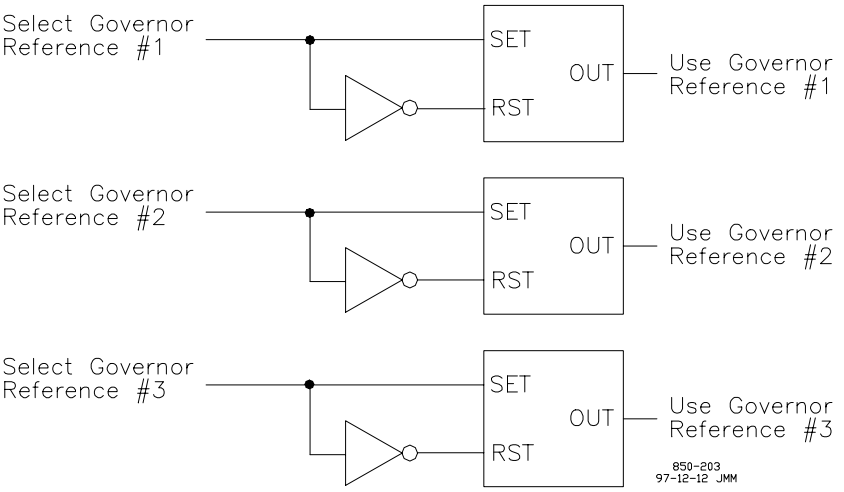

Figure 5-5. Maintained Control Signal Interface

The keypad interface is covered in chapter 8. The Modbus interface is covered in Chapter 9. The contact input interface is done by selecting the proper contact inputs from the list of available Signal Inputs (Table 5-2).

Override Command

An Override Command bypasses the Selection Process shown above and forces a particular Governor Reference to be used. Override Commands are determined by the Status Engine. When the unit is in any of the off line statuses, the unit is forced into Speed Control using the Isochronous Reference (these are both described below). Any governor control or reference selection is overridden during this period. Another time when the operator selection is overridden is during the Unit Unload status. At this point, the unit is forced to use either the Droop Reference (if operating in Speed Control) or Gate Reference (if operating in Position Control). The complete list of command overrides is shown in Figure 5-6 below.

STATUS	SPEED			POSITION			LIMIT		
	Override	Signal	Rate	Override	Signal	Rate	Override	Signal	Rate
Waiting For Prestart	Yes	20	1000	X	X	X	Yes	0	1000
Unit Breakaway	Yes	20	1000	X	X	X	⎍	*g	1000
Unit Start	*a	100	*c	X	X	X	⎍	*h	1000
Ready to Synchronize	No	X	X	X	X	X	No	X	X
On–Line Operation	No	X	X	No	X	X	⎍	*j	1000
Unit Unload	Yes	*b	*d	Yes	*e	*f	No	X	X
Unit Stop	Yes	20	1000	X	X	X	Yes	0	1000
Unit Shutdown	Yes	20	1000	X	X	X	Yes	0	1000

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Figure 5-6. Override Command Matrix

The key to the Override Command Matrix is given in Table 5-8.

*a Extended Speed Range is disabled.
*b The Override Position under Droop Reference.
*c The Override Rate under Isochronous Reference during Unit Start.
*d The Override Rate under Droop Reference.
*e The Override Position under Gate Reference.
*f The Override Rate under Gate Reference.
*g The Override Position under Gate Limit during Unit Breakaway.
*h The Override Position under Gate Limit during Unit Start.
*j The Override Position under Gate Limit during On Line Operation.
X Don't care whether value is Yes or No.
A pulse indicating a transition to this status.

Table 5-8. Key to Override Command Matrix

GOVERNOR OPERATION

Governor Control

This is a general description of a Governor Control. Following this are detailed descriptions of each Governor Control used within the 505H. A Governor Control is a software device which determines a signal to be sent to the Governor Dynamics based on the Mode Select Logic. Each Governor Control has any number of Governor References feeding it. This is depicted in Figure 5-7. The Governor Control is priority based, with the Governor Reference with the highest value getting the priority. Thus, if Governor Reference #1 and Governor Reference #3 both request to be used, Governor Reference #3 is used because it has higher priority.

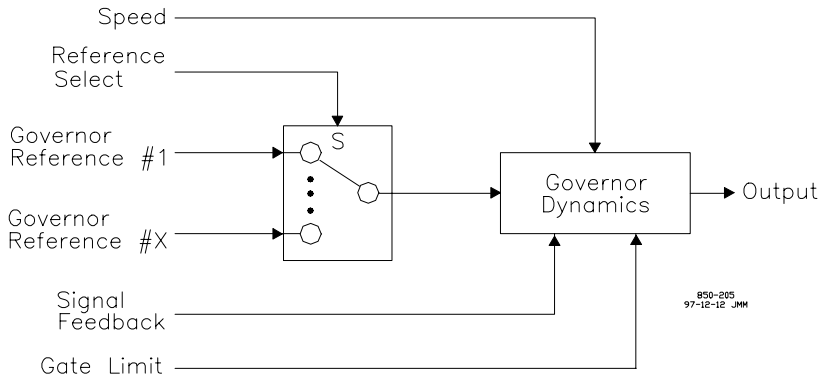

Figure 5-7. Governor Control Block Diagram

Governor Reference

This is a general description of a Governor Reference. Following this are detailed descriptions of each governor reference used in the 505H. A governor reference is a software device which can be adjusted either via operator intervention or the 505H control. A governor reference has four operating modes. Any failure condition causes the Governor Reference to disable itself, thus sending a signal to the Governor Control saying that it can no longer function.

Follow Mode. This mode is selected when the Governor Reference is not In Control. In this mode, the Governor Reference follows the output of the Governor Control. The Governor Reference is put into Follow Mode to insure that if it becomes the controlling reference for the governor, it will be in the correct position to allow for a Bumpless Transfer from one Governor Reference to another. In the Follow Mode, the Governor Reference moves at an instantaneous rate, meaning that it always tracks the output of the Governor Control.

Override Mode. This mode is selected when the Governor Reference is In Control. In this mode, the Governor Reference operates at the discretion of the 505H. The Override Mode is typically used during the unit start and stop sequencing, when references must be moved quickly to insure a good start or stop control. In the Override Mode, the Governor Reference moves at the override rate as shown in Figure 5-6.

External Mode. This mode is selected when the Governor Reference is In Control. In this mode, the Governor Reference follows an External Signal (an analog input signal properly scaled to determine the desired output). In the External Mode, the Governor Reference moves at the programmed Normal Rate.

The Governor Reference does have one additional rate it can also use, the Soft-Load Rate. The Soft-Load Rate can be programmed to operate when the Governor Reference changes from either Follow Mode or Override Mode to External Mode. In this case, output ramps from its present value to the value required by the External Signal. Once the output attains the desired value, the Governor Reference reverts to the Normal Rate. Figure 5-8 depicts the Soft-Load Rate as the time between when the Governor Reference is switched to External Mode until when the External Signal and Governor Reference output are matched.

If this mode is selected, you will be required to program an analog input to provide the External Signal. The name of the required analog input signal is provided in the Program Data Sheet. If the Governor Reference is programmed as Use On Ext Signal Fail, it will remain In Control in the event of a failure of the External Signal.

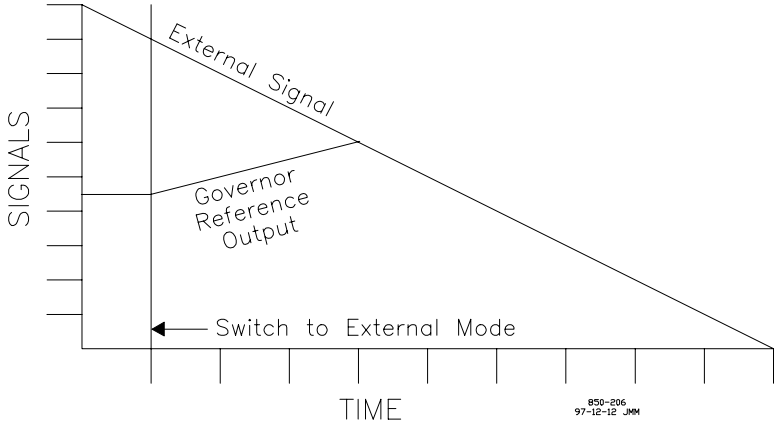

Figure 5-8. Example of Soft-Load

Local Mode. This mode is selected when the Governor Reference is In Control. In this mode, the Governor Reference can be adjusted via raise / lower contacts, the keypad adjust keys, entering a value from the keypad, or via digital communications (Modbus port). In the Local Mode, the Reference Output moves at the programmed Normal Rate. In this case, the Reference Output is limited to its Maximum Limit and Minimum Limit. Note that the lower command has priority over the raise command.

Priority. The modes have the following priority: Follow Mode has the highest priority, followed by Override Mode, External Mode, with Local Mode having the lowest priority. Thus, if both the External Mode and Follow Mode are selected, the Governor Reference will operate in Follow Mode, as it has higher priority.

Definitions. Table 5-9 give some general terms and definitions connected with Governor Controls and References.

Base Reference	The Governor Reference used by the Governor Control when a Governor Reference is not selected.
Bumpless Transfer	A change from one Governor Reference to another can be done with no disturbance to the gate servomotor.
Control Output	Output signal from the Governor Control which the reference is feeding.
External Signal	A 4-20mA analog input used to set the desired Reference Output.
In Control	This Governor Reference is the reference which is determining the actual setpoint for the 505H.
Mode	Operating parameter for the reference. This can be either Follow, Override, External, or Local.
Reference Output	Output signal from the Governor Reference.

Table 5-9. Governor Control and Reference Definitions

In the descriptions of each of the Governor References there is a table which contains ranges of setup values listed in Table 5-10. Chapter 6 lists the Program Mode selections along with the available ranges for each of the inputs. Chapter 7 contains the Service Mode selections.

Minimum Limit (%) =	Minimum limit for the Governor Reference.
Maximum Limit (%) =	Maximum limit for the Governor Reference
Normal Rate (%/s) =	Rate at which the Governor Reference moves when in External or Local Mode.
Override Position (%) =	Position to which the Governor Reference goes when in Override Mode.
Override Rate (%/s) =	Rate at which the Governor Reference moves when in Override Mode.
Soft-Load Rate (%/s) =	Rate at which the Governor Reference moves when in External Mode and there is a mismatch between the External Signal and the Reference Output.
Use External Signal?	Option to use an External Signal to position the Governor Reference
Use On Ext Signal Fail?	Option to continue to use the Governor Reference in the event that the External Signal fails.
Use Reference?	Option to enable the Governor Reference.
Use Soft-Load?	Option to enable the Slow Rate.

Table 5-10. Governor Reference Setup

Speed Control

The Speed Control has three Governor References feeding it: the Droop Reference, the Isochronous Reference, and the Loadsharing Reference. These are each described below. The Speed Control is used any time the unit is off-line or the unit is not configured to use the Position Control (found under Turbine Configuration in the Program Mode). The one exception to this if Loadsharing is selected. The Loadsharing Reference can be selected while in Position Control. The software internally overrides Position Control to allow the 505H to loadshare with any other devices in the system. Figure 5-9 gives an overview of the Speed Control functionality.

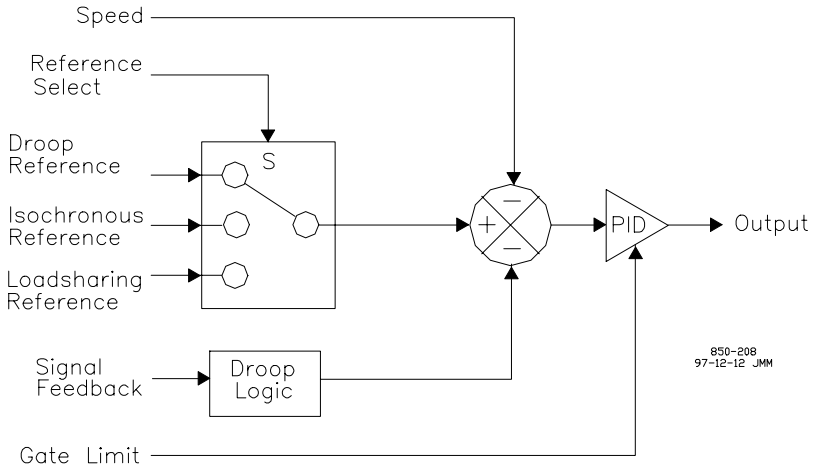

Figure 5-9. Speed Control Block Diagram

Droop Reference

This is a typical speed refererence which, when enabled, provides a speed setpoint to the Speed Control. This signal is then summed with the Unit Speed, along with the gate position feedback signal multiplied by the droop gain. In Follow Mode, the Reference Output follows the unit speed plus the droop correction signal. This is a Base Reference, meaning that it is always enabled.

Max Speed Setpoint (%)=	100.0 - 180.0
Min Speed Setpoint (%)=	20.0 - 100.0
Speed Set Rate (%/s) =	0.01 - 10.0
Unloading Setpoint (%)=	85.0 - 110.0
Unloading Rate (%/s) =	0.01 - 10.0
Soft-Load Rate (%/s) =	0.001 - 10.0
Use External Signal?	No or Yes
Use On Ext Signal Fail?	Yes
Use Reference?	Yes
Use Soft-Load?	No or Yes

Table 5-11. Droop Reference Setup Values

Isochronous Reference

This is similar to the Droop Reference above. The primary difference is that the Isochronous Reference sends a signal to the Speed Control to set the droop gain to zero. This means that the governor will control the unit speed at the speed setpoint. In Follow Mode, the Isochronous Reference always follows the actual unit speed. Also, the Isochronous Reference is not allowed to operate in External Mode. Although this is not a Base Reference, it is used exclusively while the unit is off-line. While in the On Line Operation status, the Isochronous Reference can only be selected if it has been enabled.

The Override Position (%) is internally set to 20% during the Unit Shutdown, Waiting For Prestart, Unit Breakaway, and Unit Stop statuses; and 100% during the Unit Start status. The Acceleration Rate (%/s) dictates the rate that the speed setpoint is ramped from 20% to 100% during the Unit Start status.

Max Speed Setpoint (%)=	Same as Droop Reference
Min Speed Setpoint (%)=	Same as Droop Reference
Speed Set Rate (%/s) =	Same as Droop Reference
Override Position (%) =	See text
Acceleration Rate (%/s)=	1.0 - 100.0
Soft-Load Rate (%/s) =	n/a
Use External Signal?	No
Use On Ext Signal Fail?	No
Use Reference?	No or Yes
Use Soft-Load?	No

Table 5-12. Isochronous Reference Setup Values

Loadsharing Reference

This is equivalent to an Isochronous Reference which can operate only in External Mode. The External Signal is programmed so that a 12mA Analog Input is translated into a 100% speed signal (normal speed) with the 4mA and 20mA values offset from 100% speed by the Speed Window. This is shown in Figure 5-10. The Speed Window (%) (Program) determines the Minimum and Maximum Limits for

the Loadsharing Reference. Be sure that the External Signal and Speed Window are calibrated the same. For instance, if you set your Speed Window to 5%, the 4mA value for your External Signal should be equivalent to 95% speed, and the 20mA value should be equivalent to 105% speed. If you are displaying RPM for speed, you will have to calculate these corresponding values.

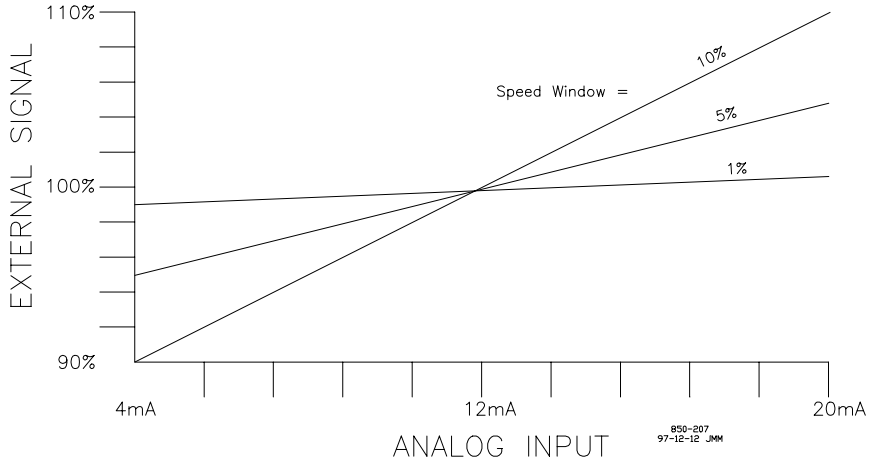

Figure 5-10. Loadsharing Speed Window

Max Speed Setpoint (%)=	See text
Min Speed Setpoint (%)=	See text
Speed Set Rate (%/s) =	100.0
Override Position (%) =	n/a
Override Rate (%/s) =	n/a
Soft-Load Rate (%/s) =	n/a
Use External Signal?	Yes
Use On Ext Signal Fail?	No
Use Reference?	No or Yes
Use Soft-Load?	No

Table 5-13. Loadsharing Reference Setup Values

Position Control

The Position Control has three Governor References feeding it: the Gate Reference, the Level Reference, and the Power Reference. These are each described below. The Position Control can only be used during the On Line Operation and Unit Unload statuses. Then, it must be enabled through under Turbine Configuration in the Program Mode. Position Control may generally be considered a “large system” or “infinite bus” control. This is because the three Governor References feeding the Position Control are outputting position setpoints. If there is a speed mismatch, there will be a difference between the position setpoint and gate position. This may cause some confusion unless you recognize that you are still dealing with a speed droop governor. However, if you want to use the Level Reference on a “small system” or while “isolated”, you must configure the 505H to operate in Position Control while in the On Line Operation and Unit Unload statuses. The 505H also has a feedforward control algorithm (see Appendix D) which is only enabled in Position Control.

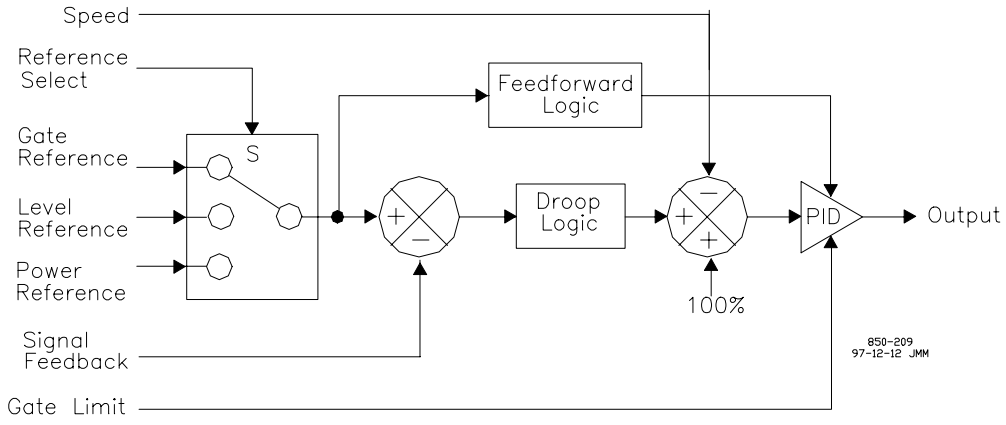

Figure 5-11. Position Control Block Diagram

From Figure 5-11, the unit speed is always compared to normal speed (100%). As long as the unit speed is equal to the rated speed, the other comparison is done between the Governor Reference and the appropriate Signal Feedback. The difference between these two is multiplied by the droop gain to determine an error signal to the PID. The Feedforward Logic is also located here. This logic is to help preposition the Control Output based on the Reference Output presently In Control.

Feedforward Logic. The Feedforward Logic handles the anticipatory positioning of the gates based on a change in the desired gate setpoint. Within the 505H, this is set up as an exponential function based on the droop setting. This is shown in Figure 5-12. The value KFF is the Feed Forward Gain entered in Program Mode.

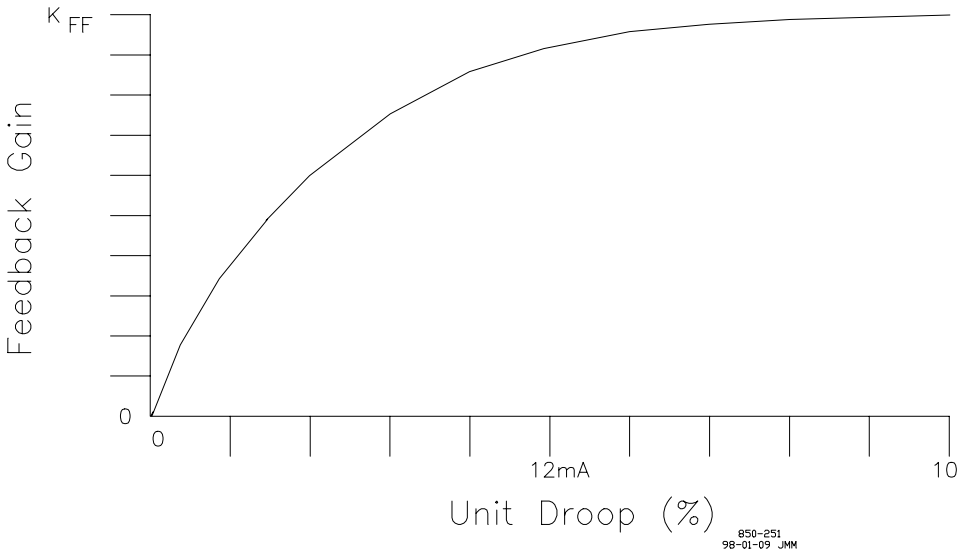

Figure 5-12. Feedforward Gain

Gate Reference

The Gate Reference is a Governor Reference whose output is the desired gate position for the unit. In Follow Mode, the Reference Output follows the preset gate position. This is the Base Reference for Position Control.

Max Gate Setpoint (%) =	Gate Limit Value
Min Gate Setpoint (%) =	0.0
Gate Set Rate (%/s) =	1.0 - 100.0
Unloading Setpoint (%)=	0.0 - 100.0
Unloading Rate (%/s) =	1.0 - 100.0
Soft-Load Rate (%/s) =	0.1 - 100.0
Use External Signal?	No or Yes
Use On Ext Signal Fail?	Yes
Use Reference?	Yes
Use Soft-Load?	No or Yes

Table 5-14. Gate Reference Setup Values

Level Reference

The Level Reference basically takes a level setpoint and level input and uses these to compute a gate setpoint. The Level Reference can be used in one of two ways: it can either be used to control forebay level or tailbay level. Figure 5-13 shows how the forebay level control is implemented, while Figure 5-14 shows how the tailbay level control is implemented. These two are essentially the same, except for a change in the slope of the line. This is valid because: in the event your forebay level is greater than your setpoint, you want to open the gates to help lower the forebay level; in the event your tailrace level is greater than your setpoint, you want to close the gates to help lower the tailrace level. For the same error signal, we want opposite behavior.

For graphs 5-13 and 5-14, the Level Error is determined as the Level Setpoint minus the Actual Level. If the Level Error is equal to zero, the Gate Setpoint is set to the average of the Minimum Gate Setpoint and Maximum Gate Setpoint. If the Level Error is greater than or equal to the Window Size, the Gate Setpoint goes to the Minimum Gate Setpoint (Forebay Level Control) or Maximum Gate Setpoint (Tailbay Level Control). If the Level Error is less than or equal to the negative Window Size (negative Level Error), the Gate Setpoint goes to the Maximum Gate Setpoint (Forebay Level Control) or Minimum Gate Setpoint (Tailbay Level Control). The Gate Setpoint is limited to the Minimum or Maximum Gate Setpoints. This feature is useful in preventing the unit from motoring (set the Minimum Gate Setpoint greater than the speed-no-load opening) and limiting the maximum unit output (setting the Maximum Gate Setpoint at some point less than 100% gate opening).

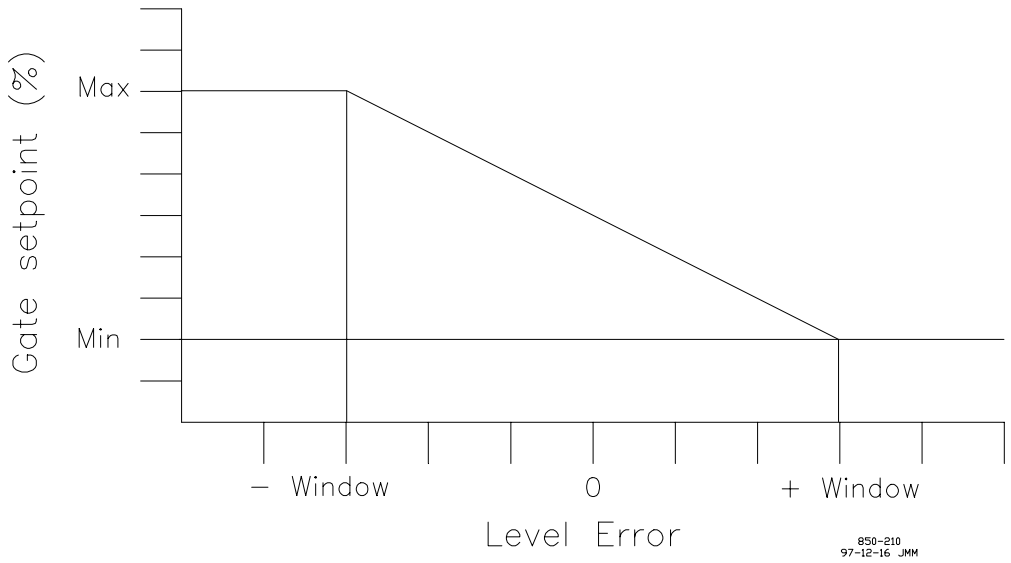

Figure 5-13. Forebay Level Control

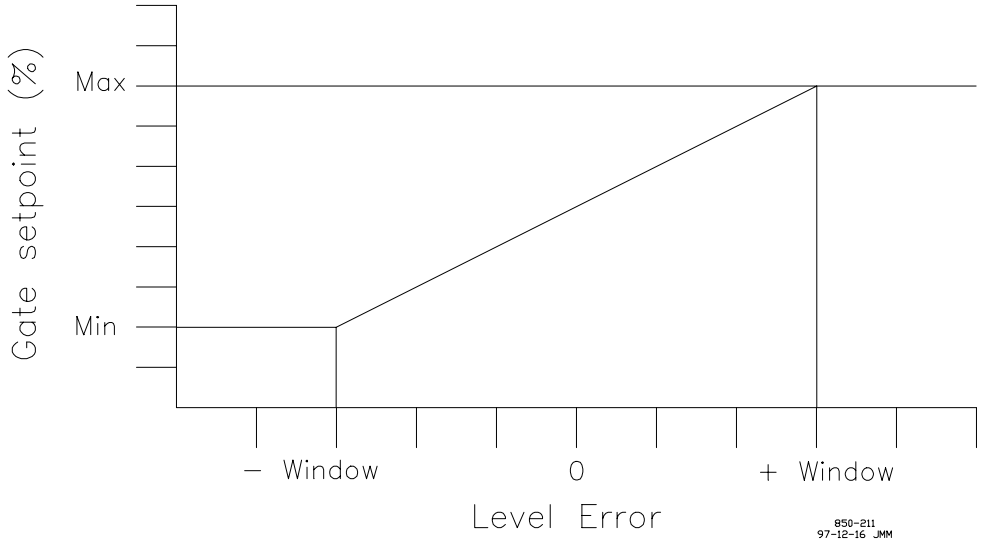

Figure 5-14. Tailbay Level Control

CAUTION

If you are controlling your forebay level, be aware that increasing your forebay level setpoint results in a decreasing gate opening, and vice-versa. Thus, the Raise input will result in moving the gates in the closing direction.

Additional values to be entered in Program Mode for the Level Reference are: Window Size, Maximum Gate Set, Minimum Gate Set.

Max Level Set (ft or m) =	-999,999.0 - 999,999.0
Min Level Set (ft or m) =	-999,999.0 - 999,999.0
Level Set Rate (1/s) =	0.001 - 10.0
Override Position (ft or m) =	n/a
Override Rate (1/s) =	n/a
Soft-Load Rate (1/s) =	0.001 - 10.0
Use External Signal?	No or Yes
Use On Ext Signal Fail?	No or Yes
Use Reference?	No or Yes
Use Soft-Load?	No or Yes

Table 5-15. Level Reference Setup Values

Power Reference

The Power Reference basically generates a desired gate setpoint based on a programmed curve to help determine gate position. It also changes the feedback signal to be the power feedback running through the same curve. The reason the curve is used is because the feedforward command is based on gate position. We must be fairly close on the gate position for a given power setpoint to avoid over- or undershooting the gates via the feedforward signal. The curve is required only to approximate the shape of the power versus gate position curve. It is understood that, with variations in the net head across the unit, the unit power will vary. You may want to program your unit based on the maximum generation available out of your machine. This will insure that your setpoint can reach the maximum your machine can achieve. In periods of low net head, the unit may not be able to attain this value.

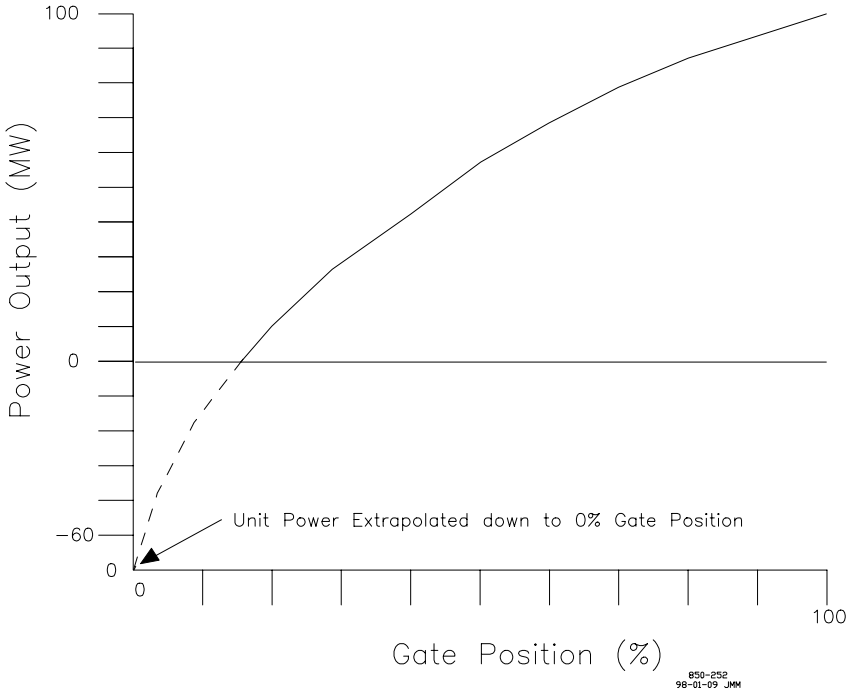

Figure 5-15. Power Curve Entry

The power versus gate position points are entered in 10% gate increments. It is important that you extrapolate your line below zero power (see Figure 5-15). This insures proper operation of the control near zero power. It is also important to realize the your Maximum Limit is assumed to be your power at 100% gate opening. Be sure you program the control using this assumption.

Max Power Set(kW or MW) =	-999,999.0 - 999,999.0
Min Power Set(kW or MW) =	-999,999.0 - 999,999.0
Power Set Rate (1/s) =	0.1 - 100.0
Override Position(kW or MW) =	n/a
Override Rate (1/s) =	n/a
Soft-Load Rate (1/s) =	0.1 - 100.0
Use External Signal?	No or Yes
Use On Ext Signal Fail?	No or Yes
Use Reference?	No or Yes
Use Soft-Load?	No or Yes

Table 5-16. Power Reference Setup Values

Gate Limit Control

The Gate Limit Control has the Gate Limit Control and Gate Limit Reference rolled into one. This is because there is only one Governor Reference used (no switching between different Governor References). The Gate Limit Control feeds into both the Speed and Position Controls to limit their respective outputs. This is effectively a hard limit placed on the gate setpoint.

Manual Control

Like the Gate Limit Control above, this is a Manual Control and Manual Reference rolled into one. Once again, this is the only Governor Reference used. When Manual Control is used, the signals from the Speed and Position Controls are blocked, and the Manual Control signal is fed directly to the Output Driver. In this mode, the Overspeed Trip is disabled. It is assumed that you are at the unit and will be responsible for the overspeed protection.

Manual Control is primarily assumed to be a maintenance feature. It has been designed to operate as closely as possible to a standalone manual positioning device. However, any Emergency Shutdown within the 505H will cause the Output Driver to immediately go to 0mA, forcing immediate closure of the gates. This is a hardware feature of the 505H to remove the Output Driver current in the event of an Emergency Shutdown.

WARNING

The 505H Overspeed Trip is disabled while the unit is in Manual Control. You are responsible for protecting the unit against any overspeed while using Manual Control.

Speed/Position Switch

The Speed/Position Switch selects between the Speed and Position Controls. In the off-line statuses, the Speed Control is automatically picked. In the on-line statuses, the selection is based on the Turbine Configuration, along with any possible Small System Detection.

Auto/Manual Switch

The Auto/Manual Switch selects between the outputs of the Speed/Position Switch and the Manual Control. Selection of Manual Control activates this switch. The switch is automatically disabled in the event of an Emergency Shutdown.

ESD Switch

The Emergency Shutdown Switch forces the Output Driver to 0mA. This is done in both the hardware and software of the 505H to maintain consistency in the unit behavior. The pushbutton and shutdown input contacts are both tied to the hardware, which removes the current. So all internal emergency shutdowns have been tied to this software switch to keep the 505H's behavior consistent.

There is one additional signal available to de-energize the ESD Switch: it is Remove mA On Unit Stop (Program). This signal operates in parallel with the Emergency Shutdown to allow the driver current to be removed. This may be useful in applications where you wish to ensure that you have adequate squeeze on the gates on unit stop.

Output Driver

The Output Driver takes a setpoint signal and, using information from the Output Driver configuration, rescales the output signal for the proper value. The Auto/ Manual Switch is used to select between the Governor Setpoint and Manual Setpoint. There are options built into here for proportional and integrating outputs, inverting the output signal, etc. Figure 5-16 shows the function of the Output Driver.

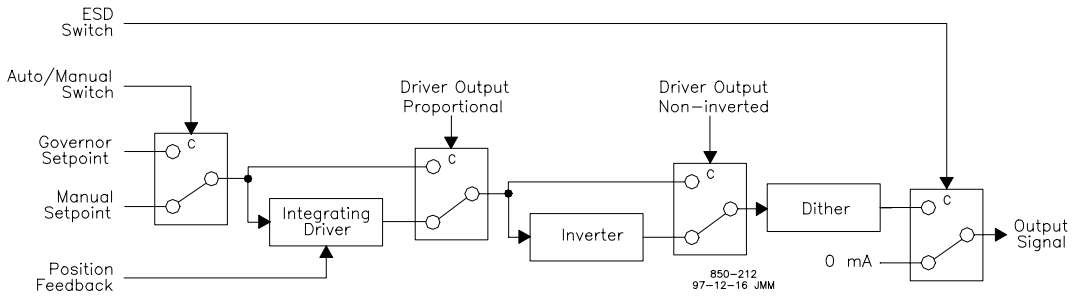

Figure 5-16. Output Driver Block Diagram

Driver Output Proportional. This configurable switch states that the output signal is to be a proportional output. That is, if we ask the servomotor to go to 50%, it will go to 50%. If the Driver Output is selected to be integrating, the output signal is assumed to be an error signal. If there is zero error between the setpoint and position, the output signal is 50% (centered). The error signal can be scaled by a P Gain (Service) to help optimize the response.

Driver Output No inverted. This configurable switch states that the signal input is passed straight to the signal output. This is used in the event that we have a 4-20mA (or 20-160mA) setpoint signal required from the output driver. If our required output signal is 20-4mA (or 160-20mA) for 0-100%, we should set the Output Driver up as Inverted.

Integrating Driver. This driver takes basically performs the function shown in the block diagram in Figure 5-17. The setpoint and feedback are compared. Any error between these signals is multiplied by a P Gain. This value is then offset by 50 to provide a 12mA (or 90mA) signal to keep the valve centered in the case of zero error.

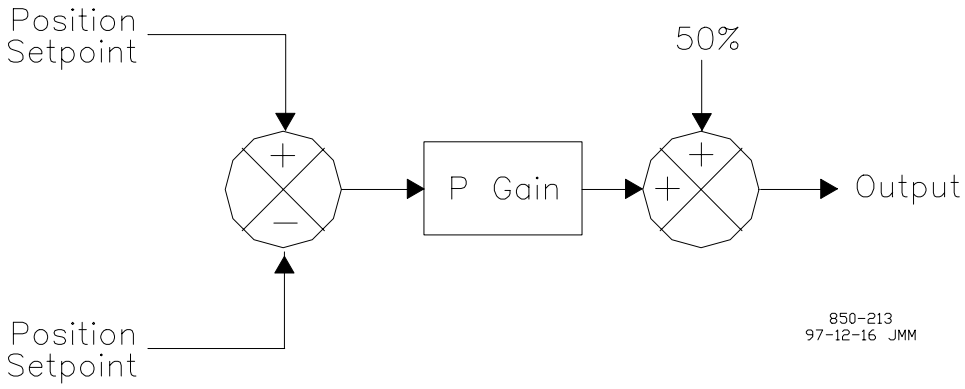

Figure 5-17. Integrating Driver Block Diagram

Inverter. This block turns 0% into 100% and 100% into 0%. This effectively changes the sense of the current signal from the Output Driver.

Dither. The Dither circuit places a square wave on top of the output signal. This is a 25 Hz. signal, where the amplitude can be varied between 0% and 100% of the signal.

TURBINE START MODES

The 505H has two turbine start modes (automatic and manual) from which to choose. One of these start modes must be chosen and programmed to perform a unit start. Once a Run Command is issued, the speed setpoint and gate limit are manipulated automatically by the 505H or manually, depending on the selected start mode. The differences between the modes are listed below.

Automatic Start Mode

The Automatic Start Mode will be used under normal circumstances. The Automatic Start Mode takes care of performing a controlled unit breakaway and start until the unit achieves normal speed. Basically, an automatic start forces the unit through flow chart shown in Figure 5-18.

In the Automatic Start Mode, the Zero Speed Signal Logic is enabled (see Speed Sensor). This means that the Speed Input(s) must detect a valid speed signal within the speed signal fail time, or the Speed Input(s) will fail due to loss of speed signal. If all available Speed Inputs fail, the ESD Logic will issue an Emergency Shutdown due to Speed Sensor failure.

Once the 505H sees a valid “start speed level” (default is 20% speed, the control status transitions from the ‘unit breakaway” to the “unit start” status. Concurrently, speed control is enabled and the speed setpoint starts to ramp from the “start speed level” to rated speed.

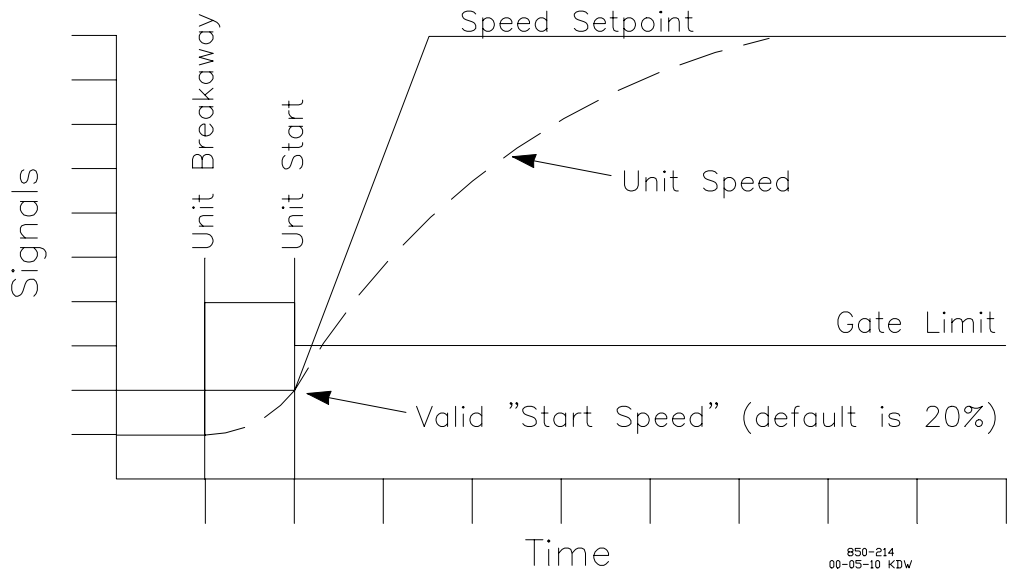

Figure 5-18. Automatic Start Sequence

Manual Start Mode

The Manual Start Mode handles a couple of things differently than the Automatic Start Mode.

The Gate Limit Override signals are disabled during a Manual Start. This means that the Gate Limit is not moved via the Control Override commands. The Gate Limit must be taken out of the way manually (raising the Gate Limit via the appropriate Control Input).

In the Manual Start Mode, the Zero Speed Signal Logic is disabled until either the Manual Start Mode is disabled (see Extended Speed Range) or the 505H attains the On Line Operation status (see Status Engine).

In general, the Manual Start Mode is the equivalent of automatically selecting Extended Speed.

Extended Speed

Extended Speed is a feature which gives you the ability to switch between Automatic and Manual Start Modes while the unit is operating. If you are shutdown and press the F2 key, the key illuminates. Any time this key is illuminated, the 505H is indicating that Extended Speed is enabled. When Extended Speed is enabled, the 505H is made to believe it is in a Manual Start Mode. Thus, you can switch between Manual and Automatic Start by pressing the F2 key.

If you are configured for a Manual Start, the Extended Speed is automatically enabled and maintained while the 505H is in the Unit Breakaway status. The 505H stays in the Unit Breakaway status until a speed in excess of 10% is detected by the 505H. At this point, Extended Speed can be enabled or disabled via the F2 key.

If you are in Extended Speed, the 505H cannot proceed to the Ready To Synchronize status. This is prevented internally. However, you are able to change the speed setpoint via the raise lower contacts when in the Unit Start status. The Control Override command is disabled when using Extended Speed.

The speed setpoint always ramps at a rate of 5% per second, the Minimum and Maximum Limits for the Governor Reference are set to 20% and 180%, respectively. Thus, it will be difficult to synchronize the unit when Extended Speed Range is enabled.

Once you have attained the Ready To Synchronize status, you cannot go to Extended Speed.

Chapter 6
Configuration Procedures

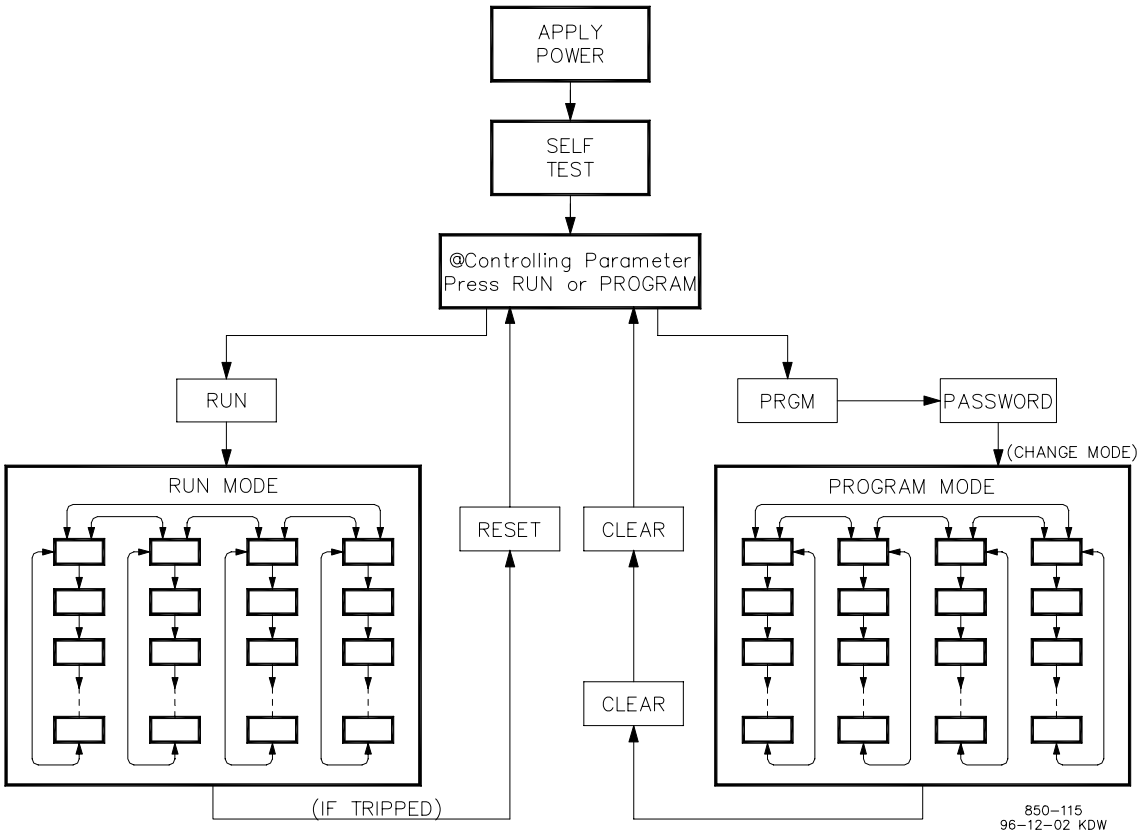

Figure 6-1. Basic Program Architecture

PROGRAM ARCHITECTURE

The 505H is easy to program, due in large part to the menu-driven software. Basic program architecture is illustrated in Figure 6-1. When the control is powered up, and after the brief CPU self test has been completed, the control displays a ready status (Controlling Parameter / Run or Program). The operating procedures are divided into two sections: the Program Mode (Figure 6-3) and the Run Mode (refer to Chapter 8 for Run Mode information). The Program Mode is used to configure the 505H for the specific application and set all operating parameters. The Run Mode is the normal turbine operation mode and is used to view operating parameters and run the turbine.

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

The 505H can be programmed and the turbine run using the display and the touch keypad on the front of the control. If desired, the program can be uploaded for storage and/or modification into a personal computer (pc). Additionally, this configuration can be downloaded into any 505H.

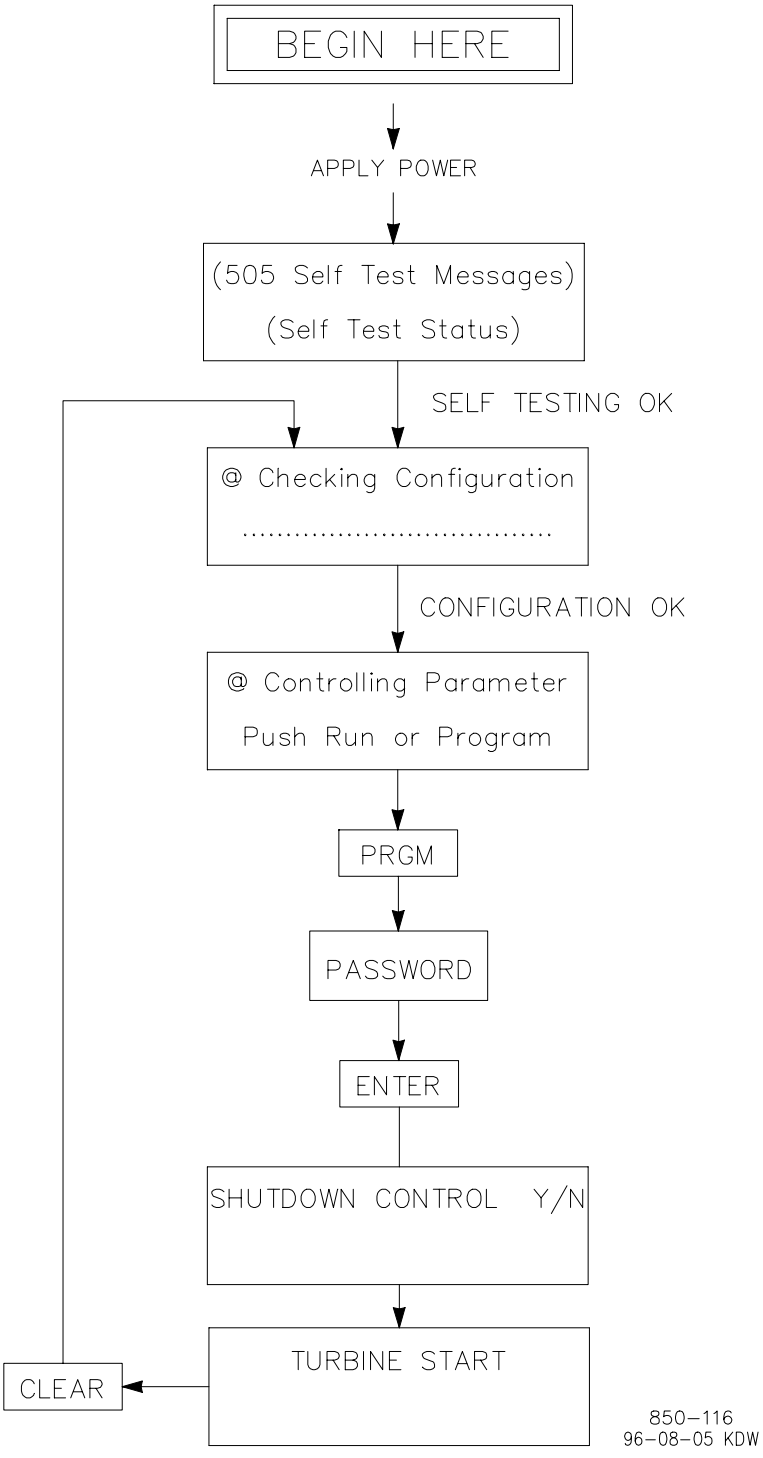

Figure 6-2. Initial 505H Program Mode Entry

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

PROGRAMMING THE 505H

Before the 505H can be used to operate any turbine, it must be configured with a valid program. A handy 505H Program Mode Worksheet is provided in appendix G. This chapter contains additional information related to completing this worksheet and programming the specific application. It is recommended that this worksheet be completed and used to document your specific program.

Figure 6-2 illustrates the 505H screens displayed when power is applied and how to enter the Program Mode from this point. The password is required to protect against both intentional and inadvertent program changes. The password can be changed if desired, refer to appendix F for information on changing passwords. Once the turbine is running, selecting the PRGM key will allow the program to be viewed but not changed.

Using Program Menus

Once the Program Mode has been entered with the password, the specific application information must be entered into the 505H. Figure 6-3 illustrates the 505H configuration menus and the questions/options available under each header/ column.

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

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

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

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

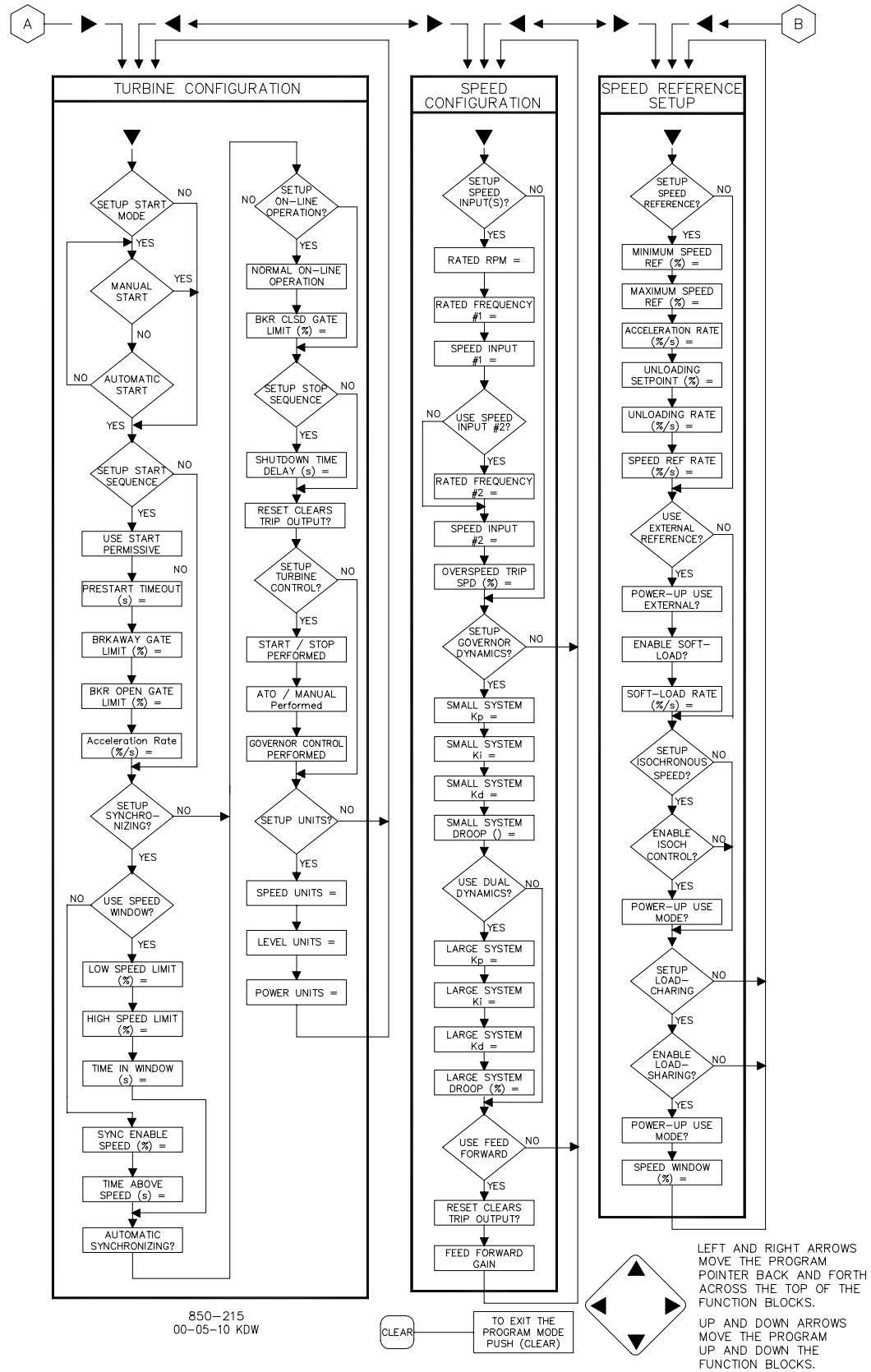

Figure 6-3. Program Mode Blocks

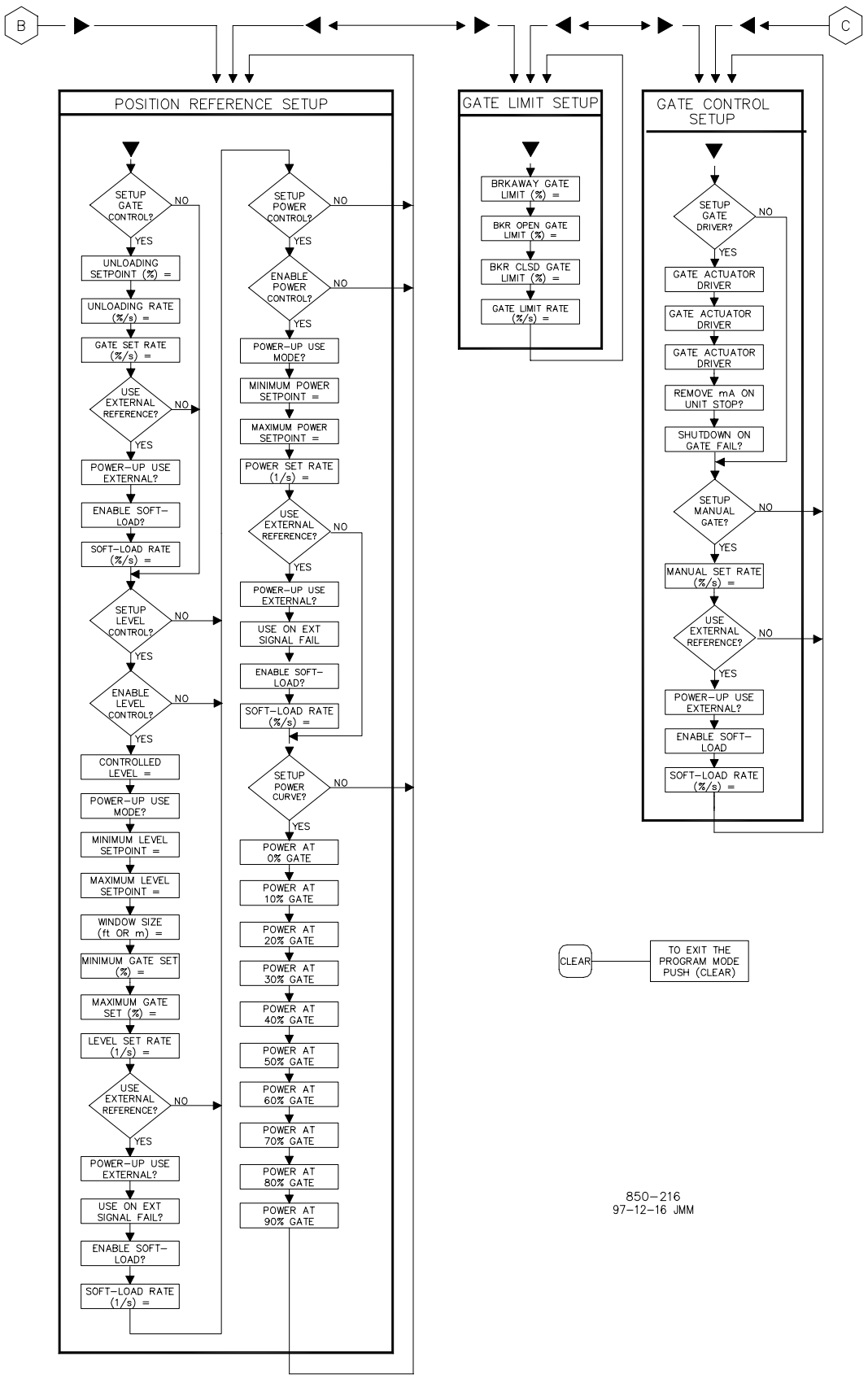

Figure 6-3. Program Mode Blocks (continued)

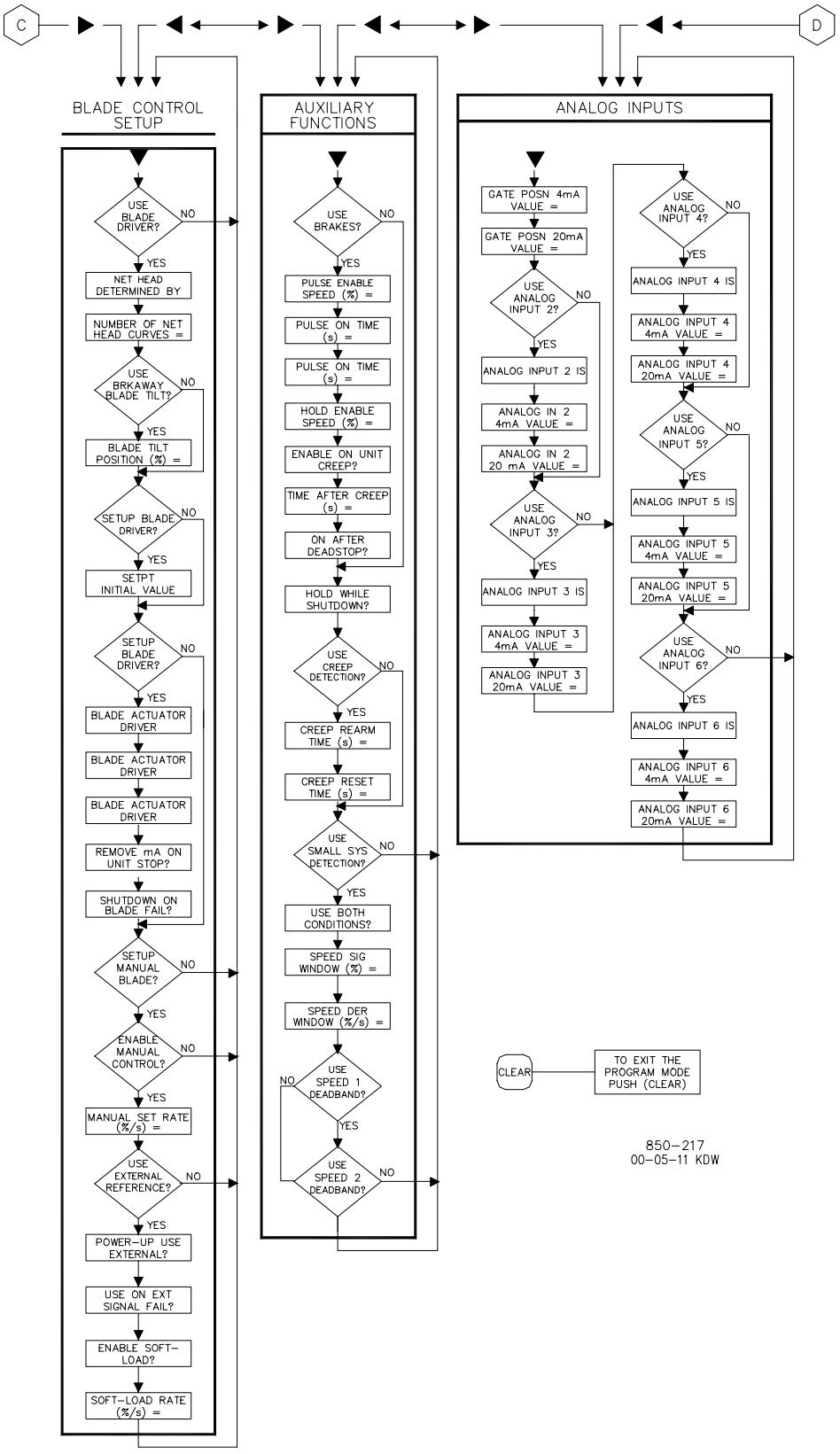

Figure 6-3. Program Mode Blocks (continued)

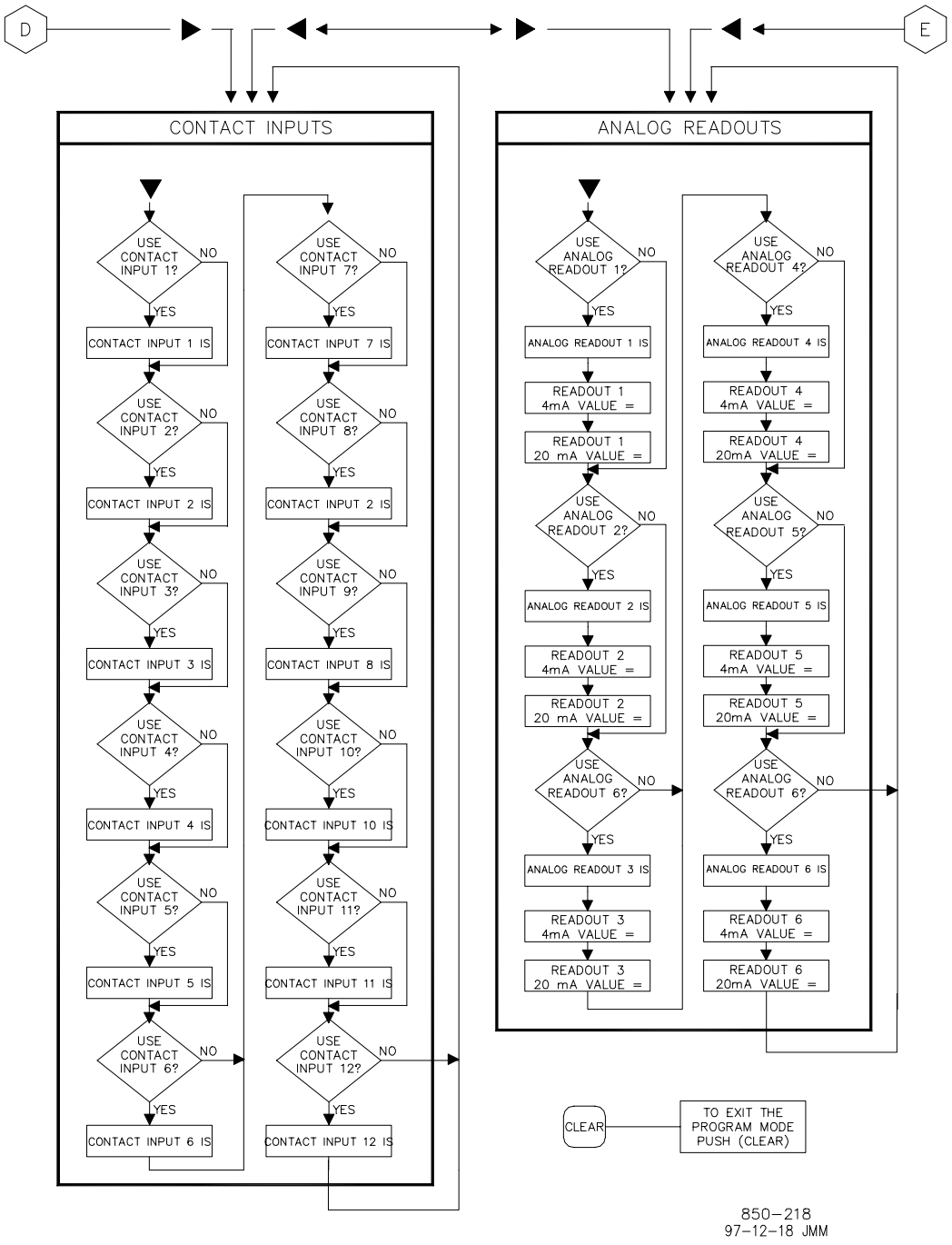

Figure 6-3. Program Mode Blocks (continued)

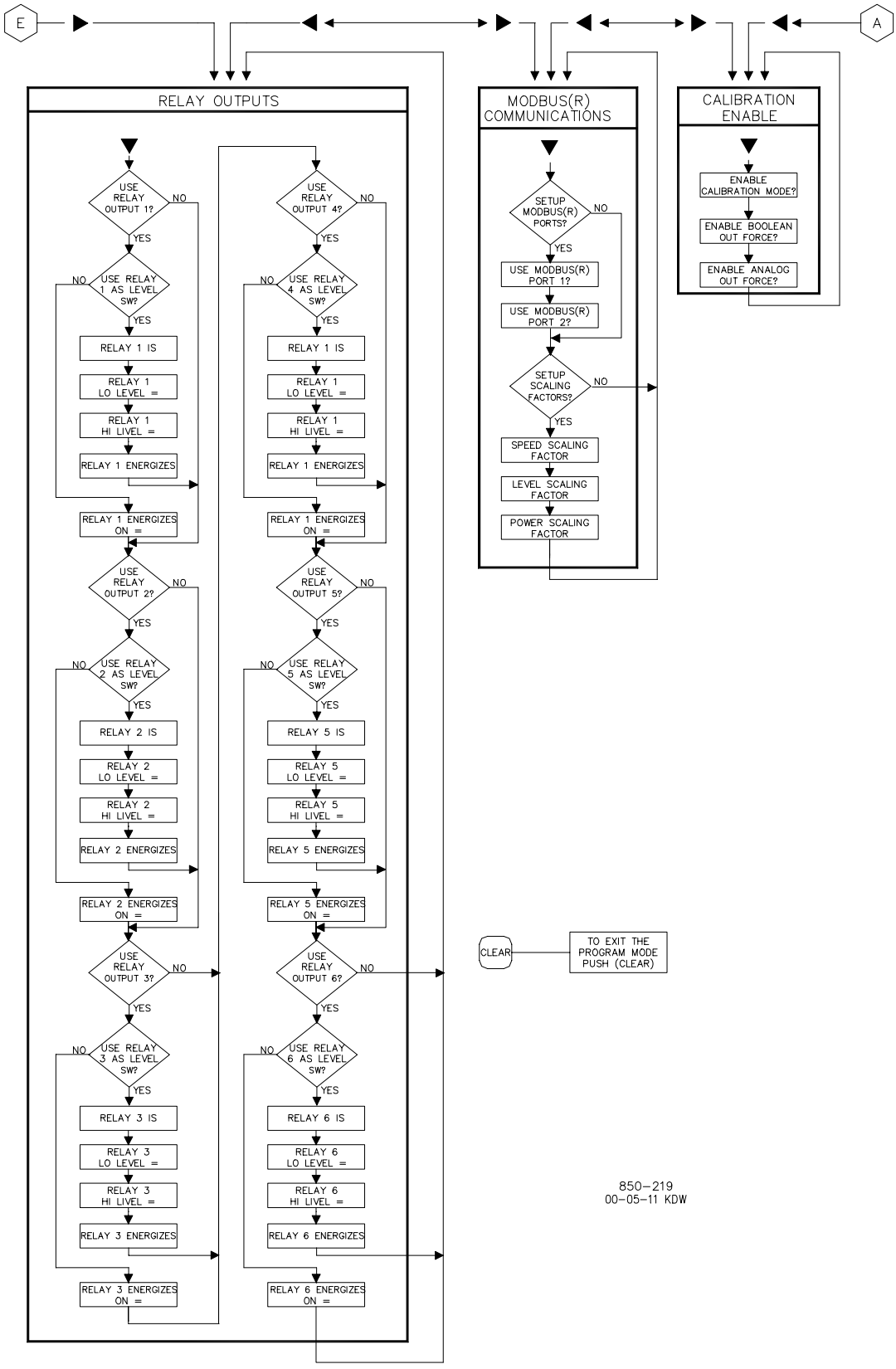

Figure 6-3. Program Mode Blocks (continued)

Program Blocks

Figure 6-3 shows the fourteen Program Blocks. To program the control, simply step through the blocks as described above and configure the control features for the desired application. The fourteen blocks and their basic functions are described in detail below.

Program Blocks:

Turbine Configuration:	to configure general turbine operating parameters;
Speed Configuration:	to configure the speed inputs, the overspeed trip setpoint, and speed control dynamics settings;
Speed Control Setup:	to configure the Speed Control Governor References - Droop, Isochronous, and Loadsharing;
Position Control Setup:	to configure the Position Control Governor References - Gate, Level, and Power;
Gate Limit Setup:	to configure the gate limit operation;
Gate Control Setup:	to configure the gate actuator driver and manual control options;
Blade Control Setup:	to configure the blade control, actuator driver and manual control options;
Auxiliary Functions:	to configure the brakes, creep detection, and small system detection functions;
Analog Inputs:	to configure analog input options;
Contact Inputs:	to configure contact input options;
Analog Readouts:	to configure analog readout options;
Relay Outputs:	to configure relay output options;
Modbus Communications:	to configure Modbus communication options;
Calibration Enable:	to configure the unit so that the I/O can be calibrated.

Each of the Program Blocks are described in detail below. Figure 6-3 can be referred to for a graphical program block reference. After a column has been configured and the display is back at the top of the column, use the left or right arrow keys to select the next column to configure or check.

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

The Program Blocks (Figure 6-3) contain information detailing each question and/ or 505H program configuration option. Each question/option shows the default (dflt) value and the adjustable range of that parameter (shown in parentheses). Also, any additional constraints on the configuration are shown in italics following the description. There is a Program Mode worksheet in Appendix G that should be completed/filled-in and used as a guide for your particular application. This worksheet can also be used for future reference to document your application program.

Turbine Configuration Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SETUP START MODE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the start mode. Select NO followed by the ENTER key to collapse the header and jump to the SETUP START SEQUENCE header.

MANUAL START? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to configure the 505H for a manual start. When configured for a manual start, the unit is placed in Extended Speed Range, the Gate Limit is left at 0%, and the Speed Signal Failure Detection is disabled.

AUTOMATIC START DFLT= NO (YES/NO)
Select YES followed by the ENTER key to configure the 505H for an automatic start. When configured for an automatic start, the 505H presets the gate limit to configured position(s), and controls the acceleration of the turbine up to normal speed. In this case, the Speed Signal Failure Detection is enabled.

NOTE
One of the two start modes must be selected before the unit will run.

SETUP START SEQUENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the start sequence. Select NO followed by the ENTER key to collapse the header and jump to the SETUP SYNCHRONIZING header.

USE START PERMISSIVE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if a start permissive is required before allowing the unit to start. Select NO followed by the ENTER key to allow the unit to start as soon as a start command is issued.

PRESTART TIMEOUT (SEC) = DFLT= 1.0 (1.0, 600.0)
Enter the Prestart Timeout, in seconds, followed by ENTER. The Prestart Timeout is the length of time within which the unit must receive a start permissive after it has been given a start command. Failure to receive the start permissive will result in an emergency shutdown. Examples of a start permissive are gate lock raised, governor pressure acceptable, turbine lift pump on, etc.

BRKAWAY GATE LIMIT (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Breakaway Gate Limit, in percent, followed by ENTER. The Breakaway Gate Limit is the maximum gate position which the unit is able to attain while in the Breakaway State (from the time the unit has started until the unit has attained 10% of the rated turbine speed).

BKR OPEN GATE LIMIT (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Breaker Open Gate Limit, in percent, followed by ENTER. The Breaker Open Gate Limit is the maximum gate position which the unit is able to attain while in the Starting State (from the time the unit has attained 10% of rated turbine speed until the unit has attained 100% of rated turbine speed).

ACCELERATION RATE (%/S) = DFLT= 100.0 (1.0, 100.0)
Enter the Acceleration Rate, in percent per second, followed by ENTER. The Acceleration Rate is the rate at which the speed setpoint is ramped from the starting value of 20% of rated turbine speed to the final value of 100% of rated turbine speed.

SETUP SYNCHRONIZING? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure unit synchronizing. Select NO followed by the ENTER key to collapse the header and jump to the SETUP ON-LINE OPERATION header.

USE SPEED WINDOW? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to use a Speed Window to allow the unit to make the transition to the Synchronizing State. Select NO followed by the ENTER key to use the Synchronizer Enable Speed to transition to the Synchronizing State.

LOW SPEED LIMIT (%) = DFLT= 99.0 (20.0, 100.0)
Enter the Low Speed Limit, in percent, followed by ENTER. The Low Speed Limit is the minimum speed (as a percent of rated turbine speed) above which the unit must remain to allow a transition to the Synchronizing State.

HIGH SPEED LIMIT (%) = DFLT= 99.0 (20.0, 100.0)
Enter the High Speed Limit, in percent, followed by ENTER. The High Speed Limit is the maximum speed (as a percent of rated turbine speed) below which the unit must remain to allow a transition to the Synchronizing State.

TIME IN WINDOW (SEC) = DFLT= 5.0 (0.0, 60.0)
Enter the Time In Window, in seconds, followed by ENTER. The Time In Window is the length of time which the turbine must remain between the Low and High Speed Limits before allowing the transition to the Synchronizing State.

SYNC ENABLE SPEED (%) = DFLT= 99.0 (20.0, 100.0)
Enter the Synchronizer Enable Speed, in percent, followed by ENTER. The Synchronizer Enable Speed is the speed (as a percent of rated turbine speed) which the unit must attain to allow a transition to the Synchronizing State.

TIME ABOVE SPEED (SEC) =DFLT= 5.0 (0.0, 60.0)
Enter the Time Above Speed, in seconds, followed by ENTER. The Time Above Speed is the length of time which the turbine must remain above the Synchronizer Enable Speed before allowing the transition to the Synchronizing State.

AUTOMATIC SYNCHRONIZING? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to use Automatic Synchronizing (the use of a synchronizer supplying an analog setpoint to the control to synchronize the unit to the system). Select NO followed by the ENTER key to use Raise / Lower contacts to synchronize the unit to the system.

SETUP ON-LINE OPERATION? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure on-line operation. Select NO followed by the ENTER key to collapse the header and jump to the SETUP STOP SEQUENCE header.

NORMAL ON-LINE OPERATION (MUST CHOOSE FROM LIST)
Select the normal on-line operating mode from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR NORMAL ON-LINE OPERATION
Is Speed Control Is Position Control
Is Determined By Contact

BKR CLSD GATE LIMIT (%) = DFLT= 100.0 (0.0, 100.0)
Enter the Breaker Closed Gate Limit, in percent, followed by ENTER. The Breaker Closed Gate Limit is the maximum gate position which the unit is able to attain while the Generator Breaker is closed.

SETUP STOP SEQUENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the stop sequence. Select NO followed by the ENTER key to collapse the header and jump to the SETUP TURBINE CONTROL header.

SHUTDOWN TIME DELAY (S) = DFLT= 10.0 (1.0, 1000.0)
Enter the Shutdown Time Delay, in seconds, followed by ENTER. The Shutdown Time Delay is the time required for the attain a dead stop after decelerating past 20% of rated turbine speed. This value determines the transition from the Stopping State to the Shutdown State.

RESET CLEARS TRIP OUTPUT? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to enable a reset command to energize the ESD relay output, before an external trip to the 505H has been cleared.

SETUP TURBINE CONTROL?DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the turbine control interface. Select NO followed by the ENTER key to collapse the header and jump to the SETUP UNITS header.

START / STOP PERFORMED (MUST CHOOSE FROM LIST)
Select the controlling interface from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR TURBINE CONTROL INTERFACE
Via Keypad Via Modbus® Ports
Via Contact Inputs Via Priority Select Lines

AUTO / MANUAL PERFORMED (MUST CHOOSE FROM LIST)
Select the controlling interface from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

GOVERNOR CTRL PERFORMED (MUST CHOOSE FROM LIST)
Select the controlling interface from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

SETUP UNITS? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the units for various signals. Select NO followed by the ENTER key to collapse the header and jump to the TURBINE CONFIGURATION block.

SPEED UNITS = (MUST CHOOSE FROM LIST)
Select the units to be displayed for speed from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR SPEED UNITS
% RPM rpm

LEVEL UNITS = (MUST CHOOSE FROM LIST)
Select the units to be displayed for level from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR LEVEL UNITS
Feet Meters

POWER UNITS = (MUST CHOOSE FROM LIST)
Select the units to be displayed for power from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR POWER UNITS
MW kW

Speed Configuration Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE
The maximum turbine speed is 20000 rpm and the maximum speed input frequency is 15000 hertz.

SETUP SPEED INPUT(S)? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the speed input channel(s). Select NO followed by the ENTER key to collapse the header and jump to the SETUP GOVERNOR DYNAMICS header.

RATED RPM = DFLT= 100.0 (0.0, 10000.0)
Enter the Rated RPM, followed by ENTER. The Rated RPM is the speed of the unit, in revolutions per minute, when operating at synchronous speed.

RATED FREQUENCY #1 = DFLT= 60.0 (0.0, 10000.0)
Enter the Rated Frequency for speed input channel #1, followed by ENTER. The Rated Frequency is the frequency the speed sensor is seeing, in hertz, when operating at synchronous speed.

SPEED IN 1 Y=ZVPU N=PT DFLT= NO (YES/NO)
Configure speed input one to be either a ZVPU or a PT input.

USE SPEED INPUT #2? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if both speed input channels are to be used. Select NO followed by the ENTER key if only one speed input channel is to be used.

RATED FREQUENCY #2 = DFLT= 60.0 (0.0, 10000.0)
Enter the Rated Frequency for speed input channel #2, followed by ENTER. The Rated Frequency is the frequency the speed sensor is seeing, in hertz, when operating at synchronous speed.

SPEED IN 2 Y=ZVPU N=PT DFLT= NO (YES/NO)
Configure speed input two to be either a ZVPU or a PT input.

SPEED INPUT SW SPEED= DFLT= 50 (0, 200)
Enter the speed at which the control will switch from ZVPU input to the PT speed input.

OVERSPEED TRIP SPD (%) = DFLT= 120.0(100.0, 200.0)
Enter the Overspeed Trip Speed, in percent, followed by ENTER. The Overspeed Trip Speed is the speed, in percent of rated speed, at which the 505H issues an overspeed trip.

SETUP GOVERNOR DYNAMICS? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the governor dynamics. Select NO followed by the ENTER key to collapse the header and jump to the SPEED CONFIGURATION block. Reference appendix D for more information.

SMALL SYSTEM KP = DFLT= 1.0 (0.0, 20.0)
Enter the Small System Proportional Gain, followed by ENTER.

SMALL SYSTEM KI = DFLT= 0.1 (0.0, 10.0)
Enter the Small System Integral Gain, in seconds-1, followed by ENTER.

SMALL SYSTEM KD = DFLT= 0.0 (0.0, 5.0)
Enter the Small System Derivative Gain, in seconds, followed by ENTER.

SMALL SYSTEM DROOP (%) = DFLT= 5.0 (0.0, 10.0)
Enter the Small System Droop, in percent, followed by ENTER.

USE DUAL DYNAMICS? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if Large System Dynamics are to be used during Large System Operation. Select NO followed by the ENTER key if only the Small System Dynamics are to be used.

LARGE SYSTEM KP = DFLT= 1.0 (0.0, 20.0)
Enter the Large System Proportional Gain, followed by ENTER.

LARGE SYSTEM KI = DFLT= 0.1 (0.0, 10.0)
Enter the Large System Integral Gain, in seconds-1, followed by ENTER.

LARGE SYSTEM KD = DFLT= 0.0 (0.0, 5.0)
Enter the Large System Derivative Gain, in seconds, followed by ENTER.

LARGE SYSTEM DROOP (%) = DFLT= 5.0 (0.0, 10.0)
Enter the Large System Droop, in percent, followed by ENTER.

USE FEED FORWARD? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Feed Forward Control Algorithm is desired during Large System Operation. Select NO followed by the ENTER key to disable the Feed Forward Control Algorithm.

FEED FORWARD GAIN = DFLT= 1.0 (0.0, 1.0)
Enter the Feed Forward Gain, followed by ENTER.

Speed Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SETUP SPEED REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the Droop Reference. Select NO followed by the ENTER key to collapse the header and jump to the SETUP ISOCHRONOUS REF header.

MIN SPEED SETPOINT (%) = DFLT= 85.0 (20.0, 100.0)
Enter the Minimum Speed Setpoint, in percent, followed by ENTER. The Minimum Speed Setpoint is the minimum value, in percent of rated speed, at which the unit can control speed.

MAX SPEED SETPOINT (%) = DFLT= 110.0 (100.0, 180.0)
Enter the Maximum Speed Setpoint, in percent, followed by ENTER. The Maximum Speed Setpoint is the maximum value, in percent of rated speed, at which the unit can control speed.

ACCELERATION RATE (%/S) = DFLT= 100.0 (1.0, 100.0)
Enter the Acceleration Rate, in percent per second, followed by ENTER. The Acceleration Rate is the rate at which the speed setpoint is ramped from the starting value of 20% of rated turbine speed to the final value of 100% of rated turbine speed.

UNLOADING SETPOINT (%) = DFLT= 100.0 (85.0, 110.0)
Enter the Unloading Setpoint, in percent, followed by ENTER. The Unloading Setpoint is the speed setpoint to which the speed reference ramps in the event that a stop command is issued while the unit is On Line. See Unloading State.

UNLOADING RATE (%/S) = DFLT= 0.1 (0.01, 10.0)
Enter the Unloading Rate, in percent per second, followed by ENTER. The Unloading Rate is the rate at which the speed setpoint is ramped to the unloading setpoint if a stop command is issued while the unit is On Line. See Unloading State.

SPEED SET RATE (%/S) =DFLT= 0.1 (0.01, 10.0)
Enter the Speed Setpoint Rate, in percent per second, followed by ENTER. The Speed Setpoint Rate is the rate at which the speed setpoint is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an external signal is to be used as the speed setpoint for the Droop Reference. Select NO followed by the ENTER key if there is no external signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the external signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the external signal is not to be automatically selected.

USE SOFT-LOAD?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Droop Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Droop Reference is to ramp at the Speed Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the Droop Reference is allowed to ramp from its present value to the value determined by the External Signal.

SETUP ISOCHRONOUS REF? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the Isochronous Reference. Select NO followed by the ENTER key to collapse the header and jump to the SETUP LOADSHARING REF header.

USE ISOCHRONOUS REF? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to enable the Isochronous Reference. Select NO followed by the ENTER key to disable the Isochronous Reference.

POWER-UP USE REF?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Isochronous Reference is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the Isochronous Reference is not to be automatically selected.

SETUP LOADSHARING REF?DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the Loadsharing Reference. Select NO followed by the ENTER key to collapse the header and jump to the SETUP SPEED REFERENCE block.

USE LOADSHARING REF? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to enable the Loadsharing Control Mode. Select NO followed by the ENTER key to disable the Loadsharing Control Mode.

POWER-UP USE REF?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the mode is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the mode is not to be automatically selected.

SPEED WINDOW (%) = DFLT= 5.0 (0.0, 10.0)
Enter the Speed Window, in percent, followed by ENTER. See the description of Loadsharing for more information.

Position Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SETUP GATE REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the Gate Reference. Select NO followed by the ENTER key to collapse the header and jump to the SETUP LEVEL REFERENCE header.

UNLOADING SETPOINT (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Unloading Setpoint, in percent, followed by ENTER. The Unloading Setpoint is the gate setpoint to which the gate setpoint ramps in the event that a stop command is issued while the unit is On Line. See Unloading State.

UNLOADING RATE (%/S) = DFLT= 1.0 (1.0, 100.0)
Enter the Unloading Rate, in percent per second, followed by ENTER. The Unloading Rate is the rate at which the gate setpoint is ramped to the unloading setpoint if a stop command is issued while the unit is On Line. See Unloading State.

GATE SET RATE (%/S) = DFLT= 0.1 (0.01, 10.0)
Enter the Gate Setpoint Rate, in percent per second, followed by ENTER. The Gate Setpoint Rate is the rate at which the gate setpoint is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an External Signal is to be used as the gate setpoint for the Gate Reference. Select NO followed by the ENTER key if there is no external signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the External Signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the External Signal is not to be automatically selected.

USE SOFT-LOAD? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Gate Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Gate Reference is to ramp at the Gate Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the Gate Reference is allowed to ramp from its present value to the value determined by the External Signal.

SETUP LEVEL REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the Level Reference. Select NO followed by the ENTER key to collapse the header and jump to the SETUP POWER REFERENCE header.

USE LEVEL REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to enable the Level Reference. Select NO followed by the ENTER key to disable the Level Reference.

CONTROLLED LEVEL = (MUST CHOOSE FROM LIST)
Select the level to be controlled from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR LEVEL CONTROL
Forebay Tailbay

POWER-UP USE REF? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Level Reference is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the Level Reference is not to be automatically selected.

MIN LEVEL SET (FT OR M) = DFLT= 0.0 (0.0, 30000.0)
Enter the Minimum Level Setpoint, in configured units, followed by ENTER. The Minimum Level Setpoint is the minimum value at which the unit can control level.

MAX LEVEL SET (FT OR M) = DFLT= 0.0 (0.0, 30000.0)
Enter the Maximum Level Setpoint, in configured units, followed by ENTER. The Maximum Level Setpoint is the maximum value at which the unit can control level.
(Must be greater than the 'Minimum Level Setpoint' Setting)

WINDOW SIZE (FT OR M) = DFLT= 1.0 (0.001, 999999.0)
Enter the Window Size, in configured units, followed by ENTER. See Chapter 4 for more information.

MINIMUM GATE SET (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Minimum Gate Setpoint, in percent, followed by ENTER. See Chapter 4 for more information.

MAXIMUM GATE SET (%) = DFLT= 100.0 (0.0, 100.0)
Enter the Maximum Gate Setpoint, in percent, followed by ENTER. See Chapter 4 for more information.
(Must be greater than the 'Minimum Gate Set (%)' Setting)

LEVEL SET RATE (1/S) = DFLT= 0.1 (0.01, 10.0)
Enter the Level Setpoint Rate, in configured units per second, followed by ENTER. The Level Setpoint Rate is the rate at which the level setpoint is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an External Signal is to be used as the setpoint for the Level Reference. Select NO followed by the ENTER key if there is no External Signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the External Signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the External Signal is not to be automatically selected.

USE ON EXT SIGNAL FAIL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Level Reference is to be used in the event that the External Signal fails. Select NO followed by the ENTER key if the Level Reference is to be disabled in the event that the External Signal fails.

USE SOFT-LOAD?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Level Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Level Reference is to ramp at the Level Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the Level Reference is allowed to ramp from its present value to the value determined by the External Signal.

SETUP POWER REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the power control. Select NO followed by the ENTER key to collapse the header and jump to the POSITION REFERENCE SETUP block.

USE POWER REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to enable the Power Reference. Select NO followed by the ENTER key to disable the Power Reference.

POWER-UP USE REF?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Power Reference is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the Power Reference is not to be automatically selected.

MIN POWER SET(KW OR MW)= DFLT= 0.0 (0.0, 999999.0)
Enter the Minimum Power Setpoint, in configured units, followed by ENTER. The Minimum Power Setpoint is the minimum value at which the unit can control power.

MAX POWER SET(KW OR MW)= DFLT= 0.0 (0.0, 999999.0)
Enter the Maximum Power Setpoint, in configured units, followed by ENTER. The Maximum Power Setpoint is the maximum value at which the unit can control power. This value also serves as the Power at 100% Gate point for the power versus gate opening curve. See Chapter 4 for more information.
(Must be greater than the 'Minimum Power Setpoint' Setting)

POWER SET RATE (1/S) = DFLT= 1.0 (0.1, 999999.0)
Enter the Power Setpoint Rate, in configured units per second, followed by ENTER. The Power Setpoint Rate is the rate at which the power setpoint is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an external signal is to be used as the setpoint for the Power Reference. Select NO followed by the ENTER key if there is no External Signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the External Signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the External Signal is not to be automatically selected.

USE ON EXT SIGNAL FAIL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Power Reference is to be used in the event that the External Signal fails. Select NO followed by the ENTER key if the Power Reference is to be disabled in the event that the External Signal fails.

USE SOFT-LOAD?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Power Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Power Reference is to ramp at the Power Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the Power Reference is allowed to ramp from its present value to the value determined by the External Signal.

SETUP POWER CURVE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to program the power versus gate curve. Select NO followed by the ENTER key if you want to leave the existing curve in. See Chapter 4 for more information.

POWER AT 0% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 0% Gate, in configured units, followed by ENTER.

POWER AT 10% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 10% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 0% Gate' Setting)

POWER AT 20% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 20% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 10% Gate' Setting)

POWER AT 30% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 30% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 20% Gate' Setting)

POWER AT 40% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 40% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 30% Gate' Setting)

POWER AT 50% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 50% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 40% Gate' Setting)

POWER AT 60% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 60% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 50% Gate' Setting)

POWER AT 70% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 70% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 60% Gate' Setting)

POWER AT 80% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 80% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 70% Gate' Setting)

POWER AT 90% GATE = DFLT= 0.0 (-999999.0, 999999.0)
Enter the Power At 90% Gate, in configured units, followed by ENTER.
(Must be greater than the 'Power At 80% Gate' Setting)

Gate Limit Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BRKAWAY GATE LIMIT (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Breakaway Gate Limit, in percent, followed by ENTER. The Breakaway Gate Limit is the maximum gate position which the unit is able to attain while in the Breakaway State (from the time the unit has started until the unit has attained 10% of the rated turbine speed).

BKR OPEN GATE LIMIT (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Breaker Open Gate Limit, in percent, followed by ENTER. The Breaker Open Gate Limit is the maximum gate position which the unit is able to attain while in the Starting State (from the time the unit has attained 10% of rated turbine speed until the unit has attained 100% of rated turbine speed).

BKR CLSD GATE LIMIT (%) = DFLT= 100.0 (0.0, 100.0)
Enter the Breaker Closed Gate Limit, in percent, followed by ENTER. The Breaker Closed Gate Limit is the maximum gate position which the unit is able to attain while in the Generator Breaker is closed.

GATE LIMIT RATE (%/S) = DFLT= 5.0 (1.0, 100.0)

Enter the Gate Limit Rate, in percent per second, followed by ENTER. The Gate Limit Rate is the rate at which the gate limit is ramped during normal operation.

Gate Control Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SETUP GATE DRIVER? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to expand this collapsible header and configure the gate actuator driver. Select NO followed by the ENTER key to collapse the header and jump to the SETUP MANUAL GATE header. See the description of Actuator Drivers for more information.

GATE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)

Select the level to be controlled from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT RANGE

Is 4 - 20 mA Is 20 - 160 mA

GATE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)

Select the level to be controlled from the available list by using ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT TYPE

Is Proportional Is Integrating

GATE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)

Select the level to be controlled from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT DIRECTION

Is Noninverted Is Inverted

REMOVE MA ON UNIT STOP? DFLT= YES (YES/NO)

Select YES followed by the ENTER key if the current signal is to be removed from the gate actuator driver during normal unit stops. Select NO followed by the ENTER key if the current is not to be removed.

SHUTDOWN ON GATE FAIL? DFLT= YES (YES/NO)
Select YES followed by the ENTER key if an emergency shutdown is to be issued on failure of either the gate actuator driver or gate feedback signals. Select NO followed by the ENTER key if the control is not to shut down in these instances.

SETUP MANUAL GATE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the manual gate control Select NO followed by the ENTER key to collapse the header and jump to the GATE CONTROL SETUP block.

MANUAL SET RATE (%/S) = DFLT= 5.0 (1.0, 100.0)
Enter the Manual Setpoint Rate, in percent per second, followed by ENTER. The Manual Setpoint Rate is the rate at which the Gate Manual Reference is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an External Signal is to be used as the setpoint for the Gate Manual Reference. Select NO followed by the ENTER key if there is no External Signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the External Signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the External Signal is not to be automatically selected.

USE SOFT-LOAD?DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Gate Manual Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Gate Manual Reference is to ramp at the Manual Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its present value to the value determined by the External Signal.

Blade Control Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

USE BLADE DRIVER? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the blade control. Select NO followed by the ENTER key to collapse the header and jump to the BLADE CONTROL SETUP block. See the description of Blade Control

NET HEAD DETERMINED BY: (MUST CHOOSE FROM LIST)
Select the method of determining net head from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR NET HEAD DETERMINATION
Forebay / Tailbay Inputs Net Head Input

NUM OF NET HEAD CURVES = DFLT= 1 (1, 11)
Enter the Number of Net Head Curves, followed by ENTER. The Number of Net Head Curves tells the control how many net head curves to use in determining the blade setpoint.

USE EXTERNAL BLADE TILT? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an external contact is to be used to drive the blades to a blade tilt position. Select NO followed by the ENTER key if there is no external contact for this function.

BLADE TILT POSITION (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Blade Tilt Position, in percent, followed by ENTER. This Blade Tilt Position is tied to the external blade tilt (above).

USE BRKAWAY BLADE TILT? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the blades are to go to a blade tilt position during unit breakaway. Select NO followed by the ENTER key if no breakaway blade tilt is required.

BLADE TILT POSITION (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Blade Tilt Position, in percent, followed by ENTER. The Blade Tilt Position is associated with unit breakaway.

SETUP BLADE DRIVER? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the blade actuator driver. Select NO followed by the ENTER key to collapse the header and jump to the SETUP MANUAL BLADE header. See the description of Actuator Drivers for more information.

BLADE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)
Select the level to be controlled from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT RANGE
Is 4 - 20 mA Is 20 - 160 mA

BLADE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)
Select the level to be controlled from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT TYPE
Is Proportional Is Integrating

BLADE ACTUATOR DRIVER (MUST CHOOSE FROM LIST)
Select the level to be controlled from the available list by using ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR DRIVER OUTPUT DIRECTION
Is Noninverted Is Inverted

REMOVE MA ON UNIT STOP? DFLT= YES (YES/NO)
Select YES followed by the ENTER key if the current signal is to be removed from the blade actuator driver during normal unit stops. Select NO followed by the ENTER key if the current is not to be removed.

SHUTDOWN ON BLADE FAIL? DFLT= YES (YES/NO)
Select YES followed by the ENTER key if an emergency shutdown is to be issued on failure of either the gate actuator driver or gate feedback signals. Select NO followed by the ENTER key if the control is not to shut down in these instances.

SETUP MANUAL BLADE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the manual blade control Select NO followed by the ENTER key to collapse the header and jump to the BLADE CONTROL SETUP block.

ENABLE MANUAL REFERENCE? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Blade Manual Reference is to be used. Select NO followed by the ENTER key if the Blade Manual Reference is not to be used.

MANUAL SET RATE (%/S) = DFLT= 5.0 (1.0, 100.0)
Enter the Manual Setpoint Rate, in percent per second, followed by ENTER. The Manual Setpoint Rate is the rate at which the Blade Manual Reference is ramped during normal operation.

USE EXTERNAL SIGNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if an External Signal is to be used as the setpoint for the Blade Manual Reference. Select NO followed by the ENTER key if there is no External Signal.

POWER-UP USE EXTERNAL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the External Signal is to be selected on applying power to the 505H. Select NO followed by the ENTER key if the External Signal is not to be automatically selected.

USE ON EXT SIGNAL FAIL? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Blade Manual Reference is to be used in the event that the External Signal fails. Select NO followed by the ENTER key if the Blade Manual Reference is to be disabled in the event that the External Signal fails.

USE SOFT-LOAD? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the Blade Manual Reference is to ramp from its present value to the value determined by the External Signal at a controlled rate. Select NO followed by the ENTER key if the Blade Manual Reference is to ramp at the Manual Setpoint Rate.

SOFT-LOAD RATE (%/S) = DFLT= 0.01 (0.001, 10.0)
Enter the Soft-Load Rate, in percent per second, followed by ENTER. The Soft-Load Rate is the rate at which the Blade Manual Reference is allowed to ramp from its present value to the value determined by the External Signal

Auxiliary Functions Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

USE BRAKES? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the brake control. Select NO followed by the ENTER key to collapse the header and jump to the USE CREEP DETECTION header.

PULSE ENABLE SPEED (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Pulse Enable Speed, in percent, followed by ENTER. The Pulse Enable Speed is the speed, in percent of rated speed, at which the brake pulsing circuit is activated.

PULSE ON TIME (S) = DFLT= 1.0 (0.1, 100.0)
Enter the Pulse On Time, in seconds, followed by ENTER. The Pulse On Time is the length of time the brake output is held on while pulsing circuit is activated.

PULSE OFF TIME (S) = DFLT= 1.0 (0.1, 100.0)
Enter the Pulse Off Time, in seconds, followed by ENTER. The Pulse Off Time is the length of time the brake output is held off while pulsing circuit is activated.

HOLD ENABLE SPEED (%) = DFLT= 0.0 (0.0, 100.0)
Enter the Hold Enable Speed, in percent, followed by ENTER. The Hold Enable Speed is the speed, in percent of rated speed, at which the brakes are maintained.

ENABLE ON UNIT CREEP? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the brakes are to be applied on detection of unit creep. Select NO followed by the ENTER key to disable this function.

ON AFTER DEADSTOP(S)? DFLT= 0.0 (0, 1200)
Enter the time, in seconds, to hold the breaks after the unit has reached deadstop (the Shutdown State). Enter a zero to disable this function.

HOLD WHILE SHUTDOWN? DFLT= NO (YES/NO)
Select YES followed by the ENTER key if the brakes are to remain applied after the unit has reached a dead stop (shutdown state).

USE CREEP DETECTION? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the creep detection circuit. Select NO followed by the ENTER key to collapse the header and jump to the USE SMALL SYS DETECTION header.

CREEP REARM TIME (S) = DFLT= 1.0 (0.1, 100.0)
Enter the Creep Rearm Time, in seconds, followed by ENTER. The Creep Rearm Time is the time from when the Creep Detection Circuit has detected creep until the Creep Detection Circuit attempts to detect creep again.

CREEP RESET TIME (S) = DFLT= 1.0 (0.1, 100.0)
Enter the Creep Reset Time, in seconds, followed by ENTER. The Creep Reset Time is the time from when the Creep Detection Circuit has last detected creep until the creep indication is cleared.

USE SMALL SYS DETECTION? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to expand this collapsible header and configure the small system detection circuit. Select NO followed by the ENTER key to collapse the header and jump to the AUXILIARY FUNCTIONS block.

USE BOTH CONDITIONS? DFLT= NO (YES/NO)
Select YES followed by the ENTER key IF SMALL SYSTEM DETECTION REQUIRES BOTH THE “Speed Sig Window” and “Speed Der Window’ to be true, before enabling small system logic.

SPEED SIG WINDOW (%) = DFLT= 1.0 (0.1, 10.0)
Enter the Speed Signal Window, in percent, followed by ENTER. The Speed Signal Window is a speed window around rated speed within which the unit speed must remain. If the unit speed deviates from this window, the 505H detects a small system, switching to Speed Control.

SPEED DER WINDOW (%) = DFLT= 1.0 (0.1, 10.0)

Enter the Speed Derivative Window, in percent per second, followed by ENTER. The Speed Derivative Window is the rate of change of speed below which the unit speed change must remain. If the rate of change of unit speed exceeds this value, the 505H detects a small system, switching to Speed Control.

USE SPEED 1 DEADBAND? DFLT= NO (YES/NO)

Select YES to use noise reduction filtering on speed input #1.

USE SPEED 2 DEADBAND? DFLT= NO (YES/NO)

Select YES to use noise reduction filtering on speed input #2.

Analog Inputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE

The first five (1-5) analog inputs are differential inputs that can be from a self-powered or a loop-powered (24Vdc from 505) transducer. However, analog input #6 is an isolated analog input and should be used when isolation is required (refer to Chapter 3 for information on the analog input hardware). Analog Input #1 is dedicated to gate position feedback. Analog Input #2 is dedicated to blade position feedback, if it exists. No two analog inputs can be programmed for the same function. . There are five programmable analog inputs available to be configured. The descriptions given below are repeated five times (once for each analog input).

GATE POSN 4 MA VALUE = DFLT= 0.0 (-100.0, 200.0)

Set the value (in percent) that corresponds to 4 milliamps (mA) for the gate position feedback signal, followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

GATE POSN 20 MA VALUE =DFLT= 0.0 (-100.0, 200.0)

Set the value (in percent) that corresponds to 20 milliamps (mA) for the gate position feedback signal, followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

USE ANALOG INPUT X? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to use analog input #X (where X is any number 2 - 6). Select NO followed by the ENTER key to disable analog input #X. Note that analog input #2 is the only input which can be used for blade feedback.

ANALOG INPUT X IS (MUST CHOOSE FROM LIST)

Select option for analog input #X from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

ANALOG INPUT OPTIONS

External Speed Setpoint	Loadsharing Signal
Forebay Level Signal	External Gate Setpoint
Tailbay Level Signal	Net Head Signal
External Level Setpoint	Ext Gate Manual Setpoint
Power Level Signal	Ext Blade Manual Setpoint
External Power Setpoint	Blade Position Signal (Analog Input #2 Only)

ANALOG IN X 4 MA VALUE = DFLT= 0.0 (-999999.0, 999999.0)
Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog input followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

ANALOG IN X 20 MA VALUE = DFLT= 1.0 (-999999.0, 999999.0)
Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog input followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.
(Must be greater than the 'Analog In X 4 mA Value' Setting for analog inputs 3 - 6)

Contact Inputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

☞ **NOTE**

One of the contact inputs must be programmed as a generator breaker contact. If there is no generator breaker input, the unit will not run in any of the On Line states. See the description of the State Machine for more information. No two contact inputs can be configured for the same function. There are twelve contact inputs available to be configured. The descriptions given below are repeated twelve times (once for each contact input).

USE CONTACT INPUT X? DFLT= NO (YES/NO)
Select YES followed by the ENTER key to use contact input #X (where X is any number 1 - 12). Select NO followed by the ENTER key to disable contact input #X.

CONTACT INPUT X IS (MUST CHOOSE FROM LIST)
Select option for contact input #X from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

CONTACT INPUT OPTIONS

Generator Breaker	Gate Ref Enable
Run/Stop (Maintained)	Level Ref Enable
Start (Momentary)	Power Ref Enable
Stop (Momentary)	Loadsharing Enable

Start Permissive	Manual Control Enable
Gate Limit Raise	Contact Input Priority
Gate Limit Lower	Modbus® Port Priority
Creep Input #1	Blade Tilt Enable
Creep Input #2	Blade Lock Enable
Droop Ref Enable	Position Control Select
Isoch Ref Enable	Enable/Disable External Setpoint

Analog Readouts Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE

There are six 4-20 mA analog readouts available to be configured. The descriptions given below are repeated six times (once for each analog readout).

USE ANALOG READOUT X? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to use analog readout #X (where X is any number 1 - 6). Select NO followed by the ENTER key to disable analog readout #X.

ANALOG READOUT X IS (MUST CHOOSE FROM LIST)

Select option for analog readout #X from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

ANALOG READOUT OPTIONS

Unit Speed	Power Setpoint
Speed Setpoint	Gate Position
Forebay Level	Gate Setpoint
Tailbay Level	Gate Limit
Level Setpoint	Blade Position
Power Level	

READOUT X 4 MA VALUE = DFLT= 0.0 (-999999.0, 999999.0)

Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog readout followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

READOUT X 20 MA VALUE = DFLT= 1.0 (-999999.0, 999999.0)

Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog readout followed by the ENTER key. If the value on the display is correct, just select the ENTER key which will advance you to the next question.

(Must be greater than the 'Readout X 4 mA Value' Setting)

Relay Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE

There are six relay outputs available to be configured. Two relays are preassigned (Shutdown, Alarm). Each relay can be configured as either a level switch or as an indication. An example of a level switch is a Speed Switch, while and example of an indication is Creep Indication. The descriptions given below are repeated six times (once for each relay output).

USE RELAY OUTPUT X? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to use relay output #X (where X is any number 1 - 6). Select NO followed by the ENTER key to disable relay output #X.

USE RELAY X AS LEVEL SW? DFLT= NO (YES/NO)

Set to YES followed by ENTER to use this relay output as a level switch. Selecting NO followed by ENTER will skip you to the 'RELAY X ENERGIZES ON' question which allows you to energize the relay based on a state or status indication in the control.

RELAY X IS (MUST CHOOSE FROM LIST)

Select option for the Level Switch from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

LIST OF OPTIONS FOR LEVEL SWITCH

Speed Switch	Gate Limit Switch
Gate Position Switch	Power Switch

RELAY X LO LEVEL = DFLT= 0.0 (-100000, 100000)

Enter the LO level switch setting in engineering units followed by the ENTER key. There are LO and HI settings for each level switch option. This allows the user to program the desired hysteresis for the function selected.

RELAY X HI LEVEL = DFLT= 1.0 (-100000, 100000)

Enter the HI level switch setting in engineering units followed by the ENTER key.
(Must be greater than the 'Relay X LO Level' Setting)

RELAY X ENERGIZES (MUST CHOOSE FROM LIST)

Select option for the Level Switch activation from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

LIST OF OPTIONS FOR LEVEL SWITCH ACTIVATION

At And Below LO Level	At And Above HI Level

RELAY X ENERGIZES ON (MUST CHOOSE FROM LIST)

Select option for the relay output from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR RELAYS IF USED TO INDICATE STATE

ESD (normally energized)	Droop Ref In Control
Alarm	Isoch Ref In Control
Reset	Gate Ref In Control
Overspeed Trip	Level Ref In Control
Shutdown Indication	Power Ref In Control
Waiting For Prestart	Loadsharing In Control
Synchronizer Enable	Manual Ref In Control
Apply Brakes	Automatic Control
Creep Indication	

Modbus Communications Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SETUP MODBUS(R) PORT(S)? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to expand this collapsible header and configure the Modbus communication ports. Select NO followed by the ENTER key to collapse the header and jump to the SETUP SCALING FACTORS header.

USE MODBUS(R) PORT 1? DFLT= NO (YES/NO)

Select YES followed by the ENTER key if Modbus Port 1 is to be used to control the unit. Select NO followed by the ENTER key if it is not to be used.

USE MODBUS(R) PORT 2? DFLT= NO (YES/NO)

Select YES followed by the ENTER key if Modbus Port 2 is to be used to control the unit. Select NO followed by the ENTER key if it is not to be used.

SETUP SCALING FACTORS? DFLT= NO (YES/NO)

Select YES followed by the ENTER key to expand this collapsible header and configure the scaling factors for the Modbus communications. Select NO followed by the ENTER key to collapse the header and jump to the MODBUS COMMUNICATIONS block.

SPEED SCALING FACTOR (MUST CHOOSE FROM LIST)

Select the Speed Scaling Factor from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

OPTIONS FOR SCALING FACTORS
= 0.1 = 10.0
= 1.0 = 100.0

LEVEL SCALING FACTOR (MUST CHOOSE FROM LIST)
Select the Level Scaling Factor from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

POWER SCALING FACTOR (MUST CHOOSE FROM LIST)
Select the Power Scaling Factor from the available list by using the ADJUST UP / ADJUST DOWN arrows or by selecting the NO key until the option desired appears on the display. To select the option shown on the display, select the YES key and the ENTER key or just select ENTER.

Calibration Enable Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

ENABLE CALIBRATION MODE? DFLT= NO (YES/NO)
Set to YES followed by ENTER to enable calibration mode. See the description of Calibration for more information. Select NO followed by ENTER to disable calibration mode.

Exiting the Program Mode

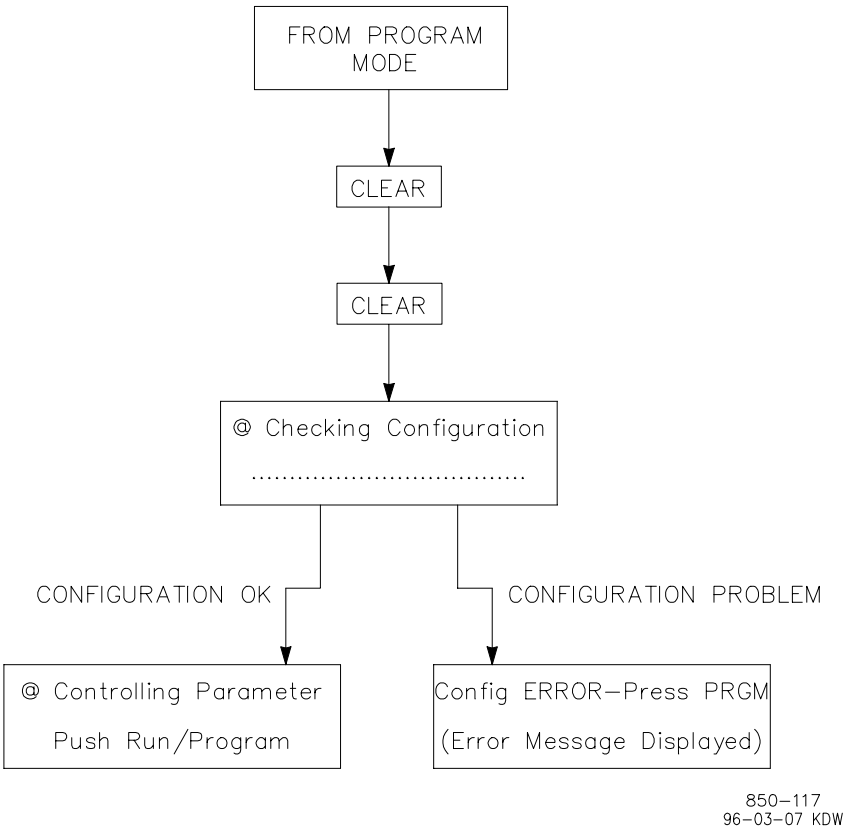

Figure 6-4. Exiting the Program Mode

Once the programming steps have been completed, the Program Mode can be exited (refer to figure 6-4 Exiting the Program Mode). To exit the Program mode the CLEAR key is pressed twice. This initiates the 505H to save the configuration and to begin a Configuration Check procedure. If there are no errors in the programming, the 505H front-panel will return to the ready state and display the Controlling Parameter / Run or Program screen. However, if there is an error in the program, the 'Config Error - Press PRGM' display will appear along will the programming error(s) discovered. The next section identifies the various configuration error messages and explains the meaning of the error.

Program Configuration Error Messages

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

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

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

Repeated Analog Inputs - - More than one analog input is programmed for the same function.

Repeated Contact Inputs - - More than one analog input is programmed for the same function.

Undefined Anlg Readout - - Reserved for future use.

Undefined Relay Output - - Reserved for future use.

Undefined Switch Level - - Reserved for future use.

Improper Blade Config - - *Use Blade Control* is selected; but either the analog input Blade Position Signal is not programmed, or *External Blade Tilt* is selected and the contact input Blade Tilt Enable is not programmed.

Improper Net Head Ins - - - *Use Blade Control* is selected, but either the analog input Net Head Signal, or the analog inputs *Forebay Level Signal* and *Tailbay Level Signal* is/are not properly programmed (dependent on how net head is determined).

Auto-Sync Incomplete - - *Use Loadsharing Ref* or *Automatic Synchronizing* is selected; but either the analog input *Loadsharing Signal*, or the relay output *Loadsharing In Control*, is not programmed.

Brake Output Required - - *Use Brake Control* is selected, but the relay output *Apply Brakes* is not programmed.

Creep Input(s) Required - - Use Creep Detection is selected, but the contact inputs *Creep Input #1* and *Creep Input #2* are not programmed.

Start Perm In Required - - *Use Start Permissive* is selected, but the contact input *Start Permissive* is not programmed.

Start Mode Required - - *Neither Automatic Start* nor *Manual Start* has been selected.

Start / Stop Incomplete - - *Contact Input Control* is selected; but the contact inputs *Run/Stop (Maintained)*, *Start (Momentary)*, and *Stop (Momentary)* are improperly configured (see Chapter 4 for more information).

Need Position Ctrl Sel - - Normal On-Line *Operation Is Determined By Contact* but the contact input *Position Control Select* is not programmed.

Droop Ref Incorrect - - *Use External Signal* is selected, but the analog input *External Speed Setpoint* is not programmed.

Gate Ref Incorrect - - *Use External Signal* is selected, but the analog input *External Gate Setpoint* is not programmed.

Power Ref Incorrect - - *Use Power Reference* is selected; but either the analog input *Power Level Signal* is not programmed, or *Use External Signal* is selected, but the analog input *External Power Setpoint* is not programmed.

Loadsharing Incorrect - - *Use Loadsharing Ref* is selected, but the analog input *Loadsharing Signal* is not programmed.

Gate Manual Incorrect - - *Use External Signal* is selected, but the analog input Ext *Gate Man Setpoint* is not programmed.

Blade Manual Incorrect - - *Use Blade Reference* is selected; but either the analog input *Blade Position Signal* is not programmed, or *Use External Signal* is selected, but the analog input *Ext Blade Man Setpoint* is not programmed.

Level Ref Incorrect - - *Use Level Reference* is selected, but either the analog input *Forebay Level Signal* or *Tailbay Level Signal* (depending on the *Controlled Level* is not programmed, or *Use External Signal* is selected, but the analog input *External Level Setpoint* is not programmed.

Chapter 7
Service Mode Procedures

Overview

The Service Mode of the 505H 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 505H 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 7-1 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 F of this manual for information on changing passwords.

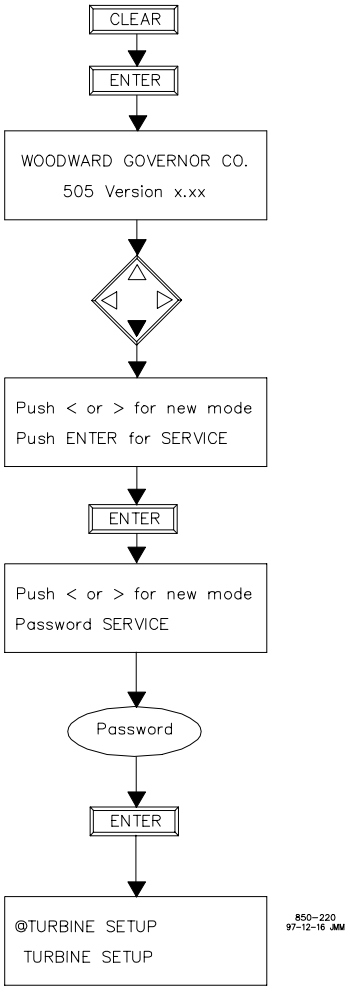

Figure 7-1. Service Mode Entry

The 505H Service Mode

Using The Service Menus

Once the Service Mode has been entered with the password, any Service Value that has a * before it can be adjusted. A worksheet is provided in appendix G to document any changes for future reference. Figure 7-2 illustrates the 505H service menus and the questions/options available under each block.

The arrow keys (SCROLL LEFT, SCROLL RIGHT) allow you to move right or left across the tops of the function the Service Mode columns. The SCROLL UP and SCROLL 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.

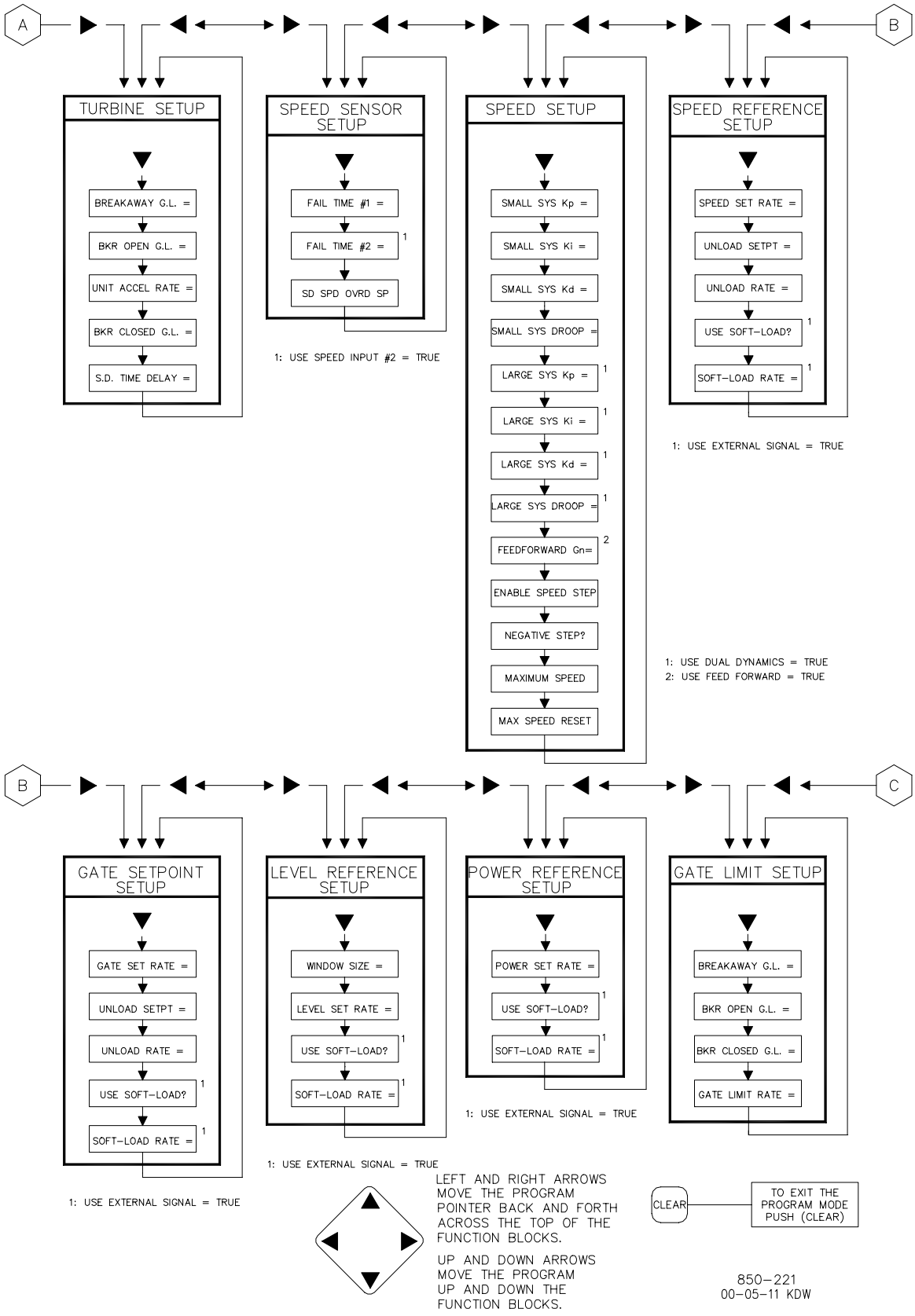

Figure 7-2. Service Mode Blocks

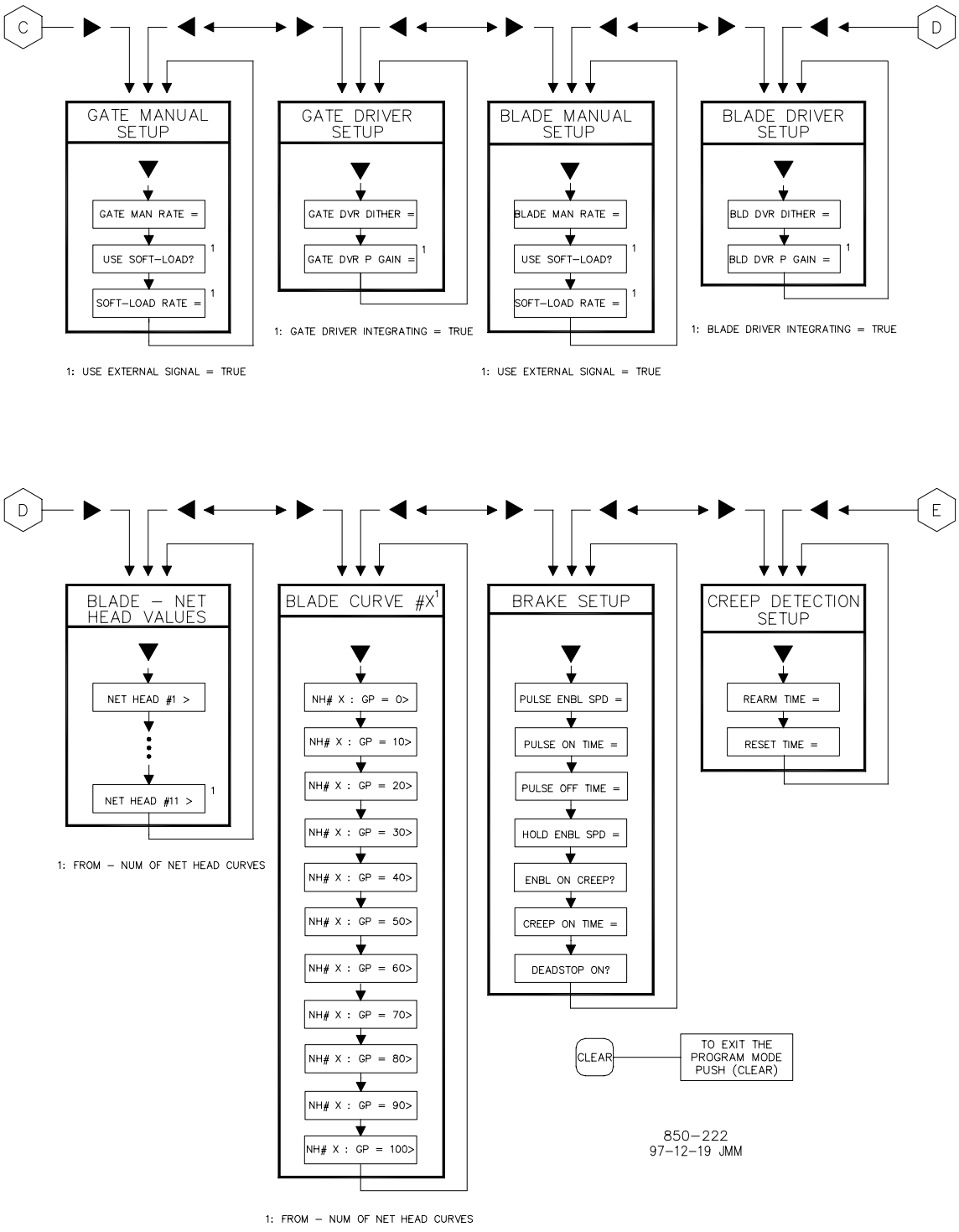

Figure 7-2. Service Mode Blocks (continued)

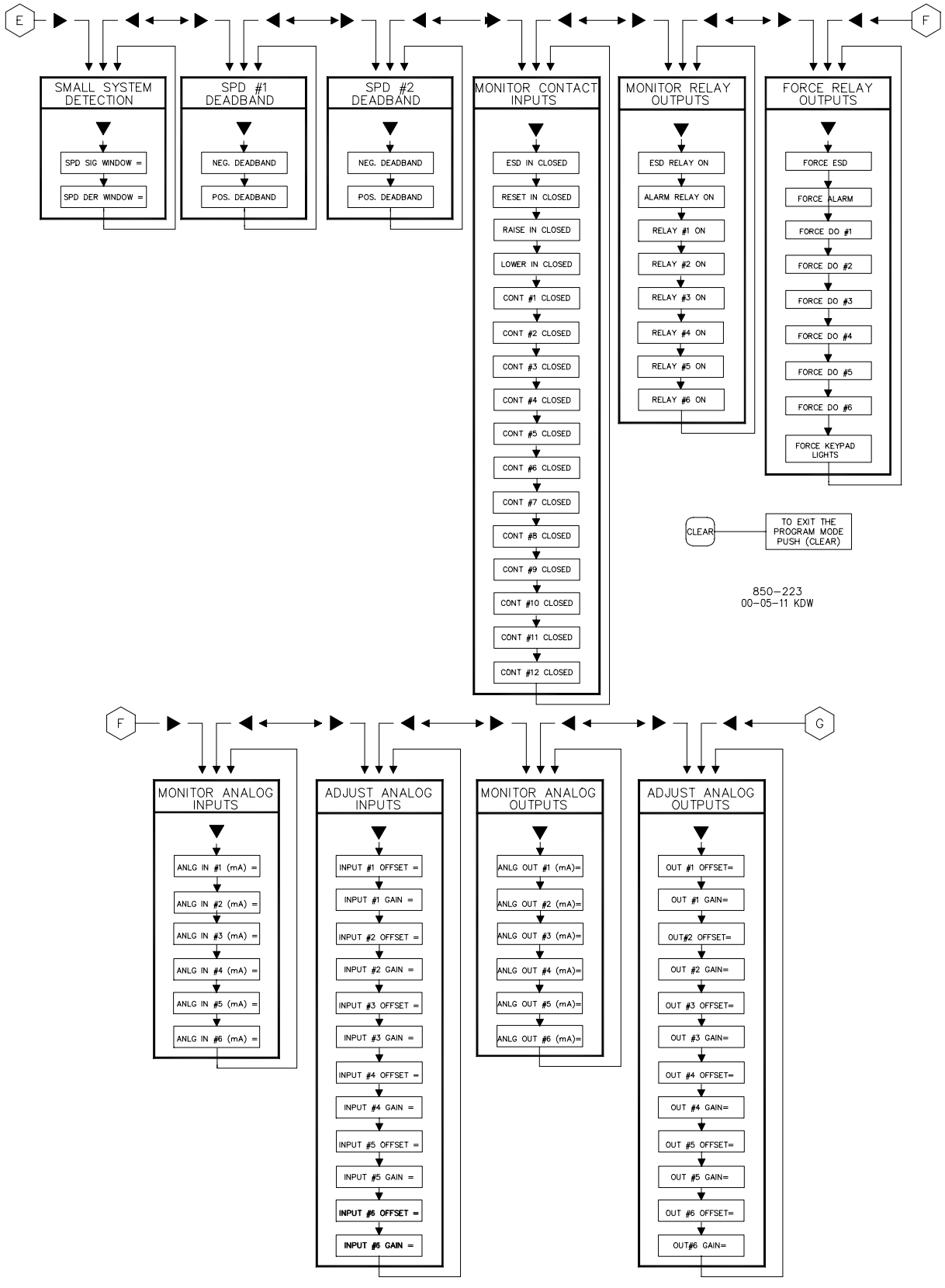

Figure 7-2. Service Mode Blocks (continued)

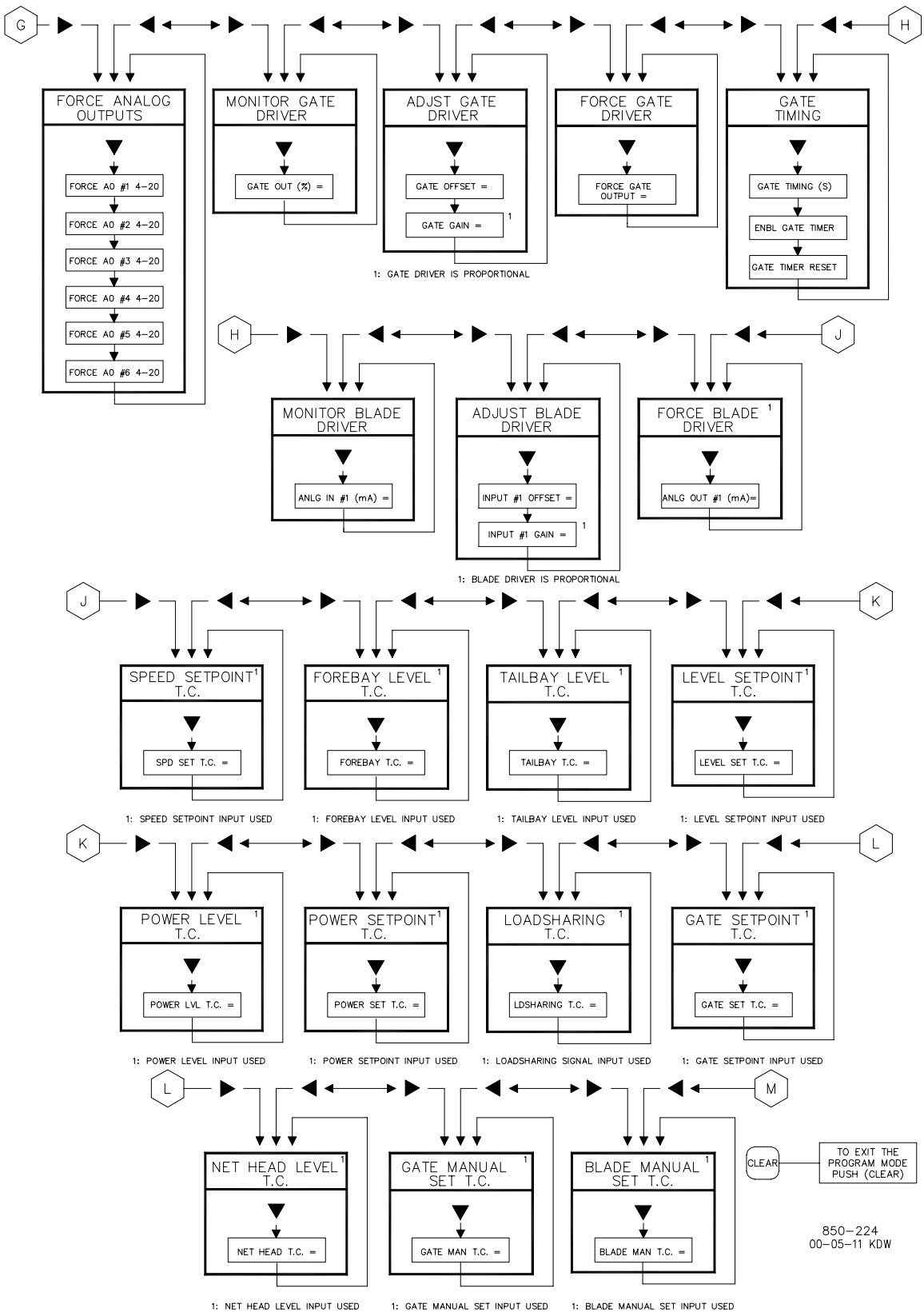

Figure 7-2. Service Mode Blocks (continued)

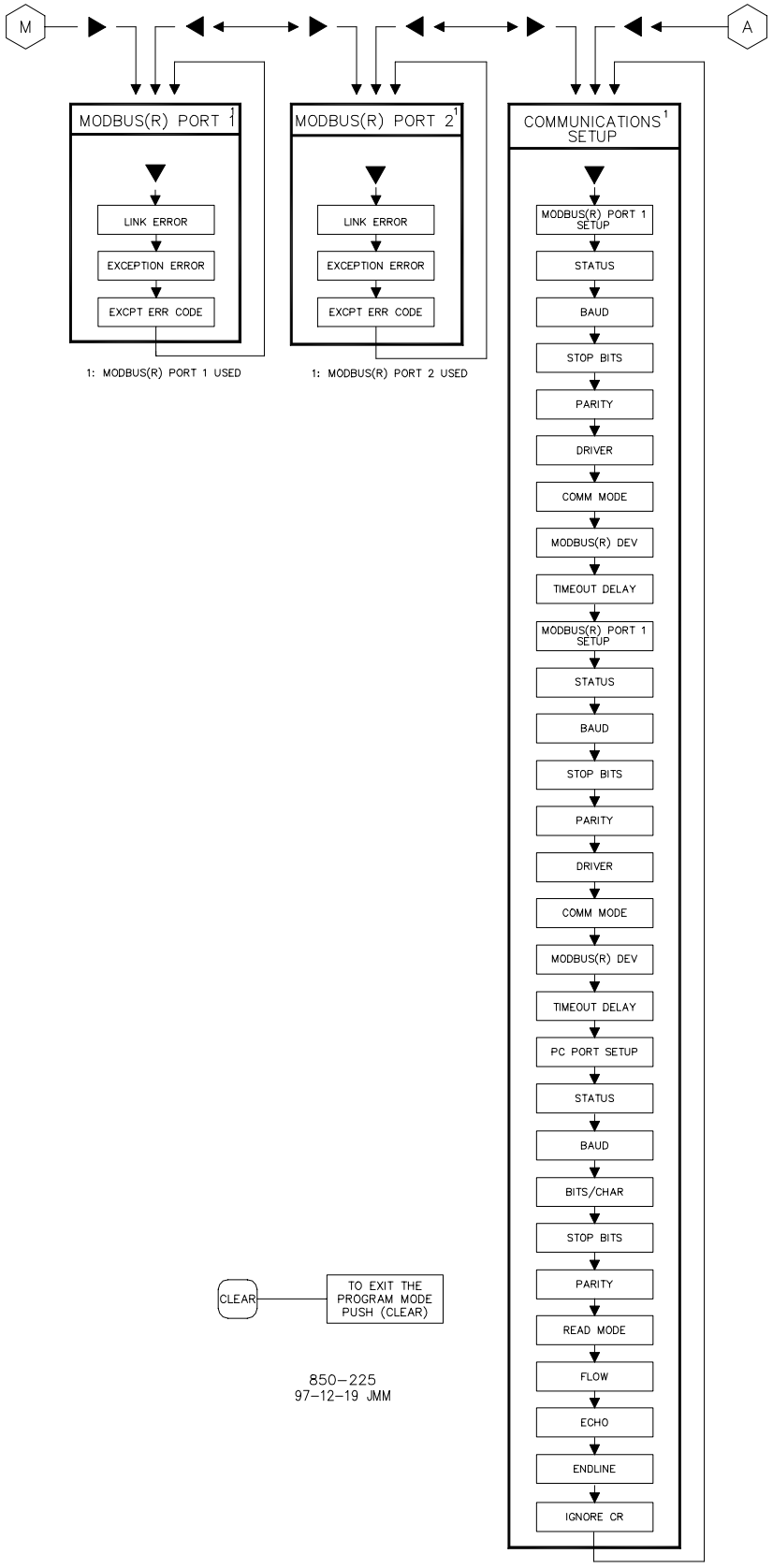

Figure 7-2. Service Mode Blocks (continued)

Service Mode Blocks

Figure 7-2 shows the 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 columns and their basic functions are described in detail below.

Service Blocks:

Turbine Setup:	monitor or change unit starting and stopping parameters - gate limit, time delay to shutdown, etc.;
Speed Sensor Setup:	monitor or change the speed sensor failure times;
Speed Setup:	monitor or change the unit dynamics (gains, droop, etc.);
Speed Reference Setup:	monitor or change Speed Reference settings;
Gate Reference Setup:	monitor or change Gate Reference settings;
Level Reference Setup:	monitor or change Level Reference settings;
Power Reference Setup:	monitor or change Power Reference settings;
Gate Limit Setup:	monitor or change Gate Limit settings;
Gate Manual Setup:	monitor or change gate Manual Control settings;
Gate Driver Setup:	monitor or change gate Output Driver settings;
Blade Manual Setup:	monitor or change blade Manual Control settings;
Blade Driver Setup:	monitor or change blade Output Driver settings;
Blade - Net Head Values:	monitor or change net head values;
Blade Curve #X:	monitor or change blade - gate curves;
Brake Setup:	monitor or change brake settings;
Creep Detection Setup:	monitor or change creep detection settings;
Small System Detection:	monitor or change small system detection settings;
Monitor Contact Inputs:	monitor the status of the contact inputs;
Monitor Relay Outputs:	monitor the status of the relay outputs;
Force Relay Outputs:	force the programmed relay outputs either on or off;
Monitor Analog Inputs:	monitor the status of the analog inputs;
Adjust Analog Inputs:	offset and gain adjustments for the analog inputs;
Monitor Analog Outputs:	monitor the status of the analog outputs;
Adjust Analog Outputs:	offset and gain adjustments for the analog outputs;
Force Analog Outputs:	force the programmed analog outputs to their maximum or minimum settings;
Monitor Gate Driver:	monitor the status of the gate actuator driver;
Adjust Gate Driver:	offset and gain adjustments for the gate actuator driver;
Force Gate Driver:	force the gate actuator driver to its maximum or minimum settings;
Monitor Blade Driver:	monitor the status of the blade actuator driver;
Adjust Blade Driver:	offset and gain adjustments for the blade actuator driver;
Force Blade Driver:	force the blade actuator driver to its maximum or minimum settings;
Signal Time Constants:	set the time constants (input filtering) for the analog input signals;
Modbus Port X:	monitor or change Modbus Port X settings;
Communications Setup:	monitor or change the communications setup;

Each of the Service Blocks is described in detail below. Figure 7-2 can be referred to for a graphical Service Mode reference. Use the SCROLL DOWN key to step through the column and back to the top. Use the SCROLL LEFT and SCROLL RIGHT keys to select the next column.

In Service Mode, the line with the @ symbol at the left side is the active line (the line which can be modified). The other line (inactive) does not change as a result of any scrolling done on the active line. You can change the active line by pressing the SELECT key. This gives you the flexibility to, for example, change the offset of an analog input signal on the active line while monitoring the value of the analog input signal on the inactive line.

The Service Blocks contain information detailing each question and/or 505H 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 used as a guide for your specific application. This worksheet can also be used for future reference to document your application program.

Service Mode Worksheet Parameters

Turbine Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BREAKAWAY G.L. = DFLT= 0.0 (0.0, 100.0)
Adjust the Breakaway Gate Limit, in percent. The Breakaway Gate Limit is the maximum gate position which the unit is able to attain while in the Breakaway State (from the time the unit has started until the unit has attained 10% of the rated turbine speed).

BKR OPEN G.L. = DFLT= 0.0 (0.0, 100.0)
Adjust the Breaker Open Gate Limit, in percent. The Breaker Open Gate Limit is the maximum gate position which the unit is able to attain while in the Starting State (from the time the unit has attained 10% of rated turbine speed until the unit has attained 100% of rated turbine speed).

UNIT ACCEL RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Unit Acceleration Rate, in percent per second. The Unit Acceleration Rate is the rate at which the speed setpoint is ramped from the starting value of 20% of rated turbine speed to the final value of 100% of rated turbine speed.

BKR CLOSED G.L. = DFLT= 100.0 (0.0, 100.0)
Adjust the Breaker Closed Gate Limit, in percent. The Breaker Closed Gate Limit is the maximum gate position which the unit is able to attain while in the Generator Breaker is closed.

S.D. TIME DELAY = DFLT= 5.0 (1.0, 100.0)
Adjust the Shutdown Time Delay, in seconds. The Shutdown Time Delay is the time required for the unit to attain dead stop after decelerating below 20% of rated turbine speed. This value determines the transition from the Stopping State to the Shutdown State.

Speed Sensor Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

FAIL TIME #X = DFLT= 0.0 (0.0, 100.0)
Adjust the Speed Sensor Failure Time, in seconds. The Speed Sensor Failure Time is the time after the unit has been started before a valid speed signal must be attained by the speed sensor input. Note that speed sensor inputs #1 and #2 can have different failure times.

S.D. SPD OVRD S.P. = DFLT= 50 (1.0, 100.0)
Enter the speed setpoint at which the speed signal fail alarm override is active on a stop or shutdown.

Speed Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure. Reference Chapter X, Fundamentals of Governor Dynamics.

SMALL SYSTEM KP = DFLT= 0.0 (0.0, 100.0)
Adjust the Small System Proportional Gain.

SMALL SYSTEM KI = DFLT= 0.0 (0.0, 100.0)
Adjust the Small System Integral Gain, in seconds-1.

SMALL SYSTEM KD = DFLT= 0.0 (0.0, 100.0)
Adjust the Small System Derivative Gain, in seconds.

SMALL SYSTEM DROOP = DFLT= 0.0 (0.0, 100.0)
Adjust the Small System Droop, in percent.

LARGE SYSTEM KP = DFLT= 0.0 (0.0, 100.0)
Adjust the Large System Proportional Gain.

LARGE SYSTEM KI = DFLT= 0.0 (0.0, 100.0)
Adjust the Large System Integral Gain, in seconds-1.

LARGE SYSTEM KD = DFLT= 0.0 (0.0, 100.0)
Adjust the Large System Derivative Gain, in seconds.

LARGE SYSTEM DROOP = DFLT= 0.0 (0.0, 100.0)
Adjust the Large System Droop, in percent.

FDFORWARD GN = DFLT= 0.0 (0.0, 100.0)
Adjust the Feed Forward Gain.

ENABLE SPD STEP = DFLT= NO (NO/YES)
Tune true to enable speed step testing logic (used for field tuning only).

NEGATIVE STEP? = DFLT= NO (NO/YES)
Tune true to input a negative speed to the speed PID (used for field tuning only).

MAXIMIM SPEED = (FOR STATUS ONLY)
This is the maximum speed seen by the unit since the last "Max Speed Reset" command was issued.

MAX SPEED RESET = DFLT= NO (NO/YES)
Tune true to reset the "Maximum Speed" (menu item above).

Speed Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SPEED SET RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Speed Reference Rate, in percent per second. The Speed Reference Rate is the rate at which the speed setpoint is ramped during normal operation.

UNLOAD SETPT = DFLT= 0.0 (0.0, 100.0)
Adjust the Unloading Setpoint, in percent. The Unloading Setpoint is the value to which the speed setpoint is ramped in the event that a stop command is issued while the unit is On Line. See Unloading State.

UNLOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Unloading Rate, in percent per second. The Unloading Rate is the rate at which the speed setpoint is ramped to the Unloading Setpoint. See Unloading State.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Gate Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE SET RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Setpoint Rate, in percent per second. The Gate Setpoint Rate is the rate at which the gate setpoint is ramped during normal operation.

UNLOAD SETPT = DFLT= 0.0 (0.0, 100.0)
Adjust the Unloading Setpoint, in percent. The Unloading Setpoint is the value to which the setpoint is ramped in the event that a stop command is issued while the unit is On Line. See Unloading State.

UNLOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Unloading Rate, in percent per second. The Unloading Rate is the rate at which the gate setpoint is ramped to the Unloading Setpoint. See Unloading State.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Level Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

WINDOW SIZE = DFLT= 0.0 (0.0, 100.0)
Adjust the Window Size, in configured units. See description of Level Control for more information.

LEVEL SET RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Level Reference Rate, in percent per second. The Level Reference Rate is the rate at which the level setpoint is ramped during normal operation.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Power Reference Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

POWER SET RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Power Reference Rate, in percent per second. The Power Reference Rate is the rate at which the level setpoint is ramped during normal operation.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Gate Limit Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BREAKAWAY G.L. = DFLT= 0.0 (0.0, 100.0)
Adjust the Breakaway Gate Limit, in percent. The Breakaway Gate Limit is the maximum gate position which the unit is able to attain while in the Breakaway State (from the time the unit has started until the unit has attained 10% of the rated turbine speed).

BKR OPEN G.L. = DFLT= 0.0 (0.0, 100.0)
Adjust the Breaker Open Gate Limit, in percent. The Breaker Open Gate Limit is the maximum gate position which the unit is able to attain while in the Starting State (from the time the unit has attained 10% of rated turbine speed until the unit has attained 100% of rated turbine speed).

BKR CLOSED G.L. = DFLT= 100.0 (0.0, 100.0)
Adjust the Breaker Closed Gate Limit, in percent. The Breaker Closed Gate Limit is the maximum gate position which the unit is able to attain while in the Generator Breaker is closed.

GATE LIMIT RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Limit Ramp Rate, in percent per second. The Gate Limit Ramp Rate is the rate at which the gate limit is ramped during normal operation.

Gate Manual Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE MAN RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Manual Setpoint Rate, in percent per second. The Manual Setpoint Rate is the rate at which the gate manual setpoint is ramped during normal operation.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Gate Driver Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE DVR DITHER = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Driver Dither, in percent. See the description of the Actuator Driver for more information.

GATE DVR P GAIN = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Driver Proportional Gain. See the description of the Actuator Driver for more information.

Blade Manual Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BLADE MAN RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Manual Setpoint Rate, in percent per second. The Manual Setpoint Rate is the rate at which the blade manual setpoint is ramped during normal operation.

USE SOFT-LOAD? DFLT= NO (NO/YES)
Adjust to YES if the reference is to ramp from its Follow Position to the External Reference Position at a controlled rate. Adjust to NO if the reference is to ramp at the normal reference rate.

SOFT-LOAD RATE = DFLT= 0.0 (0.0, 100.0)
Adjust the Soft-Load Rate, in percent per second. The Soft-Load Rate is the rate at which the reference is allowed to ramp from its Follow Position to the External Reference Position.

Blade Driver Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BLD DVR DITHER = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Driver Dither, in percent. See the description of the Actuator Driver for more information.

BLD DVR P GAIN = DFLT= 0.0 (0.0, 100.0)
Adjust the Gate Driver Proportional Gain. See the description of the Actuator Driver for more information.

Blade - Net Head Values Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NET HEAD # X> DFLT= 0.0 (0.0, 100.0)
Adjust the Net Head value for curve #X. See description of Blade Control for more information.

Blade Curve # X Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NH # X : GP= Y> DFLT= 0.0 (0.0, 100.0)
Adjust the Desired Blade Setpoint for curve #X, gate position = Y. See description of Blade Control for more information.

Brake Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

PULSE ENBL SPD= DFLT= 0.0 (0.0, 100.0)
Adjust the Pulse Enable Speed for the brake circuit. This is the percentage of rated speed at which the brake pulsing circuit is enabled.

PULSE ON TIME= DFLT= 0.0 (0.0, 100.0)
Adjust the Pulse On Time for the brake circuit. This is the length of time that the pulsing circuit is left on.

PULSE OFF TIME= DFLT= 0.0 (0.0, 100.0)
Adjust the Pulse Off Time for the brake circuit. This is the length of time that the pulsing circuit is left off.

HOLD ENBL SPD= DFLT= 0.0 (0.0, 100.0)
Adjust the Hold Enable Speed for the brake circuit. This is the percentage of rated speed at which the maintained brake circuit is enabled.

ENBL ON CREEP? DFLT= NO (NO/YES)
Adjust to YES if the brakes are to be applied upon detection of unit creep. Adjust to NO if the brakes are not to be applied upon creep detection.

CREEP ON TIME= DFLT= 0.0 (0.0, 100.0)
Adjust the Creep On Time for the brake circuit. This is the length of time after unit creep has ceased until the brakes are released.

DEADSTOP ON? DFLT= NO (NO/YES)
Adjust to YES if the brakes are to be applied when in the Unit Shutdown status. Adjust to NO if the brakes are not to be applied when in the Unit Shutdown status.

Creep Detection Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

REARM TIME = DFLT= 0.0 (0.0, 100.0)
Adjust the Creep Rearm Time for the creep detection circuit. This is the length of time after unit creep is detected before the creep circuit rearms itself to again look for unit creep.

RESET TIME= DFLT= 0.0 (0.0, 100.0)
Adjust the Creep Reset Time for the creep detection circuit. This is the length of time after unit creep is detected before the creep circuit attempts to clear the unit creep alarm.

Small System Detection Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SPD SIG WINDOW= DFLT= 0.0 (0.0, 100.0)
Adjust the Speed Signal Window for the small system detection circuit. This is the window in percent around rated speed within which the unit speed must remain to not detect small system operation.

SPD DER WINDOW= DFLT= 0.0 (0.0, 100.0)
Adjust the Speed Derivative Window for the small system detection circuit. This is the window in percent per second under which the rate of change of unit speed must remain to not detect small system operation.

SPD #1 Deadband Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL Left or SCROLL RIGHT arrow to select another block to configure.

NEG. DEADBAND = DFLT= 0.5 (0.0, 5.0)
Adjust the Negative Speed Deadband for speed input #1. this is the window, in percent speed, below the rated speed for which speed is fixed.

POS. DEADBAND = DFLT= 0.5 (0.0, 5.0)
Adjust the Positive Speed Deadband for speed input #1. this is the window, in percent speed, above the rated speed for which speed is fixed.

SPD #2 Deadband Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL Left or SCROLL RIGHT arrow to select another block to configure.

NEG. DEADBAND = DFLT= 0.5 (0.0, 5.0)
Adjust the Negative Speed Deadband for speed input #2. this is the window, in percent speed, below the rated speed for which speed is fixed.

POS. DEADBAND = DFLT= 0.5 (0.0, 5.0)
Adjust the Positive Speed Deadband for speed input #2. this is the window, in percent speed, above the rated speed for which speed is fixed.

Monitor Contact Inputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

ESD IN CLOSED (STATUS INDICATION ONLY)
Monitor the status of the ESD Contact Input.

RESET IN CLOSED (STATUS INDICATION ONLY)
Monitor the status of the Reset Contact Input.

RAISE IN CLOSED (STATUS INDICATION ONLY)
Monitor the status of the Raise Contact Input.

LOWER IN CLOSED (STATUS INDICATION ONLY)
Monitor the status of the Lower Contact Input.

CONT #X CLOSED (STATUS INDICATION ONLY)
Monitor the status of Contact Input #X, where X is any of the Contact Inputs 1 through 12.

Monitor Relay Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

ESD RELAY ON (STATUS INDICATION ONLY)
Monitor the status of the ESD Relay Output.

ALARM RELAY ON (STATUS INDICATION ONLY)
Monitor the status of the Alarm Relay Output.

RELAY #X ON (STATUS INDICATION ONLY)
Monitor the status of Relay #X, where X is any of the Relay Outputs 1 through 6.

Force Relay Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE
"Calibrate" must be selected from "Configure" to make this menu active.

FORCE ESD = DFLT = NO (NO/YES)
Use adjust key to tune the force output true, thereby energizing the relay output.

FORCE ALARM = DFLT = NO (NO/YES)

Use adjust key to tune the force output true, thereby energizing the relay output.

FORCE DO # (1-6) = DFLT = NO (NO/YES)

Use adjust key to tune the force output true, thereby energizing the relay output.

FORCE KEYPAD LIGHTS = DFLT = NO (NO/YES)

Use adjust key to tune the force output true, thereby turning on all the keypad LEDs.

Monitor Analog Inputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

ANLG IN #X (MA) = (STATUS INDICATION ONLY)
Monitor the value of Analog Input #X, where X is any of the Analog Inputs 1 through 6.

Adjust Analog Inputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

INPUT #X OFFSET = DFLT= 0.0 (-4.0, 4.0)
Adjust the offset value, in milliamps, for Analog Input #X, where X is any of the Analog Inputs 1 through 6.

INPUT #X GAIN = DFLT= 1.0 (0.0, 2.0)
Adjust the gain value for Analog Input #X, where X is any of the Analog Inputs 1 through 6.

Monitor Analog Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

ANLG OUT #X(MA)= (STATUS INDICATION ONLY)
Monitor the value of Analog Output #X, where X is any of the Analog Outputs 1 through 6.

Adjust Analog Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

OUT #X OFFSET = DFLT= 0.0 (-4.0, 4.0)
Adjust the offset value, in milliamps, for Analog Output #X, where X is any of the Analog Outputs 1 through 6.

OUT #X GAIN = DFLT= 1.0 (0.0, 2.0)
Adjust the gain value for Analog Output #X, where X is any of the Analog Outputs 1 through 6.

Force Analog Outputs Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

NOTE
"Calibrate" must be selected from "Configure" to make this menu active.

FORCE ANALOG OUTPUT 1, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA.

FORCE ANALOG OUTPUT 2, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA

FORCE ANALOG OUTPUT 3, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA

FORCE ANALOG OUTPUT 4, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA

FORCE ANALOG OUTPUT 5, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA

FORCE ANALOG OUTPUT 6, 4-20mA = DFLT = 4mA (4-20mA)
Tuning this number will drive the output from 4mA to 20mA.

Monitor Gate Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE OUT (%) = (STATUS INDICATION ONLY)
Monitor the value of the gate Output Driver, in percent.

Adjust Gate Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE OFFSET = DFLT= 0.0 (-20.0, 20.0)
Adjust the offset value, in percent, of the gate Output Driver.

GATE GAIN = DFLT= 1.0 (0.0, 2.0)
Adjust the gain value of the gate Output Driver.

Force Gate Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

FORCE GATE OUTPUT (MUST CHOOSE FROM LIST)
Select the forcing value for the gate Output Driver from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR GATE OUTPUT DRIVER

0%	95%
5%	100%
50%	

Gate Timing Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

GATE TIMING (S) = (STATUS INDICATION ONLY)
Capture the gate timing in seconds.

ENABLE GATE TIMER= DFLT = NO (NO/YES)
Tune true (yes) to enable the gate timing feature. This timer captures the time for the gates to move from 30-80%, then multiplies this value by two for display ("Gate Timing (S)")

GATE TIMER RESET = DFLT = NO (NO/YES)
Tune true to reset the "Gate Timing (S)" value to zero.

Monitor Blade Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BLADE OUT (%) = (STATUS INDICATION ONLY)
Monitor the value of the blade Output Driver, in percent.

Adjust Blade Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

BLADE OFFSET = DFLT= 0.0 (-20.0, 20.0)
Adjust the offset value, in percent, of the blade Output Driver.

BLADE GAIN = DFLT= 1.0 (0.0, 2.0)
Adjust the gain value of the blade Output Driver.

Force Blade Driver Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

FORCE BLADE OUTPUT (MUST CHOOSE FROM LIST)
Select the forcing value for the blade Output Driver from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR BLADE OUTPUT DRIVER

0%	95%
5%	100%
50%	

Signal Time Constant Blocks. There are eleven input signals which can have time constants (input filtering) assigned to them. These are divided into eleven independent blocks. The block for a specific signal will appear only if it has been configured as an Analog Input. When you have chosen the signal for which you wish to set the time constant, press the SCROLL DOWN arrow to set the value, or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

SPD SET T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

FOREBAY T.C. = DFLT= 60.0 (10.0, 1000.0)
Adjust the Speed Setpoint Time Constant, in seconds.

TAILBAY T.C. = DFLT= 60.0 (10.0, 1000.0)
Adjust the Speed Setpoint Time Constant, in seconds.

LEVEL SET T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

POWER LVL T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

POWER SET T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

LDSHARING T.C. = DFLT= 0.1 (0.1, 10.0)
Adjust the Speed Setpoint Time Constant, in seconds.

GATE SET T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

NET HEAD T.C. = DFLT= 60.0 (10.0, 1000.0)
Adjust the Speed Setpoint Time Constant, in seconds.

GATE MAN T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

BLADE MAN T.C. = DFLT= 1.0 (0.2, 5.0)
Adjust the Speed Setpoint Time Constant, in seconds.

Modbus Port 1 and Port 2 Blocks. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure.

LINK ERROR (STATUS INDICATION ONLY)
Displays YES if the port has a communication error. The Timeout Delay or port configuration may need to be adjusted under the COMMUNICATIONS SETUP block.

EXCEPTION ERROR (STATUS INDICATION ONLY)
Displays YES if the port has a Modbus exception error.

EXCPT ERROR CODE (STATUS INDICATION ONLY)
Displays the error code related to the communication problem.

0 = No Errors 3 = Illegal Data Value
1 = Illegal Function 9 = Checksum Error
2 = Illegal Data Address 10 = Garbled Message

Communication Setup Block. When this block appears in the display, press the SCROLL DOWN arrow to configure this block or press the SCROLL LEFT or SCROLL RIGHT arrow to select another block to configure**.**

Modbus(R) PORT 1 SETUP

STATUS (STATUS INDICATION ONLY)
Indicates a hardware communication problem with port 1.

BAUD (MUST CHOOSE FROM LIST)
Select the baud rate required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR BAUD RATE

110	4800
300	9600
600	19200
1200	38400
1800	57600
2400	

STOP BITS (MUST CHOOSE FROM LIST)

Select the number of stop bits required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR STOP BITS

1 1.5 2

PARITY (MUST CHOOSE FROM LIST)

Select the parity required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR PARITY

off odd even

DRIVER (MUST CHOOSE FROM LIST)

Select the driver required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR DRIVER

RS232 RS422 RS485

COMM MODE (MUST CHOOSE FROM LIST)

Select the serial communications mode required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR COMMUNICATIONS MODE

RTU ASCII

Modbus (R) DEV: DFLT= 1 (1, 247)

Adjust the Modbus device number / address required for port 1.

TIMEOUT DELAY= DFLT= 2.0 (0.0, 100.0)

Adjust the delay for no communication on the Modbus link for port 1 before the link is considered failed and an alarm is issued.

Modbus (R) PORT 2 SETUP

STATUS (STATUS INDICATION ONLY)

Indicates a hardware communication problem with port 2.

BAUD (MUST CHOOSE FROM LIST)

Select the baud rate required for port 2 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR BAUD RATE

110	4800
300	9600
600	19200
1200	38400
1800	57600
2400	

STOP BITS (MUST CHOOSE FROM LIST)

Select the number of stop bits required for port 2 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR STOP BITS

1 1.5 2

PARITY (MUST CHOOSE FROM LIST)

Select the parity required for port 2 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR PARITY

off odd even

DRIVER (MUST CHOOSE FROM LIST)

Select the driver required for port 2 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR DRIVER

RS232 RS422 RS485

COMM MODE (MUST CHOOSE FROM LIST)

Select the serial communications mode required for port 2 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR COMMUNICATIONS MODE

RTU ASCII

Modbus (R) DEV: DFLT= 1 (1, 247)

Adjust the Modbus device number / address required for port 2.

TIMEOUT DELAY= DFLT= 2.0 (0.0, 100.0)

Adjust the delay for no communication on the Modbus link for port 2 before the link is considered failed and an alarm is issued.

PC PORT SETUP

STATUS (STATUS INDICATION ONLY)

Indicates a hardware communication problem with the PC port.

BAUD (MUST CHOOSE FROM LIST)

Select the baud rate required for the PC port from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR BAUD RATE

110	2400
300	4800
600	9600
1200	19200
1800	38400

BITS/CHAR (MUST CHOOSE FROM LIST)

Select the bits per character required for the PC port from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR BITS / CHARACTER

7 8

STOP BITS (MUST CHOOSE FROM LIST)

Select the number of stop bits required for port 1 from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR STOP BITS

1 1.5 2

PARITY (MUST CHOOSE FROM LIST)

Select the parity required for the PC port from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR PARITY

off odd even

READ MODE (MUST CHOOSE FROM LIST)

Select the read mode required for the PC port from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR READ MODE

char line

FLOW (MUST CHOOSE FROM LIST)

Select the asynchronous data flow required for the PC port from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR FLOW

off xon-xoff cts-rts

ECHO (MUST CHOOSE FROM LIST)

Select whether the PC port is to echo the received data from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR ECHO

off on

ENDLINE (MUST CHOOSE FROM LIST)

Select what the PC port interprets as an end-of-line indication from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR END OF LINE

cr lf crlf

IGNORE CR (MUST CHOOSE FROM LIST)

Select whether the PC port is to ignore carriage returns from the available list by using the adjust up / adjust down arrows.

OPTIONS FOR IGNORE CR

off on

Chapter 8
505H Operation

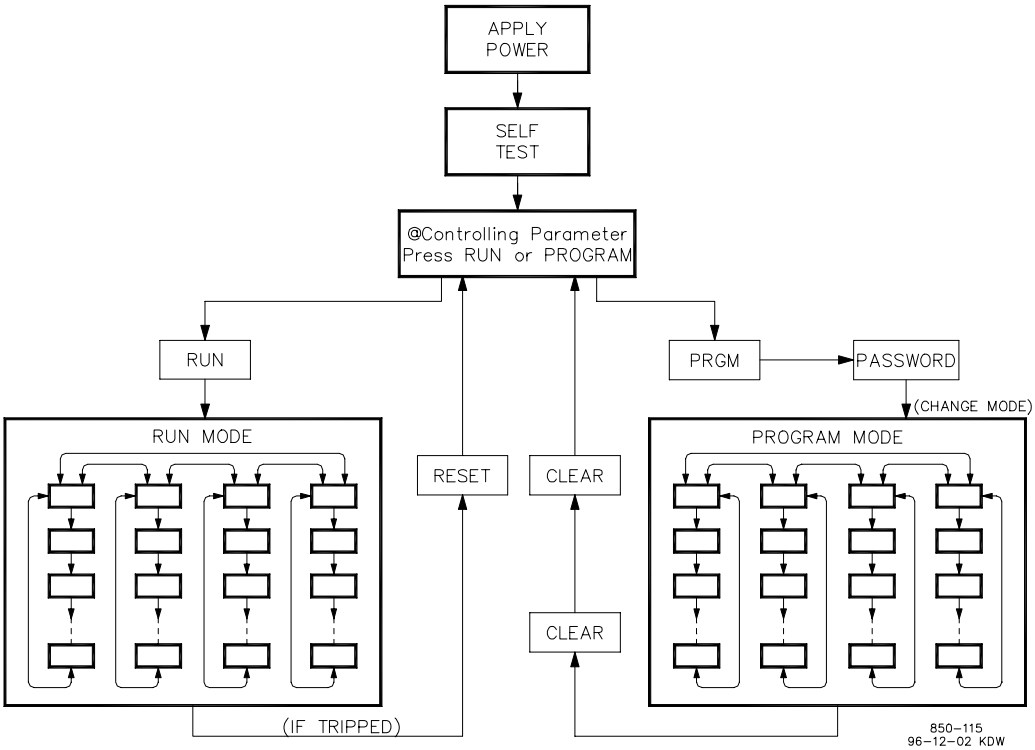

Figure 8-1. Basic Program Architecture

RUN MODE ARCHITECTURE

The 505H is designed to be interfaced with through a user-friendly service panel, discrete and analog input/outputs or Modbus communications. Basic program architecture is illustrated in Figure 8-1. When the control is powered up and after the brief CPU self test has been completed, the control displays a ready status (Controlling Parameter / Run or Program). The 505H's operating architecture is divided into two sections: the Run Mode and the Program Mode. The Program Mode is used to configure the 505H for the specific application and set all operating parameters (see Chapter 6). The Run Mode is simply the normal turbine operation mode and is used to view operating parameters and run the turbine.

An overview of Run Mode keys and screens is shown in Figure 8-2. This diagram shows all of the potential screens that could appear. However, only the screens that are related to the 505H's programmed functionality will appear. Figure 8-2 also shows the keys that are active for each screen. The 'hot' keys (speed, gat/ndl, etc.) are always active if the function is programmed. The ADJUST UP, ADJUST DOWN, ENTER, F3, and F4 keys, however, are only active with certain screens. Figure 8-2 can be referred to, when determining what keys are active and what screens will appear on the display.

From the Control Interface section of Chapter 5, the 505H control is divided into three separate sections: Auto/Manual Logic, Operating Logic, and Start/Stop Logic. The selected Control Source for each of these three sections dictates whether the keypad can be used to operate the control.

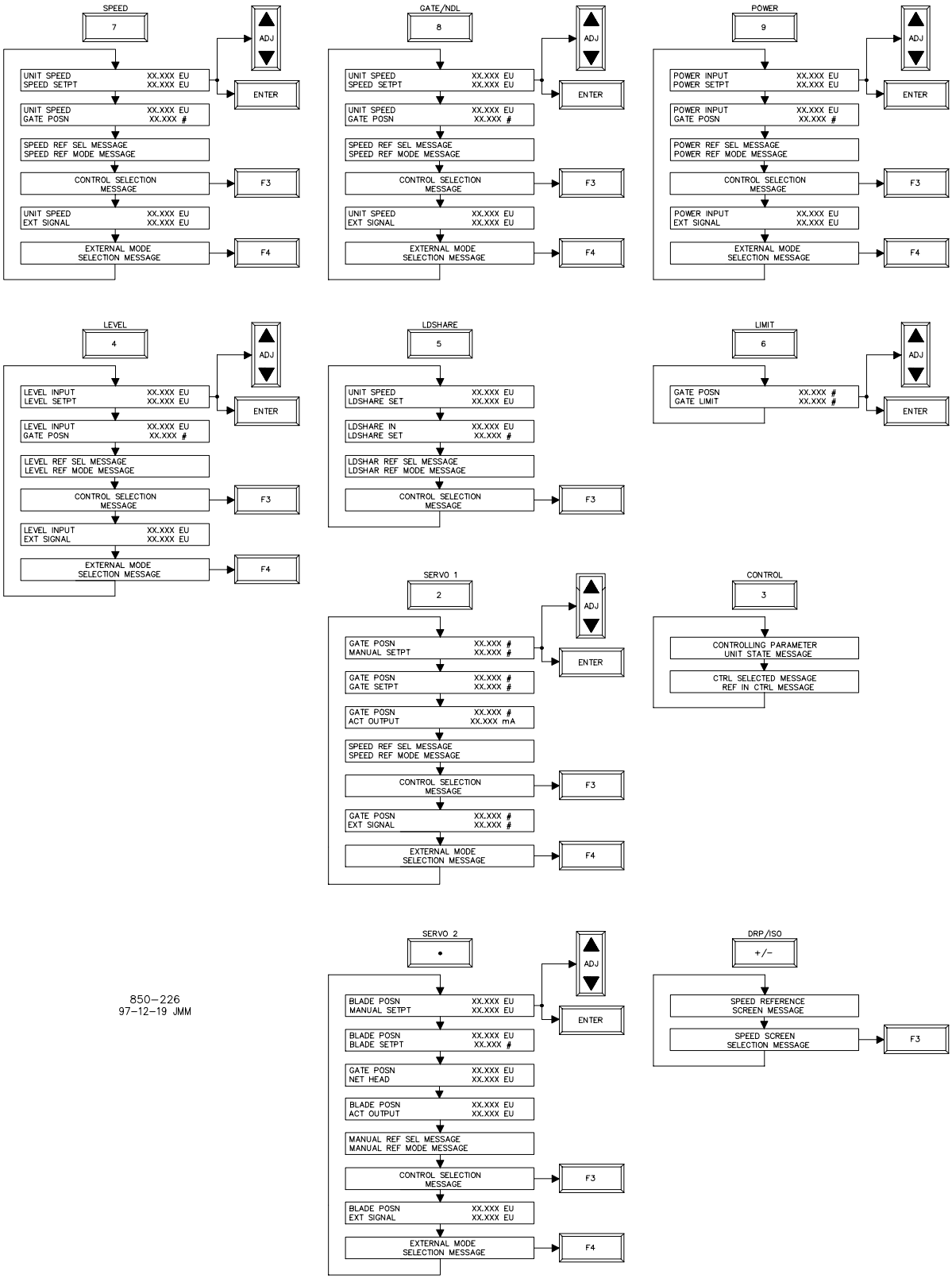

Figure 8-2. Overview of Run Mode

Table 8-1 is the key to all of the italic words / phrases contained in this chapter. This is a one point reference to cover all of the possible messages which can appear on the various screens.

Control Selection Message

Governor Ref Selection Via Contact Input	Use contact inputs to select the displayed Governor Reference to be In Control.
Governor Reference selected to	The displayed Governor Reference is already Selected to be In Control.
Governor Ref Selection Modbus(R) Port	Use Modbus port to select the displayed Governor Via Reference to be In Control.
Push F3 To Select Governor Reference	Push the f3 key to select the displayed Governor Reference to be In Control.

Ctrl Selected Message

Manual Control Selected	The 505H is presently in Manual Control.
Posn Control Selected	The 505H is presently in Position Control.
Speed Control Selected	The 505H is presently in Speed Control.

External Mode Selection Message

External Mode Disabled	External Mode for the displayed Governor Reference is disabled.
Push F4 To Enbl Extern	Pushing the F4 key will enable the External Mode.
External Mode	External Mode for the displayed Governor Reference is enabled.
Enabled Push F4 To Dsbl Extern	Pushing the F4 key will disable the External Mode.

Mode Message

Following	The displayed Governor Reference is in Follow Mode.
In External	The displayed Governor Reference is in External Mode.
In Local	The displayed Governor Reference is in Local Mode.
Overridden	The displayed Governor Reference is in Override Mode.

Ref In Ctrl Message

Droop Ref In Control	Droop Reference is presently In Control.
Gate Ref In Control	Gate Reference is presently In Control.
Isoch Ref In Control	Isochronous Reference is presently In Control.
Ldshare Ref In Control	Loadsharing Reference is presently In Control.
Level Ref In Control	Level Reference is presently In Control.
Manual Ref In Control	Manual Reference is presently In Control.
Power Ref In Control	Power Reference is presently In Control.
Unit In Emergency SD	The 505H has an Emergency Shutdown.

Sel Message

Not Selected	The displayed Governor Reference is not selected to be In Control.
Selected	The displayed Governor Reference is selected to be In Control.

Table 8-1. Key to Screen Messages

Speed	
Droop	The speed key screens are configured to show the Droop Reference values.
Isoch	The speed key screens are configured to show the Isochronous Reference values.
Speed Reference Screen Message	
Droop Reference Screen the Currently Selected	The Droop Reference Screen is displayed under speed key.
Isoch Reference Screen Currently Selected	The Isochronous Reference Screen is displayed under the speed key.
Speed Screen Selection Message	
Droop Ref Selected Via Contact Input	The Speed Screen will display the Droop Reference if selected via contact inputs.
Droop Ref Selected Via Modbus(R) Port	The Speed Screen will display the Droop Reference if selected via the Modbus ports.
Isoch Ref Selected Via Contact Input	The Speed Screen will display the Isochronous Reference if selected via contact inputs.
Isoch Ref Selected Via Modbus(R) Port	The Speed Screen will display the Isochronous Reference if selected via the Modbus ports.
Isoch Reference Is Not Available	The Isochronous Reference is not enabled.
Push F3 To Select Droop Reference Screen	Pushing the F3 key will allow the Speed Screen to display the Droop Reference.
Push F3 To Select Isoch Reference Screen	Pushing the F3 key will allow the Speed Screen to display the Isochronous Reference.
Unit Status Message	
Waiting For Prestart	The Status Engine is in the Waiting For Prestart status.
Unit Breakaway	The Status Engine is in the Unit Breakaway status.
Unit Start	The Status Engine is in the Unit Start status.
Ready To Synchronize	The Status Engine is in the Ready To Synchronize status.
On Line Operation	The Status Engine is in the On Line Operation status.
Unit Unload	The Status Engine is in the Unit Unload status.
Unit Stop	The Status Engine is in the Unit Stop status.
Unit Shutdown	The Status Engine is in the Unit Shutdown status.

Table 8-1. Key to Screen Messages (cont)

Keypad and Display

The 505H's service panel consists of a keypad and LED display located on the front of the control. The LED display has two, 24 character lines that can be used to display operating parameters and trouble-shooting parameters in plain English. Also, there are 30 keys available to provide complete control from the front of the 505H. No additional control panels are required to operate the turbine, every turbine control function can be accomplished from the 505H's front panel. However, the turbine can also be operated remotely. Almost all of the front panel control functions can be performed via contact closures or a Modbus link. For safety purposes, the 505H's Extended Speed function cannot be performed either via contact inputs or a Modbus link.

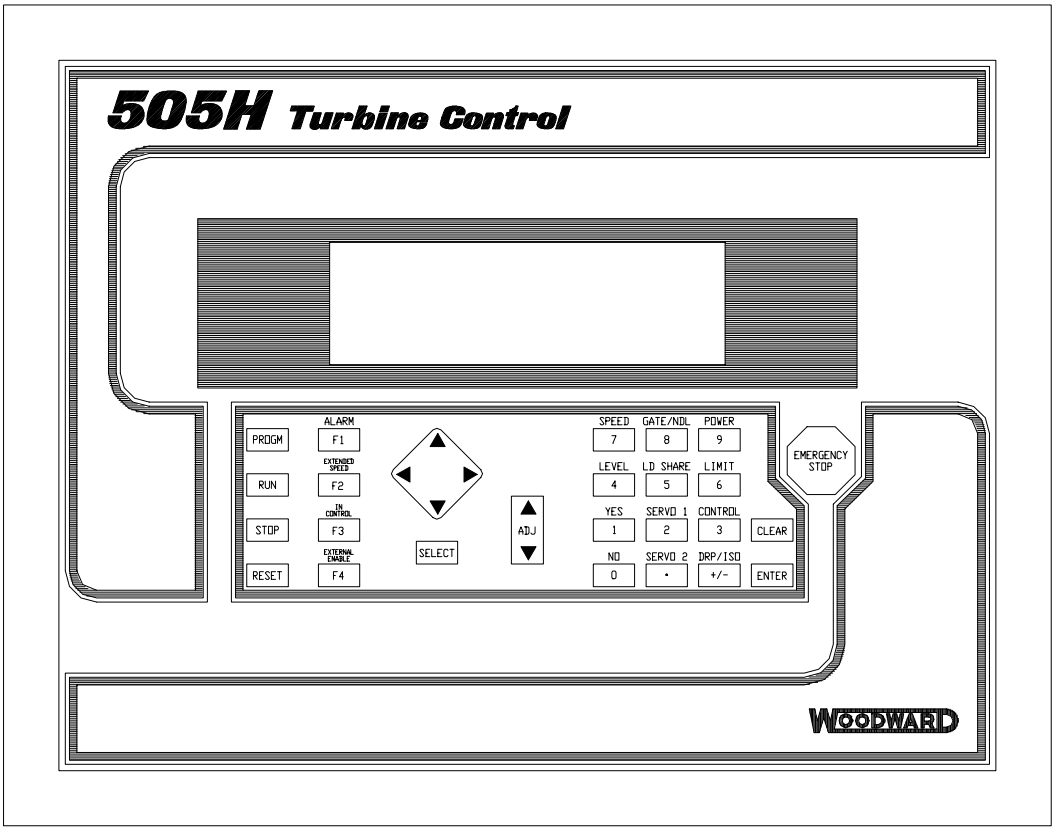

Figure 8-3. 505H Keypad and Display

Run Mode Front Panel Keys

For a detailed description of each 505H key functionality see Chapter 2.

Of the thirty front panel keys, not all are active at all times in the Run Mode. However, from the 505H's service panel, the keys that are active will be apparent since there is immediate display feedback when an active key is pressed. When a respective "Hot" key (Power, Level, Loadsharing, etc.) function is not programmed, the 505H will ignore the keystroke if the corresponding key is pressed. The following are generalizations when determining what keys will function:

- The ADJUST UP / ADJUST DOWN keys are active when a setpoint is displayed, the Governor Reference is in Local Mode, and the Control Source is the keypad.
- The ENTER key is active whenever the adjust up / adjust down keys are active. This is when a setpoint is displayed, the Governor Reference is in Local Mode, and the Control Source is the keypad.
- The EXTENDED SPEED (F2) key is active during the Waiting For Prestart, Unit Breakaway, and Unit Start statuses.
- The IN CONTROL (F3) key is active whenever the Control Selection Message is displayed on the screen and the Control Source is the keypad.
- The EXTERNAL ENABLE (F4) key is active when an External Signal is used to control the Governor Reference and the message to push the F4 key appears on the screen.
- The POWER, LEVEL, LD SHARE, and SERVO 2 keys are only active if the function is configured in the Program Mode.
- The SPEED, GATE/NDL, LIMIT, SERVO 1, CONTROL, and DRP/ISO keys are always active.
- The PRGM, RESET, and ALARM (F1) keys are always active.
- The RUN and STOP keys are active if the Control Source for the Start/ Stop Logic is the keypad.

Starting Procedures

Refer to the turbine manufacturer's operating procedures for complete information on turbine start up, and Chapter 5 of this manual for a step by step procedure, depending on the start mode selected. The following is a typical start-up procedure:

⚠ **WARNING**

The turbine, or other type of prime mover should be equipped with a separate overspeed shutdown device that operates totally independently of the prime mover control devices. This protects against runaway or damage to the turbine and associated equipment, possible personal injury, or loss of life, due to equipment failure or human error.

- If any Alarms or Emergency Shutdown conditions exist, clear these conditions and press the RESET key to reset the 505H.
- Issue a unit start to the 505H (via the proper Control Source: keypad, contact inputs, or Modbus port). The front panel display will automatically jump to the SPEED screen. If Manual Start Mode is configured, the gate limit must be manually increased for the gates to open.
- If a start permissive is required, the unit will wait the for the unit start permissive before making a transition to the Unit Breakaway status.

Direct Setpoint Entry

Many of the setpoints can be directly set to a specific value by using the ENTER key from Screen #1 when the particular Governor Reference is in Local Mode and the Control Source is the keypad. To directly enter a setpoint, press the ENTER key. The front screen will prompt you to enter the desired setpoint. Use the number keys to enter the new setpoint and press the ENTER key again. The messages which may appear on the screen are listed in Table 8-2. There are limits on the ranges of the various setpoints (see Chapter 5) within which the entered value must be set.

Value xxx.xx Accepted	The entered value is accepted as a valid setpoint. The Reference Output will move to the entered setpoint at the Normal Rate.
Press ENTER to continue	New value more than max The entered value is greater than the maximum value for the Governor Reference. Press the ENTER key to clear the message
New value less than min	The entered value is less than Press ENTER to continue the minimum value for the Governor Reference Press the ENTER key to clear the message.

Table 8-2. Direct Setpoint Entry Messages

Screen Descriptions

The various screens which may appear are described below. The screens contain some text which refers to messages which can change dependent on the present state of operation of the 505H. Refer to Table 8-1 to determine what the particular message means. The initials EU (engineering units) is replaced with the programmed units for the particular field.

SPEED Screens

Figure 8-4 shows the possible screens that may appear if the SPEED key is pressed. The SPEED screens display information for both the Droop and Isochronous References. The keyword *Speed* will be substituted with *Droop* when the Droop Reference information is displayed, and with *Isoch* when the Isochronous Reference information is displayed. This is the only dual function key.

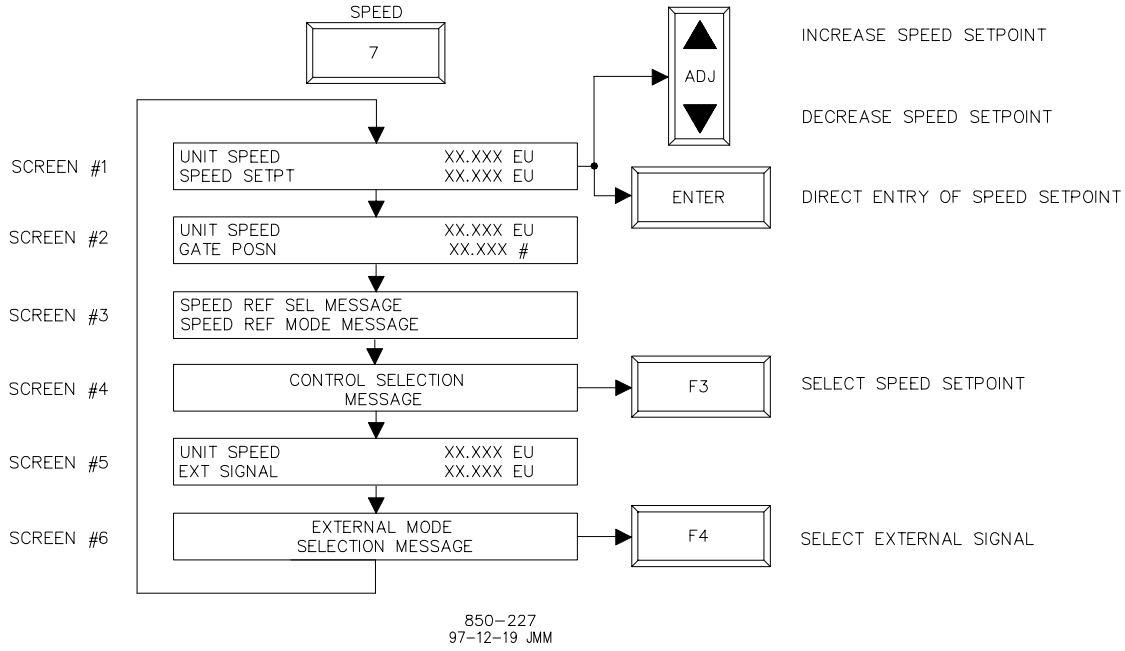

Figure 8-4. SPEED Screens

Screen #1 is automatically displayed at any time a Run Command is generated within the 505H (see Chapter 5). This screen displays the present unit speed along with the speed setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the speed setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled.

Screen #2 has the dual display of unit speed and gate position. This is a good one-point reference to show the present location of the turbine. No keypad actions can be performed from this screen.

Screen #3 displays the *Speed* Reference *Sel Message* and *Mode Message.* This helps determine whether the Speed Reference is In Control of the unit.

Screen #4 gives the *Control Selection Message*. From this screen, you can select the Speed Reference to be In Control by pressing the F3 key. It can only be selected to be In Control if Speed Control is selected. When the Speed Reference is In Control, the F3 key is illuminated when looking at any of the SPEED screens.

Screen #5 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #5 is displayed only if Use External Signal is true.

Screen #6 gives the *External Mode Selection Message*. From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the SPEED screens. Screen #6 is displayed only if Use External Signal is true.

GATE/NDL Key Screens

Figure 8-5 shows the screens which may appear if the GATE/NDL key is pressed. The GATE/NDL screens display information about the Gate Reference.

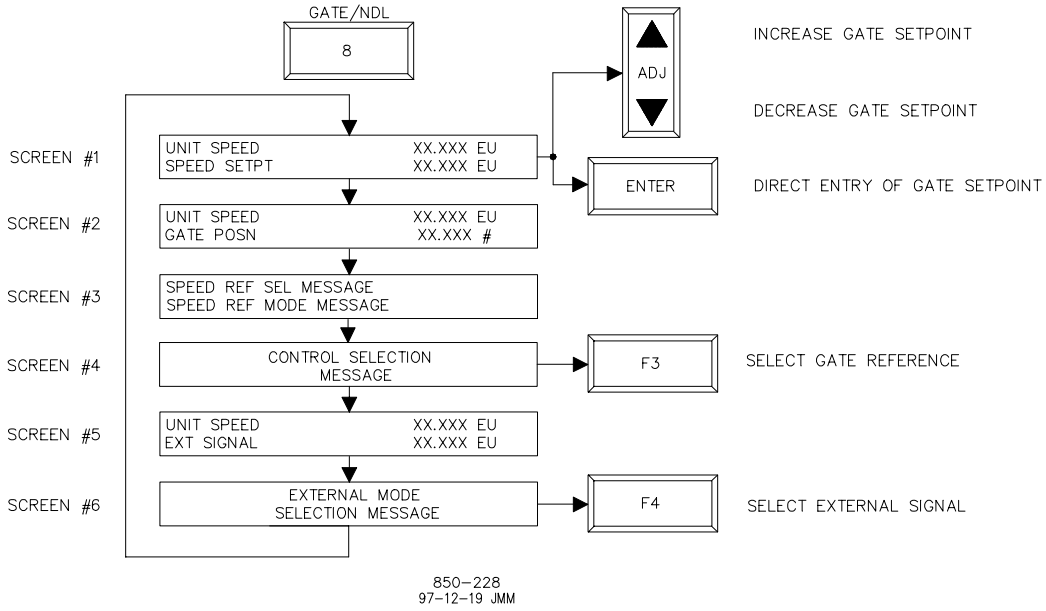

Figure 8-5. GATE/NDL Screens

Screen #1 displays the present gate position along with the gate setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the gate setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled.

Screen #2 has the dual display of gate position and unit speed. This is a good one-point reference to show the present location of the turbine. No keypad actions can be performed from this screen.

Screen #3 displays the Gate Reference *Sel Message* and *Mode Message*. This helps determine whether the Gate Reference is In Control of the unit.

Screen #4 gives the *Control Selection Message*. From this screen, you can select the Gate Reference to be In Control by pressing the F3 key. It can only be selected to be In Control if Position Control is selected. When the Gate Reference is In Control, the F3 key is illuminated when looking at any of the GATE/NDL screens.

Screen #5 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #5 is displayed only if Use External Signal is true.

Screen #6 gives the *External Mode Selection Message*. From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the GATE/NDL screens. Screen #6 is displayed only if Use External Signal is true.

POWER Screens

Figure 8-6 shows the screens which may appear if the POWER key is pressed. The POWER screens display information about the Power Reference.

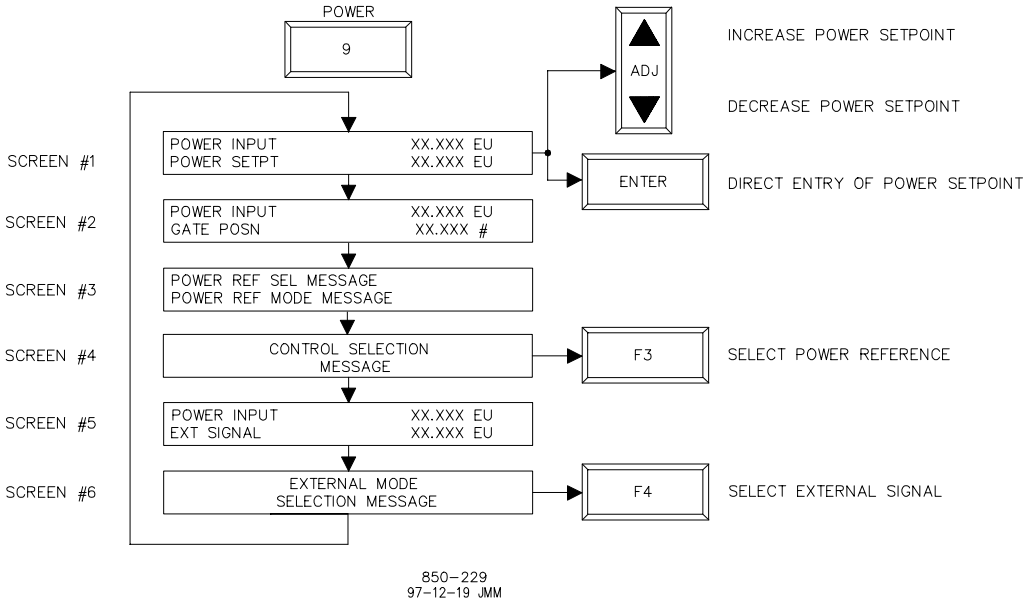

Figure 8-6. POWER Screens

Screen #1 displays the present unit power along with the power setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the power setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled.

Screen #2 has the dual display of unit power and gate position. This is a good one-point reference to show the present location of the turbine. No keypad actions can be performed from this screen.

Screen #3 displays the Power Reference *Sel Message* and *Mode Message*. This helps determine whether the Power Reference is In Control of the unit.

Screen #4 gives the *Control Selection Message*. From this screen, you can select the Power Reference to be In Control by pressing the F3 key. It can only be selected to be In Control if Position Control is selected. When the Power Reference is In Control, the F3 key is illuminated when looking at any of the POWER screens.

Screen #5 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #5 is displayed only if Use External Signal is true.

Screen #6 gives the *External Mode Selection Message*. From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the POWER screens. Screen #6 is displayed only if Use External Signal is true.

LEVEL Screens

Figure 8-7 shows the screens which may appear if the LEVEL key is pressed. The LEVEL screens display information about the Level Reference.

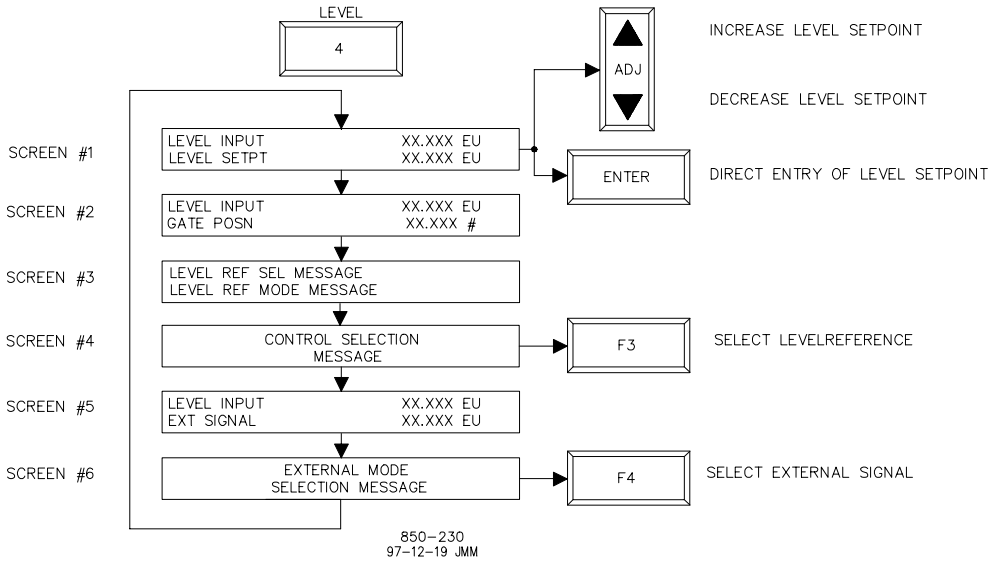

Figure 8-7. LEVEL Screens

Screen #1 displays the controlled level along with the level setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the level setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled.

Screen #2 has the dual display of the controlled level and gate position. This is a good one-point reference to show the present location of the turbine. No keypad actions can be performed from this screen.

Screen #3 displays the Level Reference *Sel Message* and *Mode Message*. This helps determine whether the Level Reference is In Control of the unit.

Screen #4 gives the *Control Selection Message*. From this screen, you can select the Level Reference to be In Control by pressing the F3 key. It can only be selected to be In Control if Position Control is selected. When the Level Reference is In Control, the F3 key is illuminated when looking at any of the LEVEL screens.

Screen #5 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #5 is displayed only if Use External Signal is true.

Screen #6 gives the *External Mode Selection Message*. From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the power key screens. Screen #6 is displayed only if Use External Signal is true.

LDSHARE Screens

Figure 8-8 shows the screens which may appear if the LDSHARE key is pressed. The LDSHARE screen displays information about the Loadsharing Reference.

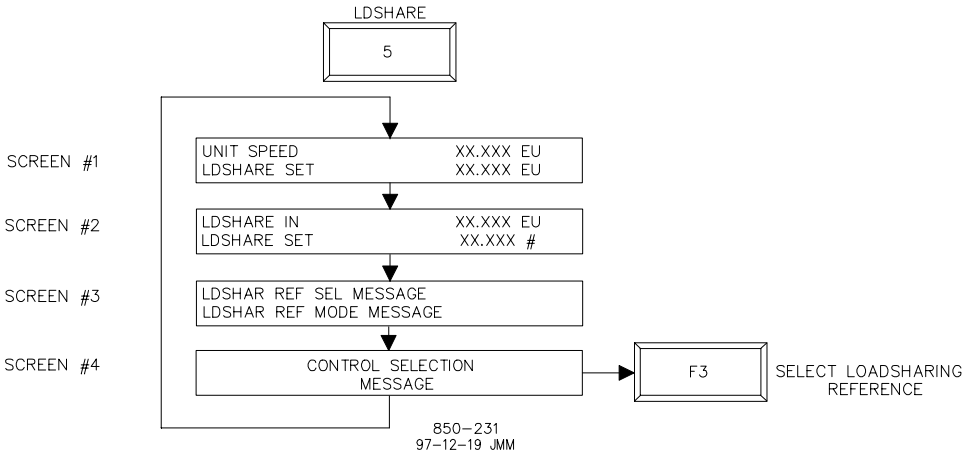

Figure 8-8. LDSHARE Screens

Screen #1 displays the unit speed along with the loadsharing setpoint. Because the Loadsharing Reference cannot operate in Local Mode, there are no adjustments to be made from the keypad.

Screen #2 displays the External Signal used to drive the Loadsharing Reference along with the loadsharing setpoint. The F4 key is always illuminated when looking at any of the LDSHARE screens, as the External Signal is always enabled.

Screen #3 displays the Loadsharing Reference *Sel Message* and *Mode Message*. This helps determine whether the Loadsharing Reference is In Control of the unit.

Screen #4 gives the *Control Selection Message.* From this screen, you can select the Loadsharing Reference to be In Control by pressing the F3 key. The Loadsharing Reference can be selected from either Speed Control or Position Control. When the Loadsharing Reference is In Control, the F3 key is illuminated when looking at any of the LDSHARE screens.

LEVEL Screen

Figure 8-9 shows the screen which will appear if the LIMIT key is pressed. The LIMIT screen displays information about the Gate Limit.

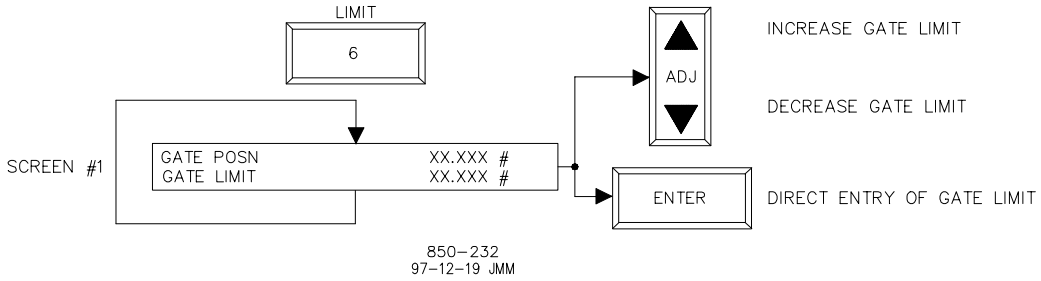

Figure 8-9. LIMIT Screen

Screen #1 displays the gate position along with the gate limit. If you are using the keypad to control the 505H, you will be able to adjust the gate limit via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled. Because the Gate Limit is always In Control, the F3 key is illuminated when looking at any of the LIMIT screen.

SERVO 1 Screens

Figure 8-10 shows the screens which may appear if the SERVO 1 key is pressed. The SERVO 1 screens display information about the gate Manual Reference.

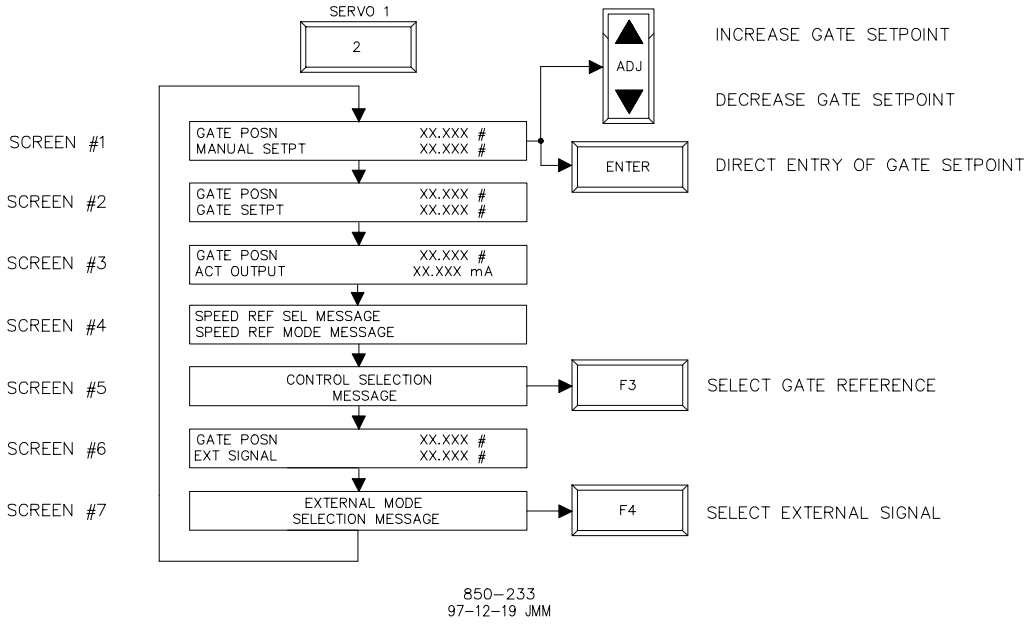

Figure 8-10. SERVO 1 Screens

Screen #1 displays the gate position along with the manual setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the manual setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key. If you are controlling the unit via contact inputs or the Modbus port, the adjustment keys are disabled.

Screen #2 displays the gate position along with the gate setpoint. No keypad actions can be performed from this screen.

Screen #3 displays the gate position along with the gate driver current. No keypad actions can be performed from this screen.

Screen #4 displays the Manual Reference *Sel Message* and *Mode Message*. This helps determine whether the Manual Reference is In Control of the unit.

Screen #5 gives the *Control Selection Message*. From this screen, you can select the Manual Reference to be In Control by pressing the F3 key. When the Manual Reference is In Control, the F3 key is illuminated when looking at any of the SERVO 1 screens.

Screen #6 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #6 is displayed only if Use External Signal is true.

Screen #7 gives the *External Mode Selection Message*. From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the SERVO 1 screens. Screen #7 is displayed only if Use External Signal is true.

SERVO 2 Screens

Figure 8-11 shows the screens which may appear if the SERVO 2 key is pressed. The SERVO 2 screens display information about the blade Manual Reference.

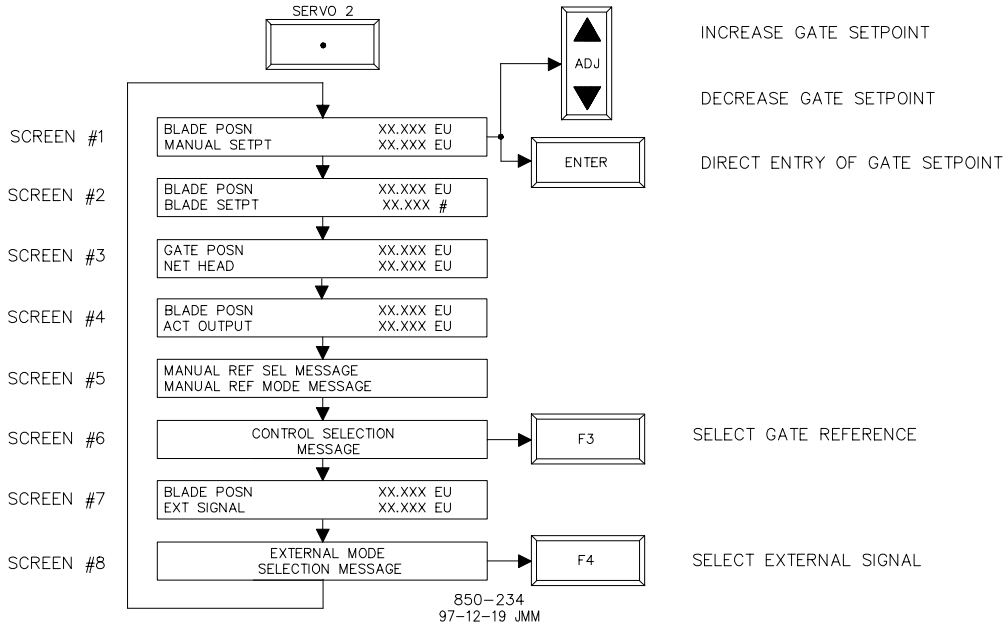

Figure 8-11. SERVO 2 Screens

Screen #1 displays the blade position along with the manual setpoint. If you are using the keypad to control the 505H and you are in Local Mode, you will be able to adjust the manual setpoint via this screen. This can be done either with the ADJUST UP / ADJUST DOWN keys or via the ENTER key.

Screen #2 displays the blade position along with the blade setpoint. No keypad actions can be performed from this screen.

Screen #3 displays the gate position along with the net head. This screen is used to display the inputs to the blade curve block as a on-point reference to verify the blade curves. No keypad actions can be performed from this screen.

Screen #4 displays the blade position along with the blade driver current. No keypad actions can be performed from this screen.

Screen #5 displays the Manual Reference *Sel Message* and *Mode Message*. This helps determine whether the Manual Reference is In Control of the unit.

Screen #6 gives the *Control Selection Message*. From this screen, you can select the Manual Reference to be In Control by pressing the F3 key. When the Manual Reference is In Control, the F3 key is illuminated when looking at any of the SERVO 2 screens.

Screen #7 lists the unit speed along with the External Signal. This indicates that the unit is in External Mode. Screen #7 is displayed only if Use External Signal is true.

Screen #8 gives the *External Mode Selection Message.* From this screen, you can select the External Signal to be used by pressing the F4 key. When the External Signal is used, the F4 key is illuminated when looking at any of the SERVO 2 screens. Screen #8 is displayed only if Use External Signal is true.

CONTROL Screens

Figure 8-12 shows the screens which will appear if the CONTROL key is pressed. The CONTROL screens display information about the present unit status and controlling reference.

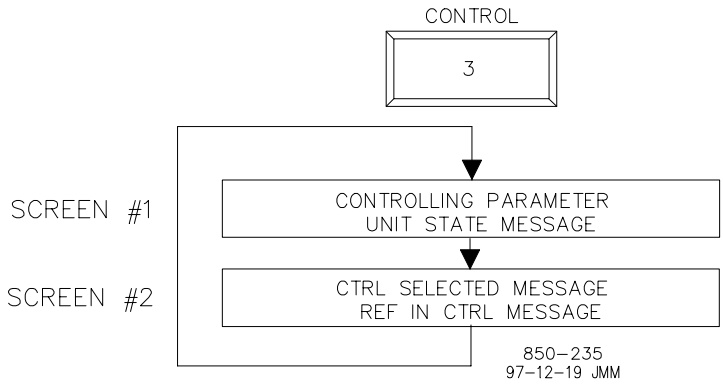

Figure 8-12. CONTROL Screens

Screen #1 displays the *Unit Status Message*. Reference the Status Engine in Chapter 4 for information on the unit status.

Screen #2 displays the *Ctrl Selected Message* and *Ref In Ctrl Message*.

DRP/ISO Screens

Figure 8-13 shows the screens which will appear if the DRP/ISO key is pressed. The DRP/ISO screens displays information about what will be displayed if the SPEED key is pressed.

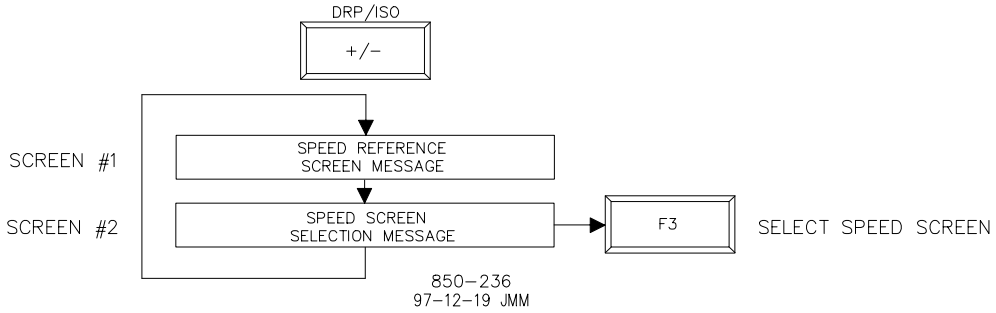

Figure 8-13. DRP/ISO Screens

Screen #1 displays the *Speed Reference Screen Message*.

Screen #2 displays the *Speed Screen Selection Message*.

Chapter 9
Communications

Modbus Communication

The 505H control can communicate with plant distributed control systems and/or CRT based operator control panels through two Modbus communication ports. These ports support RS-232, RS-422, RS-485 communications using ASCII or RTU Modbus transmission protocols. Modbus utilizes a master/slave protocol. This protocol determines how a communication network's master and slave devices establish and break contact, how a sender is identified, how messages are exchanged, and how errors are detected.

Monitor Only

The two Modbus communication ports, as defaulted from the factory, are not programmed. Although these ports are not programmed they continue to update all information to all registers. This allows the 505H to be monitored but not controlled from an external device. By simply connecting a monitoring device, configured to communicate through Modbus, and to the 505H's defaulted protocol settings (parity, stop bits, etc.), this device can be used to monitor all the 505H's controlling parameters, modes, etc. without effecting control.

To use a 505H port to only monitor 505H parameters and operational modes or not use the port at all (Boolean and analog write commands are ignored), program the port's 'Use Modbus Port' setting to 'NO'.

Monitor and Control

Once a Modbus port is configured within the 505H's Program Mode, the 505H will accept RUN mode commands from an external network master device (DCS, etc.). This allows a Modbus compatible device to monitor and perform all 505H Run Mode parameters and commands except for the Wide Speed Range selection.

Both Modbus ports are independent of each other, and can be used simultaneously. The last command given between the two ports has priority or is the mode or function selected.

To use a 505H Modbus port to monitor and operate the 505H through, program the port's 'Use Modbus Port' setting to 'YES'.

Modbus Communication

The 505H control supports two Modbus transmission modes. A mode defines the individual units of information within a message and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in the following table.

CHARACTERISTIC	ASCII	RTU
Coding System	hexadecimal	(uses 8-bit binary ASCII printable binary characters: 0-9,A-F)
Start Bits	1	1
Data Bits per Char	7	8
Parity	even, odd or none	even, odd or none
Stop Bits	1, 1.5, or 2	1, 1.5, or 2
Baud Rate	110, 300, 600, 1200 1800,2400, 4800, 9600 19200, 38400, or 57600	110,300, 600, 1200 1800, 2400, 4800, 9600 19200, 38400, or 57600
Error Checking	LRC (Longitudinal Redundancy Check)	CRC (Cyclical Redundancy Check)

Table 9-1. ASCII vs RTU Modbus

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 9-1 below).

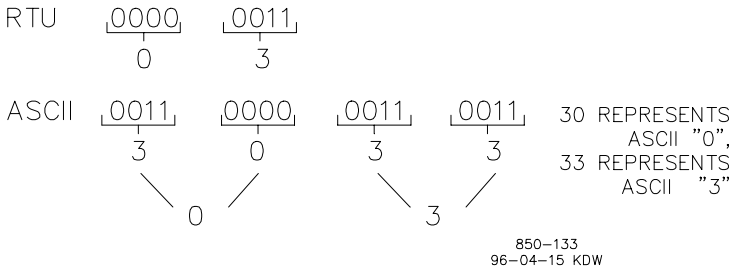

Figure 9-1. ASCII Representation of 3

The Modbus protocol allows one master and up to 247 slaves on a common network. Each slave is assigned a fixed, unique device address in the range of 1 to 247. With the Modbus protocol, only the network master can initiate a transaction. A transaction consists of a request from the master to a slave unit and the slave's response. The protocol and Modbus device number can be adjusted in the SERVICE Mode, if required.

The 505H control is programmed to function as a slave unit only. As a slave unit, the 505H will only respond to a transaction request by a master device. The 505H can directly communicate with a DCS or other Modbus supporting device on a single communications link, or through a multidropped network. If multidropping is used, up to 246 devices (505H's or other customer devices) can be connected to one Master device on a single network. The control address is programmed under the 505H's communications block and can be changed in the SERVICE mode, if needed.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information. See the figure 9-2.

	BEGINNING OF FRAME	SLAVE ADDRESS	FUNCTION CODE	DATA	ERROR CHECK CODE	END OF FRAME
ASCII	:	2 CHARS 8 BITS	2 CHARS 8 BITS	4 BITS DATA PER CHAR	2 CHAR 8 BITS	CR LF
RTU	3–CHAR DEAD TIME	1 CHAR 8 BITS	1 CHAR 8 BITS	8 BITS DATA PER CHAR	2 CHAR 16 BITS	3 CHAR DEAD TIME

855–382
93–09–27 DAR

Figure 9-2. Modbus Frame Definition

Modbus Function Codes

The Modbus function code tells the addressed slaves what function to perform. The following table lists the function codes supported by this control.

CODE	DEFINITION	REFERENCE ADDRESS
01	Read Digital Outputs (Raise/Lower and Enable/Disable Commands)	0XXXX
02	Read Digital Inputs (Status Indications / Alarms and Trips)	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs (Speed, Setpt, etc.)	3XXXX
05	Write Single Discrete Output (Raise/Lower and Enable/Disable Commands)	0XXXX
06	Write Single Register (Enter Setpt Directly)	4XXXX
08	Loopback Diagnostic Test (Subfunction 0 only)	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

Table 9-2. Modbus Function Codes

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the control issues an alarm message. The error codes are defined in the following table. The exception error status and respective error codes can be viewed in the SERVICE mode under MODBUS PORT #, where # is the number of the port (1 or 2).

If the control has not received a message for the configured time-out period, the control will alarm with an error message, but no message is sent to the master. This time-out is defaulted to 2 seconds and only applies to units using both monitor and control (adjustable in the Service Mode).

Modbus Slave Exception Error Codes

ERROR CODE	ERROR MESSAGE	CODE SENT TO MASTER	DESCRIPTION
0	No Error	0	No Error
1	Bad Modbus function	1	The specified function is not supported for this control.
2	Bad Modbus data address	2	The Modbus value addressed is not valid for this control.
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid.
9	Bad Modbus checksum	None	Message checksum did not match.
10	Bad Modbus message	None	Message could not be decoded.
N/A	Lost Modbus link	None	No messages received for the configured time-out period

Table 9-3. Modbus Error Codes

Port Adjustments

Before the 505H will communicate with the master device, the communication parameters must be verified. These values can be adjusted, if required, from the SERVICE Mode.

PARAMETER	ADJUSTMENT RANGE
Baud Rate	110 TO 57600
Parity	NONE, ODD, EVEN
Stop Bits	1 TO 2
Driver	RS232, RS422, RS485

Table 9-4. Modbus Communication Port Adjustments

505H Control Modbus Addresses

The Modbus communication ports in the 505H control are programmed for unique Modbus addresses. A complete listing of these addresses for your application is located at the end of this section in the manual. The Modbus address listing consists of Boolean Writes, Boolean Reads, Analog Reads, and Analog Writes. The Boolean reads and writes are also referred to as input and holding coils. The analog reads and writes are also referred to as input registers and holding registers.

All values that can be addressed by the Modbus protocol are considered to be discrete and numeric. The discretes are a 1 bit binary, on or off value and the numerics are 16 bit values. Discretes are sometimes referred to as coils or digitals and numerics are referred to as registers or analogs. All read/write registers are interpreted by the 505H as signed 16 bit integer values. Since the Modbus protocol can only handle integers, values that require a decimal point in the Modbus Master Device are multiplied by a scaling constant before being sent by 505H. See Tables 8-8 & 8-9 for defaulted communication constants and ranges.

The maximum number of discretes and registers that can be transmitted in one packet is dependent on each implementation of the Modbus interface. The following table defines these limits.

MODE OF TRANSMISSION	MAX DISCRETES	MAX REGISTERS
ASCII	944	59
RTU	1188	118

Table 9-5. Maximum Modbus Discrete and Analog Values

Boolean Writes (Holding Coils)

Holding coils are logical signals that are both readable from and writeable to the 505H control. An example of an Boolean write value would be raise or lower commands. A logical true denoted by the value 1 will cause the command listed in the description to be executed. For example, if a 1 is written to address 0:0010 and this corresponded to a speed raise command, the manual speed setpoint will increase until a 0 is written to address 0:0010. The 505H control supports function codes 1, 5, and 15. These correspond to reading selected holding coils, writing to a single holding coil, and writing to multiple holding coils, respectively. The holding coils available are listed in Table 9-6.

Boolean Reads (Input Coils)

Input coils are logical signals that are readable from, but not writeable to, the 505H control. An example of an Boolean read value would be a turbine trip status indication. The input coil will have the value 1 if the statement in the description column is true and a 0 if false. The `1:' term in the address identifies an input coil. The 505H control supports Modbus function code 2, which involves reading selected input coils. The input coils available are listed in Table 9-7.

Analog Reads (Input Registers)

Input registers are analog values that are readable from, but not writeable to, the 505H control. An example of an analog read value would be turbine speed. The values of the input registers are stored internal to the control as floating point numbers representing engineering units (i.e. KPA or RPM). The values that are transmitted are integer values ranging from -32767 to +32767. Since Modbus can only handle integers, values that have a decimal point are multiplied by a constant before being sent by Modbus. For example, these input registers may be listed as the Modbus value `x100' or `x10' under the description heading to denote the value is multiplied by a scaling constant. This will allow transmission of decimal parts of a unit if this is necessary for better resolution.

See the 505H Service Mode for defaulted communication constants and ranges. The 505H control supports Modbus function code 4, which involves reading selected input registers. The input registers available are listed in Table 9-8.

Analog Writes (Holding Registers)

Holding registers are analog values that are writeable to the 505H control. These values can also be read from by a device performing error checking. An example of an analog write value would be a direct speed setpoint value as opposed to raise and lower commands. The value of the holding registers are also stored in the control as numbers representing engineering units (i.e. PSI or RPM). The 505H control supports Modbus function codes 3, 6, and 16. These correspond to reading selected holding registers, writing to a single holding register, and writing to multiple holding registers, respectively. The holding registers available are listed in Table 8-9.

The following tables give the address and description of all Boolean and analog, reads and writes:

Boolean Writes

ADDR	DESCRIPTION	ADDR	DESCRIPTION
0.0001	System Reset	0.0026	Lower Level Setpoint
0.0002	Emergency Shutdown	0.0027	Select Power Reference
0.0003	Emergency Shutdown Acknowledge	0.0028	Select External Power Setpoint
0.0004	Alarm Acknowledge	0.0029	Raise Power Setpoint
0.0005	Run Command	0.0030	Lower Power Setpoint
0.0006	Stop Command	0.0031	Spare
0.0007	Select Droop Reference	0.0032	Spare
0.0008	Select External Droop Setpoint	0.0033	Raise Gate Limit
0.0009	Raise Droop Setpoint	0.0034	Lower Gate Limit
0.0010	Lower Droop Setpoint	0.0035	Select Gate Manual Reference
0.0011	Select Isochronous Reference	0.0036	Select External Gate Manual Setpoint
0.0012	Spare	0.0037	Raise Gate Manual Setpoint
0.0013	Raise Isochronous Setpoint	0.0038	Lower Gate Manual Setpoint
0.0014	Lower Isochronous Setpoint	0.0039	Spare
0.0015	Select Loadsharing Mode	0.0040	Spare
0.0016	Spare	0.0041	Spare
0.0017	Spare	0.0042	Spare
0.0018	Spare	0.0043	Spare
0.0019	Select Gate Reference	0.0044	Spare
0.0020	Select External Gate Setpoint	0.0045	Spare
0.0021	Raise Gate Setpoint	0.0046	Spare
0.0022	Lower Gate Setpoint	0.0047	Spare
0.0023	Select Level Reference	0.0048	Spare
0.0024	Select External Level Setpoint	0.0049	Spare
0.0025	Raise Level Setpoint	0.0050	Spare

Table 9-6. Boolean Write Addresses

Boolean Reads

ADDR	DESCRIPTION	ADDR	DESCRIPTION
1.0001	Alarm - Speed Sensor #1 Failed	1.0033	Alarm - Spare
1.0002	Alarm - Speed Sensor #2 Failed	1.0034	Alarm - Spare
1.0003	Alarm - Gate Driver Failed	1.0035	Alarm - Spare
1.0004	Alarm - Blade Driver Failed	1.0036	Alarm - Spare
1.0005	Alarm - Gate Feedback Failed	1.0037	Alarm - Spare
1.0006	Alarm - Blade Feedback Failed	1.0038	Alarm - Spare
1.0007	Alarm - Power Signal Failed	1.0039	Alarm Horn
1.0008	Alarm - External Power Setpt Failed	1.0040	Alarm Exists (Alarm Indication)
1.0009	Alarm - Forebay Signal Failed	1.0041	ESD - External Shutdown
1.0010	Alarm - Tailbay Signal Failed	1.0042	ESD - E-Stop Button
1.0011	Alarm - External Gate Setpoint Failed	1.0043	ESD - Overspeed Trip
1.0012	Alarm - External Level Setpoint Failed	1.0044	ESD - Speed Sensor Failure
1.0013	Alarm - External Speed Setpt Failed	1.0045	ESD - Gate Feedback Failed
1.0014	Alarm - Loadsharing Signal Failed	1.0046	ESD - Gate Driver Failed
1.0015	Alarm - Ext Gate Man Setpt Failed	1.0047	ESD - Blade Feedback Failed
1.0016	Alarm - Ext Blade Man Setpt Failed	1.0048	ESD - Blade Driver Failed
1.0017	Alarm - Net Head Signal Failed	1.0049	ESD - Prestart Timer Expired
1.0018	Alarm - Unit Overspeed	1.0050	ESD - Comm Link #1 Emer SD
1.0019	Alarm - Emergency Shutdown	1.0051	ESD - Comm Link #2 Emer SD
1.0020	Alarm - Droop Reference Trouble	1.0052	ESD - Spare
1.0021	Alarm - Isochronous Ref Trouble	1.0053	ESD - Spare
1.0022	Alarm - Level Reference Trouble	1.0054	ESD - Spare
1.0023	Alarm - Gate Limit Trouble	1.0055	ESD - Spare
1.0024	Alarm - Gate Manual Trouble	1.0056	ESD - Spare
1.0025	Alarm - Blade Manual Trouble	1.0057	ESD - Spare
1.0026	Alarm - Gate Set Reference Trouble	1.0058	ESD - Spare
1.0027	Alarm - Power Reference Trouble	1.0059	ESD Horn
1.0028	Alarm - Loadsharing Ref Trouble	1.0060	ESD Exists (ESD Indication)
1.0029	Alarm - Comm Link #1 Failed	1.0061	Shutdown Relay Energized
1.0030	Alarm - Comm Link #2 Failed	1.0062	Alarm Relay Energized
1.0031	Alarm - Spare	1.0063	Relay #1 Energized
1.0032	Alarm - Spare	1.0064	Relay #2 Energized

Table 9-7. Boolean Reads

ADDR	DESCRIPTION	ADDR	DESCRIPTION
1.0065	Relay #3 Energized	1.0099	DI - Gate Limit Lower
1.0066	Relay #4 Energized	1.0100	DI - Creep Input #1
1.0067	Relay #5 Energized	1.0101	DI - Creep Input #2
1.0068	Relay #6 Energized	1.0102	DI - Contact Input Priority
1.0069	ESD Contact Input (Closed)	1.0103	DI - Modbus Port Priority
1.0070	Reset Contact Input (Closed)	1.0104	DI - Droop Reference Selected
1.0071	Raise Contact Input (Closed)	1.0105	DI - Isochronous Reference Selected
1.0072	Lower Contact Input (Closed)	1.0106	DI - Gate Set Reference Selected
1.0073	Contact Input #1 (Closed)	1.0107	DI - Level Reference Selected
1.0074	Contact Input #2 (Closed)	1.0108	DI - Power Reference Selected
1.0075	Contact Input #3 (Closed)	1.0109	DI - Loadsharing Reference Selected
1.0076	Contact Input #4 (Closed)	1.0110	DI - Manual Reference Selected
1.0077	Contact Input #5 (Closed)	1.0111	DI - Blade Tilt Enabled
1.0078	Contact Input #6 (Closed)	1.0112	DI - Blade Lock Enabled
1.0079	Contact Input #7 (Closed)	1.0113	DI - Position Control Selected
1.0080	Contact Input #8 (Closed)	1.0114	DI - Spare
1.0081	Contact Input #9 (Closed)	1.0115	DI - Spare
1.0082	Contact Input #10 (Closed)	1.0116	DI - Spare
1.0083	Contact Input #11 (Closed)	1.0117	DI - Spare
1.0084	Contact Input #12 (Closed)	1.0118	DI - Spare
1.0085	Status - Waiting For Prestart	1.0119	DO - ESD Indication (Normally Ener-
1.0086	Status - Unit Breakaway	1.0120	DO - Alarm Indication
1.0087	Status - Unit Start	1.0121	DO - System Reset
1.0088	Status - Ready To Synchronize	1.0122	DO - Overspeed Trip
1.0089	Status - On Line Operation	1.0123	DO - Unit Shutdown
1.0090	Status - Unit Unload	1.0124	DO - Waiting For Prestart
1.0091	Status - Unit Stop	1.0125	DO - Ready To Synchronize
1.0092	Status - Unit Shutdown	1.0126	DO - Apply Brakes
1.0093	DI - Generator Breaker Closed	1.0127	DO - Creep Indication
1.0094	DI - Run (Maintained)	1.0128	DO - Droop Reference In Control
1.0095	DI - Start (Momentary)	1.0129	DO - Isochronous Reference In Con-
1.0096	DI - Stop (Momentary)	1.0130	DO - Gate Set Reference In Control
1.0097	DI - Start Permissive	1.0131	DO - Level Reference In Control
1.0098	DI - Gate Limit Raise	1.0132	DO - Power Reference In Control

Table 9-7. Boolean Reads (Contd.)

ADDR	DESCRIPTION	ADDR	DESCRIPTION
1.0133	DO - Loadsharing Reference In Con-	1.0147	Spare
1.0134	DO - Manual Reference In Control	1.0148	Spare
1.0135	DO - Automatic Control	1.0149	Spare
1.0136	DO - Spare	1.0150	Spare
1.0137	DO - Spare	1.0151	Spare
1.0138	DO - Spare	1.0152	Spare
1.0139	DO - Spare	1.0153	Spare
1.0140	DO - Spare	1.0154	Spare
1.0141	Spare	1.0155	Spare
1.0142	Spare	1.0156	Spare
1.0143	Spare	1.0157	Spare
1.0144	Spare	1.0158	Spare
1.0145	Spare	1.0159	Spare
1.0146	Spare	1.0160	Spare

Table 9-7. Boolean Reads (Contd.)

Analog Reads

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0001	Modbus Speed Setpoint Readback	speed units	speed scale factor
3:0002	Modbus Gate Setpoint Readback	%	none
3:0003	Modbus Level Setpoint Readback	level units	level scale factor
3:0004	Modbus Power Setpoint Readback	power units	power scale factor
3:0005	Modbus Gate Man Set Readback %	none	none
3:0006	Modbus Gate Lim Set Readback %	none	one
3:0007	Modbus Spare Readback	none	none
3:0008	Modbus Spare Readback	none	none
3:0009	Modbus Spare Readback	none	none
3:0010	Modbus Spare Readback	none	none
3:0011	Modbus Spare Readback	none	none
3:0012	Modbus Spare Readback	none	none
3:0013	AI - Gate Feedback	%	10
3:0014	AI - Blade Feedback	%	10
3:0015	AI - Power Feedback	power units	power scale factor
3:0016	AI - External Power Setpoint	power units	power scale factor
3:0017	AI - Forebay Level Signal	level units	level scale factor
3:0018	AI - Tailbay Level Signal	level units	level scale factor

Table 9-8. Analog Read Addresses

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0019	AI - External Gate Setpoint	%	10
3:0020	AI - External Level Setpoint	level units	level scale factor
3:0021	AI - External Speed Setpoint	speed units	speed scale factor
3:0022	AI - Loadsharing Signal	speed units	speed scale factor
3:0023	AI - External Gate Man Setpoint	%	10
3:0024	AI - External Blade Man Setpoint	%	10
3:0025	AI - Net Head Signal	level units	level scale factor
3:0026	AI - Spare		
3:0027	AI - Spare		
3:0028	AI - Spare		
3:0029	AI - Spare		
3:0030	AI - Spare		
3:0031	AO - Unit Speed	speed units	speed scale factor
3:0032	AO - Speed Setpoint	speed units	speed scale factor
3:0033	AO - Forebay Level	level units	level scale factor
3:0034	AO - Tailbay Level	level units	level scale factor
3:0035	AO - Level Setpoint	level units	level scale factor
3:0036	AO - Unit Power	power units	power scale factor
3:0037	AO - Power Setpoint	power units	power scale factor
3:0038	AO - Gate Feedback	%	10
3:0039	AO - Gate Setpoint	%	10
3:0040	AO - Gate Limit	%	10
3:0041	AO - Blade Feedback	%	10
3:0042	AO - Spare		
3:0043	AO - Spare		
3:0044	AO - Spare		
3:0045	AO - Spare		
3:0046	AO - Spare		
3:0047	Analog Input #1	mA	100
3:0048	Analog Input #2	mA	100
3:0049	Analog Input #3	mA	100
3:0050	Analog Input #4	mA	100
3:0051	Analog Input #5	mA	100
3:0052	Analog Input #6	mA	100
3:0053	Actuator Driver #1	mA	100
3:0054	Actuator Driver #2	mA	100
3:0055	Analog Output #1	mA	100
3:0056	Analog Output #2	mA	100

Table 9-8. Analog Read Addresses (Contd.)

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0057	Analog Output #3	mA	100
3:0058	Analog Output #4	mA	100
3:0059	Analog Output #5	mA	100
3:0060	Analog Output #6	mA	100
3:0061	Analog Input #1 Configuration*	none	none
3:0062	Analog Input #2 Configuration*	none	none
3:0063	Analog Input #3 Configuration*	none	none
3:0064	Analog Input #4 Configuration*	none	none
3:0065	Analog Input #5 Configuration*	none	none
3:0066	Analog Input #6 Configuration*	none	none
3:0067	Analog Output #1 Configuration*	none	none
3:0068	Analog Output #2 Configuration*	none	none
3:0069	Analog Output #3 Configuration*	none	none
3:0070	Analog Output #4 Configuration*	none	none
3:0071	Analog Output #5 Configuration*	none	none
3:0072	Analog Output #6 Configuration*	none	none
3:0073	Relay Output #1 Configuration*	none	none
3:0074	Relay Output #2 Configuration*	none	none
3:0075	Relay Output #3 Configuration*	none	none
3:0076	Relay Output #4 Configuration*	none	none
3:0077	Relay Output #5 Configuration*	none	none
3:0078	Relay Output #6 Configuration*	none	none
3:0079	Contact Input #1 Configuration*	none	none
3:0080	Contact Input #2 Configuration*	none	none
3:0081	Contact Input #3 Configuration*	none	none
3:0082	Contact Input #4 Configuration*	none	none
3:0083	Contact Input #5 Configuration*	none	none
3:0084	Contact Input #6 Configuration*	none	none
3:0085	Contact Input #7 Configuration*	none	none
3:0086	Contact Input #8 Configuration*	none	none
3:0087	Contact Input #9 Configuration*	none	none
3:0088	Contact Input #10 Configuration*	none	none
3:0089	Contact Input #11 Configuration*	none	none
3:0090	Contact Input #12 Configuration*	none	none
3:0091	Speed Unit Configuration*		
3:0092	Level Unit Configuration*	none	none
3:0093	Power Unit Configuration	none	none
3:0094	Start / Stop Configuration	none	none

Table 9-8. Analog Read Addresses (Contd.)

ADDR	DESCRIPTION	UNITS	MULTIPLIER
3:0095	Auto / Manual Configuration*	none	none
3:0096	Governor Control Configuration*	none	none
3:0097	Speed Scaling Factor	none	10
3:0098	Power Scaling Factor	none	10
3:0099	Level Scaling Factor	none	10
3:0100	Spare		
3:0101	Spare		
3:0102	Spare		
3:0103	Spare		
3:0104	Spare		
3:0105	Spare		
3:0106	Spare		
3:0107	Spare		
3:0108	Spare		
3:0109	Spare		
3:0110	Spare		

Table 9-8. Analog Read Addresses (Contd.)

* Look up table at end of section

Analog Writes

ADDR	DESCRIPTION	UNITS	MULTIPLIER
4:0001	Modbus Speed Setpoint	speed units	speed scale factor
4:0002	Modbus Gate Setpoint	%	none
4:0003	Modbus Level Setpoint	level units	level scale factor
4:0004	Modbus Power Setpoint	power units	power scale factor
4:0005	Modbus Gate Manual Setpoint	%	none
4:0006	Modbus Gate Limit Setpoint	%	none
4:0007	Speed Sig. #1 Neg Deadband	% Speed	none
4:0008	Speed Sig. #1 Pos Deadband	% Speed	none
4:0009	Speed Sig. #2 Neg Deadband	% Speed	none
4:0010	Speed Sig. #2 Pos Deadband	% Speed	none
4:0011	Spare		
4:0012	Spare		

Table 9-9. Analog Write Addresses

Analog Read addresses 3:0061 - 0066 give the configuration value of the analog inputs, one to six in order. The configuration for the analog inputs is defined in the table below.

ANALOG INPUT CONFIGURATION

VALUE	DESCRIPTION
1.	External Speed Setpoint
2.	Forebay Level Input
3.	Tailbay Level Input
4.	External Level Setpoint
5.	Power Input
6.	External Power Setpoint
7.	Loadsharing Signal
8.	External Gate Setpoint
9.	Net Head Input
10.	External Gate Manual Setpoint
11.	External Blade Manual Setpoint
12.	Blade Position Feedback
13.	Gate Position Feedback
14.	Reserved For Future Use
15.	Reserved For Future Use
16.	Reserved For Future Use
17.	Reserved For Future Use
18.	Reserved For Future Use
19.	(Not Used)

Table 9-10. Analog Input Configuration

Analog Read addresses 3:0067 - 0072 give the configuration value of the analog outputs, one to six in order. The configuration for the analog outputs is defined in
the table below

ANALOG OUTPUT CONFIGURATION

VALUE	DESCRIPTION
1.	Unit Speed
2.	Speed Setpoint
3.	Forebay Level
4.	Tailbay Level
5.	Level Setpoint
6.	Unit Power
7.	Power Setpoint
8.	Gate Position
9.	Gate Setpoint
10.	Gate Limit
11.	Blade Position
12.	Reserved For Future Use
13.	Reserved For Future Use
14.	Reserved For Future Use
15.	Reserved For Future Use
16.	Reserved For Future Use
17.	(Not Used)

Table 9-11. Analog Output Configuration

Analog Read addresses 3:0073 - 0078 give the configuration value of the relays, one to six in order. The configuration for the relays is defined in the table below.

RELAY CONFIGURATION

VALUE	DESCRIPTION
1.	Emergency Shutdown (Normally Closed)
2.	Unit Alarm
3.	System Reset
4.	Overspeed Trip
5.	Shutdown Indication
6.	Waiting For Prestart
7.	Synchronizer Enable
8.	Apply Brakes
9.	Creep Indication
10.	Droop Mode Enabled
11.	Isochronous Mode Enabled
12.	Gate Set Mode Enabled
13.	Level Mode Enabled
14.	Power Mode Enabled
15.	Loadsharing Mode Enabled
16.	Manual Control Enabled
17.	Reserved For Future Use
18.	Reserved For Future Use
19.	Reserved For Future Use
20.	Reserved For Future Use
21.	Reserved For Future Use
22.	Reserved For Future Use
23.	(Not Used)
24.	Speed Switch
25.	Gate Position Switch
26.	Gate Limit Switch
27.	Power Switch

Table 9-12. Relay Configuration

Analog Read addresses 3:0079 - 0090 give the configuration value of the contact inputs, one to twelve in order. The configuration for the contact inputs is defined in the table below.

CONTACT INPUT CONFIGURATION

VALUE	DESCRIPTION
1.	Generator Breaker
2.	Run Contact (Maintained)
3.	Start Contact (Momentary)
4.	Stop Contact (Momentary)
5.	Start Permissive
6.	Gate Limit Raise
7.	Gate Limit Lower
8.	Creep Input #1
9.	Creep Input #2
10.	Droop Mode Enable
11.	Isochronous Mode Enable
12.	Gate Set Mode Enable
13.	Level Mode Enable
14.	Power Mode Enable
15.	Loadsharing Mode Enable
16.	Manual Control Enable
17.	Contact Input Priority
18.	Modbus Port Priority
19.	Blade Tilt Enable
20.	Blade Lock Enable
21.	Position Control Select
22.	Reserved For Future Use
23.	Reserved For Future Use
24.	Reserved For Future Use
25.	Reserved For Future Use
26.	Reserved For Future Use
27.	(Not Used)

Table 9-13. Contact Input Configurations

Analog Read address 3:0091 gives the configuration value of the Speed Units. The configuration for the units is defined in the table below

SPEED UNITS CONFIGURATION

VALUE	DESCRIPTION
1.	%
2.	rpm
3.	RPM

Table 9-14. Speed Units Configuration

Analog Read address 3:0092 gives the configuration value of the Level Units. The
configuration for the units is defined in the table below

LEVEL UNITS CONFIGURATION

VALUE	DESCRIPTION
1.	Feet
2.	Meters

Table 9-15. Level Units Configuration

Analog Read address 3:0093 gives the configuration value of the Power Units. The configuration for the units is defined in the table below

POWER UNITS CONFIGURATION

VALUE	DESCRIPTION
1.	MW
2.	kW

Table 9-16. Power Units Configuration

Analog Read addresses 3:0094 - 0096 give the configuration values of the Control
Priority selection. The configuration for the units is defined in the table below

CONTROL PRIORITY CONFIGURATION

VALUE	DESCRIPTION
1.	Via Keypad
2.	Via Modbus Ports
3.	Via Contact Inputs
4.	By Priority Select Lines

Table 9-17. Units Configuration

For More Modbus Information

Detailed information on the Modbus protocol is presented in “Reference Guide PI-MBUS-300” published by AEC Corp./Modicon Inc., formerly Gould Inc. To implement your own source code, you must register with Modicon. Registration includes purchasing document PI-MBUS-303 and signing a non-disclosure agreement. You can register to use Modbus at your nearest Modicon field office. To find the office nearest you, contact Modicon Technical Support at 1-800-468-5342.

Chapter 10
Operator Interface

Interface to the control may be performed through the 505H'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.

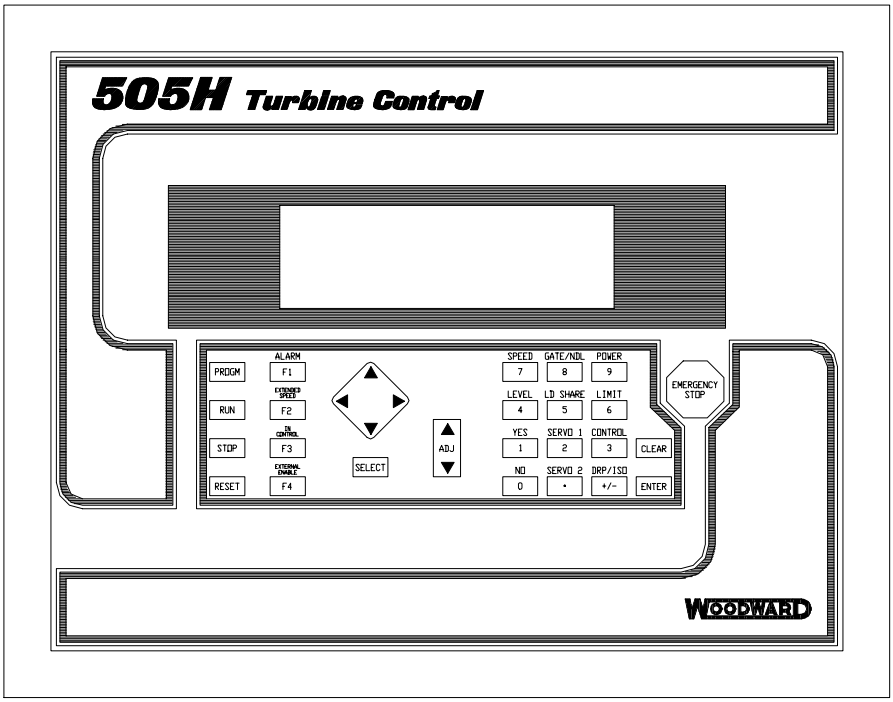

Figure 10-1. 505H Keypad and Display

The system operator uses the service panel to communicate with the 505H 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 10-1, 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 10-2.

Service Panel Modes

The 505H 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 10-2 , 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.

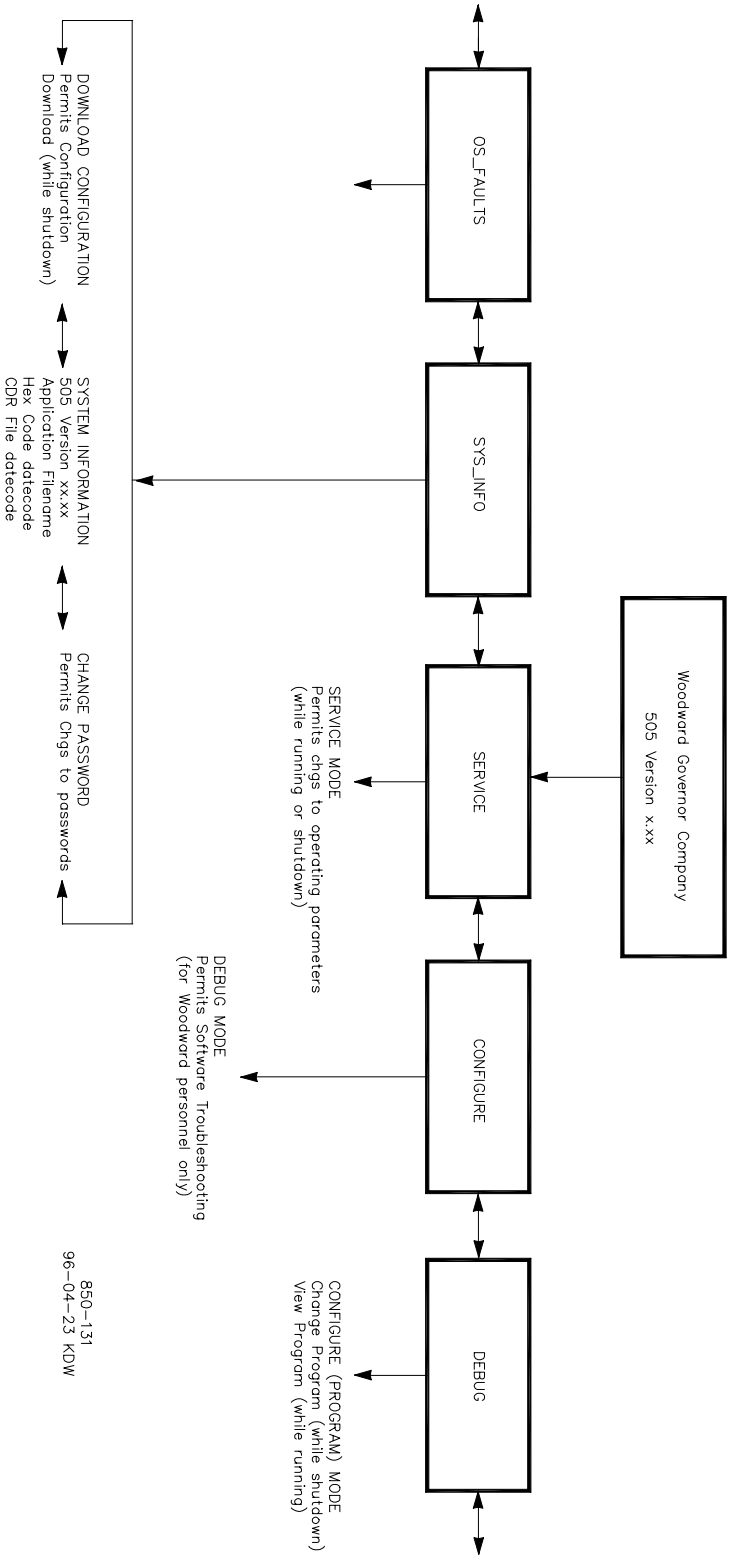

Figure 10-2. Software Structure Overview

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:

WOODWARD GOVERNOR CO. 505 Version x.x

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

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 10-3. Scroll left (<) or right (>) to display each mode.

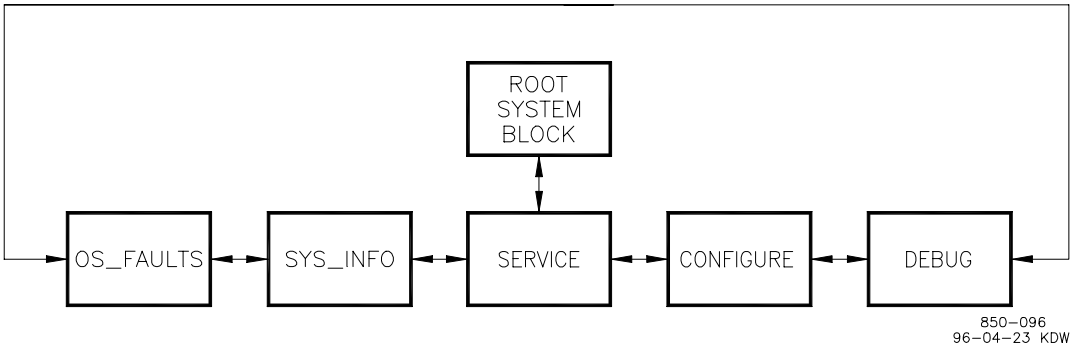

Figure 10.3. The Select Mode Level

NOTE
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 10-4. 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.

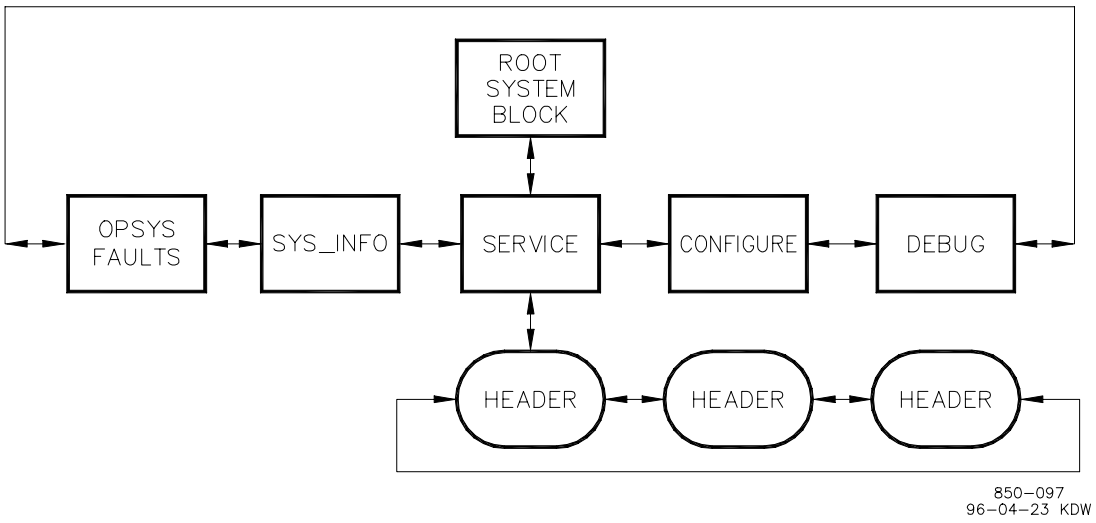

Figure 10-4. Header Level

Block Level

The third level, the block level, is shown in Figure 10-5. 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.

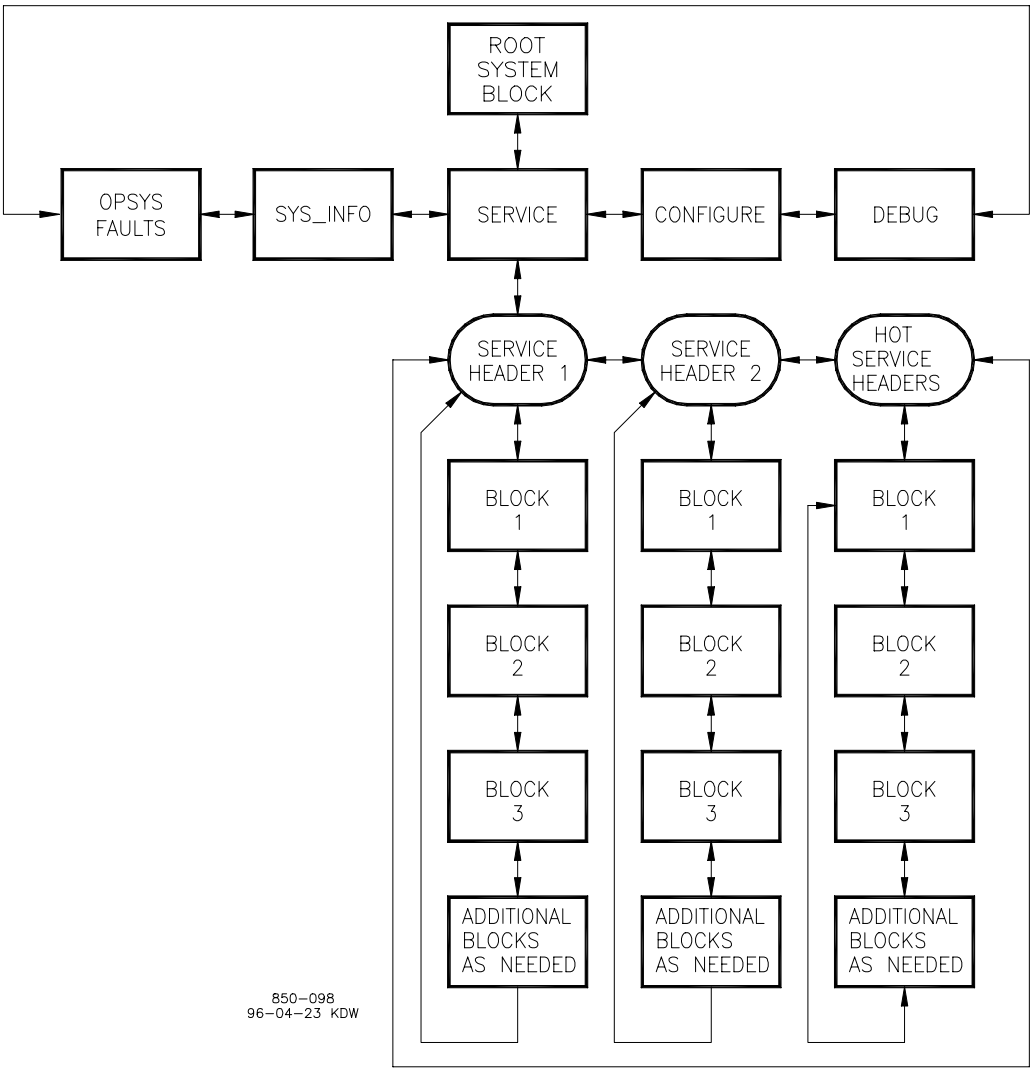

Figure 10-5. Block Level

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 G.

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

NOTE

For password information see Appendix F 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
  XXXXXXXXXXXXXXXXXXX
```

NOTE
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 Prop 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.

NOTE
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.

NOTE

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. 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.

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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 10-5).

CAUTION

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 G.

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

NOTE

For password information see Appendix F 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

NOTE

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.

NOTE

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.

NOTE

For password information see Appendix F 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 10-6. 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.

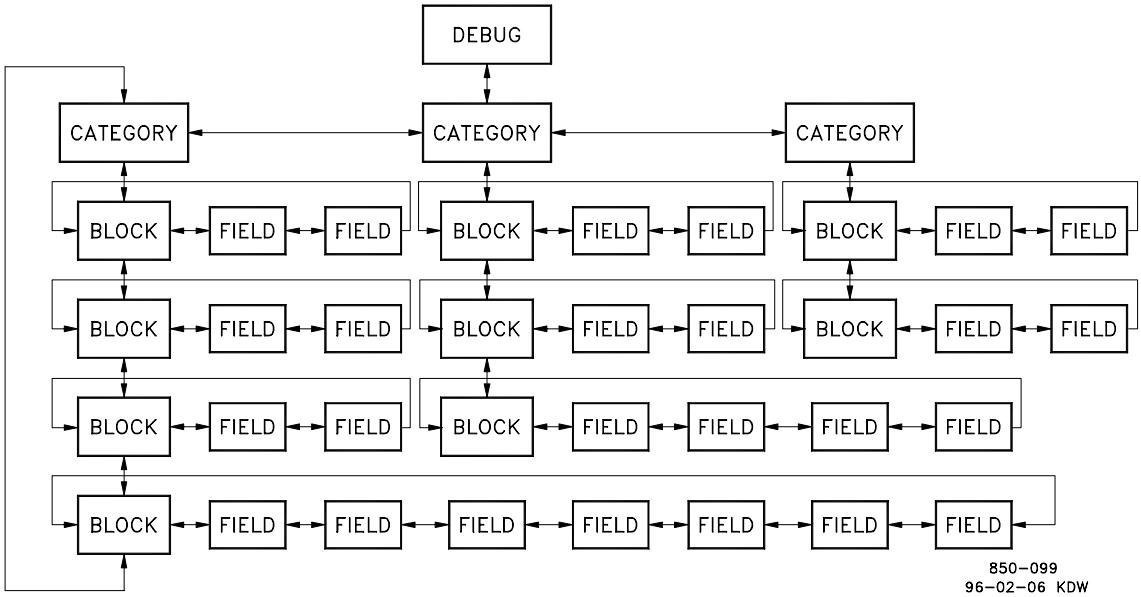


Figure 10-6. Debug Information Arrangement

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 10-7.

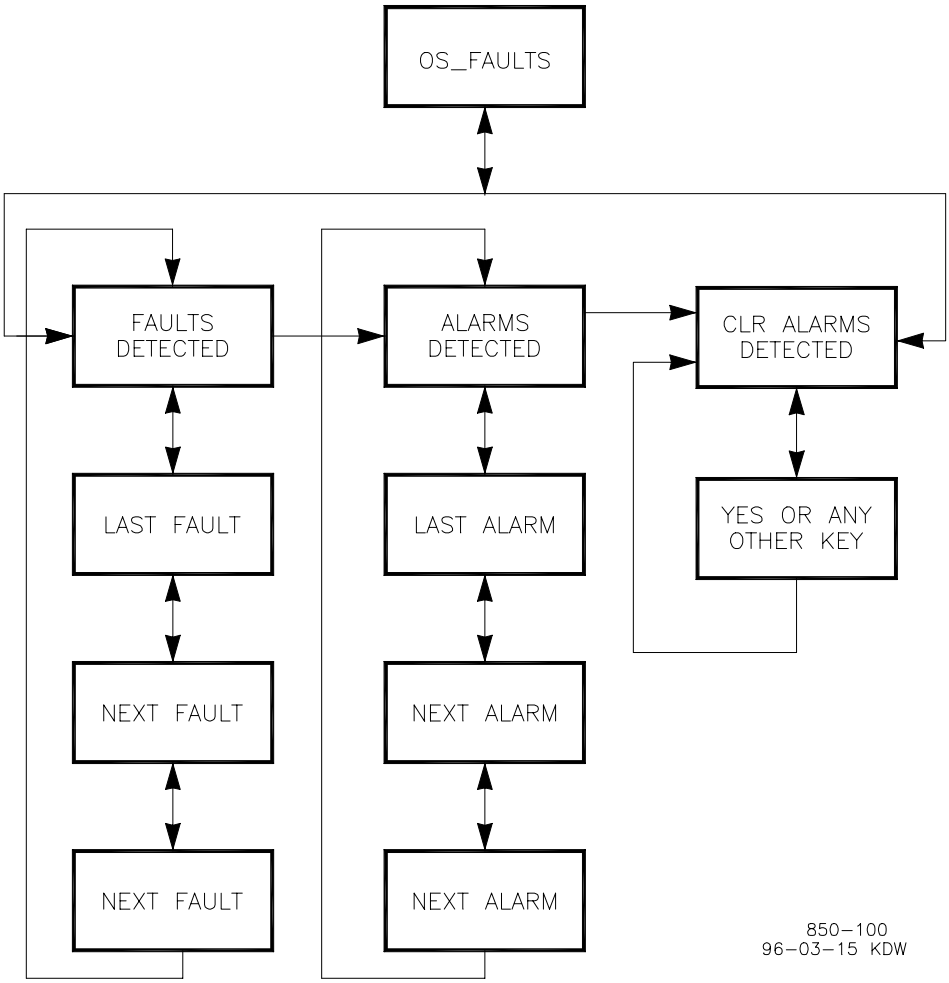


Figure 10-7. OS_FAULTS Mode Information Arrangement

To Enter the OS_FAULTS 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 MMMMMMMM

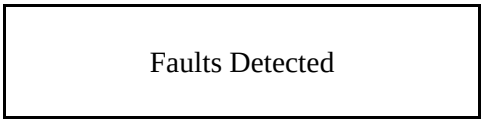
   (MMMMMMMM = name of mode: SERVICE, CONFIGURE, DEBUG, OS_FAULTS or SYS_INFO)

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.

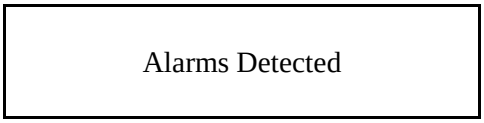
NOTE
For password information see Appendix F at the back of this manual. If the password information is not in this manual, see the supervisor or equipment engineer.

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



5. Use the scroll left (<) or scroll right (>) key to select the desired OS_FAULTS mode header. The header will display as shown below.

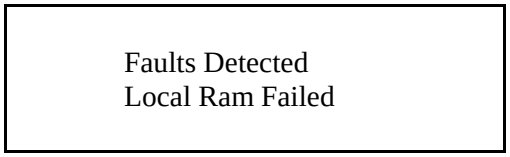
or



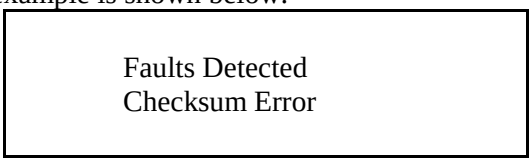
or

Faults Detected Header

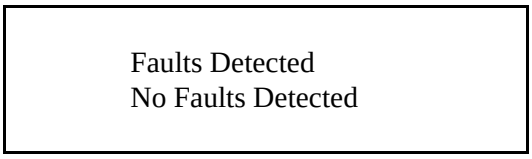
1. While the Faults Detected header is displaying, use the scroll down (∨) key or scroll up (∧) key to display the faults detected under it. A message describing the most recent fault detected will display under the header message, as shown below.



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.



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



After one second, only the header message will display.

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.

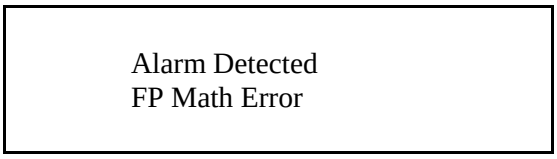
☞ **NOTE**

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.

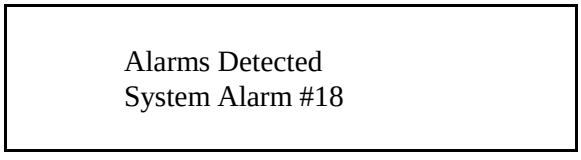
The meanings of the fault messages generated by the 505H System are shown in Chapter 11.

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.



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.



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

Alarms 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.

NOTE

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 505H System are shown in Chapter 11.

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.

Clear Alarms Detected

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

NOTE

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 10-8.

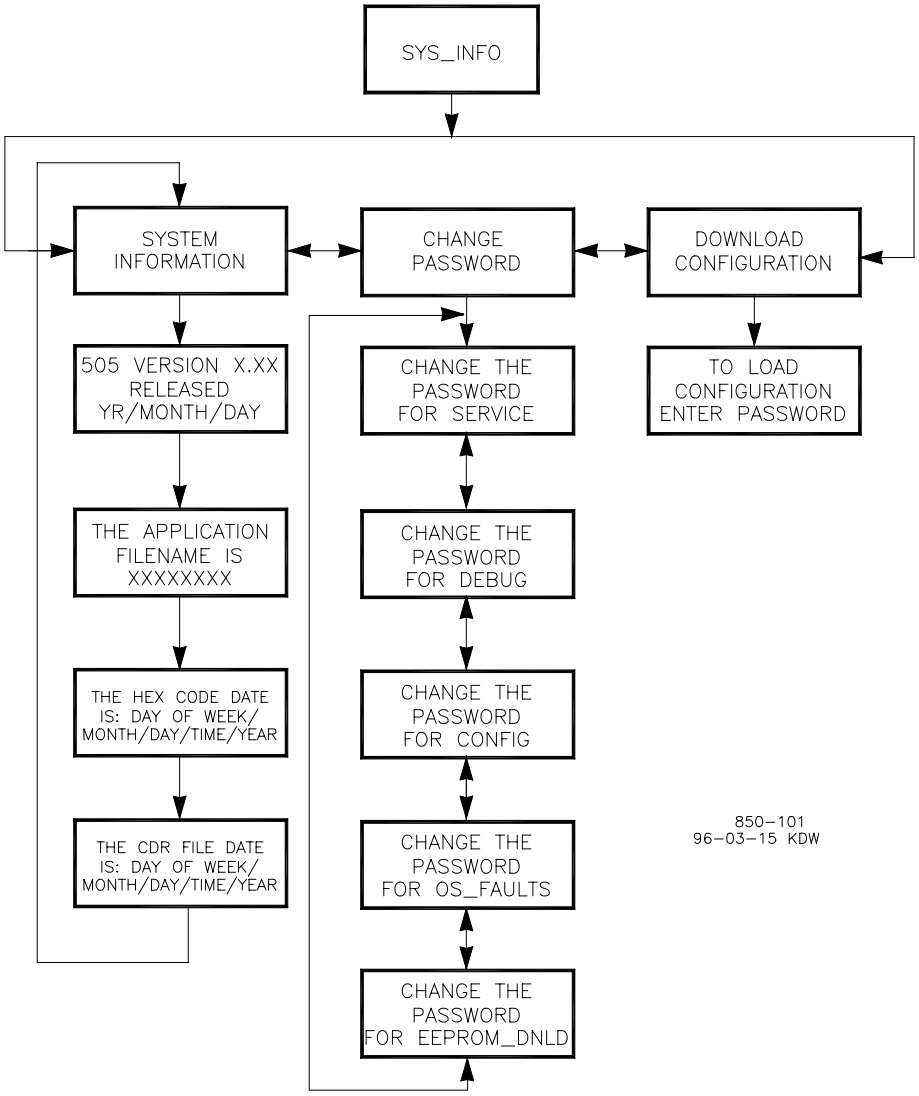


Figure 10-8. SYS_INFO Mode Information Arrangement

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 MMMMMMMM

   (MMMMMMMM = 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.

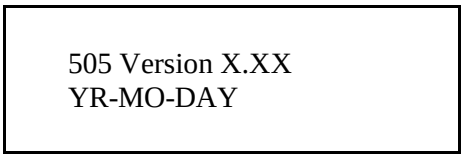
4. Use the scroll left (<) or scroll right (>) key to select the desired SYS_INFO mode header. The header will display as shown below.

or

or

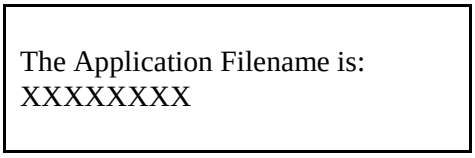
System Information Header

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.



This is information about the version being used.

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



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

NOTE
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.

1. 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.

NOTE
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

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

To Load Configuration Enter Password

NOTE

For password information, see Appendix F 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.

CAUTION

Entry into the SYS_INFO 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 11
Hardware/Operating System Faults

WARNING
Explosion Hazard - Do not disconnect equipment unless power has been switched off or the area is known to be nonhazardous.

WARNING
Risque d'explosion - Avant de déconnecter l'équipement, couper le courant ou s'assurer que l'emplacement est désigne non dangereux.

GENERAL

Most 505H 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.

Of-Line Diagnostics

When the 505H 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 the LED. See Figure 10 in Chapter 4 for more information on the self-test.

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.

[RTF bookmark start: _Toc359121431][RTF bookmark start: _Toc359123659]ON-LINE DIAGNOSTICS[RTF bookmark end: _Toc359121431][RTF bookmark end: _Toc359123659]

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.

TEST	MESSAGE ON FAILURE
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.

TEST	MESSAGE ON FAILURE
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. These errors and their associated messages are listed in the tables which follow.

OPERATION ERRORS

MESSAGE	MEANING
System Error (#)	A system error has occurred. See the table describing Numbered System Errors and explanations.
EEProm Fault	The CPU attempted to program the EEPROM and failed.
Math Exception	Illegal math instruction.
Rate Group Slip (#)	Rate group # (numbered from 10 through 160) is scheduled to run and it did not complete its previous scheduled run.
EE Initialization Fault	The CPU attempted to program the EEPROMS during system initialization and failed, or the EEPROM was detected bad (EEPROM FAULT). The system is not permitted to run because the EEPROM data is not current.
Exception Error (#)	An error was detected by the processor. The vector number indicates which exception the 68332 processor took.

NUMBERED SYSTEM ERRORS

NUMBER	OPER. SYS. FILE	MEANING
1	CREATE	Cannot create task with priority less than one.
2	CREATE	Stack size requested is smaller than the minimum size.
3	NEWPID	The priority is greater than the maximum allowed.
4	NEWPID	The rate group Proctab entry is not free
5	NEWPID	All the Proctab entries are full.
6	GETMEM	Tried to get a (zero-byte) block of memory.
7	GETMEM	No memory available.
8	GETMEM	Not enough memory available for block size requested.
9	FREEMEM	Returned a (zero-byte) block of memory.
10	FREEMEM	Returned a block of memory outside of heap boundaries.
11	FREEMEM	Unable to return the block of memory.
12	NEWSEM	No semaphores available.
13	SUSPEND	Cannot suspend a task that is not current or ready.

14	SCOUNT	The semaphore number is invalid.
15	SCOUNT	The semaphore number passed in is undefined.
16	SCREATE	The initial count is smaller than zero.
17	SIGNAL	The semaphore number is invalid.
18	SIGNAL	The semaphore number passed in is undefined.
19	SIGNALN	The semaphore number is invalid.
20	SIGNALN	The semaphore number passed in is undefined.
21	SIGNALN	Must signal semaphore one or more times.
22	SRESET	The semaphore number is invalid.
23	SRESET	The semaphore number passed in is undefined.
24	SRESET	Must set semaphore to zero or larger.
25	WAIT	The semaphore number is invalid.
26	WAIT	The semaphore number passed in is undefined.

System Alarms

The possible system alarms AND numbered system alarms are listed in the tables which follow. The ALARMS described in the tables do not automatically display; they are stored by the system and to see them the OPSYS_FAULTS mode of the Service Panel must be used.

SYSTEM ALARMS

MESSAGE	MEANING
System Alarm #n	A numbered system alarm has occurred. The number of the alarm is n (see the Numbered System Alarms table).
FP Math Error	A divide by zero or underflow/overflow condition has occurred.

NUMBERED SYSTEM ALARMS

NUMBER	OPER SYS. FILE	MEANING
1	CLOSE	The device number is invalid.
2	CONTROL	The device number is invalid.
3	GETC	The device number is invalid.
4	INIT	The device number is invalid.
5	OPEN	The device number is invalid.
6	PUTC	The device number is invalid.
7	READ	The device number is invalid.
8	RECVTIM	The time passed in was less than zero.
9	SEND	The PID number is invalid.
10	SEND	Cannot send message to undefined task.
11	SEND	Process has message pending.
12	SENDF	The PID number is invalid.
13	SENDF	Cannot send message to undefined task.
14	WRITE	The device number is invalid.
15	IOERR	The function is not implemented for this device.
16	TTYCNTL	Baud rate invalid.
17	TTYCNTL	Mode (line/char) invalid.
18	TTYCNTL	Function invalid.
19	TTYREAD	Attempt to read fewer than zero characters.
20	TTYWRITE	Attempt to write fewer than zero characters.
21	ICCCNTL	Function invalid.

Wiring Problems

Most 505H problems are caused by wiring problems. Carefully and thoroughly check all wiring connections at both ends. Be very careful when installing wires into the 505H 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 505H measures. This comparison can be used to determine if the 505H 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 505H except input power, then remeasure 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 505H.

The operation of a contact input to the 505H 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. All 4-20 mA inputs use a 200 ohm, 3W resistor to sense input current. Refer to the wiring diagram in the front of this manual to determine if input power is sourced or sinked by the 505H. All current outputs are constant current sources and will drive into 600 ohms impedance.

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 the system's valve is unsteady or hunts, try manually positioning the valve by closing the gate limit. 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.

If the 505H 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 505H control is not able to control speed above or below a certain speed, the valve may not be adjusted correctly. Verify that the valve position is indeed in the position indicated by the 505H (by pressing the SERVO 1 key). If these positions do not match, correct the problem (actuator linkage, or current calibration).

Chapter 12
Service Options

Product Service Options

The following are the factory options available for the service of Woodward equipment under Woodward's standard Product and Service Warranty (25222), in effect at the time the product is sold from Woodward or the service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In most cases, your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

Replacement/Exchange

Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is also a Flat Rate structured program and includes the full standard Woodward product warranty, pursuant to Woodward's Product and Service Warranty (25222).

This option allows you to call in advance of a scheduled outage or an unexpected outage and request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Woodward facility as explained later in this chapter.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned to Woodward within 60 days, Woodward will issue a credit for the core charge. [The core charge is the average difference between the flat rate replacement/exchange charge and the current list price of a new unit.]

Return Shipment Authorization Label. To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could be delayed and cause additional charges to be applied.

Flat Rate Repair

Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty, pursuant to Woodward's Product and Service Warranty (25222) on replaced parts and labor.

Flat Rate Remanufacture

Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in "like new" condition and carry with it the full standard Woodward product warranty, pursuant to Woodward's Product and Service Warranty (25222). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned to Woodward for repair, please contact Woodward in advance to obtain a Return Authorization Number. When shipping the item(s), attach a tag with the following information:

- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

CAUTION

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*.

Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

CAUTION

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

Return Authorization Number

When returning equipment to Woodward, please telephone and ask for the Customer Service Department [(1)(800) 835-5182 in North America or (1)(970) 498-5811]. They will help expedite the processing of your order through our distributors or local service facility. To expedite the repair process, contact Woodward in advance to obtain a Return Authorization Number, and arrange for issue of a purchase order for the item(s) to be repaired. No work can be started until a purchase order is received.

NOTE

We highly recommend you make arrangement in advance for return shipments. Contact a Woodward customer service representative at (1)(800) 835-5182 in North America or (1)(970) 498-5811 for instructions and for a Return Authorization Number.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

How to Contact Woodward

In North America use the following address when shipping or corresponding:

Woodward Governor Company
PO Box 1519
1000 East Drake Rd
Fort Collins CO 80522-1519, USA

TELEPHONE: (1)(970) 498-511 (24 hours a day)
TOLL-FREE PHONE (in North America): (1)(800) 835-5182
FAX: (1)(970) 498-3058

For assistance outside North America, call one of the following international Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

FACILITY	PHONE NUMBER
Australia	(61)(2) 9758 2322
Brazil	(55)(19) 708 4800
England	(44)(118) 975 2727
India	(91)(129) 230419
Japan	(81)(476) 93-4661
The Netherlands	(31)(23) 56 61111
Singapore	(65) 270-0081

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's Internet website for the name of your nearest Woodward distributor or service facility:

http://www.woodward.com/industrial/address.htm

[Woodward's website address is **http://www.woodward.com**]

Additional Aftermarket Product Support Services

Woodward Aftermarket Services offers the following after-sale support for all Woodward products:

- Customer Training
- Technical Assistance
- Field Service
- Specialized Services

Customer Training is offered at our facility in Loveland, Colorado, or at your site. This training, conducted by experienced trainers, will assure that customer personnel will be able to maintain system reliability and availability. For information concerning training available, call the number above and ask for *customer training.*

Technical Assistance is available using the Woodward toll-free number. The Aftermarket application engineering group is available to assist customers with technical questions or problem solving during normal business hours or as emergency support 24 hours a day. This group can also provide engineering support for changes or enhancements after the commissioning of your system. For technical engineering assistance, call the number above and ask for *technical assistance*.

Field Service engineers are dispatched from the Woodward facility in Colorado, or from one of many regional or worldwide offices located near the customer to provide prompt response. Woodward field engineers are experienced and are continually updated on all Woodward products as well as much of the non-Woodward equipment they interface with. The field engineers ensure that all documentation is updated, and all field engineers are well informed as to new problems which might arise. Woodward field service engineers are on-call 24 hours a day. Call the number above and ask for *field service.*

Specialized Services can be tailored to your specific needs. These services can be based on a particular aspect of a single service or a combination of services and are covered under one low-cost service contract. A contract may be for regularly scheduled training courses or possibly to have a field engineer visit your site at pre-determined intervals to provide a system analysis, verify proper operation, and make recommendations for maintenance improvements, enhancements, or other needs. These contracts are usually custom-designed and structured to allow ultimate flexibility, thereby allowing you to plan and budget more accurately. For more details, contact the Woodward sales representative, or call the number above and ask for *sales support* to discuss specific needs.

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

General

Your Name_____
Site Location_____
Phone Number_____
Fax Number_____

Prime Mover Information

Engine/Turbine Model Number_____
Manufacturer_____
Number of Cylinders (if applicable)_____
Type of Fuel (gas, gaseous, steam, etc)_____
Rating_____
Application_____

Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number_____

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number_____

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix A
Blade Control

General

The functional block diagram for the blade control portion of the 505H is shown in Figure A-1. This is similar to the block diagram shown for the gate control in Figure 3-1. The software implementation for several of the blade and gate control blocks is identical, thus allowing the block diagrams to have the same look-and-feel.

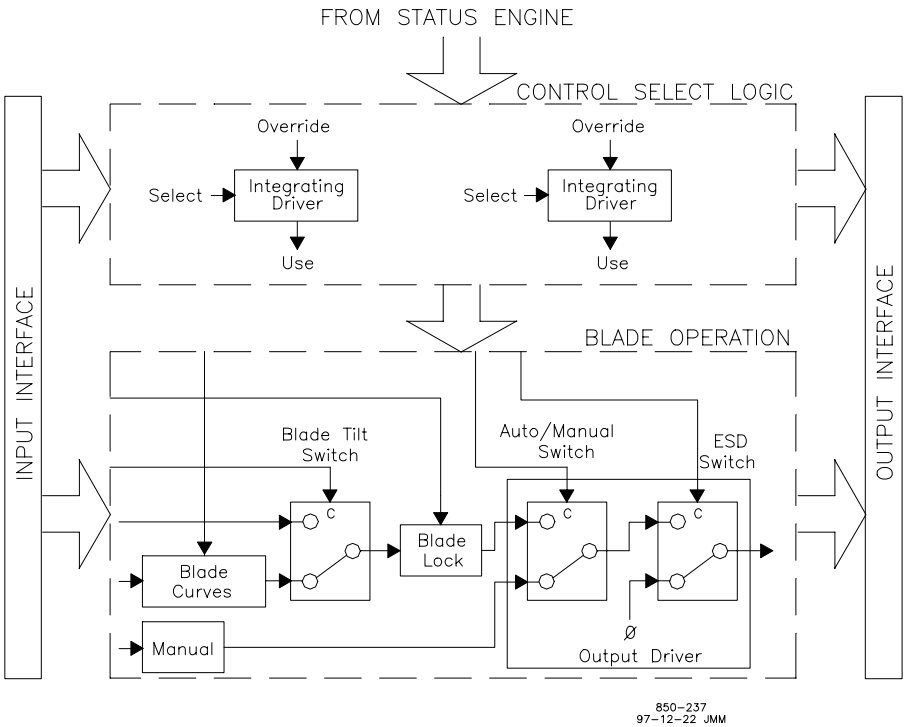


Figure A-1. Blade Control Functional Block Diagram

INPUT INTERFACE

The Input Interface for the blades is limited with respect to the gate control portion. The blade Input Interface is primarily limited to the control signals to the Blade Curves, the blade Manual Control, and the Blade Tilt Switch.

Control Input

The only Control Input used in the blade portion is for the blade Manual Control. The blade Manual Control is limited to the keypad input as a Control Source. The Modbus ports and contact inputs are not allowed.

Signal Input

From Chapter 5, it is seen that several Signal Inputs are used in conjunction with the Blade Control. These are Blade Lock Enable, Blade Tilt Enable, Blade Position Signal, Ext Blade Manual Setpoint, Gate Position Signal, and Net Head Signal (or a combination of Forebay Level Signal and Tailbay Level Signal).

Net Head Signal

The Net Head Signal is a special signal input which is handled quite differently than the other inputs. Figure A-2 gives an illustration of this. The switch is set with the option Net Head Determined By: (Chapter 6).

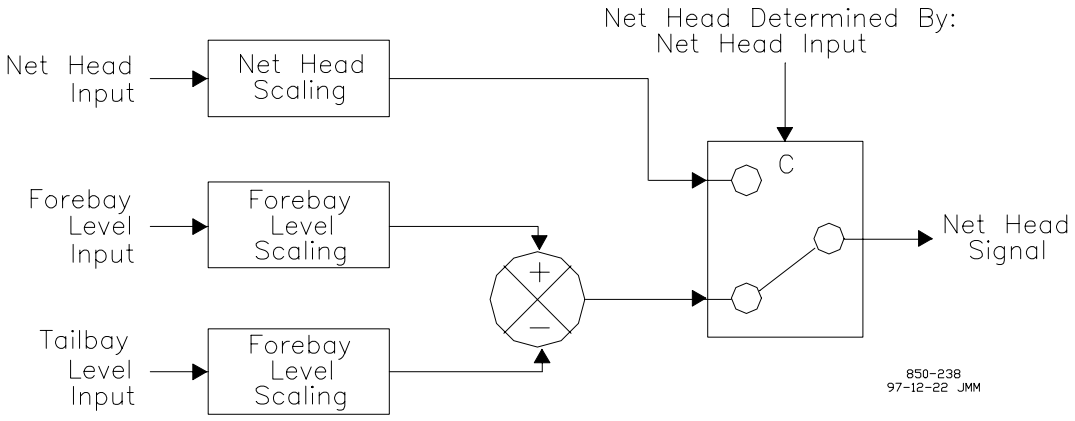


Figure A-2. Net Head Signal

Output interface

The blade Output Interface is the same device as the gate Output Interface. Refer to Chapter 5 for information on this.

CONTROL SELECT LOGIC

Selection Process

As was noted under the Input Interface section, the Control Source for the blade Manual Control can be only the keypad. The keypad input is assumed to be a momentary Control Signal. Figure 5-4 (Chapter 5) gives a simplified block diagram of the Control Signal interface used for Manual Control selection.

Override Command

Figure A-3 gives the Override Command Matrix for Blade Control. Basically, there is a programmable breakaway blade tilt available in the 505H. This Override Command is to help with unit breakaway, in that tilting the blades at this time will increase the torque applied by the water, allowing better unit acceleration.

STATUS		BLADE Override	BLADE Signal	BLADE Rate
	Waiting For Prestart	No	0	1000
S	Unit Breakaway			1000
T	Unit Start	No	0	1000
A	Ready to Synchronize	No	0	1000
T	On–Line Operation	No	0	1000
U	Unit Unload	No	0	1000
S	Unit Stop	No	0	1000
	Unit Shutdown	No	0	1000

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*a Breakaway Blade Tilt is being used

*b Blade Tilt Position for Breakaway Blade Tilt

Figure A-3. Override Command Matrix

Blade Operation

Blade Curves

The Blade Curves block is a special form of a Governor Reference. The Follow Mode and External Mode operate identically to those of the normal Governor References (Chapter 5). The External Mode uses the net head - gate - blade relationship curves to determine position. Thus, the Blade Curves use two input signals, net head and gate position, along with a set of relationship functions between the two to determine the desired blade position. The Blade Curves do not operate in Local Mode. See Curve Entry below for information on setting up your curve(s).

Blade Tilt Switch

This is a switch driven by an external contact to force the blades to a certain location. This overrides the signal from the Blade Curves. Some potential uses for this are:

- You wish to design your own unit breakaway blade tilt, where the blades remain tilted for a longer period of time than the 505H remains in the Unit Breakaway status.
- An overspeed blade tilt. If the unit hits the overspeed trip point, the blades are automatically run to the maximum angle to help limit the unit overspeed.

Blade Lock

The Blade Lock freezes the output signal from the Blade Tilt Switch, thus freezing the blades when under normal control. This Blade Lock may be used under conditions of limited hydraulic fluid, when it is imperative that all available fluid be reserved for closing the gates.

Auto/Manual Switch

The Auto/Manual Switch selects between the outputs of the Blade Lock and the Manual Control. Selection of Manual Control activates this switch.

ESD Switch

The ESD Switch forces the Output Driver to 0mA. This is done in both the hardware and software of the 505H to maintain consistency in the unit behavior. The pushbutton and shutdown input contacts are both tied to the hardware which removes the current. So all internal emergency shutdowns have been tied to this software switch to keep the 505H's behavior consistent.

There is one additional signal available to de-energize the ESD Switch: it is Remove mA On Unit Stop (Chapter 6). This signal operates in parallel with the Emergency Shutdown to allow the driver current to be removed.

Manual Control

As with the gate Manual Control (Chapter 5), the blade Manual Control is a single Governor Reference which is not forced through a selection process. When Manual Control is selected, the signal from the Blade Curve is blocked, and the Manual Control signal is fed directly to the Output Driver.

Blade Manual Control is primarily assumed to be a maintenance feature. It is an excellent tool for use during unit testing (index testing, etc.). It should not, however, be used as a long term blade positioner. Blade Manual Control selection is allowed only from the keypad, ensuring that an operator is at the 505H to make this selection.

Output Driver

The blade Output Driver is identical to that of the gate Output Driver. Refer to Chapter 5 for information on this.

Curve Entry

The curve(s) to be entered are in increments of 10% of gate position. Values in the range of -100% to +200% blade position are allowed. It is important that when you enter the data, you generate points beyond the 0% to 100% normal operating range. Although the output is limited to this range, failure to generate points beyond this can cause very large interpolation errors. In some cases, errors in excess of 10% can occur. Figure A-4 gives a graphical depiction of this.

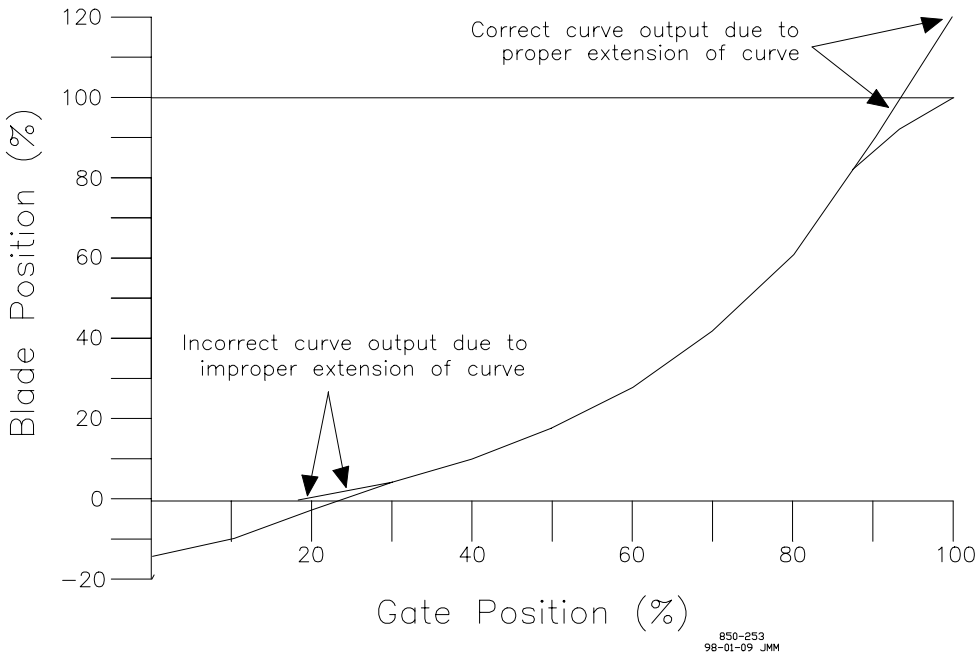

Figure A-4. Blade Curve Entry Results

It is recommended that you enter one set of data for each of the curves given in your data. The more curves you enter, the better the results will be. A maximum of eleven net head curves can be entered. If you enter one curve, the unit will behave like a 2D cam. The number of curves to be used is determined by Num of Net Head Curves = (Chapter 6). The values for the various curves are then entered in the Service Mode.

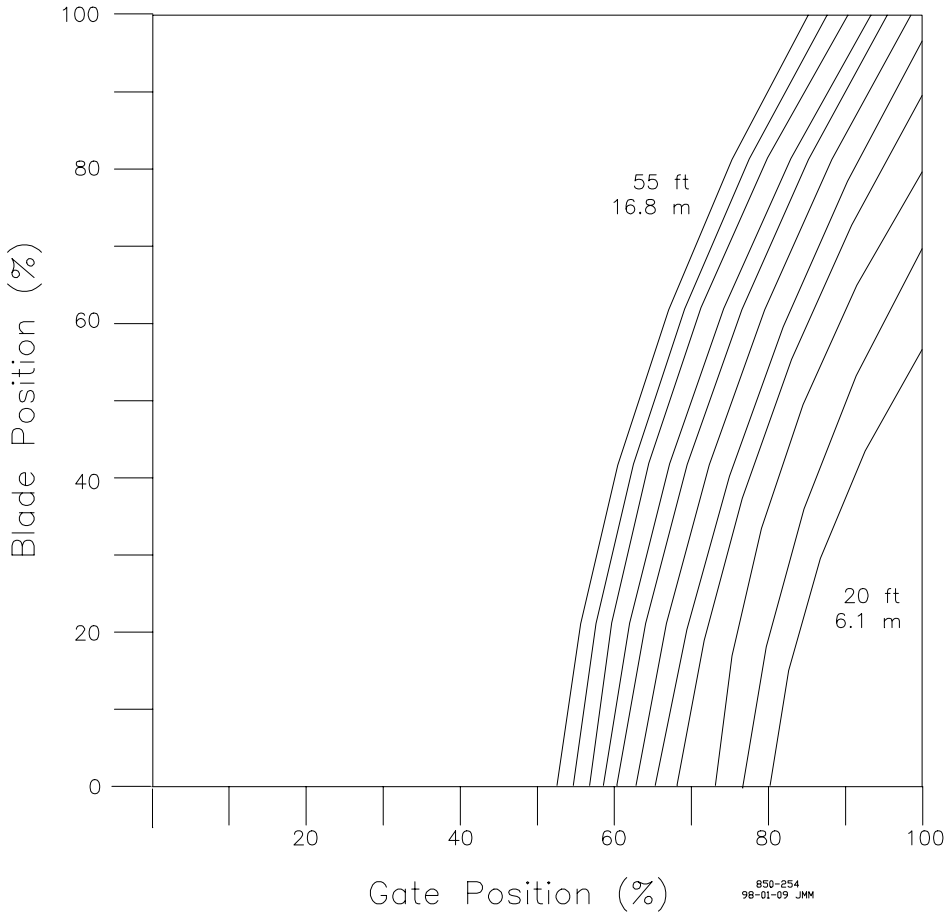

Figure A-5. Example Curves for Error Determination

Below are some examples showing the results of using various numbers of curves along with the relative errors measured in relation to eleven curves being entered. These data and results are based on tests performed using the 505H and data from a real unit. The curves shown in Figure A-5 represent (from right to left) net heads of 20 ft (6.1 m) to 55 ft (16.8 m) in increments of 3.5 ft (1.07 m).

Table A-2 gives the measured error in percent between the interpolated blade position using all eleven curves shown in Figure A-5 and the interpolated blade position using two curves (20 ft and 55 ft). Note that with two curves, some of the errors in this example exceed 15%.

NET HEAD (ft)

GATE POSITION (%)	20	23.5	27	30.5	34	37.5	41	44.5	48	51.5	55
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−6.5	−7.4	−3.3	0.0
70	0.0	0.0	0.0	−3.0	−14.7	−15.7	−15.2	−12.5	−7.9	−3.2	0.0
80	0.0	−4.5	−7.8	−10.1	−11.9	−12.7	−11.9	−9.3	−5.5	−2.0	0.0
90	0.0	−3.1	−5.2	−6.4	−7.2	−7.1	−5.7	−3.2	−0.7	0.0	0.0
100	0.0	−4.9	−8.1	−9.7	−8.9	−5.2	0.0	0.0	0.0	0.0	0.0

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Table A-1. Error Table - Two Curves

Table A-3 gives the measured error in percent between the interpolated blade position using all eleven curves shown in Figure A-5 and the interpolated blade position using three curves (20 ft, 37.5 ft, and 55 ft). Note that with three curves, some of the errors in this example are in the area of 6%.

NET HEAD (ft)

GATE POSITION (%)	20	23.5	27	30.5	34	37.5	41	44.5	48	51.5	55
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−0.6	−0.6	0.2	0.0
70	0.0	0.0	0.0	−3.0	−2.2	0.0	−2.6	−3.1	−1.6	−0.1	0.0
80	0.0	−2.0	−2.7	−2.5	−1.7	0.0	−1.8	−1.7	−0.5	0.5	0.0
90	0.0	−1.6	−2.4	−2.1	−1.6	0.0	−0.1	1.1	1.5	0.0	0.0
100	0.0	−3.7	−5.8	−6.1	−4.2	0.0	0.0	0.0	0.0	0.0	0.0

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Table A-2. Error Table - Four Curves

Table A-4 gives the measured error in percent between the interpolated blade position using all eleven curves shown in Figure A-5 and the interpolated blade position using six curves (20 ft, 27 ft, 34 ft, 41 ft, 48 ft, and 55 ft). Note that with six curves, some of the errors in this example are in the area of 1%.

NET HEAD (ft)

GATE POSITION (%)	20	23.5	27	30.5	34	37.5	41	44.5	48	51.5	55
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−0.3	0.0	0.4	0.0
70	0.0	0.0	0.0	0.9	0.0	−0.7	0.0	−0.9	0.0	0.8	0.0
80	0.0	−0.6	0.0	−0.3	0.0	−0.8	0.0	−0.6	0.0	0.8	0.0
90	0.0	−0.5	0.0	−0.2	0.0	−0.6	0.0	0.0	0.0	0.0	0.0
100	0.0	−0.8	0.0	−1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table A-3. Error Table - Six Curves

Appendix B
Signal Calibration

GENERAL

Several handles have been implemented in the 505H software to facilitate calibration of the control. It is easy to both monitor and the input and output signals to and from the control. This appendix is provided to give you guidelines for calibrating the various signals into and out of the 505H. You are able to perform the following calibration to the signals

	Monitor	Adjust	Force
Actuator Outputs	Yes	Yes	Yes
Analog Inputs	Yes	Yes	No
Analog Outputs	Yes	Yes	Yes
Contact Inputs	Yes	No	No
Relay Outputs	Yes	No	Yes

Table B-1. Signal Calibration

In Table B-1, monitor refers to looking at the value of the input, adjust refers to making offset and gain adjustments to the signal, and force refers to driving a signal to a certain state. Note that the values can always be monitored. The unit must be placed in Calibration Mode in order to adjust or force values. This is can be done from the Program Mode under the CALIBRATION ENABLE Block. You can verify that the unit is in Calibration Mode by pressing RESET. If the message Calibrate Control appears on the screen, the unit is in Calibration Mode. If the message Run Or Program appears on the screen, the unit is not in Calibration Mode.

Many of the calibration routines below require that you enter Service Mode. Refer to Chapter 7 for information on entering Service Mode along with the flowcharts showing where the required blocks are located.

The typical approach for calibration of the gates and blades is as follows:

- Calibrate the Actuator Feedback Signal. The Gate Feedback Signal is Analog Input #1, and the Blade Feedback Signal is Analog Input #2. You may want to stroke the Actuator using the Actuator Output Calibration.
- Calibrate the Actuator Output.
- Calibrate the Actuator Dither and Proportional Gain, if necessary.

WARNING

The unit must be hydraulically shutdown during calibration. This requires dewatering the unit if the gates must be calibrated. Otherwise, a manual shutdown of the valve is necessary. The actuator output signals are not kept at the minimum value while the unit is being calibrated, possibly allowing the unit to spin.

ACTUATOR OUTPUTS

Below are the two options for calibrating the actuator outputs: the proportional and integrating actuator.

Proportional Actuator

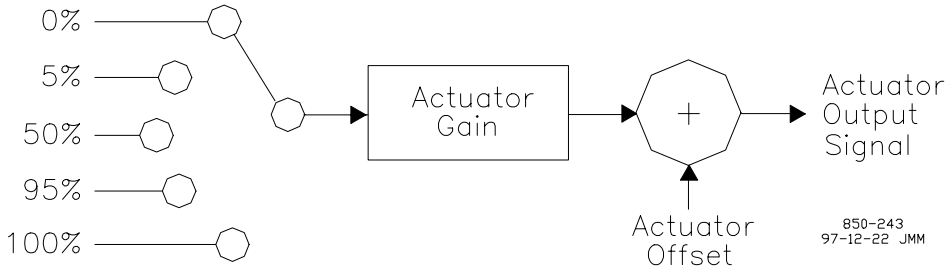


Figure B-1. Actuator Calibration

Figure B-1 shows the block diagram of the actuator driver when it is placed in Calibration Mode. Below are the steps involved in calibrating the actuator output.

- Enter Service Mode.
- Locate the ADJUST ACTUATOR DRIVER Block. Within this block are the offset and gain adjustments for the Actuator Output.
- Press SELECT to choose the other display line and locate the FORCE ACTUATOR DRIVER Block. Within this block is the forcing switch for the Actuator Output. Use the ADJUST UP / ADJUST DOWN keys to force the Actuator Output to 5%.
- Under the ADJUST ACTUATOR DRIVER Block, locate Actuator Offset. Adjust this up or down as required to attain the desired actuator position. If the Actuator Output is noninverting, 5% output in Calibration Mode is equal to 5% output during normal 505H operation. If the Actuator Output is inverting, 5% output in Calibration Mode is equal to 95% output during normal 505H operation.
- Force the Actuator Output to the 95% position using the ADJUST UP / ADJUST DOWN keys. Use the Actuator Gain to attain the desired actuator position.
- Repeat the offset and gain adjustments until the no further adjustments need to be made.
- Locate the forcing switch for the Actuator Output. Use the ADJUST UP / ADJUST DOWN keys to force the Actuator to the failsafe position. This is to insure that the unit does not run away upon entering Calibration Mode the next time.

Integrating Actuator

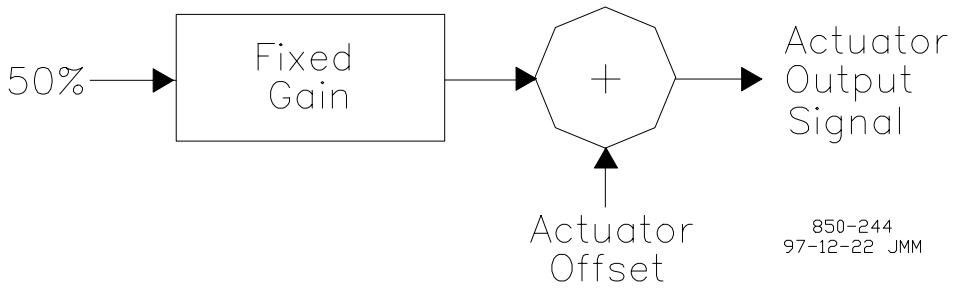


Figure B-2. Integrating Actuator Calibration

Figure B-2 shows the block diagram of the actuator driver when it is placed in Calibration Mode. Below are the steps involved in calibrating the Actuator Output. Note that 50% is assumed to be the nominal zero-error output from the 505H.

- Enter Service Mode.
- Locate the FORCE ACTUATOR DRIVER Block. Within this block is the forcing switch for the Actuator Output. Use the ADJUST UP / ADJUST DOWN keys to for the Actuator Output to 50%.
- Locate the ADJUST ACTUATOR DRIVER Block. Within this block is the offset adjustment for the Actuator Output. Locate the Actuator Offset. Initially adjust this so that the actuator is somewhere between the 0% and 100% positions. After this, adjust the Actuator Offset so that the actuator stops moving (or nearly so). This determines the centered position for the Actuator Driver.
- Locate the forcing switch for the Actuator Output. Use the adjust up / adjust down keys to force the Actuator to the failsafe position. This is to insure that the unit does not run away upon entering Calibration Mode the next time.

ANALOG INPUTS

The Analog Inputs can be monitored in either Calibration or Run Mode. They can be adjusted only in Calibration Mode.

- Enter Service Mode.
- Locate the ADJUST ANALOG INPUTS Block. Within this block are the offset and gain adjustments for the Analog Inputs.
- Press select to choose the other display line and locate the MONITOR ANALOG INPUTS Block. Within this block are the input values for the various Analog Inputs.
- Apply 4 mA to Analog Input #X (where X is the input channel you wish to calibrate). Adjust Input #X Offset so that Anlg In #X (mA)= 4mA.
- Apply 20 mA of Analog Input #X. Adjust Input #X Gain so that Anlg In #X (mA)= 20mA.
- Repeat the offset and gain adjustments as necessary.

ANALOG OUTPUTS

With the Analog Outputs, a forcing switch is available to force the Analog Outputs between (4mA and 20mA) when the 505H is placed in Calibration Mode. All Analog Outputs can be forced individually.

- Enter Service Mode.
- Locate the ADJUST ANALOG OUTPUTS Block. Within this block are the offset and gain adjustments for the Analog Outputs.
- Press select to choose the other display line and locate the FORCE ANALOG OUTPUTS Block. Within this block is the forcing switch for the Analog Outputs. Use the adjust up / adjust down keys to force the active Analog Outputs to (4mA).
- Under the ADJUST ANALOG OUTPUTS Block, locate Out #X Offset (where X is the output channel you wish to calibrate). Adjust Out #X Offset for 4mA at the output.
- Force the active Analog Outputs to 20mA using the adjust up / adjust down keys. Use Out #X Gain to adjust the output signal to 20mA.
- Repeat the offset and gain adjustments as necessary.
- Force the active Analog Outputs to (4mA) so that they are at a known position for the next time you enter Calibration Mode.

CONTACT INPUTS

All of the Contact Inputs can be monitored in either Run Mode or Calibration Mode. This is located in the Service Mode under the MONITOR CONTACT INPUTS Block.

RELAY OUTPUTS

The Relay Outputs can be both monitored and forced either on or off in Service Mode. The monitoring is done under the MONITOR RELAY OUTPUTS Block. The forcing is done under the FORCE RELAY OUTPUTS Block. The Relay Output forcing can be performed only when the unit is in Calibration Mode. The Relay Outputs can be forced individually.

Additional Actuator Output Calibration

Dither

This adjustment can be performed in either Calibration Mode or Run Mode. If you are in Run Mode, however, you may want to place the 505H in Manual Control so that the valve is active. The valve cannot be in a shutdown position.

- Enter Service Mode.
- Locate the GATE DRIVER SETUP Block. Within this block is the Actuator Driver Dither calibration.
- Use the adjust up / adjust down keys to set the Dither to the level recommended for the particular valve.

Proportional Gain

This adjustment pertains only to controls with integrating actuators (see Chapter 5). This adjustment can be performed only in Run Mode. The Proportional Gain is switched out during Calibration Mode. To set this gain, the 505H must be controlling the valve at some non-zero position. You will be required to step the valve and check the response to determine if the Proportional Gain is correct. You can do the above steps by placing the 505H in Manual Control, increasing the Actuator Manual Setpoint Rate to a high value, and giving the 505H raises and lowers to change the manual setpoint. The best response, as required below, is a response where the actuator moves to the desired position as quickly as possible without overshooting the target.

- Enter Service Mode
- Locate the GATE DRIVER SETUP Block. Within this block are the Actuator Driver Dither and Proportional Gain adjustments.
- Use the adjust up / adjust down keys to set the Proportional Gain to the level for best response. Check the response by moving the actuator up and down.

Appendix C
Auxiliary Functions

The variables listed below are found in the Program Mode (see Chapter 6). Many of these are also available in the Service Mode (see Chapter 7) under abbreviated names.

BRAKES

There is a built-in brake circuit to the 505H. The brake circuit is active only when the 505H is in the Unit Stop and Unit Shutdown statuses (see Chapter 5).

BRAKE PULSING

The 505H can be programmed to apply the brakes using a pulsing algorithm in the Unit Stop status. It can be enabled at a Pulse Enable Speed (%) which is an enabling speed (in percent of rated speed) for the pulsing circuit. There is a Pulse On Time (s),which tells how long the brakes will be applied while the pulsing algorithm is used. And there is a Pulse Off Time (s) which tells how long the brakes are left off while the pulsing algorithm is used.

Brake Hold

The 505H can be programmed to apply the brakes continuously (hold the brakes on) in the Unit Stop status. This algorithm is enabled using the Hold Enable Speed (%) Using this algorithm, the brakes are held on until the 505H reaches the Unit Shutdown status.

Creep Enable

The brakes can be set up to be applied upon Creep Detection within the 505H (see Creep Detection below). This is done be setting Enable On Unit Creep to YES You can also set the length of time after unit creep has been cleared before for the brakes are released using the Time After Creep (s)value.

Brake On While Shutdown

If you wish to have the brakes maintained after the unit has reached deadstop (Unit Shutdown status), you can set the Apply After Deadstop to YES This will keep the brakes on as long as the 505H is in the Unit Shutdown status.

Creep Detection

There is a built-in high resolution Creep Detection circuit within the 505H. This circuit is enabled in the Unit Shutdown status (see Chapter 5). The Creep Detection circuit can detect unit rotation to within one tooth of the gear being used to drive the Zero Velocity Pickups.

Creep Rearm Time

The Creep Rearm Time (s) s the time after a 505H has detected creep before it begins to look again to see if the unit is still creeping.

Creep Reset Time

The Creep Reset Time (s)is the time after the 505H has detected creep before it clears the creep indication.

Small System Detection

The Small System Detection circuit can be used to automatically switch the 505H from Position Control to Speed Control (see Chapter 5). If you program the 505H to use Position Control while the generator breaker is closed, the Small System Detection circuit can be used to force the 505H into Speed Control based on deviation from rated speed. If the Small System Detection circuit is activated, it can be cleared by issuing a Reset to the 505H.

Speed Signal Window

The Speed Sig Window (%)sets a window around rated speed (in percent) within which the unit speed must remain. If the unit speed deviates from this window, the Small Signal Detection circuit is activated, placing the 505H in Speed Control.

Speed Derivative Window

The Speed Der Window (%/s)set a value (in percent per second) below which the rate of change of unit speed must remain. It the rate of change of unit speed deviates from this window, the Small System Detection circuit is activated, placing the 505H in Speed Control.

Appendix D
Understanding PID Settings

OVERVIEW

The term “PID” refers to a control algorithm composed of three functions: proportional, integral, derivative, working together to provide a control for hydroelectric (and many other types of) plants. It is the control algorithm characteristic of analog and digital electronic systems.

First, we examine the specific characteristics of each of the terms. This is done by both showing graphs relating the outputs to the inputs, by giving mechanical representations, and by showing Bode plots for each of the three terms. For the graphs, two sets of inputs are given. The first is a set of steps in the positive and negative directions. The second is a set of ramps in the positive and negative directions. The signal is assumed to start and finish with a magnitude of zero (important for the integral term).

Then, we look at a control consideration that must be implemented due to system nonlinearities. This is known as integrator clamping.

After this, we look at the combined effect the proportional, integral, and derivative terms have on signals.

Finally, we are walked through a PID tuning algorithm that can be applied in the field.

The Proportional Term

Figure D-1. The Proportional Term

Figure D-1 gives an example of a proportional term. We see that the output looks identical to the input. The only thing a proportional gain does is take an input signal and scale it by some value (the proportional gain) to determine its output signal. Thus, if an input signal to a proportional term with a gain of 1.5 has a magnitude of 2, the output signal has a magnitude of (2 x 1.5 =) 3.

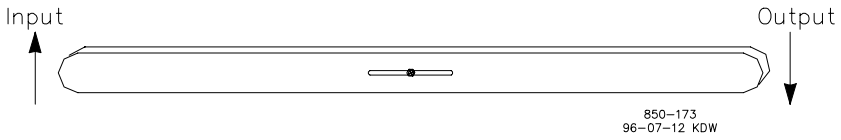


Figure D-2. Mechanical Representation of the Proportional Term

Figure D-2 provides a mechanical example of the operation of a proportional term. For this example, the pin in the center slot is assumed to be pinned to some fixed point. For a given change of position on the left hand side (input signal), we see a corresponding change of position on the right hand side (output signal). The position of the pin in the slot determines how much the right hand side moves with respect to the left hand side. This corresponds to the proportional gain.

Figure D-3 shows the Bode plot of a proportional term. Note that the gain for the Bode plot shown is one (of movement of one inch at the input gives a movement of one inch at the output). This is denoted by the 0dB gain of the system.

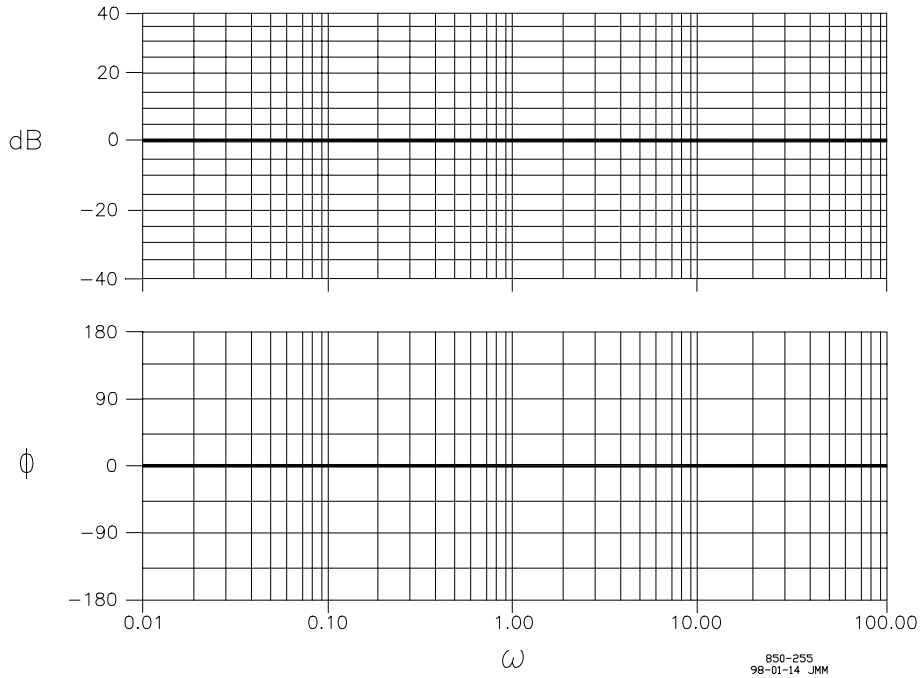


Figure D-3. Bode Plot of a Proportional Term

The Derivative Term

Figure D-4 shows a derivative term. The output signal of a derivative term indicates the rate of change of its input signal. Relating to the graph, we see that the rate of change of a step input is infinite. Thus, the output signal is of extremely large magnitude (for an ideal derivative, it should be of infinite magnitude). The graph of the output signal "chops off" a majority of the signal so that we have some resolution for the remainder of the signal. From this portion of the graph we can conclude that a derivative term can be very susceptible to noise. If we assume that noise is made up of a number of small spikes, the output signal of the derivative term will be very sporadic.

Figure D-4. The Derivative Term

For a ramp, the rate of change is some constant value. Here we see that the output signal gives an output signal with a magnitude of some constant.

Figure D-5 shows a realistic example a derivative used in the field. Here, the input signal to the derivative term is filtered, giving us a less drastic response to the input. We see here that the output signal from resulting from the input is much more rounded. This helps somewhat with noise susceptibility.

Figure D-5. The Derivative Term (Filtered)

Figure D-6 gives an example of a mechanical representation of a derivative term. This is referred to as a dashpot. By pushing down on the input plunger (in the middle of the dashpot), we displace the output plunger (on the left hand side) due to the increased oil pressure in the bottom of the dashpot. As the plunger rises, the spring exerts a force in an attempt to recenter it. This recentering force keeps a slightly higher pressure in the bottom half of the dashpot.

The reset time is determined by adjusting bleed valve on the right hand side. As the bleed valve is opened, the output plunger recenters more quickly. This portion can be referred to as the filtering portion of the derivative term.

Note that no gain adjustment is shown on this particular arrangement. A gain adjustment can be added by simply attaching a lever (see Figure D-2 above) to the output plunger. Another method of adjusting the gain is to vary the diameters of the two plungers.

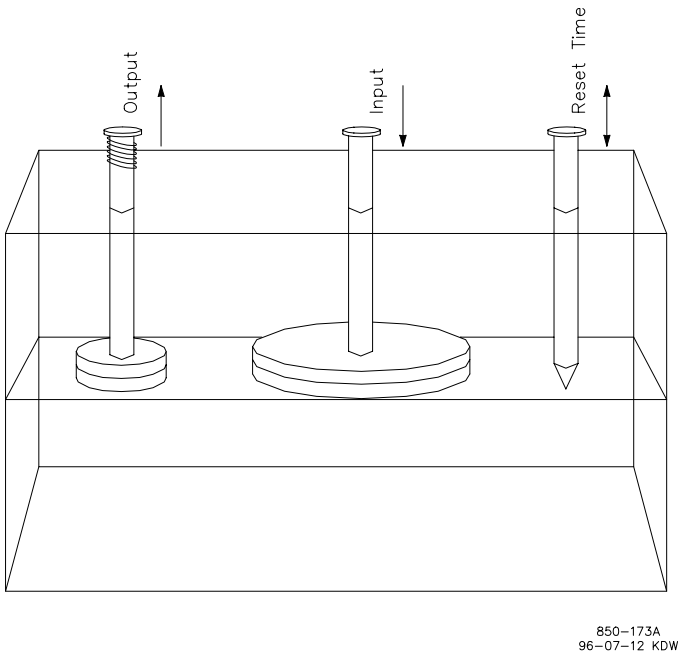


Figure D-6. Mechanical Representation of a Derivative Term

Figure D-7 shows a Bode plot of the derivative term.

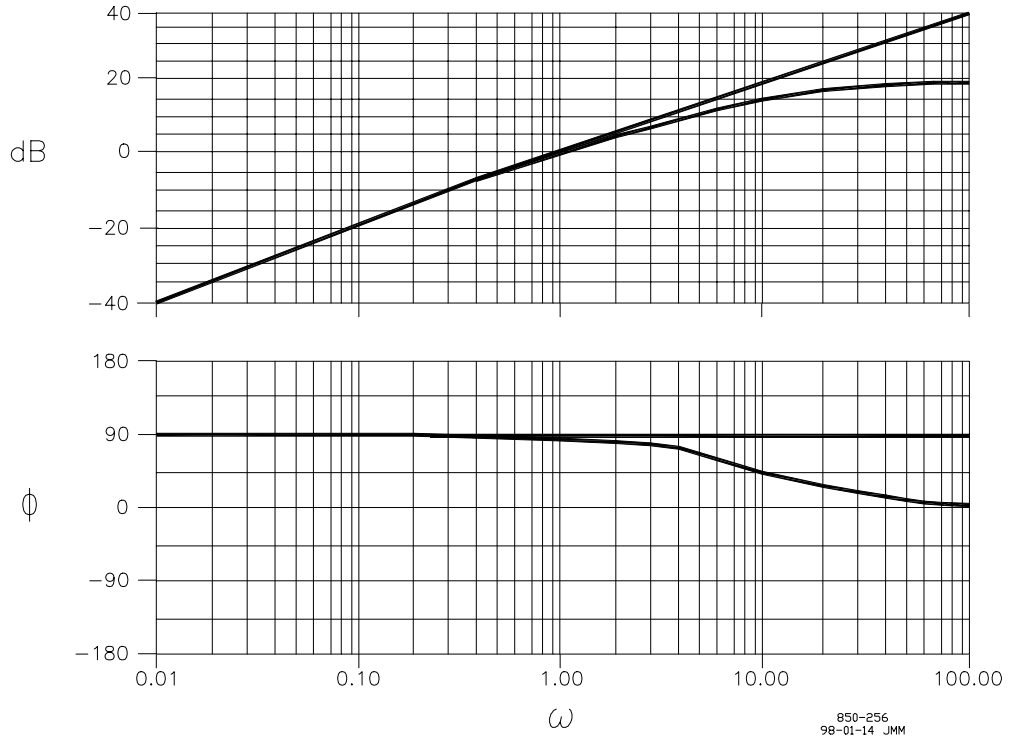


Figure D-7. Bode Plot of a Derivative Term

Figure D-8. The Integral Term

The output of an integral term is the total sum of the input signal over time, e.g. it adds the total error over the past history. If the input signal is zero (0), the output signal of the integral term remains unchanged. The integral effect takes place only when there is a change in the input signal. This is shown in Figure D-8 where over time the output ramps upward. When the input signal returns to zero (0), the output signal remains unchanged.

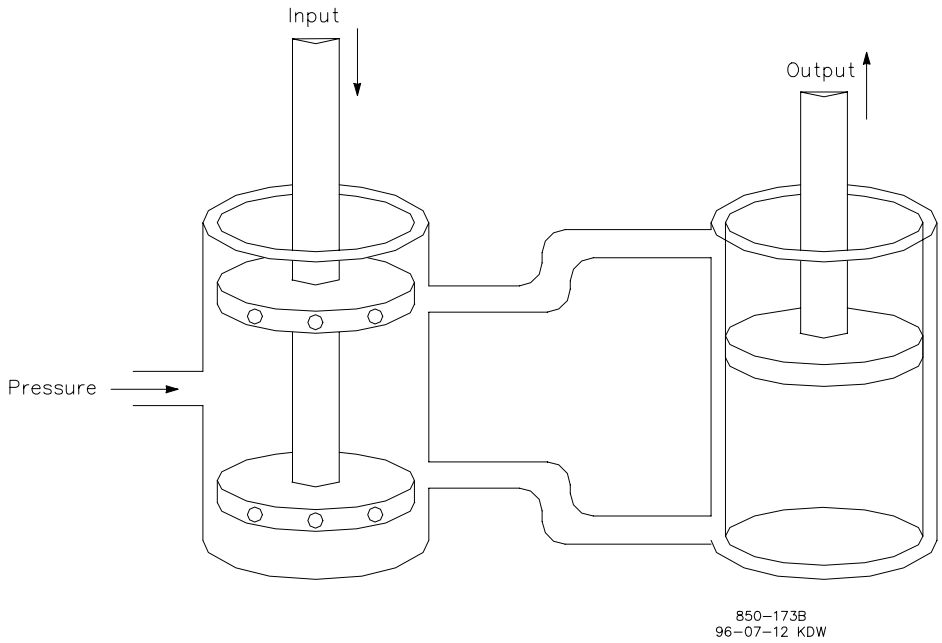


Figure D-9. Mechanical Representation of the Integral Term

Figure D-9 gives a mechanical representation of an integrator. When the plunger is centered in the bushing, no oil flows to the servomotor. This is equivalent to an input signal of magnitude zero, as there is no movement at the servomotor.

As we move the valve bushing in the downward direction, high pressure oil is allowed to pass through the bottom port, while oil from the top port is directed to tank. This forces the servomotor in the upward direction. The more the port is open, the faster the servomotor moves.

Note that no gain adjustment is shown on this particular arrangement. A gain adjustment can be added by simply attaching a lever (see Figure D-2 above) to the output plunger. Alternate methods include varying the pressure, the number of ports in the plunger, the servomotor diameter, etc.

Figure D-10 shows a bode plot of the integral term.

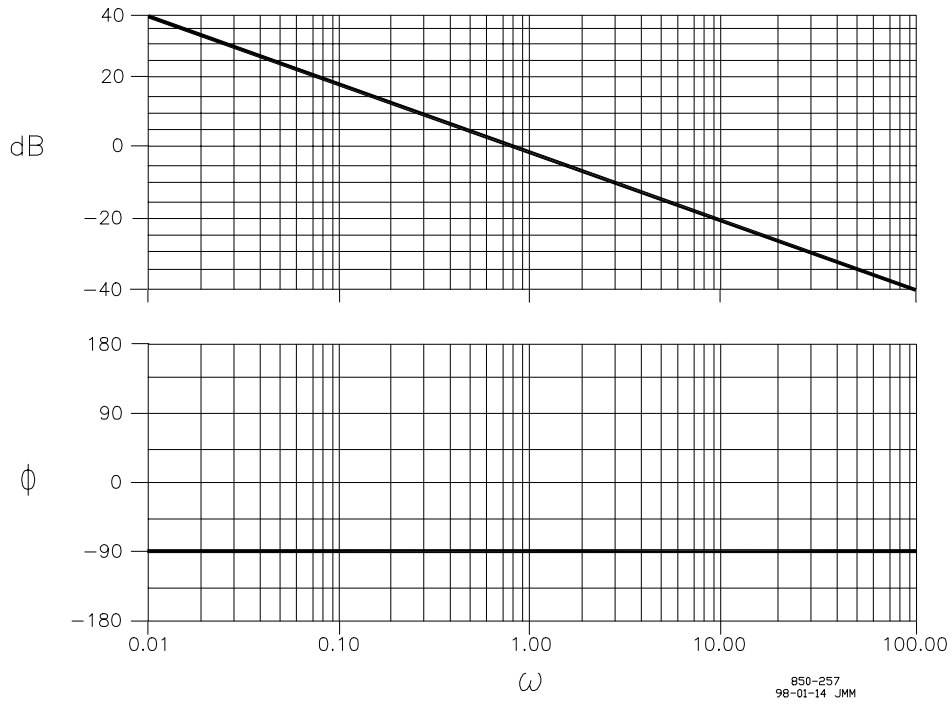


Figure D-10. Bode Plot of an Integral Term

Integrator Clamping

As can be seen above, an integrator's output will continue to change as long as its input is not zero. If an integral term is applied exactly as described above, two primary problems will occur in the control of hydroelectric units. For each of these problems, the implementation of integrator clamping will solve these.

Problem 1

The total travel of the servomotor is limited, e.g. there is some minimum and some maximum position of the servomotor. It makes sense to allow the integrator to travel only as far as the servomotor. Allowing the integrator to travel beyond a position attainable by the servomotor causes a phenomenon known as integrator windup, where the integrator value would be travel well beyond the servomotor position. When a movement in the opposite direction is required, the integrator must unwind (integrate back to the servomotor position) before any servomotor movement can occur.

This problem is handled with a device termed a static integrator clamp. The term static is used because the ends of travel of the servomotor are fixed (static), thus the integrator limits can be static

Problem 2

The rate of change of the servomotor is limited, e.g. only so much oil can be passed to the servomotor in a certain period of time. If a large error occurs where the integrator is requested to move very rapidly, its output may change at a rate faster than the servomotor. Once the unit error signal has again reached zero (the integrator output is constant), the servomotor is not yet caught up with the integrator output. Because of this, the change in the

servomotor after the zero error point is attained can cause a severe over correction for the given error. It makes sense to keep the integrator somewhere close to the servomotor position, meaning that when the governor error signal again reaches zero, the servomotor is very close to the integrator output.

This problem is handled with a device termed a dynamic integrator clamp. The term dynamic is used because this device comes into effect while the servomotor is moving. The integrator clamp is dependent on the changing servomotor position.

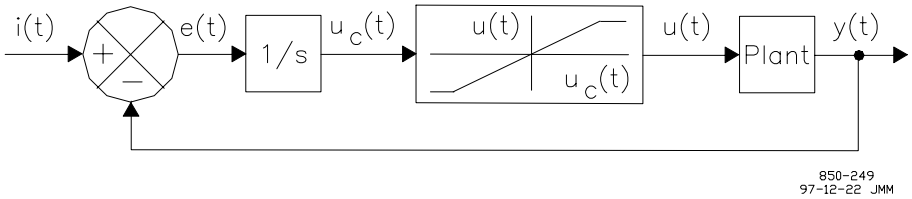


Figure D-11. An Example of a System With Actuator Saturation

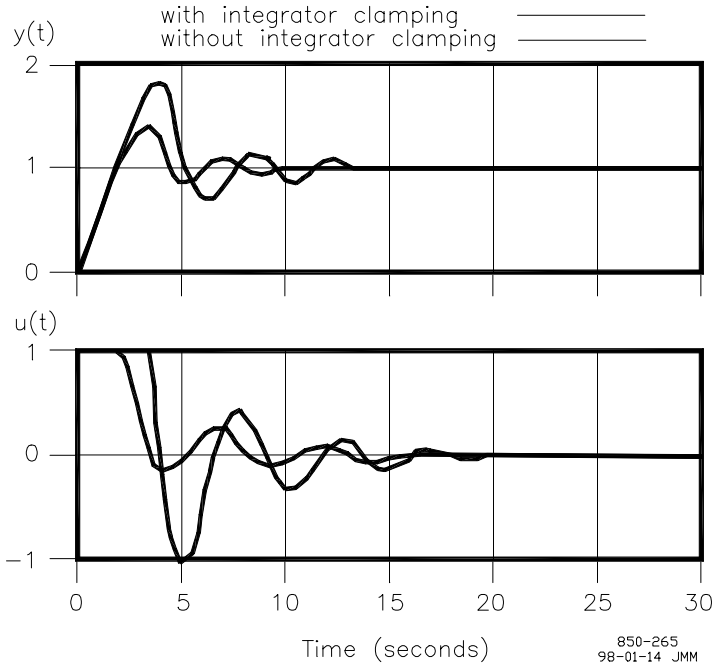


Figure D-12. Effects of Integrator Clamping on a System

A block diagram implementation of integrator clamping is shown in Figure D-11. Figure D-12 shows the time response of the system with and without integrator clamping. As can be seen, excessive overshoots can occur when integrator clamping is not implemented. Note that y(t) is the output of the plant, while u(t) is the output of the actuator.

Proportional + Integral + Derivative Control

Figure D-13 shows the total effect on the output of the three terms, combining the effects of the P and I and D signals. Note that the output signals from the previous three graphs are added together to provide an output signal. The relative magnitude of each of the three terms can be changed by setting the gain for each. The overall response of the output to the input is given in the equation below.

$$O(s) = \left(K_P + K_I/s + K_D s/\tau s + 1\right) I(s)$$

s = Laplace operator
I(s) = input signal
O(s) = output signal
KP = proportional gain
KI = integral gain
KD = derivative gain
t = time constant (typically 0.1 seconds)

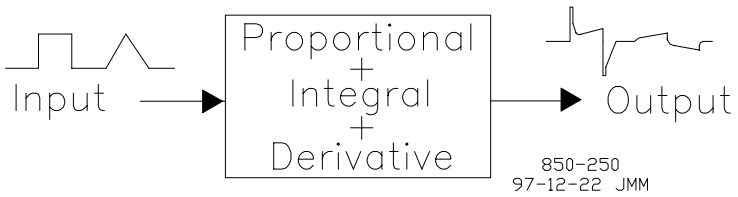


Figure D-13. Proportional + Integral + Derivative Control

Feedforward Signal

The feedforward signal is a signal the control uses to help preposition the governor dynamics based on the unit setpoint. In general, unit control is performed via a feedback signal, such as speed. The term “feedforward” suggests a signal which is the opposite of a feedback signal. The feedforward signal is an anticipatory signal based on a change in setpoint. Basically, it is a signal which prepositions the integrator based on the unit setpoint. If a change of 10% in servomotor position is requested by the setpoint, the feedforward signal drives the integrator approximately 10% in anticipation of the PID having to perform this function via the feedback signal.

PID Tuning

In this section, we walk through a method of tuning the PID gains that can be applied in the field, with no data from mathematical models or simulations required. This method is best performed with a chart recorded or some other type of graphing device, as the results from the speed upsets can e much more easily observed in this manner. This is a step-by-step process that should allow anyone to tune a governor for good response. Below are a number of graphs showing the results of various stages of PID tuning on a governor for a hydroelectric unit.

Figures D-14 through D-20 walk us through the various stages of PID tuning on a hydroelectric unit, looking at the intermediate steps as we go. Note that the process below targets a certain response. This response has the characteristic of one speed undershoot, followed by a speed overshoot, followed by a flat speed

signal. This occurs after the initial speed overshoot, due to the method used to tune the PID. Each speed transient is no greater than 1/4 of the previous in magnitude. This response is referred to in the controls world as 0.707 damping. For various hydroelectric plant owners, the ideal response may differ from this. We at Woodward use this because it gives a good tradeoff between stability and settling time.

NOTE

The following PID tuning method is a suggested method based on experience in field-tuning governors. In providing the following method, we do not guarantee that you will attain the optimum settings for your unit.

NOTE

Before doing the PID Tuning, it is critical to tune the hydraulic valve system. Unless the hydraulics are tuned properly, the PID gains cannot be set properly, which could lead to an unstable unit.

Before beginning the process, we start with a set of gains that guarantee a stable response. To do this, we set the proportional and integral gains fairly low, and set the derivative gain to zero. The derivative gain is needed only during final tuning to give a good speed response with higher proportional and integral gains. We then lower the unit speed with the gate limit. Once the speed has dropped to approximately 95% of normal speed, we bring the gate limit out of the way to allow the PID to bring the speed back.

NOTE

We do not want to lower the speed too much with the gate limit, as this will cause large gate movements when the gate limit is removed. If the gate movements are too large, the PID may force the servomotor into a rate limit (timing nuts or timing valves). If a rate limit is encountered during the tuning process, the results of the test are invalid, as the actual response of the servomotor due to the PID cannot be determined.

Two terms that are used in this procedure are overdamped and underdamped. These are defined as follows:

Overdamped

The number of speed swings after the initial overshoot is too small. In this case, the control is responding slower than it can, meaning that we have a longer settling time than the optimum. In this case, the integral gain is too low with respect to the proportional gain.

Underdamped

The number of speed swings after the initial overshoot is too great. In this case, the control is responding too quickly to the speed transients, meaning that we have a longer settling time than the optimum. In this case, the integral gain is too high with respect to the proportional gain.

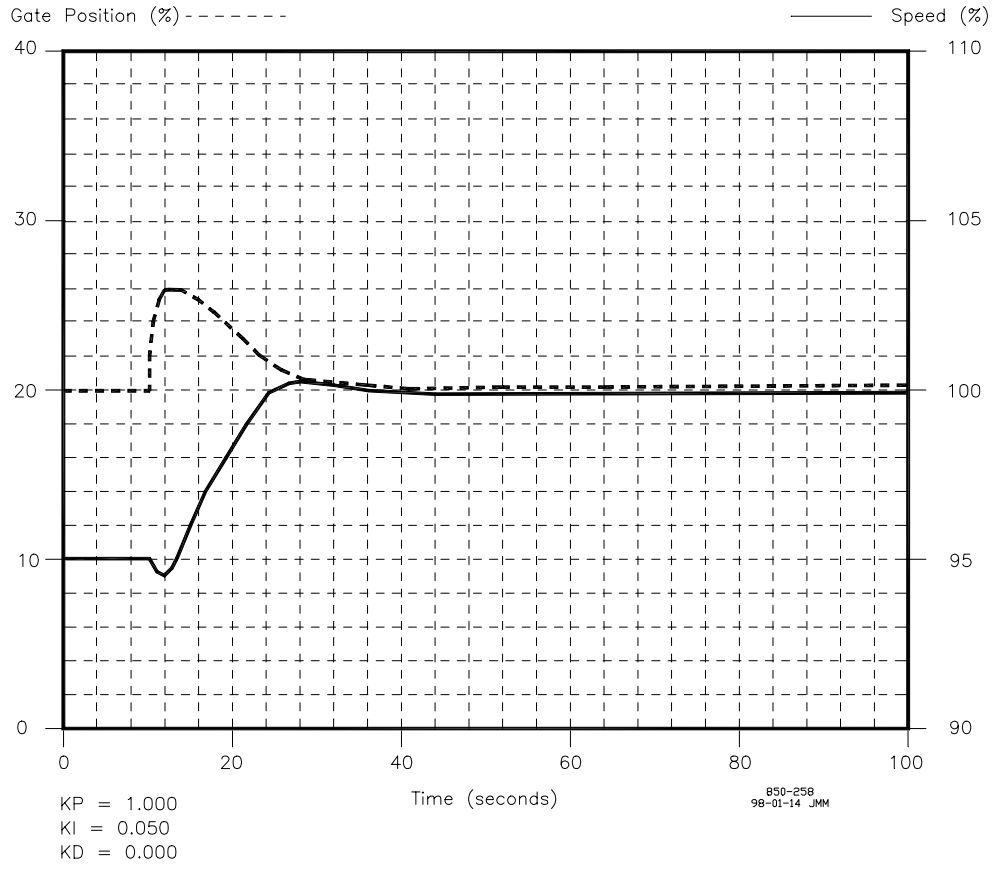


Figure D-14. PID Tuning - Step 1

We start the tuning with the settings shown in Figure D-14. After performing the speed upset, we observe from the graph that the hydroelectric unit is overdamped. From the explanation above, we know that the integral gain is too low with respect to the proportional gain. We want to increase the integral gain and try again.

In Figure D-15, we see that the system is still somewhat overdamped, meaning that the integral gain is still too low with respect to the proportional gain. We want to again increase the integral gain. Note that this is a process that may be repeated several times. Do not worry about not reaching the ideal setting after one or two attempts. Just slowly adjust the integral gain until the ideal response is achieved.

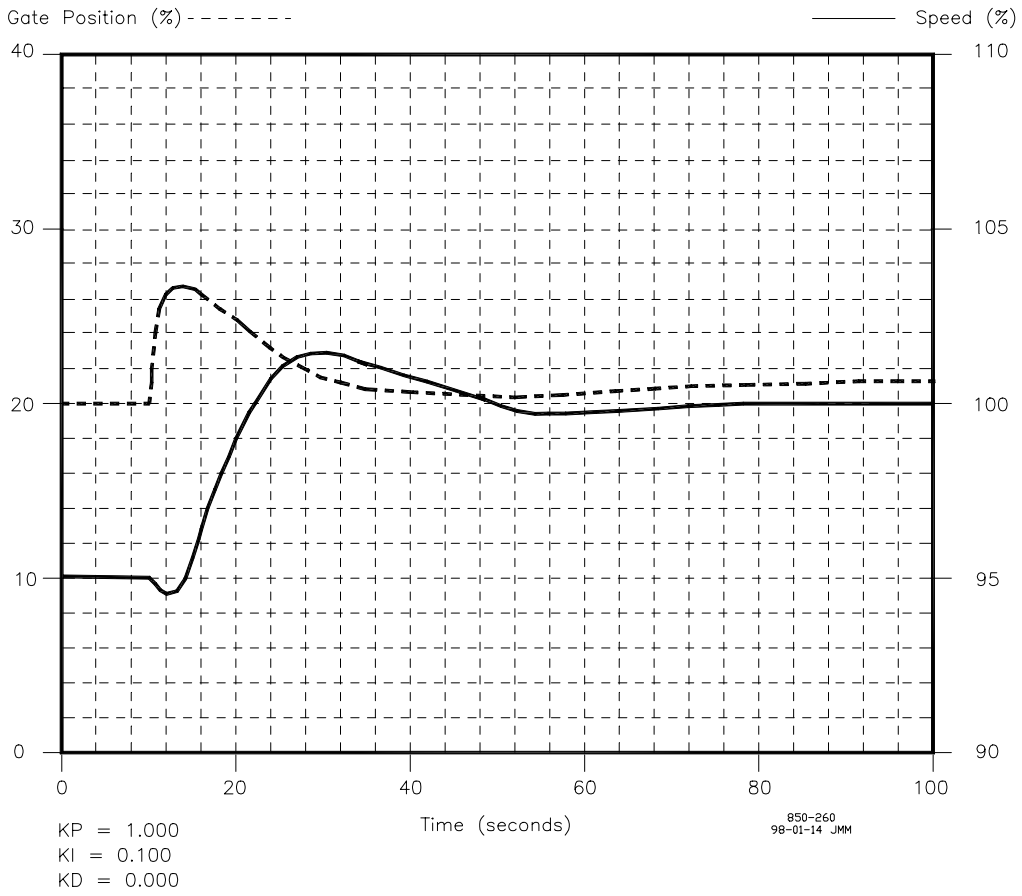


Figure D-15. PID Tuning - Step 2

In Figure D-16, we still have a case of an overdamped system. We want to again increase the integral gain slightly to achieve our optimum response.

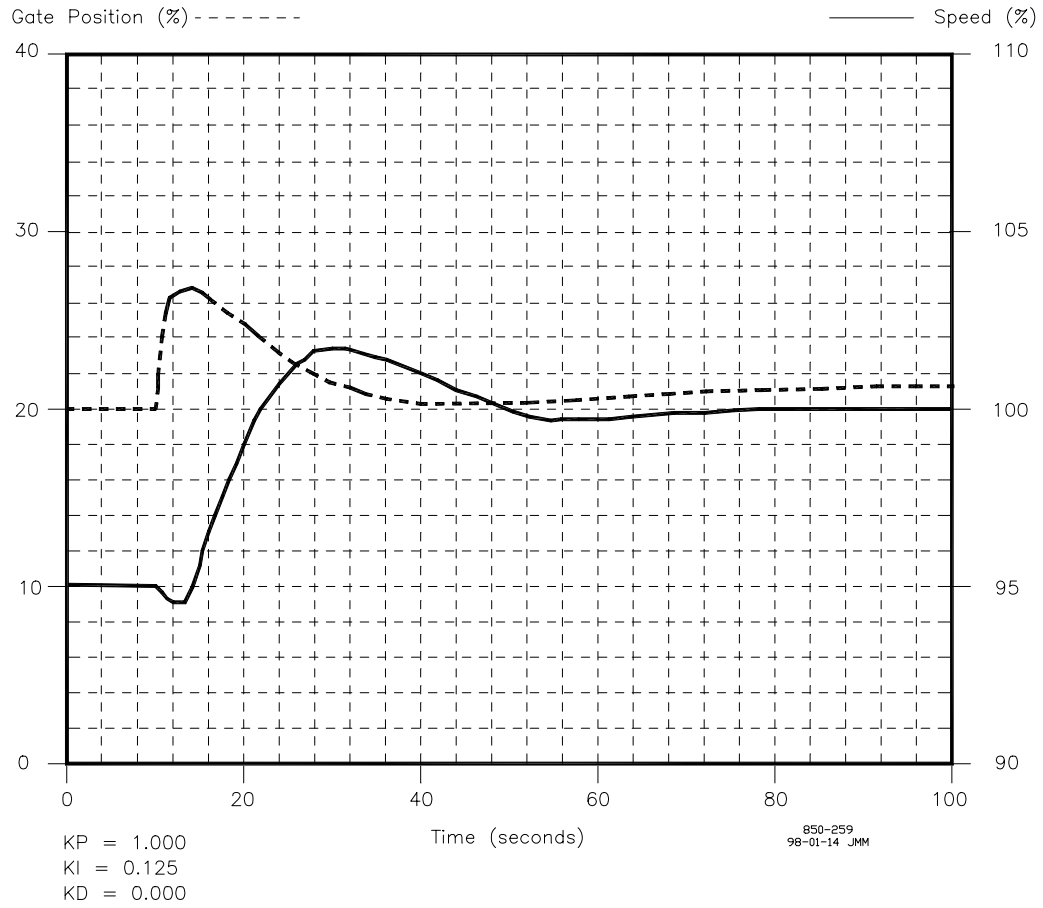
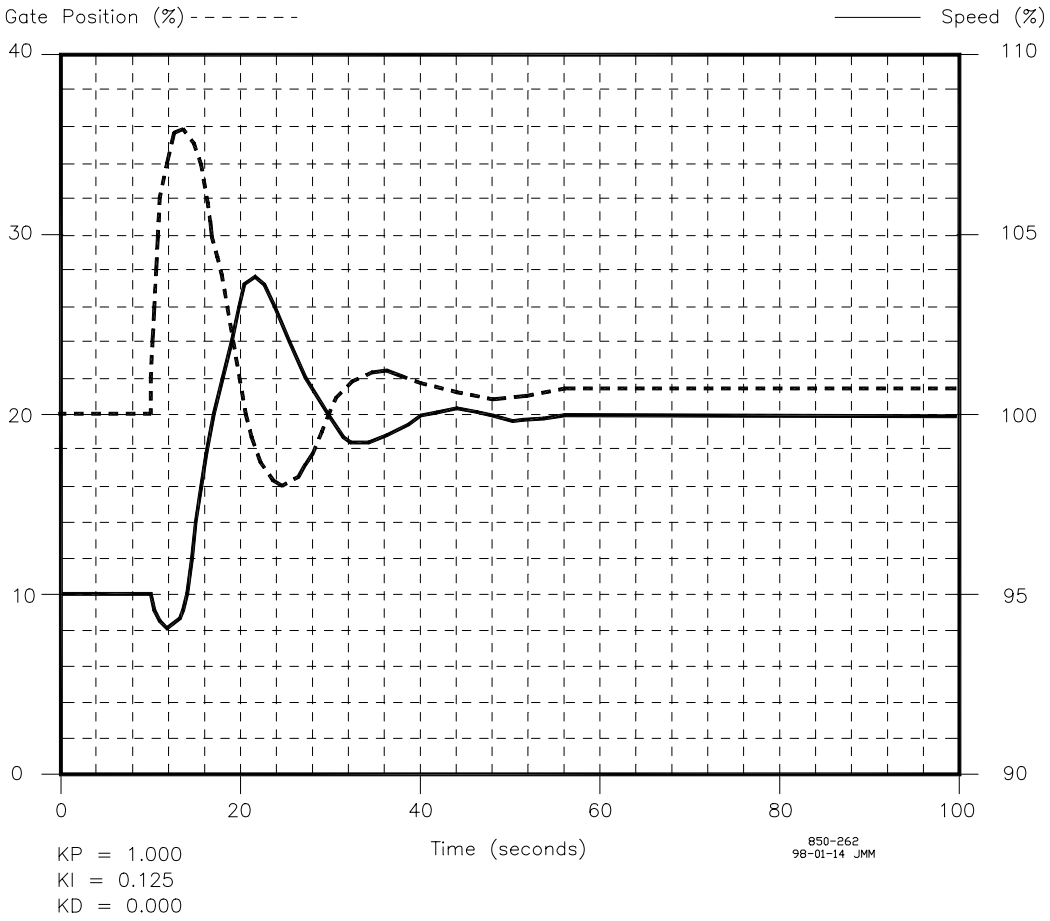


Figure D-16. PID Tuning - Step 3

In Figure D-17, we have achieved the response we want. Here, we see the first overshoot, followed by one undershoot and one overshoot. What we have done is determine the proper proportional gain to integral gain ratio for the unit. We can record this as the P to I ratio. In this case, the P to I ratio is

K_P / K_I = 1.000 / 0.150

K_P / K_I = 6.67



PID Tuning - Step 4

Once the proper P to I ratio is determined, we can increase the proportional and integral gains while maintaining this ratio. Note that as the gains are increased, the unit will become more underdamped. In Figure D-18, we have the results of doubling each of the terms while maintaining this same ratio, namely

K_P / K_I = 2.000 / 0.300

K_P / K_I = 6.67

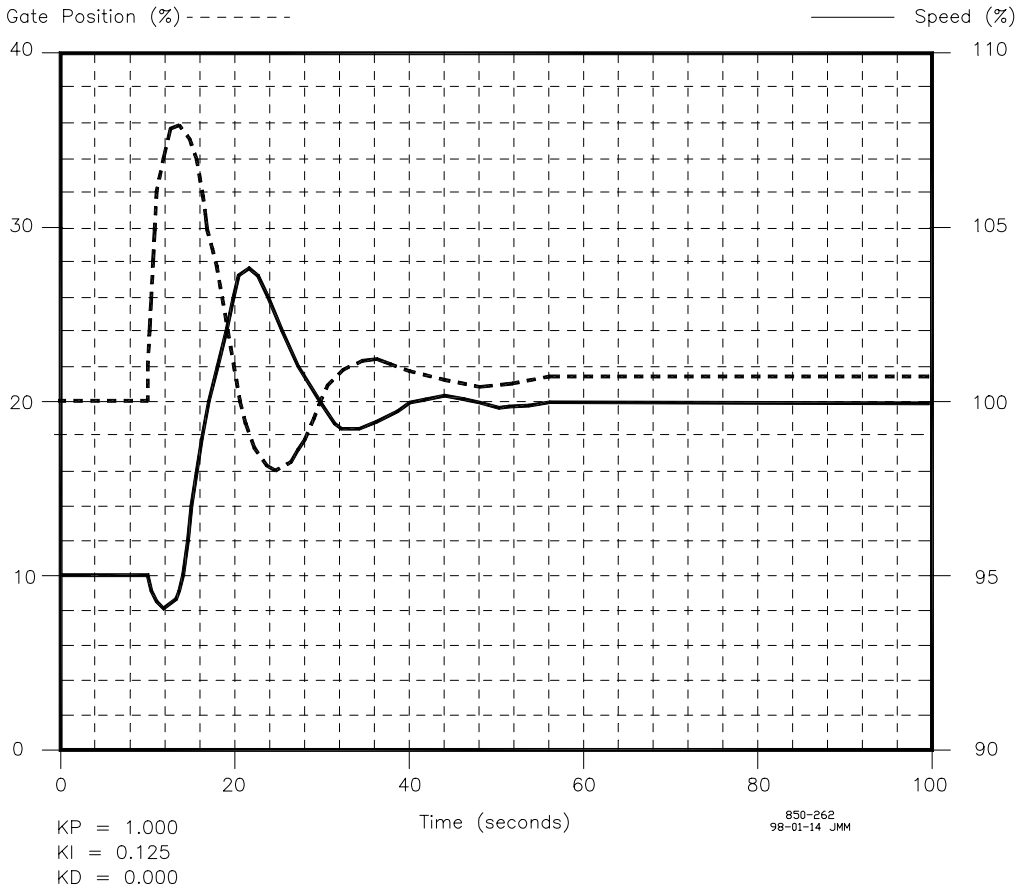


Figure D-18. PID Tuning - Step 5

In this case, we see that the response is underdamped with respect to the previous graph. This is expected, because we are trying to move the gates much more quickly for a given speed upset (higher gains). This time, however, we do not want to adjust the integral gain to return the unit to proper damping.. We determined previously that the P to I ratio of 6.67 was correct for the unit. What do we want to do to return the unit to a well responding system? Adjust the derivative gain. Up to this point, we have not adjusted the derivative gain. We have left it at zero so that we could determine the proper P to I ratio. Now that we have made the unit underdamped while maintaining the proper P to I ratio, we increase the derivative gain to again return the unit to good damping. This is shown in Figure D-19.

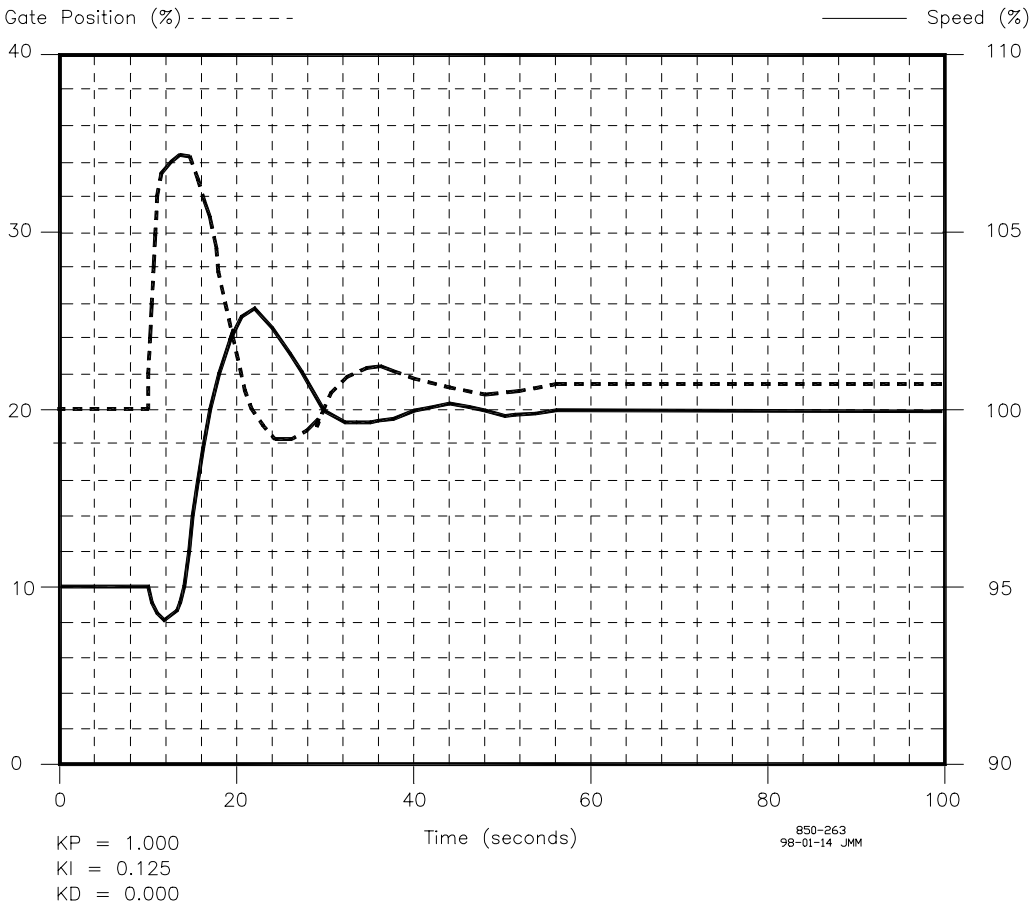


Figure D-19. PID Tuning - Step 6

NOTE

We want to limit the magnitude of the derivative gain to a value of, generally, not greater than 1.00. This is due to the noise susceptibility of the derivative term. Too high of a derivative gain causes excessive motion in the hydraulic valve and servomotor, causing wear in the components.

One final graph is included in this chapter, Figure D-20, to enforce the note made earlier about proper valve tuning. We see here that even with proper PID gains, if the valve is not tuned properly, the unit will not respond well. Improper valve tuning can cause unit instability even with good gain settings.

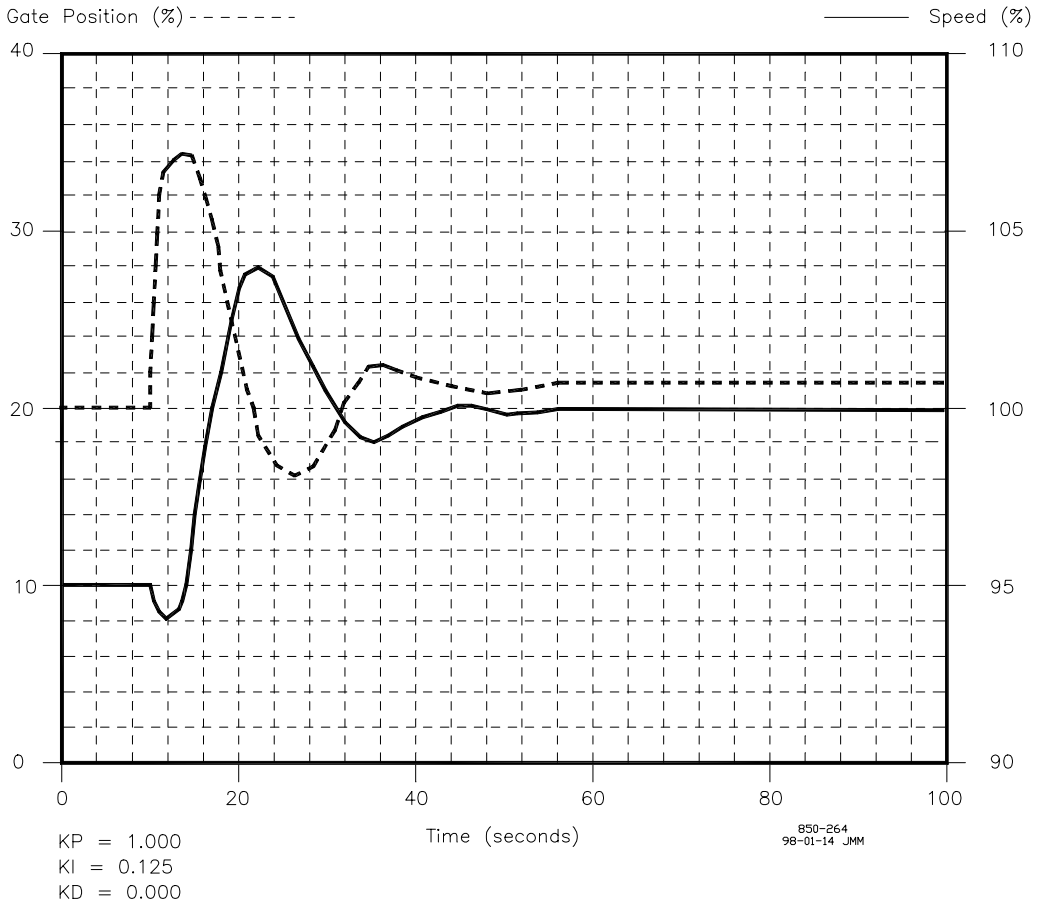


Figure D-20. Example of Improper Tuning of Hydraulics

Appendix E
505H Design Specifications

Hardware

Area Classification

Hazardous environments:
Per NEC article 500 Class 1 Division 2 groups A,B,C,D
Temperature Code T4 (TBD)

Package

Flush mount package
Approximate physical size of 11" x 14" x 4"
Environmental Category:
Lloyd's Type ENV2
Nema: Type 4 or IEC 529: IP66
(applies only to front of flush mount package)
Optional bulkhead, external mount
Optional NEMA Type 4X hubs

Certifications

UL & CUL Certified
CE Certified (24V versions only)

Electromagnetic Compatibility (EMC)

Testing per EC directive to obtain CE certification:
EC Directive 89/336/EEC;
EN 50081-2 (CENELEC): EMC - Generic Emission Standard, Part 2: Industrial Environment, Issue 2, 25 March 1994;
EN 50082-2 (CENELEC): EMC - Generic Immunity Standard, Part 2: Industrial Environment, Issue 2, 15 March 1995;

Humidity

Lloyd's type ENV2 Humidity test #1:

Two temperature cycles between 20 to 55 °C at 95% Relative humidity within 48 hours

Shock

MIL-STD-810C, Figure 516.2-1 procedure 1b
(30g 11ms Half Sine pulse)

Vibration

Lloyd's type ENV2 Vibration test #1
13-100 Hz @ 1.0 G Ten sweeps at one octave per minute

Insulation Resistance / HiPot

24V power supply: 707 Volts DC from power input to chassis
AC/DC and HVAC version: 2200 Volts DC from power input to chassis

Operating Temperature

-25°C to +65°C, still air, no external heat loads.
Passes Lloyd's type ENV3 Dry Heat test

Electronic Component Temperature Rating

-40°C to +85°C industrial grade components or better

Storage Temperature

-40 °C to +85 °C

Power Supply Specification

Power Inputs

1. Low Voltage DC
   a. 18-32VDC
      - input power fuse rating (F1 & F2) - 6.25A slow blow
2. AC/ DC
   a. 90-150VDC
   b. 88-132VAC, 47-63Hz
      - input power fuse rating (F1 & F2) - 2.5A slow blow
3. High Voltage AC
   a. 180-264VAC, 47-63Hz
      - input power fuse rating (F1 & F2) - 1.5A slow blow

Power Outputs

1. Three 5VDC communications port isolated power supplies (100 mA max.)
2. 5VDC digital power (2.5 Amp max.)
3. 24VDC analog power (1.275 Amp max.)
4. 15VDC analog power 150 mA max.)
5. -15VDC analog power (150 mA max.)
6. 24VDC isolated contact input power (100 mA max.)

General I/O Specifications

Analog Inputs

1. Six 4-20 mA inputs
   a. One isolated input.
   b. Five non-isolated differential inputs or may use 24V provided with single common.
2. 16 Bit resolution.
3. 200 ohm input impedance on all inputs.
4. Software calibrated to 0.1% initial error.
5. Temperature drift.
   a. Non-isolated inputs: 130ppm/°C worst case, 40ppm/°C RSS.
   b. Isolated input: 245ppm/°C worst case, 60ppm/°C RSS.

6. Accuracy
   a. Non-isolated input: 0.045% worst case over voltage, rate, and time.
   b. Isolated input: 0.086% worst case over voltage, range, and time.
7. Isolation
   a. Non-isolated input: 2M ohms to chassis.
   b. Isolated input: 22M 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.
3. Proximity input.
   a. Two isolated channels, independent channels.
   b. 16 - 28 VDC voltage range, at the input.
   c. 0.5 - 15000 Hz.
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 range, or 20-160 mA range.
2. Current readback on each channel, to detect over/under current.
3. Dither is software selectable.
4. 45 ohm maximum load on the 20-160 mA version.
5. 360 ohm maximum load on the 4-20 mA version.
6. Software calibrated to 0.1% initial error, 20-160 mA version; 1% for the 4-20 mA version. 4-20 mA version may be field calibrated for greater accuracy.
7. Temperature drift is 153ppm/°C worst case and 143ppm/°C RSS.
8. Accuracy is 0.04% worst case over voltage, range, and time.

Analog Outputs

1. Six software configurable 4-20 mA outputs.
2. 600 ohm maximum load.
3. Software calibrated to 0.1% initial error.
4. Temperature drift is 118ppm/°C worst case and 100ppm/°C RSS.
5. Accuracy is 0.025% worst case over voltage, range, and time.

Relay Outputs

1. Eight software configurable relay outputs
2. One set of form C contacts provided for each relay output.

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

UL Recognized Ratings

Rated Voltage	Resistive
28 Vdc	5 A
115 Vac	0.5 A

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 +24V power provided for discrete inputs.
3. 2.5 mA draw on each input when contact is closed.
4. 18 - 26Vdc external contact power may be used instead of the 505H's internal power supply.
5. Solid state relays may be used to drive any discrete input:
   a. 505H Discrete Input Thresholds: <8Vdc = "OFF", >16Vdc = "ON"
   b. 505H Discrete Input Impedance = 25k ohms, 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 4000 feet.

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 50 feet.

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.

Appendix F
Password Information

General

The 505H 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:

Password SERVICE

The password for your control is: 1 1 1 1

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

DEBUG MODE PASSWORD

When the display reads:

Password DEBUG

The password for your control is: 1 1 1 2

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

OS_FAULTS MODE PASSWORD

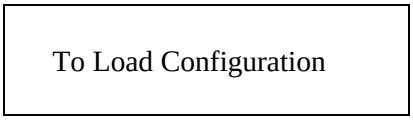
When the display reads:

The password for your control is: 1 1 1 4

Press the keys on the 505H front panel in this sequence to gain access to the OS_FAULTS mode.

DOWNLOAD CONFIGURATION FUNCTION PASSWORD

When the display reads:



Enter Password

The password for your control is: 1 1 1 6

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

Appendix G
505H Worksheets

505H PROGRAM MODE WORKSHEET SUMMARY

GOVERNOR SERIAL NUMBER_____DATE_____

APPLICATION_____

TURBINE CONFIGURATION

Manual Start_____Yes____ No____
Automatic Start_____Yes____ No____
Use Start Permissive_____Yes____ No____
Prestart Timeoutm_____Sec
Breakaway Gate Limit_____%
Breaker Open Gate Limit_____ %
Acceleration Rate_____%/Sec
Use Speed Window_____Yes____ No____
Low Speed Limit_____ %
High Speed Limit_____ %
Time In Window_____ Sec
Sync Enable Speed_____ %
Time Above Speed_____ Sec
Automatic Synchronizing____Yes____No____
Normal On_Line Operation_____
Breaker Closed Gate Limit_____ %
Shutdown Time Delay_____ Sec
Reset Clears Trip Output ____Yes____No____
Start / Stop Performed_____
Auto / Manual Performed_____
Governor Control Performed_____
Speed Units_____%____RPM____rpm____
Level Units_____ft___ M___
Power Units_____MW____ kW____

SPEED CONFIGURATION

Rated RPM_____RPM
Rated Frequency #1_____ Hz
Speed Input #1_____ZVPU____PT_____
Use Speed Input #2_____Yes____ No____
Rated Frequency #2_____ Hz
Speed Input #2_____ZVPU____PT_____
Speed Input SW Speed_____%
Overspeed Trip Speed_____
Small System Kp_____
Small System Ki_____ 1/Sec
Small System Kd_____Sec
Small System Droop_____%
Use Dual Dynamics_____Yes____ No____
Large System Kp_____
Large System Ki_____1/Sec
Large System Kd_____Sec
Large System Droop_____%
Use Feed Forward_____Yes____ No____
Feed Forward Gain_____

SPEED REFERENCE SETUP

Minimum Speed Setpoint_____%
Maximum Speed Setpoint_____ %
Acceleration Rate_____%/Sec
Unloading Setpoint_____ %
Unloading Rate_____%/Sec
Speed Set Rate_____ /Sec
Use External SignalYes____ No____
  Power-Up Use External__Yes____ No____
  Use Soft-Load_____Yes____ No____
  Soft-Load Rate_____ %/Sec
Use Isochronous Reference_Yes____ No____
  Power-Up Use Reference_Yes____ No____
Use Loadsharing Reference_Yes____ No____
  Power-Up Use Reference__Yes____ No____
  Speed Window_____%

POSITION REFERENCE SETUP

Unloading Setpoint_____%
Unloading Rate_____%/Sec
Gate Set Rate_____ %/Sec
Use External Signal_____Yes____ No____
  Power-Up Use External___Yes____ No____
  Use Soft-Load_____Yes____ No____
  Soft-Load Rate_____ %/Sec
Use Level Reference_____Yes____ No____
  Controlled Level_____HW____ TW___
  Power-Up Use Reference___Yes____ No____
  Minimum Level Setpoint_____ft or m
  Maximum Level Setpoint_____ft or m
  Window Size_____ft or m
  Minimum Gate Setpoint_____ %
  Maximum Gate Setpoint_____ %
  Level Setpoint Rate_____ ft or m/Sec
  Use External Signal_____Yes____ No____
    Power-Up Use External__Yes____ No____
    Use On Ext Signal Fail___Yes____ No____
    Use Soft-Load_____Yes____ No____
    Soft-Load Rate_____ %/Sec
Use Power Reference_____Yes____ No____
  Power-Up Use Reference___Yes____ No____
  Minimum Power Setpoint_____kW or MW
  Maximum Power Setpoint_____kW or MW
  Power Setpoint Rate_____kW or MW/Sec
  Use External Signal_____Yes____ No____
    Power-Up Use External __Yes____ No____
    Use On Ext Signal Fail___Yes____ No____
    Use Soft-Load_____Yes____ No____
    Soft-Load Rate_____kW or MW/Sec
  Power At 0% Gate_____kW or MW
  Power At 10% Gate_____kW or MW
  Power At 20% Gate_____kW or MW
  Power At 30% Gate_____kW or MW
  Power At 40% Gate_____kW or MW
  Power At 50% Gate_____kW or MW

Power At 60% Gate_____kW or MW
Power At 70% Gate_____kW or MW
Power At 80% Gate_____kW or MW
Power At 90% Gate_____kW or MW

GATE LIMIT SETUP
Breakaway Gate Limit_____ %
Breaker Open Gate Limit_____%
Breaker Closed Gate Limit_____%
Gate Limit Rate_____%/Sec

GATE CONTROL SETUP
Gate Actuator Driver_____
Gate Actuator Driver_____
Gate Actuator Driver _____
Remove mA on Unit Stop __Yes____ No____
Shutdown On Gate Fail___Yes____ No____
Manual Set Rate_____%/Sec
Use External Signal_____Yes____ No____
Power-Up Use External__Yes____ No____
UseSoft-Load_____Yes_____ No____
Soft-Load Rate_____%/Sec

BLADE CONTROL SETUP
Use Blade Driver_____Yes____ No____
Net Head Determined By _HW/TW__ NH__
Num Of Net Head Curves_____ Units
Use External Blade Tilt__Yes____ No____
Blade Tilt Position_____Yes____ No____
Use Breakaway Blade Tilt_Yes____ No____
Shutdown On Blade Fail__Yes____ No____
Blade Tilt Position_____%
Blade Actuator Driver_____
Blade Actuator Driver_____
Blade Actuator Driver_____
Remove mA on Unit Stop _Yes____ No____
Shutdown on Blade Fail _Yes____ No____
Use Manual Reference___Yes____ No____
Manual Set Rate_____ %/Sec
Use External Signal_____Yes____ No____
Use on Ext. Signal Fail_Yes____ No____
Use Soft-Load_____Yes____ No____
Soft-Load Rate_____ %/Sec

AUXILIARY FUNCTIONS
Use Brakes_____Yes____ No____
Pulse Enable Speed_____ %
Pulse On Time_____ Sec
Pulse Off Time_____ Sec
Hold Enable Speed_____ %
Enable On Unit Creep___Yes____ No____
Time After Creep_____Sec
On After Deadstop(s)_____Sec
Hold While Shutdown? __Yes____ No____
Use Creep Detection_____Yes____ No____
Creep Rearm Time_____ Sec

Creep Reset Time_____ Sec
Use Small System Detection__Yes____ No____
Use Both Conditions?___Yes____ No____
Speed Signal Window_____ %
Speed Derivative Window_____ %/Sec
Use Speed 1 Deadband?__Yes____ No____
Use Speed 2 Deadband?__Yes____ No____

ANALOG INPUTS

Gate Position 4 mA Value_____ %
Gate Position 20 mA Value_____ %
Use Analog Input 2_____Yes____ No____
Analog Input 2 Is_____
Analog In 2 4 mA Value_____
Analog In 2 20 mA Value_____
Use Analog Input 3_____Yes____ No____
Analog Input 3 Is_____
Analog In 3 4 mA Value_____
Analog In 3 20 mA Value_____
Use Analog Input 4_____Yes____ No____
Analog Input 4 Is_____
Analog In 4 4 mA Value_____
Analog In 4 20 mA Value_____
Use Analog Input 5_____Yes____ No____
Analog Input 5 Is_____
Analog In 5 4 mA Value_____
Analog In 5 20 mA Value_____
Use Analog Input 6_____Yes____ No____
Analog Input 6 Is_____
Analog In 6 4 mA Value_____
Analog In 6 20 mA Value_____

CONTACT INPUTS

Use Contact Input 1_____Yes____ No____
Contact Input 1 Is_____
Use Contact Input 2 _____Yes____ No____
Contact Input 2 Is_____
Use Contact Input 3 _____Yes____ No____
Contact Input 3 Is_____
Use Contact Input 4 _____Yes____ No____
Contact Input 4 Is_____
Use Contact Input 5 _____Yes____ No____
Contact Input 5 Is_____
Use Contact Input 6 _____Yes____ No____
Contact Input 6 Is_____
Use Contact Input 7 _____Yes____ No____
Contact Input 7 Is_____
Use Contact Input 8 _____Yes____ No____
Contact Input 8 Is _____
Use Contact Input 9 _____Yes____ No____
Contact Input 9 Is_____
Use Contact Input 10_____Yes____ No____
Contact Input 10 Is_____
Use Contact Input 11_____Yes____ No____
Contact Input 11 Is_____
Use Contact Input 12 _____Yes____ No____
Contact Input 12 Is_____

ANALOG READOUTS

Use Analog Readout 1 ___Yes____ No____
Analog Readout 1 Is_____
Readout 1 4 mA Value_____
Readout 1 20 mA Value_____
Use Analog Readout 2___Yes____ No____
Analog Readout 2 Is_____
Readout 2 4 mA Value_____
Readout 2 20 mA Value_____
Use Analog Readout 3___Yes____ No____
Analog Readout 3 Is_____
Readout 3 4 mA Value_____
Readout 3 20 mA Value_____
Use Analog Readout 4___Yes____ No____
Analog Readout 4 Is_____
Readout 4 4 mA Value_____
Readout 4 20 mA Value_____
Use Analog Readout 5___Yes____ No____
Analog Readout 5 Is_____
Readout 5 4 mA Value_____
Readout 5 20 mA Value_____
Use Analog Readout 6__Yes____ No____
Analog Readout 6 Is_____
Readout 6 4 mA Value_____
Readout 6 20 mA Value_____

RELAY OUTPUTS

Use Relay Output 1____Yes____ No____
Use Relay 1 As Level Sw_Yes____ No____
Relay 1 Is_____
Relay 1 LO Level_____
Relay 1 HI Level_____
Relay 1 Energizes_Above___Below___
Relay 1 Energizes On_____
Use Relay Output 2____Yes____ No____
Use Relay 2 As Level Sw_Yes____ No____
Relay 2 Is_____
Relay 2 LO Level_____
Relay 2 HI Level_____
Relay 2 Energizes_Above___Below___
Relay 2 Energizes On_____
Use Relay Output 3___Yes____ No____
Use Relay 3 As Level Sw_Yes____ No____
Relay 3 Is_____
Relay 3 LO Level_____
Relay 3 HI Level_____
Relay 3 Energizes_Above___Below___
Relay 3 Energizes On _____
Use Relay Output 4___Yes____ No____
Use Relay 4 As Level SwYes____ No____
Relay 4 Is_____
Relay 4 LO Level_____
Relay 4 HI Level_____
Relay 4 Energizes_Above___Below___
Relay 4 Energizes On_____

Use Relay Output 5___Yes____ No____
  Use Relay 5 As Level Sw_Yes____ No____
    Relay 5 Is_____
    Relay 5 LO Level_____
    Relay 5 HI Level_____
    Relay 5 Energize_Above___Below___
  Relay 5 Energizes On_____
Use Relay Output 6___Yes____ No____
  Use Relay 6 As Level Sw_Yes____ No____
    Relay 6 Is_____
    Relay 6 LO Level_____
    Relay 6 HI Level_____
    Relay 6 Energizes_Above___Below___
  Relay 6 Energizes On_____

MODBUS COMMUNICATIONS

Use Modbus Port 1___Yes____ No____
Use Modbus Port 2___Yes____ No____
Speed Scaling Factor_____
Level Scaling Factor_____
Power Scaling Factor_____

505H SERVICE MODE WORKSHEET SUMMARY
GOVERNOR SERIAL NUMBER_____DATE_____
APPLICATION_____

TURBINE SETUP
Breakaway Gate Limit_____ %
Breaker Open Gate Limit_____ %
Acceleration Rate _____ %/Sec
Breaker Closed Gate Limit_____ %
Shutdown Time Delay _____ Sec

SPEED SENSOR SETUP
Fail Time #1_____ Sec
(IF TWO SPEED INPUTS)
Fail Time #2_____ Sec
Shutdown Spd Ovrd SP_____%

SPEED SETUP
Small System Kp _____
Small System Ki _____1/Sec
Small System Kd _____Sec
Small System Droop_____%
(IF DUAL DYNAMICS)
Large System Kp _____
Large System Ki _____1/Sec
Large System Kd _____Sec
Large System Droop _____ %
(IF FEED FORWARD)
Fdforward Gain _____

SPEED REFERENCE SETUP
Speed Setpoint Rate _____ %/Sec
Unloading Setpoint_____%
Unloading Rate_____%/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate _____ %/Sec

GATE reference SETUP
Gate Setpoint Rate _____ %/Sec
Unloading Setpoint_____%
Unloading Rate_____%/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate _____ %/Sec

LEVEL REFERENCE SETUP (IF CONFIGURED)
Window Size _____
Level Setpoint Rate_____ft or m/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate _____ 1/Sec

POWER REFERENCE SETUP (if configured)
Power Setpoint Rate_____or MW/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate_____kW or MW/Sec

GATE LIMIT SETUP
Breakaway Gate Limit_____ %
Breaker Open Gate Limit_____ %
Breaker Closed Gate Limit_____ %
Gate Limit Rate _____ %/Sec

GATE MANUAL SETUP
Gate Manual Rate_____ %/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate _____%/Sec

GATE DRIVER SETUP
Gate Dvr Dither _____%
(IF INTEGRATING OUTPUT)
Gate Dvr P Gain _____

BLADE MANUAL SETUP (IF CONFIGURED)
Blade Man Rate_____ %/Sec
(IF EXTERNAL SIGNAL)
Use Soft-Load?_____Yes____ No____
Soft-Load Rate _____%/Sec

BLADE DRIVER SETUP (if configured)
Blade Driver Dither _____ %
(IF INTEGRATING OUTPUT)
Blade Driver P Gain =_____

BLADE - NET HEAD VALUES (if configured)
(based on number of net head curves)
Net Head # 1>_____ft or m
Net Head # 2>_____ft or m
Net Head # 3>_____ft or m
Net Head # 4>_____ft or m
Net Head # 5>_____ft or m
Net Head # 6>_____ft or m
Net Head # 7>_____ft or m
Net Head # 8>_____ft or m
Net Head # 9>_____ft or m
Net Head #10>_____ft or m
Net Head #11>_____ft or m

BLADE CURVE #1 (if configured)
(number of net head curves = 1)
NH# 1 : GP= 0> _____%
NH# 1 : GP= 10_____%
NH# 1 : GP= 20>_____%
NH# 1 : GP= 30>_____%
NH# 1 : GP= 40>_____%
NH# 1 : GP= 50>_____%
NH# 1 : GP= 60>_____%
NH# 1 : GP= 70>_____%
NH# 1 : GP= 80>_____%
NH# 1 : GP= 90>_____%
NH# 1 : GP=100> _____%

BLADE CURVE #2 (if configured)
(number of net head curves > = 2)
NH# 2 : GP= 0> _____%
NH# 2 : GP= 10>_____%
NH# 2 : GP= 20>_____%
NH# 2 : GP= 30>_____%
NH# 2 : GP= 40>_____%
NH# 2 : GP= 50>_____%
NH# 2 : GP= 60>_____%
NH# 2 : GP= 70>_____%
NH# 2 : GP= 80>_____%
NH# 2 : GP= 90>_____%
NH# 2 : GP=100> _____%

BLADE CURVE #3 (if configured)
(number of net head curves > = 3)
NH# 3 : GP= 0> _____%
NH# 3 : GP= 10>_____%
NH# 3 : GP= 20>_____%
NH# 3 : GP= 30>_____%
NH# 3 : GP= 40>_____%
NH# 3 : GP= 50>_____%
NH# 3 : GP= 60>_____%
NH# 3 : GP= 70>_____%
NH# 3 : GP= 80>_____%
NH# 3 : GP= 90>_____%
NH# 3 : GP=100> _____%

BLADE CURVE #4 (if configured)
(number of net head curves > = 4)
NH# 4 : GP= 0> _____%
NH# 4 : GP= 10>_____%
NH# 4 : GP= 20>_____%
NH# 4 : GP= 30>_____%
NH# 4 : GP= 40>_____%
NH# 4 : GP= 50>_____%
NH# 4 : GP= 60>_____%
NH# 4 : GP= 70>_____%
NH# 4 : GP= 80>_____%
NH# 4 : GP= 90>_____%
NH# 4 : GP=100> _____%

BLADE CURVE #5 (if configured)
(number of net head curves > = 5)
NH# 5 : GP= 0>_____ %
NH# 5 : GP= 10> _____ %
NH# 5 : GP= 20> _____ %
NH# 5 : GP= 30> _____ %
NH# 5 : GP= 40> _____ %
NH# 5 : GP= 50> _____ %
NH# 5 : GP= 60> _____ %
NH# 5 : GP= 70> _____ %
NH# 5 : GP= 80> _____ %
NH# 5 : GP= 90> _____ %
NH# 5 : GP=100>_____ %

BLADE CURVE #6 (if configured)
(number of net head curves > = 6)
NH# 6 : GP= 0>_____ %
NH# 6 : GP= 10> _____ %
NH# 6 : GP= 20> _____ %
NH# 6 : GP= 30> _____ %
NH# 6 : GP= 40> _____ %
NH# 6 : GP= 50> _____ %
NH# 6 : GP= 60> _____ %
NH# 6 : GP= 70> _____ %
NH# 6 : GP= 80> _____ %
NH# 6 : GP= 90> _____ %
NH# 6 : GP=100>_____ %

BLADE CURVE #7 (if configured)
(number of net head curves > = 7)
NH# 7 : GP= 0>_____ %
NH# 7 : GP= 10> _____ %
NH# 7 : GP= 20> _____ %
NH# 7 : GP= 30> _____ %
NH# 7 : GP= 40> _____ %
NH# 7 : GP= 50> _____ %
NH# 7 : GP= 60> _____ %
NH# 7 : GP= 70> _____ %
NH# 7 : GP= 80> _____ %
NH# 7 : GP= 90> _____ %
NH# 7 : GP=100>_____ %

BLADE CURVE #8 (if configured)
(number of net head curves > = 8)
NH# 8 : GP= 0>_____ %
NH# 8 : GP= 10> _____ %
NH# 8 : GP= 20> _____ %
NH# 8 : GP= 30> _____ %
NH# 8 : GP= 40> _____ %
NH# 8 : GP= 50> _____ %
NH# 8 : GP= 60> _____ %
NH# 8 : GP= 70> _____ %
NH# 8 : GP= 80>_____ %
NH# 8 : GP= 90>_____ %
NH# 8 : GP=100>_____ %

BLADE CURVE #9 (if configured)
(number of net head curves > = 9)
NH# 9 : GP= 0>_____ %
NH# 9 : GP= 10>_____ %
NH# 9 : GP= 20>_____ %
NH# 9 : GP= 30>_____ %
NH# 9 : GP= 40>_____ %
NH# 9 : GP= 50>_____ %
NH# 9 : GP= 60>_____ %
NH# 9 : GP= 70>_____ %
NH# 9 : GP= 80>_____ %
NH# 9 : GP= 90>_____ %
NH# 9 : GP=100>_____ %

BLADE CURVE #10 (if configured)
(number of net head curves > = 10)
NH#10 : GP= 0>_____ %
NH#10 : GP= 10>_____ %
NH#10 : GP= 20>_____ %
NH#10 : GP= 30>_____ %
NH#10 : GP= 40>_____ %
NH#10 : GP= 50>_____ %
NH#10 : GP= 60>_____ %
NH#10 : GP= 70>_____ %
NH#10 : GP= 80>_____ %
NH#10 : GP= 90>_____ %
NH#10 : GP=100>_____ %

BLADE CURVE #11 (if configured)
(number of net head curves = 11)
NH#11 : GP= 0>_____ %
NH#11 : GP= 10>_____ %
NH#11 : GP= 20>_____ %
NH#11 : GP= 30>_____ %
NH#11 : GP= 40>_____ %
NH#11 : GP= 50>_____ %
NH#11 : GP= 60>_____ %
NH#11 : GP= 70>_____ %
NH#11 : GP= 80>_____ %
NH#11 : GP= 90>_____ %
NH#11 : GP=100>_____ %

BRAKE SETUP (if configured)
Pulse Enable Speed_____%
Pulse On Time_____ Sec
Pulse Off Time_____ Sec
Hold Enbl Speed_____%
Enbl On Creep?_____Yes____ No____
Creep On Time_____ Sec
Enable On Deadstop_____Yes____ No____

CREEP DETECTION SETUP (if configured)
Rearm Time _____ Sec
Reset Time _____ Sec

SMALL SYSTEM DETECTION (if configured)
Speed Signal Window _____ %
Speed Signal Window _____ %/Sec

SPEED #1 DEADBAND
Neg. Deadband_____%
Pos. Deadband_____%

SPEED #2 DEADBAND
Neg. Deadband_____%
Pos. Deadband_____%

ADJUST ANALOG INPUTS
Input #1 Offset _____mA
Input #1 Gain _____
Input #2 Offset _____mA
Input #2 Gain _____
Input #3 Offset _____mA
Input #3 Gain _____
Input #4 Offset _____mA
Input #4 Gain _____
Input #5 Offset _____mA
Input #5 Gain _____
Input #6 Offset _____mA
Input #6 Gain _____

ADJUST ANALOG OUTPUTS
Out #1 Offset _____mA
Out #1 Gain _____
Out #2 Offset_____mA
Out #2 Gain _____
Out #3 Offset _____mA
Out #3 Gain _____
Out #4 Offset _____mA
Out #4 Gain _____
Out #5 Offset _____mA
Out #5 Gain _____
Out #6 Offset _____mA
Out #6 Gain_____

ADJUST GATE DRIVER
Gate Offset _____%
(IF PROPORTIONAL OUTPUT)
Gate Gain _____

ADJUST BLADE DRIVER (IF CONFIGURED)
Blade Offset _____%
(IF PROPORTIONAL OUTPUT)
Blade Gain _____ Units

SPEED SETPOINT T.C. (if configured)
Speed Set Time Constant_____Sec

FOREBAY LEVEL T.C. (if configured)
Forebay Time Constant_____ Sec

TAILBAY LEVEL T.C. (if configured)
Tailbay Time constant_____ Sec

LEVEL SETPOINT T.C (if configured)
Level Set Time Constant_____ Sec

POWER LEVEL T.C (if configured)
Power Lvl Time Constant_____ Sec

POWER SETPOINT T.C (if configured)
Power Set Time Constant_____ Sec

LOADSHARING T.C. (IF CONFIGURED)
Loadsharing Time Constant_____ Sec

GATE SETPOINT T.C (if configured)
Gate Set Time Constant_____ Sec

NET HEAD LEVEL T.C. (if configured)
Net Head Time Constant_____ Sec

GATE MANUAL SET T.C. (if configured)
Gate Man Time Constant_____ Sec

BLADE MANUAL SET T.C. (if configured)
Blade Man Time Constant_____ Sec

COMMUNICATION SETUP
ModBus Port 1 Setup
- Baud_____
- Stop Bits_____
- Parity _____
- Driver_____
- Communications Mode _____
- Modbus Device Number _____
- Timeout Delay _____ Sec

Modbus Port 2 Setup
- Baud_____
- Stop Bits_____
- Parity _____
- Driver_____
- Communications Mode _____
- Modbus Device Number _____
- Timeout Delay _____ Sec

PC Port Setup
- Baud_____
- Bits/Character_____
- Stop Bits_____
- Parity _____
- Read Mode_____
- Flow _____
- Echo _____
- End of Line_____
- Ignore CR_____

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