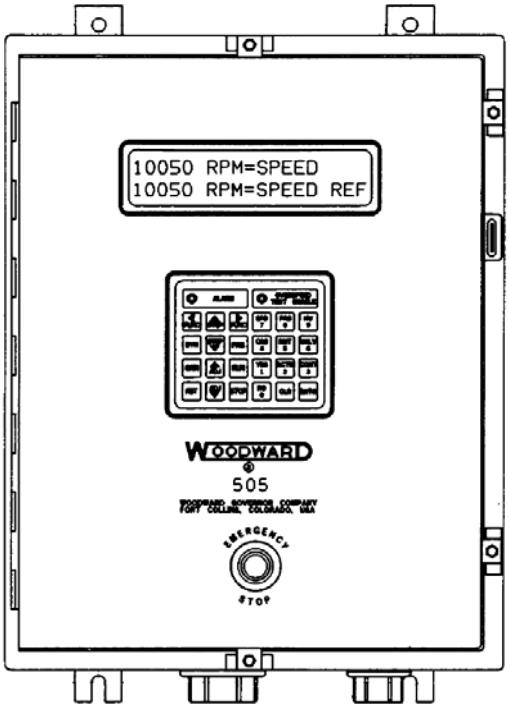
WOODWARD

Product Manual 85003
(Revision A)
Original Instructions



505 Digital Governor for Steam Turbines with Single Actuators

8238-001, 8238-003, 8238-004

Installation and Operation Manual

General Precautions

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

Practice all plant and safety instructions and precautions.

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

Revisions

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

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Proper Use

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

Translated Publications

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

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 Out-of-date translations are marked with ⚠.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

Contents

Illustrations and Tables

Warnings and Notices

Important Definitions

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

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

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

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

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

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

⚠WARNING

Automotive Applications

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

NOTICE

Battery Charging Device

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

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Chapter 1.
Installation Procedures

Mechanical Data and Hardware Installation

Packaging

Figure 1-1 shows 505 control layout. All 505 control components are contained in a single, NEMA Type 4 steel enclosure. The standard enclosure (Figure 1-1a) can be bulkhead-mounted. An optional enclosure is designed to be flush-mounted (Figure 1-1b). Access to internal components is through a left-hand-hinged door which is held closed by four screw-in clamps. A latch permits the door to be locked. The size of the enclosure allows the control to accommodate an internal heat rise of 20 °C. It also allows the enclosure to accommodate a large number of input and output connections (over a hundred wiring connections are available if all optional connections are made).

The enclosure has two openings in the bottom for wiring access. One hole is approximately 25 mm diameter, and the other is approximately 38 mm diameter. The holes are factory-fitted with English standard conduit hubs (1 inch and 1.5 inches), which can be replaced if necessary by metric standard conduit hubs. The hubs accept threaded conduit.

All internal components are industrial grade. The components include the CPU (central processing unit), its memory, the switching power supply, all relays, all input/output circuitry, all communications circuitry for the front door display and touch keypad, and the remote RS-232 communications.

A separate load sensor enclosure (if needed) houses the potential and current transformers and associated circuits.

Mounting

The standard 505 enclosure must be vertically mounted on a wall or post, allowing sufficient room for lid opening and wiring access. Four welded flanges, two on top and two on bottom, permit secure mounting. An optional enclosure permits the control to be flush-mounted (see Figure 1-1b for cut-out dimensions).

Electrical Connections

All electrical connections must be made through the two openings in the bottom of the enclosure to the terminal blocks inside the enclosure. See Figure 1-2 for the general plant wiring diagram.

Environmental Data

The 505 has been designed to operate in a wide range of environmental conditions, including outdoor operation.

Temperature

The control operates over a temperature range of –25 to +65 °C (–13 to +149 °F). Control components have a temperature range of –40 °C to +85 °C. When the enclosure is sealed, the components can withstand a 20 °C temperature rise within the enclosure without any detrimental effects.

Humidity

The exterior of the enclosure is tested to withstand a humidity specified in US MIL-STD-810D, method 507.2, procedure II, induced, non-hazardous, cycle 5. This test includes fifteen 24-hour cycles varying the relative humidity from 75 percent to 19 percent over a temperature range of +63 to +33 °C.

Water Leakage

The control is designed to withstand a water leakage conforming to US MIL-STD-108E, spray tight, table III, submergence option, which includes submerging the control just below the surface for five minutes.

Salt Fog

The control is designed to withstand a salt-fog test conforming to US MIL-STD-8100, method 509.2, including a 48-hour exposure to a 5% salt solution.

Shock and Vibration

The control is designed to withstand a shock test as defined in US MIL-STD-810D, method 516.3, procedure 1, functional shock, which includes a 40 G shock with frequency components from 45 to 2000 Hz for a duration of 6 to 9 ms. The vibration testing conforms to US MIL-STD-167, type 1, which includes a two-hour dwell at resonance in each axis with a frequency sweep from 4 Hz to 50 Hz and a maximum acceleration not exceeding 1.3 G.

Accelerated Life and Temperature

The control is designed to withstand a 500-hour accelerated life and temperature test. From 0 to 50 hours, the control environment is +25 °C in ambient room humidity. From hours 50 to 100, temperature is reduced to –25 °C with 10 percent or less humidity. From hours 100 to 400, temperature is +65 °C with 95 percent humidity. In the final 100 hours, the temperature returns to +25 °C with ambient room humidity.

Electromagnetic Interference (EMI)

The control is designed to conform to US MIL-STD-461, Part 5, for electromagnetic interference (EMI):

Conducted Emissions: ac power leads, control and signal leads
- CE01 (100 Hz to 15 kHz) ac current
- CE03 (15 kHz to 50 kHz) ac current

Radiated Emissions: entire system and external wiring
- RE02 (14 kHz to 1 GHz) electric field

Conducted Susceptibility: ac power leads
- CS0l (30 Hz to 50 kHz) ac current
- CS02 (50 kHz to 400 MHz) ac current

Radiated Susceptibility: entire system and external wiring
- RS01 (30 Hz to 30 kHz) magnetic field
- RS02 (60 Hz) magnetic field
- RS03 (14 kHz to 1 GHz) electric field–1 V/m

The control also meets US MIL-STD-461 B, Part 9.

Conducted Emissions: ac power leads—A line filter such as a Corcom 3SP1A must be installed on the ac power leads.
- UM04 (15 kHz to 50 MHz) ac current

Radiated Emissions: entire system and external wiring—All external control wiring must be contained within a grounded conduit.
- UM04 (14 kHz to 1 GHz) electric field

Radiated Susceptibility: entire system and external wiring.
- UM04 (2 MHz to 400 MHz) electric field—10 V/m; (400 MHz to 10 GHz) electric field—5 V/m

CONVERSION CHART	
MM	INCH
4.8	.188
11.1	.438
15.9	.625
68.3	2.688
76.2	3.000
106.4	4.188
177.8	7.000
258.9	10.194
254.0	10.000
304.8	12.000
406.4	16.000
539.8	21.250
571.5	22.500

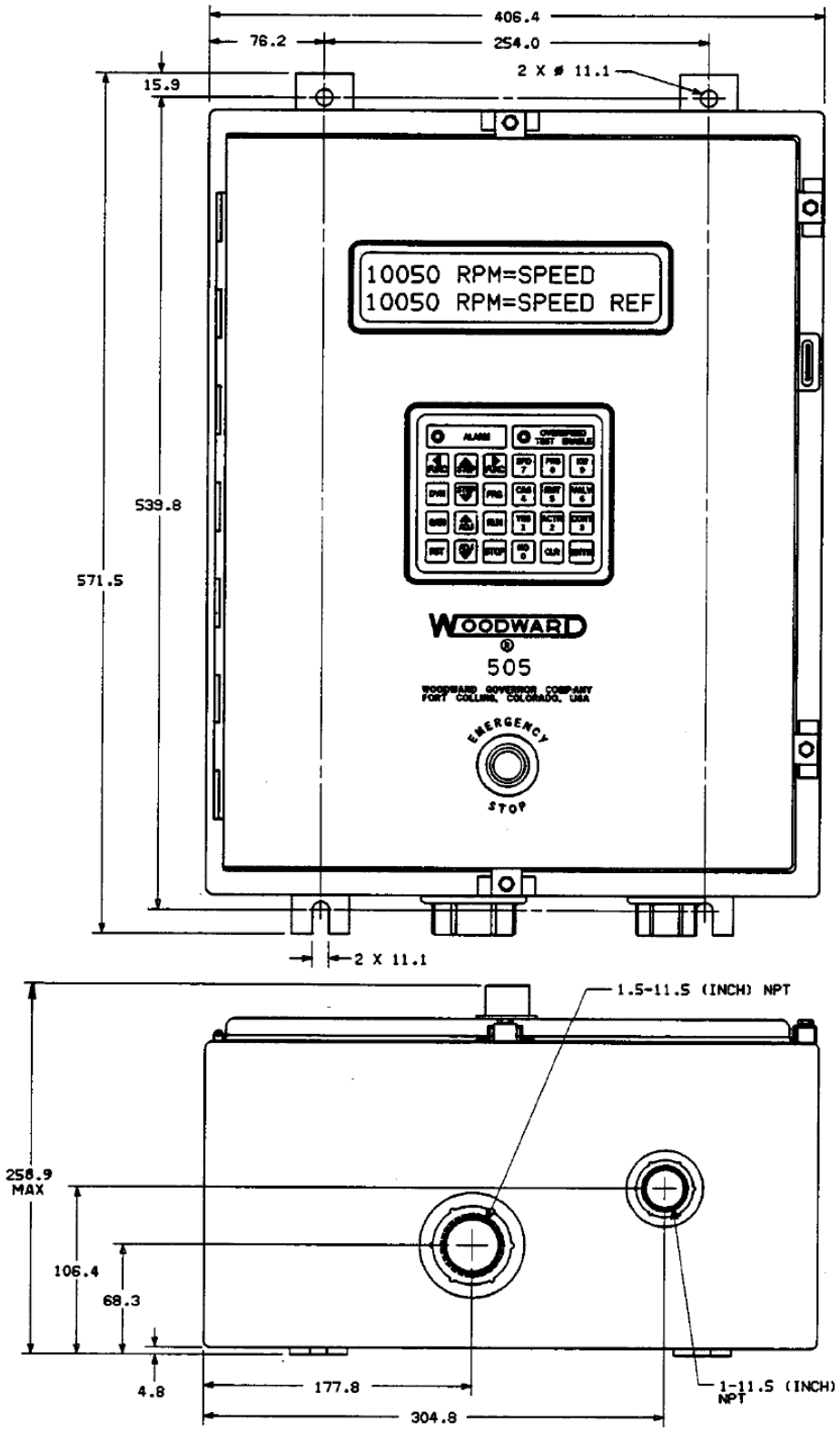
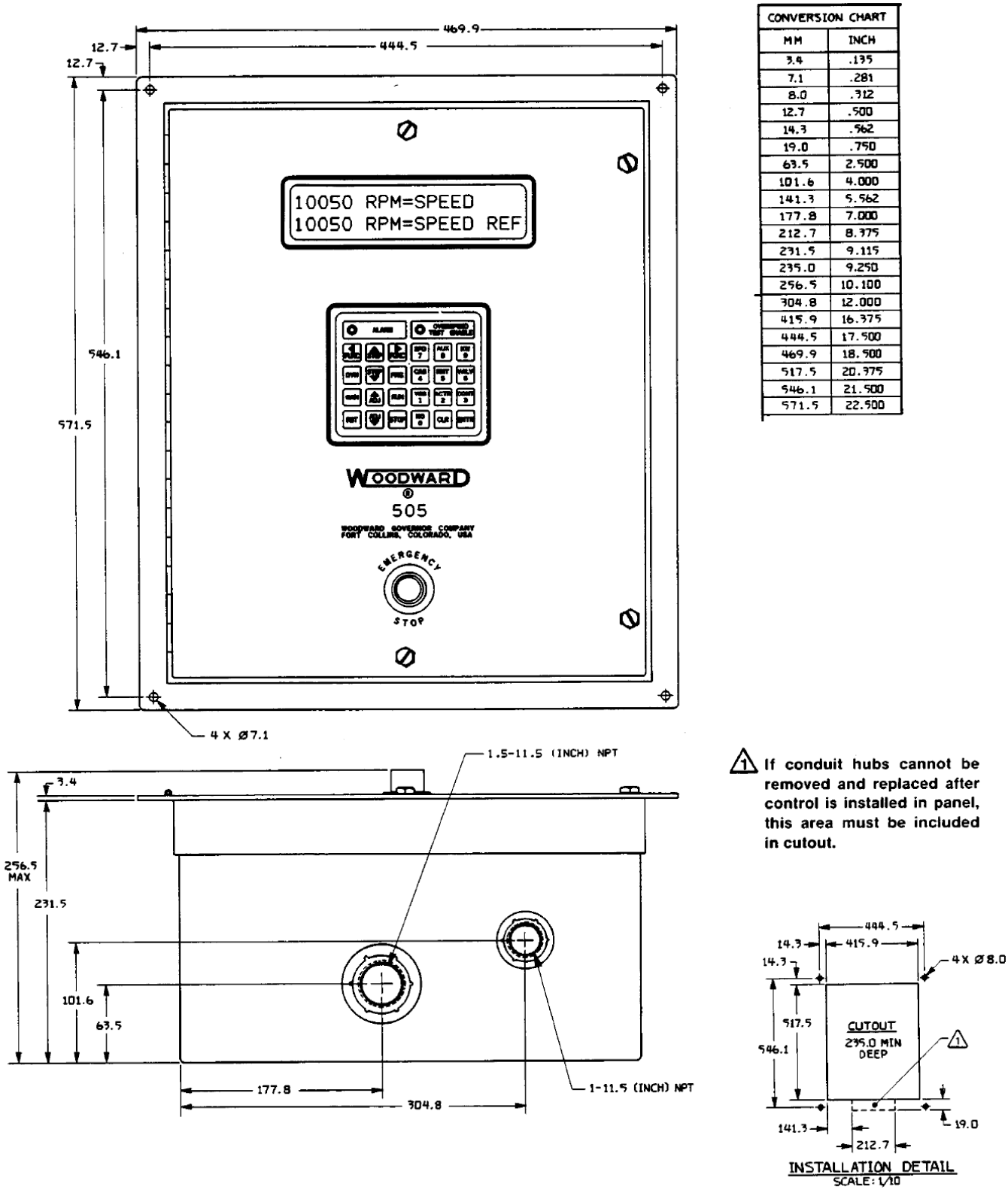
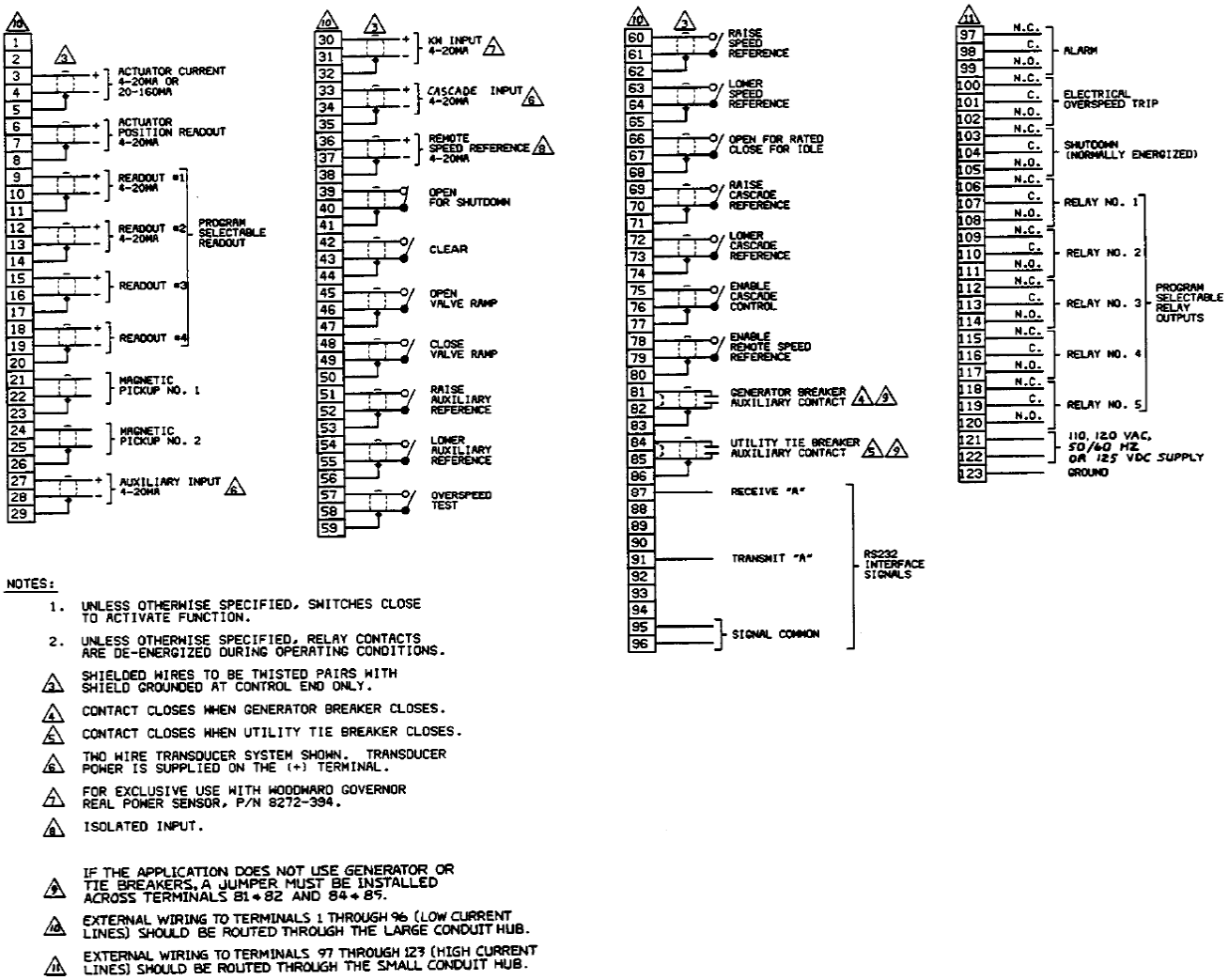


Figure 1-1a. 505 Control Layout (standard enclosure)



CONVERSION CHART	
MM	INCH
3.4	.135
7.1	.281
8.0	.312
12.7	.500
14.3	.562
19.0	.750
63.5	2.500
101.6	4.000
141.3	5.562
177.8	7.000
212.7	8.375
231.5	9.115
235.0	9.250
256.5	10.100
304.8	12.000
415.9	16.375
444.5	17.500
469.9	18.500
517.5	20.375
546.1	21.500
571.5	22.500

Figure 1-1b. 505 Control Layout (flush-mounted enclosure)



NOTES:

1. UNLESS OTHERWISE SPECIFIED, SWITCHES CLOSE TO ACTIVATE FUNCTION.
2. UNLESS OTHERWISE SPECIFIED, RELAY CONTACTS ARE DE-ENERGIZED DURING OPERATING CONDITIONS.
3. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT CONTROL END ONLY.
4. CONTACT CLOSES WHEN GENERATOR BREAKER CLOSES.
5. CONTACT CLOSES WHEN UTILITY TIE BREAKER CLOSES.
6. TWO WIRE TRANSDUCER SYSTEM SHOWN. TRANSDUCER POWER IS SUPPLIED ON THE (+) TERMINAL.
7. FOR EXCLUSIVE USE WITH WOODWARD GOVERNOR REAL POWER SENSOR, P/N 8272-394.
8. ISOLATED INPUT.
9. IF THE APPLICATION DOES NOT USE GENERATOR OR TIE BREAKERS, A JUMPER MUST BE INSTALLED ACROSS TERMINALS 81 & 82 AND 84 & 85.
10. EXTERNAL WIRING TO TERMINALS 1 THROUGH 96 (LOW CURRENT LINES) SHOULD BE ROUTED THROUGH THE LARGE CONDUIT HUB.
11. EXTERNAL WIRING TO TERMINALS 97 THROUGH 123 (HIGH CURRENT LINES) SHOULD BE ROUTED THROUGH THE SMALL CONDUIT HUB.

Figure 1-2. Plant Wiring Diagram

Chapter 2. Description

General Description

The 505 Digital Governor is a microprocessor-based control designed to control single-actuator steam turbines of all sizes. A microprocessor-based digital control provides you with considerable flexibility in configuring the governor to your specific control requirements. This field configurability allows a single part number to be used in many different control applications, and it reduces both cost and delivery time.

The 505 control has two operating modes. Using the Program Mode, you select the options needed to match the control to your turbine application. Once the control has been programmed, you will never again need to use the Program Mode, unless turbine options change. You then select Run Mode to operate the turbine from start-up through shutdown.

The 505 functions are shown in a simplified block diagram in Figure 2-1 and in more detail in Figure 2-2. Use this block diagram to configure the control to match your application.

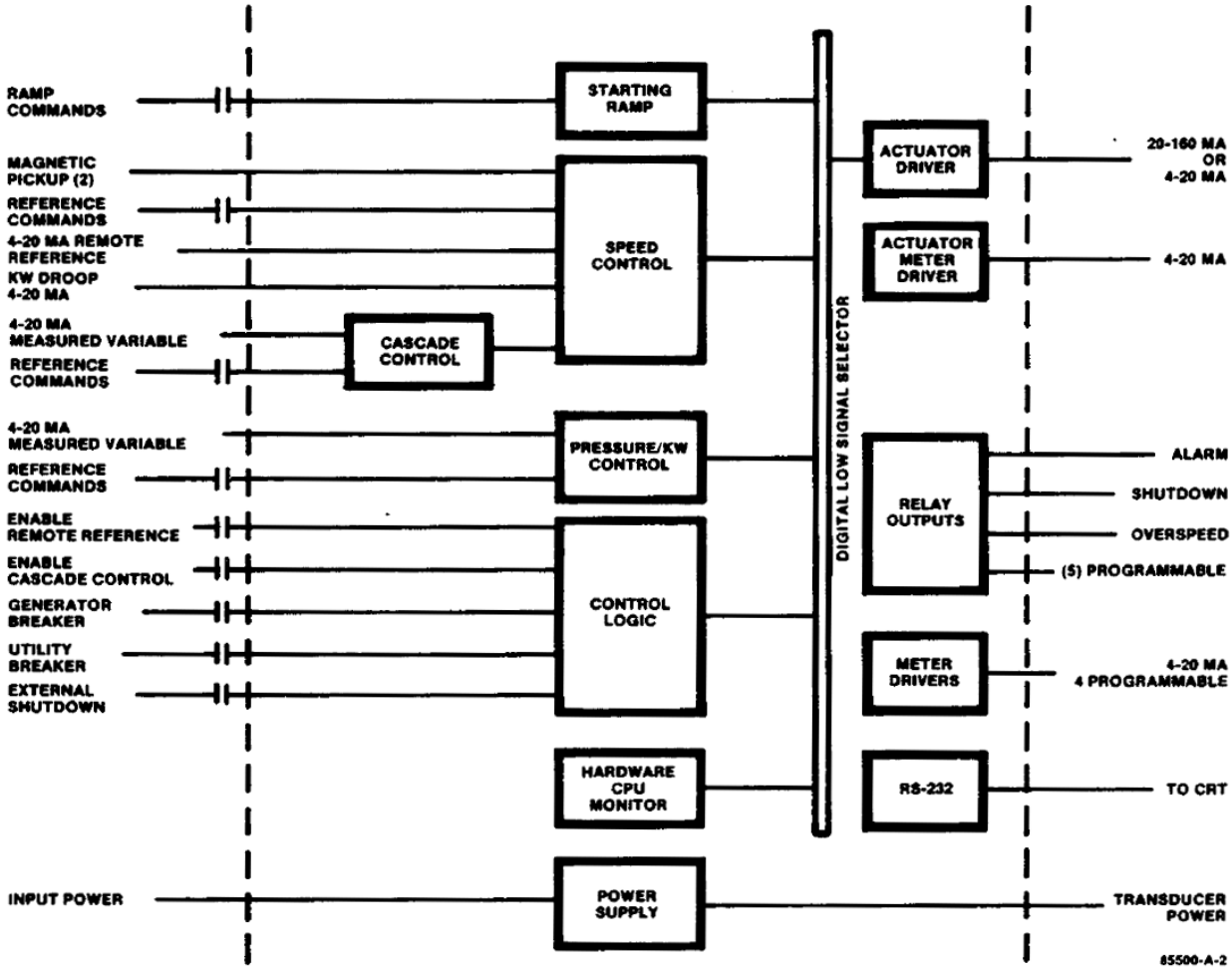


Figure 2-1. Simplified 505 Block Diagram

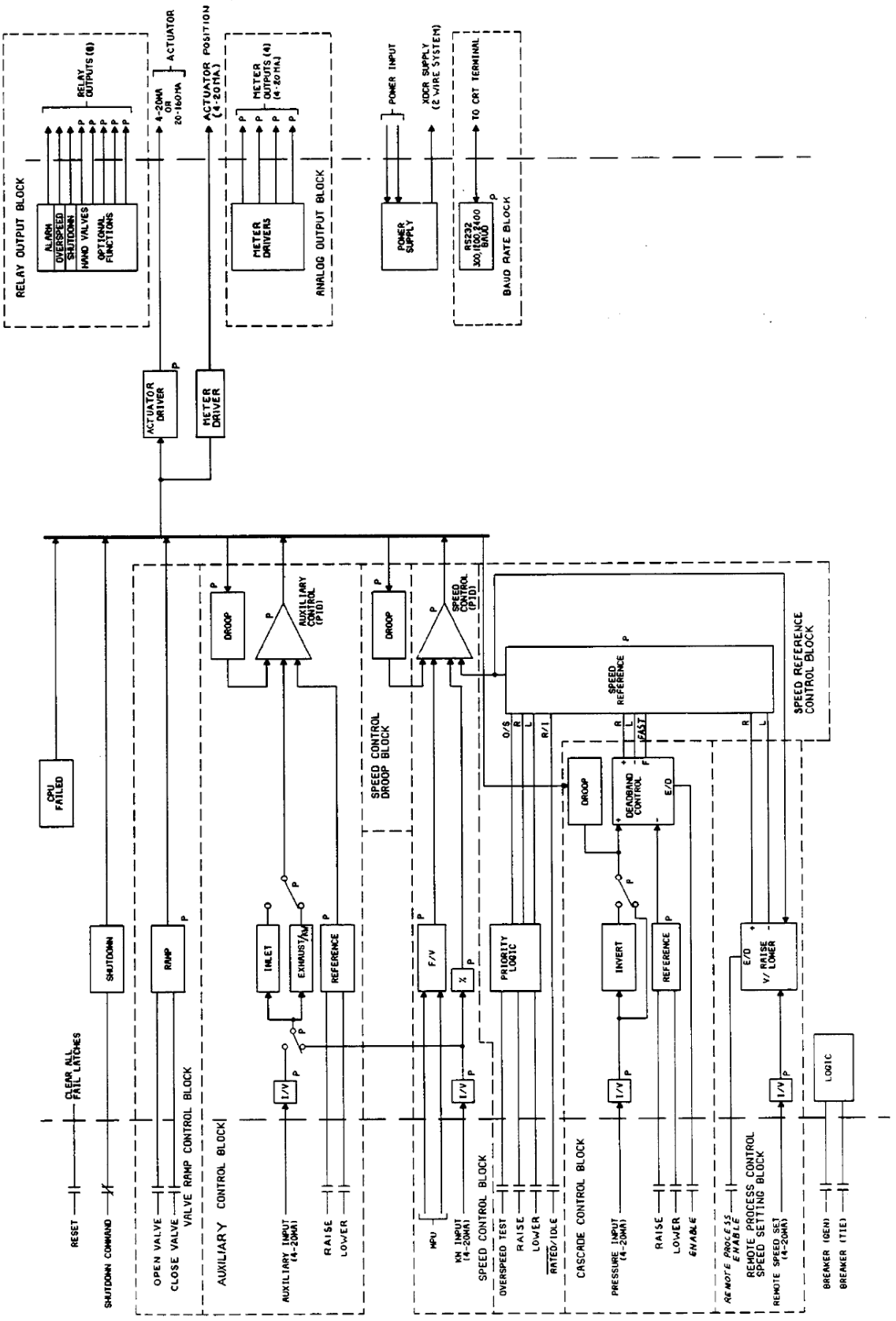


Figure 2-2. Detailed 505 Block Diagram

Communications

Communications with the control are primarily through a 26-key membrane switch keypad and LCD (liquid crystal display) window, both located on the front of the control. The control responds through the LCD window display, which consists of two lines, each containing 20 half-inch-high characters.

Keypad Functions

A description of each key's function follows. Some descriptions refer to the function blocks contained in the programming and operating flowcharts (see Figures 3-2 and 3-3).

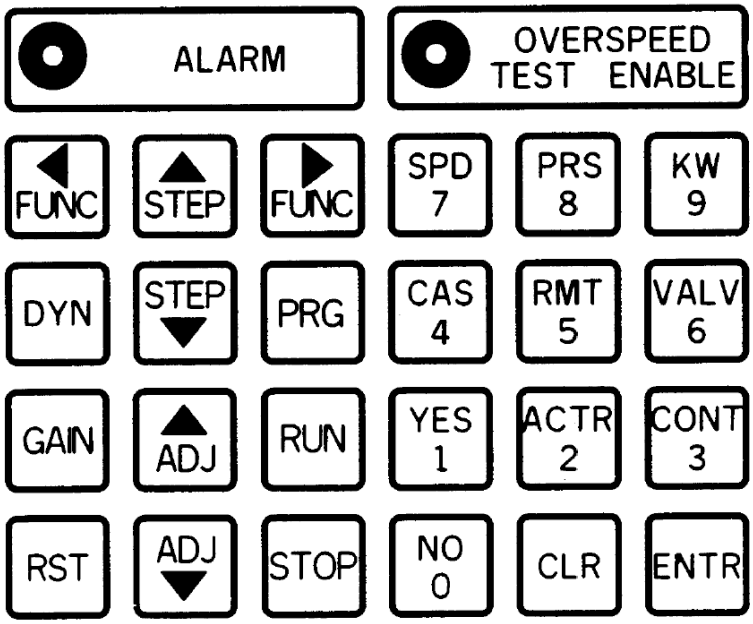


Figure 2-3. 505 Keypad

FUNC left/FUNC right (function)—Moves the display left or right through the function blocks. In the Program Mode, you must step the display up to the top of the function block before the FUNC keys have an effect.

STEP up/STEP down—Moves the display up or down within a function block.
ADJ up/ADJ down (adjust)—Moves any adjustable parameter up (larger) or down (smaller).

DYN (dynamic)—Accesses the dynamic settings of the parameter controlling actuator position in the Run Mode.

GAIN—Activates the dynamic gain setting of the displayed parameter in the Run Mode.

RST (reset)—Activates the dynamic reset setting of the displayed parameter in the Run Mode.

PRG (program)—Puts the control into the Program Mode.

RUN—Puts the control into the Run Mode.

STOP—Returns the control to the ready status (Program Mode) or initiates a controlled turbine shutdown (Run Mode).

0/NO—Enters 0 (Program Mode) or NO (Run Mode).

1/YES—Enters 1 (Program Mode) or YES (Run Mode).

2/ACTR (actuator)—Enters 2 (Program Mode) or displays the actuator position (Run Mode).

3/CONT (control)—Enters 3 (Program Mode) or displays the parameter which is in control (Run Mode).

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

5/RMT (remote)—Enters 5 (Program Mode) or displays the remote process control information (Run Mode).

6/VALV (valve)—Enters 6 (Program Mode) or displays the valve ramp information (Run Mode).

7/SPD (speed)—Enters 7 (Program Mode) or displays the speed control information (Run Mode).

8/PRS (pressure)—Enters 8 (Program Mode) or displays the pressure control information (Run Mode).

9/KW—Enters 9 (Program Mode) or displays the KW power control information (Run Mode).

CLR (clear)—Clears Program Mode entries or resets Run Mode alarms. Pressing the key also returns the control to the (UNIT READY/ SHUTDOWN) status after a shutdown.

ENTR (enter)—enters new values in the Program Mode.

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

OVERSPEED TEST ENABLE—Permits the speed reference to be raised beyond the maximum controlling speed set point to test either the electrical or the mechanical overspeed trip.

In addition to the 26-key membrane switch panel, a large red mechanical button is mounted on the front of the enclosure. This is the emergency shutdown switch for the control.

Inputs and Outputs

All inputs and outputs to the 505 are made through a terminal block inside the 505 enclosure. Wiring passes through two conduits on the bottom of the control. All inputs and outputs are shown in the block diagram.

The control monitors a change in the state of all external control contacts. Thus, the control does not react to a maintained level but only to a change (open to closed, closed to open). At start-up, the control reviews all contact states, and reacts to any closed contact as a change in state.

If your application uses two MPUs (magnetic pickups), the MPUs may be mounted on separate gears, but each gear must have the same number of teeth and rotate at the same speed, so that both MPUs record the same speed.

The 505 has one actuator output, five 4 to 20 mA meter-drive outputs, and eight relay contact outputs.

The actuator drive current can be either a 4 to 20 mA signal for pneumatic actuators or a 20 to 160 mA signal for hydromechanical actuators. The type of actuator drive current is selected in the Program Mode.

The control has five 4 to 20 mA outputs used to drive meters. The first is dedicated to the actuator position, while the remaining four can be selected in the Program Mode.

The control has eight relay contacts. The Form C type contacts are rated at 5 A of resistive current at 28 Vdc. Three relay outputs are dedicated: one to the Alarm relay, one to the Overspeed Trip relay, and one to the Shutdown relay. The remaining five can be selected in the Program Mode.

All inputs and outputs are shown in the plant wiring diagram, Figure 1-2.

RS-232

The control can communicate with a CRT terminal through an RS-232 line. The RS-232 protocol is asynchronous, eight bits/character, no parity, one start bit, one stop bit. Baud rates are 300, 1200, or 2400.

The RS-232 line can operate the turbine in the Run Mode, but cannot access the Program Mode. Program configuration must be done from the keypad on the front of the control. The RS-232 feature can perform all Run Mode functions except overspeed test. You can run an RS-232 line for approximately 50 ft (15 m), or further if the line capacitance is held below 2500 picofarads.

In manual RS-232 mode (the default mode), the control updates CRT information only when you press RETURN. If you select automatic RS-232 mode (by typing in AUTO, followed by a return), the control updates the information automatically every second at 1200 or 2400 baud or every two seconds at 300 baud.

To call up any function, type in either the same letter combinations shown on the control keypad (such as SPD for speed) or type in the function's full name (such as SPEED). The only exceptions are the arrow keys. Enter the arrow keys as follows: Function Right = FR, Function Left = FL, Step Up = SU, Step Down = SD, Adjust Up = AU, Adjust Down = AD. When using the Adjust commands, repeatedly press the RETURN key to continue the adjustment; press any other key to stop the adjustment process. The ORT screen displays the same information as shown on the control's LCD readout.

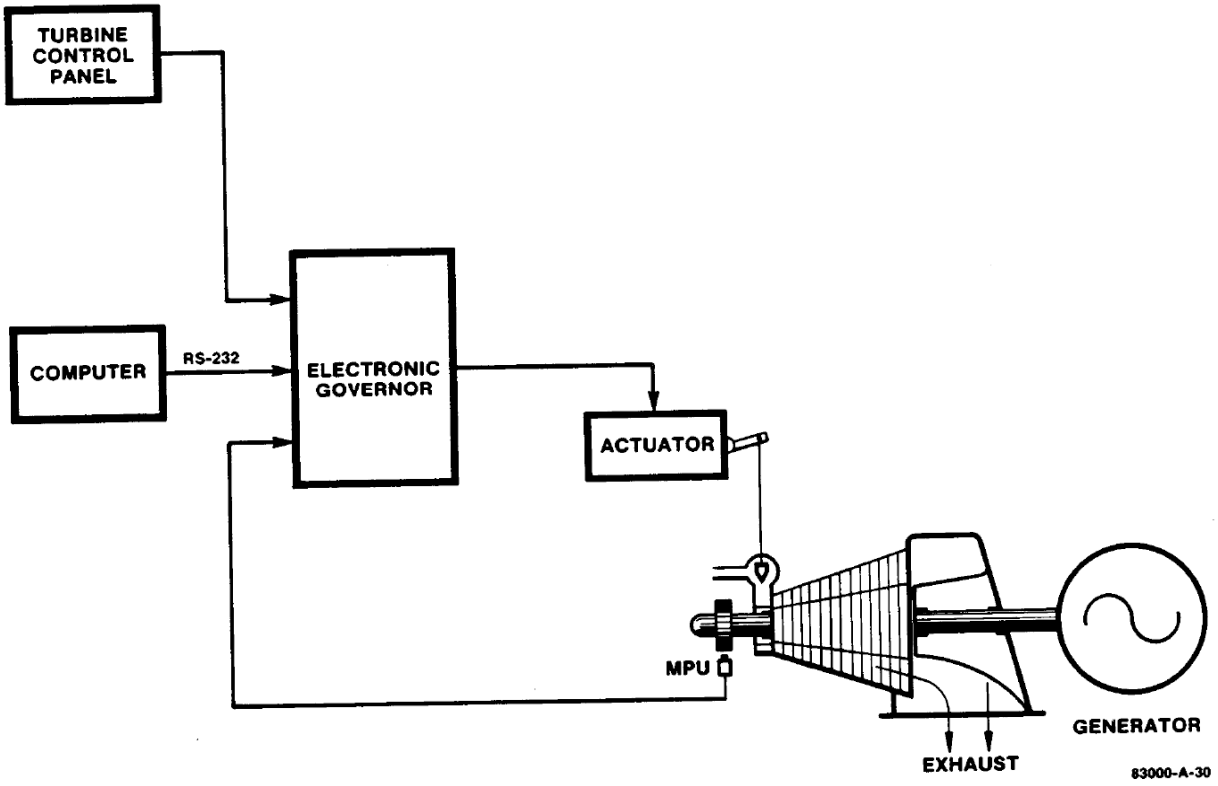


Figure 2-4. 505 Communication through an RS-232 Line

Speed Control Loop

The basic speed control receives a turbine speed signal from one or two magnetic pickups. A frequency-to-voltage converter changes the speed frequency signal into a proportional voltage signal. The PID (proportional, integrating, differentiating) control amplifier then compares this signal to the speed-reference set point to generate an output signal to the actuator driver and valve actuator.

The speed control amplifier also can receive a droop feedback signal to increase the stability of the turbine/governor system. This can be direct feedback using a portion of the speed control amplifier output, or it can be load (KW) droop feedback. The 4 to 20 mA load droop signal comes from a real-power sensor supplied by Woodward. An I/V (current-to-voltage) converter changes the load current signal to a proportional voltage. A percentage of that signal is then sent on to the control amplifier.

The speed reference is adjusted through the keypad on the front of the control. External contact closures also allow remote setting of the reference.

Auxiliary (Pressure/KW) Control Loop

The auxiliary control can be used for inlet pressure, exhaust pressure, or KW (power) control. Its input signal is a 4 to 20 mA current which the control converts to a proportional voltage. The PID control amplifier compares this with the auxiliary reference to produce a control output to a digital LSS (low-signal selector) bus. The LSS bus sends the lowest signal to the final driver circuitry.

The auxiliary reference is adjusted through the keypad on the front of the control. External contact closures also allow remote setting of the reference.

Remote Process Control Loop

The remote process control can control the speed reference set point. An external process control receives a 4 to 20 mA signal from a transducer. The process control compares that signal with an external reference to generate an output to the remote process control portion of the 505. An I/V converter changes this current signal to a proportional voltage. The internal process control compares this voltage to the output of the speed reference. If the incoming signal is greater than the speed reference set point, the 505 raises the speed reference. If it is lower, the 505 lowers the speed reference.

Cascade Control Loop

The cascade control can control the speed reference set point. It operates in the same manner as the remote process control. The cascade control contains a deadband comparator. This compares a 4 to 20 mA process signal with an internal reference signal. If the two signals do not match, the comparator issues raise or lower commands to the speed reference until the error is less than the deadband.

Valve Ramp Control

The valve ramp control opens and closes the steam valve to aid in starting and shutting down the turbine. The ramp is adjusted through the keypad on the front of the control. External contact closures also allow remote setting of the ramp.

Shutdown and CPU Fault Control

An emergency shutdown circuit and a CPU failed circuit also can control the output of the digital LSS bus.

If you press the Emergency Stop pushbutton on the front of the control, the shutdown circuitry pulls the LSS bus low, which in turn pulls the input to the actuator driver low to run the actuator current to minimum.

The CPU failed circuit functions as a watchdog timer which monitors the microprocessor operation. If the microprocessor has not executed a control calculation within a preset sampling period, the watchdog timer pulls the LSS bus low, which in turn runs the actuator current to minimum.

Power Supply

The 505 power supply accepts 85 to 132 Vac at 47 to 400 Hz or 100 to 150 Vdc. The power supply provides power for the control and for any external transducers. The 505 is designed to supply power to all transducers through a two-wire system (Figure 2-5). The only exception is the 4 to 20 mA input from the Woodward real-power sensor which has its own internal power supply.

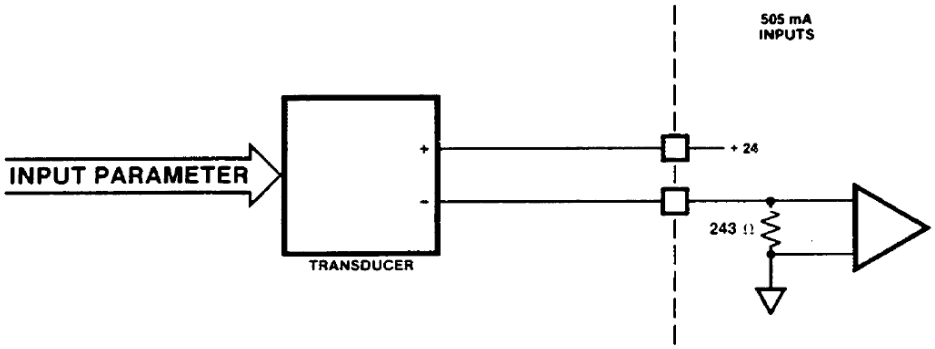


Figure 2-5. Two-Wire Transducer System

Chapter 3.
Configuration Procedures

Programming

The 505 is easy to program, due in large part to the menu-driven software.

The flowcharts for programming and running the 505 Digital Governor are shown in Figures 3-2 and 3-3. The operating procedures are divided into two sections: the Program Mode (Figure 3-3) and the Run Mode (Figure 3-2). When the control is powered up, and after the brief CPU self test has been completed, the control displays a ready status. You can then select either Run Mode or Program Mode (see Figure 3-1).

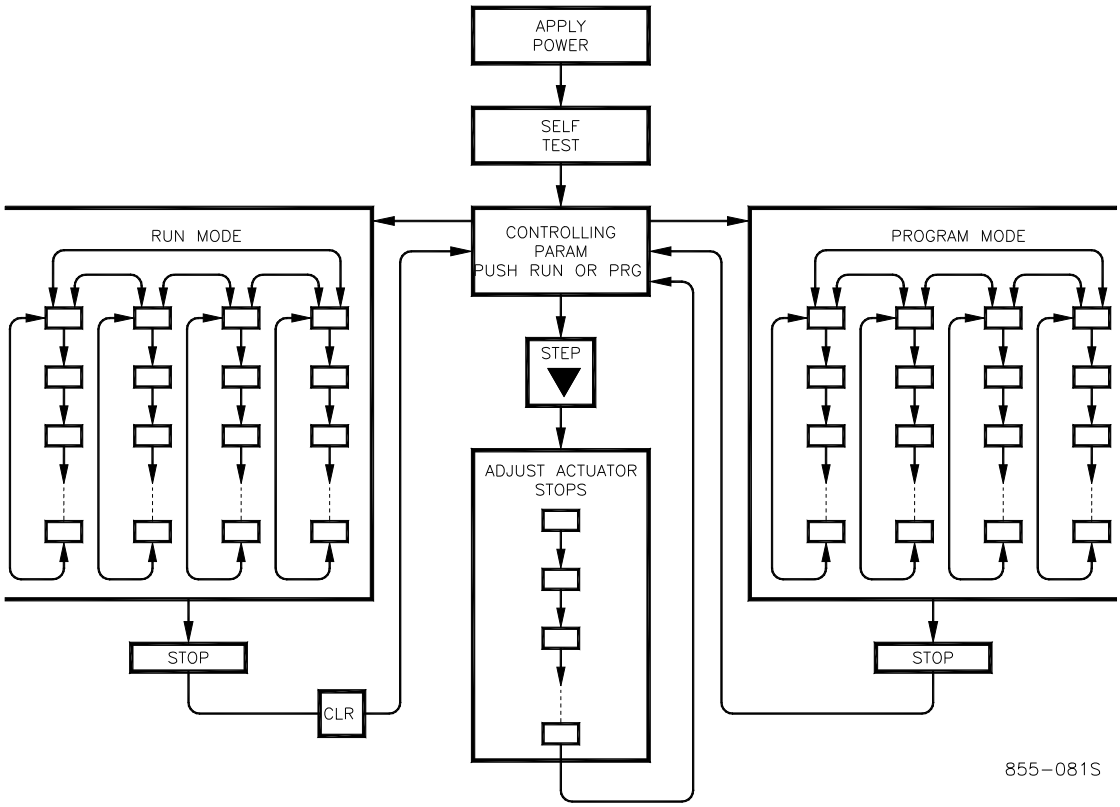


Figure 3-1. Basic Program Architecture

You cannot access the control's operating Program Mode while the turbine is running. This minimizes the possibility of introducing step disturbances into the system.

You can program and run the control using the LCD display and the touch keypad on the front of the control.

The touch keypad has several dual-function keys. Pushing any dual-function key in the Program Mode enters the numeric value printed on the key. Pushing the key in the Run Mode enters the operating parameter printed on the key.

The function keys (FUNO left, FUNC right) allow you to move right or left across the tops of the function blocks in both the Run and Program Modes.

The STEP up and STEP down keys allow you to move up or down the program columns. The control does not permit stepping down beyond a step with a valid entry.

The control displays previously entered values with each program step. If a displayed value is satisfactory, press the STEP up or STEP down key to continue. If a new value is required, enter it, then press ENTR. The ENTR key must be pressed to enter any new value.

All steps immediately following a decision step (diamond shaped block in the figures) must contain valid entries. There are no default values. If an invalid entry is made, the control displays an invalid entry message. You must press CLR before the program can advance to the next step. The control then displays the program step again so a valid entry can be made.

As a minimum, you must configure the first three functional blocks of the Program Mode before control operation (Turbine Start, Speed Control, and Speed Reference).

In the Run Mode, functional blocks allow you to display operating parameters, both the actual incoming parameter and the parameter reference. The functional blocks allow you to change set points or operating points and dynamic adjustments, and to enable or disable the remote process control and the cascade control.

Program Blocks

Figure 3-3 shows the eleven program blocks. To program the control, simply step through the blocks as described above to match the control to your installation. The first three program blocks must be programmed for every installation. The remaining eight blocks contain optional features which must either be selected or rejected. The eleven blocks and their basic functions are listed below.

Required Blocks:

(1) Turbine Start—select manual, automatic, or semi-automatic turbine start-up;
(2) Speed Control—select MPU information, actuator type, and speed gain and reset;
(3) Speed Reference—select reference set points, overspeed trip, critical speeds, idle/rated speeds.

Optional Blocks:

(4) Droop—select droop information;
(5) Remote Process—select remote process and breaker logic information;
(6) Auxiliary Control—select KW control or inlet/exhaust pressure control information;
(7) Cascade Control—select pressure or temperature control and breaker logic information;
(8) Valve Ramp Control—select valve ramp rate;
(9) Relay Output—select relay options:
(10) Analog Readout—select analog readout options;
(11) RS-232—select baud rate.

Program Configuration Completeness Check

After the program is configured, push STOP to exit the Program Mode. The control then 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 blocks. After the completeness check is finished, the control returns to the ready status and displays (UNIT READY/SHUTDOWN) (Push RUN or PRG). This occurs almost instantly, unless an error is found.

One error message alerts you that additional information is required before the configured program can operate the turbine. The control displays the message (INCOMPLETE PRG) (Push CLR key). Pushing the CLR key causes the control to display the Program Mode step that requires more information. You must enter the additional information, then attempt to exit the Program Mode by pushing STOP. The completeness check will continue to fail until the control is satisfied that the configured program is complete.

Another error message ties the automatic or semiautomatic start together with the need to have the valve ramp function block configured. If automatic or semi-automatic start is selected, the valve ramp function must be configured. If it has not been configured, the control displays the message (START/V-RAMP ERROR) (Push CLR key). Pushing the CLR key causes the control to display the beginning of the turbine start function block. You must then review the starting procedure.

The last two error messages deal with critical speed ranges. Control logic does not permit the idle speed to exist within a critical speed range. If idle is greater than a minimum critical speed, the control displays the message (IDLE > CRIT MIN) (Push CLR key). Pushing the CLR key causes the control to display the program step in which the idle speed is established. You also may wish to review the critical speed ranges selected.

Control logic also prevents a critical speed from being above the minimum control speed. The secondary speed setting functions, the remote process control, and the cascade control operate within a range defined by the minimum and maximum control speeds. The maximum control speed must be less than the maximum speed reference and overspeed trip settings. This prevents the secondary speed setting functions from attempting to operate within a critical speed range. If a critical speed is found above the minimum control speed, the control displays the message (CRIT SPO > MIN SPD) (Push CLR key). Pushing the CLR key causes the control to display the minimum control speed. You may want to review the critical speed ranges as well.

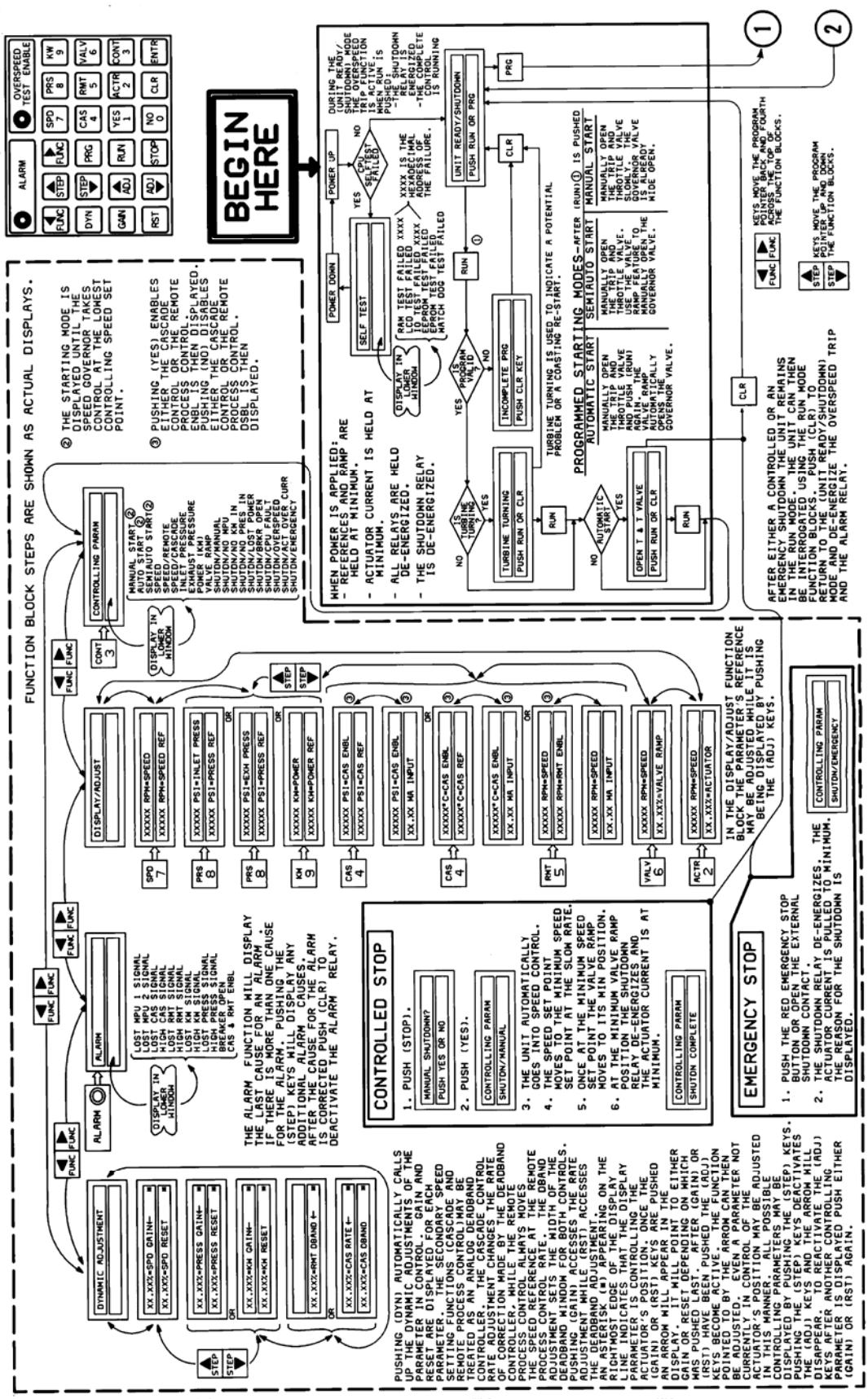


Figure 3-2. Starting and Run Mode Procedures

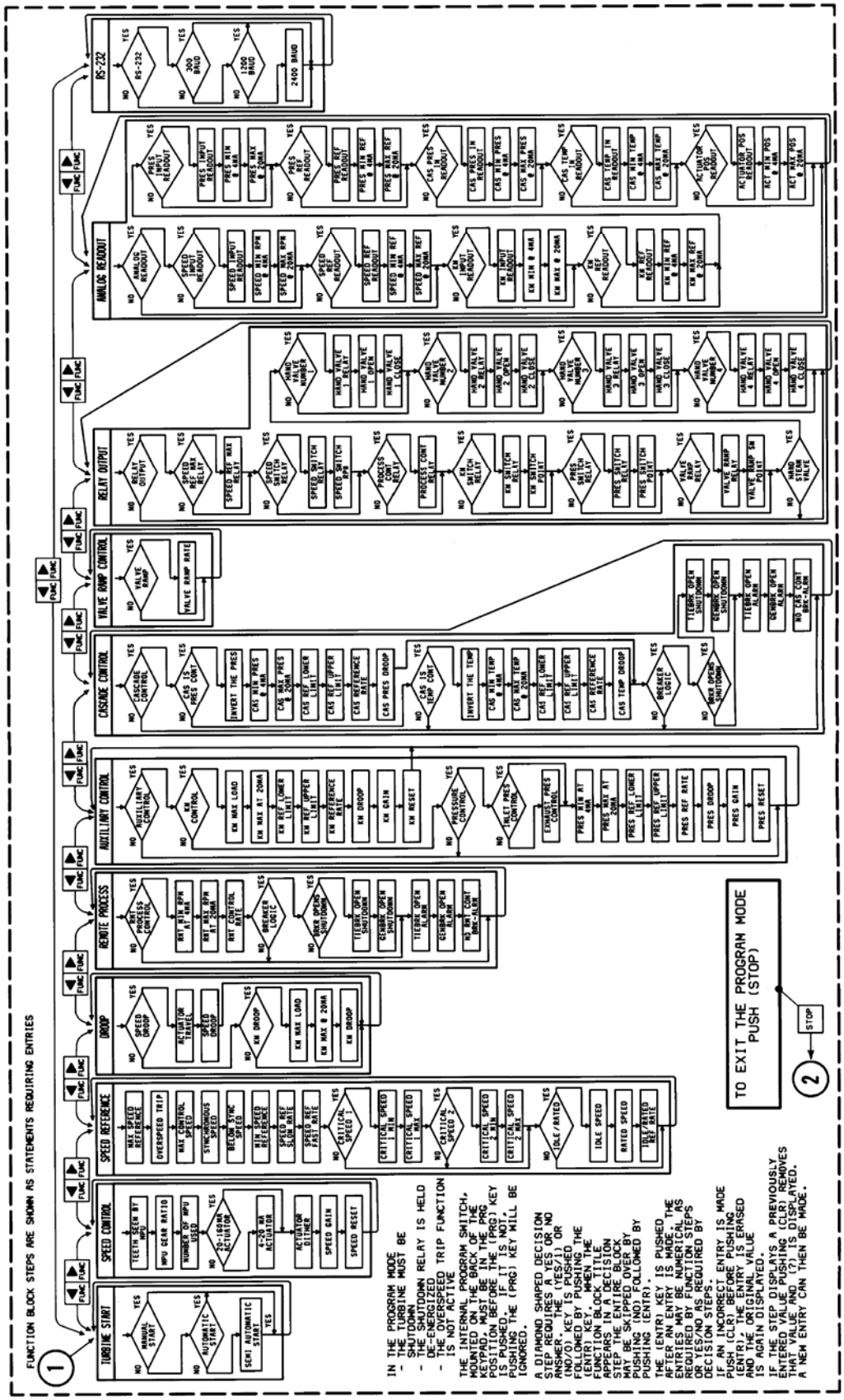


Figure 3-3. Program Mode Procedures

Chapter 4.
Operating Procedures

Operating Functions

There are four operating functions (see Figure 3-2). You can move from function to function by pushing the FUNO keys, and you can move up and down within a function block by pushing the STEP keys. The four blocks and their basic functions are listed below.

- Controlling Param (parameter)—displays all controlling parameters;
- Display/Adjust—display or adjust all inputs, outputs, and references;
- Alarm—all control alarms;
- Dynamic Adjustment—dynamic adjustments for all control channels.

Starting Procedures

To enter the Run Mode, push RUN when the (UNIT READY/SHUTDOWN) status is displayed. Immediately after RUN is pushed, the Shutdown relay energizes and the control enters the Run Mode. The upper LCD readout displays (CONTROLLING PARAM), and the lower readout displays the parameter controlling the actuator position.

The control has three starting modes: automatic, semi-automatic, and manual, one of which must have been configured during control programming.

Automatic Start Mode

After pushing RUN, you must manually open the trip-and-throttle valve. The control provides a prompt to indicate when you should open the trip-and-throttle valve. Then push RUN again, and the control automatically begins moving the valve ramp from minimum position (steam valve closed) toward maximum position (steam valve open).

You can monitor speed and valve position by pushing VALV. When turbine speed increases to either the minimum speed set point or idle speed (if used), the speed governor takes control of actuator position. The control continues to move the valve ramp toward its maximum position while speed remains controlled at minimum governor or idle speed. You may then move the speed reference to another operating speed by pushing SPD followed by the ADJ up key.

You can abort the automatic start at any time by taking manual control of the valve ramp. Pushing the ADJ up or ADJ down key while speed and valve ramp position are displayed allows you to manually override the automatic start feature. Pushing the STOP key or the Emergency Stop button also overrides the automatic start feature.

Semi-Automatic Start Mode

After pushing RUN, you must manually open the valve ramp. Pushing VALV displays both speed and valve ramp position, and it activates the ADJ up and ADJ down keys. You can then manually open the valve ramp by pushing the ADJ up key. When turbine speed increases to the minimum or idle speed set point, the speed governor takes control of actuator position.

You must continue moving the valve ramp toward its maximum position after the speed governor takes control. You may then move the speed reference to another operating speed by pushing SPO followed by the ADJ up key.

Manual Start Mode

After RUN is pushed, the trip-and-throttle valve must remain closed. The speed governor then senses zero speed and opens the actuator to its maximum position. You must then manually open the trip-and-throttle valve to admit steam to the turbine. When turbine speed increases to the minimum or idle speed set point, the speed governor takes control of actuator position and the trip-and-throttle valve can .be fully opened. Speed remains controlled at minimum governor or idle speed. You may monitor speed and control the speed set point position by pushing SPD at any time after the speed governor is in control.

Zero Speed Signal Override

At start-up, the 505 control automatically arms a zero speed signal override, and the control automatically disarms the speed signal override when turbine speed exceeds 500 rpm. Above 500 rpm, the control shuts down the turbine if all speed signals are lost. Redundant MPUs (magnetic pickups) are recommended when starting in the automatic mode.

Idle/Rated

The 505 is equipped with an idle/rated function which can be initiated only from external contacts. There are no keypad controls for this function. The feature must be configured in the Program Mode or the control ignores the idle/rated contacts.

When the external idle/rated contacts are closed, the 505 controls at idle speed. When the idle/rated contacts are opened, the control automatically ramps from idle speed to rated speed. The speed reference moves at the idle/rated reference rate. The control maintains speed control as a function of the moving speed reference. Once the speed stops at rated speed, the speed reference may be moved to another operating point.

The speed reference does not return to rated if turbine speed is above rated speed. Rated speed may be equal to or greater than the minimum control speed, but it must be less than the maximum control speed. When the idle/rated contacts are again closed, the control moves back to idle speed at the same idle/rated reference rate.

The idle/rated contacts can be either open or closed when the turbine is started. With the idle/rated contacts closed, the governor takes control at idle or minimum speed reference. whichever is lower. If the contacts are open (rated selected), the governor comes up to idle or minimum governor speed, whichever is lower, and then ramps at the idle/rated reference rate to rated speed. Note that the critical speed range avoidance feature is operational during start-up.

Manual raise speed reference and lower speed reference commands from the keypad or external contacts have priority over the idle/rated function and cancel its operation. When the turbine is used for mechanical drive, rated speed may be set at minimum governor speed. When the turbine is used for generator drive, rated speed may be set either at minimum governor speed or at synchronous speed.

References

The 505 references operate in the same manner as references in other Woodward controls, such as 2301 MOPs and 43027 digital reference modules. You select a reference ramp rate during control programming for each ramp or reference. This rate governs how fast each reference can be changed.

The LCD readout displays the reference values on the lower line and the actual turbine operating point on the upper line. Both values are updated automatically within the update time constant of the display.

Each reference and ramp can operate at several rates. The slow rate is determined in the Program Mode. External contacts such as the external raise and lower functions or the overspeed test function can move a reference/ramp only at the slow rate.

Within any critical speed range, the speed reference always moves at the fast rate within the critical range. The control does not allow the reference to stop within the critical range.

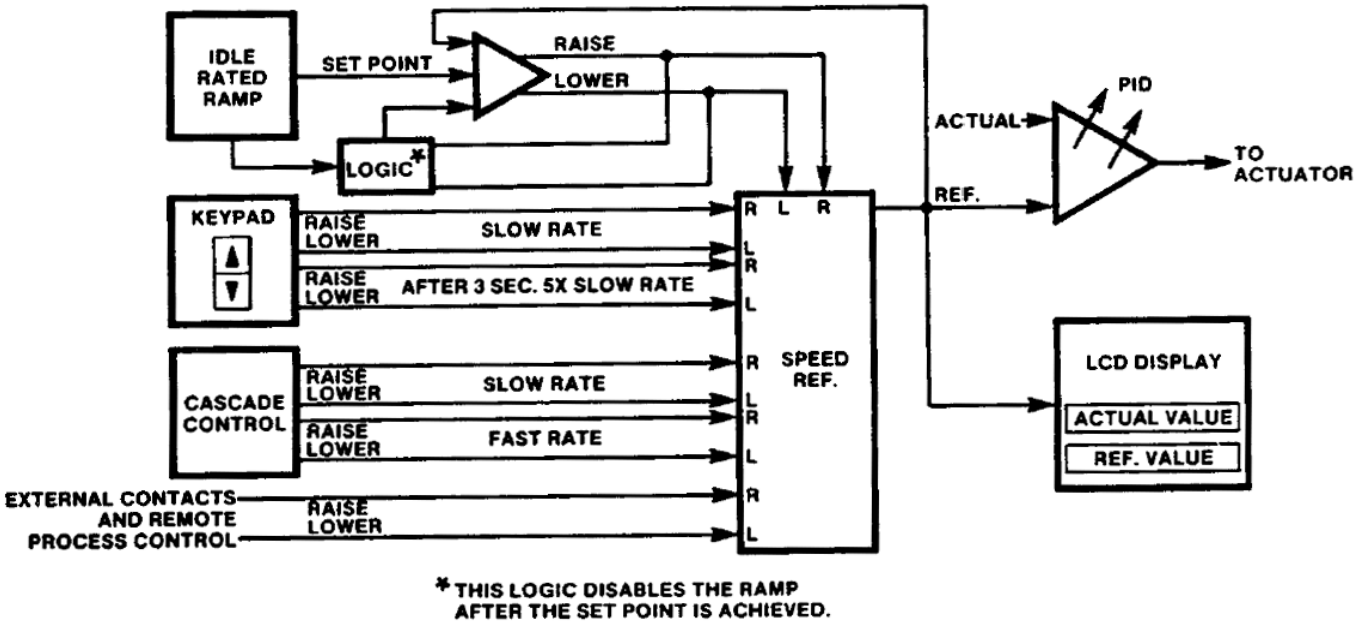


Figure 4-1. Speed Reference Rates

The cascade control can move the speed reference at a variable rate less than the fast rate. When the error between the pressure or temperature requested by the cascade control and the cascade reference is small, the speed reference moves at a very slow rate. If the error between the requested pressure or temperature and the cascade reference is great, the speed reference moves at a variable rate dependent on the amount of error. For very large errors it moves at the fast rate.

Reference rates also can be selected by the length of time the ADJ up and ADJ down keys are held down. If the ADJ key is held down longer than the time specified below, the reference moves five times faster than the slow rate. The overspeed test function and external contacts never move any faster than the speed reference slow rate. The points in time at which the dynamics, parameters, and valve ramp rates change are listed below.

The dynamics are adjusted as a percent of the existing value. For the dynamic adjustments, holding the ADJ key down for 0 to 0.25 seconds moves the dynamics (gain and reset) at a 1O/o adjustment. Holding the key down for 0.25 second or longer moves the dynamics at 50/c adjustment/0.25 second.

For the parameter reference adjustments, holding the ADJ key down for 0 to 3 seconds moves the set point at the slow rate. Holding the key down for 3 seconds or longer moves the set point at five times the slow rate. The smallest rate increment is a quarter of the slow rate.

The valve ramp adjustment always moves at the valve ramp rate. The smallest increment the valve ramp can move is a quarter of the valve ramp rate.
The control is designed to reset the speed reference to some predetermined speed if either the generator or utility tie breakers open. If the generator breaker opens on a loaded generator, the overshoot caused by the load loss could overspeed the turbine. To prevent this, the control automatically resets the speed reference to the below-synchronous-speed set point established when the control was configured.

If the utility tie breaker opens, the control automatically resets the speed reference to the reset-speed set point. This may be synchronous speed or, if plant frequency needs to be maintained after separating from the utility, the reset speed must be above synchronous speed. This speed is determined from the amount of droop programmed into the control and the amount of load the generator is expected to carry. In a droop system, plant frequency varies with generator load. The speed set point can be adjusted manually to compensate for these load changes.

The control also is capable of isochronous speed control on an isolated bus. In this type of application, both synchronous-speed and below-synchronous-speed set points could be set at the turbine’s synchronous speed.

Droop

The control is not equipped with a droop/ isochronous switch. If droop is configured in the Program Mode, it always is engaged and active when the control is operating in the Run Mode.

Speed Limits

All normal control operations occur between the maximum and minimum control speeds. To obtain a speed greater than the maximum control speed requires using the overspeed test enable function. To obtain a speed less than the minimum control speed requires closing the external idle/rated contacts. The speed reference then begins ramping to the idle speed at the idle/rated rate. Once the reference drops below the minimum control speed, you can take manual control of the reference with the ADJ up and ADJ down keys.

Priorities

The 505 has an internal priority scheme to sort out incoming commands. Listed below are the priorities, from the highest to the lowest.

Emergency Shutdown: Any type

Low Signal Select (LSS) Bus (this is an internal function to which there is only indirect access through the control channels)

Internal Priority of Control Channels Influencing the LSS Bus
Speed Control Priorities:
- Reset to Synchronous Speed/Below Synchronous Speed
- Alarm; push CLR to acknowledge
- Speed Reference Mm/Max Clamps; Overspeed Test
- Critical Speed Avoidance
- Remote Process Control/Cascade Control
- Miscellaneous Inputs; Remote/Local, Raise/Lower
- Idle/Rated Ramp

Valve Ramp Priorities:
- Mm/Max Clamps
- Mm rate of change of Speed/Limiter
- Remote/Local, Raise/Lower
- Auto Start; Raise
- Controlled Shutdown; Lower

Auxiliary Control Priorities:
- Mm/Max Clamps
- Remote/Local; Raise/Lower
- CPU Failed

Dynamic Adjustments

Dynamic adjustments are made in the Run Mode. Pushing the DYN key calls up the dynamic adjustments of the parameter in control. The LCD display shows gain on the upper line and reset on the lower. Pushing one of the STEP keys causes each parameter's dynamics to appear in turn.

The secondary speed setting functions, the cascade control, and the remote process control may be treated as analog deadband controllers. Pushing GAIN accesses the rate adjustment while RST accesses the deadband adjustment (see Figure 4-2).

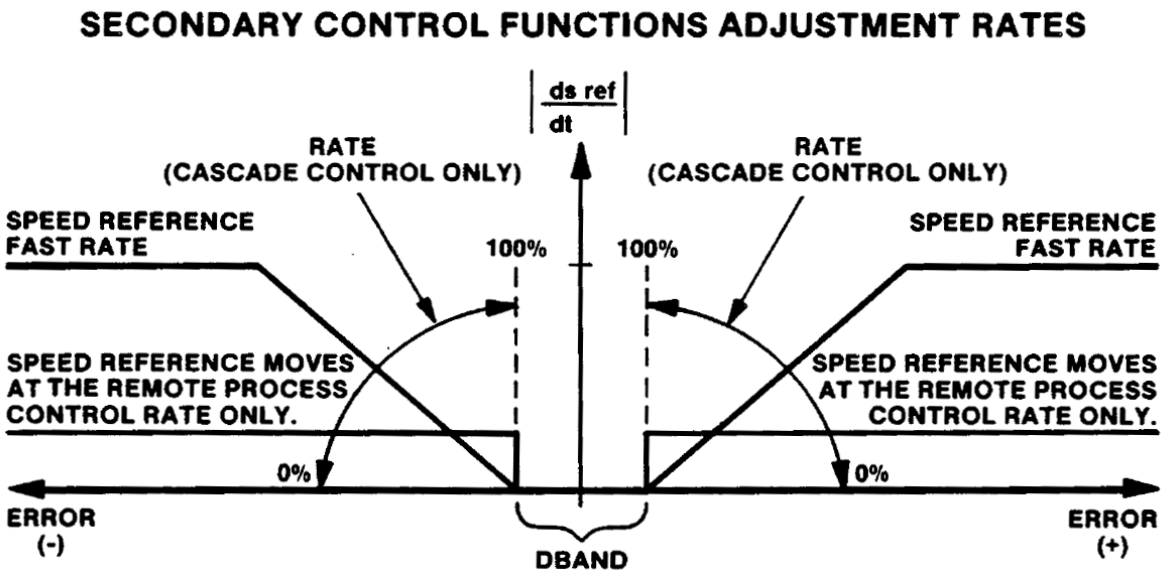


Figure 4-2. Control Function Adjustment Rates

An asterisk appearing on the right edge of the LCD display line indicates that the displayed parameter is controlling actuator position. Pushing the GAIN or RST (reset) keys causes an arrow to appear by the appropriate parameter in the display and activates the ADJ keys. Use the ADJ keys to adjust the function pointed to by the arrow.

You may display any possible controlling parameters by stepping through the dynamic adjustment block using the STEP up or STEP down keys. Pushing the STEP keys deactivates the ADJ keys, and the arrows disappear. To reactivate the adjustment keys after another controlling parameter is displayed, push the GAIN or RST keys again.

Remote Process Control and Cascade Control

The remote process control and the cascade control are secondary speed setting functions. Both functions may have values loaded into them in the Program Mode. Each function must be enabled to be used and disabled when not used. Attempting to enable both functions simultaneously causes neither to control and activates the alarm function. You must disable either the remote process control or the cascade control before the alarm can be cleared.

Both functions can adjust the speed reference only from the minimum speed reference to the maximum controlling speed. If the mA input signal to either function drops below approximately 3 mA or exceeds approximately 21 mA, the function ceases to influence the speed reference, the speed set point remains at its last setting, and an alarm is issued. No alarm occurs if the function is not enabled.

Before either function can be enabled, the generator breaker and the utility tie breaker must both be closed. If either breaker opens, the secondary speed setting functions cease to influence the speed reference. You can configure. the control to shut down the turbine or to alarm on a breaker opening, if either secondary speed setting function is enabled. You also can configure the control to alarm or to ignore a breaker opening, if both secondary speed setting functions are disabled.

You can enable either the remote process control or the cascade control once the turbine is up to speed and a load is established.

The remote process control is external to the 505. It is usually equipped with both automatic and manual operating capabilities. In the automatic mode, the process control accepts a pressure signal of 4 to 20 mA from a pressure transducer and compares it to a reference signal. The process control then sends a 4 to 20 mA signal representing the error between the pressure signal and the reference to the 505. This signal influences the speed reference set point as a function of pressure. In the manual mode, you can adjust the process control output directly regardless of the controlled parameter's value.

The remote process control enables immediately after an enable command is issued. You may expand the enabling procedure to suit the installation's particular operating procedures.

There are three procedures to enable the remote process control:

(1) You can match the speed called for by the process control to the actual speed. To do so, put the process control into the manual mode. Pushing the RMT/5 key displays the actual speed in rpm in the top LCD and the rpm called for by the 4 to 20 mA remote process control input in the bottom LCD.

    Then adjust the remote process control output up or down to bring the rpm called for by the process control in line with actual speed. Once the displayed speed is close enough for a transfer (typically 10 rpm or less), push the 1/YES key or close the external enable contacts to enable the remote process control and display (ENBL) in the lower LCD. Then switch the external process controller from manual to automatic operation, and turbine speed (power output) is controlled as a function of the process control.

(2) In applications where it is not necessary to control the turbine at a specific speed (such as compressors and pumps), you can adjust the speed reference instead of the process control output. As in (1), after the speeds are matched, pushing the 1/YES key or closing the external enable contacts enables the remote process control.

(3) You can enable the remote process control without first matching signals. The speed reference automatically begins moving at the remote process control rate toward the speed requested by the remote process control. After the actual speed matches the requested speed within the allowed deadband, the reference stops moving.

The remote process control can decrease the speed reference set point at any time while it is enabled. However, it can increase the speed reference set point only while the speed loop is controlling the actuator. This keeps the remote process control from pushing the speed reference to its maximum position while the speed loop is not in control. This prevents the speed loop from trying to control speed at some unacceptably high speed after it regains control of the actuator.

You can disable the remote process control at any time. Pushing the 0/NO key or opening the external enable contact disables the remote process control function and removes the (ENBL) message from the lower LCD. After the remote process control has been disabled, the speed reference set point remains unchanged until it is moved by some other means.

The cascade control is a secondary speed setting function internal to the 505. It operates in a manner similar to the remote process control in the automatic mode.

The cascade control receives a 4 to 20 mA signal from a transducer (such as temperature or pressure). A digital deadband comparator circuit compares this incoming parameter with an internal reference. If a difference exists between the two signals, the circuitry adjusts the speed reference set point to eliminate the difference (within the limits of the deadband).

Pushing the CAS/4 key displays the actual value of the controlled parameter (temperature or pressure) in the upper LCD and the value of the cascade reference in the lower LCD. To enable the cascade control, push the 1/YES key or close the external enable contacts. This displays (ENBL) in the top LCD. You can disable the function at any time by pushing the 0/NO key or opening the external enable contacts.

The cascade control can decrease the speed reference set point at any time while it is enabled. However, it can increase the speed reference set point only while the speed loop is controlling the actuator. This keeps the cascade control from pushing the speed reference to its maximum position while the speed loop is not in control.

This prevents the speed loop from trying to control speed at some unacceptably high speed after it regains control of the actuator.

Unlike the remote process control, the cascade control can move the speed reference at a variable rate up to the fast rate. Once enabled, the cascade control adjusts the speed reference to reduce the error between the input and the cascade reference to within its deadband window. The further the incoming signal drifts from the cascade control set point, the faster an adjustment is made to the speed set point, up to the speed reference fast rate.

You can adjust the deadband windows for both the cascade control and the remote process control in the Run Mode. The cascade control has both rate adjustment (the slope of the error versus the correction rate line) and a deadband adjustment (the size of the deadband window). The remote process control has only a deadband adjustment. Errors from the remote process control greater than the dead band cause the speed reference to move at only the remote process control rate. Figure 4-2 depicts the rate of adjustment made to the speed reference by the two control functions.

$$\left|\frac{ds\ ref}{dt}\right| = \text{Rate of change of the speed reference}$$

ERROR = The difference between the actual cascade input signal and the cascade reference or the difference between the remote process control and the speed reference set point.

DBAND = The deadband established for the deadband comparator. Maximum (100%) deadband is equal to 10% of the cascade references range. This range is defined as the maximum cascade reference minus the minimum cascade reference. The maximum deadband for the remote process control is defined as 10% of the speed reference's full range. In both cases, the 10% is measured from the (ds ref/dt) axis. This gives a total deadband window of 20% maximum for both the cascade control and the remote process control.

RATE = The change to the speed reference ramp rate proportional to the amount of error. Only the cascade control has a rate adjustment.

Overspeed Test

An overspeed test can be performed only while the speed and speed reference are displayed. Pressing the OVERSPEED TEST ENABLE key immediately displays the speed and speed reference. Both the cascade control and the remote process control must be disabled.

To perform an overspeed test, raise the speed reference set point to the maximum controlling speed using the ADJ up key. When the speed reference set point reaches the maximum controlling speed, the speed set point cannot be increased further by pushing the ADJ up key alone. To continue, press both the ADJ up key and the OVERSPEED TEST ENABLE key simultaneously, which illuminates the red LED on the OVERSPEED TEST ENABLE key.

Pushing both keys causes the speed set point to increase at the slow rate until the control reaches the electrical overspeed trip point, at which point the red overspeed test LED begins flashing. There are three options at this point.

If the OVERSPEED TEST ENABLE key is released, the control trips the turbine due to an overspeed condition. The Shutdown relay deactivates and the Overspeed relay activates. The actuator current immediately drops to less than one milliamp. The message (Shutdn/Overspeed) appears in the lower LCD while (CONTROLLING PARAM) appears in the upper LCD display.

After the LED starts flashing, another option is to continue pushing both keys to increase speed beyond the overspeed trip point. If a mechanical turbine trip exists above the electrical overspeed trip, but at a speed less than the maximum speed reference speed, the turbine trips due to the mechanical overspeed trip. If the mechanical trip is set above the maximum speed reference speed, or does not exist, the speed reference set point continues to increase until it reaches the maximum speed reference speed, at which point the red LED starts flashing at twice the previous rate.

The final option after reaching the electrical overspeed trip speed is to continue pushing the OVERSPEED TEST ENABLE key and release the ADJ up key and push the ADJ down key to decrease the speed reference set point. The red overspeed test LED stops flashing when the speed set point is below the overspeed trip speed.

Any time the OVERSPEED TEST ENABLE key is released while the speed reference set point is above the maximum controlling speed and below the electrical overspeed trip speed, the speed reference set point automatically moves down toward the maximum controlling speed at the slow rate. Releasing the ADJ keys at any time causes the speed reference to stop moving.

Alarms

When an alarm condition exists, the red alarm LED illuminates and the Alarm relay activates. Pushing ALARM displays the reason for the alarm. If there is more than one cause for an alarm, pushing the STEP keys displays these additional causes.

Pushing CLR clears and deactivates the Alarm relay. Each new alarm condition causes the Alarm relay to activate, and each time it must be cleared. The red Alarm LED remains illuminated until all causes for the alarm condition have been corrected.

The alarm conditions and their LCD displays are:

LOST MPU 1 SIGNAL—Loss of number 1 MPU signal.

LOST MPU 2 SIGNAL—Loss of number 2 MPU signal.

LOST CAS SIGNAL—The input current to the cascade control is less than approximately 3 mA. The cascade control ceases to influence the speed reference. The speed set point remains at its last setting. No alarm occurs if the function was not enabled.

HIGH CAS SIGNAL—The input current to the cascade control is greater than approximately 21 mA. The cascade control ceases to influence the speed reference. The speed set point remains at its last speed setting. No alarm occurs if the function was not enabled.

LOST RMT SIGNAL The input current to the remote process control is less than approximately 3 mA. The remote process control ceases to influence the speed reference. The speed set point remains at its last setting. No alarm occurs if the function was not enabled.

HIGH RMT SIGNAL—The input current to the remote process control is greater than approximately 21 mA. The remote process control ceases to influence the speed reference. The speed set point remains at its last speed setting. No alarm occurs if the function was not enabled.

LOST KW SIGNAL—The input current to the auxiliary power (KW) control is less than approximately 3 mA, when it is not in control of the actuator position.

HIGH KW SIGNAL—The input current to the auxiliary power (KW) control is greater than approximately 21 mA. The function may or may not be in control of the actuator position.

LOST PRES SIGNAL—The input current to the auxiliary pressure (inlet or exhaust) control is less than approximately 3 mA, when it is not in control of the actuator position.

HIGH PRES SIGNAL—The input current to the auxiliary pressure (inlet or exhaust) control is greater than approximately 21 mA. The function may or may not be in control of the actuator position.

BREAKER OPEN—The generator breaker or the utility tie breaker is open. Both the remote process control and the cascade control immediately cease to influence the speed reference. This alarm may be cleared without re-closing the opened breaker by pushing CLR. This alarm function must be specifically configured during programming of the remote process control or the cascade control.

CAS & RMT ENBL—Both the remote process control and the cascade control are enabled at the same time. Neither function gains control.

Shutdowns

Listed below are all the shutdown conditions and their LCD displays. When a shutdown condition occurs, the shutdown cause is displayed in the bottom LCD while (CONTROLLING PARAM) is displayed in the top LCD.

There are two types of shutdown: a controlled shutdown and an emergency shutdown.

A controlled shutdown can be initiated while the 505 is controlling the turbine in the Run Mode. Pressing the STOP key and giving verification places the control in speed control and moves the speed reference to its minimum speed set point at the slow rate. Once the speed reference is at the minimum speed set point, the valve ramp (if used) moves to its minimum position, the Shutdown relay deactivates, and the actuator is at minimum. (If the valve ramp is not configured, the actuator goes completely closed after the speed reference reaches its minimum position.) The top LCD displays (CONTROLLING PARAM) and the bottom LCD displays (Shutdown Complete). The control remains in the Run Mode. Push the CLR key to return to (UNIT READY/SHUTDOWN) (Push RUN or PRG).

The verification feature prevents an unwanted shutdown should you accidentally push the STOP key. When STOP is pushed, the LCD displays (Manual Shutdown) (Push yes or no). At this point, you can push 1/YES to stop the turbine in an orderly fashion. Pushing 0/NO causes the LCD to return to the (CONTROLLING PARAM) display.

In an emergency shutdown, the control automatically goes to minimum actuator position. The Shutdown relay deactivates. The control displays the reason for the shutdown in the bottom LCD and (CONTROLLING PARAM) in the top LCD.

In a shutdown, the control saves all prior operating values, including the references and valve ramp positions. The control remains in the Run Mode with the Shutdown relay deactivated and the actuator current at minimum. You can review these reference and ramp values as if the turbine were operating with the Run Mode function blocks. To exit the Run Mode and return to the (UNIT READY/SHUTDOWN) (Push RUN or PRG) display, push the CLR key. The external CLR contact does not return the control to the (UNIT READY/SHUTDOWN) status.

Emergency shutdown causes and their LCD displays are listed below:

Shutdn/Manual—The actuator is at its minimum position as a result of an operator-initiated manual shutdown. The external shutdown command contacts (normally closed) are tied in series with the Emergency Stop button on the front of the control. When they are opened, the control responds the same as if the red Emergency Stop button had been pushed.

Shutdn/No MPU—The actuator is at its minimum position because all MPU signals have been lost.

Shutdn/No kW input—The actuator is at its minimum position because the power (kW) input signal has dropped below approximately 3 mA. Shutdown occurs only if the function was controlling the actuator position or power (kW) droop is used.

Shutdn/No pres in—The actuator is at its minimum position because the pressure (inlet or exhaust) signal has dropped below approximately 3 mA. Shutdown occurs only if the function was controlling the actuator position.

Shutdn/Lost Power—The actuator is at its minimum position because one or more of the internal power sources has failed.

Shutdn/Brkr Open—The actuator is at its minimum position because the tie breaker or the generator breaker has opened. Shutdown when a breaker opens is a programmable feature.

Shutdn/CPU Fault—The actuator is at its minimum position because of an internal CPU problem.

Shutdn/Overspeed—The actuator is at its minimum position as a result of an overspeed condition. When an overspeed condition exists, both the Overspeed relay and the Shutdown relay change state. Both relays can be re-armed only when the CLR key is pushed.

Chapter 5.
Service Options

Product Service Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM and Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.
- A **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

www.woodward.com/directory

Woodward Factory Servicing Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return authorization number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

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

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: **www.woodward.com**.

How to Contact Woodward

For assistance, call one of the following Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Turbine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

You can also locate your nearest Woodward distributor or service facility on our website at:

www.woodward.com/directory

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
Control/Governor #1	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Control/Governor #2	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Control/Governor #3	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix.
505 Program Mode Worksheet

The 505 Program Mode Worksheet provides a step-by-step guide for programming (configuring) the 505 control. If may be a good idea to make copies of the worksheet.

Governor Serial Number _____

Application _____

TURBINE START

MANUAL START **yes ___ no ___**
Push RUN, actuator moves to max position, operator opens T&T valve manually until governor takes control.

AUTOMATIC START **yes ___ no ____**
T&T valve left open, operator pushes RUN, control valve opens at valve ramp rate until governor takes control.

SEMIAUTOMATIC START **yes ___ no ___**
T&T valve left open, operator pushes RUN, actuator remains at mm, operator controls actuator position using valve ramp feature until governor takes control.

SPEED CONTROL

TEETH SEEN BY MPU _____
No. of teeth on gear.

MPU GEAR RATIO _____
Relationship to turbine shaft.

NUMBER OF MPUs USED **1 ____ 2 ____**
1 or2

20-160 MA ACTUATOR **yes ___ no ___**
All Woodward actuators are 20-1 60 mA.

4-20 MA ACTUATOR **yes ___ no ___**
For actuators other than Woodward.

ACTUATOR DITHER **yes ___ no ___**
Required for Woodward TM-type actuator.

SPEED GAIN _____ **%**
If value unknown set at 10% for start.

SPEED RESET _____ **%**
If value unknown set at 10% for start.

SPEED REFERENCE

MAX SPEED REFERENCE _____ **RPM**
Absolute max. speed governor will control at.

OVERSPEED TRIP _____ **RPM**
Governor only. Not to be used as ultimate protection.

MAXIMUM CONTROL SPEED _____ **RPM**
Normal governor operation upper limit.

SYNCHRONOUS SPEED _____ **RPM**
Turbine generator 50 or 60 Hz speed in rpm. Control resets to this speed if utility tie breaker opens.

BELOW SYNC SPEED _____ **RPM**
Slightly less than sync speed that governor resets to when the generator breaker opens.

MIN SPEED REFERENCE _____ **RPM**
Normal governor operation lower limit.

SPEED REF SLOW RATE _____ **RPM/SEC**
Rate of speed change for normal operation.

SPEED REF FAST RATE _____ **RPM/SEC**
Rate of speed change for critical speed range and cascade control during large changes.

CRITICAL SPEED 1 **yes ___ no____**

CRITICAL SPEED 1 MIN _____ **RPM**

CRITICAL SPEED 1 MAX _____ **RPM**

CRITICAL SPEED 2 **yes ___ no____**

CRITICAL SPEED 2 MIN _____ **RPM**

CRITICAL SPEED 2 MAX _____ **RPM**

IDLE/RATED **yes ___ no____**
Ramp from selected low speed to selected high speed actuated by external switch.

IDLE SPEED _____ **RPM**
Can be lower than mm speed ref.

RATED SPEED _____ **RPM**
Rated speed is defined as 100%' speed, this value can be less than rated however.

IDLE/RATED REF RATE _____ **RPM/SEC**
Rate at which ramp travels from Idle to Rated.

DROOP

SPEED DROOP **yes ___ no___**
Increased actuator position causes decreased speed setting.

ACTUATOR TRAVEL _____ **%**
Percent of actuator travel used from no load to full load.

SPEED DROOP _____ **%**
Percent of speed setting drop from rated speed. No load to full load. 10% maximum.

KWDROOP **yes ___ no___**
Increased kW load causes decreased speed setting. 4-20 mA input from external kW sensor required.

KW MAX LOAD _____ **KW**
Clamp on max kW desired.

KWMIN @ 4MA ____Zero____ **KW**
Will not appear on readout. 4 mA always considered zero kW.

KWMAX @ 20MA _____ **KW**

KW DROOP _____ **%**
Percent of speed setting drop from min kW to max kW. 10% maximum.

REMOTE PROCESS

RMT PROCESS CONTROL **yes ___ no ___**
Receives process signal from process controller and moves speed reference through a deadband comparator.

RMT MIN RPM @ 4MA _____ **RPM**

RMT MAX RPM @ 20MA _____ **RPM**

RMT CONTROL RATE _____ **RPM/SEC**
Rate at which speed ref. can be moved by process controller.

BREAKER LOGIC **yes ___ no____**
Alarms and shutdowns initiated by breaker opening.

BRKR OPENS SHUTDOWN **yes ___ no___**
Governor shuts down if breaker opens.

TIEBRK OPEN SHUTDOWN **yes ___ no___**

GENBRK OPEN SHUTDOWN **yes ___ no___**

TIEBRK OPEN ALARM **yes ___ no___**

GENBRK OPEN ALARM **yes ___ no___**

NO RMT CONT BRK-ALRM **yes ___ no___**
If the process control is not enabled should the unit alarm if either breaker opens?

AUXILIARY CONTROL

AUXILIARY CONTROL **yes ___ no____**
The aux. control is a separate control channel (PID) with slower dynamics than the speed control channel. Both channels bid for control of the actuator.

KW CONTROL **yes ___ no____**
Will the aux. control be used for controlling kW? If "no," proceed to pressure control section.

KW MAXIMUM LOAD **yes ___ no____**

KW MAX LOAD _____ **KW**
Max kW generator can carry.

KW MAX at 20MA _____ **KW**
4 mA will be zero kW.

KW REF LOWER LIMIT _____ **KW**

KW REF UPPER LIMIT _____ **KW**
Lower and upper limits set the range over which the kW set point operates.

KW REFERENCE RATE _____ **KW/SEC**
Rate at which kW set point ref. can be changed.

KW DROOP _____ **%**
Not more than 10%.

KW GAIN _____ **%**
If value unknown set at 10% for start.

KW RESET _____ **%**
If value unknown set at 10% for start.

PRESSURE CONTROL **yes ___ no____**
Will the aux. control be used for pressure control?

INLET PRES CONTROL **yes ___ no____**

EXHAUST PRES CONT **yes ___ no____**

PRES MIN at 4MA _____ **PSI**
Pressure at 4 mA output from transducer.

PRES MAX at 20MA _____ **PSI**
Pressure at 20 mA output from transducer.

PRES REF LOWER LIMIT _____ **PSI**

PRES REF UPPER LIMIT _____ **PSI**
Limits designate the range over which the pressure set point operates.

PRES REF RATE _____ **PSI/SEC**
Rate at which pressure ref. set point can be changed.

PRES DROOP _____ **%**
Not more than 10%.

PRES GAIN _____ **%**
If value unknown set at 10% for start.

PRES RESET _____ **%**
If value unknown set at 10% for start.

CASCADE CONTROL

CASCADE CONTROL **yes ___ no____**
Compares 4-20 mA input with cascade ref. error then moves speed ref. through a deadband comparator.

CAS IS PRES CONT **yes ___ no____**
Is the cascade to control pressure?

INVERT THE PRES **yes ___ no____**
Invert for Inlet Pressure Control.

CAS MIN PRES @ 4MA _____ **PSI**
Pressure at 4 mA output from transducer.

CAS MAX PRES @ 20MA _____ **PSI**
Pressure at 20 mA output from transducer.

CAS REF LOWER LIMIT _____ **PSI**
Lower limit of cascade set point ref.

CAS REF UPPER LIMIT _____ **PSI**
Upper limit of cascade set point ref.

CAS REFERENCE RATE _____ **PSI/SEC**
Rate at which cascade set point can be changed.

CAS PRES DROOP _____ **%**
10% maximum.

CAS IS TEMP CONT **yes ___ no___**
Is the cascade to control temperature?

INVERT THE TEMP **yes ___ no____**
Invert for refrigeration control.

CAS MIN TEMP @ 4MA _____ **°C**
Temp. at 4 mA output from transducer.

CAS MAX TEMP @ 20MA _____ **°C**
Temp. at 20 mA output from transducer.

CAS REF LOWER LIMIT _____ **°C**
Lower limit of cascade set point ref.

CAS REF UPPER LIMIT _____ **°C**
Upper limit of cascade set point ref.

CAS REFERENCE RATE _____ **°C/SEC**
Rate at which cascade set point can be changed.

CAS TEMP DROOP _____ **%**
10% maximum.

BREAKER LOG1C **yes ___ no ___**
Alarms and shutdowns activated by breaker opening.

BRKR OPEN SHUTDOWN **yes ___ no___**
Governor shuts down if breaker opens.

TIEBRK OPEN SHUTDOWN **yes ___ no____**

GENBRK OPEN SHUTDOWN **yes ___ no____**

TIEBRK OPEN ALARM **yes ___ no____**

GENBRK OPEN ALARM **yes ___ no____**

NO CAS CONT BRK-ALRM **yes ___ no____**
If the cascade control is not enabled should the unit alarm if either breaker opens?

VALVE RAMP CONTROL

VALVE RAMP **yes ___ no**
Used to move actuator from mm to max. Required for auto and semiauto start.

VALVE RAMP RATE _____ **%/SEC**
Rate at which the valve ramp moves the actuator.

RELAY OUTPUT

RELAY OUTPUT **yes ___ no___**
Used to configure relays other than three pre-assigned relays which are overspeed trip, shutdown, and alarm. Only five can be selected.

SPEED REF MAX RELAY **yes ___ no___**
Activates at max control speed.

SPEED REF MAX RELAY **Relay No. _____**
Assign relay 1 thru 5.

SPEED SWITCH RELAY **yes ___ no___**
Activates at speed switch set rpm.

SPEED SWITCH RELAY **Relay No._____**
Assign relay 1 thru 5.

SPEED SWITCH RPM _____ **RPM**
RPM at which speed switch is to activate.

PROCESS CONT RELAY **yes ___ no___**
Provides indication of when process control is enabled.

PROCESS CONT RELAY **Relay No._____**
Assign relay 1 thru 5.

KW SWITCH RELAY **yes ___ no___**
Activates when kW switch point power is obtained.

KW SWITCH RELAY **Relay No._____**
Assign relay 1 thru 5.

KW SWITCH POINT
KW at which switch is to activate.

PRES SWITCH RELAY **yes ___ no___**
Activates when pressure switch point is obtained.

PRES SWITCH RELAY **Relay No. _____**
Assign relay 1 thru 5.

PRES SWITCH POINT _____ **PSI**
PSI at which switch is to activate.

VALVE RAMP RELAY **yes ___ no____**
Activates when valve-ramp switch-point position is obtained.

VALVE RAMP RELAY **Relay No. _____**
Assign relay 1 thru 5.

VALVE RAMP SW POINT **_____ %**
Percent of actuator stroke at which switch activates.

HAND STEAM VALVE **yes ___ no____**
Provides automatic hand valve control. Can also be used for actuator position indication.

HAND VALVE NUMBER 1 **yes ___ no___**

HAND VALVE 1 RELAY **Relay No._____**
Assign relay 1 thru 5.

HAND VALVE 1 OPEN **_____ %**
Percent of actuator stroke at which valve is to open.

HAND VALVE 1 CLOSE **_____ %**
Percent of actuator stroke at which valve is to close. Value must be less than the opening percentage.

HAND VALVE NUMBER 2 **yes ___ no___**

HAND VALVE 2 RELAY **Relay No._____**
Assign relay 1 thru 5.

HAND VALVE 2 OPEN **_____ %**
Percent of actuator stroke at which valve is to open.

HAND VALVE 2 CLOSE **_____ %**
Percent of actuator stroke at which valve is to close. Value must be less than the opening percentage.

HAND VALVE NUMBER 3 **yes ___ no___**

HAND VALVE 3 RELAY **Relay No._____**
Assign relay 1 thru 5.

HAND VALVE 3 OPEN **_____ %**
Percent of actuator stroke at which valve is to open.

HAND VALVE 3 CLOSE **_____ %**
Percent of actuator stroke at which valve is to close. Value must be less than the opening percentage.

HAND VALVE NUMBER 4 **yes ___ no___**

HAND VALVE 4 RELAY **Relay No._____**
Assign relay 1 thru 5.

HAND VALVE 4 OPEN **_____ %**
Percent of actuator stroke at which valve is to open.

HAND VALVE 4 CLOSE **_____ %**
Percent of actuator stroke at which valve is to close. Value must be less than the opening percentage.

ANALOG READOUT

ANALOG READOUT **yes ___ no___**
Are 4-20 mA readouts required? Only four readouts can be selected.

SPEED INPUT READOUT **yes ___ no____**
Remote readout of turbine speed.

SPEED INPUT READOUT **Readout No. _____**
Assign readout 1 thru 4.

SPEED MIN RPM @ 4MA **_____ RPM**

SPEED MAX RPM @ 20MA **_____ RPM**
Calibrates range of 4-20 mA signal to meter.

SPEED REF READOUT **yes ___ no____**
Remote readout of governor speed setting.

SPEED REF READOUT **_____ RPM**
Assign readout 1 thru 4.

SPEED MIN REF @ 4MA **_____ RPM**
Readout No. _____

SPEED MAX REF @ 20MA **_____ RPM**
Calibrates range of 4-20 mA signal to meter.

KW INPUT READOUT **yes ___ no____**
Remote readout of kW load.

KW INPUT READOUT **Readout No. _____**
Assign readout 1 thru 4.

KW MIN @ 4MA **_____ KW**

KW MAX @ 20MA **_____ KW**
Calibrates range of 4-20 mA signal to meter.

KW REF READOUT **yes ___ no ____**
Remote readout of kW set point when in auxiliary control.

KW REF READOUT **Readout No. _____**
Assign readout 1 thru 4.

KW MIN REF @ 4MA **_____ KW**

KW MAX REF@ 20MA **_____ KW**
Calibrates range of 4-20 mA signal to meter.

PRES INPUT READOUT **yes ___ no____**
Remote readout of pressure input to auxiliary control.

PRES INPUT READOUT **Readout No. _____**
Assign readout 1 thru 4.

PRES MIN @ 4MA **_____ PSI**

PRESMAX@20MA **_____ PSI**
Calibrates range of 4-20 mA signal to meter.

PRES REF READOUT **yes ___ no____**
Remote readout of pressure set point when in auxiliary control.

PRES REF READOUT **Readout No. _____**
Assign readout 1 thru 4

PRES MIN REF @ 4 mA _____ **PSI**

PRES MAX REF@20mA _____ **PSI**
Calibrate range of 4-20 mA signal to meter.

CAS PRES IN READOUT **yes ___ no____**
Remote readout of pressure signal into cascade control.

CAS PRES IN READOUT **Readout No. _____**
Assign readout 1 thru 4.

CAS MIN PRES @ 4MA _____ **PSI**

CAS MAX PRES @ 20MA _____ **PSI**
Calibrates range of 4-20 mA signal to meter.

CAS TEMP IN READOUT **yes ___ no____**
Remote readout of temp. signal into cascade control.

CAS TEMP IN READOUT **Readout No. _____**
Assign readout 1 thru 4.

CAS MIN TEMP @ 4MA _____ **°C**

CAS MAX TEMP @ 20MA _____ **°C**
Calibrates range of 4-20 mA signal to meter.

ACTUATOR POS READOUT **yes ___ no____**
Remote readout of percent of actuator stroke.

ACT POS READOUT **Readout No. _____**
Assign readout 1 thru 4.

ACT MIN POS @ 4MA _____ **%**

ACT MAX POS @ 20MA _____ **%**
Calibrates range of 4-20 mA signal to meter.

BAUD RATE
Select baud rate for RS-232 port if used.

300 BAUD **yes ___ no___**
1200 BAUD **yes ___ no___**
2400 BAUD **yes ___ no___**

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 85003A.

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