WOODWARD

Product Manual 35117
(Revision -, 11/2019)
Original Instructions

505HT for Francis/Kaplan Turbines
8200-1402, 8200-1403

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 *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

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

Proper Use

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

Translated Publications

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

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Revisions— A bold, black line alongside the text identifies changes in this publication since the last revision.

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Important Definitions

This is the safety alert symbol 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

IOLOCK. When a CPU or I/O module fails, watchdog logic drives it into an IOLOCK condition where all output circuits and signals are driven to a known de-energized state as described below. The System MUST be designed such that IOLOCK and power OFF states will result in a SAFE condition of the controlled device.

- **CPU and I/O module failures will drive the module into an IOLOCK state**
- **CPU failure will assert an IOLOCK signal to all modules and expansion racks to drive them into an IOLOCK state.**
- **Discrete outputs / relay drivers will be non-active and de-energized**
- **Analog and Actuator outputs will be non-active and de-energized with zero voltage or zero current.**

The IOLOCK state is asserted under various conditions including

- **CPU and I/O module watchdog failures**
- **Power Up and Power Down conditions.**
- **System reset and hardware/software initialization**
- **Entering configuration mode**

NOTE: Additional watchdog details and any exceptions to these failure states are specified in the related CPU or I/O module section of the manual.

⚠CAUTION

Emergency Disconnecting Device

An emergency switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator. The switch or circuit breaker shall be clearly marked as the disconnecting device for the equipment. The switch or circuit breaker shall not interrupt the Protective Earth (PE) conductor.

⚠CAUTION

Risk of Calibration and Checkout

The calibration and checkout procedure should only be performed by authorized personnel knowledgeable of the risks posed by live electrical equipment.

⚠CAUTION

Fuse Power Supply Mains

The Power Supply MAINS should be properly fused according the NEC/CEC or Authority Having Final Jurisdiction per the Input Power Specifications.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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

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

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

Follow these precautions when working with or near the control.

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

Regulatory Compliance

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

EMC Directive Declared to Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility. (EMC)

Low Voltage Directive: Declared to Directive 2014/35/EU on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits.

North American Compliance:

CSA: CSA Certified for Ordinary Locations.
For use in Canada and the United States
Certificate 70006135

This product is certified as a component for use in other equipment. The final combination is subject to acceptance by the authority having jurisdiction or local inspection.

Special Conditions for Safe Use

A fixed wiring installation is required. Field wiring must be in accordance with the Local Inspection Authority having jurisdiction. On high voltage versions of the control the interior of the enclosure shall not be accessible in normal operation without the use of a tool.

Field wiring must be suitable for the following temperatures:

- Power Input rated minimum of +95˚C.
- All remaining connections; +10˚C above highest ambient.

A switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator. The switch or circuit breaker shall be clearly marked as the disconnecting device for the equipment. The switch or circuit breaker shall not interrupt the Protective Earth (PE) conductor.

The 505 Digital Control shall not be installed in areas exceeding Pollution Degree 2 as defined in IEC 60664-1.

Protective Earth Grounding of the 505 Digital Control is required to be connected to the PE terminal.

The Real Time Clock Battery located on the CPU board is not to be recharged and is not user replaceable. Contact a Woodward Authorized Service Center if a replacement service is needed.

This equipment must be installed in an area or enclosure providing adequate protection against high impact. (7 Joules) The control is rated for 2 Joules impact.

Chapter 1.
General Information

Introduction

This manual describes the Woodward 505HT Digital Governor for Francis or Kaplan Turbines.

The option charts below shows the part numbers and the differences between the models. 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.

Part Number Options

Part Number	Description
8200-1402	505H (LV-STD) FRANCIS/KAPLAN TURBINE CONTROL
8200-1403	505H (HV-STD) FRANCIS/KAPLAN TURBINE CONTROL

Terminology

505 Refers to the overall Woodward Product family / hardware platform
505HT Refers specifically to the Control/GUI application software features described in this manual – identified on unit p/n label and logo on Home screen

General Installation and Operating Notes and Warnings

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

> **Note:** For additional installation and operating information, see the Regulatory Compliance section of this manual.

Controller Overview

The 505HT is field programmable which allows a single design to be used in many different control applications and reduces both cost and delivery time. It uses a built in graphical user interface (GUI) with menu driven screens to instruct site engineers on configuring the control to a specific application. The 505HT can be configured to operate as a stand-alone unit or in conjunction with a plant's Distributed Control System.

Designed for hydro turbine control, the 505HT control includes four PID controllers (Offline, Online, Baseload and Isoch), start-up routine, and multiple protection functions overspeed, Small System Detection, etc.) which can be configured by a user depending on the specific turbine application's requirements. Users can configure the 505's different PID controllers, start routines, discrete and analog I/O functions and protection levels themselves without the need for a special control engineer. A first-out indication feature for system shutdowns reduces troubleshooting time. Once configured, the 505HT performs a configuration check routine to ensure that the programmer did not make any basic configuration mistakes.

This control is exclusive for Francis or Kaplan Turbines. The Actuator output 1 is dedicated to gate and the actuator output 2 is dedicated to blade (if a Kaplan turbine is being controlled). Front panel ESTOP button will shut down the actuators circuits 1 and 2.

Operator Control Panel

The 505HT is a field configurable hydro turbine control and operator control panel (OCP) integrated into one package. A comprehensive graphical operator control panel display and keypad is located on the 505HT's front panel. This display can be used to configure the 505, make On-Line program adjustments, and operate the turbine/system.

Features

The 505HT provides the following features:

- Start / Stop / unload routines
- Black Start routine
- Feed forward control
- Speed Control / Droop Control (kW and Position) / Baseload / Isoch Control
- Manual Control (for gate and Blade)
- Small System detection logic
- Level control (pond or Tail)
- Speed / Load / Gate / Blade Switches
- Gate / Blade Limit
- Remote analog setpoints for speed, level, power and manual control
- Generator breaker logic
- Brake Logic
- Integrated first-out problem indicator
- Trip and Alarm event recorder
- User-friendly menu format
- Real-time trend screens
- Real-time clock synchronization via SNTP
- Ethernet communications
- Multi-language capability

Using the 505HT

The 505HT control has three normal operating modes, Configuration Mode, Service Mode and the Run Mode.

Configuration Mode –

This mode is used to select the options needed to configure the control to your specific turbine application. While in this mode, the control will force the hardware into IO LOCK, meaning that no outputs will be active, all Relays will be de energized, and all Analog output signals will be at 0 current. Once the control has been configured, the Configuration mode is typically not needed again, unless turbine options or operation changes. It is available to be viewed at any time. A password is required to log into this mode.

⚠WARNING

Anytime the control is in IOLOCK all Relays will be de-energized and all Analog outputs will be at 0 current. Ensure that the devices receiving these commands are fail-safe at these states.

Calibration Mode –

This mode is used to calibrate, tune and adjust certain parameters either while the unit is shutdown, or during turbine run time. A password is required to log into this mode.

Operation Mode -

This mode is the typical state for normal operations of the control and the turbine. The Run Mode is used to operate the turbine from start-up through shutdown.

505 Inputs and outputs

Control Inputs

Speed Input Signals

Four speed inputs are available. Two of these are exclusively for MPUs (magnetic pickup units), and the other two are exclusively for active proximity probes.

Analog 4-20mA Input Signals

There are eight configurable analog inputs available on the 505 hardware, each of which can be configured as one of the following input functions: (the functions with "*" means that it is only available for Kaplan turbines)

Table 1-1. Selectable functions for 4-20mA Analog Inputs

1- Not used	8- Remote level reference
2- Pond level	9- Gate Position feedback
3- Generator Power	10- Blade Position feedback *
4- Speed Bias	11- Blade Position Limiter *
5- Remote Speed Reference	12- Tail Level
6- Gate Position Limiter	13- Net Head *
7- Remote Baseload reference	

Discrete Contact Input Signals

Twenty contact inputs are available. The first five inputs are dedicated for Run/Stop (DI-1), Raise Speed/load (DI-2), Lower Speed/Load (DI-3), Breaker Closed (DI-4) and Emergency Shutdown (DI-5). The rest of the additional contact inputs are available for configuration to function as various controller discrete input functions as listed below (the functions with "*" means that it is only available for Kaplan turbines).

Table 1-2. Selectable functions for Discrete Inputs

1- Not Used	17 - Remote Fault #3
2- Manual Gate Control Enable	18 - Remote Fault #4
3- Pond / Tail Level Control Enable	19 - Remote Fault #5
4- Gate Limit Raise	20 - Remote Fault #6
5- Gate Limit Lower	21- Enable Remote Speed
6- Creep input #1	22- Enable Remote Baseload
7- Creep input #2	23- Enable Remote Level
8- Reset	24- Overspeed test Enable
9- External Start Permissive	25- Manual Blade Control Enable *
10- Sync Enable	26- Manual Blade Position Raise *
11- Baseload Enable	27- Manual Blade Position Lower *
12- Unload	28- Enable Blade Tilt *
13- Local / Remote	29- Enable Blade Lock *
14- Load droop Enable	30- Isochronous Arm / Disarm *
15- Remote Fault #1	31- Blade Limit Raise *
16 - Remote Fault #2	32- Blade Limit Lower *

On the front panel display there are 4 additional keys that are always available for operational functions (GREEN keys) – Start/Stop/Reset and Adjust Up/Down for raising or lowering a highlighted value.

Control Outputs

Actuator Outputs

Two 4-20mA or 20-160mA actuator outputs are available for use. These outputs are defined to be used as Gate and Blade (for Kaplan turbines) and cannot be used for other functions.

WARNING

Front panel ESTOP button will shutdown the actuators circuits 1 and 2 (remove actuator power), while pressed. The actuation system should be prepared to handle this situation.

Analog 4-20mA Outputs

Six 4–20 mA analog outputs are available for use and each can be configured as one of the following output functions: (the functions with "*" means that it is only available for Kaplan turbines)

Table 1-3. Selectable functions for 4-20mA Analog Outputs

1- Not Used	8- Speed Reference
2- Tachometer	9- Level Reference
3- Gate Position	10- Baseload Reference
4- Blade Position *	11- Speed Bias
5- Pond Level	12- Generator Power
6- Tail Level	13- Gate Limit Value
7- Net Head	14- Blade Limit Value *

Relay Outputs

Eight Form-C relay contact outputs are available. Each relay can be programmed to provide a contact related to a conditional state as listed (the functions with "*" means that it is only available for Kaplan turbines).

Table 1-4. Selectable functions for Relay Outputs

1- Not Used	26- Remote Speed Signal Fail
2- Gate Position Switch #1	27- Speed Bias Input Signal Fail
3- Gate Position Switch #2	28- Incomplete Start
4- Gate Position Switch #3	29- Total Speed Signal Fail
5- Gate Position Switch #4	30- Speed Signal #1 Fault
6- Speed Switch #1	31- Speed Signal #2 Fault
7- Speed Switch #2	32- Speed Signal #3 Fault
8- Speed Switch #3	33- Speed Signal #4 Fault
9- Speed Switch #4	34- Analog Gate Limiter Signal Fail
10- Speed Switch #5	35- Remote Baseload Signal Fail
11- Speed Switch #6	36- Power Transducer Signal Fail
12- General Governor Alarm	37- Internal Fault
13- Creep indication	38- Control Powered On
14- Speed Bias Enabled	39- Blade Position Switch #1 *
15- Start Permissive Enabled	40- Blade Position Switch #2 *
16- Overspeed Shutdown	41- Blade Position Switch #3 *
17- Gen Breaker open Command	42- Blade Position Switch #4 *
18- Active Power Switch #1	43- Analog Blade Limiter Signal Fail *
19- Active Power Switch #2	44- Trip Relay #1
20- Active Power Switch #3	45- Trip Relay #2
21- Active Power Switch #4	46- Baseload Control Enabled
22- Ready for Start	47- Level Control Enabled
23- Turbine Stable Speed	48- Isoch Control Enabled
24- Reset Command	49- Manual Gate Control Enabled
25- Level Signal Fail	50- Apply Brakes

Control Communication Interfaces

A complete Modbus list of information is available for HMI, plant DCS or other control interfaces. Five channels are available for this communication method, 4 Ethernet (RJ45) ports and 1 serial port. The serial port protocol can be either ASCII or RTU and the communications can be RS-232 or RS-485. The Ethernet links are TCP and can be connected to Ethernet ports 1, 2 or 3 (not restricted to one TCP channel per port).

The control also communicates Servlink protocol (Woodward proprietary) via the Ethernet ports. Using Woodward's Servlink to OPC Server tool any PC can use this connection to communicate to the control and relay OPC data to the various service tools that support the product.

CAN

The CAN communication ports are available for interfacing the control application with other products. This feature is not being used.

Keypad and Display

Graphical Display Key Inputs

The front panel display is designed to provide the user with multiple levels of access for configuring, calibrating, tuning, operating, and monitoring the turbine operation. No additional control panels are required to operate the turbine, every turbine control function can be performed from the 505's front panel.

Figure 1-1. 505 Keypad and Display

A description of each key's function follows.

Hard Key Commands

NUMERIC KEYPAD: These are available for entering numeric values or text strings directly into the control when a configurable or programmable edit field has been selected. The bottom row of keys have some special features.

This is a backspace and delete (used when entering text)

In text mode this functions as a Shift key. When making analog adjustments with the ADJUST key – pressing this key at the same time as the ADJUST will invoke a 'Fast' rate of adjustment

Brightness key – hold this down and then use the ADJUST key to increase/decrease the screen brightness

EMERGENCY TRIP KEY: This will Trip the Turbine and remove all current from the Actuator outputs (zero current) while pressed.

LED

Four LED's are on the left side – a Summary Trip, Summary Alarm, IO Lock, and CPU Health. The first two are controlled solely by the GAP program and relate to the status of the control. The IOLOCK and CPU LED's relate to the H/W status and are identical to these same indications on the back of the 505

VIEW buttons will jump to the Trip or Alarm Summary screen to show these events in sequence with time stamp.

MODE button will jump to a Login screen that allows the user to view current permissions and allow access to changing the user login level

ESC Key – this will always step the user 'back' one page from the current page displayed

HOME Key

Brings the user to the Home menu.

NAVIGATION CROSS KEYS

These are the primary keys for navigating from page to page, or for navigation of the FOCUS on any page.

Soft Key Commands – Dependent on the screen currently in view – the user must use the navigation cross keys to move the "Focus" to the desired component

GREEN KEYS

Generally perform Operational Actions – such as Enabling, Disabling, Starting, Stopping, Tuning or Adjusting values

MAROON KEYS

Generally perform Navigational actions that escort the user through the screen menus

BLACK KEYS

Are soft-key functions that relate to the display indication located above them. They can be navigational or operational. These items do not require “Focus”, they are always available on that particular screen.

Watchdog Timer/CPU Fault Control

The IO Lock and CPU Health LED’s on the front left side of the display – are always in an identical state as the LED’s on the back side of the control. They are completely controlled by the 505 control hardware and are not controlled by the GAP application.

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

Chapter 2.
Hardware Specifications

Flex 500 Description and Features

The Flex505 controller is a significant upgrade to the existing 505 product line with enhanced CPU, Graphical display, communications, and I/O functions.

Note: This controller supports expanded I/O options when using Woodward CAN distributed I/O nodes.

Features

- Same installation/mounting as current 505
- 8.4” LCD Display (800x600) and Keypad
- (LV) input power: 18-36 Vdc input, isolated
- (HV) input power: 88-264 Vac / 90-150 Vdc, isolated
- Operating range of –30 °C to +70 °C (with display)

Communications

- (4) Ethernet 10/100 communication ports, isolated
- (4) CAN communication ports (1 Mbit), isolated
- RS-232/RS-485 port, isolated
- RS-232 Service port, isolated

I/O circuits

- GAP configurable update rates of 5 ms to 160 ms
- (2) Speed Sensor inputs (MPU/Prox) (with Prox Power)
- (8) Analog input 4-20 mA channels (with Loop Power)
- (6) Analog output 4-20 mA channels
- (2) Actuator output channels (configurable 4-20 mA/20-200 mA)
- (20) Discrete input channels (with Contact Power)
- (8) Relay outputs (form-c)

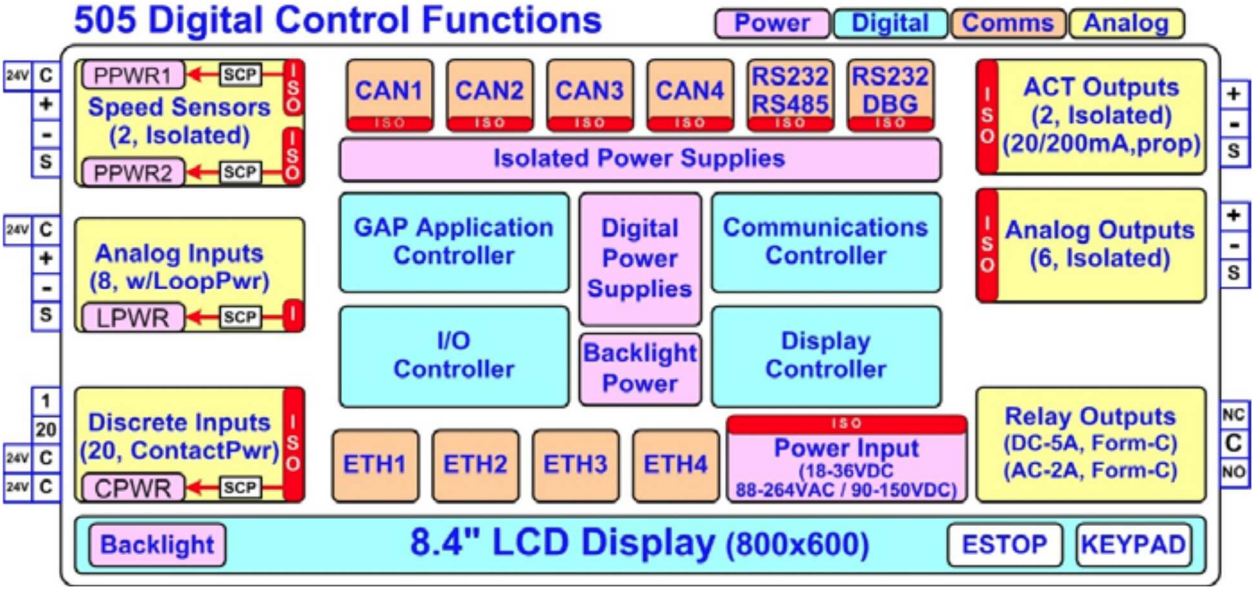


Figure 2-1. Functional Block Diagram (505 Control)

Environmental Specifications

Table 2-1. Environmental Specifications

Operating Temperature 1:	–30 °C to +70 °C (with display)
Storage Temperature:	–30 °C to +70 °C (recommended 10 °C to 40 °C)
Vibration:	8.2 Grms, industrial skid mount, per Woodward RV1
Shock 2:	10 G, 3x each axis, per Woodward MS1 procedure
Humidity 3,4:	5 % to 95 %, non-condensing
Altitude:	3000m (9842 ft.)
Ingress Rating / Installation 5:	IP20, Pollution Degree2, Overvoltage Category 2
Conformal coating:	Polyacrylate, sulfur resistant (see AppNote #51530)
EMC Emissions 6	EN 61000-6-4 (Heavy Industrial) IACS UR E10 (Commercial Marine)
EMC Immunity 6	EN 61000-6-2 (Heavy Industrial) IACS UR E10 (Commercial Marine)

1. Limited by LCD display
2. Limited by internal relay specification
3. Relative humidity levels of < 55% will prolong LCD life
4. Cyclic condensing humidity is supported with an appropriate enclosure

Maintenance Info and Recommendations

The 505 Control is designed for continuous operation in a typical industrial environment and includes no components that require periodic service. However, to take advantage of related product software and hardware improvements, we recommend that your product be sent to a Woodward Authorized Service Facility after every five to ten years of continuous service for inspection and component upgrades.

Clock battery

The Real Time Clock (RTC) battery is designed to last approximately 10 years during normal turbine operation. When powered, the RTC automatically disables the battery usage to preserve it. During power-off the battery is enabled and only used to maintain date and time. For long term storage, the battery is specified to last > 5 years.
The RTC battery is a replaceable lithium coin cell Woodward PN 1743-1017. Contact a Woodward Authorized Service Center if a replacement service is needed.

Calibration and Functional verification

It is recommended to verify calibration and functional operation every 24-36 months.
This is especially important for spare units that need to be ready for immediate use.
Contact a Woodward Authorized Service Center for assistance.

Aluminum Electrolytic capacitors

It is recommended to apply power to spare units every 24-36 months for 3 hours to reform the electrolytic capacitors used in the power module.

Display LCD with backlight

The 505 uses a low power LED backlight display with a life expectancy of 60K hours to half brightness, at maximum operating temperature. If the display appears dim, use the “SCREEN SETTINGS” menu to verify the brightness setting and adjust as needed with the ADJ ARROW-BRIGHTNESS keypad combination. Contact a Woodward Authorize Service Center for a replacement display when damaged or if display quality is unacceptable.

Electromagnetic Compatibility (EMC)

The Flex500 product family complies with Heavy Industrial EMC requirements per EN 61000-6-4 & EN 61000-6-2 specifications. Marine Type Approval is also met per IACS UR E10 EMC test requirements when a Marine qualified version is used.

Emissions EN 61000-6-4 & IACS UR E10

- Radiated RF Emissions Limits 150 kHz to 5000 MHz per IEC 61000-6-4 & Marine Type Approval.
- Power Line Conducted RF Emissions Limits 10 kHz to 30 MHz per IEC 61000-6-4 & Marine Type Approval.

Immunity EN 61000-6-2 & IACS UR E10

- Electrostatic Discharge (ESD) immunity to ±6 kV contact / ±8 kV air per IEC 61000-4-2.
- Radiated RF Immunity to 10 V/m from 80 MHz to 3000 MHz per IEC 61000-4-3.
- Electrical Fast Transients (EFT) Immunity to ±2.0 kV on I/O and Power Supply inputs per IEC 61000-4-4.
- Surge Immunity on DC Power Supply inputs to ±1.0 kV line to earth and ±0.5 kV line to line per IEC 61000-4-5.
- Surge Immunity on AC Power Supply inputs to ±2.0 kV line to earth and ±1.0 kV line to line per IEC 61000-4-5.
- Surge Immunity on I/O to ±1.0 kV line to earth per IEC 61000-4-5.
- Conducted RF Immunity to 10 V (rms) from 150 kHz to 80 MHz per IEC 61000-4-6.
- Conducted Low Frequency Injection Immunity at 10% of the nominal supply level from 50 Hz to 12 kHz on Power Inputs per Marine Type Approval test requirements.

Outline Drawing for Installation

The physical outline dimensions for the 505 control are shown below. See Woodward Reference drawing 9989-3210 for additional details if necessary.

NOTICE

This 505 unit has the identical mounting hole pattern as the previous version, however the holes do not come through the front of this unit; therefore mounting screws of correct length must be used.

NOTICE

Mounting of the 505HT and Flex500 with the LCD Display and Keypad must be in the vertical orientation with the ventilation slots at the top and bottom of the control. The surrounding air temperature of the control cannot exceed 70°C.

Panel Mounting information –

- There are 8 x 10-32 UNF-2B tapped holes that are used to mount the 505.
- The holes are tapped to 0.312” min Depth. Choose the proper length screw to not exceed this depth into the Bezel.
- Use screw 1069-949 (.375 Long, 10-32) for panel thickness (including washers) .065” - .100"
- Use screw 1069-948 (.438 Long, 10-32) for panel thickness (including washers) .101”- .125”
- Use screw 1069-946 (.500 Long, 10-32) for panel thickness (including washers) .126” - .187”

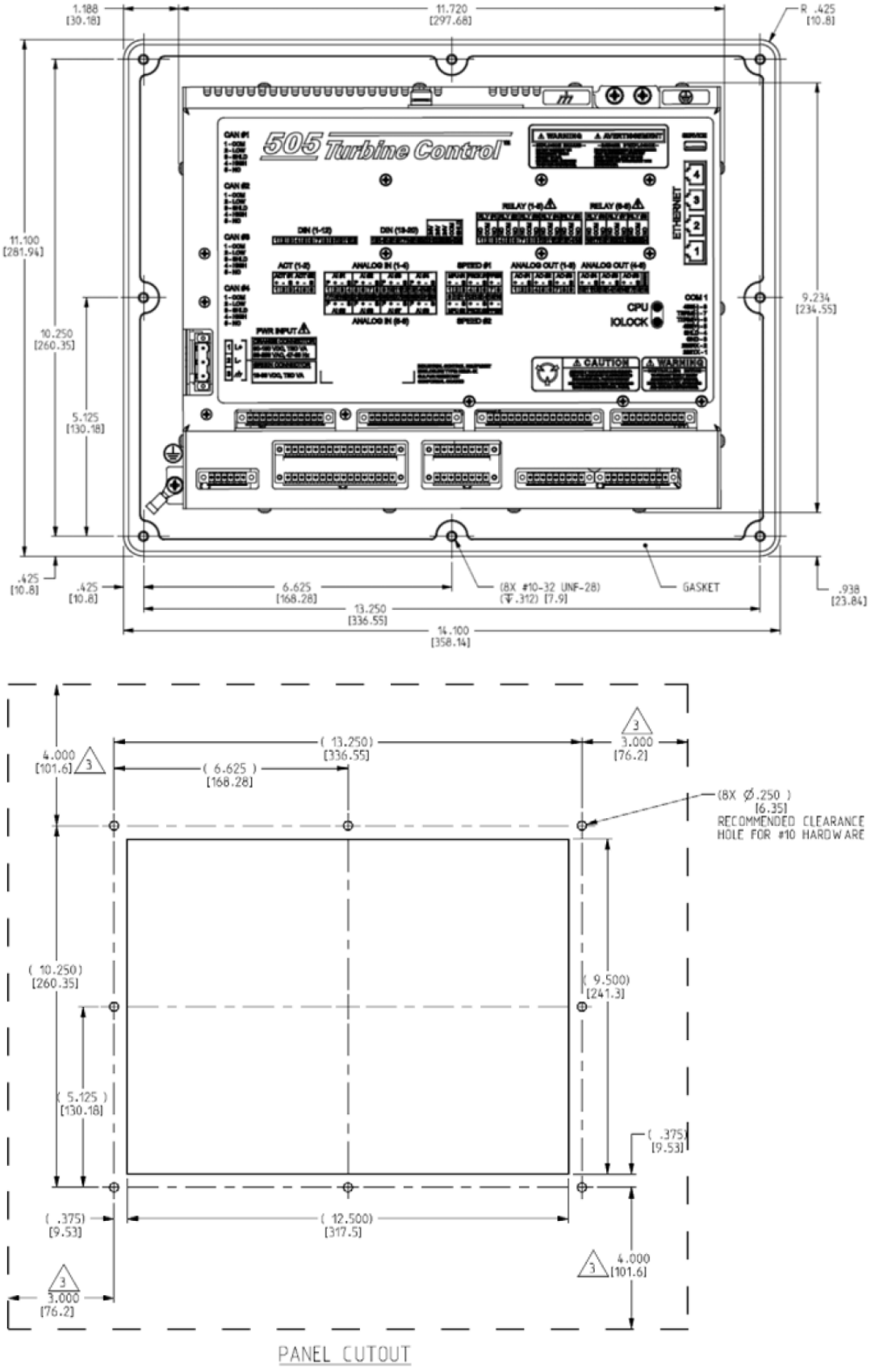


Figure 2-2. 505D Outline Drawing

Input Power Specification

Table 2-2. Specifications (LV)

LV Input Voltage range:	18-36 Vdc
Input Power (max):	< 77 W, 4.3 A max
Output Voltage Holdup time:	> 14 ms with 24 Vdc input voltage
Isolation to other circuits:	> 500 Vrms to all other circuits
Isolation to EARTH:	> 500 Vrms to EARTH
Input Overvoltage Protection:	±60 Vdc @ 25 °C
Reverse Polarity Protection:	60 Vdc @ 25 °C
Input Undervoltage shutdown:	~11 Vdc, non-latching

Note: Breaker or power-line fusing of 8 A min is recommended to protect the power wiring network from possible wiring shorts.

Table 2-3. Specifications (HV)

HV Input Voltage range:	88-264 Vac / 90-150 Vdc
HV Input Frequency range:	45-65 Hz
Input Power (AC max):	< 73 W, 1.6 A max
Input Power (DC max):	< 73 W, 0.8 A max
Output Voltage Holdup time:	> 30 ms with 110 Vac input voltage
Output Voltage Holdup time:	> 120 ms with 220 Vac input voltage
Isolation to other circuits:	> 3000 Vrms to all other circuits
Isolation to EARTH:	> 1500 Vrms to EARTH
Input Overvoltage Protection	±375 Vdc @ 25 °C
Reverse Polarity Protection:	375 Vdc
Input Undervoltage Shutdown:	~65 Vdc, non-latching

Note: Breaker or power-line fusing of 3.5 A min is recommended to protect the power wiring network from possible wiring shorts.

Power Connector

Input Power is provided through a 3 position, latching terminal block with removable plug. Green connectors are used for low voltage DC units. Orange connectors are used for high voltage AC/DC units.

Table 2-4. Input Power Connector Pinout

Plug Type: Side entry 7.62 mm, 12 A, pluggable with latching screw down

PIN	Name	Description
1	L+	Input Power (+)
2	L-	Input Power (-)
3	EARTH	Earth / shield connection

⚠WARNING

Electric Shock

To reduce the risk of Electrical Shock the Protective Earth (PE) must be connected to the PE ⏚ terminal on the enclosure. The conductor providing the connection must have a properly sized ring lug and wire gauge equal to or larger than 4mm² (12AWG).

Visual Indicators (LED's) & CPU Configuration

Visual indicators are located on the Front Panel keypad, the controller board, back cover, and related communications ports for diagnostic use.

CPU OK indicator (green/red)

This bi-color LED indicates the CPU status is operational (green) or faulty (red).
The CPU will flash fault codes (red) if they exist. This LED exists on both the Front Panel and back cover.

IOLOCK indicator (red)

Indicate the controller is shutdown and held in an IOLOCK state. This LED exists on both the Front Panel and back cover.

ALARM indicator (yellow)

Viewable from the front panel and controlled by GAP software.

TRIPPED indicator (red)

Viewable from the front panel and controlled by GAP software.

Ethernet LED's

(green=link, yellow=traffic) on each RJ45 connector indicate port status and operation.

CPU Hardware Configuration

The CPU Configuration Switch (S1) is reserved for future use and is not active at this time.

Communications (Ethernet)

There are (4) isolated RJ45 Ethernet Ports (10/100 Mbit/sec) available to the application software for system use. These ports are full duplex with auto crossover detection.

Features

- Interface standard: IEEE 802.3 (Ethernet)
- Port Isolation: 1500 Vrms to PS, EARTH, and all other circuits
- Control configuration using Woodward AppManager
- Control monitoring, trending, and datalog collection
- Control configuration of Ethernet IP addresses
- General communications such as Modbus master/slave
- Manage Configuration data and tunables with Control Assistant
- Network time setup and control (SNTP)

Network Configuration.

Ethernet ports (ETH1-4) can be configured for the customer network as desired.
See the on-site Network Administrator to define an appropriate I/P address configuration.

IMPORTANT

ETHERNET CABLES—Max cable length is 100 meters. To ensure signal integrity and robust operation, double shielded (SSTP) Cat5 Ethernet cables are required for customer installations. (Woodward PN 5417-394, 10 feet)

IMPORTANT

This module has been factory configured with fixed Ethernet IP addresses of

- **Ethernet #1 (ETH1) = 172.16.100.15, Subnet Mask = 255.255.0.0**
- **Ethernet #2 (ETH2) = 192.168.128.20, Subnet Mask = 255.255.255.0**
- **Ethernet #3 (ETH3) = 192.168.129.20, Subnet Mask = 255.255.255.0**
- **Ethernet #4 (ETH4) = 192.168.130.20, Subnet Mask = 255.255.255.0**

IMPORTANT

Each of the ETHERNET ports is required to be configured for a unique subnet (domain) (view default settings as an example).

Table 2-5. Ethernet Ports #1-4 (10/100)

Board Connection	Description
	Pin 1 – TX+ Pin 2 – TX- Pin3 – RX+ Pin 4 – Not used Pin 5 – Not used Pin 6 – RX- Pin 7 – Not used Pin 8 – Not used SHIELD = Chassis GND

Network Configuration Utility (AppManager)

Woodward's AppManager™ software can be used to configure network setting and load Control software (GAP), HMI display software (QT), and operating system service packs. The AppManager utility can be downloaded from www.woodward.com/software.

A PC connection must be made to Ethernet #1 (ETH1) using a RJ45 Ethernet cable.

Note: AppManager can always be used to “discover/view” the current CPU IP Address. However, to modify settings or load applications, the PC running AppManager must be reconfigured to be on the same “network” as the CPU.

- Locate the ControlName on the module faceplate and highlight it in AppManager.
- To VIEW the IP address configuration, select menu option CONTROL - CONTROL INFORMATION. Look for the Ethernet adapter addresses under the Footprint Description.
- To CHANGE the IP address configuration, select menu option CONTROL - CHANGE NETWORK SETTINGS.

Communications (CAN)

Four (4) Isolated CAN ports are available for general communications as well as simplex or redundant distributed control. Compatible devices include Woodward RTCnet nodes, LINKnet HT nodes, DVP valve products, and other 3rd party devices. Removable latching connector plugs are provided for field wiring.

Network Termination: CAN networks must include a 120 Ω termination resistor at each end of the trunk line.

Network Topology: Daisy chain connections between multiple devices are recommended. Any drop cable connection of a device to the trunk line should be as short as possible and much less than 6 meters. It is recommended to design the network trunk to be less than 100 meters with a max cumulative drop length of less than 39 meters.

Important: For 1 Mbit/sec communication it is required that each drop cable be less than 1 meter and as short as possible.

Table 2-6. CAN Specifications

Interface Standard	CAN 2.0B, CANopen
Network Connections	(4) CAN ports, separate connectors
Network Isolation	500 Vrms to EARTH, other CAN ports, all other I/O
Network Speed/Length	1 Mbit @ 30 m 500 Kbit @ 100 m 250 Kbit @ 250 m (thick cable only, otherwise limited to 100 m) 125 Kbit @ 500 m (thick cable only, otherwise limited to 100 m)
Network Termination:	(120 ± 10) Ω is required at each end of the network trunk line. **The termination resistor is NOT built into the hardware.
CAN Address	Software configurable
CAN Baud Rate	Software configurable for 125 K, 500 K, 250 K, and 1 Mbit
Cable / Part Number	2008-1512 (120 Ω, 3-wire, shielded twisted pair) —Belden YR58684 or similar
Cable Drops (1 Mbit)	CAN Cable drops shall be < 1 m and as short as possible
Cable Drops (500K, etc)	CAN Cable drops shall be < 6 m and as short as possible

**If needed, an isolated CAN to USB converter is IXXAT, HW221245

Table 2-7. CAN Connector Pinout

PIN	Name	Description
1	BLACK	CAN Signal Ground
2	BLUE	CAN Low
3	Shield	CAN Shield (30 Meg + AC coupled to EARTH
4	WHITE	CAN High
5	n/a	Not used, no internal connection

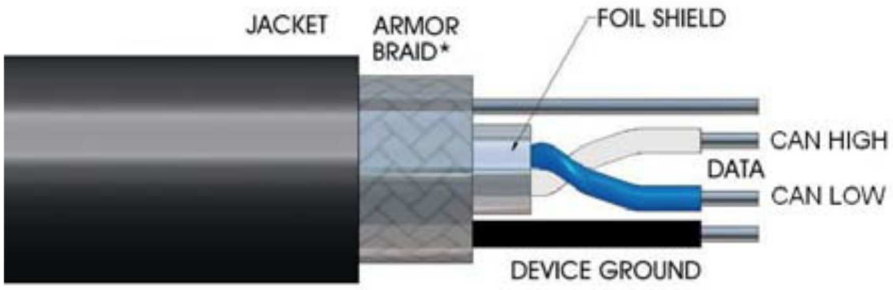
Plug Type: Side entry 3.5 mm, 8 A, pluggable with latching screw down
Max wire size: 1.3 mm² / 16 AWG for single wires, 0.5 mm² / 20 AWG for two wires

CAN Cable Specifications

Belden YR58684 (Woodward PN 2008-1512) communications / CAN cable is approved and recommended. This is a smaller and more flexible 0.3 mm² / 22 AWG, low capacitance cable suitable for tight routing in industrial environments.

Table 2-8. CAN Cable Specifications

Belden YR58684, bulk cable (Woodward PN **2008-1512**)



Impedance	120 Ω ±10 % at 1 MHz
DC resistance	17.5 Ω per 1000 ft
Cable capacitance:	11 pF/ft at 1 kHz
Data Pair:	0.3 mm² / 22 AWG, 7 strands, individually tinned, FEP insulation (BLUE, WHITE twisted pair)
Ground:	0.3 mm² / 22 AWG, 7 strands, individually tinned, FEP insulation (BLACK)
Drain / Shield Wire:	0.3 mm² / 22 AWG, 7 strands, individually tinned
Shielding:	Foil 100 % with outer Braid 65 %
Jacket:	FEP Insulation, BLACK
Cable type:	1.5 pair, twisted shielded
Outer Diameter:	0.244 inch
Bend Radius:	2.5 inches
Temperature:	–70 °C to +125 °C
Similar Cable:	Belden 3106A (has different colors & lower temperature specs)

CAN Wiring / Shield Terminations & Limitations

For robust communications performance, the CAN cabling needs to minimize the exposed, non-shielded cable section that occurs at terminal blocks. The exposed length of CAN wiring must be limited to less than 3.8 cm / 1.5 inches from the end of the shield to the terminal block.

CAN shields are terminated to chassis (EARTH) through a capacitor-resistor network. This is designed into the Flex500 / 505 hardware products. However, the shield must also be directly terminated to chassis (Earth) at one point in the network. In the case of Woodward equipment, the direct ground is meant to be located at the master device end, as it exits the master device's enclosure.

IMPORTANT

Always use shielded cables for improved communications in industrial environments. Wire terminations should expose as little un-shielded cable as possible (less than 3.8 cm / 1.5 inches).

Communications (RS-232/RS-485)

An isolated, configurable RS-232 / 485 serial port is available for customer use, as configured by the GAP software application. RS-422 communications is NOT supported.

Table 2-9. Communications (RS-232/RS-485) Specifications

Interface standard:	RS-232C and RS-485
Isolation:	500 Vrms to EARTH and all other I/O
Baud Rates:	19.2K, 38.4K, 57.6K, and 115.2 K
Max Distance (RS-232):	15 m (50 feet) max
Max Distance (RS-485):	1220 m (4000 feet) max
A shielded cable is required when using this port.	
RS-485 networks require termination at both ends with approx. 90–120 Ω impedance that matches the characteristic impedance of the cable used.	

Cable Note: Woodward cable 2008-1512 (3-wire) is a shielded, low capacitance 120 ohm cable that is designed for communications. This cable is also used for CAN communications.

Table 2-10. COM1 Serial port (RS-232/485)

Board Connection	Description
 (8 pins)	Pin 1 – RS232 Transmit Pin 2 – RS-232 Receive Pin 3 – Signam Common Pin 4 – Shield (AC) Pin 5 – RS-485 (+) Pin 6 – Termination Resistor (+) Pin 7 – Termination Resistor (-) Pin 8 – RS-485 (-)

Plug Type: Side entry 3.5 mm, 8 A, pluggable with latching screw down
Max wire size: 1.3 mm² / 16 AWG for single wires, 0.5 mm² / 20 AWG for two wires

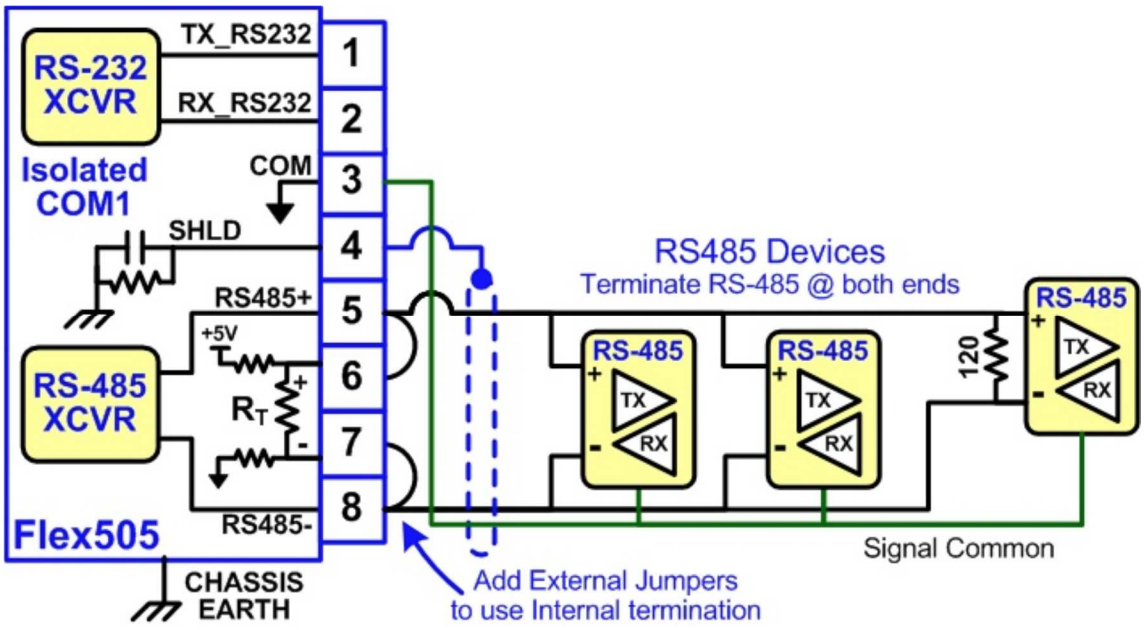


Figure 2-3. COM1 Example RS-485 wiring

Communications (Service Ports)

RS-232 Service Port

An isolated RS-232 service port is located on the CPU board. Isolation is specified at 500 Vrms and baud rate is fixed at 115.2K baud, 8 data bits, no parity, 1 stop-bit, and no flow control. This port is for VxWorks operating system use only and cannot be configured for application software use.

For debug use, a Woodward PN 5417-1344, USB to serial debug cable is required to attach this port to a PC. **This port is to be used by trained Field Service personnel only!**

Table 2-11. CPU Service Port (3 pin, 2 mm)

Dura-Click connector (male)
Pin 1 – RS232 Transmit
Pin 2 – RS-232 Receive
Pin 3 – Signam Ground

USB Service Port

Note: A USB service port is provided for future use, but is disabled.

Hardware - Terminal Blocks & Wiring

Back cover view with wiring label.

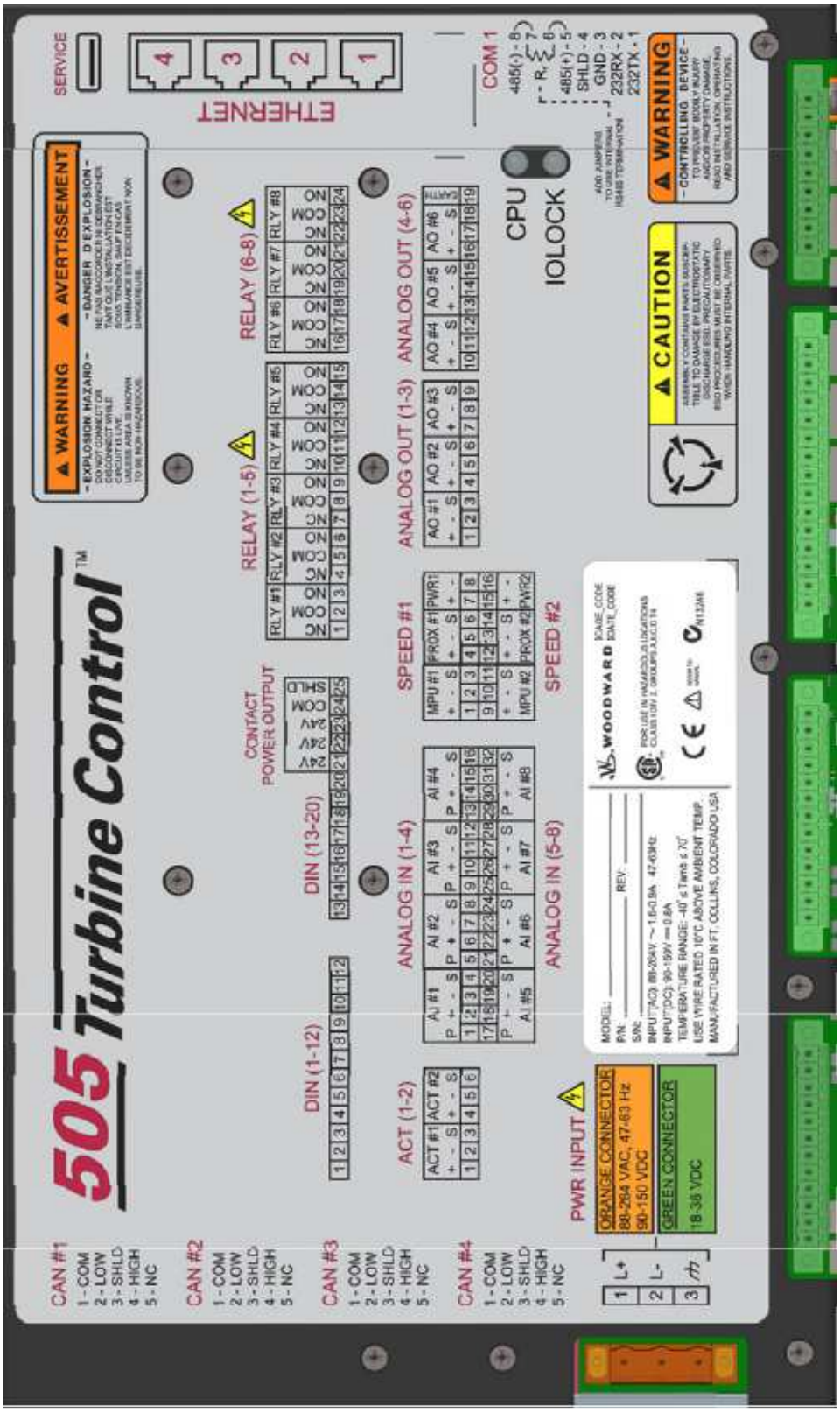


Figure 2-4. 505 Back Cover Label

Terminal Block Connectors

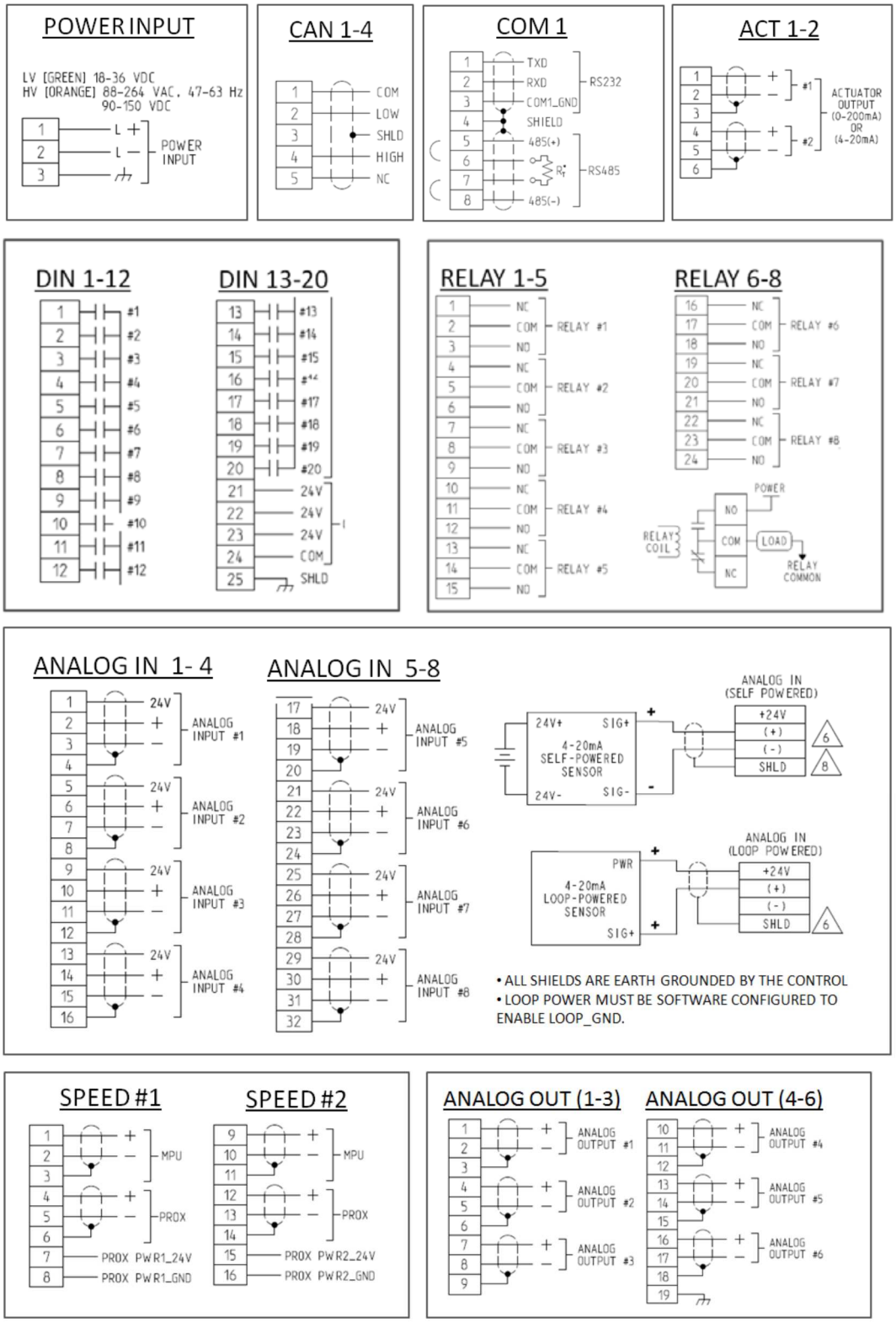


Figure 2-5. Terminal Block Connectors

Hardware - Speed Sensor Inputs

This controller includes four (4) Digital Speed Sensor circuits that are capable of interfacing to MPU (2) and Proximity speed probe sensors (2). Each channel is isolated from each other. A dedicated and isolated, PROX power (+24 V) is provided on each channel for proximity sensor use.

Note: Do not use the Prox Power outputs to power any other type devices.

Features

- Four (4) Digital Speed Sensor circuits, isolated individually
- Separate terminals provided for MPU and Prox sensors
- Isolated Prox Power (+24 Vdc) is provided with short-circuit protection
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Table 2-12. Specifications (SSI)

MPU Input Voltage:	1 to 35 Vrms
MPU Input Frequency:	10 Hz to 35 KHz
MPU Input Impedance:	2000 Ω, DC
MPU Input Isolation:	500 Vrms to EARTH and all other I/O 500 Vrms to other MPU and PROX channels
Prox Input Voltage:	0-32 VDC
Prox Input Frequency:	0.04 Hz to 35 KHz (low limit depends on range)
Prox Input Impedance:	2000 Ω, DC
Prox Threshold:	Low is < 8 VDC, High is > 16VDC
Prox Input Isolation:	500 Vrms to EARTH and all other I/O 500 Vrms to other MPU and PROX channels.
Prox Power1+2 outputs:	24 VDC ± 14%, 0-200 mA, short circuit & diode protected
Prox Power Isolation:	500 Vrms to EARTH, all other I/O, & other Prox Power
Max Speed Range:	software selectable from 5 kHz to 35 kHz
Accuracy (-40,70c):	< ±0.01% of full scale range selected
Resolution:	> 22 bits
Speed Filter (ms):	5-10,000 ms (2 poles)
Derivative Filter (ms):	5-10,000 ms (speed filter + 1 pole)
Derivative Accuracy:	0.1% of full scale range, over full temperature range
Acceleration limit:	1-10,000 %/sec

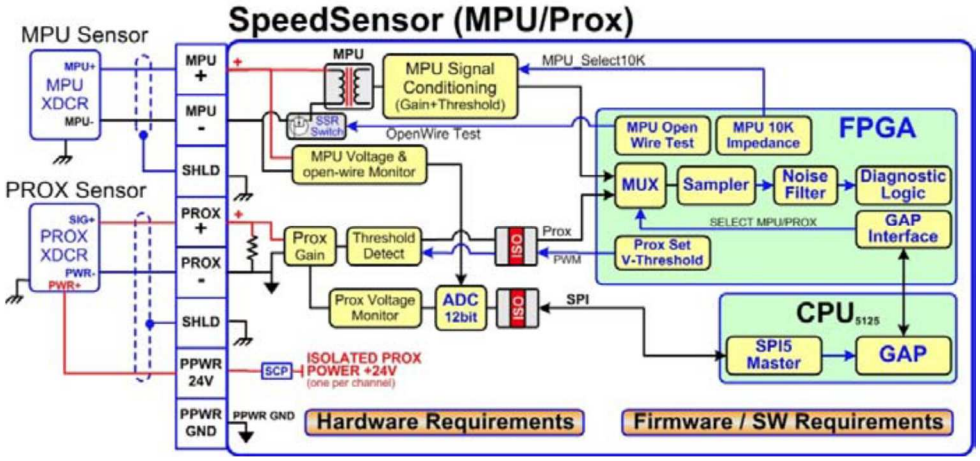


Figure 2-6. Speed Sensor Block Diagram

Hardware - Analog Inputs (4-20 mA)

AI Description and Features

The Flex500 controller includes eight (8) 4–20 mA input channels for I/O monitoring and control. Each channel is differential (self-powered) but can be software configured for Loop Power mode. An Isolated Loop Power (+24 Vdc) is provided for analog input transducers and includes short-circuit/over-voltage protection.

Note: Do not use the Loop Power output to power any other type devices.

Features

- Eight (8) 4–20 mA Analog Input Channels, 16 bit resolution
- Differential inputs with high common-mode voltage capability
- Isolated Loop Power +24 V is provided with short-circuit protection
- Fast AI channel #8 for special control functions
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms
- GAP configurable for Loop power operation

Table 2-13. Specifications (AI)

Number of channels:	8
AI Input Range:	0 to 24 mA
AI Input Isolation	0 V channel to channel. 500 Vrms to EARTH and all other I/O (except USB)
AI Accuracy (@ 25 °C):	≤ 0.06 mA (0.25% of FS=24 mA)
AI Accuracy (–40, +70 °C):	≤ 0.024 mA (0.1% of FS=24 mA)
AI Resolution:	~16 bits of full scale 2 poles @ ~10 ms
AI Hardware filter:	**Fast channel (ch 8) has 2 poles @ ~5 ms
AI Input Impedance:	200 ohms (Rsense = 162 ohms)
AI Loop power output”	24 V ±14% (0-250 mA) short circuit & diode protected
AI Loop power Isolation:	500 Vrms to EARTH and all other I/O
AI CMRR over temp:	> 70 dB @ 50/60 Hz (typical 86 db)
AI CMVR:	> 200 V (dc) to EARTH
AI Overvoltage:	±36 V (dc) continuous at room temperature

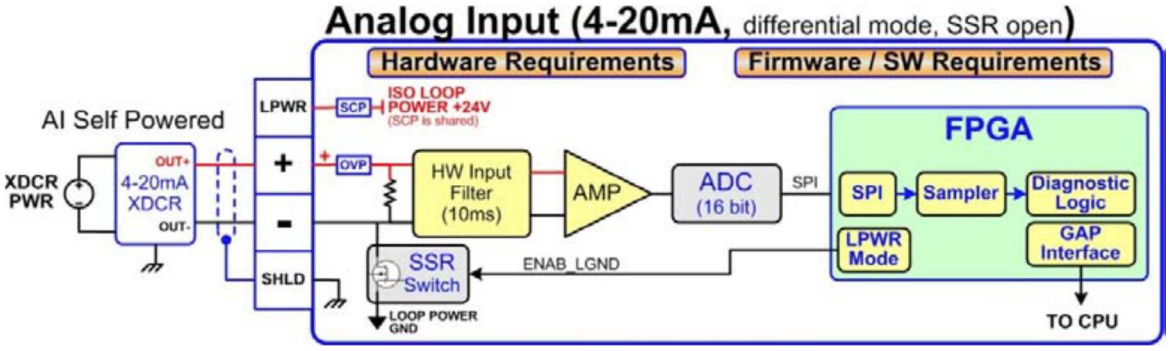


Figure 2-7. Analog Input – Self-Powered Block Diagram

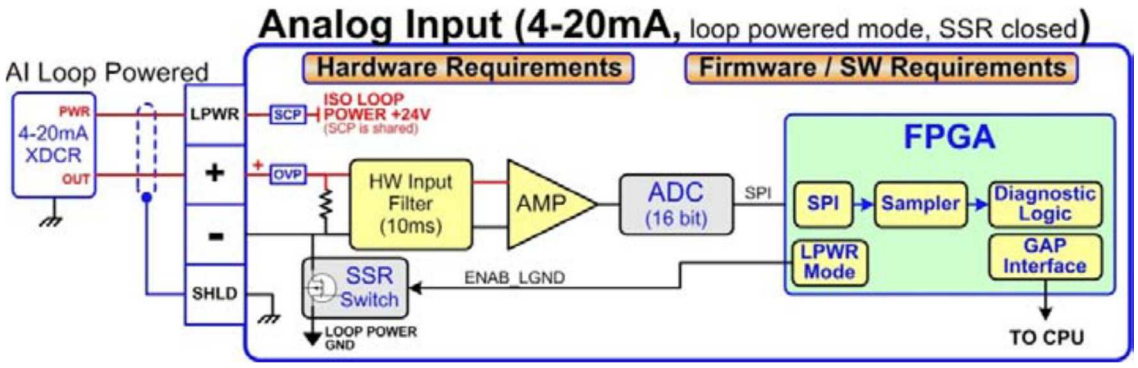


Figure 2-8. Analog Input – Loop-Powered Block Diagram

Hardware - Analog Outputs (4-20 mA)

This control provides an isolated group of (6) 4-20 mA outputs for customer use. Each output can drive up to 600 ohm loads and provides fault monitoring of individual source and return currents.

Features

- (6) Analog Output channels (4-20 mA)
- Source and return current monitors
- Group isolated from other circuits
- Capable of driving higher impedance loads up to 600 ohms
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Table 2-14. Specifications (AO)

Number of Channels:	6 (each with readback)
AO Output Range:	0 to 24 mA, 0 mA during shutdown
AO Output Isolation:	0 V channel to channel 500 Vrms to EARTH and all other I/O
AO Accuracy (@ 25 °C):	≤ 0.024 mA (0.1% of FS=24 mA)
AO Accuracy (–40, +70 °C):	≤ 0.120 mA (0.5% of FS=24 mA)
AO Resolution:	~14 bits of full scale
AO Hardware filter (max):	3 poles @ 250 µs
AO Load Capability:	600 Ω at 20 mA
AO Output Readbacks:	(0 to 24) mA, source and return
AO Readback Accuracy:	< 1% at 25°C, < 3% over full temperature range
AO Readback HW Filter:	~0.5 ms nominal
IOLOCK state	AO circuits are driven to 0 mA during power-up, powerdown, core voltage failures, and watchdog failures

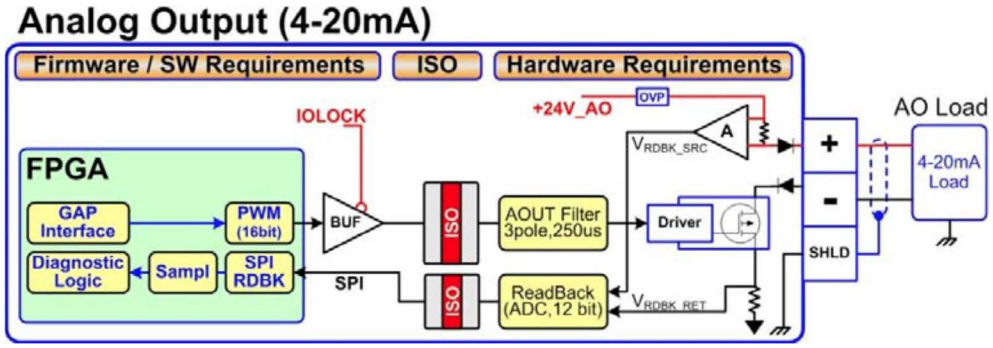


Figure 2-9. Analog Output Block Diagram

Hardware - Actuator Outputs

This control provides an isolated group of two (2) Actuator outputs for customer use. Each driver can be configured for low-range (20 mA) or high-range (200 mA) operation. Fault monitoring of individual source and return currents is included.

Features

- Two (2) Actuator Output channels (4-20 mA, 20-200 mA)
- Source and return current monitoring
- Group isolated from other circuits
- Capable of driving higher impedance loads
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms

Table 2-15. Specifications (ACT)

Number of Channels:	(2) proportional drivers with source & return readbacks
ACT Output Range:	Configurable for 24 mA or 200 mA range
ACT Output Range (low):	0-24 mA, 0 mA during shutdown (FS = 24 mA)
ACT Output Range (high):	0-200 mA, 0 mA during shutdown (FS = 210 mA)
ACT Output Isolation:	0 V channel to channel 500 Vrms to EARTH and all other I/O
ACT Accuracy (25 °C):	Low Range ≤ 0.024 mA (0.1%) High Range ≤ 0.21 mA (0.1%)
ACT Accuracy (–40, +70 °C):	Low Range ≤ 0.120 mA (0.5%) High Range ≤ 1.00 mA (0.5%)
ACT Resolution:	~14 bits of full scale
ACT Hardware filter (max)	3 poles @ 500 µs
ACT Load Capability (low)	600 Ω at 20 mA
ACT Load Capability (high)	65 Ω at 200 mA
ACT Output Readbacks:	(0 to 24) mA, source and return
ACT Readback Accuracy:	< 1% at 25°C, < 3% over full temperature range, (source & return)
ACT Readback HW Filter:	~0.5 ms nominal
ESTOP Action:	Front panel ESTOP button will shut down the actuator circuit, remove actuator power, and set an alarm in GAP software.
IOLOCK Action:	During IOLOCK, ACT power is shutdown and ACT circuits are driven to 0 mA during power-up, power-down, core voltage failures, and watchdog failures.

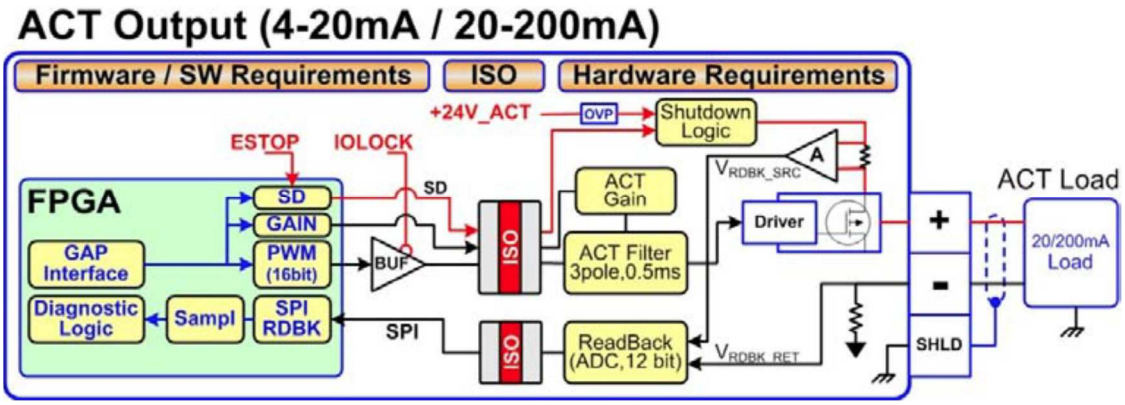


Figure 2-10. Actuator Output Block Diagram

Hardware - Discrete Inputs

This control provides an isolated group of (20) discrete input channels for use with +24 V (dc) signals. An isolated Contact Power voltage supply of +24 V (dc) is provided to use with the discrete inputs. This supply includes short-circuit and over-voltage protection.

Note: Do not use the Contact Power output to power any other devices.

Features

- (20) Discrete Input Channels for +24 V (dc) signals
- +24 V Contact Power with short-circuit and diode protection
- Isolated power and discrete input group
- Woodward GAP block, diagnostics, and configuration support
- GAP configurable update rates of 5 ms to 160 ms
- Time-stamping capability (1 ms)

Table 2-16. Specifications (DI)

Number of Channels:	20
DI Input Low State:	(0 to 8) V (dc)
DI Input High State:	(16 to 32) V (dc)
DI Input Current:	< 5 mA per channel
DI Input Impedance:	25K approximate
DI Hardware Filter:	1.0 ms approximate at room temp
DI Channel Isolation:	0 V channel to channel 500 Vrms to EARTH and all other I/O
DI Overvoltage:	Overvoltage to 36 V (dc) for inputs
Contact Power Output	24 V ±14 %, 150 mA (max), short circuit & diode protected
Contact Power Isolation	500 Vrms to EARTH and all other I/O

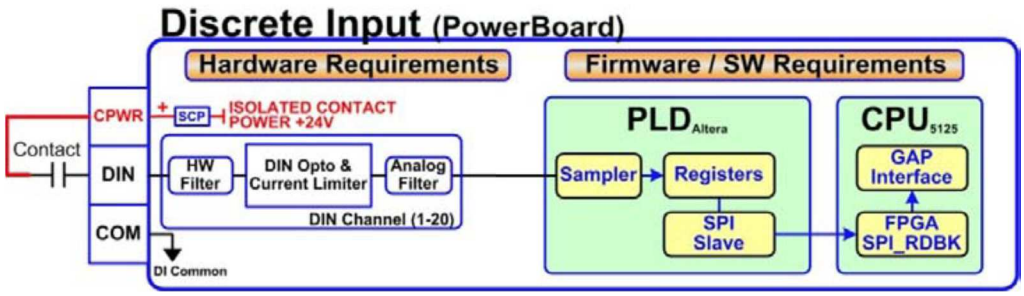


Figure 2-11. Discrete Input Block Diagram

Hardware - Relay Outputs

This control provides (8) Isolated, Form-C Relay outputs with NO, COM, NC contacts available at the terminal block.

Features

- (8) Relay Output Channels
- Each Relay Output provides NO, COM, and NC contacts
- Each Relay Output channel provides a coil voltage readback fault
- Woodward GAP block, diagnostics, and configuration support
- Contact isolation maintained at terminal blocks
- ATEX approved version available using hermetically sealed relays
- GAP configurable update rates of 5 ms to 160 ms

Table 2-17. Specifications (RO)

Number of Channels:	(8) relays
Contact Type:	Form-C with NO, COM, and NC terminals
STD Relay, Contacts (DC):	5 A, 5-30 Vdc (resistive)
STD Relay, Contacts (AC):	2 A, 115 Vac (resistive)
STD Relay, Operate Time:	< 15 ms typical
RELAY Coil Readback:	Coil voltage readback status is available
RELAY Coil Rdbk Filter	1 ms approx at room temp
RELAY Output Isolation:	500 Vrms minimum to EARTH and all other I/O
RELAY Contact Isolation:	500 Vrms minimum between open contacts
RELAY to RELAY Isolation:	500 Vrms minimum between relays
IOLOCK State:	Relay outputs are de-energized during power-up, power-down, core voltage failures and watchdog failures
ATEX Version:	The ATEX approved control uses a Hermetically sealed relay
ATX Relay, Contacts (DC):	5 A, 5-30 Vdc (resistive), 0.2-0.5 A (inductive)
ATX Relay, contacts (AC)**:	2 A, 115 Vac (resistive), 0.1-0.2 A (inductive)

⚠WARNING

Explosion Hazard

****ATEX/IECEx Compliance requires relay contact loads be limited to < 32 Vac rms / < 32 Vdc.**

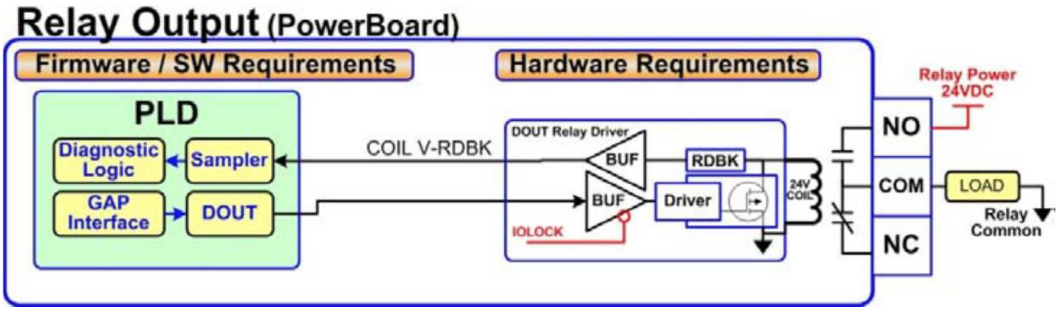


Figure 2-12. Relay Output Block Diagram

Troubleshooting Fault Codes

The CPU board runs diagnostics that display troubleshooting messages through the debug Service Port and AppManager. Additional information on diagnostics tests, subsequent LED flash codes, and serial port messages is contained in the VxWorks manual.

Table 2-18. Troubleshooting Fault Codes

Failure	Flash Code
CPU not operational, IOLOCK state	Solid Red
RAM Test Failure	2, 1
FPGA Test Failure	2, 9
Watchdog not enabled	2, 10
RAM drive error	2, 11
Flash drive error	2, 12

Troubleshooting & Commissioning Checks

Power checks

- Verify proper polarity on power connections
- Verify power source and wire size is sufficient for all loads
- Verify input power voltage is correct (i.e.: low voltage unit is 18 V to 36 Vdc)
- Verify PS(+) and PS(–) impedance to EARTH is > 10 MΩ

RS-232 wiring checks

- Verify the RS-232 wiring uses a high quality shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify the RS-232 wiring uses the signal common (COM1_GND)
- Verify RS-232 network length is within specifications (typically < 50 feet)
- Verify Signal wires (TX+,RX-) are not shorted to each other
- Verify Signal wires (TX+,RX-) are not shorted to COM1_GND
- Verify Signal wires (TX+,RX-) are not shorted to COM1_SHLD
- Verify Signal wires (TX+,RX-) are not connected to PS(+), PS(–), EARTH
- Verify COM1_GND is not connected to PS(+), PS(–), EARTH
- Verify the overall cable shield is terminated to EARTH at only (1) location.

RS-485 wiring checks

- Verify the RS-485 wiring uses a high quality shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify RS-485 network length is within spec for the baud-rate (typically < 4000 feet)
- Verify the network is terminated properly at both ends with approx. 90–120Ω
- Verify the RS-485 wiring uses the signal common (COM1_GND)
- Verify Signal wires (RS-485+, RS-485–) are not shorted to each other
- Verify Signal wires (RS-485+, RS-485–) are not shorted to COM1_GND
- Verify Signal wires (RS-485+, RS-485–) are not shorted to COM1_SHLD
- Verify Signal wires (RS-485+, RS-485–) are not connected to PS(+), PS(–), EARTH
- Verify COM1_GND is not connected to PS(+), PS(–), EARTH
- Verify the overall cable shield is terminated to EARTH at only (1) location.

CAN wiring checks

- Verify the CAN wiring uses a high quality, 3-wire, shielded communication cable. For example, Woodward 2008-1512 (Belden YR58684) or equivalent low capacitance, shielded communications wire.
- Verify CAN network length is < max length spec for the baud rate being used
- Verify network is terminated properly at both ends with 120 _, ±10%
- Verify the CAN wiring uses the signal common (CAN_GND)
- Verify CAN drop cables to each device are as short as possible and meets spec.
- Verify CANH is not connected to PS(+), PS(–), EARTH
- Verify CANL is not connected to PS(+), PS(–), EARTH
- Verify CAN_COM is not connected to PS(+), PS(–), EARTH
- Verify CAN_SHLD shield wire is not shorted to PS(+), PS(–)
- Verify the CAN overall cable shield is terminated to EARTH at only (1) location for each network.
- For redundant CAN devices, verify CAN1 and CAN2 networks are not miswired and connected together.

AI (non-loop), Analog Input wiring checks

- Verify that external XDCR's are NOT used with these self-powered channels.
- Verify each AI(+,–) is not shorted to another input channel.
- Verify each AI(+) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AI(–) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AI shield wire is not shorted to PS(+), PS(–).
- Verify each AI shield wire is terminated at the node properly.
- Functionally verify the wiring for each AI channel using a simulator source.

AI (Loop power), Analog Input wiring checks

- Verify that external XDCR's are connected to these channels.
- Verify the LPWR voltage level (+24 V dc) is correct for the XDCR.
- Verify each LPWR(+) terminal is wired to the XDCR POWER(+).
- Verify each LPWR(+) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AI(–) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AI shield wire is not shorted to PS(+), PS(–).
- Verify each AI shield wire is terminated at the node properly.
- Verify that all XDCR's channels use less than 250 mA of LPWR.
- Functionally verify the wiring for each AI channel using a simulator source.

AO, Analog Output wiring checks

- Verify each AO(+,–) is not shorted to another output channel.
- Verify each AO(+,–) is not shorted to another Analog Input channel.
- Verify each AO(+) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AO(–) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each AO shield wire is not shorted to PS(+), PS(–).
- Verify each AO shield wire is terminated at the node properly.
- Functionally verify the wiring for each AOUT by driving 4 mA and 20 mA to the load from the GAP application. Verify correct output current with a meter. Verify the correct SRC_RDBK & RET_RDBK values in GAP.

DI, Discrete Input wiring checks

- Verify each DI(+) is not shorted to another input.
- Verify each DI(+) is not shorted to CPWR(+), CPWR(–), PS(+), PS(–), EARTH.
- Verify each DI(+) wiring is functional by setting each input HIGH (>16 VDC) and then LOW (<8 V DC). Verify GAP software detects the state change.
- When possible, consider using a shielded DIN cable.

DI, Contact Power (CPWR) wiring checks

- CPWR(+) is an output voltage, it should never be connected to any other supply.
- To maintain node isolation, verify CPWR(–) is not shorted to PS(–).
- Using the internal isolated Contact Power output (CPWR,COM) is highly recommended to maintain discrete input isolation for other plant devices /controls
- Verify CPWR(+) is not connected to CPWR(–), PS(–), EARTH.
- Verify CPWR(–) is not connected to CPWR(+), PS(+), EARTH.
- Verify CPWR voltage meets spec at the terminal block (18 to 32 V dc).

DO Relays, Relay wiring checks

- Verify each Relay output (NO, C, NC) contact is connected to the load properly
- Verify each Relay output (NO, C, NC) is not shorted to another output channel.
- Verify the function of each Relay output (NC, NO) wiring by driving each output ON then OFF. Verify the GAP software detects the readback state change.
- When possible, consider using shielded wiring for relay cables.

Additional wiring checks when using RTCnet/LINKnet nodes

TC, Thermocouple Input wiring checks

- Verify each TC(+,–) is not shorted to another input channel.
- Verify each TC(+) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each TC(–) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each TC shield wire is not shorted to PS(+), PS(–).
- Verify no wires are landed accidently on the NC, no-connect terminals.
- Verify each TC shield wire is terminated at the node properly.
- Functionally verify the wiring for each TC channel using a simulator source.
- TC OPENS: A TC input will read MAX DegC if the (+) or (–) wire is broken / open.
- TC SHORTS: A TC input will read 0 DegC if the (+) and (–) wires are shorted.

NOTICE

GROUND FAULTS: Input channels accidently shorted to EARTH will be more susceptible to spurious noise events related to the installation and environment.

RTD, Input wiring checks

- Verify each RTD(+,–) is not shorted to another input channel.
- Verify each RTD(+) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each RTD(–) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each RTD(sense) terminal is not shorted to PS(+), PS(–), EARTH.
- Verify each RTD(sense) terminal is connected properly for 3-wire sensors.
- Verify each RTD(sense) terminal is jumpered to RTD(–) for 2-wire sensors.
- Verify each RTD shield wire is not shorted to PS(+), PS(–).
- Verify each RTD shield wire is terminated at the node properly.
- Functionally verify the wiring for each RTD channel using a simulator source.
- RTD OPENS: RTD channels will read MAX DegC if the (+) or (–) wire is broken.

Chapter 3.
505HT Control Description

Description of IO

The 505HT Control has a wide selection of functions to choose from a fixed amount of I/O (inputs and outputs). The control can be configured in the field to use the I/O to best fit the specific application. During the initial setup of the control, the functions that are needed for the specific application are selected and the necessary I/O points are assigned accordingly. The control monitors the configuration and if there is any inconsistence the control will generate an alarm and show to the operator what is wrong.

Control Inputs

Speed Input

The software provides up to four speed inputs. MPU#1 and #2 can be configured for either MPU inputs or PT sensors. On the other hand PROX#1 and #2 can be used for proximity probes only. This approach provides a wide variety of possibilities for speed/frequency sensing.

All speed inputs that are configured for either MPU of proximity probe have their signals passing through a HSS (high signal selector), so the highest signal will be considered the mechanical speed of the turbine.

All speed inputs that are configured for PT sensors have their signals passing through a HSS (high signal selector), so the highest signal will be considered the generator frequency of the turbine. PT sensors have their own speed setting for removing speed override.

After the evaluation of both mechanical and electrical speed the control can be configured to “Use “PT as Primary Input” or not. If this parameter if configured to TRUE the PT sensor signals are used as the main speed sensing. If all PT sensors fail then the speed measurement falls back to MPU and proximity probes. This configuration is useful in case the MPU and proximity probes are not extremely reliable. Generally PT sensor signals tend to be less noisy than MPU and proximity probes signals. If parameter “Use “PT as Primary Input” is configured to FALSE then mechanical speed (through MPUs and proximity probes) and generator frequency (through PT sensors) pass through an HSS (high signal selector) at all times.

Analog Inputs

There are eight configurable analog inputs available on the 505 hardware, each of which can be configured as one of the following input functions:

- **Not Used:** choose this option if this analog input won’t be used on this application
- **Pond Level:** this analog input is mandatory if pond level control is desired. If Net Head (for Kaplan turbines only) is chosen to be calculated through the difference between pond and tail levels this input is also mandatory.
- **Generator Power:** this analog input is used to express the generator load. This input is mandatory if load droop or baseload mode is desired.
- **Speed Bias:** this analog input comes from a synchronizer/load controller. If the synchronizer/load controller does not have an analog speed bias output there can be used alternatively digital inputs in the Control to perform this function (called Speed Bias Raise and Speed Bias Lower).
- **Remote Speed Reference:** this analog input is used to provide remote speed reference, when speed remote control is enabled.
- **Gate Position Limiter:** this analog input is used when it is necessary for any reason to limit the Gate position to a certain value. If this gate limit is desired but an analog input is not available there are two digital inputs there can be used alternatively (gate limit raise and gate limit lower). Gate Position Limiter can also be set through Modbus or QT display.
- **Remote Baseload Reference:** this analog input is used if the control is in Baseload mode and a remote Baseload reference is needed.

- **Remote Level reference:** this analog input is used if the control is in pond/tail level control mode and a remote pond/tail level reference is needed. The value will be Pond or Tail status according to the control mode used.
- **Gate Position Feedback:** this analog input provides information about gate actual position. This is mandatory if Integrating Actuators are used. If Proportional Actuators are used this input can be used as well just for monitoring purposes.
- **Blade Position Limiter:** this analog input is used when it is necessary for any reason to limit the Blade position to a certain value. If this blade limit is desired but an analog input is not available there are two digital inputs there can be used alternatively (blade limit raise and blade limit lower). Blade Position Limiter can also be set through Modbus or QT display. This analog input configuration is only applicable for Kaplan turbines.
- **Tail Level:** this analog input is mandatory if tail level control is desired. If Net Head (for Kaplan turbines only) is chosen to be calculated through the difference between pond and tail levels this input is also mandatory.
- **Net Head:** this analog input is mandatory in case the Net Head input is chosen to come from a dedicated analog input. This is used for 3D blade curves. This analog input configuration is only applicable for Kaplan turbines.

Discrete Inputs

Twenty contact inputs are available. The first five inputs are dedicated for Run/Stop (DI-1), Raise Speed/load (DI-2), Lower Speed/Load (DI-3), Breaker Closed (DI-4) and Emergency Shutdown (DI-5). The rest of the additional contact inputs are available for configuration to function as various controller discrete input functions as listed below.

- **Not Used:** choose this option if this analog input won't be used on this application
- **Manual Gate Control Enable:** When this discrete input is closed, the gate position can be controlled "manually" with the Raise and Lower discrete inputs.
- **Pond / Tail Level Control Enable:** When this discrete input is closed, the control will switch into pond/tail level control. The Raise and Lower discrete inputs will raise and lower the pond/tail level set point, depending on which level control type is being used.
- **Gate Limit Raise:** When this discrete input is closed, the Gate Limit ramps up at a configurable rate. If the remote gate limit is selected this input will not be effect on the control.
- **Gate Limit Lower:** When this discrete input is closed, the Gate Limit ramps down at a configurable rate. If the remote gate limit is selected this input will not be effect on the control.
- **Creep Input #1 & Creep Input #2:** Creep detection requires two inputs from proximity probes (or from ZVPU interface modules). By monitoring the Creep #1 and Creep #2 discrete inputs, the control can detect when the unit is creeping.
- **Reset:** All shutdowns and alarms are latched until the fault condition clears and the control is reset. When this input is closed, it resets the control.
- **External Start Permissive:** If this function is configured for any discrete input, the control will monitors it and a start command will only be accepted if this input is closed. If there is no discrete input configured for this function, the start command will be accepted at all time (sure, if no shutdown is present). After the turbine is running this input has no effect in the control.
- **Sync Enable:** When this discrete inputs is closed, the Speed Bias analog input signal is used as a speed fine tuning adjustment, used for either synchronization or for load sharing. If ordinary discrete raise/lower speed inputs are used for synchronization the Sync Enable input has the function of changing the speed rate of change to a lower value in order to allow fine speed tuning.
- **Baseload Enable:** This input is used to enable the Baseload control mode. In Baseload the generator load will stay in a set point determined either by the Raise Speed/Load inputs, or by a remote Baseload input or by a Baseload Modbus reference. The following conditions must also be present in order to the baseload control be enabled: the generator breaker must be closed, there must be a valid electrical transducer signal and the manual and level control modes must be disabled.
- **Unload:** When the unload contact is closed (rising edge triggered) it starts to slowly decrease the load reference and either when it reaches a minimum value (unload trip level) or a certain maximum delay after the reference reaches the unload trip level (configurable) it gives an open breaker command (if configured). After that the turbine stays in its rated speed waiting for another command.

- **Local/Remote:** This input defines if the controller will accept commands coming from discrete inputs (local mode) or via Modbus (remote mode). If there is no input configured for this function the controller accepts both commands indistinctly. The commands from Display are always accepted.
- **Load (kW) Droop Enable:** this input is used to enable the load droop, when the control is in droop mode. In this mode the droop feedback is given by the generator active power.
- **Remote Fault #1 to #6:** these inputs are used for alarm or trip (they can be configured for any of these functions). It's possible to also define a delay (configurable parameter) for each one of these alarms/trips.
- **Enable Remote Speed:** This input enables the remote speed control. In this control mode an analog input needs to be configured for Remote Speed. This control will work when the control is in droop mode.
- **Enable Remote Baseload:** This input enables the remote baseload control. In this control mode an analog input needs to be configured for Remote baseload. This control will work when the control is in baseload mode.
- **Enable Remote Level:** This input enables the remote level control. In this control mode an analog input needs to be configured for Remote level. This control will work when the control is in level control mode.
- **Overspeed Test Enable:** This input enables the overspeed test. Discrete input closes to enable and opens to disable the test.
- **Manual Blade Control Enable:** When this discrete input is closed, the blade position can be controlled "manually" with the "Manual Blade Position Raise" and "Manual Blade Position Lower" discrete inputs. This discrete input configuration is only applicable for Kaplan turbines.
- **Manual Blade Position Raise:** When this discrete input is closed and the blade control is in manual, the Blade demand ramps up at a configurable rate. This discrete input configuration is only applicable for Kaplan turbines.
- **Manual Blade Position Lower:** When this discrete input is closed and the blade control is in manual, the Blade demand ramps down at a configurable rate. This discrete input configuration is only applicable for Kaplan turbines.
- **Blade Tilt Enable:** When this discrete input is closed, the voluntary blade tilt is enabled, tilting the blade demand to a pre-defined position (configurable). This discrete input configuration is only applicable for Kaplan turbines.
- **Blade Lock Enable:** When this discrete input is closed, the blade lock is enabled, locking the blade demand to its last position. This discrete input configuration is only applicable for Kaplan turbines.
- **Isochronous Arm/Disarm:** When this discrete input is closed the Frequency (Isochronous) mode is armed. If a small system is detected Isochronous Mode is enabled, otherwise droop mode (either position or load) is enabled.
- **Blade Limit Raise:** When this discrete input is closed, the Blade Limit ramps up at a configurable rate. If the analog blade limit is selected this input will not have effect on the control. This discrete input configuration is only applicable for Kaplan turbines.
- **Blade Limit Lower:** When this discrete input is closed, the Blade Limit ramps down at a configurable rate. If the analog blade limit is selected this input will not have effect on the control. This discrete input configuration is only applicable for Kaplan turbines.

Control Outputs

Actuator outputs

Two 4-20mA or 20-160mA actuator outputs are available for use. These outputs are defined to be used as Gate Output and Blade Output (for Kaplan turbines only) demands and cannot be used for other functions.

⚠WARNING

Front panel ESTOP button will shutdown the actuators circuits 1 and 2 (remove actuator power), while pressed. The actuation system should be prepared to handle this situation.

Analog outputs

Six analog outputs are available. All analog outputs are 4–20 mA. It is possible to configure the range of each analog input, using the 505´s display.
The configurable analog outputs have the following options:

- **Tachometer:** This output is a mirror of the speed of the turbine, in percent.
- **Gate Position:** These outputs represent the actual gate position, in percent.
- **Blade Position:** These outputs represent the actual blade position, in percent. This analog output configuration is only applicable for Kaplan turbines.
- **Pond Level:** This is the actual pond level, in engineering units. Only available if either pond level control is used or net head is configured to be calculated via pond and tail level inputs
- **Tail Level:** This is the actual tail level, in engineering units. Only available if either tail level control is used or net head is configured to be calculated via pond and tail level inputs
- **Net Head:** This is the actual net head, in engineering units. This analog output configuration is only applicable for Kaplan turbines.
- **Speed Reference:** This is the actual speed reference, in percent. If the generator breaker is opened this is the offline speed setpoint. If the generator breaker is closed this is the online/droop speed setpoint.
- **Level Reference:** This is the actual level reference, in engineering units. Only applicable if level control (either pond or tail) is being used.
- **Baseload Reference:** This is the actual baseload reference, in percent. Only applicable if baseload control is being used.
- **Speed Bias:** This is a mirror of the speed bias used by the control.
- **Generator Power:** This output reflects the actual generator power that came from the Analog Input programmed for generator power.
- **Gate Limit:** This output is the actual gate limit value that the control is considering to control the turbine.
- **Blade Limit:** This output is the actual blade limit value that the control is considering to control the turbine. This analog output configuration is only applicable for Kaplan turbines.

Relay outputs

Twenty relays outputs are available. All relay outputs can be used as normally open or normally closed (configurable). They're all configurable and the available configuration is shown below:

- **Gate Position Switch #1 to Gate Position Switch #4:** These are four outputs to gate position switch. Each gate position switch is individually configured.
- **Speed Switch #1 to Speed Switch #6:** These are six outputs to speed switch. Each speed switch is individually configured.
- **General Governor Alarm:** An output that monitors if the control has any alarm.
- **Creep indication:** Output to indicate that the turbine is creeping.
- **Speed Bias Enabled:** Output to indicate the Speed Bias is enabled.
- **Start Perm Enabled:** Output to indicate that the start permissive is in condition to start the turbine.
- **Overspeed Shutdown:** Output to indicate that an overspeed shutdown exists.
- **Gen Breaker open Command:** Output used to open the generator breaker.
- **Active Power Switch #1 to Active Power Switch #4:** These are four outputs to active power switch. Each active power switch is individually configured.
- **Ready for Start:** Indicates that the turbine is ready to start (no shutdown and start permissive ok).
- **Turbine Stable Speed:** Indicates that the turbine is running and the speed is stable (speed between configurable values during a configurable time).
- **Reset Command:** When the control receives a command to reset (Modbus, discrete input or Display) this output will pulse to reset optional external equipment.
- **Level Signal Fail:** This output will be activated if level signal input fails. If pond level control is being used then this digital output reflects pond level signal fault. If tail level control is being used then this digital output reflects tail level signal fault.
- **Remote Speed Sig Fail:** This output will be activated if level signal input fails.
- **Speed Bias Input Signal Fail:** This output will be activated if Speed Bias signal input fails.

- **Incomplete Start:** If the operator send a command to start and the turbine does not reach a configured speed in a configured time the Incomplete Start shut down will be issued and this output will be activated.
- **Total Speed Signal Fail:** If all speed probes in use fail this output will be activated
- **Speed Signal Fail #1:** If the speed input 1 fails this output will be activated.
- **Speed Signal Fail #2:** If the speed input 2 fails this output will be activated.
- **Speed Signal Fail #3:** If the speed input 3 fails this output will be activated.
- **Speed Signal Fail #4:** If the speed input 4 fails this output will be activated.
- **Analog Gate Lim Sig Fail:** This output will be activated if analog gate limit signal input fails.
- **Remote Baseload Signal Fail:** This output will be activated if remote baseload signal input fails.
- **Power Transducer Sig Fail:** This output will be activated if power transducer signal input fails.
- **Internal Fault:** This output will be activated if there is any hardware fault in the control.
- **Control Powered On:** This output is always on and can be used as a watch dog fault.
- **Blade Position Switch #1 to Gate Position Switch #4:** These are four outputs to blade position switch. Each blade position switch is individually configured. This digital output configuration is only applicable for Kaplan turbines.
- **Trip Relay #1:** An output that monitors if the control is in shutdown mode. Each individual trip cause can be configured to be present on this trip relay. If “Reset clears trip” is enabled the output will be energized when the selected trips occur and when the reset command is sent the output will be de-energized. If “Reset clears trip” is not enabled the output will be energized while the control is in shutdown mode (selected shutdowns), even if the reset command is sent.
- **Trip Relay #2:** An output that monitors if the control is in shutdown mode. Each individual trip cause can be configured to be present on this trip relay. If “Reset clears trip” is enabled the output will be energized when the selected trips occur and when the reset command is sent the output will be de-energized. If “Reset clears trip” is not enabled the output will be energized while the control is in shutdown mode (selected shutdowns), even if the reset command is sent.
- **Baseload Control Enabled:** Output to indicate that the Baseload Control Mode is enabled. Only applicable if Baseload Control Mode is being used.
- **Level Control Enabled:** Output to indicate that the Level Control Mode is enabled. Only applicable if Level Control Mode is being used.
- **Isoch Control Enabled:** Output to indicate that the Isoch Control Mode is enabled. Only applicable if Isoch Control Mode is being used.
- **Manual Gate Control Enabled:** Output to indicate that the Manual Gate Control Mode is enabled.
- **Apply Brakes:** Output used to apply brakes. If this digital output is being used the Apply Brakes algorithm must be configured properly.

Functions

The functions of the 505HT for Francis/Kaplan Turbines are described in detail in this section. The values that are in “quotes” can be configured for the specific application. Configuration of these values is discussed in greater detail in this manual.

External Start Permissive

An external start permissive is available when one of the configurable inputs is configured to do it. When the unit is started up and the control resets, the start permissive contact must be closed before the unit issue a governor run command.

Start, Stop, Unload and Gate Limit

When the Control is given a start command, once all shutdowns have cleared and the optional input “Start Permissive” is true, if used, the Gate Limit ramps at “start gate rate” to the “Breakaway Limit”, and stays there for the “Hold at Breakaway Time” (see Figure 3-1). For Kaplan turbines, if “Blade Preposition” is being used the blade will be positioned at “Start Tilt Position” prior to start opening the gates (see Figure 3-2). If “Blade Preposition” is not being used the blade will be positioned at “Start Tilt Position” at the same time the gate is positioned at “Breakaway Limit, so for this case Figure 3-1 also applies.

Since the control does not have any speed signal yet, the gates will follow the Gate Limit. After the “Hold at Breakaway Time” expires, the Gate Limit ramps to the “Speed-No-Load Limit” at the “Start gate Rate”. It will remain there while the control is synchronizing. At some point during this sequence, the turbine should reach its rated speed and the Offline Control will start controlling speed. If the control does not sense at least the “Start Speed” by the time the “Time to Start Speed” timer has expired, then the control issues an emergency shutdown due to an incomplete start. In case the “Speed-No-Load Limit” is not enough to make the turbine achieve rated speed within the “Auto Raise Timer” time the Gate Limit value will increase at the “Auto Raise Rate” until the offline PID takes control of the gate demand.

When the breaker closes, the gate limit steps to the “Maximum gate Limit”.

If the unit experiences a load rejection, the gate limit will automatically step to the “Speed-No-Load Limit”. If the load rejection algorithm is used the gate limit will step to the load rejection gate limit while the algorithm is running and then step back to the “Speed-No-Load Limit”.

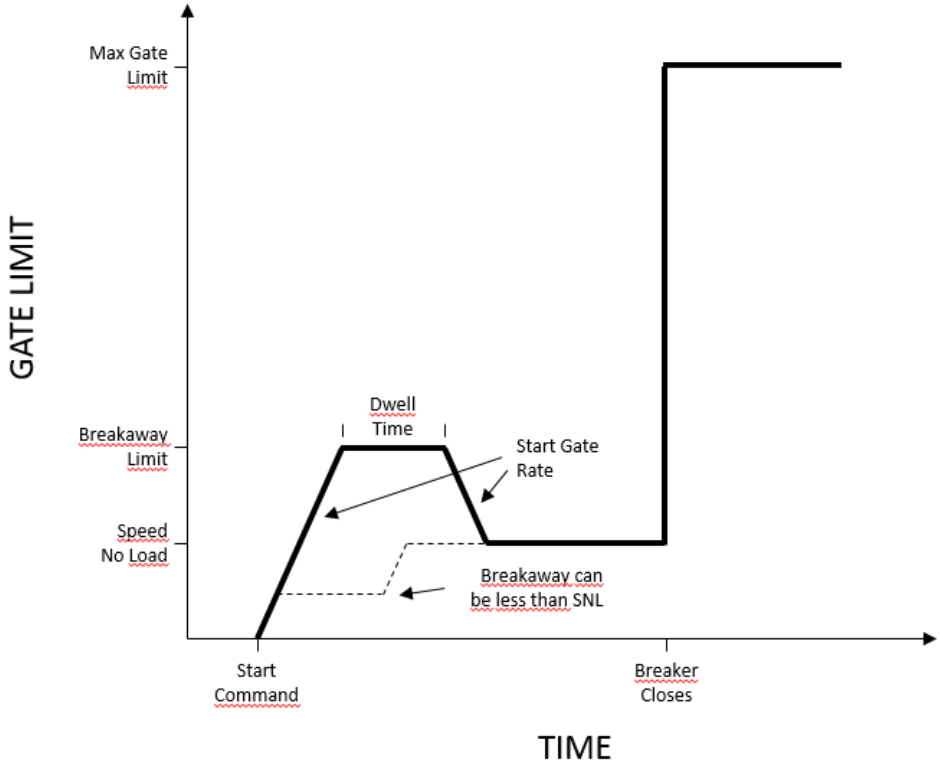


Figure 3-1. Gate Limit (Francis Turbine)

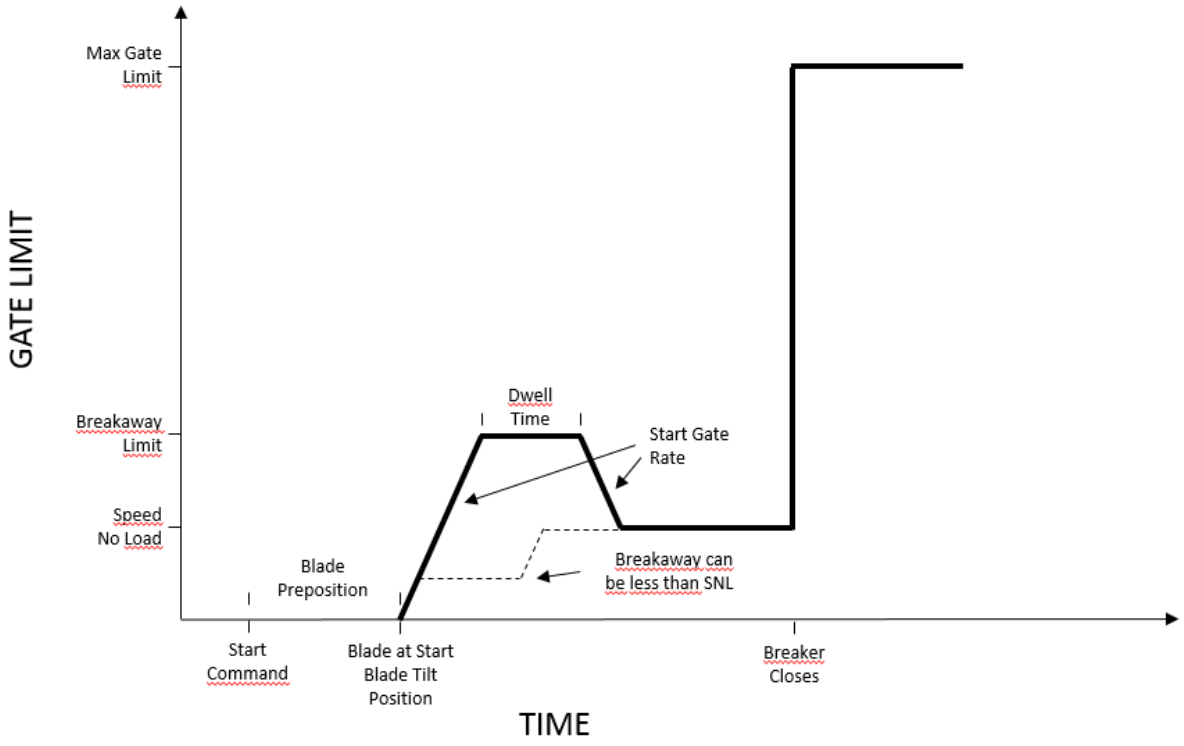


Figure 3-2. Gate Limit (Kaplan Turbine with Blade Preposition)

When a stop command is issued, there are some actions that can be taken:

1. If the generator Breaker is opened the gate limit will decrease to zero, therefore the gate position will decrease to zero and the turbine will stop. Blade will move to “Stop Blade Tilt” position, if this function is being used (for Kaplan turbines only).
2. If the generator breaker is closed the gate limit will decrease to zero, therefore the gate position will decrease to zero. When the load is less than the unload trip level a command to open breaker will be issued (if used). When the breaker opens blade will move to “Stop Blade Tilt” position, if this function is being used (for Kaplan turbines only) the turbine speed will decrease until deadstop.
3. If open breaker function is in use and the Gate Limit reference goes less than Speed no load for a configured time before the load reaches unload trip level the command to open breaker will be issued.

When an unload command is issued, there are some actions that can be taken:

1. If the generator breaker is opened, no action will be taken
2. If the generator breaker is closed the control will be forced to go to load droop mode and the load reference will be reduced to unload trip level. When the load is less than the unload trip level a command to open breaker will be issued (if used). When the breaker opens the turbine will keep running at rated speed.
3. If open breaker function is in use and the load reference goes less than load trip level for a configured time before the load reaches unload trip level the command to open breaker will be issued. When the breaker opens the turbine will keep running at rated speed.

See Appendix F (block diagram) for additional detail of Gate Limit

Speed Signal Processing

The 505HT for Francis/Kaplan turbines has four speed signal inputs, but only one speed signal is required. Using the other speed signals provides redundancy. If one speed signal fails, the control sends out an alarm but does not shut the unit down, if the other speed signals has not failed. A shutdown will be issued if all speed signals fail. At least one speed input must be configured either for MPU or Proximity Probe.

MPU#1 and #2 can be configured for either MPU inputs or PT sensors. On the other hand PROX#1 and #2 can be used for proximity probes only. This approach provides a wide variety of possibilities for speed/frequency sensing.

All speed inputs that are configured for either MPU of proximity probe have their signals passing through a HSS (high signal selector), so the highest signal will be considered the mechanical speed of the turbine.

All speed inputs that are configured for PT sensors have their signals passing through a HSS (high signal selector), so the highest signal will be considered the generator frequency of the turbine.

The Control accepts any sine wave or square wave provided by a speed sensor that is proportional to the speed of the turbine. This can come from magnetic pickups, proximity switches, and active pickups or directly from generator voltage (in this case a PT should be used to decrease the voltage).

The Control must be configured according to the type of speed signal being provided, the rated speed (rpm) of the turbine, the number of gear teeth (if applicable), and the system frequency (50 Hz or 60 Hz). The Control then converts the speed signal frequency into percent of rated speed. All speed values during the configuration and operation of the control are in terms of percent of rated speed unless stated otherwise.

The Control monitors speed signal failures and overspeed. When the turbine is stopped or moving very slowly, the control will not have a valid speed signal, but the control should not see this as a speed signal failure. When the turbine is started, the speed signal is ignored by the control until the “Time to Start Speed” expires. This approach is applicable for all speed inputs configured for either MPU or Proximity Probe.

For the PT sensors the frequency signal is ignored until it surpasses the “PT Enable Speed” value for at least “PT Enable Delay” in seconds. When a stop command is issued, the gates are shut and the frequency signal falls below “PT Disable Speed” the frequency signals are ignored again.

After the evaluation of both mechanical and electrical speed the control can be configured to “Use “PT as Primary Input” or not. If this parameter if configured to TRUE the PT sensor signals are used as the main speed sensing. If all PT sensors fail then the speed measurement falls back to MPU and proximity probes. This configuration is useful in case the MPU and proximity probes are not extremely reliable. Generally PT sensor signals tend to be less noisy than MPU and proximity probes signals. If parameter “Use “PT as Primary Input” is configured to FALSE then mechanical speed (through MPUs and proximity probes) and generator frequency (through PT sensors) pass through an HSS (high signal selector) at all times.

When the turbine is stopped, the speed signal is ignored once the speed drops below 50% and the gates are closed. In addition to the previous speed override conditions if a speed input is configured for “PT Sensor” its speed value is overridden/neglected if the generator breaker opened. If more than one speed inputs are used, all of them would have to fail to cause a shutdown.

The Control has an electronic overspeed detection, which issues a shutdown to the control. The “Overspeed” value configured in the control is in percent of rated speed. The overspeed detection is also ignored at the same time the speed signal failure is ignored, as mentioned above.

An overspeed test feature is available so that the mechanical overspeed (or independent secondary overspeed) trip can be easily tested. To enable the overspeed test, the turbine should be at the rated speed, not in manual control and the breaker should be opened. The test enable switch is hooked up to a configurable timer so that the test is not accidentally left enabled. When the overspeed test is enabled, the electronic overspeed trip is disabled, the isochronous speed reference ceiling is raised to the overspeed test limit, and the raise/lower rate on the isochronous speed reference is increased to the overspeed test rate. The speed reference must be raised until the turbine trips from the mechanical overspeed. When the overspeed test is disabled and the speed setpoint is automatically ramped back to the “Max Reference Offline”.

The Control has a speed deadband function that can be enabled. The speed deadband function is a configurable window around rated speed within which the Control will not respond to speed changes. The deadband window has configurable set points above and below rated speed. In the example below, the high set point is 100.05% rated speed (60.03 Hz on a 60 Hz system), and the low set point is 99.97% rated speed (59.97 Hz on a 60 Hz system). When the unit's speed fluctuates around rated speed the control will not respond unless the speed gets outside the configurable window.

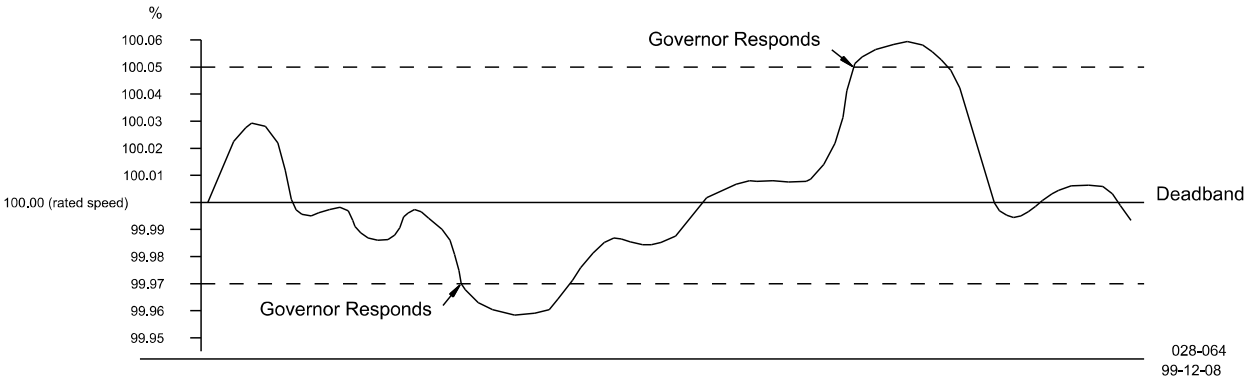


Figure 3-3. Speed Deadband Function

Sometimes it is not desirable to have the unit responding to these slight frequency fluctuations. The speed deadband can be enabled and the deadband window adjusted accordingly. When the speed deadband function is set up, there are three options. The speed deadband function can be enabled at all times, disabled at all times, or only when the unit is online.

See Appendix F (block diagram) for additional detail of Speed Processing

Offline/Load Sharing Speed Control

When the unit is off-line or in on-line control following an analog speed bias signal, the Off-line algorithm is used. The Off-line/Load Sharing algorithm controls the turbine speed to a set point determined by the operator. The droop setting does not affect this control algorithm.

For example, if the unit is off-line and the operator adjusts the set point to 95% rated speed, the Control will position the gates appropriately to control the turbine speed at 95% rated speed. If the operator raises the set point to 100% rated speed, the control reacts by opening the gates and raising the turbine speed to 100%. The operator can synchronize the turbine to the system and close the generator breaker.

When the control is given a Start command, the control pre-positions the speed set point to the "Speed-No-Load Ref". The speed set point can be adjusted from the Raise and Lower discrete inputs or Modbus (raise and lower commands). The high and low limits for the speed set point are set up as "Upper Limit-Ref" and "Lower Limit-Ref".

The speed set point follows actual speed when the turbine is in Manual control. This provides a bumpless transfer into Off-line or Load Sharing control.

The Control has two sets of PID gains, off-line and load sharing. The only difference between off-line control and load sharing control is that the off-line gains are used during off-line control and the load sharing gains are used during load sharing control. Load sharing control is used when the generator breaker is closed and an analog speed bias is not used for synchronization only. So in this case the 505HT is acting as a slave of the load controller.

When the off-line/load sharing PID algorithm is in control, a temporary compensation function is available to help dampen any control instability. The PID gains should be tuned properly for optimum control response before the "Temporary Compensation" is adjusted. The temporary compensation acts much like a mechanical dashpot. As the gates open or close, the speed set point is temporarily lowered or raised depending on the speed of the gates to slightly dampen the controls response.

When a Synchronizer/Load Control unit is used with the Control, the speed reference in the internal ramp of the control is fixed to 100%, so the final speed reference becomes 100% ± Speed Bias, and the off-line/load sharing (depending if the generator breaker is closed or opened) PID algorithm is used to control the unit. The Synchronizer/Load Control unit controls the turbine by biasing the fixed speed set point through the Synchronizer/Load Control signal input. The Synchronizer/Load Control speed set point biasing is ignored by the Control if it isn't being used with a Synchronizer/Load Control unit, if the speed is not stable, or if the unit is on-line but not in Synchronizer/Load Control.

See Appendix F, for additional detail regarding Offline/Load Sharing Speed Control

Online/Droop Speed Control

The On-line/Droop PID algorithm is used when the unit is on-line and in Level Control or Droop Speed Control. It's also used the On-line/Droop PID algorithm allow the unit to be paralleled with other units and still remain stable. The droop value, the droop speed set point, and the turbine speed, together determine how far the gates move, or how much load the turbine picks up.

There are two possible droop modes: load droop or position droop. When the controller is in load droop mode the controller will use the generator active power as a droop feedback. The controller will keep the active power in the desired value, given by the curve droop. If position droop is selected the controller will keep the gate position at the desired value, given by the droop curve. For the load droop the controller actually picks the active power value (from a 4–20 mA analog input). In case there is a failure on the active power signal the control until can stay on load droop, but it uses a 2D-curve for the relationship between the gate position and the generator active power. There is tracking between kW and actuator position droop in order to maintain the same active power when changing between actuator to load droop and vice versa.

A Remote Speed Reference can be used as well. There are three ways to enable the Remote Speed Reference: closing a digital input called "Enable Remote Speed", or by enabling it via a Modbus Command, or via display command. The remote speed reference comes from a 4–20 mA analog input. This input is scaled to 0-100% load or actuator position, depending if kW or position droop is enabled. In order to enable Remote Speed Reference the control must be either in kW or position droop mode previously. Therefore, Baseload, Level and Isochronous control modes must be disabled in order to put the control in pure droop mode before enabling remote speed reference. Direct setpoint can also be sent via Modbus or via display.

For the example below let's assume that the controller is configured for actuator position droop.

For example, if the speed is fixed at 100% rated speed and the droop is set to 5%, a 1% droop speed set point change will move the gates 20%. If the droop is set to 3%, the gates will move 33.3% for a 1% change in the droop speed set point. The speed is always being monitored and reacted to by the control, but the control will only respond by an amount determined by the droop setting. For example, at 5% droop a +0.1% speed change (60.00 Hz to 60.06 Hz) will result in a gate position change of 2.0%. At 3% droop, the same speed fluctuation would result in a gate position change of 3.3%.

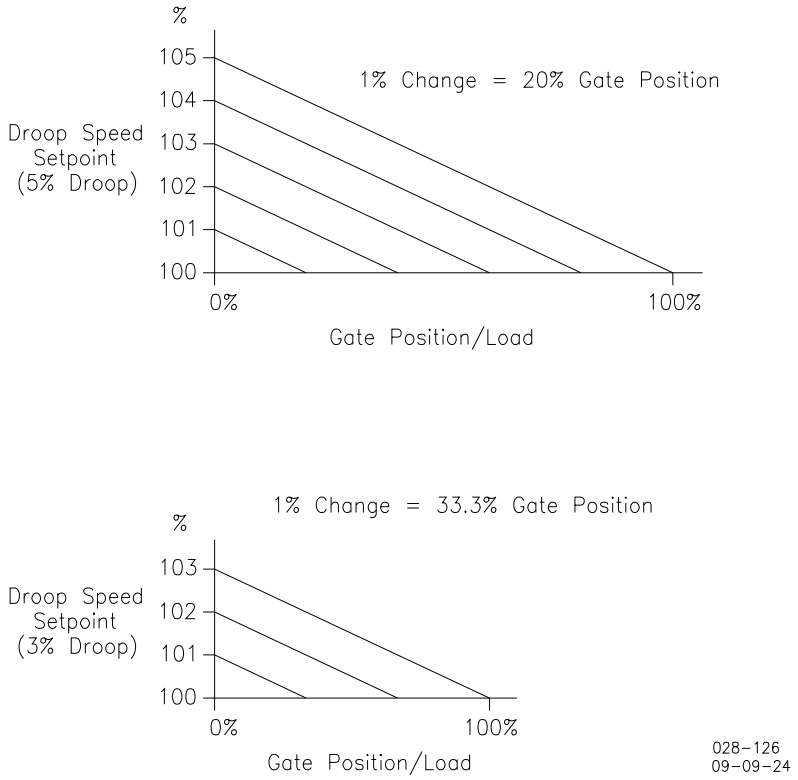


Figure 3-4. Gate Position

The Level Control algorithm calculate a droop speed set point to position the gates to a desired position.

When the generator breaker closes, the default control mode is given by a configurable parameter. The droop speed set point can be raised and lowered using the Raise/Lower discrete inputs or Modbus. The Low Limit is 85%, and the High Limit is 100% plus the Droop percentage. For example, at 5% Droop, the High Limit would be 105%.

When the on-line/Droop PID algorithm is not in control (Baseload, Isochronous, Offline, Load Sharing or Manual), it calculates a droop speed set point based on the current speed and gate position / load value. This provides a bumpless transfer into On-line/Droop speed control.

The on-line/Droop PID algorithm has a Feed Forward function that manipulates the PID feedback to accelerate the control's response to set point changes. Feed Forward is only enabled when the control is using the On-line/Droop PID algorithm. This parameter should be handled carefully and left at its default value as much as possible.

The output of the On-line/Droop PID is also clamped by a "PID Clamp Window" value to eliminate set point wind up in the control.

See Appendix F, for additional detail of Online Droop Control

Baseload Control

When the unit is in parallel with the grid it may be desired to put it into Baseload control. In this mode the unit will assume a fixed amount of load given by the Baseload Reference. In order to perform that action an electrical transducer is needed to convert the load power into a 4–20 mA signal and a PID that compares the actual load with the Baseload Reference in order to generate a gate demand. The Baseload Control tracks the generator load, so the transfer from any control mode to Baseload Control is bumpless.

At the moment that the Baseload mode is enabled the load reference ramps to the “Initial Baseload Reference” at a configurable rate if the first control mode when the generator breaker closes is Baseload. Otherwise it tracks the actual generator load when the Baseload Control is enabled.

After that the baseload reference can be raised or lowered by the Raise and Lower inputs, respectively. Direct setpoint can also be sent via Modbus or via display.

A Remote Baseload Reference can be used as well. There are three ways to enable the Remote Baseload Reference: closing a digital input called “Enable Remote Baseload”, or by enabling it via a Modbus Command, or via display command. The remote baseload reference comes from a 4–20 mA analog input. In order to enable Remote Baseload Reference the Baseload Control must be enabled previously.

If there is a failure in the Remote Baseload signal the remote baseload control is automatically disabled and an alarm is issued.

If there is a failure in the Electrical Transducer signal the baseload control is automatically disabled and an alarm is issued.

The Baseload PID algorithm has a Feed Forward function that manipulates the PID feedback to accelerate the control’s response to set point changes. Feed Forward is only enabled when the control is using the Baseload PID algorithm. This parameter should be handled carefully and left at its default value as much as possible.

While in Baseload Control the load droop mode is forced enabled and cannot be disabled.

See Appendix F, for additional detail of Baseload Control

Pond/Tail Level Control

The Pond/Tail Level Control mode can control the forebay level (pond level) or the tailbay level to a set point by opening and closing the Gates. Level Control can be enabled using the “Pond/Tail Level Control Enable” discrete input, Modbus or display command. The pond/tail level input signal must be valid for Level Control mode to be enabled. If the level signal is lost, an alarm will indicate the failure, and the control will disable Level Control.

The only difference between Pond and Tail Level control is that the Gates will move in opposite directions as a result of the Level Error. If the control is configured for Tail Level control and the level is greater than the set point, the Gates must close to reduce the error. However, if the control is configured for Pond Level control and the level is greater than the set point, the Gates must open to reduce the error.

NOTICE

If you are controlling the Pond Level (forebay level), be aware that increasing your Pond Level set point results in decreasing the Gate position, and vice-versa. Thus, the Raise input will result in moving the Gates in the closing direction.

When Level Control is enabled, the Raise and Lower contact inputs control the Level Set Point. The Level Set Point “Raise/Lower Rate” controls how fast the set point ramps up and down. The level set point can also be adjusted using either Modbus or display commands.

A Remote Level Reference can be used as well. There are three ways to enable the Remote Level Reference: closing a digital input called “Enable Remote Level, or by enabling it via a Modbus Command, or via display command. The remote level reference comes from a 4–20 mA analog input. In order to enable Remote Level Reference the Level Control must be enabled previously.

When Level Control is enabled, there are two options. The control can be configured to maintain a preset level set point, or it can be configured to “follow” actual level and Gate position. If the application always requires the same level set point when in Level Control, the control should be set up to maintain the preset level set point. Each time the Level Control mode is enabled, the control will use the preset level set point. The set point can still be adjusted using the Raise and Lower commands. If a bumpless transfer is needed or desired when Level Control is enabled, the control should be set to “follow” actual level and Gate position. When Level Control is enabled, the Gates will stay where they are at that time.

The level transducer range must also be entered into the Control during the initial configuration. The “Level at 4 mA” and the “Level at 20 mA” refer to the elevation of the water level when the level transducer is generating 4 and 20 mA. These high and low limits become the limits of the Level set point, and they are also used to calculate the Remote Reference for Level Control (if used). The elevations can be in any unit of measurement, but the units must stay consistent for all other values relating to Pond/Tail Level control (level feedback signal, level set point, and desired accuracy). The “Maximum Gate Position” and “Minimum Gate Position” in Level Control mode must also be configured. This can prevent the unit from motoring or from overloading in Level Control.

The Level Control algorithm is designed so that several units can be controlling pond/tail level together without any communication between controls and without fighting each other. However, the consequence of being able to do this is that the control does not integrate out all error between actual level and the level reference. By design, the only Gate position where there won’t be any level error is the midpoint between “Maximum Gate Position” and “Minimum Gate Position”. Therefore, the “Desired Control Accuracy” must be configured. This desired control accuracy has the same units as the elevation levels discussed above. If the desired control accuracy is 1 meter, the Control will control the level, but there may be some error (less than 1 meter) remaining during steady state.

For example, assume the control is configured for Pond Level control. The “Maximum Gate Position” has been configured for 100% and the “Minimum Gate Position” has been configured for 20%. The “Desired Control Accuracy” has been configured for 0.5 meter. If the level error (level set point - actual level) is greater than +0.5, the Gates will close to the minimum Gate position (20%). If the level error is less than –0.5, the Gates will open to the maximum Gate position (100%). As the actual level approaches the set point and the error is reduced, the Gate position will find an equilibrium value along the curve shown below. The only time the level error will be zero is when the equilibrium point falls on the midpoint of the “Minimum” and “Maximum” Gate position values.

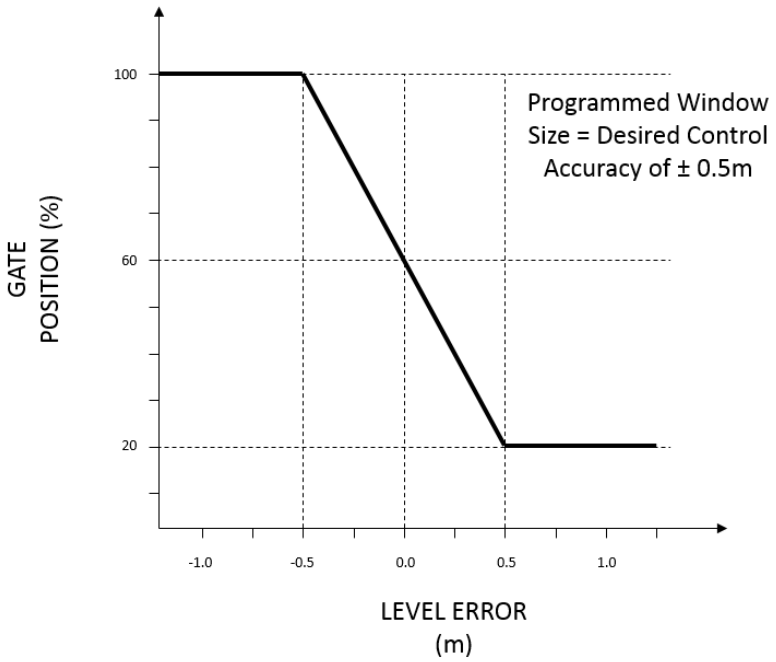


Figure 3-5. Pond Level Control Accuracy

The smaller the “Desired Control Accuracy” value is, the steeper the slope will be on the above graph. This will result in a very high “gain” on the Gate position, and small error fluctuations in the Pond/Tail Level will move the Gates very quickly. The “Desired Control Accuracy” value should be made as large as possible for each given application.

If “Fixed Speed in Level Control” is used the gate position demand will not be compensated by the turbine speed (grid frequency). In other words, it won’t follow the position droop curve and will stay exactly at the gate demand given by the level control loop.

While in Level Control the load droop mode is forced disabled and cannot be enabled.

See Appendix F, for additional detail on Level Control.

Step Test

During the initial calibration of the control system, the control loops must be calibrated for optimum performance. Five step test logics are built into the control to aid in the tuning of the following control loops:

- Offline PID
- Online PID
- Baseload PID
- Isoch PID
- Manual Control

All step tests follow the same logic: there’s an Enable command, an expiration time, a step amount/magnitude and a Boolean to say if the step is positive or negative. There’s no need to disable the step test. Once the time expires the step demand automatically goes to zero.

Deadstop Detection

The control has a deadstop detection algorithm, which is used for creep and apply brakes logics. The deadstop is detected once the following conditions are met

- The unit is given a “Stop” command
- The speed has decreased below the 2% (there’s a contingency logic to detect zero speed upon total speed input fault)
- Gates are closed
- Generator breaker is opened

If there’s a total speed failure shutdown present the customer have to properly configure a timer called “Deadstop Time”. This is the expected time the turbine takes to deadstop if no brake is applied. This will allow the software to safety detect a deadstop condition under any given circumstances.

Creep

The control can be configured to detect unit Creep. Two discrete inputs are required to use this function. The inputs come from proximity switches focused on the speed gear. Preferably one proximity switch should be centered on a gear tooth, and the other proximity switch should be centered on a gear trough (or in between two gear teeth), however this approach is not mandatory for this logic to work. The Control will detect a creep as slight as one gear tooth of rotation.

After deadstop conditions are met and the “Creep Stop Time” has expired the Creep logic starts looking for undesired turbine movement. Once a creep is detected, the control will stay in the alarm condition until the “Reset Creep Time” expires. The Control will look for creep again when the “Look Again Time” has expired. The creep logic can be configured to be reset manually only, but the auto reset logic due to “Reset Creep Time” expiring is the default configuration.

The Creep alarm is sent to the general governor alarms and to Modbus. A configurable relay output can be configured to energize upon a Creep Detection.

Apply Brakes

The control can be configured to apply turbine brakes. The apply brakes logic is used to allow the turbine to come to a deadstop condition on a reasonable time. This algorithm works in the following way:

- State 1: Turbine is stopping

  Permissives:

  -Generator breaker is opened
  -Speed measurement is valid
  -Gates are shut (position valid and less than 2%)

  Action1:

  -Once turbine speed gets below “Pulse Speed” the apply brakes output will pulse according to “Pulse On Timer” and “Pulse Off Timer”
  -Once turbine speed gets below “Hold Speed” the apply brakes output will hold until deadstop

- State 2: Turbine is at deadstop

  If the parameter “Use Brake on Deadstop” is configured to TRUE the apply brakes output will be maintained for “Brake Deadstop Time”

- State 3: Turbine is at creep condition

  If the parameter “Use Brake on Creep” is configured to TRUE the apply brakes output will be maintained for “Brake Creep Time”

Overspeed Test

When the overspeed test is enabled, the **electronic overspeed trip is disabled**, the offline speed reference ceiling is raised to “Overspeed Test Limit” and the raise/lower rate on the offline speed reference is increased to configurable rate.

To perform the overspeed test, the following permissives must be met:

- The unit is given a “Run” command
- The speed has increased above 97%
- Generator breaker is opened
- Gate control must be in Automatic Mode

Then the speed reference can be raised until the unit trips from the **mechanical overspeed**. If the mechanical overspeed device does not trip the unit, the speed reference will have to be manually lowered or the unit can be tripped manually to prevent a trip if the test is disabled and the speed is greater than the overspeed limit. If the test is forgot enabled it will be disabled automatically after the “Time to Disable Test” expires. When the test is disabled the following things can happen:

- If the actual speed is above the “Overspeed Level” for at least the “Overspeed Delay” the unit will trip
- If the actual speed is between the “Maximum Speed Reference” and “Overspeed Level” the speed will be ramped back to the “Maximum Speed Reference”
- If the actual speed is below the “Maximum Speed Reference” no speed action is taken

⚠WARNING

When this test is performed, there is NO internal overspeed protection in the Control. If the mechanical overspeed device does NOT trip the unit, the speed reference will have to be manually lowered below the “Overspeed Level” or the unit can be tripped manually.

To prevent possible serious damage or injury from an overspeeding engine, be prepared to make an EMERGENCY SHUTDOWN when performing this test, to protect against runaway or failure of mechanical or other secondary overspeed devices.

Valve Driver

The Control's valve driver can be configured for many different applications. The valve driver (actuator output) can be configured as a proportional signal or as an integrating signal.

For explaining purposes let's suppose that the actuator output has been configured for 4–20 mA.

A proportional signal is a 4 to 20 mA signal that is proportional to the actuator set point, 0 to 100%. The proportional signal is 4 mA for 0% gate/blade position, 12 mA for 50% gate/blade position, and 20 mA for 100% gate/blade position. No gain or offset adjustments are available in the Control when a proportional signal is supplied due to the nature of the signal.
An integrating signal is a 4 to 20 mA signal that positions a proportional valve, or pilot stage valve. The integrating signal is about 12 mA to center the proportional, or pilot stage, valve. When the current is less than 12 mA the valve moves one way, and when the current is greater than 12 mA the valve moves the other way. The further the signal is from the null current, the further the proportional valve plunger moves from its center position. Typically, the proportional valve ports oil to another valve, or hydraulic amplifier, which then positions the servomotor.

The integrating signal has two adjustments that must be made. The first adjustment is the "Valve Offset". The null current will probably never be equal to exactly 12.00 mA, so the valve offset makes up for this difference. If this is not adjusted properly, the gate/blade position will not match the gate/blade position demand. The second adjustment that needs to be made to the integrating signal is the "Valve Gain". This controls how much the current deviates from the null current for a given gate position error. If the gates/blades are sluggish to step changes, the gain can be adjusted to increase the gate/blade response, or if the gates/blades overshoot during a step change, the gain can be adjusted to decrease the response. The control has an "Offline Valve Gain", which is used when the generator breaker is opened, and an "Online Valve Gain", which is used when the generator breaker is closed. If this feature is not to be used both these variables must have the same value.

The Control has a dither function designed into its valve driver output. The valve dither function induces an AC current on the actuator output. Valve dither accomplishes two things. First, it keeps the valve plunger(s) constantly moving which reduces "stiction", or static friction. "Stiction" can cause gate/blade hunting if the valve does not respond correctly to the electronic signal. Second, dither makes a positive lap valve respond as though it were a zero lap valve. The control has 5 possible dither frequencies, which are: 50Hz, 25Hz, 12.5Hz, 6.25Hz and 3.125Hz. Dither function should be used with caution.

The Control continuously compares the actual gate/blade position to the gate position demand in the control. If they do not match within the "Minor Mismatch Window" for more than the "Minor Mismatch Delay" time, the control will issue a "Minor Mismatch" alarm. If the gate/blade position does not match the demand within the "Major Mismatch Window" for more than the "Major Mismatch Delay" time, the control will issue a "Major Mismatch" alarm. When a Major Mismatch occurs a turbine shutdown is issued.

See Appendix F, for additional detail on Gate/Blade Output.

Manual Gate Mode

When manual gate mode is enabled all automatic PID's that were in control (Offline, Online, Baseload or Isoch) goes to tracking mode and the gate demand can be driven manually. There's a tracking between Manual and Automatic modes. The gate position in this mode can be driven by Raise and Lower commands (the same Raise and Lower speed commands used in automatic modes). Direct setpoint can also be sent via Modbus or via display. The rate at which the manual position moves is configurable.

Manual control mode can be enabled when the unit is running or when the unit is stopped. Generally manual gate mode is enabled during turbine first start attempt or in situations where the gate position should be maintained at a given position regardless of turbine speed or other conditions.

In manual gate mode the control still monitors speed failures and overspeed conditions.

See Appendix F, for additional detail on Manual Gate Control.

WARNING

When manual gate control mode is enabled the gate demand is not limited by Gate Limit logic. Therefore operator should proceed with cautious in order to prevent any undesired situations.

Gate/Blade Auto Test

The control has a Gate/Blade Auto Test algorithm. This algorithm is used to automatically step up and down gate/blade demand sequentially in order to test the position driver for the gates/blades. In order to enable the Gate/Blade Auto Test the control must be on a shutdown condition. If any of the following conditions happen the Gate/Blade Auto Test will be disabled/inhibited:

- All shutdown conditions are cleared
- The turbine speed is greater than 1%

Before enabling the Gate/Blade Auto Test algorithm the following variables must be configured:

- Gate/Blade Minimum Demand
- Gate/Blade Maximum Demand
- Step Value
- Step Time

When the Auto Test algorithm is enabled the control will send a sequence of steps to the gate demand following the logic below:

- The configuration values will be sampled to be used by the algorithm and cannot be changed during the algorithm running
- Demand will be step to the “Minimum Value” demand and for the “Step Time”
- The demand will increase in steps with “Step Value” amount. In each new step it will stay there for the “Step Time”
- When the demand reaches the “Maximum Value” it will stay there for the “Step Time”
- The demand will decrease in steps with “Step Value” amount. In each new step it will stay there for the “Step Time”
- When the demand reaches the “Minimum Value” it will stay there for the “Step Time”
- Demand is step to zero and the test is disabled

The test can be aborted at any times. By doing that the demand will be step to zero automatically. The idea of this test is to confirm in an automatic way if the gate is being positioned accordingly at different gate demands.

WARNING

Gate/Blade Auto Test algorithm should only be run when the unit is de-watered. However if the unit starts to run during the test it will be automatically aborted and the Gate/Blade Auto Test demand will be sent to zero.

Small System Detection / Black Start

When the turbine is in parallel to the grid it may be desirable to detect if the turbine is in island mode. This algorithm has this function. In order to do it monitors the turbine speed (when the turbine is in parallel to the grid) and verifies if both the speed and its derivative value are within configurable windows. In case either one of these parameters is outside its configurable window the controller automatically send a disable Baseload, disable Level, and/or disable Remote Speed control. Therefore the unit will stay either in droop mode (load or position) if frequency is disarmed or isochronous mode if frequency is armed. In this case, as the unit is in not in a large system anymore a second set of on-line PID adjustments are available. The control also issues an alarm.

If any control mode is enabled (baseload, level, remote level or remote speed) the small system will be disabled. The control can go to small system and back to large system voluntarily via either Modbus or display commands.

Before starting the turbine it's possible to set it for black start. If the unit is set for black start as soon as the generator breaker closes the control jumps to small system mode. After that the same premises to send the control back to large system are applicable.

Isochronous Arm/Disarm

This logic is used when the generator breaker is closed. When the frequency (isochronous) is armed the control won't take any action immediately, but will wait for a small system detection trigger. When a small system detection is triggered the control will jump into isochronous control. Otherwise it will jump into droop control (load or position droop). For droop mode the control explanation is in the section **"Online/Droop Speed Control"**, however the P, I, D and feed-forward settings have different values for large system (regular droop PID gains) and small system. Generally the P, I and D settings for small system tend to be close to the "Offline Speed Control" PID adjustments.

Online Isochronous Control

This control mode is used when the frequency is armed and the small system detection algorithm detects a small system. In this mode the controlled variable is turbine speed in the same way as the Offline Speed Control. When the ""Online Isochronous Control" is enabled the initial setpoint can be either the actual speed value (sampled at the moment this control algorithm is enabled) or rated speed, depending on the parameter "Use Rated Initial Setpoint"

Once enabled the speed reference can be raised or lowered by the Raise and Lower inputs, respectively. Direct setpoint can also be sent via Modbus or via display.

When the online isochronous PID algorithm is in control, a temporary compensation function is available to help dampen any control instability. The PID gains should be tuned properly for optimum control response before the "Temporary Compensation" is adjusted. The temporary compensation acts much like a mechanical dashpot. As the gates open or close, the speed set point is temporarily lowered or raised depending on the speed of the gates to slightly dampen the controls response.

See Appendix F, for additional detail regarding Online Isochronous Control

Local / Remote

The control provides a local/remote feature. When local/remote discrete input is not used any configurable discrete input and Modbus commands are accepted at any times. If local/remote feature is used we have the following:

- If we are in Local mode Modbus commands are NOT accepted
- If we are in Remote mode discrete inputs commands are NOT accepted
- Display commands are accepted at all times

Even if Remote mode is enabled a specific Modbus port (there are four Ethernet and one serial) can have its commands (analog and Boolean writes) suppressed via configuration of the referred Modbus port.

Load Rejection

The control provides a load rejection algorithm to detect a load surge upon a generator breaker opening in order to avoid turbine trip due to overspeed. This algorithm is triggered once all the following conditions are present:

- Load rejection logic is being used
- Generator breaker is opened
- Actual speed value is greater than "Max Speed" or speed derivative is greater than "Max Speed Derivative"

Once triggered this algorithm does the following:

- Send the Gate Demand to "Gate Position Value"
- Send the Blade Demand to "Blade Position Value" (if "Use Blade Load Rejection" is set to TRUE). This is applicable for Kaplan turbines only

These two actions are maintained until any of the following conditions occur:

- Speed is below 102% and Gates are positioned at “Gate Position Value”
- “Maximum Algorithm Time” expires

WARNING

Proper configuration of “Maximum Algorithm Time” is important, otherwise the turbine speed can experience an undershoot (if both the “Maximum Algorithm Time” and “Gates Close Time” are too high) or a second overshoot can happen (if “Maximum Algorithm Time” is too small and “Gates Close Time” are too high).

Net Head Evaluation

NOTICE

This subsection is only applicable for Kaplan turbines

Net Head calculation is used, along with the gate position, as an input of the 3D CAM curves which define the blade curve demand. The control provides three ways of inputting the net head value:

1- Single Net Head analog input
2- Net Head calculation through Pond and Tail level inputs
3- Direct Net Head input through either Modbus or display

This is defined by the parameter “Net Head Type”. The minimum and maximum allowed Net Head values are defined by parameters “Minimum Net Head Value” and “Maximum Net Head Value”, respectively. In order to provide a smooth Net Head value change the proper configuration of parameter “Net Head Rate” must be observed.
If “Net Head Type” is configured as “Pond and Tail Signals” the Net Head value is considered as the difference between pond and tail levels. Therefore in order for this calculation to work properly pond and tail signals must have the same level reference, as shown below:

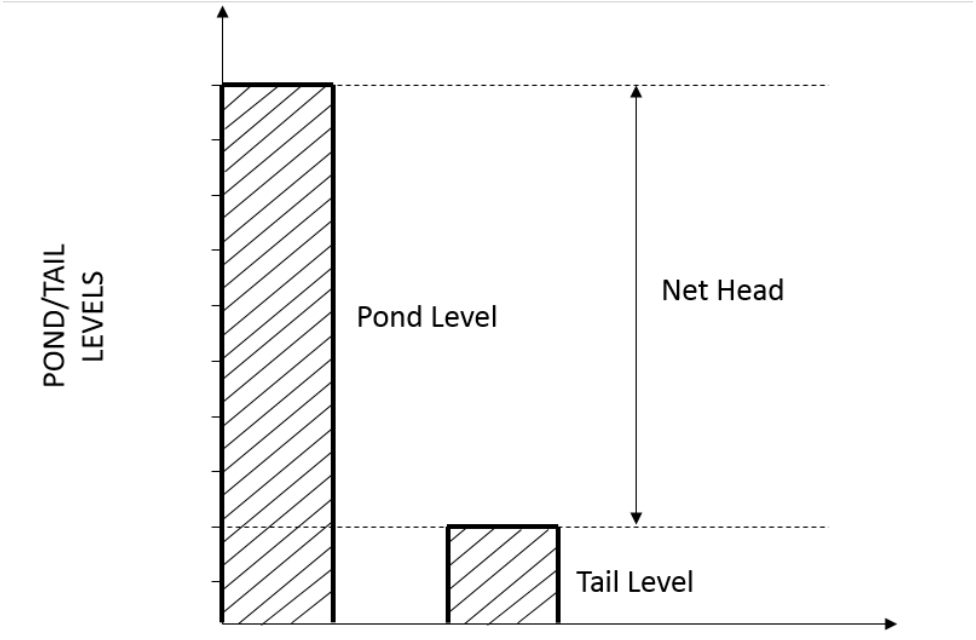


Figure 3-6. Net Head Calculation via Pond/Tail Level Inputs

If neither Net Head nor Pond/Tail Level are available the Net Head value can be directly entered on the control either via Modbus or display. This is also useful in cases where the net head level almost doesn't change, so it's quite safe to not have an analog input for net head and write it directly via Modbus or display in the control.

If Net Head is configured to come from either a dedicated input or calculated from pond and tail levels parameter "Action in Case of Signal Fail" should be configured properly. The possibilities for action upon signal fail are:

1- Blade Lock
2- Revert to Manual Blade
3- Shutdown
4- Revert to Fixed Curve

Each of the functions above will be properly explained in the following subsections. One thing, however is important to notice: there's a hierarchy of blade control modes, in terms of how critical the control type is. The control modes hierarchy, from less critical to most critical, are:

1- Blade Curves (3D)
2- Blade Fixed Curve (2D)
3- Blade Tilt
4- Blade Manual
5- Blade Lock

With that being said the "Action in Case of Signal Fail" will have the following actions:

1- Inhibit Blade Curves (3D)
2- Force Blade Fixed Curve (2D) – unless action is configured for "Shutdown"
3- Give an enable pulse for the referred control mode, if no higher hierarchy mode is in control already

NOTICE

For example: if the Blade Lock is enabled for any reason and the "Action in Case of Signal Fail" is configured for Revert to Manual Blade when a Het Head Fault occurs Blade Manual won't be enabled, as Blade Lock mode is more critical than Blade Manual.

See Appendix F, for additional detail on Net Head.

3D Blade Curves

NOTICE

This subsection is only applicable for Kaplan turbines.

This is the normal operation for the blade demand. This curve make a 3D relationship between net head value and gate position, providing blade demand as an output. This relationship is a turbine characteristic, so is generally provided by turbine manufacturer.
The control has up to 9 curves, with 11 points each. The customer must configure properly parameter "Number of Blade Curves". For each curve points "Blade for Gate xx%" (where xx is 0%, 10%, …, 90% and 100%) are available, as well as "Net Head Value" for this curve.
If the Net Head value is between two blade curves the control will interpolate the blade demand between these two curves. The 3D blade curves should be configured in crescent values of net head, so "Net Head Value" for curve 2 should be greater than the value for curve 1; the value for curve 3 should be greater than the value for curve 2, and so for.
The 3D blade curves are inhibited in case there's a failure in the net head signal.

See Appendix F, for additional detail on Blade Curves 3D and 2D.

2D Fixed Blade Curve

NOTICE **This subsection is only applicable for Kaplan turbines.**

This is the blade curve used when the net head signal is faulted. In this contingency mode there's only a direct 2D table between gate position (input of the table) and blade demand (output of the table). This will lead to a sub-optimal control situation, therefore this 2D fixed curve should be configured in such a way to find a compromise among the available 3D blade curves.
In this fixed curve there's no Net Head Value configuration. The values that need to be configured are just "Blade for Gate xx%" (where xx is 0%, 10%, 90% and 100%).
The 2D fixed blade curve is forced in case there's a failure in the net head signal. So if blade tilt, blade manual and blade lock modes are not enabled this 2D fixed curve will be used for blade demand control.

See Appendix F, for additional detail on Blade Curves 3D and 2D.

Blade Tilt

NOTICE **This subsection is only applicable for Kaplan turbines.**

Blade tilt algorithm are sets of logics that drive the blade demand to a pre-defined position, bypassing the blade curves demands (either 3D or 2D) The available criteria for blade tilt are:

1- Voluntary Blade Tilt
2- Start Blade Tilt
3- Stop Blade Tilt
4- Load Rejection Blade Tilt

The control was designed in such a way that if more than one type of blade tilt is selected the highest number has priority. The four types of blade tilt will be explained below:

Voluntary Blade Tilt
This blade tilt type can de enabled/disabled at all times via discrete inputs, Modbus or display commands. When the voluntary blade tilt is enabled the blade demand will ramp up or down (at "Blade Demand Rate" value) to its actual value to the value configured on "Position Tilt" parameter.

Start Blade Tilt
This blade tilt type is automatically enabled when turbine is being started. This algorithm is used if parameter "Use Start Tilt" is configured to TRUE. When a start command is given the blade demand will ramp up or down (at "Blade Demand Rate" value) from its actual value to the value configured on "Start Tilt Position" parameter. The start blade tilt logic will stay enabled while turbine speed is below "Speed to Disable Start Tilt".

This start blade tilt logic can be used in conjunction with parameter "Use Blade Start Pre Position". If this parameter is configured to TRUE then when a start command is given the blade is positioned at start tilt position before start opening the gate. If it's configured to FALSE then the blade demand will go to start blade tilt demand (if "Use Start Tilt" is used) at the same moment as the gate is being positioned at Breakaway value.

Stop Blade Tilt
This blade tilt type is automatically enabled when turbine is being stopped. This algorithm is used if parameter "Use Stop Tilt" is configured to TRUE. When a stop command is given, generator breaker is opened and gate position is less than 2% the blade demand will ramp up or down (at "Blade Demand Rate" value) from its actual value to the value configured on "Stop Tilt Position" parameter. The stop blade tilt logic will stay enabled while turbine speed is above "Speed to Disable Stop Tilt".

NOTICE

If a shutdown occurs and "Use Stop Tilt" is configured to TRUE the blade demand will follow the same Stop Blade Tilt demand logic. This will allow the turbine go for a deadstop condition on a faster way.

Load Rejection Blade Tilt
This blade tilt type is automatically enabled when turbine at a load rejection situation (please see section Load Rejection). This algorithm is used if parameter "Use Blade Load Rejection" is configured to TRUE. As long as the turbine is at load rejection the blade demand will step up or down to its actual value to the value configured on "Blade Load Rejection Value" parameter.
See Appendix F, for additional detail on Blade Tilt.

Blade Manual

NOTICE

This subsection is only applicable for Kaplan turbines.

When manual blade mode is enabled the blade demand can be driven manually. There's a tracking between manual blade and other blade control modes. The blade position in this mode can be driven by Raise and Lower manual blade commands. Direct setpoint can also be sent via Modbus or via display. The rate at which the manual position moves is configurable.

Manual control mode can be enabled when the unit is running or when the unit is stopped. Generally manual blade mode is enabled during turbine first start attempt or in situations where the blade position should be maintained at a given position different than the voluntary blade tilt position, regardless of turbine speed or other conditions.

This mode can also be enabled automatically in case a Net Head Fault is configured to "Revert to Manual Blade"

See Appendix F, for additional detail on Manual Blade Control.

Blade Lock

NOTICE

This subsection is only applicable for Kaplan turbines.

This blade control mode is the most critical one. When this control mode is enabled the blade demand is locked at its actual position and cannot be changed. Blade lock control mode can be enabled voluntarily via discrete inputs, Modbus or display commands.

This mode can also be enabled automatically in case a Net Head Fault is configured to "Blade Lock".

Blade Limit

NOTICE

This subsection is only applicable for Kaplan turbines.

Among all blade control algorithm this controller also provides a blade limiter logic in case the blade demand should not surpass a given value for any reason. This blade limit logic goes on an LSS (low signal selector) with all other blade control algorithms. When the turbine starts the blade limiter is set to 101%. Therefor if the customer doesn't want to use blade limit nothing needs to be done.

From this point on it blade limit demand can be changed via discrete commands (Blade Limit Raise/Lower), direct Modbus or display commands.

An analog blade limiter input can also be configured (generally configured from 0 to 100%). If analog blade limit analog input is used then discrete inputs, Modbus and display commands won't work.

The rate at which the blade limit demand changes should be configured at parameter "Blade Limit Rate".

Speed Switches

There are six speed switches that can be used in one of the configurable outputs. All speed switches are also passed along to Modbus.

The speed switches can be configured as increasing switches or decreasing switches. This means that the relay energizes as the unit speed is increasing above the set point or decreasing below the set point. Each speed switch has a High set point and a Low set point. When the speed switch is configured as an increasing switch, the High set point is the trip point and the Low set point is the switch's reset point. When the speed switch is configured as a decreasing switch, the Low set point is the trip point, and the High set point is the reset point. There are also configurable delays for activation and deactivation of the switches.

Here is an example of a speed switch setup: A speed switch is desired to turn on the unit's exciter when the unit reaches 90% rated speed after a startup. Configurable relay #1 is configured as speed switch #1. The speed switch is configured as an increasing switch. The High set point is adjusted to 90%. It is decided that the switch should reset at 80% rated speed, so the Low set point is adjusted to 80%.

A failsafe logic is available in case both speed inputs fails. If this failsafe logic is used the referred output can be forced to a "Fail Safe State" for the "Time to Disable Fail Safe", expressed in minutes. After the "Time to Disable Fail Safe" time expires the switch output gets back to its natural state. If a turbine start command is issued the failsafe logic is disabled automatically.

Gate Position Switches

There are four gate position switches that can be used in one of the configurable outputs. All gate position switches are also passed along to Modbus.

The gate position switches can be configured as increasing switches or decreasing switches. This means that the relay energizes as the gate position is increasing or decreasing compared to the set point. Each gate position switch has a High set point and a Low set point. When the gate position switch is configured as an increasing switch, the High set point is the trip point and the Low set point is the switch's reset point. When the gate position switch is configured as a decreasing switch, the Low set point is the trip point, and the High set point is the reset point.

Here is an example of a gate position switch setup: A gate position switch is desired to turn on a light when the gates are closed. Configurable relay #1 is configured as gate position switch #1. The gate position switch is configured as a decreasing switch. The Low set point is adjusted to 1. It is decided that the switch should reset at 4% gate position, so the High set point is adjusted to 4%.

A failsafe logic is available in case all gate feedback signal fails. If this failsafe logic is used the referred output can be forced to a "Fail Safe State" for the "Time to Disable Fail Safe", expressed in minutes. After the "Time to Disable Fail Safe" time expires the switch output gets back to its natural state. If a turbine start command is issued the failsafe logic is disabled automatically.

Active Power Switches

There are four active power switches that can be used in one of the configurable outputs. All active power switches are also passed along to Modbus.

The active power switches can be configured as increasing switches or decreasing switches. This means that the relay energizes as the unit active power is increasing above the set point or decreasing below the set point. Each active power switch has a High set point and a Low set point. When the active power switch is configured as an increasing switch, the High set point is the trip point and the Low set point is the switch's reset point. When the active power switch is configured as a decreasing switch, the Low set point is the trip point, and the High set point is the reset point. There are also configurable delays for activation and deactivation of the switches.

Here is an example of an active power switch setup: An active power switch is desired to provide a permissive for opening the generator breaker when the unit reaches 3% rated active power. Configurable relay #1 is configured as active power switch #1. The active power switch is configured as a decreasing switch. The Low set point is adjusted to 3%. It is decided that the switch should reset at 5% rated active power, so the High set point is adjusted to 5%.

A failsafe logic is available in case the power transducer signal fails. If this failsafe logic is used the referred output can be forced to a "Fail Safe State" as long as this signal failure remains. When the signal gets back to normal the switch gets back to its natural state.

Blade Position Switches

NOTICE **This subsection is only applicable for Kaplan turbines.**

There are four blade position switches that can be used in one of the configurable outputs. All blade position switches are also passed along to Modbus.

The blade position switches can be configured as increasing switches or decreasing switches. This means that the relay energizes as the blade position is increasing or decreasing compared to the set point. Each blade position switch has a High set point and a Low set point. When the blade position switch is configured as an increasing switch, the High set point is the trip point and the Low set point is the switch's reset point. When the blade position switch is configured as a decreasing switch, the Low set point is the trip point, and the High set point is the reset point.

Here is an example of a blade position switch setup: A blade position switch is desired to turn on a light when the blades are closed. Configurable relay #1 is configured as blade position switch #1. The blade position switch is configured as a decreasing switch. The Low set point is adjusted to 1. It is decided that the switch should reset at 4% blade position, so the High set point is adjusted to 4%.

A failsafe logic is available in case all blade feedback signal fails. If this failsafe logic is used the referred output can be forced to a "Fail Safe State" for the "Time to Disable Fail Safe", expressed in minutes. After the "Time to Disable Fail Safe" time expires the switch output gets back to its natural state. If a turbine start command is issued the failsafe logic is disabled automatically.

Customized Trip Relays

The control has two independent trip relays which can be configured independently. For each trip relay the customer can define exactly which trip conditions will be passed through the relays. An independent "Reset Clears Trip" configuration can be defined for each relay. If it's configured to TRUE the referred trip relay will be deactivated upon a reset command, even if trip condition still exists.
This allow a wide variety of applications, with different trip configurations for different type of trip circuits.

Turbine Operating Values

The control provides the following counters/accumulators:

1- Turbine Running Hours
2- Turbine Running with Load Hours
3- Turbine Running with Load > 25%
4- Turbine Running with Load > 75%
5- Number of Turbine Starts
6- Number of Turbine Shutdowns
7- Number of Turbine Shutdowns (Load > 25%)
8- Number of Turbine Shutdowns (Load > 75%)

All these counters/accumulators will be automatically saved on non-volatile memory every time one of the following conditions happen:

1- Turbine shutdown and speed above 20%
2- Controller is in I/O Lock state
3- Every 24h

If the controller is replaced it's recommended to "Rewrite" these counters/accumulators.

Shutdown Datalog

The control provides a shutdown datalog with its relevant Boolean and analog variables. At the moment the turbine starts the datalog starts collecting data on a circular buffer. When the buffer is full the new data overwrites the old one in a first-in-first-out method. When a shutdown occurs the datalog still collects some data after it and then prints a file called **TURBDAT_x.log**, where x is an index that varies from 1 to 4. Therefore it will store the datalog files from the last four shutdown for later analysis. These files can be retrieved using a Woodward software called App Manager and can be opened/analyzed using Control Assistant.

Chapter 4.
505HT Display

Program Architecture

The 505 is easy to configure, due in large part to the menu-driven software. When the control is powered up and after the CPU self-test has been completed, the control displays the home screen and the CPU LED on the left side of the front panel should be green. The operating procedures are divided into two sections: the Configuration Mode and the Run Modes (Operation and Calibration). The Configure Mode is used to configure the 505 for the specific application and set all operating parameters. The Run Mode is the normal turbine operation mode and is used to view and modify operating parameters and run the turbine.

The configuration 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.

Display Modes and User Levels

The 505 Display operates in several modes and access user levels, each of which has a different purpose. The modes are: OPERATION, CALIBRATION, and CONFIGURATION. In order to enter and exit a particular mode, the user must be logged in with an appropriate user level. These user levels are: MONITOR, OPERATOR, SERVICE, and CONFIGURE. In addition to granting authority to enter and exit modes, user levels also determine what parameters the user is authorized to adjust. See Table 4-1.

Table 4-1. Mode Access by User Level

		Mode		
		Operation	**Calibration**	**Configuration**
User Level	Monitor			
	Operator	X		
	Service	X	X	
	Configure	X	X	X

Mode Descriptions

The OPERATION mode is the only mode that can be used to run the turbine. This is the default mode. Exiting CALIBRATION or CONFIGURATION mode will return to OPERATION mode. User levels: Operator, Service, or Configure.

The CALIBRATION mode is used to force signal outputs in order to calibrate signals and field devices. In this mode, the actuator, analog, and relay outputs can be manually controlled. To enter this mode the turbine speed must be shutdown with no speed detected. User levels: Service or Configure.

The CONFIGURE mode is used to set up the parameters for a specific application prior to operation of the unit. To enter this mode the turbine speed must be shutdown with no speed detected. When the unit enters CONFIGURE mode the control is placed in IOLOCK which will disable all Output I/O channels. If the control is not shutdown, navigating through the configuration pages will allow viewing of CONFIGURE parameters, but will not permit any changes to be made.

User Level Descriptions

The Monitor user level is view-only access. All commands from the front panel are inhibited. All values displayed on each screen are continuously updated.

The Operator user level allows for control of the turbine. Front panel commands to start, change setpoints, enable/disable functions, and stop the turbine are accepted.

The Service user level allows the same commands as the Operator user level plus tuning of Service menu parameters and issuing of additional commands.

The Configure user level allows the same commands and access as the Service user level plus tuning of Configuration menu parameters.

Use the following procedure to begin configuring the 505:
1. Press the MODE key.
2. Press the LOGIN softkey to open the User Login popup.
3. Login to the 'Configure' user level.
4. Close the User Login popup screen.
5. Press the Configuration softkey to enter configuration mode. Verify that the following Calibration and Configuration Mode Permissives are met:
   a. Unit Shutdown
   b. No Speed Detected
   c. "Configure" User Level or greater is logged in
6. Press MODE or HOME to return to the HOME screen.

Use the navigation cross to navigate up/down/left/right and use ENTER to select a menu or item.

The 505 configure mode may be accessed if the unit is in a Shutdown state, no speed is detected, and the correct user level is logged in (Configure or higher). For safety reasons the configuration may be monitored only and no changes will be accepted if the turbine is running. By pressing the MODE key, pressing the soft key for LOGIN, and logging in as the "Configure" user level by entering the password (wg1113). Select a field using the navigation cross arrows and then press ENTER to enter text. When finished, press ENTER again. All configuration values and saved service mode changes are stored in the nonvolatile memory (EEPROMs) of the 505 control. To ensure that values are saved, exit Configure mode or select 'Save Settings' from the MODE screen. If power is removed from the 505 all saved values will return once power is restored. No batteries or back up power is required.

Figure 4-1. User Login and Mode Selection Screen

Passwords

Operator: wg1111 Service: wg1112 Configure: wg1113

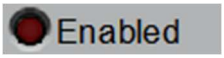
Symbols

There are some symbols used in the display, below is a list of the most important and their means.

Command button: ready to accept command (enabled).

Command button: not ready to accept command (disabled).

Screen selector button: Used to navigate between screens.



Led off: This led means the function is not enabled.

Led on: This led means the function is enabled.

Analog Write: This field is used to enter analog values.

Boolean Write: This field is used to enter Boolean values.

Breaker opened: Indicates the generator breaker is opened.

Breaker Closed: Indicates the generator breaker is closed.

Automatic screen changes

Sometimes the screen can automatically change to another screen. The situations are described below.

Screen Saver: After a configured time the display will automatically go to a screen saver screen. This time can be adjusted at the “General Configuration” screen.
Shutdown: If a shutdown occurs, the shutdown screen will automatically open.
Alarm: If an alarm occurs, the alarm screen will automatically open, since this function is enabled at the “General Configuration” menu.
Status: After a configured time with no touch at the display the screen can automatically changes to the status page. These parameters can be set at the “General Configuration” screen.

Multi-language

To change the language, go to the MODE screen and navigate to the Globe Icon and press Enter. A list of language options will appear – after selecting the desired language the GUI must be restarted. If the turbine is shutdown, you could just power cycle the control. If the turbine is in operation – or it is not desired to stop the GAP application, then the GUI restarted pressing the ‘Re-Start Gui” button.

Figure 4-2. Language Selection Screen

Menus

The navigation arrow keys (red navigation cross keypad; up, down, left, and right) are used for navigation of the menus. Press ENTER to go into a menu. Then use the navigation cross to move up or down (left/right, if needed) in the menu. A configuration error will cause the control to remain tripped. It is possible to exit program mode with such an error but the control will be tripped until the Configuration mode is entered again and the Configuration error is corrected. To check the configuration error go to Home screen and press “Config Check”.

To return to the previous screen, press the ESC key. To return to the main Home screen, press the HOME key again. To exit the Configure mode, go to the MODE screen and select the ‘Exit Configuration’ soft key. This will save values, exit I/O Lock, and reboots the 505.

Some screens have a number associated to it and it is showed between parentheses after the name of the screen on the Menu buttons, these screens can be directed accessed using the numbers buttons at the right of the control.

All commands, except reset, have confirmation screens, as showed below.

Figure 4-3. Confirmation Screen

The confirmation screen to start the turbine has a difference to the other confirmation screens. There are the conditions to start and the option to enable or disable black start (if isolated mode is enabled). If isolated mode is not enabled the option to enable or disable it will not appear on this screen.

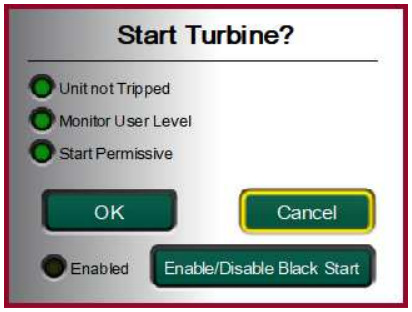


Figure 4-4. Start Confirmation Screen

Home

To program the control, navigate through the menus and configure the control features for the desired application. The menus and their basic functions are described below.

Figure 4-5. Home Screen

Table 4-2. 505HT Display Menus and Basic Functions

Overview:	An overview of the control. It shows the actual control mode, gate and blade status, generator breaker, etc.
Trend:	To monitors some parameters, using custom trend
Manual:	To configure manual control information
Baseload:	To configure baseload control information. This button will be visible only when baseload control is configured to be used in General Config screen
General Config:	To configure a bunch of general parameters, as Gate limit values, speed values, ramp rates, Isolated Mode, load rejection, etc.
PID:	To configure all PID´s parameters
Blade Values	To configure all parameters related to Blade as net head values, rates, tilt values, etc.
Blade Curves	To configure the blade curves and the fixed curve
Droop:	To configure the Gate x Load curve
Mismatches:	To configure gate and blade mismatches

Level:	To configure level control information. This button will be visible only when level control is configured to be used by the 505 in General Config screen
Overspeed Test:	To enable and disable overspeed test
Remote Faults:	To configure remote faults. This button will be visible only when any discrete input is configured to any remote fault
Communications:	To configure communication parameters
Switches:	To configure speed switches, load switches, blade and gate switches. This button will be visible only when any discrete output is configured to any switch
Status:	To show Speed and load in big gauges and gate, blade and generator breaker status. There is a second page showing tha operation values (turbine running hours, number of starts, number of trips, etc).
Trip Relays:	To configure what trip will activate the two trip relays.
Tutorial:	To see a 505's tutorial.

Hardware

Analog Inputs:	To configure all analog inputs
Contact Inputs:	To configure all Contact inputs
Analog Outputs:	To configure all analog outputs
Relay Inputs:	To configure all relay inputs
Actuators:	To configure all actuators
Speed Signals:	To configure all Speed Signals
Check Config:	To check if there is any configuration error
Save Settings:	To save the settings in the control

Overview

This purpose of this screen is to show the status of the control. Below is a description of this screen.

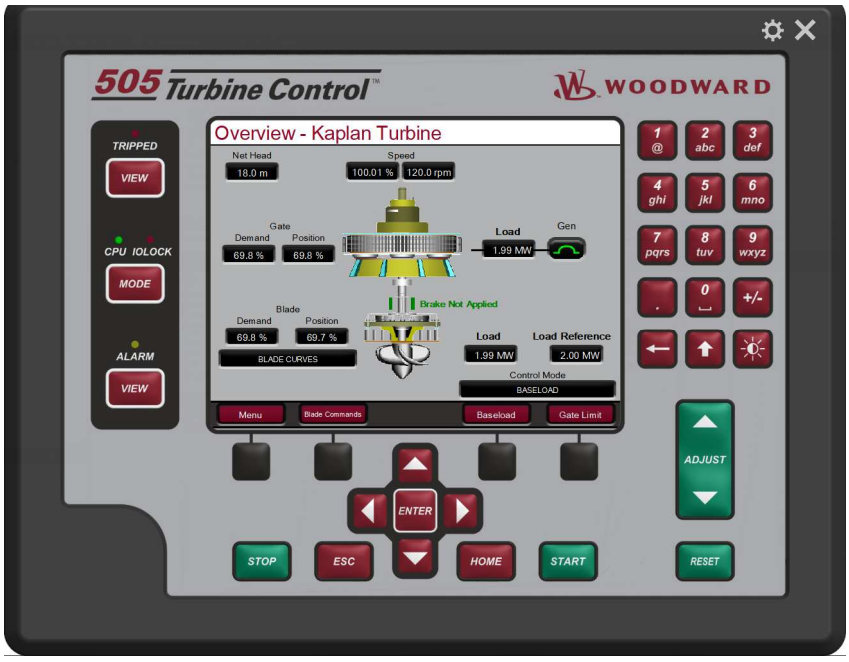


Figure 4-6. Overview Screen

At the top left of the screen there is an indication of the Net Head Value.

The screen shows the actual gate and blade position (Kaplan turbine) and also shows the actual blade control status. Above the turbine there are two indicators showing the speed in percent and in rpm. Depending on the configured turbine, the picture will show a Kaplan or Francis turbine. If a relay output is configured to "Apply Brakes" the breaker status will be showed in this screen.

At the right of the screen there is an indication of the actual load (in MW) and the status of the generator breaker.

At the bottom right there are some indications of the actual control mode. Depending on what the actual control mode is, the third black soft key will change and it will be possible to send commands to that control mode.

The second black soft key is to go to Blade Commands (Kaplan turbine), this screen will be explained later.

The fourth black soft key is to go to gate limit control popup (see below).

Figure 4-7. Gate Limit popup

The raise and lower buttons will increase or decrease the gate limit. If a value is typed in the black box and pressed GO the limit will ramp to that value. The two red indications are the actual gate limit and the actual demand. Press close to close this popup.

Blade Commands Screen (Kaplan turbine)

This screen is designed to check the blade control and has the shortcuts to the blade commands.

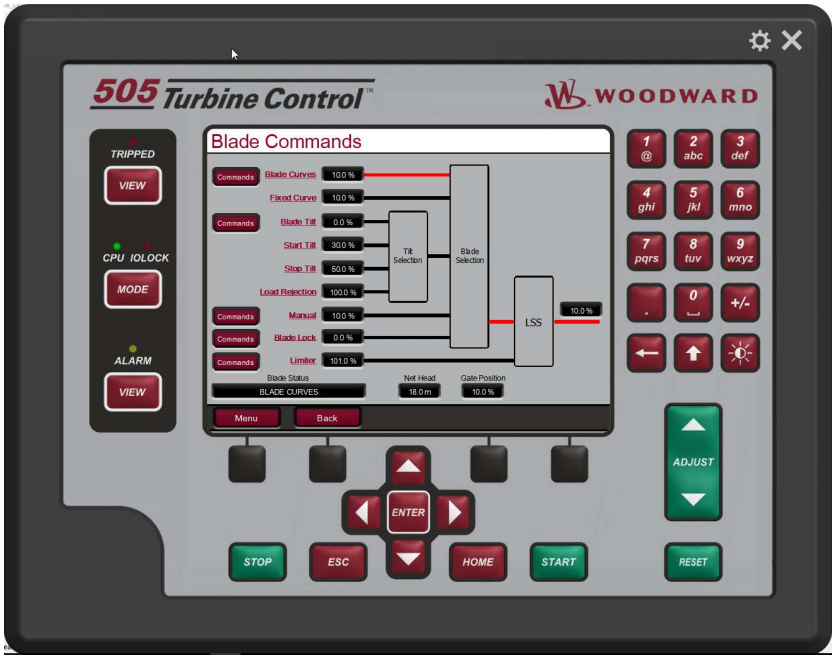


Figure 4-8. Blade Commands Screen

This screen shows every blade control mode and its actual value. If the control is in control its line will be red, if not its line will be black. Follow the red line to know what mode is actually controlling the blade position (the example above the actual control mode is blade curves).

Some control modes have commands and it is possible to access them from the buttons beside the control mode names. When these buttons are pressed the related popup will open to the operator send the commands. See below all available popups.

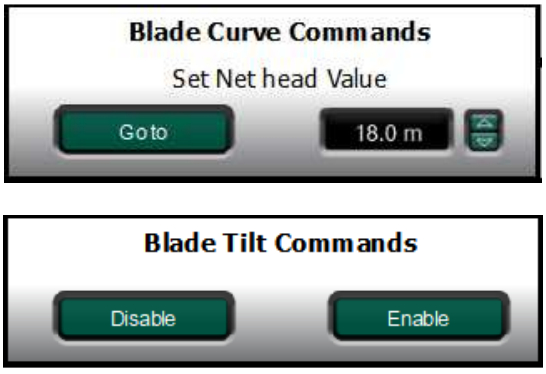


Figure 4-9. Blade Commands Popups Screen

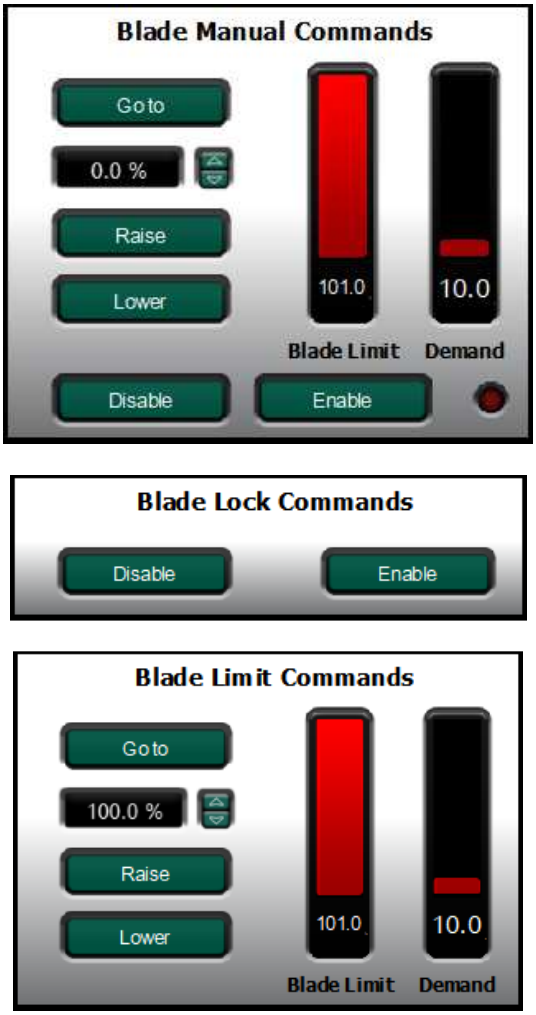


Figure 4-10. Blade Commands Popups Screen (Continued)

Custom Trend

This screen has a trend where the operator can choose what values want to monitor and the range of each one. The soft key “Settings” opens a screen to configure the trend. Pause the trend using the soft key “Pause”.

Figure 4-11. Custom Trend Screen

Time Window (sec): This is the time span of the trend
Variable: Choose the variable to monitor in the trend. There is a list of possible variables.
Y Max: Choose the Maximum Y value of the trend for this specific variable
Y Min: Choose the Minimum Y value of the trend for this specific variable
Width: Type the width of this pen
Axis: Select if this pen will have the range showed at the left of the trend

Press close to close this popup screen.

Figure 4-12. Custom Trend Settings Screen

Manual Gate

The purpose of this screen is to configure all parameters related to the gate manual control mode. The screen has command buttons and parameters, which are described in table 4-3:

Figure 4-13. Manual Gate Screen

Table 4-3. Manual Gate Command

Enable	Command
Visibility: Always **User Level:** Operator	This command will enable the manual control mode
Disable	Command
Visibility: Always **User Level:** Operator	This command will disable the manual control mode
Lower	Command
Visibility: Always **User Level:** Operator and Manual mode enabled	This command will lower the gate demand when in manual control mode
Raise	Command
Visibility: Always **User Level:** Operator and Manual mode enabled	This command will raise the gate demand when in manual control mode
R/L Pulse Timer	2.0 (1.0, 15.0) s
Visibility: Always **User Level:** Service	Maximum time to the raise and lower pulse command.
Rate	0.5 (0.01, 100.0) %/s
Visibility: Always **User Level:** Service	Rate that the manual ramp will use to increase or decrease the demand, when a pulse command is issued or when the setpoint is changed by Modbus command.
Stop Gate Rate	0.5 (0.01, 10.0) %/s
Visibility: Always **User Level:** Service	Rate that the manual ramp will use to decrease the demand, when a stop command is issued and the control is in manual mode.
Go to	Command
Visibility: Always **User Level:** Operator	Command to send the manual setpoint to the “Go to Value”.
Go to Value	0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Operator	Value where the manual demand goes when a “Go to” command is issued.

Click on the Test button to access the gate test screen.

All displays on the right of the screen are only for monitoring some parameters.

Clicking on the left and right soft keys the operator will navigate between gate and blade manual control.

Manual Blade (Kaplan turbine)

The purpose of this screen is to configure all parameters related to the blade manual control mode, when the control is controlling a Kaplan turbine. The screen has command buttons and parameters, which are described in table 4-4:

Figure 4-14. Manual Blade Screen

Table 4-4. Manual Blade Command

Enable	Command
Visibility: Always **User Level:** Operator	This command will enable the manual control mode

Disable	Command
Visibility: Always **User Level:** Operator	This command will disable the manual control mode

Lower	Command
Visibility: Always **User Level:** Operator and Manual mode enabled	This command will lower the blade demand when in manual control mode

Raise	Command
Visibility: Always **User Level:** Operator and Manual mode enabled	This command will raise the blade demand when in manual control mode

R/L Pulse Timer	2.0 (1.0, 15.0) s
Visibility: Always **User Level:** Service	Maximum time to the raise and lower pulse command.

Rate	0.5 (0.01, 100.0) %/s
Visibility: Always **User Level:** Service	Rate that the manual ramp will use to increase or decrease the demand, when a pulse command is issued or when the setpoint is changed by Modbus command.

Go to	Command
Visibility: Always **User Level:** Operator	Command to send the manual setpoint to the “Go to Value”.

Go to Value	0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Operator	Value where the manual demand goes when a “Go to” command is issued.

Click on the Test button to access the blade test screen.

All displays on the right of the screen are only for monitoring some parameters.

Clicking on the left and right soft keys the operator will navigate between gate and blade manual control.

Gate / Blade Test Screen

The purpose of this screen is to provide a way to test the gate and the blade (Kaplan turbine) of the turbine. The screens for gate and blade are identical, this manual will describe just the gate screen.

Figure 4-15. Gate / Blade Test Screen

Table 4-5. Gate and Blade Test Screen

Start Test		Command
Visibility: Always **User Level:** Operator	This command will start the gate / blade test.	
Stop test		Command
Visibility: Always **User Level:** Operator	This command will stop the gate / blade test.	
Test Running		Monitor
Visibility: Always **User Level:** N/A	Shows if the test is actually running.	
Inhibited		Monitor
Visibility: Always **User Level:** N/A	Shows if the test is Inhibited.	
Minimum Value		0 (0, 100) %
Visibility: Always **User Level:** Service	Minimum demand value to test gate / blade. The demand that will start and finish the test.	
Maximum Value		100 (0, 100) %
Visibility: Always **User Level:** Service	Maximum demand value to test gate / blade. The top of the curve.	
Step Value		10 (0, 100) %
Visibility: Always **User Level:** Service	Step of each increasing or decreasing during the test.	
Step Time		30 (1, 300) s
Visibility: Always **User Level:** Service	Time to stop the test on each step.	
Test State		Monitor
Visibility: Always **User Level:** N/A	It shows the actual state of the test (Error, Disable, Go to Min, Go to Max, Step up, Step down, etc.).	
Demand		Monitor
Visibility: Always **User Level:** N/A	It shows the actual gate / blade demand.	
Remaining Time		Monitor
Visibility: Always **User Level:** N/A	It shows the remaining time to go to another step of the test.	
Min.		0.0 (-10.0, 110.0)
Visibility: Always **User Level:** Service	It configures the minimum scale of the trend.	
Max.		100.0 (-10.0, 1100.0)
Visibility: Always **User Level:** Service	It configures the minimum scale of the trend.	
Time.		60.0 (10.0, 600.0) s
Visibility: Always **User Level:** Service	Time span of the trend	

Baseload Screen

The purpose of this screen is to configure all parameters related to the baseload control mode.

Figure 4-16. Baseload Screen

Table 4-6. Baseload Screen

Rated Load	3.0 (0.0, 30000.0) MW
Visibility: Always **User Level:** Configure	Enter the rated load of the generator in MW. **CONFIGURATION MODE REQUIRED**
Maximum Baseload Reference	3.0 (0.0, 30000.0) MW
Visibility: Always **User Level:** Service	Enter the maximum baseload setpoint, when baseload is in control. This value should be equal or less than the rated load and equal or greater than the initial baseload reference.
Initial Baseload Reference	0.5 (0.0, 30000.0) MW
Visibility: Always **User Level:** Service	Enter the initial baseload setpoint, this is the setpoint that the control will assume when the baseload control is configured to be the first control mode when generator breaker closes. This value should be equal or less than the maximum baseload reference and equal or greater than the minimum baseload reference.
Minimum Baseload Reference	0.5 (0.0, 30000.0) MW
Visibility: Always **User Level:** Service	Enter the minimum baseload setpoint, when baseload is in control. This value should be equal or less than the initial baseload and equal or greater than the unload level.
Unload Level	0.5 (0.0, 30000.0) MW
Visibility: Always **User Level:** Service	Enter the unload level, this is the value where the control will send the command to open the generator breaker (if used) and it is also the value where the control goes when the unload command is issued. This value should be equal or less than the minimum baseload reference.
Baseload Rate (Min to Max Load)	*60.0 (1.0, 600.0) s
Visibility: Always **User Level:** Service	Enter the time the control will spend to go from the minimum baseload reference to the maximum baseload reference. This value will be the rate of the baseload reference ramp.
Remote Baseload Rate (Min to Max Load)	*60.0 (1.0, 600.0) s
Visibility: Always **User Level:** Service	Enter the time the control will spend to go from the minimum baseload to the maximum load reference when in remote baseload control. Remote baseload is when the baseload setpoint is following
Use Minimum PID	*FALSE
Visibility: Always **User Level:** Service	Check to limit the minimum PID output to the “Speed no load gate limit”, to prevent the generator reverse power when in baseload.
Baseload Deadband	*0.0 (0.0, 3.0)
Visibility: Always **User Level:** Service	Enter the deadband value (in %) to be used in the baseload control.

Press the soft key “Commands” to go to the baseload commands screen.

Baseload Commands Screen

The purpose of this screen is to operate the baseload control mode.

Figure 4-17. Baseload Commands Screen

Table 4-7. Baseload Commands Screen

Enable	Command
Visibility: Always **User Level:** Operator	This command will enable the baseload control mode.
Disable	Command
Visibility: Always **User Level:** Operator	This command will disable the baseload control mode.
Lower	Command
Visibility: always **User Level:** Operator and if baseload mode enabled	This command will lower the baseload reference.
Raise	Command
Visibility: always **User Level:** Operator and if baseload mode enabled	This command will raise the baseload reference.
Rate (Min to Max)	*60.0 (1.0, 600.0) s
Visibility: Always **User Level:** Service	Enter the time the control will spend to go from the minimum baseload reference to the maximum baseload reference. This value will be the rate of the baseload reference ramp.
Go to	Command
Visibility: Always **User Level:** Operator	Command to send the baseload setpoint to the “Go to Value”.
Go to Value	0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Operator	Value where the baseload reference goes when a “Go to” command is issued.
Enable (Remote Baseload)	Command
Visibility: Remote baseload in Use **User Level:** Operator and baseload Enabled	This command will enable the remote baseload control mode.
Disable (Remote Baseload)	Command
Visibility: Remote baseload in Use **User Level:** Operator and baseload enabled	This command will disable the remote baseload control mode.
Remote Reference	Monitor
Visibility: Remote baseload in Use **User Level:** Monitor	It shows the actual Remote Reference, from the analog input.
Remote Baseload Fault	Monitor
Visibility: Remote baseload in Use **User Level:** Monitor	It shows if there is a signal fail on the analog input configured for this function.
Rate (Min to rated)	60.0 (1.0, 600.0) %/s
Visibility: Remote baseload in Use **User Level:** Service	The remote speed will follow the analog input configured for this function, but will use this rate to prevent bumps on the reference. Even if the analog input has big oscillations, the reference will always ramp slowly.

At the bottom of the screen there are two displays showing the actual load and the actual load reference.

Turbine Configuration 1 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-18. Turbine Configuration 1 Screen

Table 4-8. Turbine Configuration 1 Screen

Turbine Type Configuration	None
Visibility: Always **User Level:** Configure	Choose the turbine type that the 505 will control. The options are Francis or Kaplan. This is the first parameter to be configured in the control. **CONFIGURATION MODE REQUIRED**
Breakaway Limit	20.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Value to be used during the startup of the turbine. Breakaway is the first step of the gate to force the turbine to break its initial inertia.
Breakaway Rate	5.0 (0.01, 100.0) %/s
Visibility: Always **User Level:** Service	Rate to be used during the startup when the reference is going from zero to the breakaway limit.
Dwell Time	20.0 (0.001, 30.0) s
Visibility: Always **User Level:** Service	Time that the control will wait to start going from breakaway to speed no load during the startup.
Speed no Load Gate Limit	15.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Speed no Load should be a value a little greater than the necessary opening of the gate to run the turbine in the rated speed with no load (generator breaker opened).
Start Gate Rate	1.0 (0.01, 10.0) %/s
Visibility: Always **User Level:** Service	Rate that the control will use to go from Breakaway to Speed no Load during the startup.
Stop Gate Rate	1.0 (0.01, 10.0) %/s
Visibility: Always **User Level:** Service	Rate that the control will use send the gate demand from actual value to zero when a stop command is issued.
R/L Gate Rate	0.5 (0.01, 10.0) %/s
Visibility: Always **User Level:** Service	Rate that the control will on the gate limit ramp when a raise / lower command is issued or when the setpoint is changed from Modbus or display.

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 2 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-19. Turbine Configuration 2 Screen

Table 4-9. Turbine Configuration 2 Screen

Use Auto Raise Gate Limit	TRUE
Visibility: Always **User Level:** Service	Select if auto gate limit raise will be used.
Auto Raise Gate Limit Timer	120.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	Time that the control will wait until it assumes the control of the turbine speed during the startup. After this time the auto raise gate limit will be enabled (if configured).
Auto Raise Gate Limit Rate	0.5 (0.0, 100.0) %/s
Visibility: Always **User Level:** Service	Rate that the control will use to ramp the speed limit from speed no load to the maximum gate position when auto raise gate limit is running.
Maximum Gate Position	100.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Maximum position that the gate limit will ramp.
Overspeed Level	150.0 (0.0, 300.0) %
Visibility: Always **User Level:** Configure	Value to consider overspeed shutdown. **CONFIGURATION MODE REQUIRED**
Overspeed Delay	0.1 (0.01, 2.0) s
Visibility: Always **User Level:** Configure	Delay time to overspeed shutdown. **CONFIGURATION MODE REQUIRED**

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 3 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-20. Turbine Configuration 3 Screen

Table 4-10. Turbine Configuration 3 Screen

Rated Speed	*120.0 (10.0, 2000.0) rpm
Visibility: Always **User Level:** Configure	Enter the rated speed of the turbine. **CONFIGURATION MODE REQUIRED**
Speed Deadband Select	ONLINE ONLY
Visibility: Always **User Level:** Service	Enter when the Speed deadband will be considered by the control. The options are Not used, Online only or Always.
Speed Deadband	0.05 (0.0, 5.0) %
Visibility: Always **User Level:** Service	Enter the speed deadband to be used when the speed deadband is in use and enabled.
Time to Incomplete Start	40.0 (1.0, 600.0) s
Visibility: Always **User Level:** Service	If the turbine does not reach the “Minimum Speed to Incomplete Start” before this time expires the turbine will shut down due incomplete start. The timer starts when a start command is issued.
Minimum Speed to Incomplete Start	30.0 (-10.0, 100.0) %
Visibility: Always **User Level:** Service	Value that the speed should reach to disable incomplete start.
Low Speed to Stable Speed	98.0 (90.0, 102.0) %
Visibility: Always **User Level:** Service	Minimum speed used by the control to verify if the speed turbine is stable. To consider stable the speed needs to be between Low and High during a configurable time.
High Speed to Stable Speed	102.0 (98.0, 110.0) %
Visibility: Always **User Level:** Service	Maximum speed used by the control to verify if the speed turbine is stable. To consider stable the speed needs to be between Low and High during a configurable time.
Time to Stable Speed	15.0 (1.0, 120.0) s
Visibility: Always **User Level:** Service	Time used by the control to verify if the speed turbine is stable. To consider stable the speed needs to be between Low and High during this time.
Dead Stop Time	30.0 (0.0, 300.0)
Visibility: Always **User Level:** Service	Set the time that the turbine will completely stop since the stop command is issued, the speed turbine is less than 2 rpm and the gates are closed

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 4 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-21. Turbine Configuration 4 Screen

Table 4-11. Turbine Configuration 4

Use Baseload Control	TRUE
Visibility: Always **User Level:** Configure	Select if baseload mode will be used. **CONFIGURATION MODE REQUIRED**
Use Level Control	FALSE
Visibility: Always **User Level:** Configure	Select if level control mode will be used. **CONFIGURATION MODE REQUIRED**
Use Remote Baseload Control	FALSE
Visibility: Always **User Level:** Configure and Use Baseload Control enabled	Select if remote baseload control mode will be used. **CONFIGURATION MODE REQUIRED**
Use Remote Level Control	FALSE
Visibility: Always **User Level:** Configure and Use Level Control enabled	Select if remote level control mode will be used. **CONFIGURATION MODE REQUIRED**
Use Remote Speed Control	FALSE
Visibility: Always **User Level:** Configure	Select if remote speed control mode will be used. **CONFIGURATION MODE REQUIRED**
Speed Bias Type	NOT USED
Visibility: Always **User Level:** Configure	Select type of speed bias will be used. The options are Not used, Analog Input or Discrete Input. **CONFIGURATION MODE REQUIRED**
Speed Bias Only for Synch	FALSE
Visibility: Always **User Level:** Configure	Select if the speed bias will be used only for synch. If unselect the speed bias will work all time. **CONFIGURATION MODE REQUIRED**
Speed Bias Rate	0.1 (0.01, 1.0) %/s
Visibility: Always **User Level:** Service	Rate that Speed Bias control will ramp to increase or decrease the speed reference
Speed Bias Range	5.0 (1.0, 10.0) %
Visibility: Always **User Level:** Service	Range to be used by the speed bias. For example, if the range is configured to 5% than the bias will vary between -5% and +5%. If Speed Bias is configured for analog input 4mA will be -5%, 12mA will be 0% and 20mA will be +5%.

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 5 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-22. Turbine Configuration 5 Screen

Table 4-12. Turbine Configuration 5 Screen Command Buttons and Parameters

Rate to Increase / Decrease Speed	0.1 (0.001, 100.0) %/s
Visibility: Always **User Level:** Service	Rate that the control will use to increase or decrease the speed in offline mode.
Speed no Load Reference	100.05 (75.0, 125.0) %
Visibility: Always **User Level:** Configure	Speed reference that the control will assume every time a start command is issued or the generator breaker opens. **CONFIGURATION MODE REQUIRED**
Minimum Speed Reference	90.0 (80.0, 100.0) %
Visibility: Always **User Level:** Configure	Minimum speed reference that the control will accept when in offline control. **CONFIGURATION MODE REQUIRED**
Maximum Speed Reference	110.0 (75.0, 250.0) %
Visibility: Always **User Level:** Configure	Maximum speed reference that the control will accept when in offline control and not in overspeed test. **CONFIGURATION MODE REQUIRED**
Maximum Overspeed Test Reference	200.0 (75.0, 250.0) %
Visibility: Always **User Level:** Configure	Maximum speed reference that the control will accept when in overspeed test. **CONFIGURATION MODE REQUIRED**
Rate for Overspeed Test Reference	2.5 (0.001, 100.0) %/s
Visibility: Always **User Level:** Service	Rate that the speed reference will ramp when in overspeed test.
Temporary Compensation Gain	0.05 (0.0, 10.0)
Visibility: Always **User Level:** Service	Set the temporary compensation gain

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 6 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-23. Turbine Configuration 6 Screen

Table 4-13. Turbine Configuration 6 Screen Command Buttons and Parameters

Initial load in Droop Mode	*5.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Initial percent of load when the control is in Load droop mode or the percent of the gate position that will be added to the gate position at the moment that the generator breaker closes when in Load or position droop is the first control mode configured.
First Mode when Breaker Closes	BASELOAD CONTROL
Visibility: Always **User Level:** Service	Select which control mode will be assumed by the control when the generator breaker closes. The options are Position Droop, Load Droop, Baseload Control, Level Control, Remote Baseload or Remote level. **Note:** If a control (s) is (are) not available, a "---" will be visible at the options. If this option is selected the control will assume the position control mode as first control mode when generator breaker closes.
Droop Value	5.0 (0.0, 10.0) %
Visibility: Always **User Level:** Service	Type the droop value to be used by the control when in droop mode.
Rate to Increase / Decrease Speed	1.0 (0.1, 20.0) %/s or MW/s
Visibility: Always **User Level:** Service	Choose the rate to increase and decrease the droop setpoint. The engineering unit will be %/s when in position droop or MW/s when in load droop.
Rated Load	3.0 (0.0, 30000.0) MW
Visibility: Always **User Level:** Configure	Enter the rated load of the generator in MW. **CONFIGURATION MODE REQUIRED**
Unload Level	0.5 (0.0, 30000.0) MW
Visibility: Always **User Level:** Service	Enter the unload level, this is the value where the control will send the command to open the generator breaker (if used) and it is also the value where the control goes when the unload command is issued. This value should be equal or less than the minimum baseload reference.
Use Minimum PID	*FALSE
Visibility: Always	Check to limit the minimum PID output to the "Speed no load gate limit", to prevent the generator reverse power when in online control.
Use Small System Logic	*TRUE
Visibility: Always **User Level:** Configure	Choose if the logic to detect isolated mode (small system detection) is enabled.
Speed Window	1.0 (0.1, 100.0) %
Visibility: Always **User Level:** Service	Value that the control will use to check if the speed is out of, to consider isolated mode (if small system detection is enabled).
Derivative Window	*10.0 (0.1, 100.0) %/s
Visibility: Always **User Level:** Service	Value that the control will use to check if the derivative is out of, to consider isolated mode (if small system detection is enabled).

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 7 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-24. Turbine Configuration 7 Screen

Table 4-14. Turbine Configuration 7 Screen Command Buttons and Parameters

Enable Load rejection	TRUE
Visibility: Always **User Level:** Service	Select to use the load rejection logic.
Gate Position value	10.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Type the position that the Gate position goes when a load rejection is detected.
Max Speed Derivative	4.0 (0.0, 200.0) %/s
Visibility: Always **User Level:** Service	Maximum speed derivative value to detect load rejection.
Max Speed	105.0 (101.0, 120.0) %
Visibility: Always **User Level:** Service	Maximum speed value to detect load rejection.
Max Algorithm Time	10.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	Time the gate will keep on “Gate position Value” when a load rejection is detected. After this time 500 will take the control back.
Timer after Dead Stop to Enable Creep	30.0 (1.0, 600.0) s
Visibility: Always **User Level:** Service	The creep detection logic will be activated when the turbine is in dead stop mode for more than this time.
Creep Manual Reset	FALSE
Visibility: Always **User Level:** Service	If this parameter is enabled the operator shall reset the control to clean the Creep Alarm. If disabled the creep will auto reset each “Reset Time” and restart monitoring after “Lock Again Time”.
Reset time	15.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	After a creep is detected the control will reset the logic every “reset time” (if creep manual reset is disable).
Look Again time	5.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	After the reset is done the control will start monitoring creep again after this t”Look Again Time”.

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 8 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-25. Turbine Configuration 8 Screen

Table 4-15. Turbine Configuration 8 Screen Command Buttons and Parameters

Open Breaker on Normal Stop Command	FALSE
Visibility: Always **User Level:** Service	Select if a command to open the generator breaker will be issued when a Normal stop is in progress and the gate limit is at speed no load value for “Minimum Gate Limit Timeout”.
Minimum Gate Limit Timeout	2.0 (1.0, 30.0) s
Visibility: Always **User Level:** Service	Time the 505 will wait at speed no load reference to send a command to open the generator breaker during a normal stop (if enabled).
Open Breaker on Unload Command	FALSE
Visibility: Always **User Level:** Service	Select if a command to open the generator breaker will be issued when an Unload is in progress and the load reference is at Unload Level for “Minimum Load Reference Timeout”.
Minimum Load Reference Timeout	10.0 (1.0, 300.0) s
Visibility: Always **User Level:** Service	Time the 505 will wait at unload reference to send a command to open the generator breaker during an unload command (if enabled).
Open Time	1.0 (0.8, 60.0) s
Visibility: Always **User Level:** Service	Time from the open command until the status of “breaker opened” returns to the control. If this time is exceeded an alarm will be generated.

The operator can navigate between the general configuration screens pressing the soft keys with arrows to left or right.

Turbine Configuration 9 Screen

The purpose of this screen is to configure some general parameters.

Figure 4-26. Turbine Configuration 9 Screen

Table 4-16. Turbine Configuration 9 Screen Command Buttons and Parameters

Use Brake on Dead Stop	TRUE
Visibility: Always **User Level:** Service	Check this function to enable the brake when the turbine is on dead stop state
Brake Actuation Time on Dead Stop	180.0 (0.0, 1800.0) s
Visibility: Always **User Level:** Service	Time the brake will be activated during the turbine dead stop. The brake will be de-activated before this time expires if a new start command is issued.
Use Brake on Creep	TRUE
Visibility: Always **User Level:** Service	Check this function to enable the brak when the creep detection logic is enabled
Brake Actuation Time on Creep	30.0 (0.0, 1800.0) s
Visibility: Always **User Level:** Service	Time the brake will be activated during the creep detection. The brake will be de-activated before this time expires if a new start command is issued.
Speed to Pulse Brake	30.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	This is the speed that the brake will start pulsing during the normal stop
Pulse On Timer	3.0 (0.0, 60.0) s
Visibility: Always **User Level:** Service	Activate brake time while pulsing
Pulse Off Timer	3.0 (0.0, 60.0) s
Visibility: Always **User Level:** Service	De-activate brake time while pulsing
Speed to Hold Brake	20.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Speed that the brake will stop pulsing and be activated.

Turbine Configuration 10 Screen

The purpose of this screen is to configure gate and blade mismatches

Figure 4-27. Turbine Configuration 10 Screen

Table 4-17. Turbine Configuration 10 Screen Command Buttons and Parameters

Enable Minor Mismatch	TRUE
Visibility: Always. **User Level:** Service	Enable the gate minor mismatch (alarm).
Minor Mismatch value	3.0 (1.0, 100.0) %
Visibility: Always. **User Level:** Service	Value to gate minor Mismatch alarm. If the difference between demand and actual position is greater than this value an alarm will be generated (if enabled).
Minor Mismatch Delay	30.0 (0.0, 240.0) s
Visibility: Always. **User Level:** Service	Delay time to gate minor mismatch alarm.
Enable Major Mismatch	TRUE
Visibility: Always. **User Level:** Service	Enable the gate major mismatch shutdown.
Major Mismatch value	5.0 (1.0, 100.0) %
Visibility: Always. **User Level:** Service	Value to gate major Mismatch shutdown. If the difference between demand and actual position is greater than this value an alarm will be generated (if enabled).
Major Mismatch Delay	30.0 (0.0, 240.0) s
Visibility: Always. **User Level:** Service	Delay time to gate Major mismatch shutdown.

All these parameters are also available for the blade (Kaplan turbine).

Offline PID Screen

The purpose of this screen is to configure the offline PID. This screen has a live trend where it is possible to check the PV (Speed) in red, Setpoint in green, the PID output in blue and the gate Limiter in pink.
It is also possible to tune the PID. The red led indicates if the PID is active.

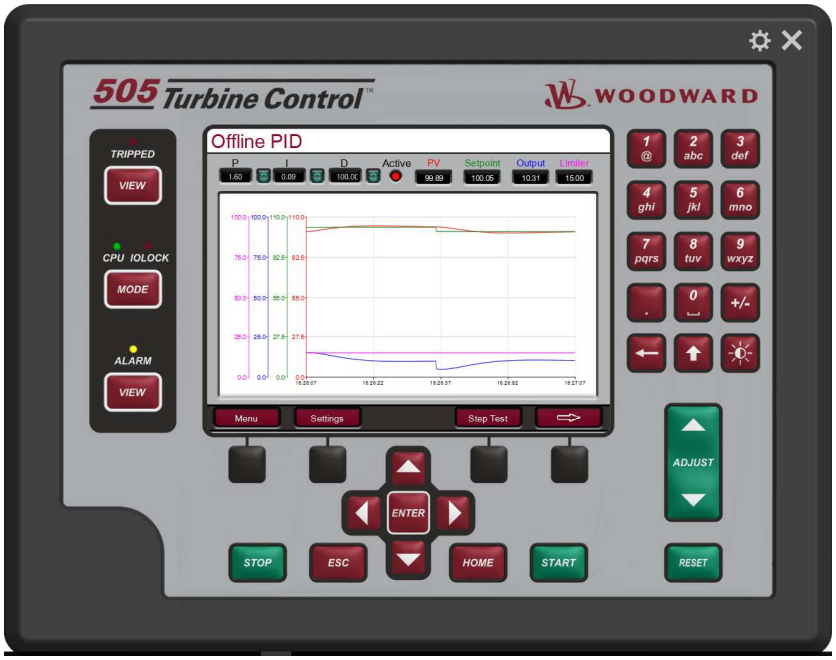


Figure 4-28. Offline PID Screen

Table 4-18. Offline PID Configuration Settings

P	1.6 (0.001, 20.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.09 (0.001, 10.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

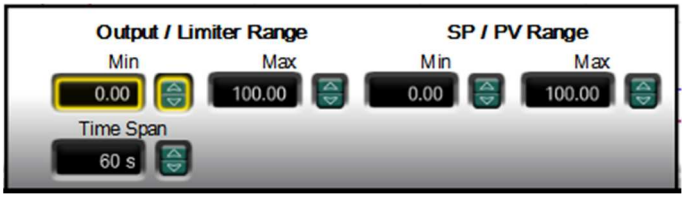


Figure 4-29 Offline PID Settings Screen

Output / Limiter ranges: change the Minimum and Maximum range of the PID output and Gate Limiter.

SP/PV Range: change the minimum and maximum range of the setpoint and PV (speed).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Step test Screen” explanation below to understand how this screen works.

Online PID Screen

The purpose of this screen is to configure the online PID. This screen has a live trend where it is possible to check the PV (Load or position) in red, Setpoint in green and the PID output in blue.
It is also possible to tune the PID and feed forward control. The red led indicates if the PID is active.

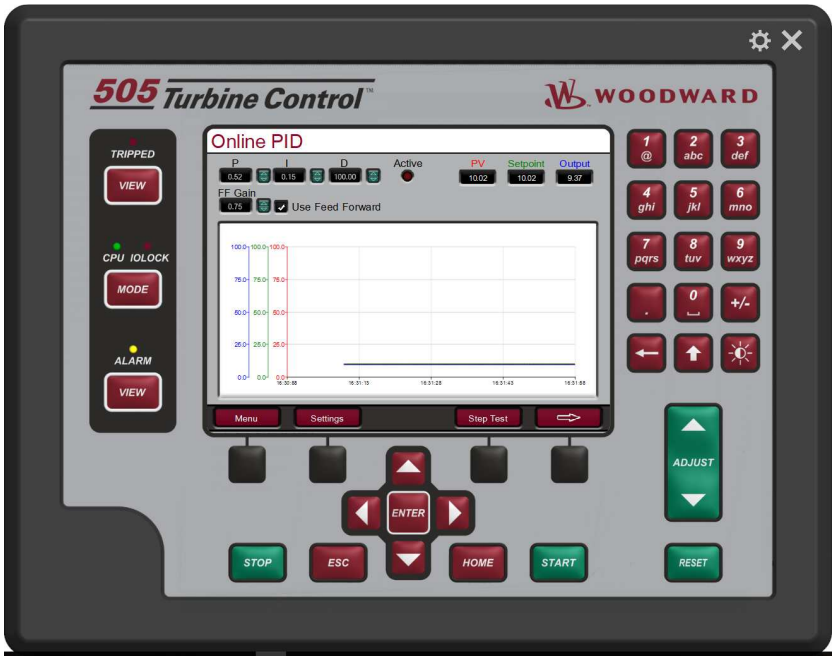


Figure 4-30. Online PID Screen

Table 4-19. Online PID Configuration Settings

P	0.52 (0.001, 20.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.15 (0.001, 10.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.
FF Gain	0.75 (0.0, 5.0)
Visibility: Always **User Level:** Service	Set the Feed Forward gain.
Use Feed Forward	TRUE
Visibility: Always **User Level:** Service	Set if the feed forward will be used.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

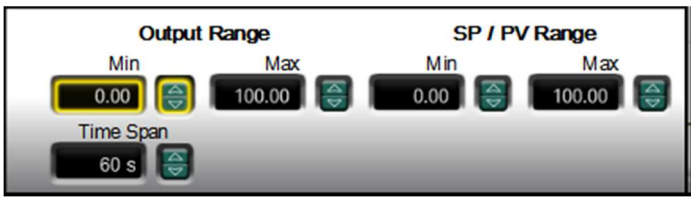


Figure 4-31. Online PID Settings Screen

Output ranges: change the Minimum and Maximum range of the PID output.
SP/PV Range: change the minimum and maximum range of the setpoint and PV (Position or Load).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Steps test Screen” explanation below to understand how this screen works.

Load Sharing PID Screen

The purpose of this screen is to configure the Load Sharing PID. This screen has a live trend where it is possible to check the PV (Speed) in red, Setpoint in green, the PID output in blue and the gate Limiter in pink.
It is also possible to tune the PID. The red led indicates if the PID is active.

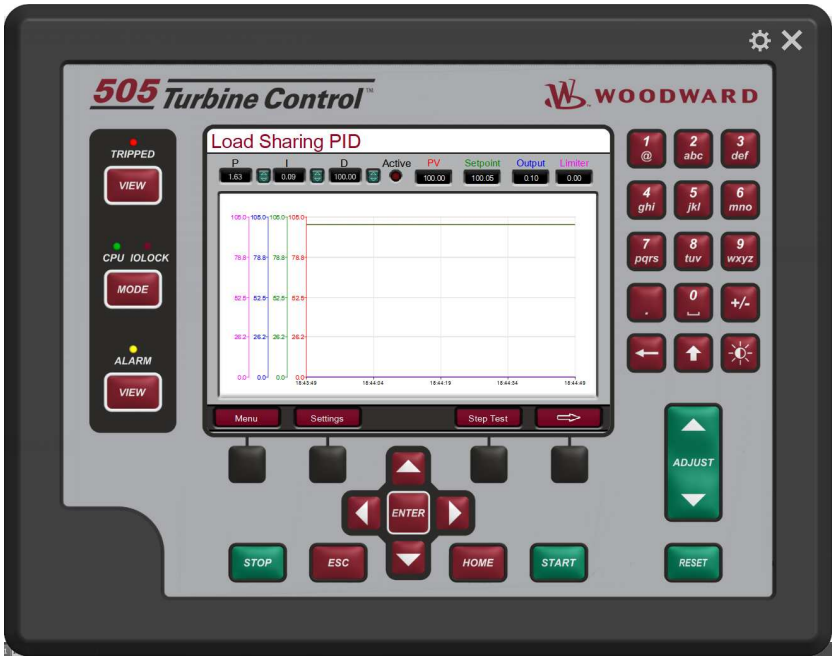


Figure 4-32. Load Sharing PID Screen

Table 4-20. Load Sharing PID Configuration Settings

P	1.6 (0.001, 20.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.09 (0.001, 10.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

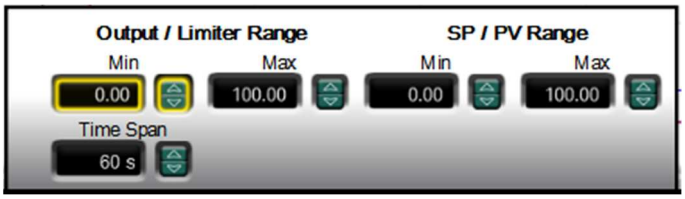


Figure 4-33. Load Sharing PID Settings Screen

Output / Limiter ranges: change the Minimum and Maximum range of the PID output and Gate Limiter.
SP/PV Range: change the minimum and maximum range of the setpoint and PV (speed).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Step test Screen” explanation below to understand how this screen works.

Baseload PID Screen

The purpose of this screen is to configure the Baseload PID. This screen has a live trend where it is possible to check the PV (Load) in red, Setpoint in green and the PID output in blue.
It is also possible to tune the PID. The red led indicates if the PID is active.

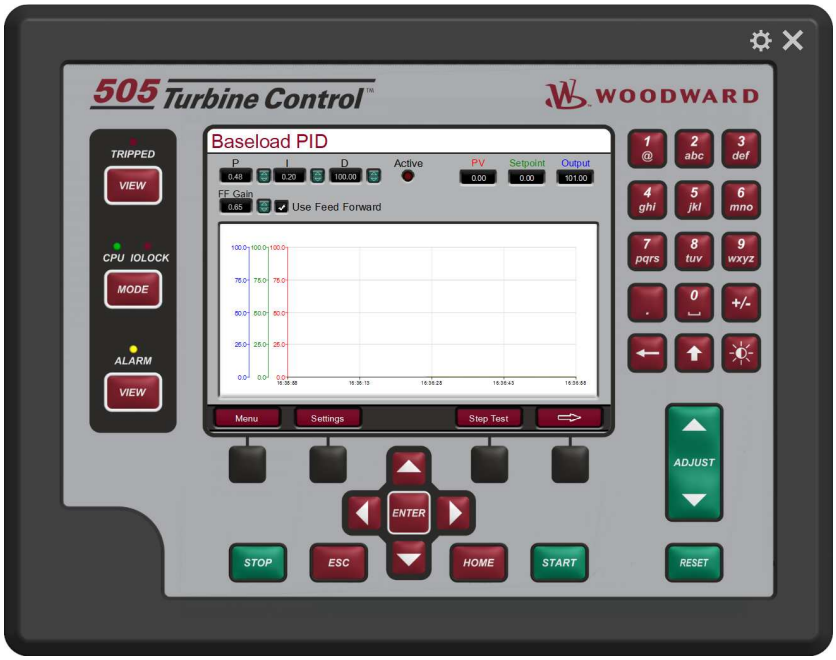


Figure 4-34. Baseload PID Screen

Table 4-21. Baseload PID Configuration Settings

P	0.48 (0.0, 20.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.2 (0.0, 10.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.
FF Gain	0.65 (0.0, 5.0)
Visibility: Always **User Level:** Service	Set the Feed Forward gain.
Use Feed Forward	TRUE
Visibility: Always **User Level:** Service	Set if the feed forward will be used.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

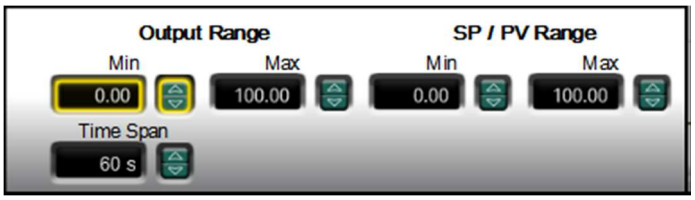


Figure 4-35. Baseload PID Settings Screen

Output ranges: change the Minimum and Maximum range of the PID output.
SP/PV Range: change the minimum and maximum range of the setpoint and PV (Load).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Step test Screen” explanation below to understand how this screen works.

Small System PID (Droop) Screen

The purpose of this screen is to configure the Small System PID (Droop). This screen has a live trend where it is possible to check the PV (Position or Load) in red, Setpoint in green and the PID output in blue.
It is also possible to tune the PID and feed forward control.

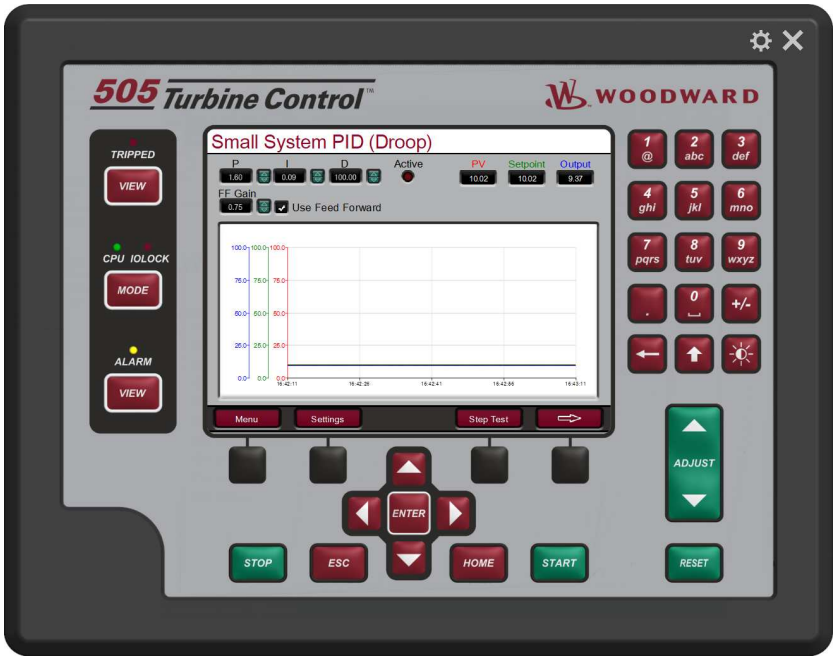


Figure 4-36. Small System PID (Droop) Screen

Table 4-22. Small System PID (Droop) Configuration Settings

P	1.6 (0.001, 50.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.09 (0.001, 50.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.
FF Gain	1.0 (0.0, 5.0)
Visibility: Always **User Level:** Service	Set the Feed Forward gain.
Use Feed Forward	TRUE
Visibility: Always **User Level:** Service	Set if the feed forward will be used.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

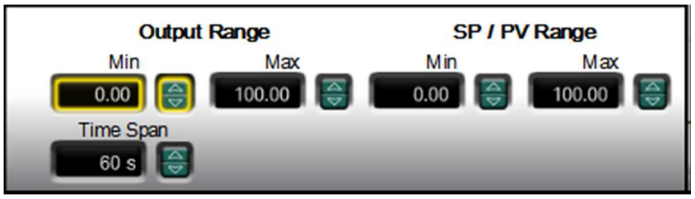


Figure 4-37. Small System Detection PID Settings Screen

Output ranges: change the Minimum and Maximum range of the PID output.
SP/PV Range: change the minimum and maximum range of the setpoint and PV (Position or Load).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Step test Screen” explanation below to understand how this screen works.

Small System PID (Isoch) Screen

The purpose of this screen is to configure the Small System PID (Isoch). This screen has a live trend where it is possible to check the PV (Speed) in red, Setpoint in green and the PID output in blue
It is also possible to tune the PID. The red led indicates if the PID is active.

Figure 4-38. Offline PID Screen

Table 4-23. Small System PID (Isoch) Configuration Settings

P	1.6 (0.001, 50.0)
Visibility: Always **User Level:** Service	The Proportional Gain Input determines the gain of the proportional component of the block's response.
I	0.09 (0.001, 50.0)
Visibility: Always **User Level:** Service	The Integral Gain Input determines the gain of the integral component of the block's response.
D	100.0 (0.01, 100.0)
Visibility: Always **User Level:** Service	The Speed Derivative Ratio (S_D_R) input affects the derivative component of the block's response.

The operator can navigate between the other PID´s screens pressing the soft key with right arrow.

To change the settings of the trend press the soft key “Settings” and the below screen will pop up.

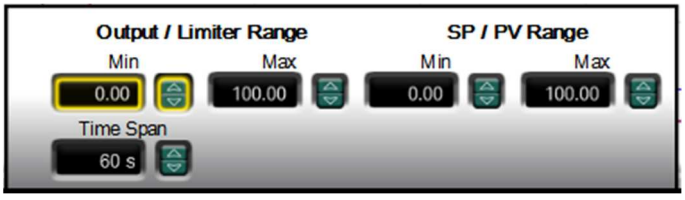


Figure 4-39. Small System PID (Isoch) Settings Screen

Output / Limiter ranges: change the Minimum and Maximum range of the PID output and gate Limiter.

SP/PV Range: change the minimum and maximum range of the setpoint and PV (speed).
Time span: change the time span of the trend.

Press the soft key “Step Test” to open the step test screen. This is a helpful tool in the tuning of the PID. Read the “Step test Screen” explanation below to understand how this screen works.

Step Test Screen

The purpose of this screen is to help users to tune the PID´s of the control. It is possible to step positive or negative values for programmed time and send the setpoints back to the initial values. The step test screen is the same for all PID´s.

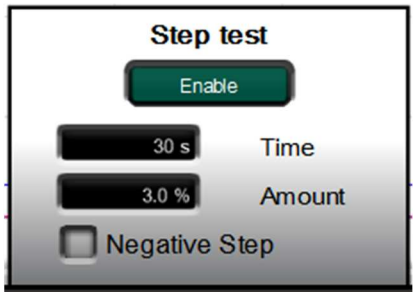


Figure 4-40. Step Test Screen

Table 4-24. Step Test Screen Configuration Settings

Enable	Command
Visibility: Always **User Level:** Service	Start the step test. The demand will increase or decrease (depending on the negative step is enabled) the amount value for the programmed time and go back to the initial value.
Time	30.0 (0.0, 1200.0) s
Visibility: Always **User Level:** Service	Time of the step test
Amount	*3.0 (-50.0, 50.0) %
Visibility: Always **User Level:** Service	Amount of the step test
Negative Step	FALSE
Visibility: Always **User Level:** Service	Select to negative step. If unselected the step will be positive.

Blade Values (1/3) Screen

The purpose of this screen is to configure the Blade values. This screen has adjusts for the net head values and Stop Tilt.

Figure 4-41. Blade Values (1/3) Screen

Table 4-25. Blade Values (1/3) Screen Configuration Values

Net Head Type	Modbus/QT Signal
Visibility: Always **User Level:** Configure	Enter the net head type. The options are “NET HEAD SIGNAL” (a specific analog input for Net Head), “POND AND TAIL SIGNALS” (net head will be the difference between Pond and Tail levels) or “MODBUS / DISPLAY” (Net head will be entered by the operator using Modbus or 505’s display). **CONFIGURATION MODE REQUIRED**
Minimum Net Head Value	18.0 (-10000.0, 10000.0) m
Visibility: Always **User Level:** Service	Enter the minimum net head value for the control.
Maximum Net Head Value	24.0 (-10000.0, 10000.0) m
Visibility: Always **User Level:** Service	Enter the maximum net head value for the control.
Net head Rate	0.1 (0.001, 1000.0) m/s
Visibility: Always **User Level:** Service	Enter the rate (in m/s) that the control will use to change the net head value.
Action in case of Head / Tail Signal Fail	FIXED CURVE
Visibility: Net Head Type is configured to “HEAD AND TAIL SIGNALS” **User Level:** Service	Enter the action that the control will take with the blade when either the Head or Tail signal fails.
Action in case of Net Head Signal Fail	FIXED CURVE
Visibility: Net Head Type is configured to “NET HEAD SIGNAL” **User Level:** Service	Enter the action that the control will take with the blade when the Net Head signal fails.
Use Stop Tilt	TRUE
Visibility: Always **User Level:** Service	Check if the stop tilt will be used.
Stop Tilt Position	50.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Enter the stop tilt value, that it is the value the blade will be demanded while the turbine is stopping.
Speed to Disable Stop Tilt	25.0 (2.0, 90.0) %
Visibility: Always **User Level:** Service	The control will disable the stop tilt when the actual speed is smaller than this parameter.

Blade Values (2/3) Screen

The purpose of this screen is to configure the Blade values. This screen has adjusts for the Position Tilt and Start Tilt.

Figure 4-42. Blade Values (2/3) Screen

Table 4-26. Blade Values (2/3) Screen Configuration Values

Position Tilt		0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Enter the position tilt value.	
Use Start Tilt		TRUE
Visibility: Always **User Level:** Service	Check if the start tilt will be used.	
Start Tilt Position		30.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Enter the start tilt value, that it is the value the blade will be demanded while the turbine is starting.	
Speed to Disable Start Tilt		50.0 (2.0, 100.0) %
Visibility: Always	The control will disable the start tilt when the actual speed is greater than this parameter.	

Blade Values (3/3) Screen

The purpose of this screen is to configure the Blade values. This screen has adjusts for the blade load rejection logic and the definition of the number of blade curves..

Figure 4-43. Blade Values (3/3) Screen

Table 4-27. Blade Values (3/3) Screen Configuration Values

Use Load Rejection	TRUE
Visibility: Always **User Level:** Service	Check if the load rejection logic will be used for the blade.
Blade Load Rejection Value	100.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Enter the value that the blade will be demanded during the load rejection..
Number of Blade Curves	4 (1, 9)
Visibility: Always **User Level:** Configure	Enter the number of curves to be used when the blade is on Blade curves control. **CONFIGURATION MODE REQUIRED**
Blade Rate Demand	3.0 (0.0, 1000.0) %/s
Visibility: Always **User Level:** Service	Enter the rate that the blade will move, except when the control detect a load rejection and the blade is configured to this function (in this case the demand will move instantaneously).
Blade Limit Rate	1.0 (0.1, 100.0) %/s
Visibility: Always	Enter the rate that the blade will move, except when the control detect a load rejection and the blade is configured to this function (in this case the demand will move instantaneously).
User Level: Service	

Blade Curves – Fixed Curve

The purpose of this screen is to configure the Blade fixed curve.

Figure 4-44. Blade Curves – Fixed Curve Screen

Table 4-28. Blade Curves – Fixed Curve Screen Configuration Values

Blade for Gate X%	X (-100.0, 200.0) %
Visibility: Always **User Level:** Service	Enter the blade value for when the gate is X%, where X goes from 0 to 100% (step 10%).

Blade Curves –Curve x

The purpose of this screen is to configure the Blade fixed curve.

Figure 4-45. Blade Curves –Curve 1 Screen

Table 4-29. Blade Curves – Fixed Curve Screen Configuration Values

Blade for Gate X%	X (-100.0, 200.0) %
Visibility: Always **User Level:** Service	Enter the blade value for when the gate is X%, where X goes from 0 to 100% (step 10%).
Net Head Value	*18.0 (-30000.0, 30000.0) %
Visibility: Always	Enter the net head value for the specific curve

Droop Screen

The purpose of this screen is to configure the droop curve (Gate x Load).

Figure 4-46. Droop Screen

Table 4-30. Droop Screen Configuration Values

Power Input (kW) Fault Forces Position Droop **Visibility:** Always **User Level:** Service	Enable this function if a fault in the analog input (Power Input) forces the control to position droop. If this function is not checked the control will go to kW Droop and it will follow the below curve.	FALSE
Load % for Gate Demand 0% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 0%.	0.0 (-100.0, 200.0) %
Load % for Gate Demand 10% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 10%.	4.0 (-100.0, 200.0) %
Load % for Gate Demand 20% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 20%.	12.0 (-100.0, 200.0) %
Load % for Gate Demand 30% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 30%.	17.5 (-100.0, 200.0) %
Load % for Gate Demand 40% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 40%.	26.0 (-100.0, 200.0) %
Load % for Gate Demand 50% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 50%.	36.0 (-100.0, 200.0) %
Load % for Gate Demand 60% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 60%.	47.0 (-100.0, 200.0) %
Load % for Gate Demand 70% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 70%.	60.0 (-100.0, 200.0) %
Load % for Gate Demand 80% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 80%.	77.0 (-100.0, 200.0) %
Load % for Gate Demand 90% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 90%.	94.0 (-100.0, 200.0) %
Load % for Gate Demand 100% **Visibility:** Always **User Level:** Service	Enter the load % for gate demand of 100%.	115.0 (-100.0, 200.0) %

Press the soft key “Commands” to go to droop commands screen.

Droop Commands Screen

The purpose of this screen is to send the droop commands.

Figure 4-47. Droop Commands Screen

Table 4-31. Droop Commands Screen Configuration Values

Go to Pos. Droop	Command
Visibility: Always **User Level:** Operator and control in droop mode	Send the control to position droop, when the control is in droop mode.
Go to Load Droop	Command
Visibility: Always **User Level:** Operator and control in droop mode	Send the control to load droop, when the control is in droop mode.
Droop Status	Monitor
Visibility: Always **User Level:** Monitor	It shows the actual droop status. The possible statuses are Load Droop, Position Droop or not in droop control.
Lower	Command
Visibility: always **User Level:** Operator and droop mode enabled	This command will lower the droop reference.
Raise	Command
Visibility: always **User Level:** Operator and droop mode enabled	This command will raise the droop reference.
Go to	Command
Visibility: Always **User Level:** Operator and droop mode enabled	Command to send the droop setpoint to the “Go to Value”.
Go to Value	*0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Operator	Value where the droop reference goes when a “Go to” command is issued.
Unload	Command
Visibility: Always **User Level:** Operator	Command to unload the generator from the actual load to the min load automatically.
Enable (Remote Droop)	Command
Visibility: Remote Speed in Use **User Level:** Operator and droop Enabled	This command will enable the remote droop control mode.
Disable (Remote Droop)	Command
Visibility: Remote Speed in Use **User Level:** Operator and droop enabled	This command will disable the remote droop control mode.
Remote Reference	Monitor
Visibility: Remote Speed in Use **User Level:** Monitor	It shows the actual Remote Reference, from the analog input.
Remote Speed Fault	Monitor
Visibility: Remote Speed in Use **User Level:** Monitor	It shows if there is a signal fail on the analog input configured for this function.

Press the soft key “Small System” to go to the Small system Mode commands.

Small System Commands Screen

The purpose of this screen is to send the Small System Mode commands.

Figure 4-48. Isolated Mode Commands Screen

Table 4-32. Isolated Mode Commands Screen Configuration Values

Small System	Command
Visibility: Always **User Level:** Operator and Isolated Mode configured to be used	Send the control to Small System mode.

Large System	Command
Visibility: Always **User Level:** Operator and Isolated Mode configured to be used	Send the control to Large System mode.

Lower	Command
Visibility: Always **User Level:** Operator and control in Small System Mode	This command will lower the demand to droop control when in Small System control mode

Raise	Command
Visibility: Always **User Level:** Operator and control in Small System Mode	This command will raise the demand to droop control when in Small System control mode

There are some status at the bottom of the page.

General Configuration (1/2) Screen

The purpose of this screen is to configure some general configuration, related to time and date.

Figure 4-49. General Configuration (1/2) Screen

Table 4-33. General Configuration (1/2) Screen Configuration Values

Year	20 (0, 99)
Visibility: Always. **User Level:** Configure	Enter the actual year to be adjusted in 505. The control will accept this value after “Set Date” command is issued.
Month	1 (1, 12)
Visibility: Always. **User Level:** Configure	Enter the actual month to be adjusted in 505. The control will accept this value after “Set Date” command is issued.
Day	1 (1, 31)
Visibility: Always. **User Level:** Configure	Enter the actual day to be adjusted in 505. The control will accept this value after “Set Date” command is issued.
Set Date	Command
Visibility: Always. **User Level:** Configure	Press “Set Date” and 505 will assume the values written on Year, Month and Day. NOTE: Adjust all them before pressing here.
Hours	0 (0, 23)
Visibility: Always. **User Level:** Configure	Enter the actual hour to be adjusted in 505. The control will accept this value after “Set Time” command is issued.
Minutes	0 (0, 59)
Visibility: Always. **User Level:** Configure	Enter the actual minutes to be adjusted in 505. The control will accept this value after “Set Time” command is issued.
Seconds	0 (0, 59)
Visibility: Always. **User Level:** Configure	Enter the actual seconds to be adjusted in 505. The control will accept this value after “Set Time” command is issued.
Set Time	Command
Visibility: Always. **User Level:** Configure	Press “Set Time” and 505 will assume the values written on Hours, Minutes and Seconds. NOTE: Adjust all them before pressing here.
Time Zone	0 (-12, 13)
Visibility: Always. **User Level:** Configure	Set the time zone to be used.
Use Half Time Zone	FALSE
Visibility: Always. **User Level:** Configure	Check to use “Half Time Zone” and half hour (30 minutes) will be added to the time zone.

General Configuration (2/2) Screen

The purpose of this screen is to configure some general configuration, related to time and date.

Figure 4-50. General Configuration (2/2) Screen

Table 4-34. General Configuration (2/2) Screen Configuration Values

Screen Saver Delay	*4.0 (0.1, 24.0) h
Visibility: Always **User Level:** Service	Time the 505 will wait to start up the screen saver (in hours)
Use Go to Status Screen	TRUE
Visibility: Always **User Level:** Service	If selected 505 will change the screen to the Status screen after "Status Screen Delay" of inactivity. This is not screen saver.
Status Screen Delay	30.0 (1.0, 600.0) min.
Visibility: Always **User Level:** Service	Time of inactivity that the 505 will wait to automatically jump to Status screen (in minutes), if enabled.
Jump to Alarm Screen when a new Alarm Occurs	FALSE
Visibility: Always **User Level:** Service	If selected 505 will change the screen to the Alarm screen when a new alarm occurs.

Level Screen

The purpose of this screen is to configure the level control parameters.

Figure 4-51. Level Screen

Table 4-35. Level Screen Configuration Values

Head or Tail Level Control	HEAD LEVEL CONTROL
Visibility: Always **User Level:** Configure	Choose which level the level control will use. The options are Head level control or Tail level control. **CONFIGURATION MODE REQUIRED**
Type of transfer	BUMPLESS
Visibility: Always **User Level:** Service	Choose the type of transfer when enabling the level control. The options are bumpless or preset level.
Fixed Speed in Level Control	FALSE
Visibility: Always **User Level:** Operator	Choose if fixed speed in level control will be used.
Level Setpoint	0.0 (-30000.0, 30000.0) eu
Visibility: Always **User Level:** Service	Level setpoint that the control will use when level control is enabled and the type of transfer is configured to preset level.
Default rate	0.2 (0.01, 1000.0) ue/s
Visibility: Always **User Level:** Service	Default that the level setpoint will ramp when a raise or lower command I sent to the control or the setpoint is changed by Modbus or display.
Minimum Gate Position	20.0 (0.0, 100.0) *
Visibility: Always **User Level:** Service	Minimum gate position when in level control.
Maximum Gate Position	100.0 (0.0, 100.0) *
Visibility: Always **User Level:** Service	Maximum gate position when in level control.
Desired Control Accuracy	*0.5 (0.0, 10000.0)
Visibility: Always **User Level:** Service	Enter the Desired Control Accuracy for the level control. **Note**: Smaller value will result in much more “gain” on the gate movement,

Press the soft key “Commands” to go to Level commands screen.

Level Commands Screen

The purpose of this screen is to send the Level control mode commands.

Figure 4-52. Level Commands Screen

Table 4-36. Level Commands Screen Configuration Values

Enable	Command
Visibility: Always **User Level:** Operator	Enable the level control mode.

Disable	Command
Visibility: Always **User Level:** Operator	Disable the level control mode.

Lower	Command
Visibility: Always **User Level:** Operator and control in Level Control	This command will lower the demand to level control when in level control mode

Raise	Command
Visibility: Always **User Level:** Operator and control in Level Control	This command will raise the demand to level control when in level control mode

Default rate	0.2 (0.01, 1000.0) eu/s
Visibility: Always **User Level:** Operator and control in Level Control	Default that the level setpoint will ramp when a raise or lower command I sent to the control or the setpoint is changed by modbus or display.

Go to	Command
Visibility: Always	Command to send the level setpoint to the “Go to Value”.
User Level: Operator and control in Level Control	

Go to Value	*0.0 (-30000.0, 30000.0) eu
Visibility: Always	Value where the level reference goes when a “Go to” command is issued.
User Level: Operator and control in Level Control	

Unload	Command
Visibility: Always	Send command to unload the generator until the unload level.
User Level: Operator	

Enable (Remote level)	Command
Visibility: Remote level in use	Enable the remote level control mode.
User Level: Operator and control in Level Control	

Disable (Remote Level)	Command
Visibility: Remote level in use	Disable the remote level control mode.
User Level: Operator and control in Level Control	

Remote Ref.	Monitor
Visibility: Remote level in use	It shows the actual remote level reference, from the analog input.
User Level: Monitor	

Remote Level Fault	Monitor
Visibility: Remote level in Use	It shows if there is a signal fail on the analog input configured for this function.
User Level: Monitor	

Remote Rate	0.2 (0.01, 1000.0) eu/s
Visibility: Remote level in Use	The remote level will follow the analog input configured for this function, but will use this rate to prevent bumps on the reference. Even if the analog input has big oscillations, the reference will always ramp slowly.
User Level: Service	

There are some level statuses at the bottom of the screen.

Overspeed Test Screen

The purpose of this screen is to send the overspeed test commands.

Figure 4-53. Overspeed Test Screen

Table 4-37 Overspeed Test Screen Configuration Values

Enable	Command
Visibility: Always **User Level:** Service	Enable the overspeed test mode.

Disable	Command
Visibility: Always **User Level:** Service	Disable the overspeed test mode.

Lower	Command
Visibility: Always **User Level:** Service and overspeed test enabled	This command will lower the speed setpoint when in overspeed test mode. **Note:** The rate of the ramp will be the overspeed rate.

Raise	Command
Visibility: Always **User Level:** Service and overspeed test enabled	This command will raise the speed setpoint when in overspeed test mode. **Note:** The rate of the ramp will be the overspeed rate.

Reset Max Speed	Command
Visibility: Always **User Level:** Service	Reset the maximum speed reached since the last start or last maximum speed reset.

Time to Disable Test	1800.0 (1.0, 7200.0) s
Visibility: Always **User Level:** Service	Time to automatically disable the overspeed test. CAUTION: If the speed reference is greater than the overspeed level and the time expires, the turbine will shut down when overspeed test is automatically disabled.

Max. Speed Reached	Monitor
Visibility: Always **User Level:** Monitor	Maximum speed reached since the last start or last maximum speed reset.

Permissions to Enable	Monitor
Visibility: Always **User Level:** Monitor	It shows if all permission to enable the overspeed test are met.

Remaining Time	Monitor
Visibility: Overspeed test enabled **User Level:** Monitor	The remaining time to automatically disable the overspeed test.

There are some speed statuses at the bottom of the screen.

Remote Alarms Screen

The purpose of this screen is to configure the remote alarms.

There are six remote alarms available on the control. Above an explanation of the first remote alarm, the other have the same configuration. The remote alarm will work only if one of the discrete inputs is configured to it. If no discrete input is configured to remote alarm these configuration will have no effect.

Figure 4-54. Remote Alarms Screen

Table 4-38. Remote Alarms Screen Configuration Values

Function	ALARM
Visibility: Always **User Level:** Configure	Choose if the specific remote alarm is an alarm or shutdown. **CONFIGURATION MODE REQUIRED**
Delay	0.0 (0.0, 100.0) s
Visibility: Always **User Level:** Service	Delay time for the specific remote alarm.
Description	REMOTE FAULT 1
Visibility: Always **User Level:** Service	Write the description of the alarm. This description will appear in the Alarm or shutdown page when this alarm / shutdown occurs.
Configured in	Monitor
Visibility: Always **User Level:** Monitor	It shows if the remote alarm is configured for any discrete input or if it is not in use (not configured in any discrete input).

The operator can navigate between the remote alarm screens pressing the soft keys with arrows to left or right.

Communications (Serial Port) Screen

The purpose of this screen is to configure serial communication port.

Figure 4-55. Communications (Serial Port) Screen

Table 4-39. Communications (Serial Port) Screen Configuration Values

Use serial	FALSE
Visibility: Always **User Level:** Service	Select if the serial port communication will be used.
Baud Rate	115200
Visibility: Always **User Level:** Service	Select the baud rate for the serial port, the options are: 110, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, 57600 and 115200.
Data Bits	8
Visibility: Always **User Level:** Service	Select the data bits for the serial port, the options are: 7 and 8
Stop Bits	1
Visibility: Always **User Level:** Service	Select the stop bits for the serial port, the options are: 1, 1.5 and 2.
Parity	Off
Visibility: Always **User Level:** Service	Select the parity for the serial port, the options are: Off, Odd and Even.
Driver	RS-232
Visibility: Always **User Level:** Service	Select the driver for the serial port, the options are: RS-232, RS-422 and RS-485.

Timeout	10.0 (0.5, 30.0) s
Visibility: Always **User Level:** Service	Enter the timeout for the serial port.

ASC-II / RTU	RTU
Visibility: Always **User Level:** Service	Enter the ASC-II or RTU for the serial port.

Network Address	1 (1, 247)
Visibility: Always **User Level:** Service	Enter the ASC-II or RTU for the serial port.

Enable Analog Write	FALSE
Visibility: Always **User Level:** Service	Enable the analog write for the serial port. If disable won't be possible to write any analog value through this port.

Enable Boolean Write	FALSE
Visibility: Always **User Level:** Service	Enable the Boolean write for the serial port. If disable won't be possible to write any Boolean value through this port.

Link Error is Shutdown	FALSE
Visibility: Always **User Level:** Configure	Enable if a link error on this port should shutdown the turbine. **CONFIGURATION MODE REQUIRED**

Enable Shutdown via Modbus	TRUE
Visibility: Always **User Level:** Configure	The first Boolean write address is designated to shutdown the turbine. Select if this shutdown command can be used. **CONFIGURATION MODE REQUIRED**

This parameter is common to both serial and Ethernet ports. If enabled or disabled on the serial port will disable on the Ethernet port also.

Communications (Ethernet) Screen

The purpose of this screen is to configure Ethernet communication ports. There are four available Ethernet links and they can be programmed on this screen. The screen has the same configuration for all ports, but the explanation will be made for just the port 1, as the port 2, 3 and 4 has the same parameters.

Figure 4-56. Communications (Ethernet) Screen

Table 4-40. Communications (Ethernet) Screen Configuration Values

Use Ethernet 1		FALSE
Visibility: Always **User Level:** Service	Select if the Ethernet specific port communication will be used.	
Timeout		10.0 (0.5, 30.0) s
Visibility: Always **User Level:** Service	Enter the timeout for the Ethernet port.	
ASC-II / RTU		RTU
Visibility: Always **User Level:** Service	Enter the ASC-II or RTU for the Ethernet port.	
Network Address		2 (1, 247)
Visibility: Always **User Level:** Service	Enter the ASC-II or RTU for the Ethernet port.	
Enable Analog Write		FALSE
Visibility: Always **User Level:** Service	Enable the analog write for the Ethernet port. If disable won't be possible to write any analog value through this port.	

Enable Boolean Write	FALSE
Visibility: Always **User Level:** Service	Enable the Boolean write for the Ethernet port. If disable won't be possible to write any Boolean value through this port.

Link Error is Shutdown	FALSE
Visibility: Always **User Level:** Configure	Enable if a link error on this port should shutdown the turbine. **CONFIGURATION MODE REQUIRED**

Enable Shutdown via Modbus	TRUE
Visibility: Always **User Level:** Configure	The first Boolean write address is designated to shutdown the turbine. Select if this shutdown command can be used. **CONFIGURATION MODE REQUIRED**

WARNING

This parameter is common to both serial and Ethernet ports. If enabled or disabled on the serial port will disable on the Ethernet port also.

To set the IP address of the port the operator should press the soft key "Set IP".

Communications (Ethernet IP) Screen

The purpose of this screen is to configure IP for the Ethernet ports communication.

Figure 4-57. Communications (Ethernet IP) Screen

IMPORTANT

Each of the ETHERNET ports is required to be configured for a unique subnet (domain) (view default settings as an example).
The IP's can be set by other service tools.
The top of the screen shows the current IP addresses in use on for each port.

Table 4-41. Communications (Ethernet IP) Screen Configuration Values

ENET 1 ADDRESS	172.16.100.15 (0, 255)
Visibility: Always **User Level:** Service	Enter the integers corresponding to the network TCP/IP address.
ENET 1 SUBNET MASK	255.255.0.0 (0, 255)
Visibility: Always **User Level:** Service	Enter the integer corresponding to the network subnet mask.
SET IP1	Command
Visibility: Always **User Level:** Service	Press this button to trigger resetting the IP of ENET 1 to the entered value
ENET 2 ADDRESS	1972.168.128.20 (0, 255)
Visibility: Always **User Level:** Service	Enter the integers corresponding to the network TCP/IP address.
ENET 2 SUBNET MASK	255.255.255.0 (0, 255)
Visibility: Always **User Level:** Service	Enter the integer corresponding to the network subnet mask.
SET IP2	Command
Visibility: Always **User Level:** Service	Press this button to trigger resetting the IP of ENET 2 to the entered value
ENET 3 ADDRESS	1972.168.129.20 (0, 255)
Visibility: Always **User Level:** Service	Enter the integers corresponding to the network TCP/IP address.
ENET 3 SUBNET MASK	255.255.255.0 (0, 255)
Visibility: Always **User Level:** Service	Enter the integer corresponding to the network subnet mask.
SET IP3	Command
Visibility: Always **User Level:** Service	Press this button to trigger resetting the IP of ENET 3 to the entered value

To set the Default gateway address of the ports the operator should press the soft key “Default gateway”.

Communications (Default Gateway) Screen

The purpose of this screen is to configure default gateway for the Ethernet ports communication.

Figure 4-58. Communications (Default Gateway) Screen

Table 4-42. Communications (Default Gateway) Screen Configuration Values

Default Gateway	10.14.128.1 (0, 255)
Visibility: Always **User Level:** Service	Enter the integers corresponding to the default gateway address.
Set Gateway	Command
Visibility: Always **User Level:** Service	Press this button to trigger resetting the default gateway to the entered value

Switches Screen

The purpose of this screen is to configure the Switches. There are six speed switches, four gate switches, four blade switches and four load (kW) switches available on the 505.

The below explanation will describe the speed switch, but the others have the same parameters.

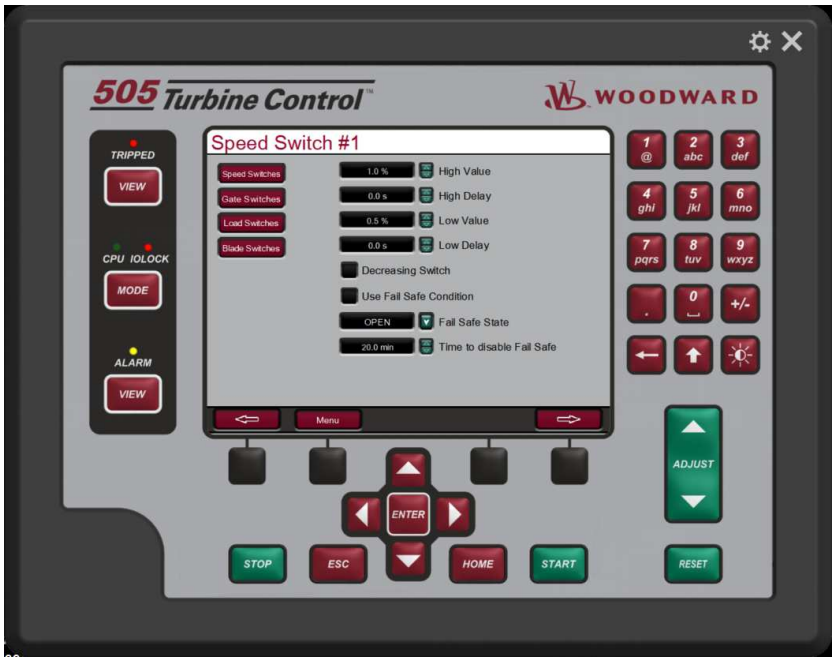


Figure 4-59 Speed Switches Screen

Table 4-43. Speed Switches Screen Configuration Values

High Value	1.0 (0.0, 200.0) %
Visibility: Always **User Level:** Service	Enter the high value (in %) for the specific speed switch.
High Delay	*0.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	Enter the high delay time for the specific speed switch.
Low Value	0.5 (0.0, 200.0) %
Visibility: Always **User Level:** Service	Enter the low value (in %) for the specific speed switch.
Low Delay	*0.0 (0.0, 600.0) s
Visibility: Always **User Level:** Service	Enter the low delay time for the specific speed switch.
Decreasing Switch	FALSE
Visibility: Always **User Level:** Service	Select if the switch is a decreasing switch.
Use Fail Safe Condition	FALSE
Visibility: Always **User Level:** Service	Select to use fail safe condition.
Fail Safe State	OPEN
Visibility: Always **User Level:** Service	Choose the fail-safe condition in case of both speed signal fail.
Time to disable Fail Safe	*20.0 (0.0, 300.0) min
Visibility: Always **User Level:** Service	Time to disable fail safe condition since both speed signals fail. After this time the switch will go back to its normal state.

The operator can navigate between the switches pressing the soft keys with arrows to left or right. The buttons to switch between the switches (load, gate, blade or speed) will be available if one or more discrete output is configured for this function.

Status (1/2) Screen

Figure 4-60. Status Screen

The purpose of this screen is to be a screen where the operator can see some important information in a fast way. This screen is atomically opened after some time (if configured) or can be accessed on the menu (Status button).

In this screen there are two big gauges showing the actual speed and actual load.

At the top of the screen it is possible to check the actual control mode of the control.

At the bottom of the screen there are some boxes showing the actual gate position and blade position (Kaplan turbine). It is also possible to check the position of the generator breaker.

Status (2/2) Screen

Figure 4-61. Status Screen

The purpose of this screen is to show the turbine operation counters and timers. It is also possible to set actual values in case of a control replacement.

Table 4-44. Status 2 Screen

Rewrite Value	FALSE
Visibility: Configuration Mode **User Level:** Configure	Write the values in all operation counters and timers that will be written to the non-volatile memory when the Rewrite button is pressed. After the Rewrite button is pressed all values will be changed at the same time. **CONFIGURATION MODE REQUIRED**

Trip Relays Screen

Figure 4-62. Trip Relays Screen

The purpose of this screen is to configure the trip relays output. Configure if each trip will act on relay 1, relay 2, both or neither one.

Table 4-45. Trip Relays Screen

[TRIP DESCRIPTION] – Relay 1	FALSE
Visibility: Always **User Level:** Configure	Check if the described trip will act on trip relay 1 output. **CONFIGURATION MODE REQUIRED**
[TRIP DESCRIPTION] – Relay 2	FALSE
Visibility: Always **User Level:** Configure	Check if the described trip will act on trip relay 2 output. **CONFIGURATION MODE REQUIRED**

The last screen will show some extra parameters, as follow:

Reset clears trip (Relay X)	FALSE
Visibility: Always **User Level:** Service	Select to configure the Reset Clears Trip Relay X output function. When selected, a Reset command will energize the trip relay output even when a trip condition is still sensed by the 505—typically due to one of the external trip inputs. Once reset, the unit will be 'Ready to Start' as soon as all external trip inputs are closed. When unselected, the trip relay output will be deenergized on a 505 trip and will not energize until all trips have cleared and a 'Reset' command is given.

Analog Inputs Screen

The purpose of this screen is to configure the analog inputs of the control.

The first screen showed is a summary of all analog inputs, and it is possible to check if the analog inputs has the signal failed, the description, tag, actual value and the engineering unit of this input (see below).

Figure 4-63. Analog Inputs Summary Screen

Click on buttons at left of the screen to go to the specific analog input and configure it, if necessary. Below you can see the explanation of the analog input configuration screen.

Figure 4-64. Analog Inputs Screen

There are three information at the top of the page: the signal (in mA), the actual value (in the configured engineering unit) and if the signal is failed.

The default values showed below are for the analog input #1.

Table 4-46. Analog Inputs Screen Configuration Values

Function	GATE POS FDBK
Visibility: Always **User Level:** Configure	Choose the function of the specific analog input. **CONFIGURATION MODE REQUIRED**
4 mA Value	0.0 (-1.0e+38, 1.0e+38)
Visibility: Always **User Level:** Service	Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog input.
20 mA Value	100.0 (-1.0e+38, 1.0e+38)
Visibility: Always **User Level:** Service	Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog input. (Must be greater than the 'Input 4 mA Value' Setting)
Lag Tau	0.0 (0.0, 100.0) s
Visibility: Always **User Level:** Service	Set the filter for this analog input (in seconds).
Loop Powered	FALSE
Visibility: Always **User Level:** Configure	Check this box if the 505 should provide loop power for the transmitter. **CONFIGURATION MODE REQUIRED**
Device Tag	AI_01
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a short description or tag name for this channel.
Units	AI 01 Units
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a unit label for this channel
Modbus Multiplier	1
Visibility: Always **User Level:** Service	This is the multiplier that will be used for this parameter address on the 505 slave Modbus communication link. The options are (1, 10, 100 or 1000)

The operator can navigate between the analog inputs pressing the soft keys with arrows to left or right.

Analog Inputs # 2 through # 8 are configured following the same rules as described for Analog Input # 1.

NOTICE

Entering Text

The Device Tag is a text field that is available for the user to enter a unique name or identifier for each I/O channel. An example would be to use the signal device tag such as GT-1234 for a gate position sensor. Enter Text characters by focusing on the field, press Enter, then press and hold down the alphanumeric keys – they will cycle through the available characters on that key

Calibrate the analog inputs pressing the soft key "Calibrate" and the below screen will open.

Figure 4-65. Analog Inputs Calibrate Screen

The adjustments for calibrate will be available if the control is in operator level or greater.

Speed Input (Common Configuration) Screen

The purpose of this screen is to configure the common configuration for all types of sensors.

Access this screen trough the analog inputs screen.

The screen is divided in three parts: configuration common to all probes, common configuration for the two MPU/Prox sensors and common configuration for the two PT sensors.

Figure 4-66. Speed Signal (Common Configuration) Screen

Table 4-47. Speed Inputs (Common Configuration) Screen Values

All Probes:

Speed/Freq Mismatch Value	0.2 (0.01, 10.0) %
Visibility: Always **User Level:** Service	This is the maximum difference (in %) acceptable between Mechanical (rpm) and electrical (Hz) speed measurement.
Speed/Freq Mismatch Delay	0.2 (0.01, 10.0) %
Visibility: Always **User Level:** Service	Delay to detect mismatch between Mechanical (rpm) and electrical (Hz) speed measurement.

MPU / Prox:

Number of Gear Teeth	60 (5, 500) teeths
Visibility: Always **User Level:** Configure	Number of gear teeth. The number of teeth on the gear the speed sensing device is mounted to. **CONFIGURATION MODE REQUIRED**
Gear Ratio	*1.0 (0.1, 10.0) ratio
Visibility: Type is not PT sensor **User Level:** Configure	The relationship of the speed of the gear on which the speed sensing device is mounted to the turbines shaft speed. **CONFIGURATION MODE REQUIRED**
Rated Speed	*120.0 (10.0, 2000.0) rpm
Visibility: Always **User Level:** Configure	Enter the rated speed of the turbine. **CONFIGURATION MODE REQUIRED**
Time to Start Speed	20.0 (0.0, 300.0) s
Visibility: Always **User Level:** Configure	Time that the control will wait after a start up command to monitor the speed against lost of sensors.

PT Sensor:

System Frequency	60 Hz
Visibility: Type is PT sensor **User Level:** Configure	Choose the system frequency. This value will be used when the type of the sensor is PT sensor. **CONFIGURATION MODE REQUIRED**
Use PT as primary Input	FALSE
Visibility: Always **User Level:** Configure	Check this function if PT should be used as primary input. In this case the PT sensor will be the primary sensor used by the control after the speed turbine is more than “PT Enabled Speed” for more then “PT Enable Delay” time. **CONFIGURATION MODE REQUIRED**
PT Enable Speed	90.0 (60.0, 98.0) %
Visibility: Always **User Level:** Configure	Speed to start using PT as primary input, if configured.
PT Enable Delay	5.0 (0.0, 30.0) s
Visibility: Always **User Level:** Configure	Delay time to start using PT as primary input, if configured.
PT Disable Speed	90.0 (60.0, 98.0) %
Visibility: Always **User Level:** Configure	Speed to stop using PT as primary input, if configured.

Speed Input (Passive Channels) Screen

This screen is designed to configure the two speed inputs (passive channels).

There are some monitored values at the left of the screen. They are just for monitor purpose, they are the speed value for this input (in rpm or Hz), the amplitude of the signal (in Vrms) and if the speed sensed is below the minimum speed..

Figure 4-67. Speed Signal (Passive Channels) Screen

Table 4-48. Speed Inputs (Passive Channels) Screen Values

Probe Type	NOT USED
Visibility: Always **User Level:** Configure	Select the type of speed probe will be used. The options are Not Used, MPU, and PT sensor. **CONFIGURATION MODE REQUIRED**
Device tag	SPD01 Input Signal
Visibility: Always **User Level:** Monitor	This is a user entered field. It allows entry of a short description or tag name for this channel.
Lag Tau	*0.01 (0.0, 1.0) s
Visibility: Always **User Level:** Service	Enter a filter to this input (in seconds)

Speed Input (Active Channels) Screen

This screen is designed to configure the two speed inputs (active channels).

There are some monitored values at the left of the screen. They are just for monitor purpose, they are the speed value for this input (in rpm), the minimu and maximum voltage and if the speed sensed is below the minimum speed.

Prox Signal Max (Volts): the maximum voltage sensed on the proximity probe speed input. This output is an average of ten samples with the minimum and maximum samples discarded. This output will be zero if the PROB_TYPE is not “Proximity Probe”.
Prox Signal Min (Volts): the minimum voltage sensed on the proximity probe speed input. This output is an average of ten samples with the minimum and maximum samples discarded. This output will be zero if the PROB_TYPE is not “Proximity Probe”.

Figure 4-68. Speed Signal (Active Channels) Screen

Table 4-49. Speed Inputs (Active Channels) Screen Values

Probe Type	PROXIMITY PROBE
Visibility: Always **User Level:** Configure	Select the type of speed probe will be used. The options are Not Used, and Proximity Probe. **CONFIGURATION MODE REQUIRED**
Device tag	SPD01 Input Signal
Visibility: Always **User Level:** Monitor	This is a user entered field. It allows entry of a short description or tag name for this channel.
Lag Tau	*0.01 (0.0, 1.0) s
Visibility: Always **User Level:** Service	Enter a filter to this input (in seconds)

Contact Inputs Screen

The purpose of this screen is to configure the contact inputs of the control.

The first screen showed is a summary of the eighth first contact inputs, and it is possible to check the status, the description and tag of this input (see below).

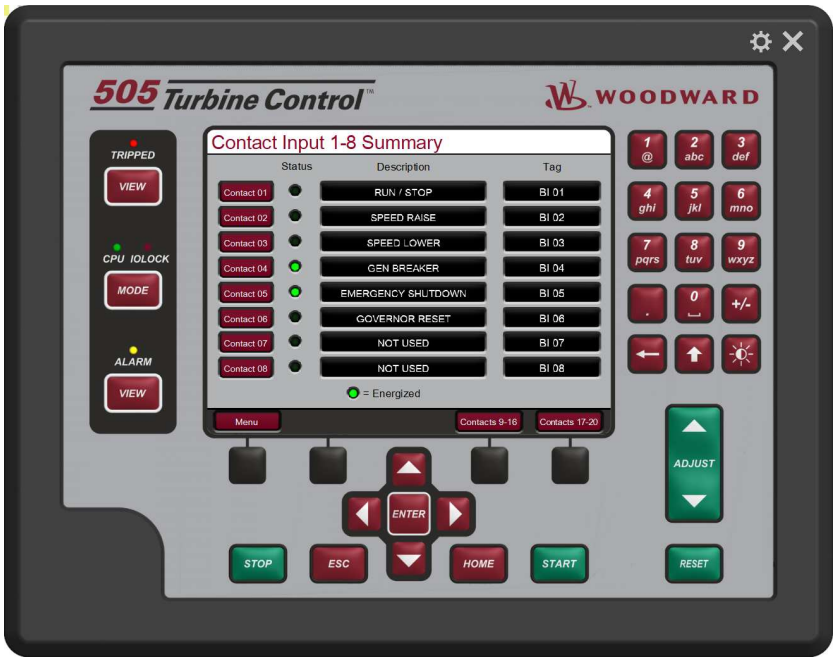


Figure 4-69. Contact Inputs Summary Screen

Click on buttons at left of the screen to go to the specific contact input and configure it, if necessary or click on the “Contacts 9-16” or “Contacts 17-20” to see the others contact inputs. Below you can see the explanation of the contact input configuration screen.

Figure 4-70. Contact Inputs Screen

There is the status of the input at the top of the page.

The contact input #1 to #5 have fixed functions and the parameter “Function” has no effect to these contact inputs. The default values showed below are for the contact input #6.All other contact inputs have the same parameters.

Table 4-50. Contact Inputs Screen Configuration Values

Function	NOT USED
Visibility: Always **User Level:** Configure	Choose the function of the specific contact input. **CONFIGURATION MODE REQUIRED**
Device tag	BI 06
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a short description or tag name for this channel.
Invert Logic	FALSE
Visibility: Always **User Level:** Configure	Check this box if the discrete input is inverted (normally closed).

The operator can navigate between the contact inputs pressing the soft keys with arrows to left or right.

Analog Outputs Screen

The purpose of this screen is to configure the analog outputs of the control.

The first screen showed is a summary of the six analog outputs, and it is possible to check is there is a fault in the each channel, the description, tag, actual value and the engineering unit (see below).

Figure 4-71. Analog Outputs Summary Screen

Click on buttons at left of the screen to go to the specific analog output and configure it. Below you can see the explanation of the analog output configuration screen.

Figure 4-72. Analog Outputs Screen

There are three status of the analog output at the top of the page: Actual Value, readback (in mA) and the signal fault.

The default values showed below are for the analog output #1. All other analog outputs have the same parameters.

Table 4-50. Analog Outputs Screen Configuration Values

Function	NOT USED
Visibility: Always **User Level:** Configure	Choose the function of the specific analog output. **CONFIGURATION MODE REQUIRED**
4mA Value	*0.0 (-1.0e+38, 1.0e+38) eu
Visibility: Always **User Level:** Service	Set the value (in engineering units) that corresponds to 4 milliamps (mA) on the analog output.
20mA Value	*100.0 (-1.0e+38, 1.0e+38) eu
Visibility: Always **User Level:** Service	Set the value (in engineering units) that corresponds to 20 milliamps (mA) on the analog output.
Device tag	AO 01
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a short description or tag name for this channel.
Units	AO 01 Units
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a unit label for this channel
Modbus Multiplier	1
Visibility: Always **User Level:** Service	This is the multiplier that will be used for this parameter address on the 505 slave Modbus communication link. The options are (1, 10, 100 or 1000)

The operator can navigate between the analog outputs pressing the soft keys with arrows to left or right.

Relay Outputs Screen

The purpose of this screen is to configure the relay outputs of the control.

The first screen showed is a summary of the eight relay outputs, and its status, description and tag (see below).

Figure 4-73. Relay Outputs Summary Screen

Click on buttons at left of the screen to go to the specific relay output and configure it. Below you can see the explanation of the relay output configuration screen.

Figure 4-74. Relay Outputs Screen

There is the status of the relay output at the top of the page.

The default values showed below are for the relay output #1. All other relay outputs have the same parameters.

Table 4-51. Relay Outputs Screen Configuration Values

Description	NOT USED
Visibility: Always **User Level:** Configure	Choose the function of the specific relay output. **CONFIGURATION MODE REQUIRED**
Device tag	Relay 01
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a short description or tag name for this channel.
Invert Logic	FALSE
Visibility: Always **User Level:** Configure	Check to invert the relay output.

The operator can navigate between the relay outputs pressing the soft keys with arrows to left or right.

Actuator Outputs Screen

The purpose of this screen is to configure the actuators outputs of the control. There are two actuators, the actuator 1 is designed to gate and the actuator 2 is the blade control (Kaplan turbine).

Figure 4-75. Actuator Output Screen

There are three status of the actuator output at the top of the page. Actual output, source in mA and the readback. It is also possible to check if the actuator is in fault.

The default values showed below are for the actuator output #1. The actuator output #2 has the same parameters.

Table 4-52. Actuator Outputs Screen Configuration Values

Actuator range	4-20 mA
Visibility: Always **User Level:** Configure	Choose the range of the actuator output. The options are 4-20 or 0-200 mA. **CONFIGURATION MODE REQUIRED**
Dither Freq.	25 Hz
Visibility: Always **User Level:** Service	Choose dither frequency. The options are 3.125 Hz, 6.25 Hz, 12.5 Hz, 25 Hz or 50 Hz.
Dither	0.0 (0.0, 100.0) %
Visibility: Always **User Level:** Service	Type the dither (in % of demand).
Device tag	ACT 01
Visibility: Always **User Level:** Service	This is a user entered field. It allows entry of a short description or tag name for this channel.
mA at 0% Demand	4.0 (0.0, 25.0) mA
Visibility: Always **User Level:** Service	Set the mA value that corresponds to 0% demand.
mA at 100% Demand	20.0 (0.0, 25.0) mA
Visibility: Always **User Level:** Service	Set the mA value that corresponds to 100% demand.
Actuator Type	AO 01 Units
Visibility: Always **User Level:** Configure	Choose if the actuator is Integral or proportional. **CONFIGURATION MODE REQUIRED**
Act. Direction	Direct
Visibility: Always **User Level:** Configure	Choose if the actuator has direct or reverse actuation. **CONFIGURATION MODE REQUIRED**
Offline Gain	1.0 (0.0, 50.0)
Visibility: If configured to integral **User Level:** Service	Type the offline gain of the actuator
Online Gain	1.0 (0.0, 50.0)
Visibility: If configured to integral **User Level:** Service	Type the online gain of the actuator
Offset	0.0 (-100.0, 100.0)
Visibility: If configured to integral **User Level:** Service	Type the offset of the actuator

If the control is in calibration mode it is possible to enter on the calibration screen pressing the soft key “Force Output” to force this output.

Force Actuator Outputs Screen

The purpose of this screen is to force the actuators outputs of the control. To access the screen the control needs to be in Calibration mode.

Figure 4-76 Actuator Outputs Screen

Procedure to force actuator:

1. The 505 must be shutdown to enter Calibration Mode.
2. Go to the MODE screen by pressing the MODE key.
3. Enter Calibration Mode by pressing the ‘Calibration’ softkey. The following permissives must be met:
   a. Unit Shutdown
   b. No Speed Detected
   c. Appropriate User Level Login
4. Navigate to the Actuator screen by pressing the ‘actuators’ in the HOME menu
5. Select the desired Actuator channel.
6. In the Actuator channel screen, press the ‘Calibration’ softkey to access the calibration options.
7. Verify the green “Calmode Enabled” LED is ON to confirm that the unit is in Calibration Mode.
8. Press the ‘Forcing’ sofkey
9. Verify that the green “Forcing Enabled” LED is now also ON.
10. Use the focus navigation to select and adjust items on the screen (Manual Adjust, Goto Demand, Force Rate, etc.).
11. Actuator current output at min and max can be adjusted by selecting “mA at 0% Demand” or “mA at 100% Demand”. Use the up/down Adjust arrows or numerical keypad and ENTER key to the change the values.
12. “GO” can be used with the “Goto Demand” value.
13. Exit Calibration Mode by pressing the ‘Exit Calmode’ softkey from the MODE page or, if it is desired to stroke another channel, return to the Driver or I/O screen to continue stroking other channels.

Trip Summary Screen

The purpose of this screen is to show the current trips on the control and the cause of the last trip. If a trip occurs this screen will open automatically.

Figure 4-77. Trip Summary Screen

On the top of this screen there is an indication of the cause of the last trip occurred. This indication will be cleared when a new start command is issued to the control. Even if more trips occurred after the trip, only the first cause will be displayed.

If a remote fault is programmed to shutdown and it trips the message of the remote fault will be showed below the trip messages.

Alarm Summary Screen

The purpose of this screen is to show the current alarms on the control and the cause of the last trip. If an alarm occurs this screen will open automatically, if this function is enabled.

Figure 4-78. Alarm Summary Screen

If a remote fault is programmed to alarm and it alarms the message of the remote alarm will be showed below the alarm messages.

Check Configuration Screen

The purpose of this screen is to show the configuration errors on the control.

Figure 4-78. Check Configuration Screen

A list of all possible configuration errors are available on Appendix C.

Chapter 5.
Product Support and Service Options

Product Support 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 or 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 current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service 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**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (124) 4399500
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

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Turbine Model Number _____

Type of Fuel (gas, steam, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.) _____

Control/Governor Information

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 _____

Symptoms

Description _____

_____

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.

Chapter 6.
Asset Management and Refurbishment Scheduling Period

This product is designed for continuous operation in a typical industrial environment and includes no components that require periodic service. However, to take advantage of related product software and hardware improvements, we recommend that your product be sent back to Woodward or to a Woodward authorized service facility after every five to ten years of continuous service for inspection and component upgrades. Please refer to the above service programs when returning products.

Appendix A – Alarm List

A list of all alarms and a brief explanation of each follows:

1	Analog Input Fault - Channel 1	Channel is being used and its current falls below 2mA or goes above 22mA
2	Analog Input Fault - Channel 2	Channel is being used and its current falls below 2mA or goes above 22mA
3	Analog Input Fault - Channel 3	Channel is being used and its current falls below 2mA or goes above 22mA
4	Analog Input Fault - Channel 4	Channel is being used and its current falls below 2mA or goes above 22mA
5	Analog Input Fault - Channel 5	Channel is being used and its current falls below 2mA or goes above 22mA
6	Analog Input Fault - Channel 6	Channel is being used and its current falls below 2mA or goes above 22mA
7	Analog Input Fault - Channel 7	Channel is being used and its current falls below 2mA or goes above 22mA
8	Analog Input Fault - Channel 8	Channel is being used and its current falls below 2mA or goes above 22mA
9	Actuator Fault - Channel 1	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
10	Actuator Fault - Channel 2	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
11	Analog Output Fault - Channel 1	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
12	Analog Output Fault - Channel 2	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
13	Analog Output Fault - Channel 3	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
14	Analog Output Fault - Channel 4	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
15	Analog Output Fault - Channel 5	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”
16	Analog Output Fault - Channel 6	Channel is being used and hardware senses either a “Driver Failure” or an “Open Load Fault”

17	Spare	Alarm not used
18	Spare	Alarm not used
19	Summary Chasis Alarm	Software detects one of the following: Display Backlight Fault, CPU/OS Fault, Chassis Temperature Alarm or Calibration Fault
20	Front Display Communication Alarm	Application software stops detecting the display software heartbeat for more than 30s
21	Speed Signal #1 Trouble	Speed Signal #1 falls below 1/49 of “Max Speed”. Max Speed if defined as 2 x Rated Speed (or Rated Frequency). This alarm is overridden during turbine start.
22	Speed Signal #2 Trouble	Speed Signal #2 falls below 1/49 of “Max Speed”. Max Speed if defined as 2 x Rated Speed (or Rated Frequency). This alarm is overridden during turbine start.
23	Pond Level Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
24	Remote Speed Reference Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
25	Analog Speed Bias Input Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
26	Gate Minor Mismatch	Gate position (if used) does not match within the “Minor Mismatch Window” for more than the “Minor Mismatch Delay” time
27	Serial Link Error Alarm	Serial Modbus communication is being used and a link error is detected
28	Governor Shutdown	Any shutdown is active
29	Creep Detected	Creep Detection logic is detecting turbine movement
30	Generator Power Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
31	Remote Baseload Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
32	Analog Gate Limiter Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
33	Small System Detection	Software detected that the turbine is not tied to a large system anymore, via either speed or speed derivative surge

34	Blade Minor Mismatch	Blade position (if used) does not match within the "Minor Mismatch Window" for more than the "Minor Mismatch Delay" time
35	Remote Level Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
36	Remote Fault #1	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
37	Remote Fault #2	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
38	Remote Fault #3	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
39	Remote Fault #4	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
40	Remote Fault #5	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
41	Remote Fault #6	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
42	Gate Position Feedback Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
43	Blade Position Feedback Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
44	Analog Blade Limiter Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
45	Tail Level Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
46	Net Head Signal Fail	A given analog input channel is being used for this function and its current falls below 2mA or goes above 22mA
47	Gate Limit Auto Raise Active	In case the " Gate Speed-No-Load Limit" is not enough to make the turbine achieve rated speed within the "Auto Raise Timer"
48	Ethernet #1 Link Error Alarm	Ethernet #1 Modbus communication is being used and a link error is detected
49	Ethernet #2 Link Error Alarm	Ethernet #2 Modbus communication is being used and a link error is detected
50	Fail to Open Generator Breaker	Generator Breaker Open command is given but breaker does not open within "Open Time" delay
51	Speed Signal #3 Trouble	Speed Signal #3 falls below 1/49 of "Max Speed". Max Speed if defined as 2 x Rated Speed (or Rated Frequency). This alarm is overridden during turbine start.

52	Speed Signal #4 Trouble	Speed Signal #4 falls below 1/49 of “Max Speed”. Max Speed if defined as 2 x Rated Speed (or Rated Frequency). This alarm is overridden during turbine start.
53	Speed/Frequency Mismatch	Speed value (measured from MPU’s and Prox Probes) does not match frequency value (measured from PT sensors) based on parameter “Speed/Frequency Mismatch Value” for “Speed/Frequency Mismatch Delay”
54	Net Head Fault – Go to Blade Lock	Net Head signal fail occurs (it can be Net Head analog input or Pond/Tail inputs, depending on how net head is configured) and the alarm is configured to revert to Blade Lock
55	Net Head Fault – Go to Blade Manual	Net Head signal fail occurs (it can be Net Head analog input or Pond/Tail inputs, depending on how net head is configured) and the alarm is configured to revert to Blade Manual
56	Net Head Fault – Go to Blade Fixed Curve	Net Head signal fail occurs (it can be Net Head analog input or Pond/Tail inputs, depending on how net head is configured) and the alarm is configured to revert to Blade Fixed Curve
57	Ethernet #3 Link Error Alarm	Ethernet #3 Modbus communication is being used and a link error is detected
58	Ethernet #4 Link Error Alarm	Ethernet #4 Modbus communication is being used and a link error is detected
59	Spare	Alarm not used
60	Spare	Alarm not used
61	Spare	Alarm not used
62	Spare	Alarm not used
63	Spare	Alarm not used
64	Spare	Alarm not used
65	Spare	Alarm not used
66	Spare	Alarm not used
67	Spare	Alarm not used
68	Spare	Alarm not used
69	Spare	Alarm not used
70	Spare	Alarm not used
71	Spare	Alarm not used
72	Spare	Alarm not used
73	Spare	Alarm not used
74	Spare	Alarm not used
75	Spare	Alarm not used
76	Spare	Alarm not used
77	Spare	Alarm not used

78	Spare	Alarm not used
79	Spare	Alarm not used
80	Spare	Alarm not used
81	Spare	Alarm not used
82	Spare	Alarm not used
83	Spare	Alarm not used
84	Spare	Alarm not used
85	Spare	Alarm not used
86	Spare	Alarm not used
87	Spare	Alarm not used
88	Spare	Alarm not used
89	Spare	Alarm not used
90	Spare	Alarm not used
91	Spare	Alarm not used
92	Spare	Alarm not used
93	Spare	Alarm not used
94	Spare	Alarm not used
95	Spare	Alarm not used
96	Spare	Alarm not used
97	Spare	Alarm not used
98	Spare	Alarm not used
99	Spare	Alarm not used
100	Spare	Alarm not used
101	Spare	Alarm not used
102	Spare	Alarm not used
103	Spare	Alarm not used
104	Spare	Alarm not used
105	Spare	Alarm not used
106	Spare	Alarm not used
107	Spare	Alarm not used
108	Spare	Alarm not used
109	Spare	Alarm not used
110	Spare	Alarm not used
111	Spare	Alarm not used
112	Spare	Alarm not used
113	Spare	Alarm not used

114	Spare	Alarm not used
115	Spare	Alarm not used
116	Spare	Alarm not used
117	Spare	Alarm not used
118	Spare	Alarm not used
119	Spare	Alarm not used
120	Spare	Alarm not used
121	Spare	Alarm not used
122	Spare	Alarm not used
123	Spare	Alarm not used
124	Spare	Alarm not used
125	Spare	Alarm not used
126	Spare	Alarm not used
127	Spare	Alarm not used
128	Spare	Alarm not used
129	Spare	Alarm not used
130	Spare	Alarm not used
131	Spare	Alarm not used
132	Spare	Alarm not used
133	Spare	Alarm not used
134	Spare	Alarm not used
135	Spare	Alarm not used
136	Spare	Alarm not used
137	Spare	Alarm not used
138	Spare	Alarm not used
139	Spare	Alarm not used
140	Spare	Alarm not used
141	Spare	Alarm not used
142	Spare	Alarm not used
143	Spare	Alarm not used
144	Spare	Alarm not used
145	Spare	Alarm not used
146	Spare	Alarm not used
147	Spare	Alarm not used
148	Spare	Alarm not used
149	Spare	Alarm not used

150	Spare	Alarm not used
151	Spare	Alarm not used
152	Spare	Alarm not used
153	Spare	Alarm not used
154	Spare	Alarm not used
155	Spare	Alarm not used
156	Spare	Alarm not used
157	Spare	Alarm not used
158	Spare	Alarm not used
159	Spare	Alarm not used
160	Spare	Alarm not used
161	Spare	Alarm not used
162	Spare	Alarm not used
163	Spare	Alarm not used
164	Spare	Alarm not used
165	Spare	Alarm not used
166	Spare	Alarm not used
167	Spare	Alarm not used
168	Spare	Alarm not used
169	Spare	Alarm not used
170	Spare	Alarm not used
171	Spare	Alarm not used
172	Spare	Alarm not used
173	Spare	Alarm not used
174	Spare	Alarm not used
175	Spare	Alarm not used
176	Spare	Alarm not used
177	Spare	Alarm not used
178	Spare	Alarm not used
179	Spare	Alarm not used
180	Spare	Alarm not used
181	Spare	Alarm not used
182	Spare	Alarm not used
183	Spare	Alarm not used
184	Spare	Alarm not used
185	Spare	Alarm not used

186	Spare	Alarm not used
187	Spare	Alarm not used
188	Spare	Alarm not used
189	Spare	Alarm not used
190	Spare	Alarm not used
191	Spare	Alarm not used
192	Spare	Alarm not used
193	Spare	Alarm not used
194	Spare	Alarm not used
195	Spare	Alarm not used
196	Spare	Alarm not used
197	Spare	Alarm not used
198	Spare	Alarm not used
199	Spare	Alarm not used
200	Spare	Alarm not used

Appendix B – Shutdown List

A list of all shutdowns and a brief explanation of each follows:

1	Emergency Stop Button	Front Panel Emergency Button was pressed
2	Calibration Mode	Control is in Calibration Mode
3	Configuration error	There's any configuration error. See configuration error list
4	Total Speed Signal failure	All four speed inputs failed. If only one speed input is being used and it fails this shutdown is also triggered
5	Overspeed	Unit speed is greater than "Overspeed Level" for at least the "Overspeed Delay" time
6	Gate Major Mismatch	Gate position (if used) does not match within the "Major Mismatch Window" for more than the "Major Mismatch Delay" time
7	Blade Major Mismatch	Blade position (if used) does not match within the "Major Mismatch Window" for more than the "Major Mismatch Delay" time
8	Incomplete Start Timeout	Turbine does not reach at least "Minimum Speed to Incomplete Start" within "Time to Incomplete Start" when a turbine start command is given
9	Modbus Input Shutdown	Control received a Modbus Shutdown command
10	Serial Link Error Shutdown	Serial Modbus communication is being used and a link error is detected
11	External Emergency Input	Emergency Shutdown Input (DI #5) is opened (this is the only input which is inverted by default)
12	Powerup Trip	When the application software starts an internal shutdown is triggered for 10s
13	Remote Fault #1	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
14	Remote Fault #2	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
15	Remote Fault #3	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
16	Remote Fault #4	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)

17	Remote Fault #5	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
18	Remote Fault #6	Discrete Input configured for this function closes (if an inverted input is used it has to be opened)
19	I/O Lock	Control is in Configuration (I/O Lock) Mode
20	Ethernet #1 Link Error Shutdown	Ethernet #1 Modbus communication is being used and a link error is detected
21	Ethernet #2 Link Error Shutdown	Ethernet #2 Modbus communication is being used and a link error is detected
22	Net Head Fault	Net Head signal fail occurs (configured for Net Head analog input) and the fault is configured for shutdown
23	Net Head Fault (via Pond/Tail Inputs	Net Head signal fail occurs (configured for Pond/Tail level analog inputs) and the fault is configured for shutdown
24	Blade Preposition Fail	Blade preposition is being used and blade position does not achieve “Start Blade Tilt Position” within “Blade Preposition Maximum Time”
25	Gate Position Feedback Signal Fail	Gate control mode is Integrating and its current falls below 2mA or goes above 22mA
26	Blade Position Feedback Signal Fail	Blade control mode is Integrating and its current falls below 2mA or goes above 22mA
27	Ethernet #3 Link Error Shutdown	Ethernet #3 Modbus communication is being used and a link error is detected
28	Ethernet #4 Link Error Shutdown	Ethernet #4 Modbus communication is being used and a link error is detected
29	Spare	Shutdown not used
30	Spare	Shutdown not used
31	Spare	Shutdown not used
32	Spare	Shutdown not used
33	Spare	Shutdown not used
34	Spare	Shutdown not used
35	Spare	Shutdown not used

Appendix C – Configuration Error List

A list of all configuration errors and a brief explanation of each follows:

1	DI#06 – Duplicated Function	This discrete input has the same function of other DI
2	DI#07 – Duplicated Function	This discrete input has the same function of other DI
3	DI#08 – Duplicated Function	This discrete input has the same function of other DI
4	DI#09 – Duplicated Function	This discrete input has the same function of other DI
5	DI#10 – Duplicated Function	This discrete input has the same function of other DI
6	DI#11 – Duplicated Function	This discrete input has the same function of other DI
7	DI#12 – Duplicated Function	This discrete input has the same function of other DI
8	DI#13 – Duplicated Function	This discrete input has the same function of other DI
9	DI#14 – Duplicated Function	This discrete input has the same function of other DI
10	DI#15 – Duplicated Function	This discrete input has the same function of other DI
11	DI#16 – Duplicated Function	This discrete input has the same function of other DI
12	DI#17 – Duplicated Function	This discrete input has the same function of other DI
13	DI#18 – Duplicated Function	This discrete input has the same function of other DI
14	DI#19 – Duplicated Function	This discrete input has the same function of other DI
15	DI#20 – Duplicated Function	This discrete input has the same function of other DI
16	AI#01 – Duplicated Function	This analog input has the same function of other AI

17	AI#02 – Duplicated Function	This analog input has the same function of other AI
18	AI#03 – Duplicated Function	This analog input has the same function of other AI
19	AI#04 – Duplicated Function	This analog input has the same function of other AI
20	AI#05 – Duplicated Function	This analog input has the same function of other AI
21	AI#06 – Duplicated Function	This analog input has the same function of other AI
22	AI#07 – Duplicated Function	This analog input has the same function of other AI
23	AI#08 – Duplicated Function	This analog input has the same function of other AI
24	Gate Feedback not Configured	Gate control configured for “Integrating” and no AI configured for “Gate Position Feedback”
25	Blade Feedback not Configured	Blade control configured for “Integrating” and no AI configured for “Blade Position Feedback”
26	Blade Lim. Dig. Out. Not Available	There is a DO configured for “Analog Blade Limit Signal Fail”, but no AI configured for “Analog Blade Limit” function
27	Pond Level (AI) not configured	There’s a DI configured for “Pond/Tail Level Control Enable”, but no AI configured for “Pond Level”
28	Tail Level (AI) not configured	There’s a DI configured for “Pond/Tail Level Control Enable”, but no AI configured for “Tail Level”
29	Speed Bias AI is not Necessary	Speed Bias is not configured for analog option, but there’s an AI configured for “Speed Bias”
30	Speed Bias AI not configured	Speed Bias is configured for analog option, but there’s no AI configured for “Speed Bias”
31	Remote Speed AI Not Configured	“Use Remote Speed Control” is checked, but there’s no AI configured for “Remote Speed Reference”
32	Remote Baseload AI Not Configured	“Use Remote Baseload Control” is checked, but there’s no AI configured for “Remote Baseload Reference”
33	Remote Level AI Not Configured	“Use Remote Level Control” is checked, but there’s no AI configured for “Remote Level Reference”
34	Remote Speed AI Not Necessary	“Use Remote Speed Control” is unchecked, but there’s an AI configured for “Remote Speed Reference”

35	Remote Baseload AI Not Necessary	“Use Remote Baseload Control” is unchecked, but there’s an AI configured for “Remote Baseload Reference”
36	Remote Level AI Not Necessary	“Use Remote Level Control” is unchecked, but there’s an AI configured for “Remote Level Reference”
37	Remote Speed DI Not Necessary	“Use Remote Speed Control” is unchecked, but there’s a DI configured for “Enable Remote Speed”
38	Remote Baseload DI Not Necessary	“Use Remote Baseload Control” is unchecked, but there’s a DI configured for “Enable Remote Baseload”
39	Remote Level DI Not Necessary	“Use Remote Level Control” is unchecked, but there’s a DI configured for “Enable Remote Level”
40	Gen Power AI Not Configured	“Use Baseload Control” is checked, but there’s no AI configured for “Remote Baseload Reference”
41	Pond Level AI Not Configured	“Use Level Control” is checked, level control type is configured to “Pond”, but there’s no AI configured for “Pond Level”
42	Tail Level AI Not Configured	“Use Level Control” is checked, level control type is configured to “Tail”, but there’s no AI configured for “Tail Level”
43	Baseload DI Not Necessary	“Use Baseload Control” is unchecked, but there’s a DI configured for “Baseload Enable”
44	Level DI Not Necessary	“Use Level Control” is unchecked, but there’s a DI configured for “Pond/Tail Level Control Enable”
45	CB Open Cmd- No Gen Power AI Conf	A DO is configured for “Gen Breaker Open Command” but there’s no AI configured for “Generator Power”
46	No CB Open Command Configured	Either “Open Breaker on Normal Stop Command” or “Open Breaker on Unload Command” is checked and there’s no DO configured for “Gen Breaker Open Command”
47	At Least one Spd has to be MPU or Prox	There’s no speed sensor configured for either MPU (speed sensor #1 and #2) or proximity probe (speed sensor #3 and #4)
48	All Speed Inputs Conf. for Not Used	At least one speed input need to be used
49	At Least one Spd has to be PT	“Use PT as Primary” option is checked but there’s no speed input configured for PT sensor
50	Level Setpoint An. Out. Not Available	“Use Level Control” is unchecked, but there’s an AO configured for “Pond/Tail Level Setpoint”
51	Speed Bias An. Out. Not Available	Speed Bias is not being used, but there’s an AO configured for “Speed Bias”
52	Gen. Power An. Out. Not Available	There’s no AI configured for “Generator Power”, but there’s an AO configured for “Generator Power”

53	Creep Dig. Out. Not Available	There is a DO configured for “Creep Detected”, but both Creep DI’s are not configured
54	Speed Bias Dig. Out. Not Available	Speed Bias is not being used, but there’s a DO configured for either for “Speed Bias Enabled” or “Speed Bias Input Signal Fail”
55	Act. Pwr. Sw. Dig. Out. Not Available	There’s no AI configured for “Generator Power”, but there’s a DO configured for “Active Power Switch”
56	Level Dig. Out. Not Available	“Use Level Control” is unchecked, but there’s a DO configured for “Level Signal Fail”
57	Rem. Speed Dig. Out. Not Available	“Use Remote Speed Control” is unchecked, but there’s a DO configured for “Remote Speed Signal Fail”
58	Spd In. 1 Dig. Out. Not Available	Speed Sensor #1 is not being used and there’s a DO configured for “Speed Signal #1 Fault”
59	Spd In. 2 Dig. Out. Not Available	Speed Sensor #2 is not being used and there’s a DO configured for “Speed Signal #2 Fault”
60	Spd In. 3 Dig. Out. Not Available	Speed Sensor #3 is not being used and there’s a DO configured for “Speed Signal #1 Fault”
61	Spd In. 4 Dig. Out. Not Available	Speed Sensor #4 is not being used and there’s a DO configured for “Speed Signal #2 Fault”
62	Gate Lim. Dig. Out. Not Available	There’s no AI configured for “Gate Position Limiter”, but there’s a DO configured for “Analog Gate Limiter Signal Fail”
63	Rem. Baseload Dig. Out. Not Available	“Use Remote Baseload Control” is unchecked, but there’s a DO configured for “Remote Baseload Signal Fail”
64	Gen Power Dig. Out. Not Available	There’s no AI configured for “Generator Power”, but there’s a DO configured for “Power Transducer Signal Fail”
65	Turbine Type not Configured	Neither Francis nor Kaplan turbine type is selected
66	Blade Man. En. DI not Necessary	Turbine type configured for Francis, but there’s a DI configured for “Manual Blade Control Enable”
67	Blade Man. Raise DI not Necessary	Turbine type configured for Francis, but there’s a DI configured for “Manual Blade Position Raise”
68	Blade Man. Lower DI not Necessary	Turbine type configured for Francis, but there’s a DI configured for “Manual Blade Position Lower”
69	Blade Tilt DI not Necessary	Turbine type configured for Francis, but there’s a DI configured for “Enable Blade Tilt”
70	Blade Lock DI not Necessary	Turbine type configured for Francis, but there’s a DI configured for “Enable Blade Lock”

71	Blade Feedback AI not Necessary	Turbine type configured for Francis, but there's an AI configured for "Blade Position Feedback"
72	Blade Limiter AI not Necessary	Turbine type configured for Francis, but there's an AI configured for "Blade Position Limiter"
73	Net Head AI not Necessary	Turbine type configured for Francis, but there's an AI configured for "Net Head"
74	Net Head AI not Configured	Turbine type configured for Kaplan, net head type configured for "Net Head Signal", but there's no AI configured for "Net Head"
75	Either Pond or Tail AI not Configured	Turbine type configured for Kaplan, net head type configured for "Pond and Tail Signals", but there's neither AI configured for "Pond Level" nor "Tail Level"
76	Blade Limiter An. Out. Not Available	Turbine type configured for Francis, but there's an AO configured for "Blade Limit Value"
77	Blade Switch Dig. Out. Not Available	Turbine type configured for Francis, but there's a DO configured for "Blade Position Switch"
78	Small System Detection Must be Enabled	There's a DI configured for "Isochronous Arm/Disarm", but Small System Detection algorithm is disable
79	Baseload Enbl. Dig. Out. Not Available	"Use Baseload Control" is unchecked, but there's a DO configured for "Baseload Control Enabled"
80	Level Enbl. Dig. Out. Not Available	"Use Level Control" is unchecked, but there's a DO configured for "Level Control Enabled"
81	Blade Position An. Out. Not Available	Turbine type configured for Francis, but there's an AO configured for "Blade Position"
82	Net Head An. Out. Not Available	Turbine type configured for Francis, but there's an AO configured for "Net Head"
83	Spare	Configuration Error not used
84	Spare	Configuration Error not used
85	Spare	Configuration Error not used
86	Spare	Configuration Error not used
87	Spare	Configuration Error not used
88	Spare	Configuration Error not used
89	Spare	Configuration Error not used
90	Spare	Configuration Error not used
91	Spare	Configuration Error not used
92	Spare	Configuration Error not used
93	Spare	Configuration Error not used
94	Spare	Configuration Error not used
95	Spare	Configuration Error not used

96	Spare	Configuration Error not used
97	Spare	Configuration Error not used
98	Spare	Configuration Error not used
99	Spare	Configuration Error not used
100	Spare	Configuration Error not used
101	Spare	Configuration Error not used
102	Spare	Configuration Error not used
103	Spare	Configuration Error not used
104	Spare	Configuration Error not used
105	Spare	Configuration Error not used
106	Spare	Configuration Error not used
107	Spare	Configuration Error not used
108	Spare	Configuration Error not used
109	Spare	Configuration Error not used
110	Spare	Configuration Error not used
111	Spare	Configuration Error not used
112	Spare	Configuration Error not used
113	Spare	Configuration Error not used
114	Spare	Configuration Error not used
115	Spare	Configuration Error not used
116	Spare	Configuration Error not used
117	Spare	Configuration Error not used
118	Spare	Configuration Error not used
119	Spare	Configuration Error not used
120	Spare	Configuration Error not used
121	Spare	Configuration Error not used
122	Spare	Configuration Error not used
123	Spare	Configuration Error not used
124	Spare	Configuration Error not used
125	Spare	Configuration Error not used
126	Spare	Configuration Error not used
127	Spare	Configuration Error not used
128	Spare	Configuration Error not used
129	Spare	Configuration Error not used
130	Spare	Configuration Error not used
131	Spare	Configuration Error not used

132	Spare	Configuration Error not used
133	Spare	Configuration Error not used
134	Spare	Configuration Error not used
135	Spare	Configuration Error not used
136	Spare	Configuration Error not used
137	Spare	Configuration Error not used
138	Spare	Configuration Error not used
139	Spare	Configuration Error not used
140	Spare	Configuration Error not used
141	Spare	Configuration Error not used
142	Spare	Configuration Error not used
143	Spare	Configuration Error not used
144	Spare	Configuration Error not used
145	Spare	Configuration Error not used
146	Spare	Configuration Error not used
147	Spare	Configuration Error not used
148	Spare	Configuration Error not used
149	Spare	Configuration Error not used
150	Spare	Configuration Error not used

Appendix D – Modbus List

The controller Modbus list, ordered by signal type (Boolean writes, Boolean reads, Analog Reads and Analog Writes) follows:

Boolean Writes

Address	Description	Data Type
0:0001	Emergency Shutdown	BOOL
0:0002	Speed/Load Raise	BOOL
0:0003	Speed/Load Lower	BOOL
0:0004	Go to Remote Speed Reference	BOOL
0:0005	Gate Limit Raise	BOOL
0:0006	Gate Limit Lower	BOOL
0:0007	Go to Gate Limit Demand	BOOL
0:0008	Governor Reset	BOOL
0:0009	Momentary START	BOOL
0:0010	Momentary STOP	BOOL
0:0011	Overspeed Test Enable	BOOL
0:0012	Overspeed Test Disable	BOOL
0:0013	Go to Remote Baseload Reference	BOOL
0:0014	Baseload Enable	BOOL
0:0015	Baseload Disable	BOOL
0:0016	Unload Enable	BOOL
0:0017	Unload Disable	BOOL
0:0018	Level Control Enable	BOOL
0:0019	Level Control Disable	BOOL
0:0020	Manual Gate Control Enable	BOOL
0:0021	Manual Gate Control Disable	BOOL
0:0022	Go to Manual Gatw Demand	BOOL
0:0023	Go to Remote Level Reference	BOOL
0:0024	Reset Maximum Speed Reached	BOOL
0:0025	Remote Baseload Reference Enable	BOOL
0:0026	Remote Baseload Reference Disable	BOOL
0:0027	Remote Speed Reference Enable	BOOL
0:0028	Remote Speed Reference Disable	BOOL
0:0029	Remote Level Reference Enable	BOOL
0:0030	Remote Level Reference Disable	BOOL
0:0031	kW Droop request	BOOL
0:0032	Position Droop request	BOOL
0:0033	Go to Small System	BOOL
0:0034	Go to Large System	BOOL
0:0035	Enable/Disable Black Start	BOOL
0:0036	Manual Blade Control Enable	BOOL
0:0037	Manual Blade Control Disable	BOOL
0:0038	Blade Lock Enable	BOOL

Address	Description	Data Type
0:0039	Blade Lock Disable	BOOL
0:0040	Voluntary Blade Tilt Enable	BOOL
0:0041	Voluntary Blade Tilt Disable	BOOL
0:0042	Go to Manual Blade Demand	BOOL
0:0043	Go to Net Head Value	BOOL
0:0044	Isochronous Control Arm	BOOL
0:0045	Isochronous Control Disarm	BOOL
0:0046	Go to Isochronous Speed Setpoint	BOOL
0:0047	Manual Blade Lower	BOOL
0:0048	Manual Blade Raise	BOOL
0:0049	Blade Limiter Lower	BOOL
0:0050	Blade Limiter Raise	BOOL
0:0051	Go to Blade Limit Demand	BOOL
0:0052	Sync Enable	BOOL
0:0053	Sync Disable	BOOL

Boolean Reads

Address	Description	Date Type
1:0001	Alm - General Governor Alarm	BOOL
1:0002	Alm - Analog Input Fault - Channel 1	BOOL
1:0003	Alm - Analog Input Fault - Channel 2	BOOL
1:0004	Alm - Analog Input Fault - Channel 3	BOOL
1:0005	Alm - Analog Input Fault - Channel 4	BOOL
1:0006	Alm - Analog Input Fault - Channel 5	BOOL
1:0007	Alm - Analog Input Fault - Channel 6	BOOL
1:0008	Alm - Analog Input Fault - Channel 7	BOOL
1:0009	Alm - Analog Input Fault - Channel 8	BOOL
1:0010	Alm - Actuator Fault - Channel 1	BOOL
1:0011	Alm - Actuator Fault - Channel 2	BOOL
1:0012	Alm - Analog Output Fault - Channel 1	BOOL
1:0013	Alm - Analog Output Fault - Channel 2	BOOL
1:0014	Alm - Analog Output Fault - Channel 3	BOOL
1:0015	Alm - Analog Output Fault - Channel 4	BOOL
1:0016	Alm - Analog Output Fault - Channel 5	BOOL
1:0017	Alm - Analog Output Fault - Channel 6	BOOL
1:0018	Alm - Mpu Open Wire - Channel 1	BOOL
1:0019	Alm - Mpu Open Wire - Channel 2	BOOL
1:0020	Alm - Summary Chassis Alarm	BOOL
1:0021	Alm - Front Display Communication Alarm	BOOL
1:0022	Alm - Speed Signal #1 Trouble	BOOL
1:0023	Alm - Speed Signal #2 Trouble	BOOL
1:0024	Alm - Pond Level Signal Fail	BOOL
1:0025	Alm - Remote Speed Reference Signal Fail	BOOL
1:0026	Alm - Analog Speed Bias Input Signal Fail	BOOL

Address	Description	Date Type
1:0027	Alm - Gate Minor Mismatch	BOOL
1:0028	Alm - Serial Link Error Alarm	BOOL
1:0029	Alm - Governor Shutdown	BOOL
1:0030	Alm - Creep Detected	BOOL
1:0031	Alm - Generator Power Signal Fail	BOOL
1:0032	Alm - Remote Baseload Signal Fail	BOOL
1:0033	Alm - Analog Gate Limiter Signal Fail	BOOL
1:0034	Alm - Small System Detection	BOOL
1:0035	Alm - Blade Minor Mismatch	BOOL
1:0036	Alm - Remote Level Signal Fail	BOOL
1:0037	Alm - Remote Fault #1	BOOL
1:0038	Alm - Remote Fault #2	BOOL
1:0039	Alm - Remote Fault #3	BOOL
1:0040	Alm - Remote Fault #4	BOOL
1:0041	Alm - Remote Fault #5	BOOL
1:0042	Alm - Remote Fault #6	BOOL
1:0043	Alm - Gate Pos Fdbck Signal Fail	BOOL
1:0044	Alm - Blade Pos Fdbck Signal Fail	BOOL
1:0045	Alm - Analog Blade Limiter Sig Fail	BOOL
1:0046	Alm - Tail Level Signal Fail	BOOL
1:0047	Alm - Net Head Signal Fail	BOOL
1:0048	Alm - Gate Limit Auto Raise Active	BOOL
1:0049	Alm - Ethernet #1 Link Error Alarm	BOOL
1:0050	Alm - Ethernet #2 Link Error Alarm	BOOL
1:0051	Alm - Fail to Open Generator Breaker	BOOL
1:0052	Alm - Speed Signal #3 Trouble	BOOL
1:0053	Alm - Speed Signal #4 Trouble	BOOL
1:0054	Alm - Speed/Frequency Mismatch	BOOL
1:0055	Alm - Net Head Flt - Goto Bld Lock	BOOL
1:0056	Alm - Net Head Flt - Goto Bld Man	BOOL
1:0057	Alm - Net Head Flt - Goto Fxd Bld Crv	BOOL
1:0058	Alm - Ethernet #3 Link Error Alarm	BOOL
1:0059	Alm - Ethernet #4 Link Error Alarm	BOOL
1:0060	Alm - Spare	BOOL
1:0061	Alm - Spare	BOOL
1:0062	Alm - Spare	BOOL
1:0063	Alm - Spare	BOOL
1:0064	Alm - Spare	BOOL
1:0065	Alm - Spare	BOOL
1:0066	Alm - Spare	BOOL
1:0067	Alm - Spare	BOOL
1:0068	Alm - Spare	BOOL
1:0069	Alm - Spare	BOOL
1:0070	Alm - Spare	BOOL
1:0071	Alm - Spare	BOOL

Address	Description	Date Type
1:0072	Alm - Spare	BOOL
1:0073	Alm - Spare	BOOL
1:0074	Alm - Spare	BOOL
1:0075	Alm - Spare	BOOL
1:0076	Alm - Spare	BOOL
1:0077	Alm - Spare	BOOL
1:0078	Alm - Spare	BOOL
1:0079	Alm - Spare	BOOL
1:0080	Alm - Spare	BOOL
1:0081	Alm - Spare	BOOL
1:0082	Alm - Spare	BOOL
1:0083	Alm - Spare	BOOL
1:0084	Alm - Spare	BOOL
1:0085	Alm - Spare	BOOL
1:0086	Alm - Spare	BOOL
1:0087	Alm - Spare	BOOL
1:0088	Alm - Spare	BOOL
1:0089	Alm - Spare	BOOL
1:0090	Alm - Spare	BOOL
1:0091	Alm - Spare	BOOL
1:0092	Alm - Spare	BOOL
1:0093	Alm - Spare	BOOL
1:0094	Alm - Spare	BOOL
1:0095	Alm - Spare	BOOL
1:0096	Alm - Spare	BOOL
1:0097	Alm - Spare	BOOL
1:0098	Alm - Spare	BOOL
1:0099	Alm - Spare	BOOL
1:0100	Alm - Spare	BOOL
1:0101	Alm - Spare	BOOL
1:0102	Alm - Spare	BOOL
1:0103	Alm - Spare	BOOL
1:0104	Alm - Spare	BOOL
1:0105	Alm - Spare	BOOL
1:0106	Alm - Spare	BOOL
1:0107	Alm - Spare	BOOL
1:0108	Alm - Spare	BOOL
1:0109	Alm - Spare	BOOL
1:0110	Alm - Spare	BOOL
1:0111	Alm - Spare	BOOL
1:0112	Alm - Spare	BOOL
1:0113	Alm - Spare	BOOL
1:0114	Alm - Spare	BOOL
1:0115	Alm - Spare	BOOL
1:0116	Alm - Spare	BOOL

Address	Description	Date Type
1:0117	Alm - Spare	BOOL
1:0118	Alm - Spare	BOOL
1:0119	Alm - Spare	BOOL
1:0120	Alm - Spare	BOOL
1:0121	Alm - Spare	BOOL
1:0122	Alm - Spare	BOOL
1:0123	Alm - Spare	BOOL
1:0124	Alm - Spare	BOOL
1:0125	Alm - Spare	BOOL
1:0126	Alm - Spare	BOOL
1:0127	Alm - Spare	BOOL
1:0128	Alm - Spare	BOOL
1:0129	Alm - Spare	BOOL
1:0130	Alm - Spare	BOOL
1:0131	Alm - Spare	BOOL
1:0132	Alm - Spare	BOOL
1:0133	Alm - Spare	BOOL
1:0134	Alm - Spare	BOOL
1:0135	Alm - Spare	BOOL
1:0136	Alm - Spare	BOOL
1:0137	Alm - Spare	BOOL
1:0138	Alm - Spare	BOOL
1:0139	Alm - Spare	BOOL
1:0140	Alm - Spare	BOOL
1:0141	Alm - Spare	BOOL
1:0142	Alm - Spare	BOOL
1:0143	Alm - Spare	BOOL
1:0144	Alm - Spare	BOOL
1:0145	Alm - Spare	BOOL
1:0146	Alm - Spare	BOOL
1:0147	Alm - Spare	BOOL
1:0148	Alm - Spare	BOOL
1:0149	Alm - Spare	BOOL
1:0150	Alm - Spare	BOOL
1:0151	Alm - Spare	BOOL
1:0152	Alm - Spare	BOOL
1:0153	Alm - Spare	BOOL
1:0154	Alm - Spare	BOOL
1:0155	Alm - Spare	BOOL
1:0156	Alm - Spare	BOOL
1:0157	Alm - Spare	BOOL
1:0158	Alm - Spare	BOOL
1:0159	Alm - Spare	BOOL
1:0160	Alm - Spare	BOOL
1:0161	Alm - Spare	BOOL

Address	Description	Date Type
1:0162	Alm - Spare	BOOL
1:0163	Alm - Spare	BOOL
1:0164	Alm - Spare	BOOL
1:0165	Alm - Spare	BOOL
1:0166	Alm - Spare	BOOL
1:0167	Alm - Spare	BOOL
1:0168	Alm - Spare	BOOL
1:0169	Alm - Spare	BOOL
1:0170	Alm - Spare	BOOL
1:0171	Alm - Spare	BOOL
1:0172	Alm - Spare	BOOL
1:0173	Alm - Spare	BOOL
1:0174	Alm - Spare	BOOL
1:0175	Alm - Spare	BOOL
1:0176	Alm - Spare	BOOL
1:0177	Alm - Spare	BOOL
1:0178	Alm - Spare	BOOL
1:0179	Alm - Spare	BOOL
1:0180	Alm - Spare	BOOL
1:0181	Alm - Spare	BOOL
1:0182	Alm - Spare	BOOL
1:0183	Alm - Spare	BOOL
1:0184	Alm - Spare	BOOL
1:0185	Alm - Spare	BOOL
1:0186	Alm - Spare	BOOL
1:0187	Alm - Spare	BOOL
1:0188	Alm - Spare	BOOL
1:0189	Alm - Spare	BOOL
1:0190	Alm - Spare	BOOL
1:0191	Alm - Spare	BOOL
1:0192	Alm - Spare	BOOL
1:0193	Alm - Spare	BOOL
1:0194	Alm - Spare	BOOL
1:0195	Alm - Spare	BOOL
1:0196	Alm - Spare	BOOL
1:0197	Alm - Spare	BOOL
1:0198	Alm - Spare	BOOL
1:0199	Alm - Spare	BOOL
1:0200	Alm - Spare	BOOL
1:0201	Alm - Spare	BOOL
1:0202	Shutdown Indication	BOOL
1:0203	SD - Emergency Stop Button	BOOL
1:0204	SD - Calibration Mode	BOOL
1:0205	SD - Configuration error	BOOL
1:0206	SD - Total Speed Signal failure	BOOL

Address	Description	Date Type
1:0207	SD - Overspeed	BOOL
1:0208	SD - Gate Major Mismatch	BOOL
1:0209	SD - Blade Major Mismatch	BOOL
1:0210	SD - Incomplete Start Timeout	BOOL
1:0211	SD - Modbus Input SD	BOOL
1:0212	SD - Serial Link Error	BOOL
1:0213	SD - External Emergency Input	BOOL
1:0214	SD - Powerup Trip	BOOL
1:0215	SD - Remote Fault #1	BOOL
1:0216	SD - Remote Fault #2	BOOL
1:0217	SD - Remote Fault #3	BOOL
1:0218	SD - Remote Fault #4	BOOL
1:0219	SD - Remote Fault #5	BOOL
1:0220	SD - Remote Fault #6	BOOL
1:0221	SD - I/O Lock	BOOL
1:0222	SD - Ethernet #1 Link Error	BOOL
1:0223	SD - Ethernet #2 Link Error	BOOL
1:0224	SD - Net Head Fault	BOOL
1:0225	SD - Net Head Flt (via Pond/Tail In)	BOOL
1:0226	SD - Blade Preposition Fail	BOOL
1:0227	SD - Gate Position Feedback Fail	BOOL
1:0228	SD - Blade Position Feedback Fail	BOOL
1:0229	SD - Ethernet #3 Link Error	BOOL
1:0230	SD - Ethernet #4 Link Error	BOOL
1:0231	SD - Spare	BOOL
1:0232	SD - Spare	BOOL
1:0233	SD - Spare	BOOL
1:0234	SD - Spare	BOOL
1:0235	SD - Spare	BOOL
1:0236	SD - Spare	BOOL
1:0237	SD - Spare	BOOL
1:0238	DI1 - Run/Stop Contact (closed)	BOOL
1:0239	DI2 - Spd/Load Raise Contact (closed)	BOOL
1:0240	DI3 - Spd/Load Lower Contact (closed)	BOOL
1:0241	DI4 - Gen Breaker Contact (closed)	BOOL
1:0242	DI5 - ESD Input (closed)	BOOL
1:0243	DI6 - Configurable	BOOL
1:0244	DI7 - Configurable	BOOL
1:0245	DI8 - Configurable	BOOL
1:0246	DI9 - Configurable	BOOL
1:0247	DI10 - Configurable	BOOL
1:0248	DI11 - Configurable	BOOL
1:0249	DI12 - Configurable	BOOL
1:0250	DI13 - Configurable	BOOL
1:0251	DI14 - Configurable	BOOL

Address	Description	Date Type
1:0252	DI15 - Configurable	BOOL
1:0253	DI16 - Configurable	BOOL
1:0254	DI17 - Configurable	BOOL
1:0255	DI18 - Configurable	BOOL
1:0256	DI19 - Configurable	BOOL
1:0257	DI20 - Configurable	BOOL
1:0258	LN1 - DI1 - Configurable (future)	BOOL
1:0259	LN1 - DI2 - Configurable (future)	BOOL
1:0260	LN1 - DI3 - Configurable (future)	BOOL
1:0261	LN1 - DI4 - Configurable (future)	BOOL
1:0262	LN1 - DI5 - Configurable (future)	BOOL
1:0263	LN1 - DI6 - Configurable (future)	BOOL
1:0264	LN1 - DI7 - Configurable (future)	BOOL
1:0265	LN1 - DI8 - Configurable (future)	BOOL
1:0266	LN1 - DI9 - Configurable (future)	BOOL
1:0267	LN1 - DI10 - Configurable (future)	BOOL
1:0268	LN1 - DI11 - Configurable (future)	BOOL
1:0269	LN1 - DI12 - Configurable (future)	BOOL
1:0270	LN1 - DI13 - Configurable (future)	BOOL
1:0271	LN1 - DI14 - Configurable (future)	BOOL
1:0272	LN1 - DI15 - Configurable (future)	BOOL
1:0273	LN1 - DI16 - Configurable (future)	BOOL
1:0274	Relay Out #1 ON	BOOL
1:0275	Relay Out #2 ON	BOOL
1:0276	Relay Out #3 ON	BOOL
1:0277	Relay Out #4 ON	BOOL
1:0278	Relay Out #5 ON	BOOL
1:0279	Relay Out #6 ON	BOOL
1:0280	Relay Out #7 ON	BOOL
1:0281	Relay Out #8 ON	BOOL
1:0282	LN2 - Relay Out #1 ON (future)	BOOL
1:0283	LN2 - Relay Out #2 ON (future)	BOOL
1:0284	LN2 - Relay Out #3 ON (future)	BOOL
1:0285	LN2 - Relay Out #4 ON (future)	BOOL
1:0286	LN2 - Relay Out #5 ON (future)	BOOL
1:0287	LN2 - Relay Out #6 ON (future)	BOOL
1:0288	LN2 - Relay Out #7 ON (future)	BOOL
1:0289	LN2 - Relay Out #8 ON (future)	BOOL
1:0290	LN2 - Relay Out #9 ON (future)	BOOL
1:0291	LN2 - Relay Out #10 ON (future)	BOOL
1:0292	LN2 - Relay Out #11 ON (future)	BOOL
1:0293	LN2 - Relay Out #12 ON (future)	BOOL
1:0294	LN2 - Relay Out #13 ON (future)	BOOL
1:0295	LN2 - Relay Out #14 ON (future)	BOOL
1:0296	LN2 - Relay Out #15 ON (future)	BOOL

Address	Description	Date Type
1:0297	LN2 - Relay Out #16 ON (future)	BOOL
1:0298	Governor Run	BOOL
1:0299	Governor Stop	BOOL
1:0300	Baseload Mode Enabled	BOOL
1:0301	Remote Baseload Mode Enabled	BOOL
1:0302	Unload Mode Enabled	BOOL
1:0303	Level Mode Enabled	BOOL
1:0304	Remote Level Mode Enabled	BOOL
1:0305	Remote Speed Mode Enabled	BOOL
1:0306	Manual Gate Mode Enabled	BOOL
1:0307	Overspeed Test Enabled	BOOL
1:0308	kW Droop Enabled	BOOL
1:0309	Position Droop Enabled	BOOL
1:0310	Small System Enabled	BOOL
1:0311	Black Start Enabled	BOOL
1:0312	Load Rejection Activated	BOOL
1:0313	Gate Auto Test Enabled	BOOL
1:0314	Blade Auto Test Enabled	BOOL
1:0315	Speed Bias Control Mode Enabled	BOOL
1:0316	Voluntary Blade Tilt Enabled	BOOL
1:0317	Blade Lock Enabled	BOOL
1:0318	Blade Manual Enabled	BOOL
1:0319	Isoch Mode Armed	BOOL
1:0320	Isoch Mode Armed/Enabled	BOOL
1:0321	Spare	BOOL
1:0322	Spare	BOOL
1:0323	Spare	BOOL
1:0324	Spare	BOOL
1:0325	Spare	BOOL
1:0326	Spare	BOOL
1:0327	Spare	BOOL
1:0328	Spare	BOOL
1:0329	Spare	BOOL
1:0330	Spare	BOOL
1:0331	Spare	BOOL
1:0332	Spare	BOOL
1:0333	Spare	BOOL
1:0334	Spare	BOOL
1:0335	Spare	BOOL
1:0336	Offline PID Active	BOOL
1:0337	Online PID Active	BOOL
1:0338	Baseload PID Active	BOOL
1:0339	Small System PID Active	BOOL
1:0340	Isoch PID Active	BOOL
1:0341	Load Sharing PID Active	BOOL

Address	Description	Date Type
1:0342	In Control - Gate Limit	BOOL
1:0343	In Control - On-Line/Droop PID	BOOL
1:0344	In Control - Off-Line PID	BOOL
1:0345	Speed Fault/Overspeed Override	BOOL
1:0346	Frequency Measurement Enabled	BOOL
1:0347	In Control - Analog Gate Limit	BOOL
1:0348	Gate Limit - At 0%	BOOL
1:0349	Gate Limit - At 100%	BOOL
1:0350	Gate Limit - At Breakaway	BOOL
1:0351	Gate Limit - At Spd-No-Load/Off-Line	BOOL
1:0352	Gate Lmt - At Max Gate Pos/On-Line	BOOL
1:0353	Gate Limit - Actual Gate Position	BOOL
1:0354	Gate Limit - At Modbus Reference	BOOL
1:0355	Gate Limit - At QT Reference	BOOL
1:0356	Offine Spd Ref - At Lower Limit	BOOL
1:0357	Offine Spd Ref - Follow Actl Pos	BOOL
1:0358	Offine Spd Ref - At SNL Setpoint	BOOL
1:0359	Offine Spd Ref - At Upper Limit	BOOL
1:0360	On-Ln/Droop Spd Ref - Tracking	BOOL
1:0361	On-Ln/Droop Spd Ref - Droop Transit.	BOOL
1:0362	On-Ln/Droop Spd Ref - At Unload	BOOL
1:0363	On-Ln/Droop Spd Ref - At Rem Stpnt	BOOL
1:0364	On-Ln/Droop Spd Ref - At Lvl Stpnt	BOOL
1:0365	On-Ln/Droop Spd Ref - At Lower Lim	BOOL
1:0366	On-Ln/Droop Spd Ref - At Upper Lim	BOOL
1:0367	On-Ln/Droop Spd Ref - At Modbus	BOOL
1:0368	On-Ln/Droop Spd Ref - At QT	BOOL
1:0369	On-Ln/Droop Spd Ref - At Initial	BOOL
1:0370	Baseload Ref - Tracking	BOOL
1:0371	Baseload Ref - At Rem Spt	BOOL
1:0372	Baseload Ref - At Lower Lim	BOOL
1:0373	Baseload Ref - At Upper Lim	BOOL
1:0374	Baseload Ref - At Modbus	BOOL
1:0375	Baseload Ref - At QT	BOOL
1:0376	Baseload Ref - At Initial	BOOL
1:0377	Level Ref - Tracking	BOOL
1:0378	Level Ref - At Rem Spt	BOOL
1:0379	Level Ref - At Lower Lim	BOOL
1:0380	Level Ref - At Upper Lim	BOOL
1:0381	Level Ref - At Modbus	BOOL
1:0382	Level Ref - At QT	BOOL
1:0383	Isoch Ref - Tracking	BOOL
1:0384	Isoch Ref - At Rated	BOOL
1:0385	Isoch Ref - At Lower Lim	BOOL
1:0386	Isoch Ref - At Upper Lim	BOOL

Address	Description	Date Type
1:0387	Isoch Ref - At Modbus	BOOL
1:0388	Isoch Ref - At QT	BOOL
1:0389	Gate Manual Ref - Tracking	BOOL
1:0390	Gate Manual Ref - At 0%	BOOL
1:0391	Gate Manual Ref - At 100%	BOOL
1:0392	Gate Manual Ref - At Modbus	BOOL
1:0393	Gate Manual Ref - At QT	BOOL
1:0394	Blade Manual Ref - Shutdown	BOOL
1:0395	Blade Manual Ref - Tracking	BOOL
1:0396	Blade Manual Ref - At 0%	BOOL
1:0397	Blade Manual Ref - At 100%	BOOL
1:0398	Blade Manual Ref - At Modbus	BOOL
1:0399	Blade Manual Ref - At QT	BOOL
1:0400	Blade Limiter - Shutdown	BOOL
1:0401	Blade Limiter - At Rem Spt	BOOL
1:0402	Blade Limiter - At Lower Lim	BOOL
1:0403	Blade Limiter - At Upper Lim	BOOL
1:0404	Blade Limiter - At Initial Setpt	BOOL
1:0405	Blade Limiter - At Modbus	BOOL
1:0406	Blade Limiter - At QT	BOOL
1:0407	Speed Switch #1	BOOL
1:0408	Speed Switch #2	BOOL
1:0409	Speed Switch #3	BOOL
1:0410	Speed Switch #4	BOOL
1:0411	Speed Switch #5	BOOL
1:0412	Speed Switch #6	BOOL
1:0413	Gate Position Switch #1	BOOL
1:0414	Gate Position Switch #2	BOOL
1:0415	Gate Position Switch #3	BOOL
1:0416	Gate Position Switch #4	BOOL
1:0417	Blade Position Switch #1	BOOL
1:0418	Blade Position Switch #2	BOOL
1:0419	Blade Position Switch #3	BOOL
1:0420	Blade Position Switch #4	BOOL
1:0421	Active Power Switch #1	BOOL
1:0422	Active Power Switch #2	BOOL
1:0423	Active Power Switch #3	BOOL
1:0424	Active Power Switch #4	BOOL
1:0425	Local Mode Enabled	BOOL
1:0426	Remote Mode Enabled	BOOL
1:0427	Local/Remote Mode Not Used	BOOL

Analog Reads

Address	Description	Unit	Multiplier	Data Type
3:0001	An. Input 1 - EU	EU	Config.	INT16
3:0002	An. Input 2 - EU	EU	Config.	INT16
3:0003	An. Input 3 - EU	EU	Config.	INT16
3:0004	An. Input 4 - EU	EU	Config.	INT16
3:0005	An. Input 5 - EU	EU	Config.	INT16
3:0006	An. Input 6 - EU	EU	Config.	INT16
3:0007	An. Input 7 - EU	EU	Config.	INT16
3:0008	An. Input 8 - EU	EU	Config.	INT16
3:0009	Linknet - An. Input 1 - EU (Future)	EU	1	INT16
3:0010	Linknet - An. Input 2 - EU (Future)	EU	1	INT16
3:0011	Linknet - An. Input 3 - EU (Future)	EU	1	INT16
3:0012	Linknet - An. Input 4 - EU (Future)	EU	1	INT16
3:0013	Linknet - An. Input 5 - EU (Future)	EU	1	INT16
3:0014	Linknet - An. Input 6 - EU (Future)	EU	1	INT16
3:0015	Linknet - An. Input 7 - EU (Future)	EU	1	INT16
3:0016	Linknet - An. Input 8 - EU (Future)	EU	1	INT16
3:0017	An. Input 1 - %	%	100	INT16
3:0018	An. Input 2 - %	%	100	INT16
3:0019	An. Input 3 - %	%	100	INT16
3:0020	An. Input 4 - %	%	100	INT16
3:0021	An. Input 5 - %	%	100	INT16
3:0022	An. Input 6 - %	%	100	INT16
3:0023	An. Input 7 - %	%	100	INT16
3:0024	An. Input 8 - %	%	100	INT16
3:0025	Linknet - An. Input 1 - % (Future)	%	100	INT16
3:0026	Linknet - An. Input 2 - % (Future)	%	100	INT16
3:0027	Linknet - An. Input 3 - % (Future)	%	100	INT16
3:0028	Linknet - An. Input 4 - % (Future)	%	100	INT16
3:0029	Linknet - An. Input 5 - % (Future)	%	100	INT16
3:0030	Linknet - An. Input 6 - % (Future)	%	100	INT16
3:0031	Linknet - An. Input 7 - % (Future)	%	100	INT16
3:0032	Linknet - An. Input 8 - % (Future)	%	100	INT16
3:0033	An. Input 1 - mA	mA	100	INT16
3:0034	An. Input 2 - mA	mA	100	INT16

Address	Description	Unit	Multiplier	Data Type
3:0035	An. Input 3 - mA	mA	100	INT16
3:0036	An. Input 4 - mA	mA	100	INT16
3:0037	An. Input 5 - mA	mA	100	INT16
3:0038	An. Input 6 - mA	mA	100	INT16
3:0039	An. Input 7 - mA	mA	100	INT16
3:0040	An. Input 8 - mA	mA	100	INT16
3:0041	Linknet - An. Input 1 - mA (Future)	mA	100	INT16
3:0042	Linknet - An. Input 2 - mA (Future)	mA	100	INT16
3:0043	Linknet - An. Input 3 - mA (Future)	mA	100	INT16
3:0044	Linknet - An. Input 4 - mA (Future)	mA	100	INT16
3:0045	Linknet - An. Input 5 - mA (Future)	mA	100	INT16
3:0046	Linknet - An. Input 6 - mA (Future)	mA	100	INT16
3:0047	Linknet - An. Input 7 - mA (Future)	mA	100	INT16
3:0048	Linknet - An. Input 8 - mA (Future)	mA	100	INT16
3:0049	An. Input 1 - Function	List	1	INT16
3:0050	An. Input 2 - Function	List	1	INT16
3:0051	An. Input 3 - Function	List	1	INT16
3:0052	An. Input 4 - Function	List	1	INT16
3:0053	An. Input 5 - Function	List	1	INT16
3:0054	An. Input 6 - Function	List	1	INT16
3:0055	An. Input 7 - Function	List	1	INT16
3:0056	An. Input 8 - Function	List	1	INT16
3:0057	Linknet - An. In 1 - Function (Future)	List	1	INT16
3:0058	Linknet - An. In 2 - Function (Future)	List	1	INT16
3:0059	Linknet - An. In 3 - Function (Future)	List	1	INT16
3:0060	Linknet - An. In 4 - Function (Future)	List	1	INT16
3:0061	Linknet - An. In 5 - Function (Future)	List	1	INT16
3:0062	Linknet - An. In 6 - Function (Future)	List	1	INT16
3:0063	Linknet - An. In 7 - Function (Future)	List	1	INT16
3:0064	Linknet - An. In 8 - Function (Future)	List	1	INT16
3:0065	An. Out 1 - EU	EU	Config.	INT16
3:0066	An. Out 2 - EU	EU	Config.	INT16
3:0067	An. Out 3 - EU	EU	Config.	INT16
3:0068	An. Out 4 - EU	EU	Config.	INT16
3:0069	An. Out 5 - EU	EU	Config.	INT16
3:0070	An. Out 6 - EU	EU	Config.	INT16

Address	Description	Unit	Multiplier	Data Type
3:0071	Linknet - An. Out 1 - EU (Future)	EU	1	INT16
3:0072	Linknet - An. Out 2 - EU (Future)	EU	1	INT16
3:0073	An. Out 1 - mA	mA	100	INT16
3:0074	An. Out 2 - mA	mA	100	INT16
3:0075	An. Out 3 - mA	mA	100	INT16
3:0076	An. Out 4 - mA	mA	100	INT16
3:0077	An. Out 5 - mA	mA	100	INT16
3:0078	An. Out 6 - mA	mA	100	INT16
3:0079	Linknet - An. Out 1 - mA (Future)	mA	1	INT16
3:0080	Linknet - An. Out 2 - mA (Future)	mA	1	INT16
3:0081	An. Out 1 - Function	List	1	INT16
3:0082	An. Out 2 - Function	List	1	INT16
3:0083	An. Out 3 - Function	List	1	INT16
3:0084	An. Out 4 - Function	List	1	INT16
3:0085	An. Out 5 - Function	List	1	INT16
3:0086	An. Out 6 - Function	List	1	INT16
3:0087	Linknet - An.Out 1-Function (Future)	List	1	INT16
3:0088	Linknet - An.Out 2-Function (Future)	List	1	INT16
3:0089	Disc. In 6 - Function	List	1	INT16
3:0090	Disc. In 7 - Function	List	1	INT16
3:0091	Disc. In 8 - Function	List	1	INT16
3:0092	Disc. In 9 - Function	List	1	INT16
3:0093	Disc. In 10 - Function	List	1	INT16
3:0094	Disc. In 11 - Function	List	1	INT16
3:0095	Disc. In 12 - Function	List	1	INT16
3:0096	Disc. In 13 - Function	List	1	INT16
3:0097	Disc. In 14 - Function	List	1	INT16
3:0098	Disc. In 15 - Function	List	1	INT16
3:0099	Disc. In 16 - Function	List	1	INT16
3:0100	Disc. In 17 - Function	List	1	INT16
3:0101	Disc. In 18 - Function	List	1	INT16
3:0102	Disc. In 19 - Function	List	1	INT16
3:0103	Disc. In 20 - Function	List	1	INT16
3:0104	Linknet - Disc. In 1 - Function	List	1	INT16
3:0105	Linknet - Disc. In 2 - Function	List	1	INT16
3:0106	Linknet - Disc. In 3 - Function	List	1	INT16
3:0107	Linknet - Disc. In 4 - Function	List	1	INT16
3:0108	Linknet - Disc. In 5 - Function	List	1	INT16
3:0109	Linknet - Disc. In 6 - Function	List	1	INT16
3:0110	Linknet - Disc. In 7 - Function	List	1	INT16
3:0111	Linknet - Disc. In 8 - Function	List	1	INT16
3:0112	Linknet - Disc. In 9 - Function	List	1	INT16
3:0113	Linknet - Disc. In 10 - Function	List	1	INT16

Address	Description	Unit	Multiplier	Data Type
3:0114	Linknet - Disc. In 11 - Function	List	1	INT16
3:0115	Linknet - Disc. In 12 - Function	List	1	INT16
3:0116	Linknet - Disc. In 13 - Function	List	1	INT16
3:0117	Linknet - Disc. In 14 - Function	List	1	INT16
3:0118	Linknet - Disc. In 15 - Function	List	1	INT16
3:0119	Linknet - Disc. In 16 - Function	List	1	INT16
3:0120	Disc. Out 1 - Function	List	1	INT16
3:0121	Disc. Out 2 - Function	List	1	INT16
3:0122	Disc. Out 3 - Function	List	1	INT16
3:0123	Disc. Out 4 - Function	List	1	INT16
3:0124	Disc. Out 5 - Function	List	1	INT16
3:0125	Disc. Out 6 - Function	List	1	INT16
3:0126	Disc. Out 7 - Function	List	1	INT16
3:0127	Disc. Out 8 - Function	List	1	INT16
3:0128	Linknet - Disc. Out 1 - Function	List	1	INT16
3:0129	Linknet - Disc. Out 2 - Function	List	1	INT16
3:0130	Linknet - Disc. Out 3 - Function	List	1	INT16
3:0131	Linknet - Disc. Out 4 - Function	List	1	INT16
3:0132	Linknet - Disc. Out 5 - Function	List	1	INT16
3:0133	Linknet - Disc. Out 6 - Function	List	1	INT16
3:0134	Linknet - Disc. Out 7 - Function	List	1	INT16
3:0135	Linknet - Disc. Out 8 - Function	List	1	INT16
3:0136	Linknet - Disc. Out 9 - Function	List	1	INT16
3:0137	Linknet - Disc. Out 10 - Function	List	1	INT16
3:0138	Linknet - Disc. Out 11 - Function	List	1	INT16
3:0139	Linknet - Disc. Out 12 - Function	List	1	INT16
3:0140	Linknet - Disc. Out 13 - Function	List	1	INT16
3:0141	Linknet - Disc. Out 14 - Function	List	1	INT16
3:0142	Linknet - Disc. Out 15 - Function	List	1	INT16
3:0143	Linknet - Disc. Out 16 - Function	List	1	INT16
3:0144	Act. Out 1 - %	%	100	INT16
3:0145	Act. Out 2 - %	%	100	INT16
3:0146	Act. Out 1 - mA	mA	100	INT16
3:0147	Act. Out 2 - mA	mA	100	INT16
3:0148	Speed Signal #1 (RPM or Hz)	rpm or Hz	Config.	INT16
3:0149	Speed Signal #2 (RPM or Hz)	rpm or Hz	Config.	INT16
3:0150	Speed Signal #3 (RPM)	rpm	10	INT16
3:0151	Speed Signal #4 (RPM)	rpm	10	INT16
3:0152	Speed Signal #1 (%)	%	100	INT16
3:0153	Speed Signal #2 (%)	%	100	INT16
3:0154	Speed Signal #3 (%)	%	100	INT16
3:0155	Speed Signal #4 (%)	%	100	INT16
3:0156	Spare	N/A	1	INT16
3:0157	Spare	N/A	1	INT16
3:0158	Spare	N/A	1	INT16

Address	Description	Unit	Multiplier	Data Type
3:0159	Spare	N/A	1	INT16
3:0160	Spare	N/A	1	INT16
3:0161	Spare	N/A	1	INT16
3:0162	Spare	N/A	1	INT16
3:0163	Spare	N/A	1	INT16
3:0164	Spare	N/A	1	INT16
3:0165	Spare	N/A	1	INT16
3:0166	Spare	N/A	1	INT16
3:0167	Spare	N/A	1	INT16
3:0168	Cause of Last trip	List	1	INT16
3:0169	Turbine First Trip	List	1	INT16
3:0170	Gate Position (%)	%	100	INT16
3:0171	Blade Position (%)	%	100	INT16
3:0172	Gate Demand (%)	%	100	INT16
3:0173	Blade Demand (%)	%	100	INT16
3:0174	Gate Output (%)	%	100	INT16
3:0175	Blade Output (%)	%	100	INT16
3:0176	Unit Speed (%)	%	100	INT16
3:0177	Speed Signal (RPM)	rpm	10	INT16
3:0178	Generator Frequency (Hz)	Hz	100	INT16
3:0179	Maximum Speed Since Last Start (%)	%	100	INT16
3:0180	Pond/Tail Level (m)	m	10	INT16
3:0181	Pond/Tail Level Setpoint (m)	m	10	INT16
3:0182	Pond/Tail Lvl Gate Pos Setp (%)	%	100	INT16
3:0183	AI Speed Remote Reference (%)	%	100	INT16
3:0184	Speed Bias (%)	%	100	INT16
3:0185	Generator Load (%)	%	100	INT16
3:0186	Generator Load (MW)	MW	100	INT16
3:0187	Baseload PID Output (%)	%	100	INT16
3:0188	Remote Baseload Reference (MW)	MW	100	INT16
3:0189	Baseload Reference (%)	%	100	INT16
3:0190	Baseload Reference (MW)	MW	100	INT16
3:0191	Online/Droop Speed Reference (%)	%	100	INT16
3:0192	Online/Droop PID Output (%)	%	100	INT16
3:0193	Online/Droop Feedback (%)	%	100	INT16
3:0194	Offline Speed Reference (%)	%	100	INT16
3:0195	Offline PID Output (%)	%	100	INT16
3:0196	Isoch Speed Reference (%)	%	100	INT16
3:0197	Isoch Speed Value (%)	%	100	INT16
3:0198	Isoch Speed PID Output (%)	%	100	INT16
3:0199	Analog Gate Limit (%)	%	100	INT16
3:0200	Gate Limit (%)	%	100	INT16

Address	Description	Unit	Multiplier	Data Type
3:0201	MB Remote Speed Stpt (%) - fdbck	%	100	INT16
3:0202	MB Remote Baseload Stpt (MW) - fdbck	MW	100	INT16
3:0203	MB Remote Level Stpt (m) - fdbck	m	10	INT16
3:0204	MB Gate Lmt Dmd (%) - fdbck	%	100	INT16
3:0205	MB Man Gate Dmd (%) - fdbck	%	100	INT16
3:0206	MB Man Blade Dmd (%) - fdbck	%	100	INT16
3:0207	MB Net Head Dmd (m) - fdbck	m	10	INT16
3:0208	MB Isoch Spd Stpt (%) - fdbck	%	100	INT16
3:0209	MB Blade Lmt Dmd (%) - fdbck	%	100	INT16
3:0210	Spare	N/A	1	INT16
3:0211	Spare	N/A	1	INT16
3:0212	Net Head Value (m)	m	10	INT16
3:0213	Blade Tilt Demand (%)	%	100	INT16
3:0214	Blade Curves Demand (%)	%	100	INT16
3:0215	Blade Fixed Curve Demand (%)	%	100	INT16
3:0216	Blade Manual Demand (%)	%	100	INT16
3:0217	Blade Lock Demand (%)	%	100	INT16
3:0218	Blade Limit Demand (%)	%	100	INT16
3:0219	Gate Control Mode	List	1	INT16
3:0220	Blade Control Mode	List	1	INT16
3:0221	Spare	N/A	1	INT16
3:0222	Spare	N/A	1	INT16
3:0223	Spare	N/A	1	INT16
3:0224	Spare	N/A	1	INT16
3:0225	Spare	N/A	1	INT16
3:0226	Spare	N/A	1	INT16
3:0227	Spare	N/A	1	INT16
3:0228	Spare	N/A	1	INT16
3:0229	Spare	N/A	1	INT16
3:0230	Spare	N/A	1	INT16
3:0231	Spare	N/A	1	INT16
3:0232	Spare	N/A	1	INT16
3:0233	Spare	N/A	1	INT16
3:0234	Spare	N/A	1	INT16
3:0235	Spare	N/A	1	INT16
3:0236	Spare	N/A	1	INT16
3:0237	Spare	N/A	1	INT16
3:0238	Spare	N/A	1	INT16
3:0239	Spare	N/A	1	INT16
3:0240	Spare	N/A	1	INT16
3:0241	Spare	N/A	1	INT16
3:0242	Spare	N/A	1	INT16
3:0243	Spare	N/A	1	INT16

Address	Description	Unit	Multiplier	Data Type
3:0244	Spare	N/A	1	INT16
3:0245	Spare	N/A	1	INT16
3:0246	Spare	N/A	1	INT16
3:0247	Spare	N/A	1	INT16
3:0248	Spare	N/A	1	INT16
3:0249	Spare	N/A	1	INT16
3:0250	Spare	N/A	1	INT16
3:0251	Spare	N/A	1	INT16
3:0252	Spare	N/A	1	INT16
3:0253	Spare	N/A	1	INT16
3:0254	Spare	N/A	1	INT16
3:0255	Spare	N/A	1	INT16
3:0256	Spare	N/A	1	INT16
3:0257	Spare	N/A	1	INT16
3:0258	Spare	N/A	1	INT16
3:0259	Spare	N/A	1	INT16
3:0260	Spare	N/A	1	INT16
3:0261	Spare	N/A	1	INT16
3:0262	Spare	N/A	1	INT16
3:0263	Spare	N/A	1	INT16
3:0264	Spare	N/A	1	INT16
3:0265	Spare	N/A	1	INT16
3:0266	Turb. Run Hours	h	1	FLOAT32
3:0268	Turb. Run Hours with Load	h	1	FLOAT32
3:0270	Turb. Run Hours with Load >25%	h	1	FLOAT32
3:0272	Turb. Run Hours with Load >75%	h	1	FLOAT32
3:0274	Turb. Starts Counter	N/A	1	INT16
3:0275	Turb. Shutdowns Counter	N/A	1	INT16
3:0276	Turb. Shutd. with Load >25% Counter	N/A	1	INT16
3:0277	Turb. Shutd. with Load >75% Counter	N/A	1	INT16

Explanation for addresses marked with List option:

3:0049 to 3:0064

1- Not Used
2- Pond Level
3- Generator Power
4- Speed Bias
5- Remote Speed Reference
6- Gate Position Limiter
7- Remote Baseload Reference
8- Remote Level Reference
9- Gate Position Feedback
10- Blade Position Feedback
11- Blade Position Limiter
12- Tail Level

13- Net Head

3:0081 to 3:0088
1- Not Used
2- Tachometer
3- Gate Position
4- Blade Position
5- Pond Level
6- Tail Level
7- Net Head
8- Speed Reference
9- Level Reference
10- Baseload Reference
11- Speed Bias
12- Generator Active Power
13- Gate Limit Value
14- Blade Limit Value

3:0089 to 3:0119
1- Not Used
2- Manual Gate Control Enable
3- Pond/Tail Level Control Enable
4- Gate Limit Raise
5- Gate Limit Lower
6- Creep Input #1
7- Creep Input #2
8- Governor Reset
9- External Start Permissive
10- Sync Enable
11- Not Used
12- Baseload Enable
13- Unload
14- Local/Remote
15- Load Droop Enable
16- Remote Fault #1
17- Remote Fault #2
18- Remote Fault #3
19- Remote Fault #4
20- Remote Fault #5
21- Remote Fault #6
22- Enable Remote Speed
23- Enable Remote Baseload
24- Enable Remote Level
25- Overspeed Test Enable
26- Manual Blade Control Enable
27- Manual Blade Position Raise
28- Manual Blade Position Lower
29- Enable Blade Tilt
30- Enable Blade Lock
31- Isochronous Arm/Disarm
32- Blade Limit Raise
33- Blade Limit Lower

3:0120 to 3:0143

1- Not Used
2- Gate Position Switch #1
3- Gate Position Switch #2
4- Gate Position Switch #3
5- Gate Position Switch #4
6- Speed Switch #1
7- Speed Switch #2
8- Speed Switch #3
9- Speed Switch #4
10- Speed Switch #5
11- Speed Switch #6
12- General Governor Alarm
13- Creep Indication
14- Speed Bias Enabled
15- Start Permissive Enabled
16- Overspeed Shutdown
17- Generator Breaker Open Command
18- Active Power Switch #1
19- Active Power Switch #2
20- Active Power Switch #3
21- Active Power Switch #4
22- Ready for Start
23- Turbine Stable Speed
24- Reset Command
25- Level Signal Fail
26- Remote Speed Signal Fail
27- Speed Bias Input Signal Fail
28- Incomplete Start
29- Total Speed Signal Failure
30- Speed Signal #1 Fault
31- Speed Signal #2 Fault
32- Speed Signal #3 Fault
33- Speed Signal #4 Fault
34- Analog Gate Limit Signal Fail
35- Remote Baseload Signal Fail
36- Power Transducer Signal Fail
37- Internal Fault
38- Control Powered On
39- Blade Position Switch #1
40- Blade Position Switch #2
41- Blade Position Switch #3
42- Blade Position Switch #4
43- Analog Blade Limit Signal Fail
44- Trip Relay #1
45- Trip Relay #2
46- Baseload Control Enabled
47- Level Control Enabled
48- Isoch Control Enabled
49- Manual gate Control Enabled
50- Apply Brakes

3:0168 to 3:0169

0- All Trips Cleared
1- Emergency Stop Button
2- Calibration Mode
3- Configuration Error
4- Total Speed Signal Failure
5- Overspeed

6- Gate Major Mismatch
7- Blade Major Mismatch
8- Incomplete Start Timeout
9- Modbus Input Shutdown
10- Serial Link Error Shutdown
11- External Emergency Input
12- Powerup Trip
13- Remote Fault #1
14- Remote Fault #2
15- Remote Fault #3
16- Remote Fault #4
17- Remote Fault #5
18- Remote Fault #6
19- I/O Lock
20- Ethernet #1 Link Error Shutdown
21- Ethernet #2 Link Error Shutdown
22- Net Head Fault
23- Net Head Fault (via Pond/Tail Inputs)
24- Blade Preposition Fail
25- Gate Position Feedback Fail
26- Blade Position Feedback Fail
27- Ethernet #3 Link Error Shutdown
28- Ethernet #4 Link Error Shutdown

3:0219
1- Deadstop
2- Shutdown
3- Blade Preposition
4- Stopped
5- Stopping Offline
6- Stopping Online
7- Overspeed Test
8- Unload
9- Remote Speed
10- Small System Mode Isoch
11- Small System Mode Droop
12- Position Droop
13- Load Droop
14- Baseload
15- Remote Baseload
16- Level
17- Remote Level
18- Manual
19- Starting
20- Speed Control
21- Black Start
22- Load Sharing

3:0220
1- Blade not Applicable
2- Blade Shutdown
3- Blade Limiter Active
4- Blade Lock
5- Blade Manual
6- Blade Tilt – Load Rejection
7- Blade Tilt – Stop
8- Blade Tilt – Start
9- Blade Tilt – Voluntary
10- Blade Fixed Curve

11- Blade Curves

Analog Writes

Address	Description	Unit	Multiplier	Data Type
4:0001	Remote Speed Setpoint (%)	%	0.01	INT16
4:0002	Remote Baseload Setpoint (MW)	MW	0.01	INT16
4:0003	Remote Level Setpoint (m)	m	0.1	INT16
4:0004	Gate Limit Demand (%)	%	0.01	INT16
4:0005	Manual Gate Demand (%)	%	0.01	INT16
4:0006	Net Head Demand (m)	m	0.1	INT16
4:0007	Manual Blade Demand (%)	%	0.01	INT16
4:0008	Isochronous Speed Setpoint (%)	%	0.01	INT16
4:0009	Blade Limit Demand (%)	%	0.01	INT16

Appendix E – Trend Variables List

See below the main variables list, to be used with control Assistant software. These variables are available to the user to do real time graphics. There are very variables on the control, but these are the more useful to the customer.

Name is the name that the Control Assistant uses to get the reading from the control and description is the description of the variable.

Digital Trend Variables

Name	Description
CNFG_BI.BI_01_SIGNAL.B_NAME	DI1 - Run/Stop Contact (closed)
CNFG_BI.BI_02_SIGNAL.B_NAME	DI2 - Spd/Load Raise Contact (closed)
CNFG_BI.BI_03_SIGNAL.B_NAME	DI3 - Spd/Load Lower Contact (closed)
CNFG_BI.BI_04_SIGNAL.B_NAME	DI4 - Gen Breaker Contact (closed)
CNFG_BI.BI_05_SIGNAL.B_NAME	DI5 - ESD Input (closed)
MAIN_CTRL.GOV_RUN.B_NAME	Governor Run
MAIN_CTRL.GOV_STOP.B_NAME	Governor Stop
DI_BASELOAD.BASELOAD_Y.B_NAME	Baseload Mode Enabled
DI_REM_BSL.REM_BSLD_Y.B_NAME	Remote Baseload Mode Enabled
DI_UNLOAD.UNLOAD_Y.B_NAME	Unload Mode Enabled
DI_LEVEL.LEVEL_Y.B_NAME	Level Mode Enabled
DI_REM_LEVEL.REM_LVL_Y.B_NAME	Remote Level Mode Enabled
DI_REM_SPD.REM_SPD_Y.B_NAME	Remote Speed Mode Enabled
DI_MANUAL.MANUAL_Y.B_NAME	Gate Manual Mode Enabled
DI_OST.OST_Y.B_NAME	Overspeed Test Enabled
DI_DROOP.DROOP_Y.B_NAME	kW Droop Enabled
DI_DROOP.DROOP_N.B_NAME	Position Droop Enabled
ISOLATION.SML_SYSTEM.B_NAME	Small System Enabled
ISOLATION.BLACK_START.T_FLIPFLOP	Black Start Enabled
LOAD_REJ.LR_LATCH.LATCH	Load Rejection Activated
VALVE_DRV1.VALVE_AUTO_STEP_TEST.ENABLED	Gate Auto Test Enabled
VALVE_DRV2.VALVE_AUTO_STEP_TEST.ENABLED	Blade Auto Test Enabled
DI_SYNC.SYNC_Y.B_NAME	Speed Bias Control Mode Enabled
DI_BLD_TILT.BL_TILT_Y.B_NAME	Voluntary Blade Tilt Enabled
DI_BLD_LCK.BL_LOCK_Y.B_NAME	Blade Lock Enabled
DI_MAN_BLD.BL_MNUAL_Y.B_NAME	Blade Manual Enabled
DI_ISOCH.ISOCH_ARM.ENABLED	Isoch Mode Armed
DI_ISOCH.ISOCH_Y.B_NAME	Isoch Mode Armed/Enabled
MODE_SLCTD.PID_OFF_ENABLED.OR	Offline PID Active
MODE_SLCTD.PID_ON_ENABLED.OR	Online PID Active
MODE_SLCTD.PID_BSL_ENABLED.OR	Baseload PID Active
MODE_SLCTD.PID_SMALL_ENABLED.OR	Small System PID Active
MODE_SLCTD.PID_ISOCH_ENABLED.OR	Isoch PID Active
MODE_SLCTD.PID_LD_SHARE_ENABLED.OR	Load Sharing PID Active

Name	Description
GATE_LIMIT.COINCIDENT_Z.ZMINUS1_B	In Control - Gate Limit
ONLINE_PID.IN_CONTROL.AND	In Control - On-Line/Droop PID
OFFLIN_PID.IN_CONTROL.AND	In Control - Off-Line/Isoch PID
SPEED.OS_BLOK.OR	Speed Fault/Overspeed Override
LOCREM.LOCAL_MB.AND	Local Mode Enabled
LOCREM.REMOTE_MB.AND	Remote Mode Enabled
LOCREM.NOT_USE_DI.NOT	Local/Remote Mode Not Used

Analog Trend Variables

Name	Description
SHUTDOWNS.CAUSE_OF_LAST_TRIP.A_NAME	Cause of Last trip
SHUTDOWNS.SD_FRSTOUT.A_NAME	Turbine First Trip
GATE_FDBCK.ACT1_MON.A_SW	Gate Position (%)
BLADE_FDBCK.ACT1_MON.A_SW	Blade Position (%)
VALVE_DRV1.GATE_DEMAND.A_SW	Gate Demand (%)
VALVE_DRV2.BLADE_DEMAND.A_SW	Blade Demand (%)
GATE_OUT.ACTUATOR.A_NAME	Gate Output (%)
BLADE_OUT.ACTUATOR.A_NAME	Blade Output (%)
SPEED.SPEED.A_NAME	Unit Speed (%)
SPEED.SPEED_RPM.A_NAME	Speed Signal LSS (RPM)
SPEED.FREQ_HZ.A_NAME	Generator Frequency (Hz)
SPEED.HOLD_RST.A_SW	Maximum Speed Since Last Start (%)
LEVEL_CTRL.POND_TAIL_LVL.LAG_2	Pond/Tail Level (EU)
LEVEL_CTRL.SETPOINT.RAMP	Pond/Tail Level Setpoint (EU)
LEVEL_CTRL.LEVEL_GP.LSS_BUS	Pond/Tail Lvl Gate Pos Setp (%)
REM_SPD.SPD_REM_REF.A_NAME	AI Speed Remote Reference (%)
OFFLIN_PID.SPD_BIAS_SW.A_SW	Speed Bias (%)
ELET_TDRC.GEN_LOAD_PCT.A_NAME	Generator Load (%)
ELET_TDRC.GEN_LOAD.A_NAME	Generator Load (MW)
LSCON.PID_OUTPUT.A_SW	Baseload PID Output (%)
BASELOAD_REF.REM_REFERENCE.A_LIMITER	Remote Baseload Reference (MW)
BASELOAD_REF.BASELOAD_REF.A_NAME	Baseload Reference (MW)
LSCON.STEP_ADD.ADD	Baseload Reference (%)
ONLINE_REF.DRP_STPNT.RAMP	Online/Droop Speed Reference (%)
ONLINE_PID.PID_DENORM_A_SW.A_SW	Online/Droop PID Output (%)
DR_FDBK.DRP_FDBK.A_SW	Online/Droop Feedback (%)
OFFLIN_REF.SETPOINT.RAMP	Offline Speed Reference (%)
OFFLIN_PID.PID_DENORM.MULTIPLY	Offline PID Output (%)
ISOCH_REF.SETPOINT.A_NAME	Isoch Speed Reference (%)
ISOCH_PID.PV.A_NAME	Isoch Speed Value (%)
ISOCH_PID.PID_OUTPUT.A_SW	Isoch Speed PID Output (%)
AN_GATE_L.AI_LIMITER.A_SW	Analog Gate Limit (%)
GATE_LIMIT.GATE_LIMIT.A_NAME	Gate Limit (%)
BLD_CFG.NET_HEAD_LEVEL.A_NAME	Net Head Value (EU)

Name	Description
BLD_CFG.BLD_TLT.A_NAME	Blade Tilt Demand (%)
VALVE_DRV2.CURVE_LMT1.A_LIMITER	Blade Curves Demand (%)
VALVE_DRV2.CURVE_LMT2.A_LIMITER	Blade Fixed Curve Demand (%)
VALVE_DRV2.MANUAL_RAMP.RAMP	Blade Manual Demand (%)
VALVE_DRV2.LOCK_SAMP.OUT_1	Blade Lock Demand (%)
AN_BLADE_L.BLADE_LIMITER.A_NAME	Blade Limit Demand (%)
MODE_SLCTD.CTRL_SLCTD_AN.OUT_1	Gate Control Mode
MODE_SLCTD_BLD.CTRL_SLCTD_AN.OUT_1	Blade Control Mode

Appendix F – Block Diagram

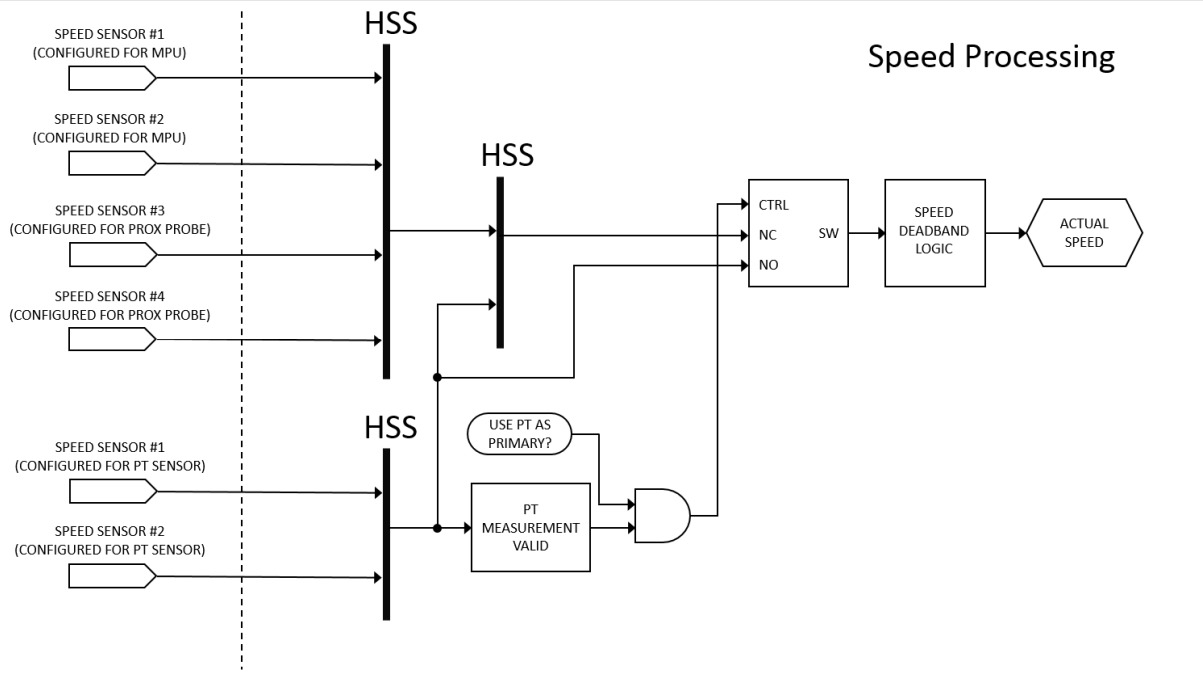


Figure F-1. Speed Processing

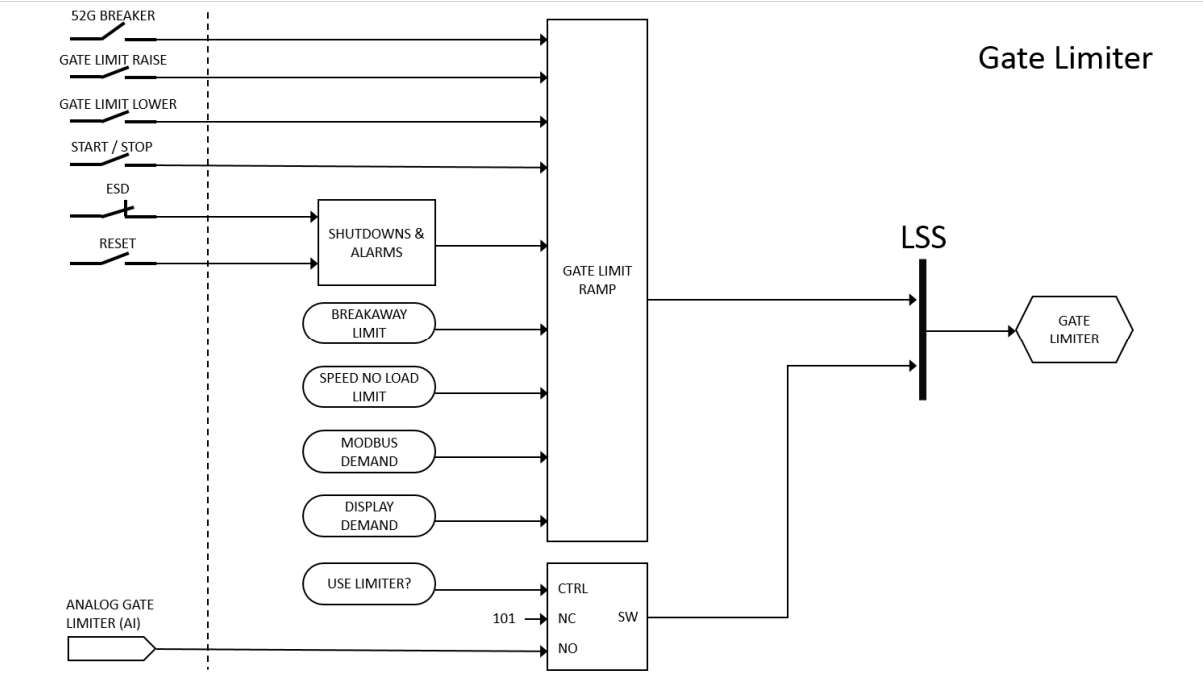


Figure F-2. Gate Limiter

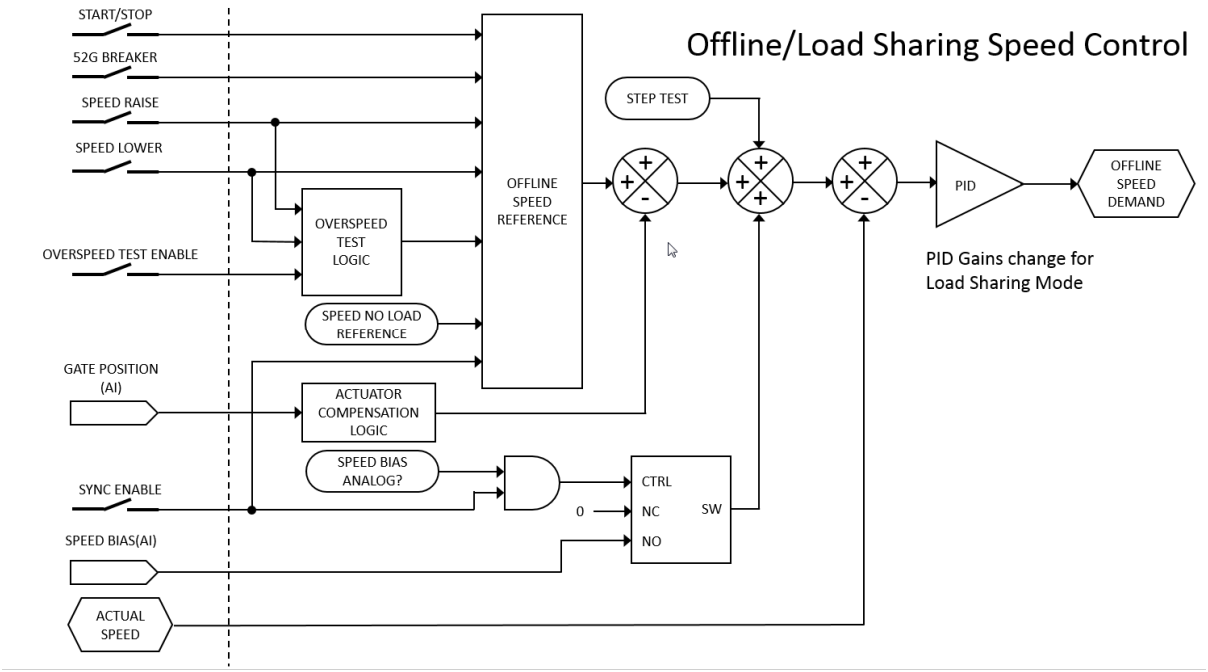


Figure F-3. Offline/Load Sharing Speed Control

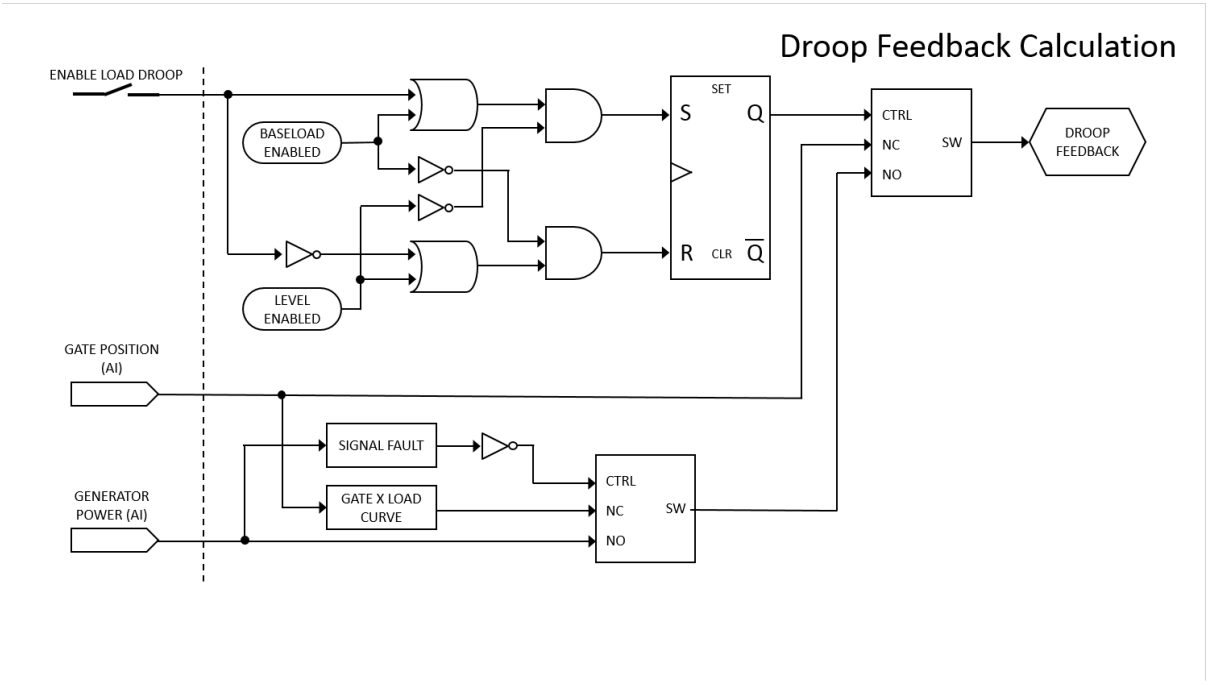


Figure F-4. Droop Feedback Calculation

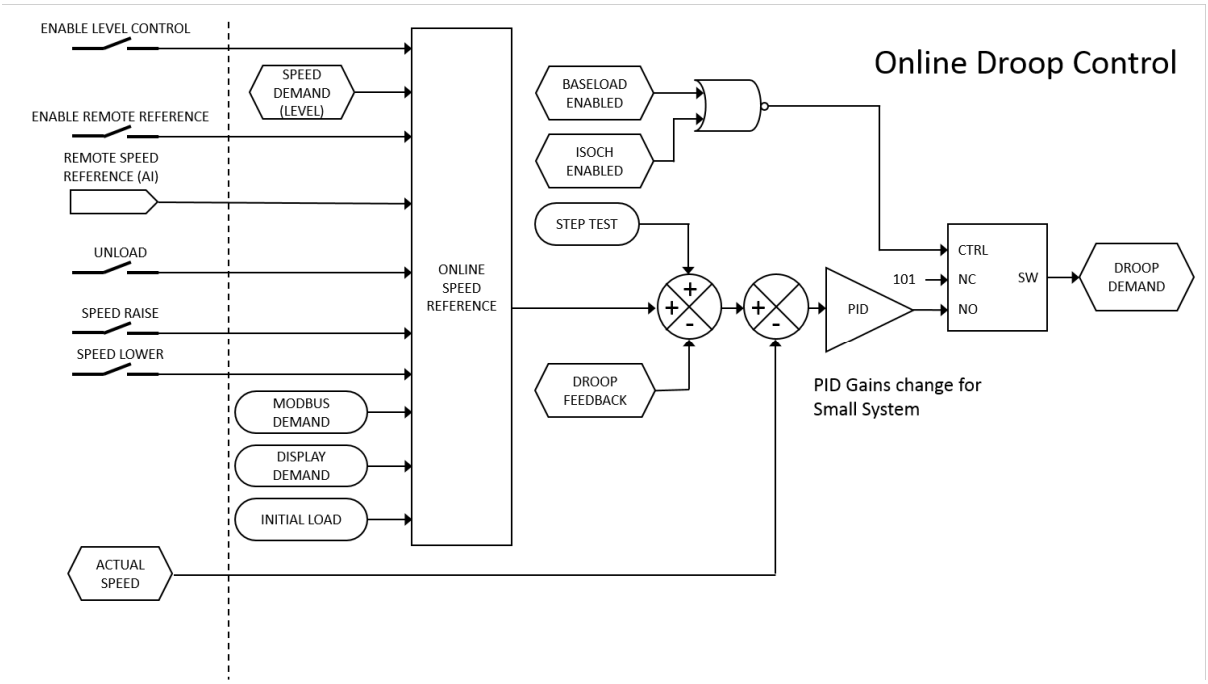


Figure F-5. Online Droop Control

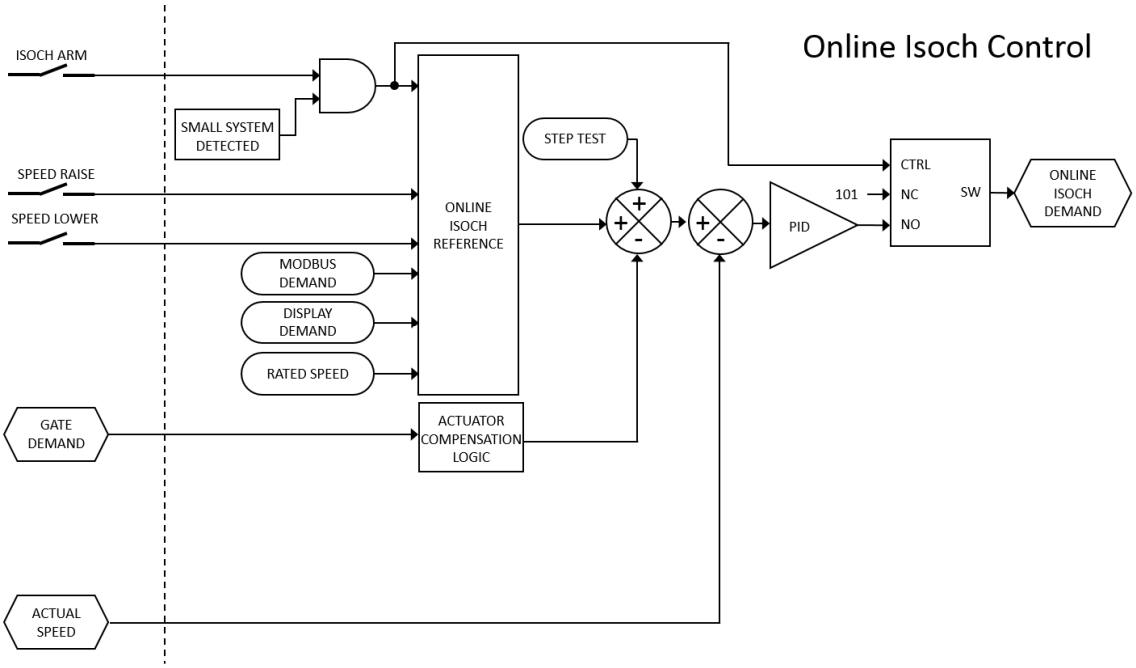


Figure F-6. Online Isoch Control

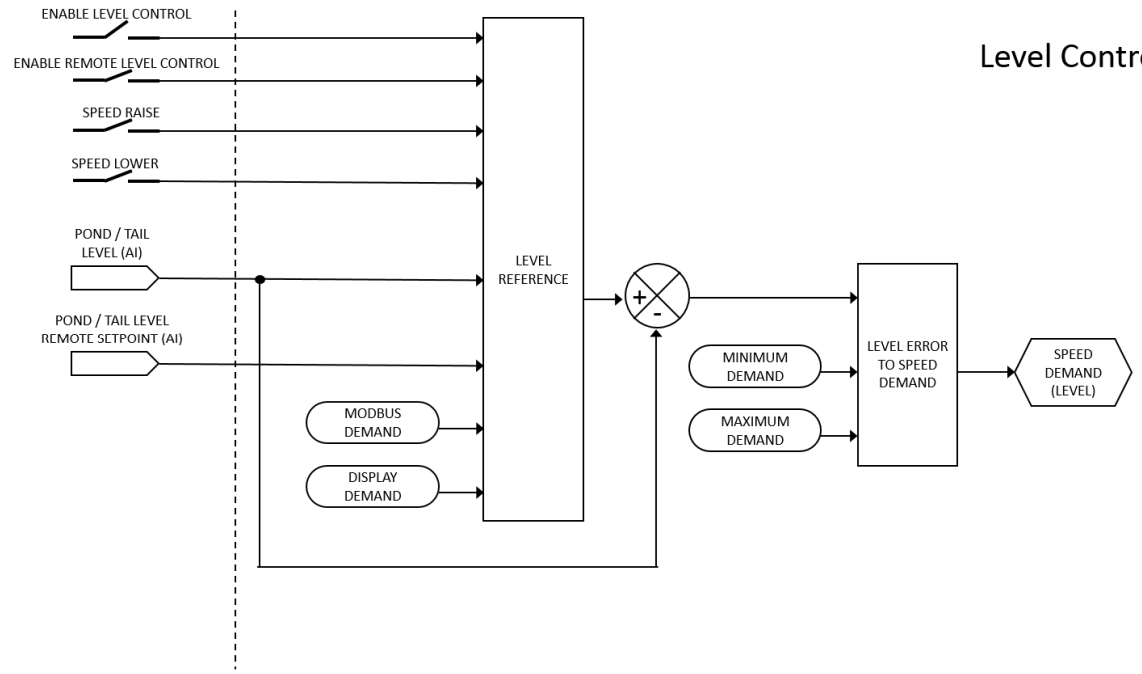


Figure F-7. Level Control

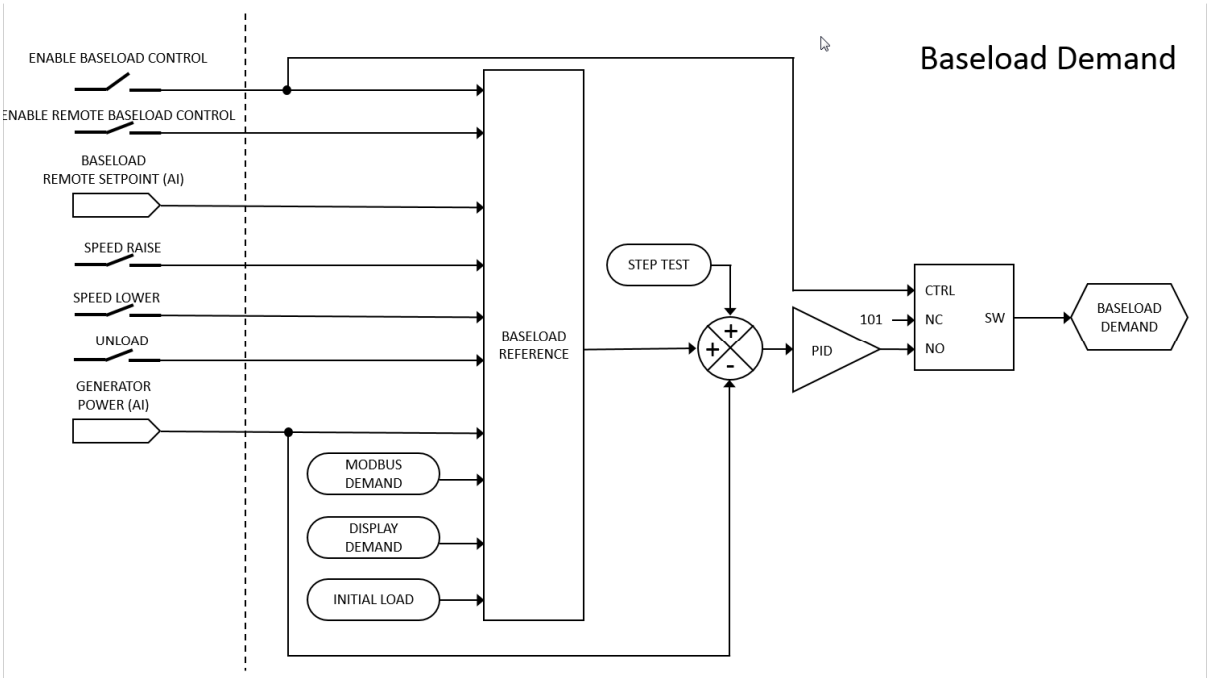


Figure F-8. Baseload Control

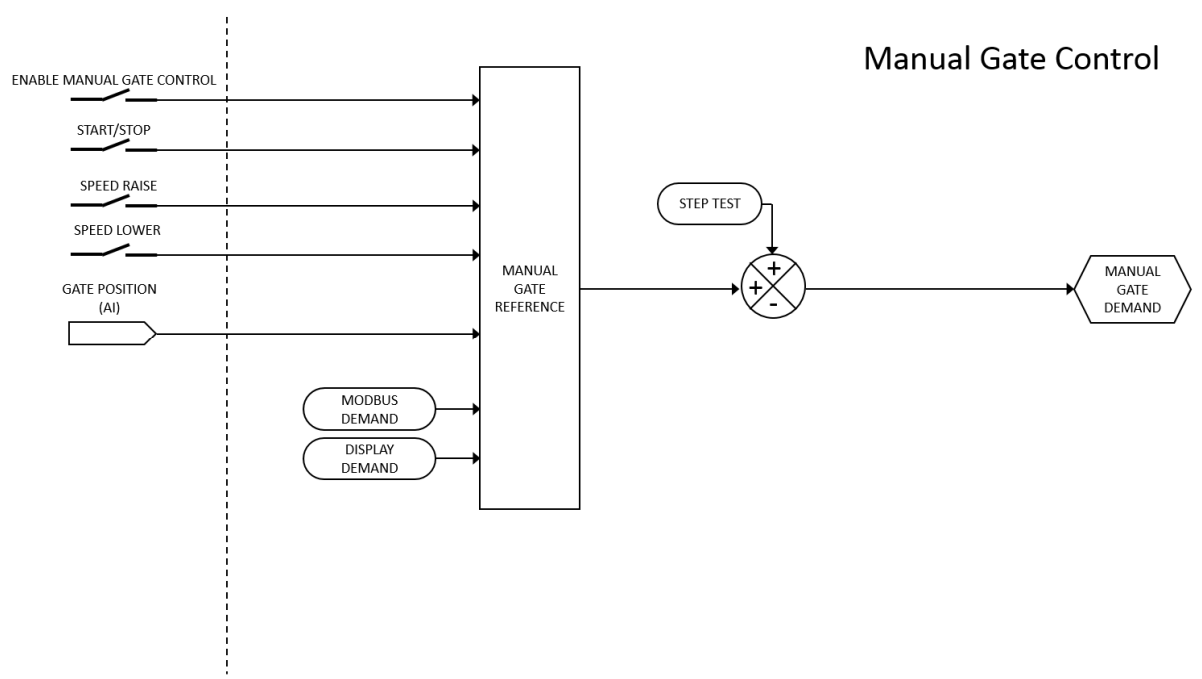


Figure F-9. Manual Gate Control

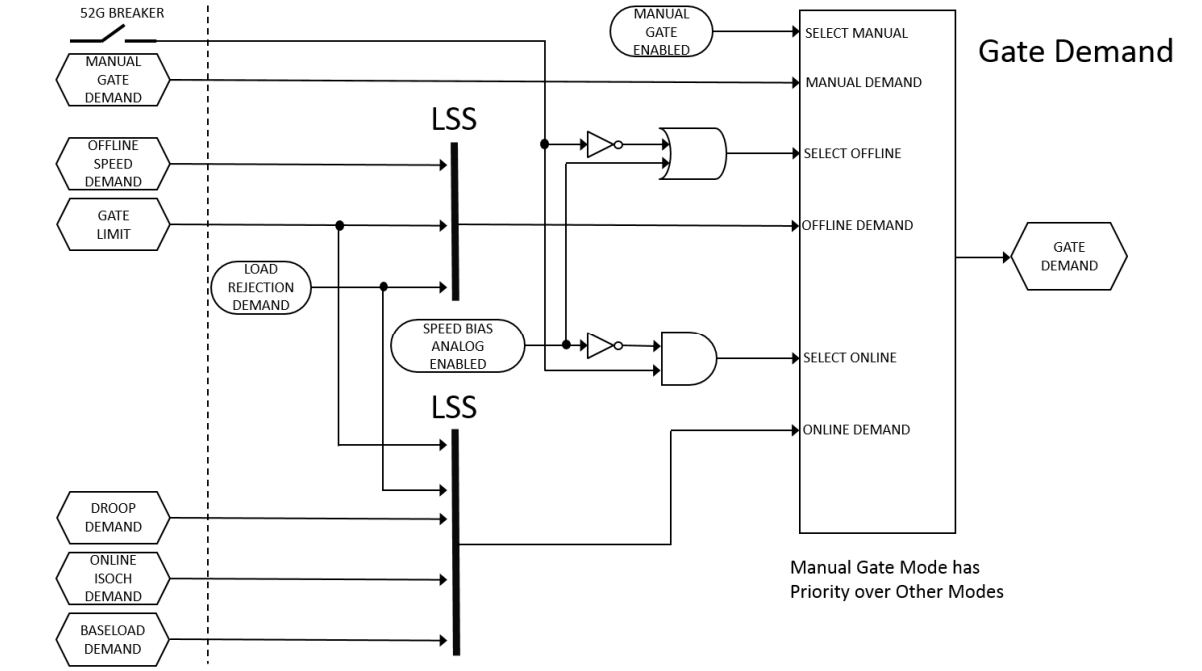


Figure F-10. Gate Demand

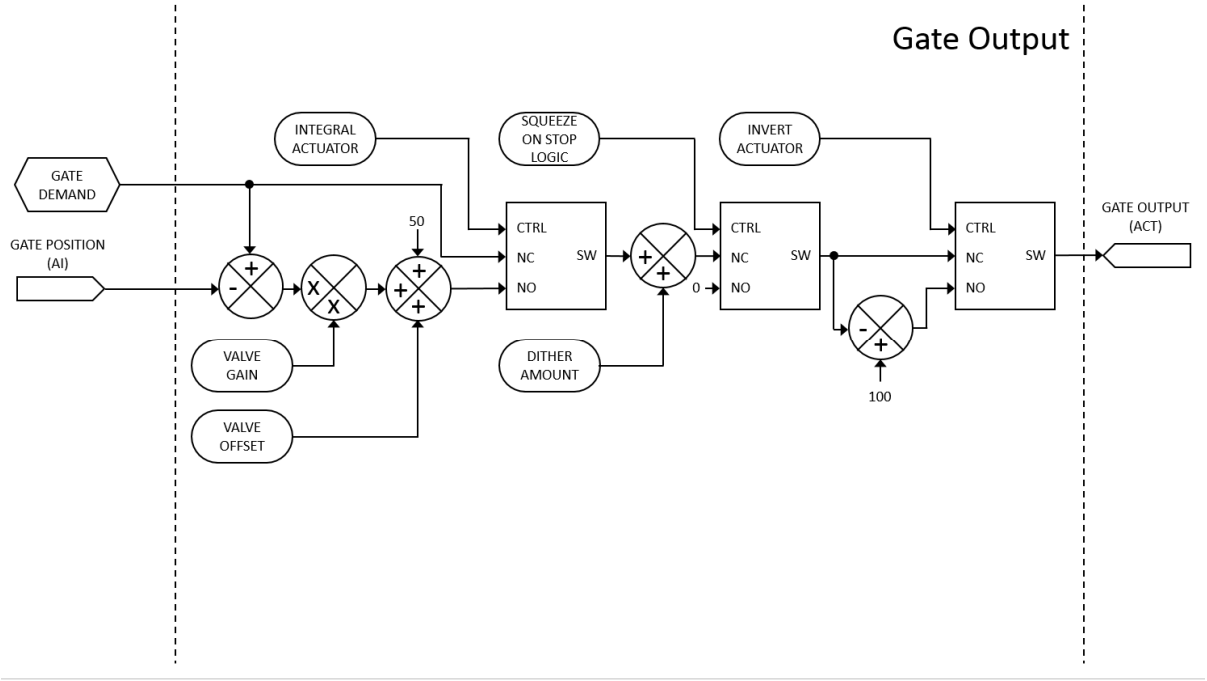


Figure F-11. Gate Demand

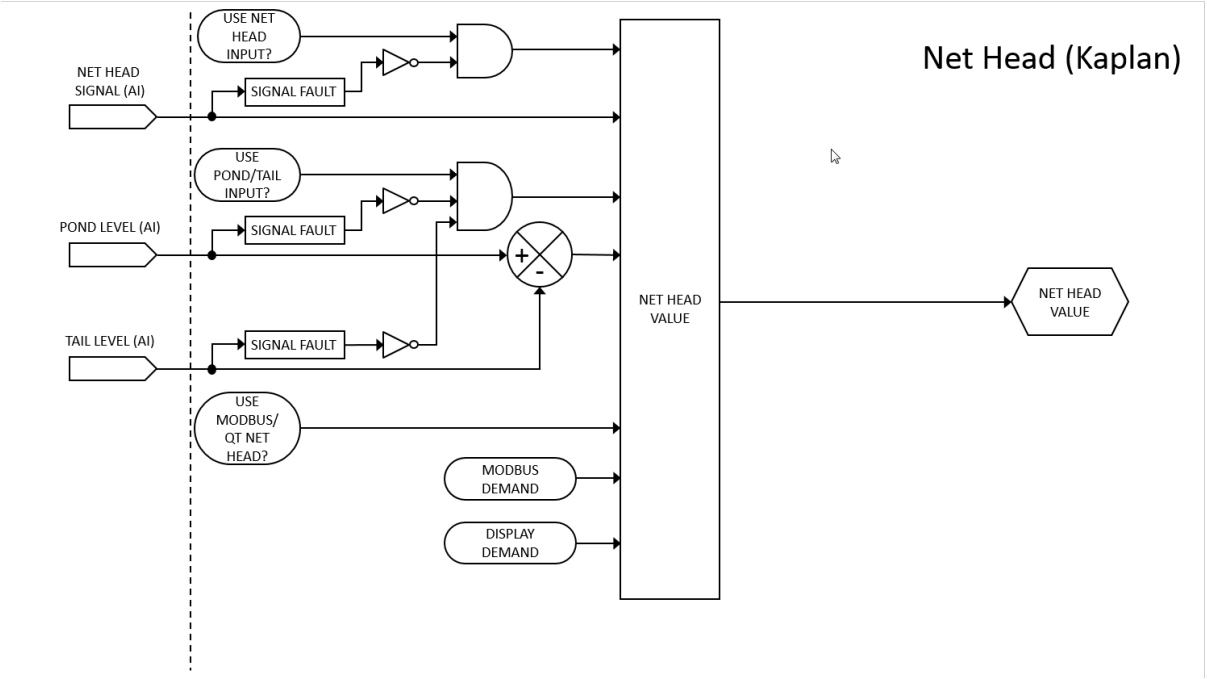


Figure F-12. Net Head (Kaplan)

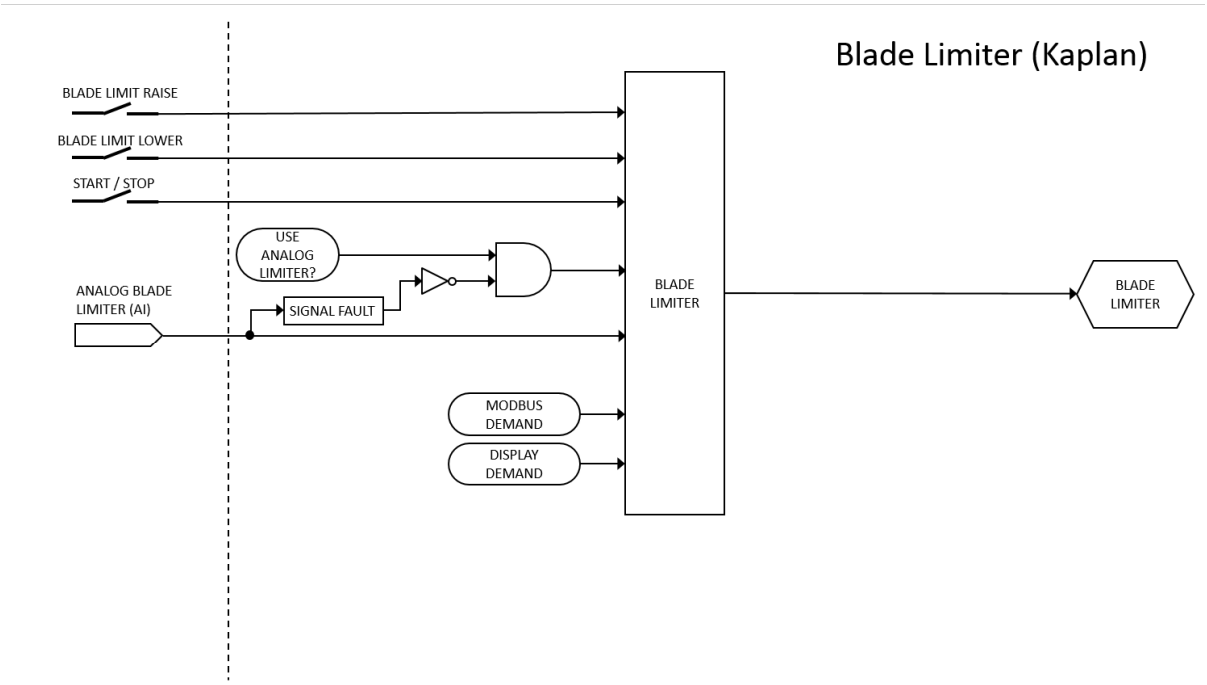


Figure F-13. Blade Limiter (Kaplan)

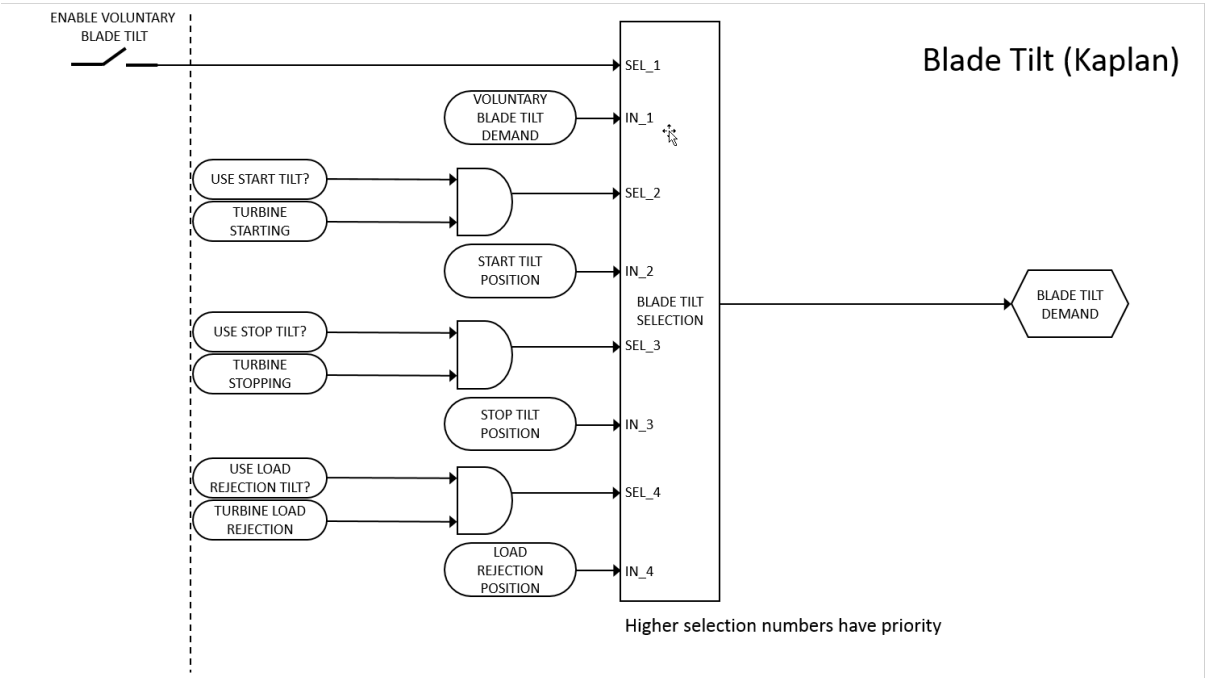


Figure F-14. Blade Tilt (Kaplan)

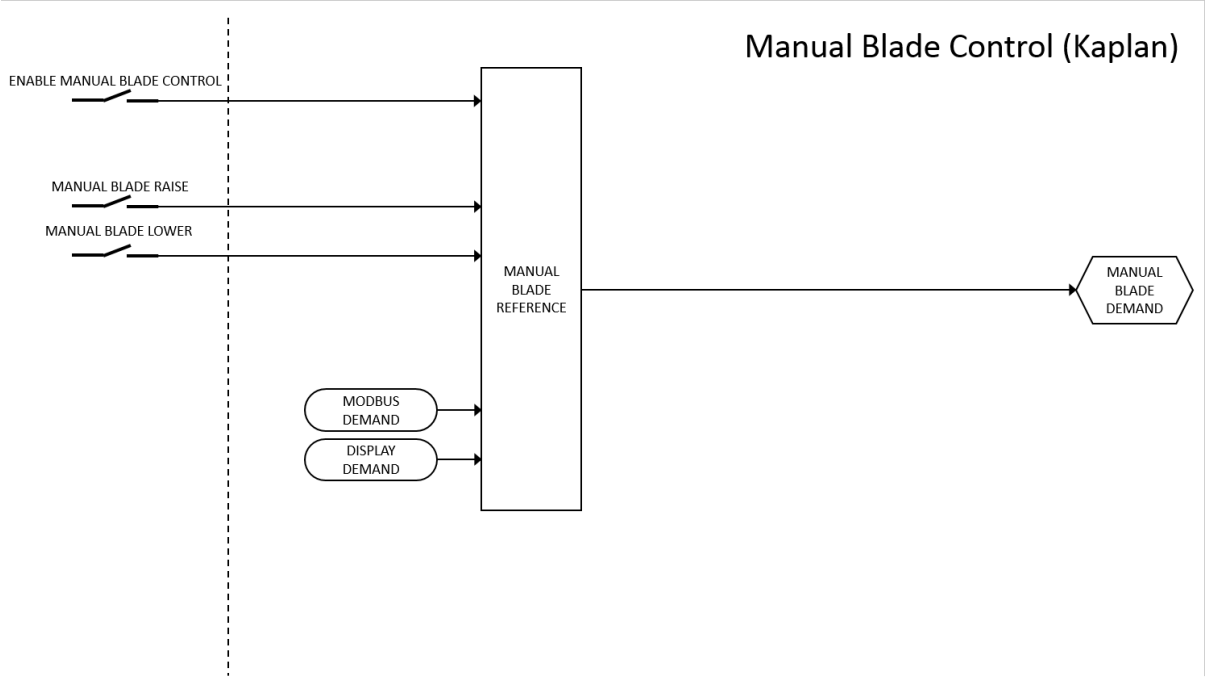


Figure F-15. Manual Blade Control (Kaplan)

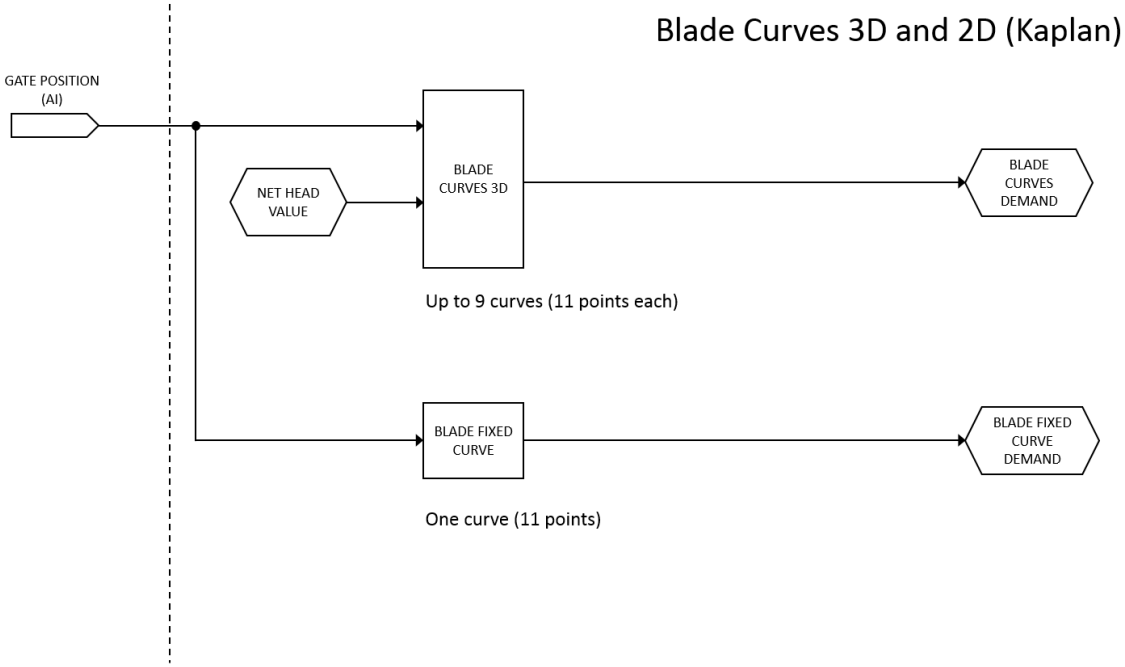


Figure F-16. Blade Curves 3D and 2D (Kaplan)

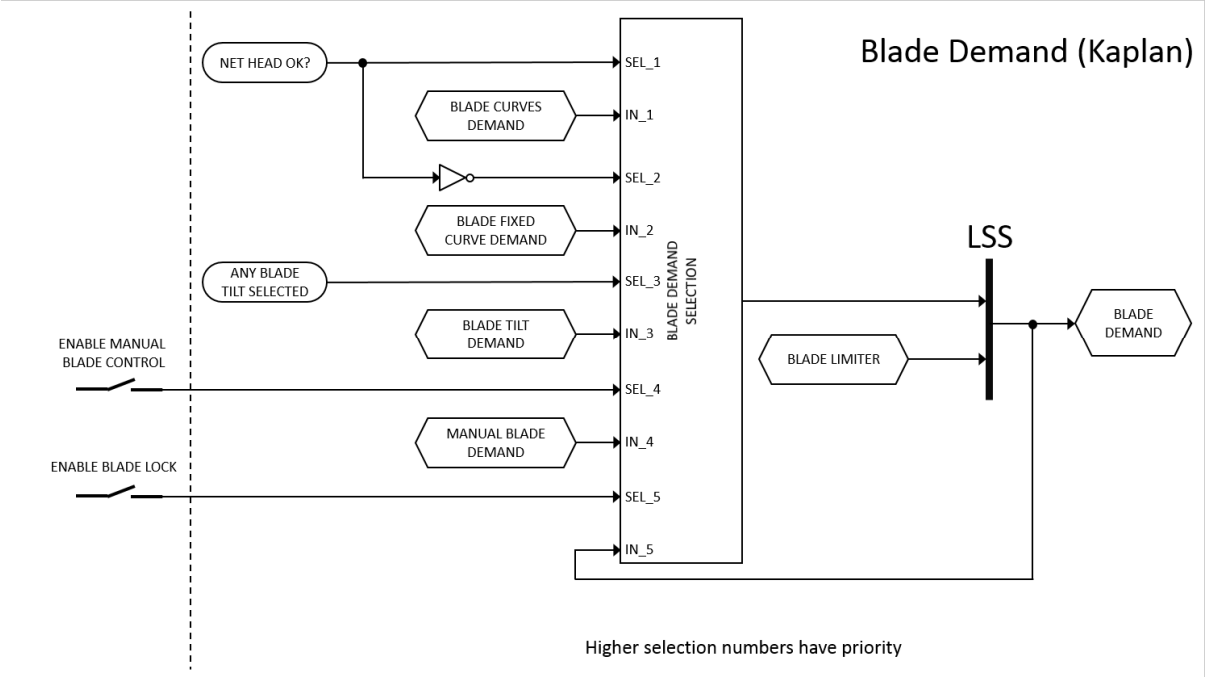


Figure F-17. Blade Demand (Kaplan)

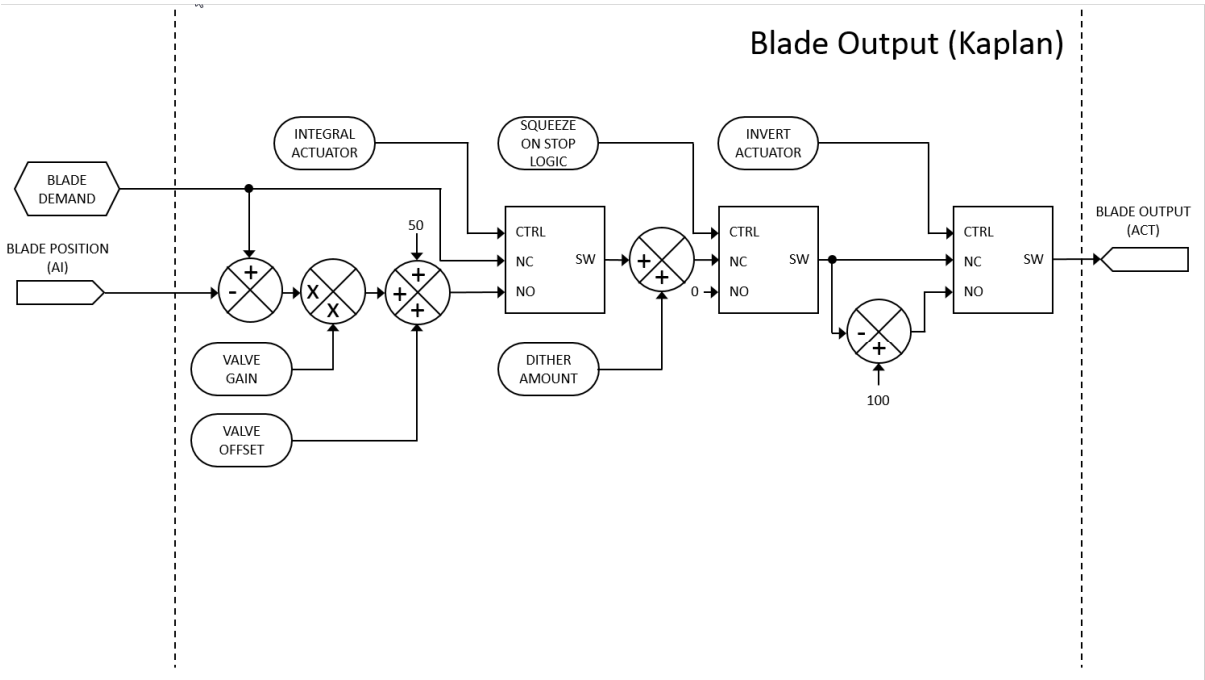


Figure F-18. Blade Output (Kaplan)

Revision History

New Manual—

-

Declarations

EU DECLARATION OF CONFORMITY

EU DoC No.:	00466-04-EU-02-01
Manufacturer's Name:	WOODWARD INC.
Manufacturer's Contact Address:	1041 Woodward Way Fort Collins, CO 80524 USA
Model Name(s)/Number(s):	505D, 505XT, Flex500, Flex500 Bulkhead, Vertex, Vertex Bulkhead and 505-HT(HV-STD) 88-264Vac, 90-150Vdc 505D, 505XT, Flex500, Flex500 Bulkhead, Vertex, Vertex Bulkhead and 505-HT (LV-STD) 18-36Vdc
The object of the declaration described above is in conformity with the following relevant Union harmonization legislation:	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC) Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits
Applicable Standards:	EN 61000-6-4, 2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments EN 61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments EN61010-1, 2010 : Safety Requirements for Electrical Equipment for measurement, control and laboratory use – Part 1 : General Requirements
Conformity Assessment(s):	Woodward EMC Conformity Assessment 00466-04-EU-EMC-03-05

This declaration of conformity is issued under the sole responsibility of the manufacturer
We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

Signature

Mike Row

Full Name

Engineering Supervisor

Position

Woodward, Fort Collins, CO, USA

Place

19 Dec 2018

Date

5-09-1183 Rev 30

WOODWARD

Corporate Headquarters
1081 Woodward Way
Fort Collins, CO 80524, USA
970-498-5811

October 7, 2019

SUBJECT: Certification of Compliance to IEEE Standard 125-2007

To whom it may concern:

Woodward's hydro turbine controls, and related control algorithms and logic comply with IEEE Standard 125-2007. Since 1870 Woodward's hydro turbine controllers have been used to control over 1000 hydro turbines globally. Throughout the installation, commissioning, and qualification of these controllers multiple hydro turbine OEMs, governmental based utilities, and Woodward engineers have tested, verified and validated that Woodward hydro turbine control systems and their related PIDs, sequencing and protection logic meet and comply with the performance requirements of IEEE Standard 125-2007.

Woodward is an independent designer, manufacturer, and service provider of energy control and optimization solutions for commercial and military aircraft, turbines, reciprocating engines, and electrical power system equipment. The company's innovative fluid energy, combustion control, electrical energy, and motion control systems help customers offer cleaner, more reliable, and more cost-effective equipment. Leading original equipment manufacturers use our products and services in aerospace, power and process industries, and transportation.

Sincerely,

Rich Kamphaus
Global Sales Director
Steam & Hydro Turbine Markets
Woodward Inc.
Work Phone: 970-498-3388, Cell: 970-215-3733
E-mail: rkamph@woodward.com

WOODWARD

Corporate Headquarters
1081 Woodward Way
Fort Collins, CO 80524, USA
970-498-5811

July 11, 2019

SUBJECT: Certification of Compliance to IEEE Standard 1207-2011

To whom it may concern:

Woodward's hydro turbine controls, and related control algorithms and logic comply with IEEE Standard 1207-2011. Since 1870 Woodward's hydro turbine controllers have been used to control over 1000 hydro turbines globally. Throughout the installation, commissioning, and qualification of these controllers multiple hydro turbine OEMs, governmental based utilities, and Woodward engineers have tested, verified and validated that Woodward hydro turbine control systems and their related PIDs, sequencing and protection logic meet and comply with the performance requirements of IEEE Standard 1207-2011.

Woodward is an independent designer, manufacturer, and service provider of energy control and optimization solutions for commercial and military aircraft, turbines, reciprocating engines, and electrical power system equipment. The company's innovative fluid energy, combustion control, electrical energy, and motion control systems help customers offer cleaner, more reliable, and more cost-effective equipment. Leading original equipment manufacturers use our products and services in aerospace, power and process industries, and transportation.

Sincerely,

Rich Kamphaus
Global Sales Director
Steam & Hydro Turbine Markets
Woodward Inc.
Work Phone: 970-498-3388, Cell: 970-215-3733
E-mail: rkamph@woodward.com

Released

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 35117.

B 3 5 1 1 7 : -

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1041 Woodward Way, Fort Collins CO 80524, USA
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Email and Website—www.woodward.com

Woodward has company-owned plants, subsidiaries, and branches, as well as authorized distributors and other authorized service and sales facilities throughout the world.

Complete address / phone / fax / email information for all locations is available on our website.