WOODWARD

HARDWARE & SOFTWARE MANUAL

STS100-P
Steam Turbine Simulator Package
(With Operation panel)

(P/N 8957-012)

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Manual 26217

WARNING—DANGER OF DEATH OR PERSONAL INJURY

WARNING—FOLLOW INSTRUCTIONS

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.

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WARNING—OVERSPEED PROTECTION

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—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.

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY

CAUTION—BATTERY CHARGING

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

CAUTION—ELECTROSTATIC DISCHARGE

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

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

IMPORTANT DEFINITIONS

- **A WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
- **A CAUTION indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment or property.**
- **A NOTE provides other helpful information that does not fall under the warning or caution categories.**

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

WARNING—THIS PUBLICATION MAY BE OUT OF DATE
The Japanese original of this publication may have been updated since this translation was made. For the most current information, be sure to check whether there is a Japanese version with a later revision.

Contents

Illustrations and Tables

CHAPTER 1
GENERAL DESCRIPTION

The STS100 simulator is a simulation package, which simulates typical steam turbine applications. This field configurable simulator allows users to enter actual plant data (pressures, flows, power & response rates), to match the simulator's responses with that of the turbine and plant.

The STS100 simulator is comprised of a Woodward 723 type hardware platform, associated peripherals and an integral software interface package. The Woodward 723 platform is packaged within a portable industrial case and wired to user interface terminal blocks. The included software interface package, once installed on a user's computer and connected to the simulator functions as a simulator configuration tool, and an operator interface.

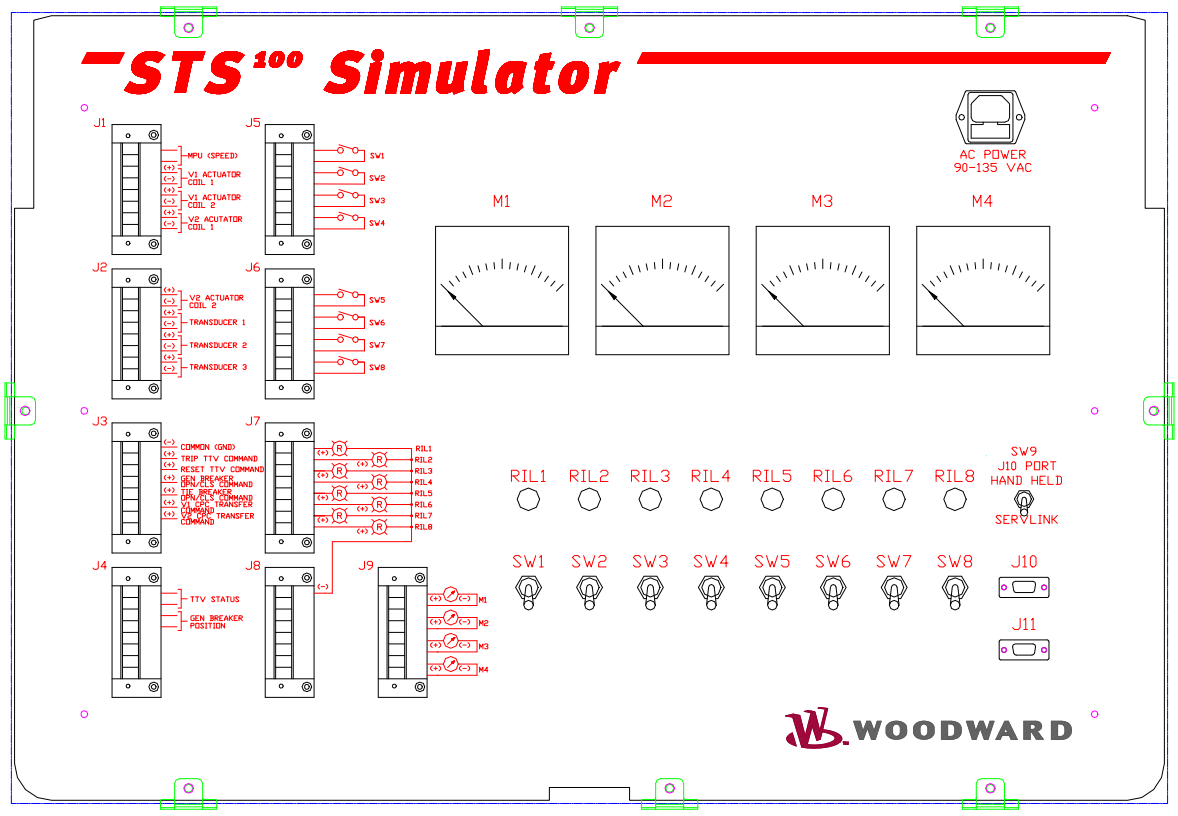


Figure 1-1. Simulator View

The STS100 can simulate the following types of turbines:

- Single Inlet Valve Turbines
- Dual Inlet Valve Turbines
- Single Extraction Turbines
- Single Admission (Induction) Turbines
- Single Extraction/Admission Turbines

The STS100 can simulate the following turbine applications:

- Mechanical Drive (pump, fan, compressor)
- Generator Drive (island & utility paralleled)

The STS100 can simulate the following turbine related parameters:

- Inlet Header Pressure Transducer
- Inlet Header Flow Transducer
- Extr/Adm Header Pressure Transducer
- Extr/Adm Header Flow Transducer
- Exhaust Header Pressure Transducer
- Exhaust Header Flow Transducer
- Generator Power
- Generator Breaker Action
- Plant Tie Breaker Action
- Pump/Compressor load
- Plant Load
- DCS Demand Signal
- V1 Servo Position
- V2 Servo Position

The STS100 can simulate the following types of actuators:

- Single Coil, 4-20mA
- Dual Coil, 4-20mA
- Single Coil, 20-160mA
- Dual Coil, 20-160mA

SIMULATOR INPUTS

- V1 (HP) Actuator Coil #1
- V1 (HP) Actuator Coil #2
- V2 (LP) Actuator Coil #1
- V2 (LP) Actuator Coil #2
- Trip Command
- Reset TTV Command
- Generator Breaker Open/Close Commands (Gen Config.)
- Tie Breaker Position (Gen Config.)
- V1 CPC-Skid Transfer Command
- V2 CPC-Skid Transfer Command
- 4-20mA Meter Readouts
- Eight Isolated LEDs

SIMULATOR OUTPUTS

- MPU #1 - Turbine Speed
- Transducer #1 - (Configurable)
- Transducer #2 - (Configurable)
- Transducer #3 - (Configurable)
- Trip & Throttle Valve Status
- Generator Breaker Status (Gen Config.)
- Eight isolated toggle switches

HARDWARE

The simulator is housed in an industrialized carrying case, with toggle switches, LEDs, meters, the associated turbine/plant input and outputs mounted on its panel. The simulator is interfaced to through removable terminal blocks. These terminal blocks allow users to create their own control-to-simulator wiring interface, as required.

OPERATOR INTERFACE

The included software interface package, once installed on a user's computer and connected to the simulator functions as a simulator configuration tool, and an operator interface. This tool is used to allow a user to configure the STS100 to simulate their plant's turbine, and turbine related parameters. After the STS100 is configured, this interface tool allows the user to operate the simulated plant. A user can open and close turbine Trip & Throttle valves, enable and disable turbine header letdown stations, and change plant flow demands and responses.

FEATURES

- Field Configurable
- User Friendly Operator Interface
- Steam Map X-Y Plot capability
- Configurable Trending package

SIMULATOR SPECIFICATIONS

Dimensions

• Case: 29"L x 20"W x 10"H

Environment:

• Operating Temperature: -25°C to 65°C

Inputs:

• Power: 90-132Vac (100 watts max)
• Discrete Inputs: 6 - Dedicated Contact Inputs
• Valve/Actuator Coil Inputs: 4 - Actuator Inputs (4-20mA or 20-160mA)

Outputs:

• Speed: 1 - MPU (1-2.5Vrms)
• Transducer Outputs: 3 - Programmable Current Outputs (4-20mA)
• Discrete Outputs: 2 - Dedicated Relay Outputs

Communications:

• Serial: 2 - Dedicated Com Ports

CHAPTER 2
CONNECTING TO THE SIMULATOR

Storage Store the STS100 and associated parts between -20° and 70°C (-4° and 158°F) at a maximum relative humidity of 90% non-condensing. If it is to be stored for a long time, it is recommended that operating power be applied to it at least once every 18 months to extend the life of the unit's capacitors.

Unpacking Unpack each part of the system carefully. Check the units for signs of damage, such as bent or dented panels, scratches, or loose or broken parts. If any damage is found, notify the shipper immediately. The following items should be removed from the packing carton (s) and checked to make sure you have all the necessary components before connecting to a control. Refer to Table 3-1.

DESIGNATION	DESCRIPTION	QUANTITY
U1	STS100 SIMULATOR	1
C1	POWER CABLE	1
C2	RS232 CABLE	1
C3	RS422 Download Cable	1
R1, R2, R3, R4	SHUNT RESISTORS (30.1ohms)	4
SK1	SOFTWARE INTERFACE KIT	1

Table 3-1. Simulator Components

SIMULATOR CONNECTIONS
Plug the provided power cable into the simulator's power receptacle and the wall outlet. The STS100 accepts an input power of 90-135Vac.

The STS100 is designed with removable terminal blocks with which to interface to. No associated wiring is provided with this package. Use Figures 3-1 to 3-2 to wire the control to the simulator.

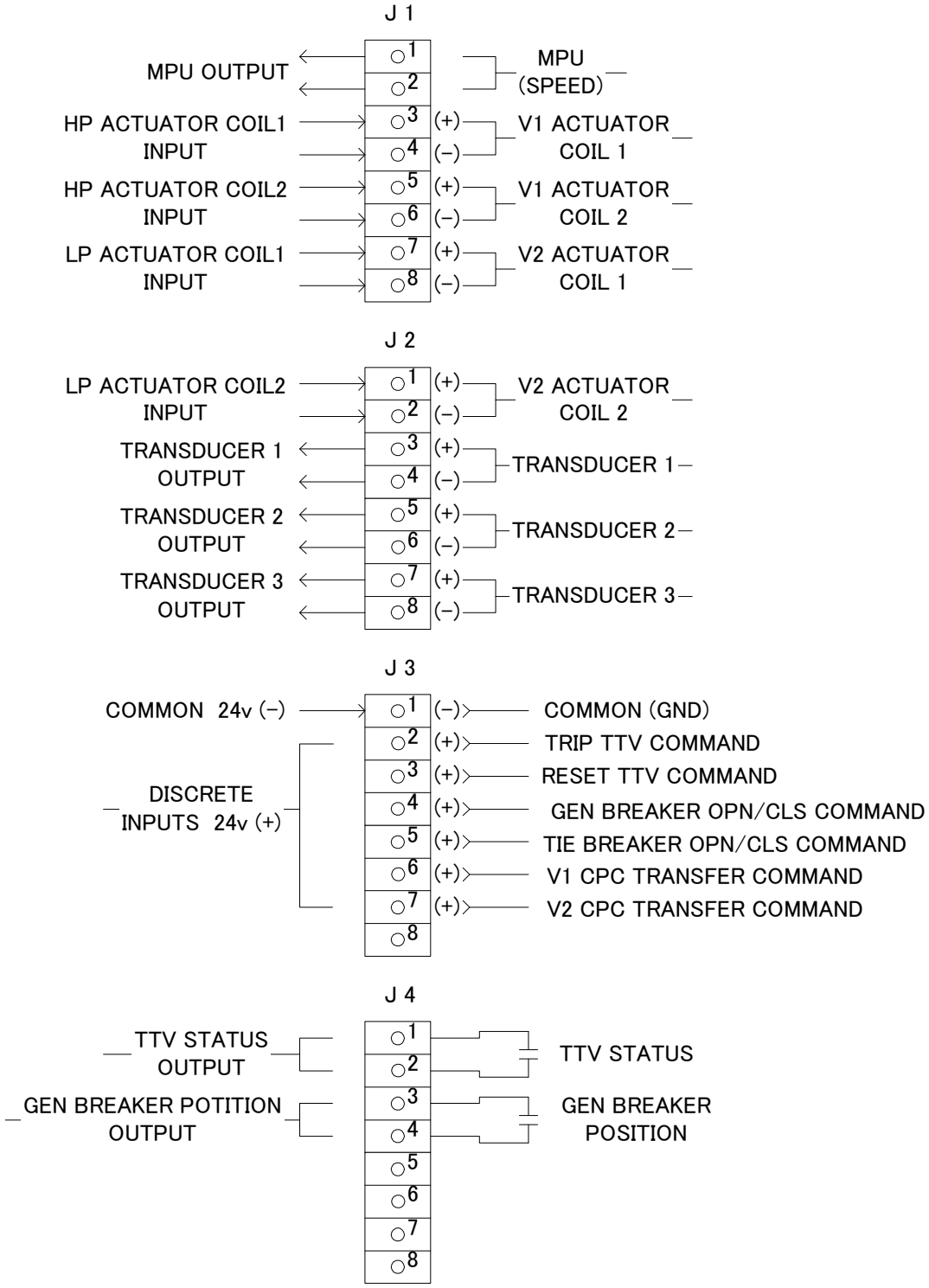


Figure 3-1. STS100 Wiring Diagram 1

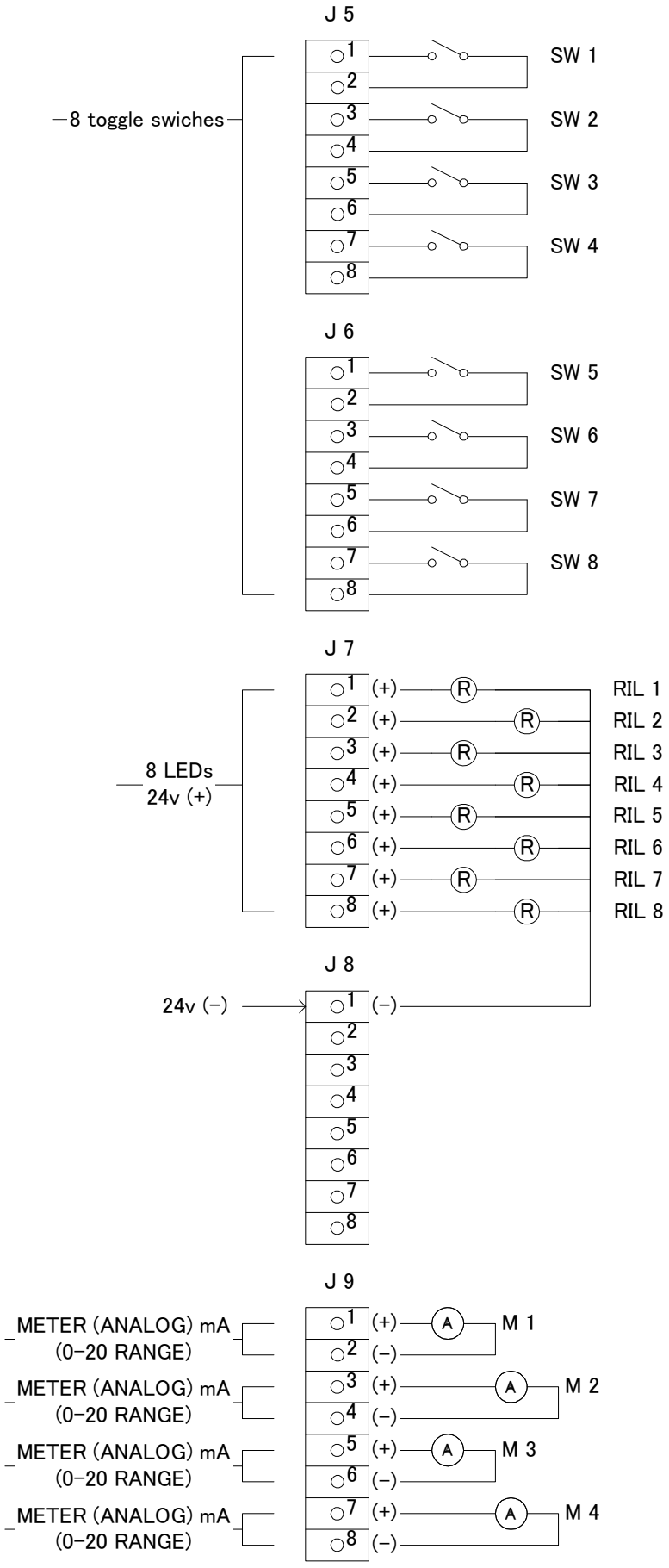


Figure 3-2. STS100 Wiring Diagram 2

Shields & Grounding

No shield terminations are provided with this package. It is envisioned that the STS100 will be utilized in a normal environments where signal noise is not an issue. It is recommended that control-to-simulator wiring be kept as short as possible to reduce signal noise susceptibility.

Speed Sensor Output

One speed sensor type output is provided with this simulator. If required, this output can be used to drive up to 12 speed sensor inputs at once. This output provides a 0 to 17000 Hz sine wave signal at 1.5 to 2.5 Vrms to simulate a typical speed sensing Magnetic Pickup Unit. The frequency put out is determined by the simulator's configuration (rated speed, gear teeth, gear ratio), and turbine's operating point. Refer to Figure 3-1.

Actuator Inputs

The STS100 can be configured to simulate the following types of actuators:

- Single Coil, 4-20mA
- Dual Coil, 4-20mA
- Single Coil, 20-160mA
- Dual Coil, 20-160mA

Four resistors (R1,R2,R3,R4) are provided with this package to be installed as shunt resistors for 20-160mA actuator configurations. When configured to simulate 20-160mA input based actuators, these resistors must be installed as shown in Figure 3-3.

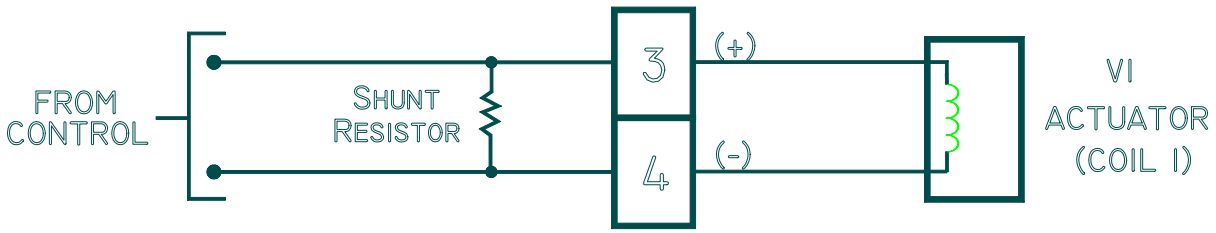


Figure 3-3. Actuator 20-160mA Shunt Resistor Connection

Transducer Outputs

Transducer outputs are self powered 4-20mA drivers that can drive into a maximum of 600 ohms. Refer to Figure 3-1. These outputs are not isolated, thus isolators may be required between the simulator's transducer output and the control's analog input.

When connecting to a Woodward 505/505E it is recommended that only Analog #6 be used to interface to the simulator. In 505E applications where interface to Analog #1 is required, install 505E jumper JPR10 for loop powered functionality, then connect to the input as a self-powered input.

In cases where more than two transducers are required by a 505/505E it is recommended that isolators be used between the simulator's transducer outputs and the 505/505E analog inputs. If isolators are not utilized when multiple 505/505E analog inputs are connected to, a calibration error offset will be realized on each analog input value.

Contact Inputs (Commands)

In general, contacts must change state for a minimum of 15 milliseconds for the simulator to sense and register a change in state. All contact inputs require 18-26Vdc contact wetting voltages. Refer to Figure 3-1.

LED Inputs (Status Indications)

The eight Light Emitting Diodes (LEDs) are connected by and use the same common. The LEDs accept 18-36Vdc circuit power and can be used to indicate the state of a control's output relays.

Relay Outputs (TTV & Gen Status)

Contact Ratings = 2.0A resistive @ 28Vdc; 0.5A resistive @ 125Vdc

Toggle Switches

Eight independent toggle switches are provided from which to simulate discrete interface commands or connect in such a way as to quickly disconnect an analog signal from the control.

Serial Communications

The STS100 has three serial communications ports. The simulator's J3-port is used for communications with Woodward's Servlink and Watchwindow programs. Refer to Chapter 3.

The simulator's J11-port is used for Modbus communications with a computer running Woodward's STS100 Interface program. Refer to Chapter 3.

Ports J10 and J11 are accessed though 9-pin Sub-D connectors located in the simulator's. J10 port utilize RS422 communications to via J10 connector, RS422, and a 5416-870 download cable interface with a computer.
J11 port utilize RS232 communications to interface with a computer. A RS232 link is limited to a distance of 50 feet. The provided RS232 cable can be utilized with either port to communicate to a computer using a RS232 based port.

A J10 port can choose communication of Handheld programmer or ServLink program by a state of switch 9.

CHAPTER 3
CONFIGURING THE SIMULATOR

Package

A software package is included as an installation kit with every STS100 simulator to allow users to configure and operate the simulated plant functions. The provided software package must be installed on a capable computer, which is connected to the simulator to allow users to interact with the simulated plant functions.

The Woodward Intellution HMI program is used with this simulator as the simulator's operator interface program.

The installation kit includes the following programs:
• STS100 Interface Program
• Watch Window - debug program
• Servlink - DDE communications program

The package's software installation kit is included with the simulator on CDROM. The CDROM must be inserted into and used to install the software kit on a computer that meets the below listed requirements. Once installed the program and associated computer function together as a configuration and operator control panel.

The STS100 interface program and the Servlink program are both 32 bit operating system programs. This means that Windows 3.1 will NOT work for this application. Windows 95 or Windows NT are the only two operating systems that these programs have been tested with. A Windows compatible 32 bit operating system should work with these programs, but only the Windows 95 and Windows NT have been verified. Do to Windows95 communication issues with the STS100 interface program it is highly recommended that only a WindowsNT based computer be used to communicate with this simulator.

STS100 Interface Program

The STS100 Interface program is a Woodward Intellution based application program that was created solely to configure and operate the STS100 simulator. This manual will cover the functionality of the STS100. For the functionality of the Intellution software, use the online help menus and supporting documentation supplied by Intellution FIX.

Watchwindow Program

The Watchwindow program is a troubleshooting and debugging tool that provides a window into the simulator. This program is provided to allow an operator to calibrate the simulator's speed output.

Servlink Program

Servlink is an interface program, which directs and manages the transfer of data between the Watch Window program and the STS100 simulator.

PC Requirements

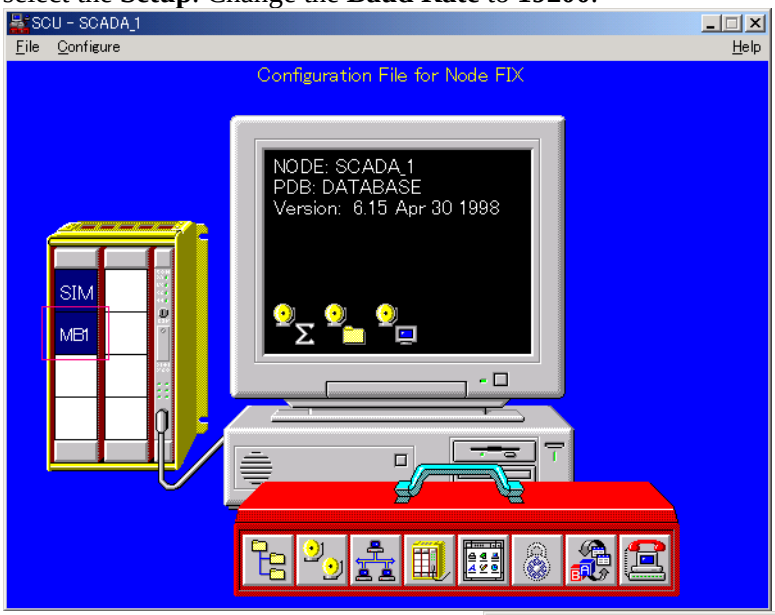
The STS100 software interface package is installed and runs on any compatible PC hardware platform with the following minimum restrictions:

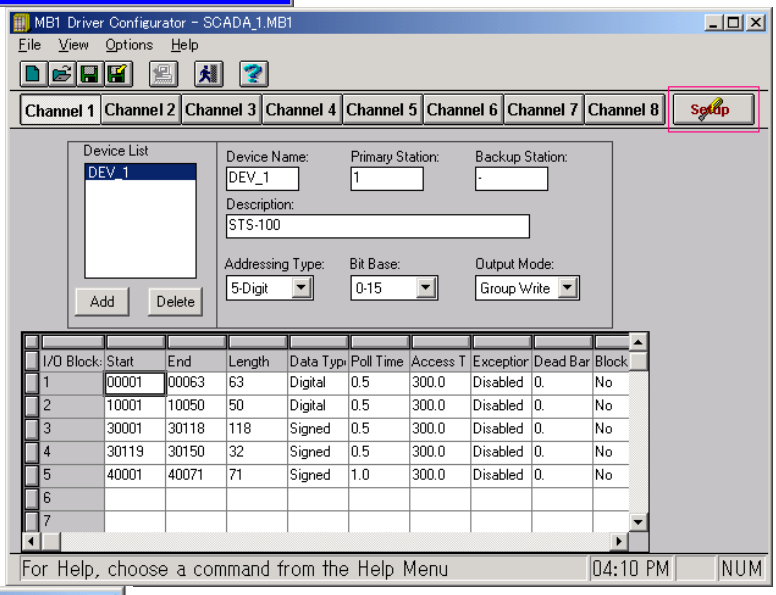
- Pentium 100 MHz
- 32 Meg RAM
- 10 Meg Disk Drive Space
- Windows NT operating system
- CDROM drive

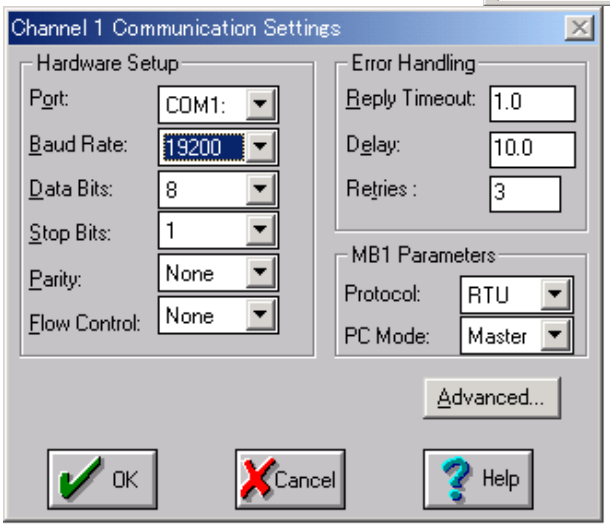
Any PC that has the above list of features will function as a host for the interface software package. As the speed and memory capabilities of the PC are increased, so will the speed of the PCI software program.

STS100 Communications

Apply power to the STS100 simulator (install and plug in the simulator's power cord).
Connect the provided RS232 serial cable between the PC's Com1 and the simulator's port J11. Port "Com1" is the defaulted port and can be changed to another port via the program's "Configure" - "Application Properties" menus.
Open the **System Configuration** program from the **Intellution-STS100** menu. Select the **MB1** and then select the **Setup**. Change the **Baud Rate** to **19200**.



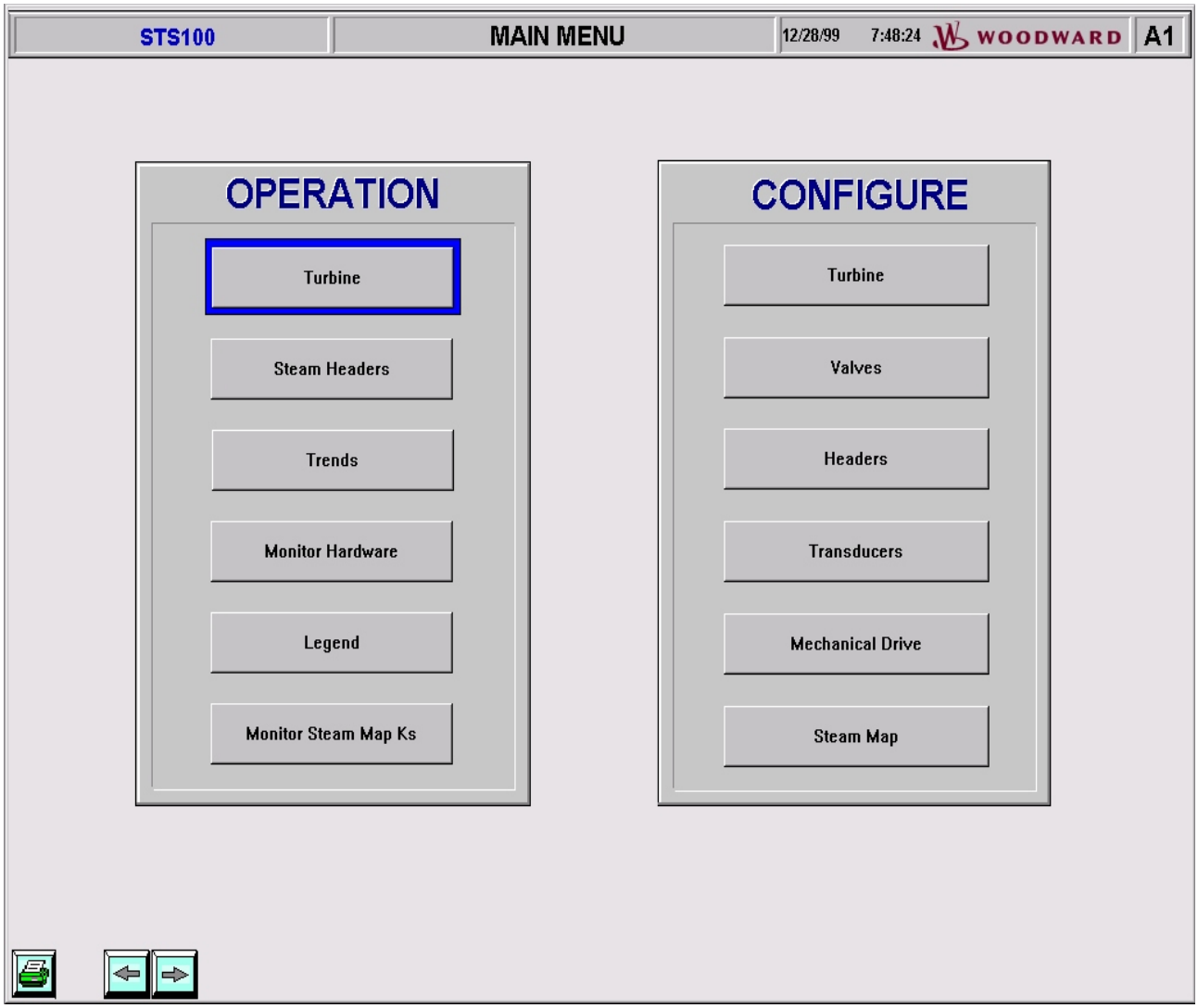




Open the **STS100** program from the **Intellution-STS100** menu in the Windows Start - Program menu tree. Program-to-simulator communications will automatically start. Verify PC-to-STS100 communications by selecting the "Configure Turbines" square on the main menu page below, and verifying that values are displayed within all blanks.

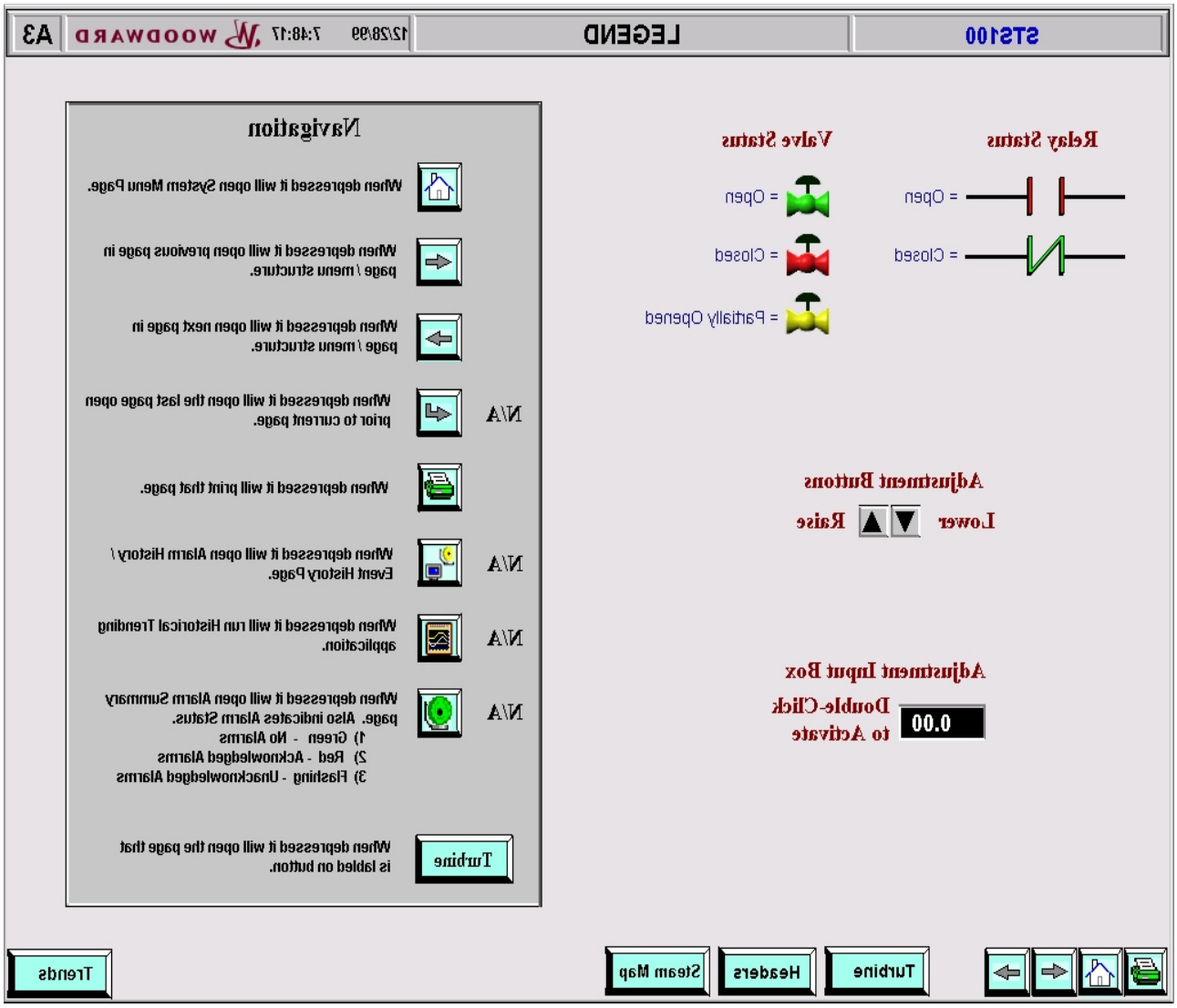
Configuration

Once program-to-simulator communication has been established the simulator can be configured and all related plant functions controlled.



MAIN MENU page

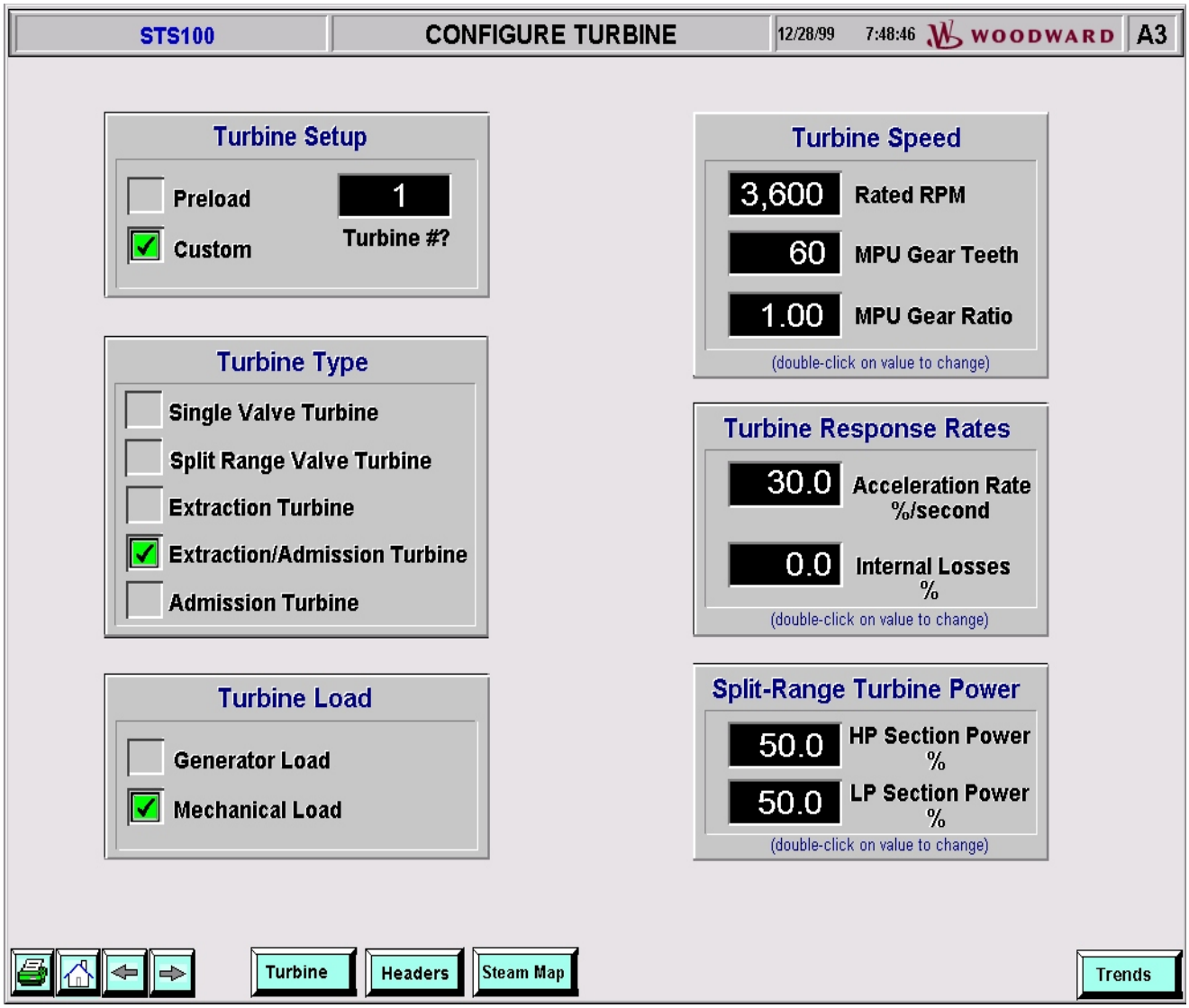
The **MAIN MENU** page is the starting point of the STS100 software package and the one page that allows navigation to all other Intellution pages. Clicking on any of the above squares with a single left mouse button click will select that particular page, and automatically move there.



LEGEND page

Select the "**Operation Legend**" page to display a listing of the most common Intellution functions. This page will demonstrate the interactive inputs and outputs between the user and the STS100 software.

CONFIGURING THE TURBINE



CONFIGURE TURBINE page

Note: *Because program default settings are associated with each turbine, it is recommended that the Turbine type setting be configured before all other settings. Configuring the Turbine Type will change all other values to a default setting.*

Turbine Setup

The STS100 is set up with 5 preloaded turbines that can be set-up using the Watchwindows program, see Chapter 7, and 5 custom programs that can be adjusted as the turbine is running. To use a preloaded turbine, enter a number in the **Turbine #?** Box, and select **Preload**. As long as the **Preload** option is selected, the turbine will remain in the same state. No changes will be allowed. At any time the user can select **Custom** and the turbine will now be in a "changeable" mode. The turbine will remain with the same settings as before, only now changes will be allowed. The one exception is the **Turbine Type**. If the **Turbine Type** changes while in **Custom** mode, all values will be set to a default condition.

Turbine Speed

The STS100 needs to be configured to the same speed values as the Woodward control. The Rated RPM, Gear Teeth, and Gear Ratio must be entered to match the control. Double-click on the desired values/settings to modify them.

Turbine Type

The STS100 is designed to simulate the five turbine types listed above. This check box will allow the user to select which type of turbine is simulated.

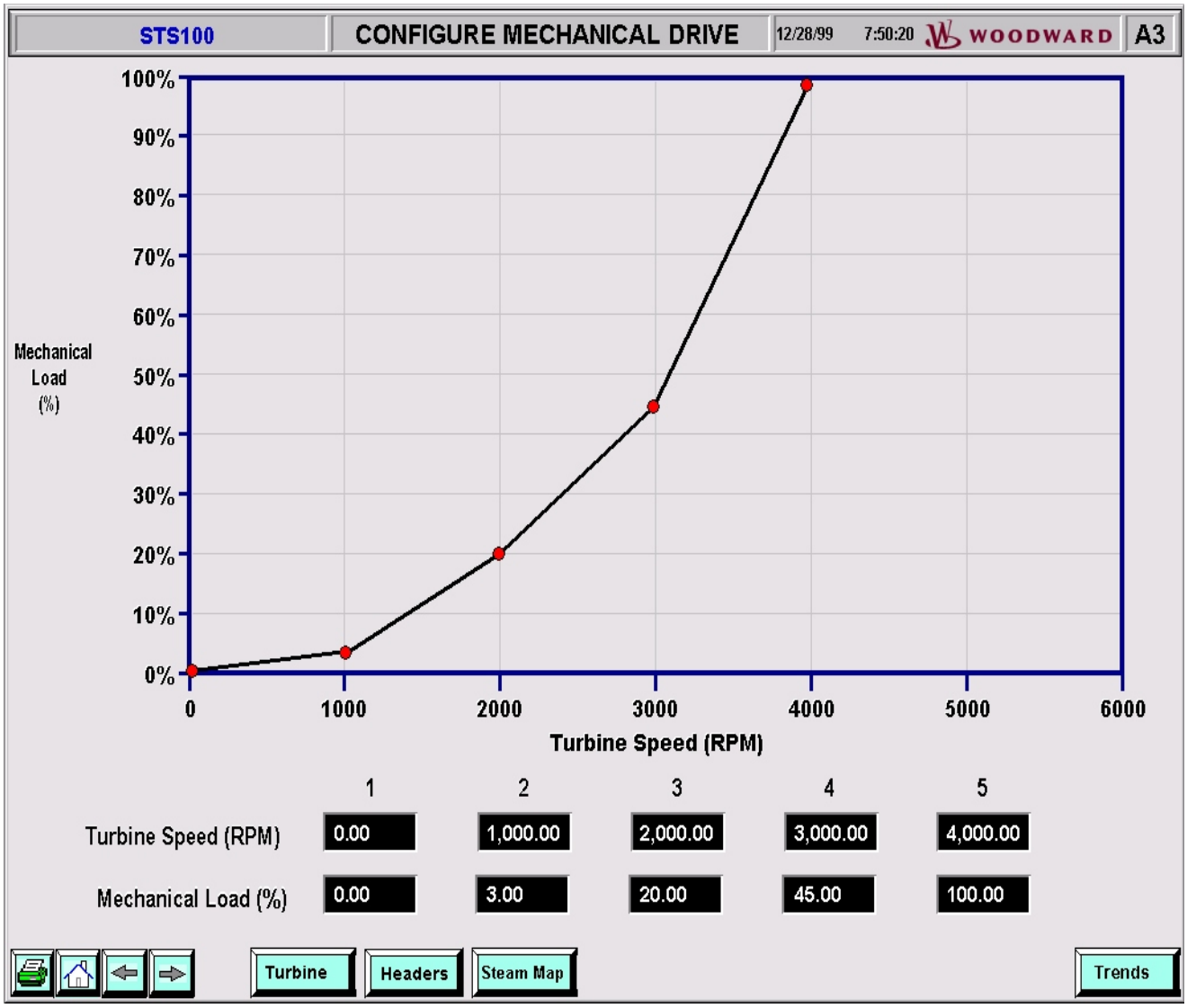
Turbine Response Rates

The STS100 is designed to simulate the dynamics of the turbine based on the Acceleration Rate and the Internal Losses of the Turbine. Both values can be adjusted from this Dialog Box. Double-click on the desired values/settings to modify them.

Turbine Load

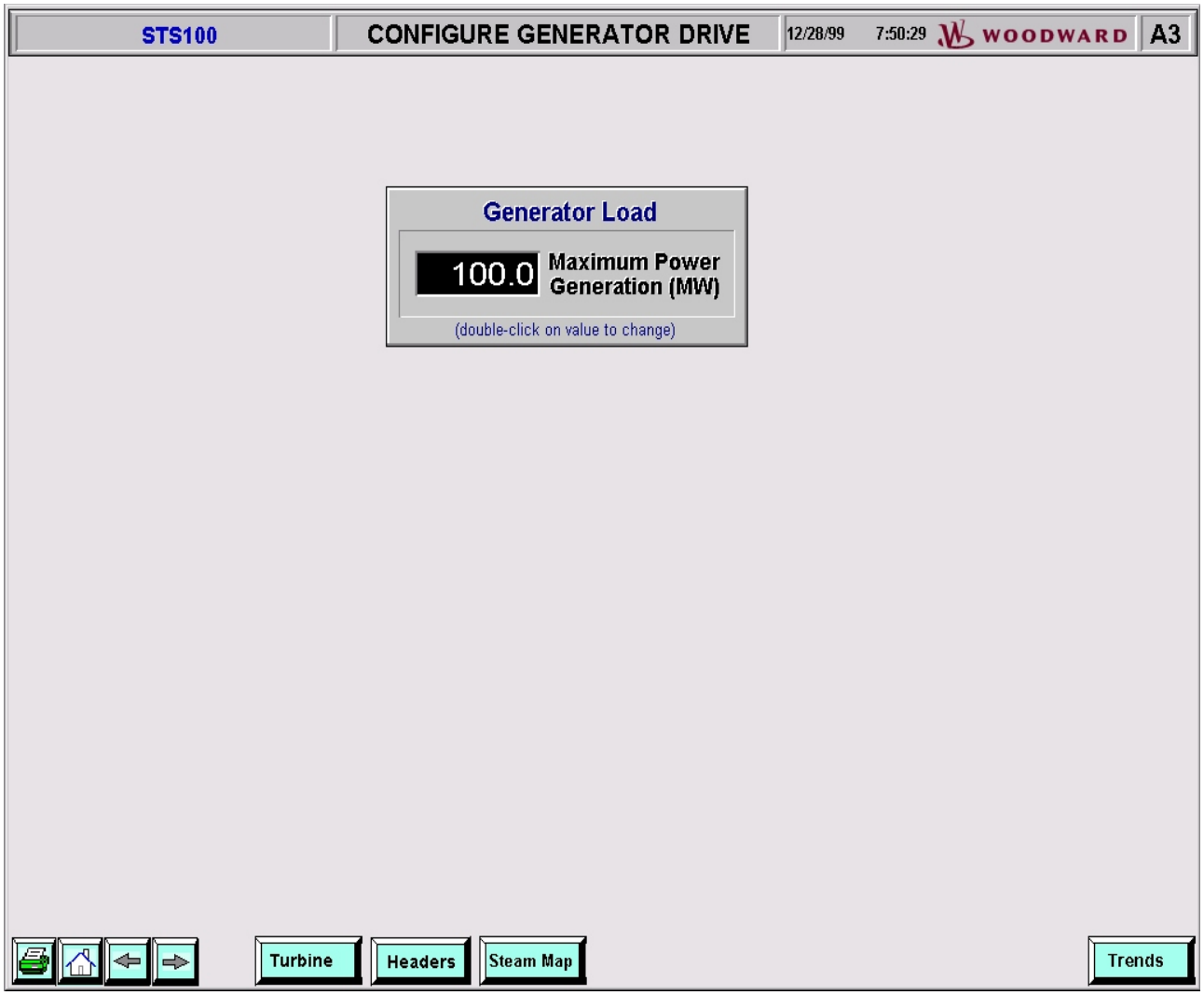
The STS100 can be configured for either a **Mechanical Load** or a **Generator Load**.

If a mechanical type of load was configured (pump, compressor, fan) select the "**Configure Mechanical Drive**" page to configure the amount of load on the turbine versus speed. From here a user can configure turbine load based on turbine speed. See below. Double-click on the desired values/settings to modify them. The graph will automatically update with the new values. The amount of load on the turbine will be calculated using the graph's load at the turbine's speed.



CONFIGURE MECHANICAL DRIVE page

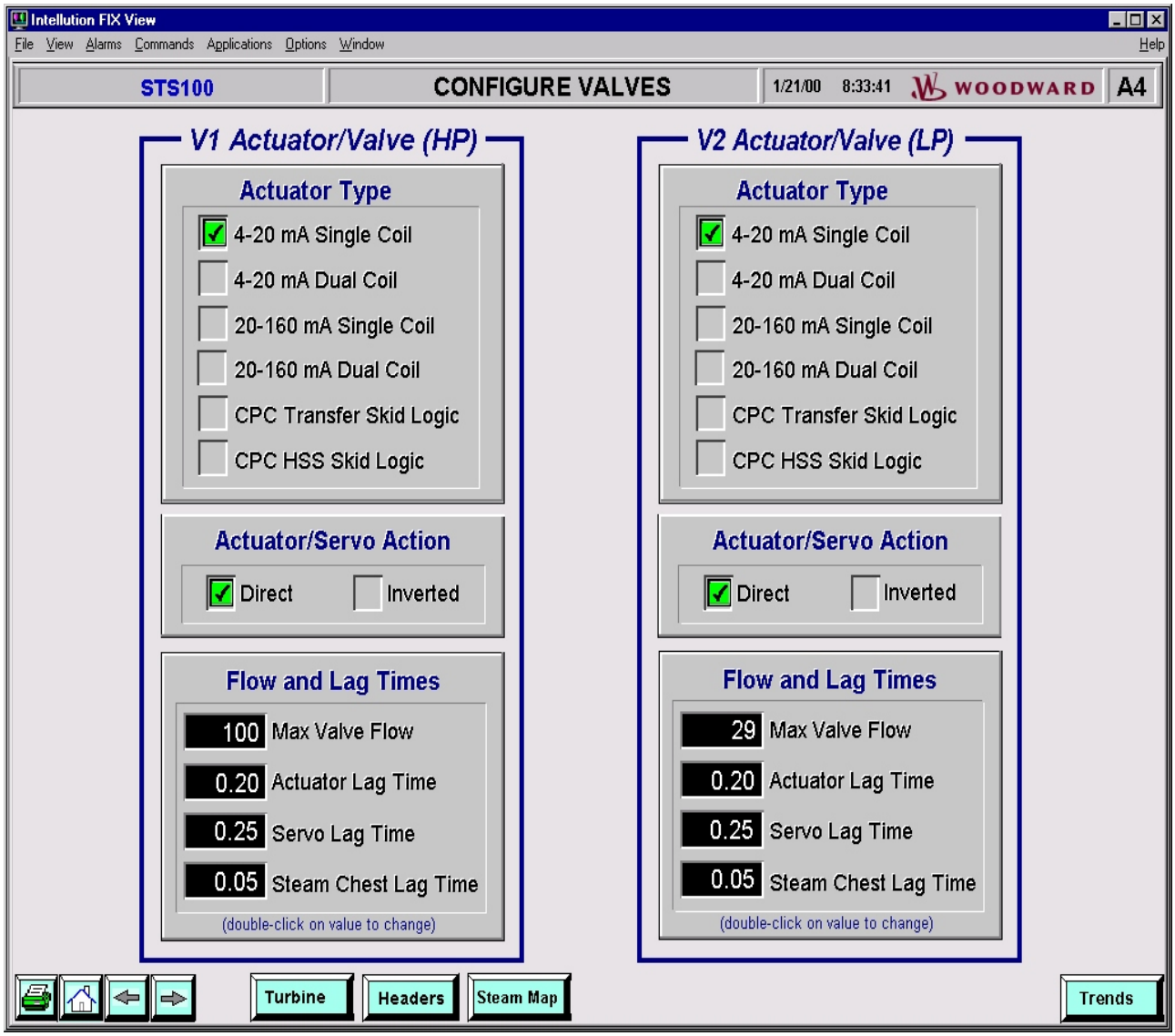
If a generator type of load was selected, the "**Configure Generator Drive**" page is used to configure the Generators maximum power.



CONFIGURE GENERATOR DRIVE page

Split Range Turbines Power

This Dialog Box is used to determine how much of the turbines power is generated in the high-pressure section and how much power is generated in the low-pressure section. Both numbers when added together must equal 100%. Double-click on the desired values/settings to modify them.



CONFIGURE VALVES page

The **CONFIGURE VALVES** page is used to select what type of control valves are on the turbine.

Actuator Type

This Check Box will select between 4-20mA, 0-200mA, single coil, and dual coil. The CPC valves are used when Woodwards CPC (Current to Pressure Converter) are to be simulated.

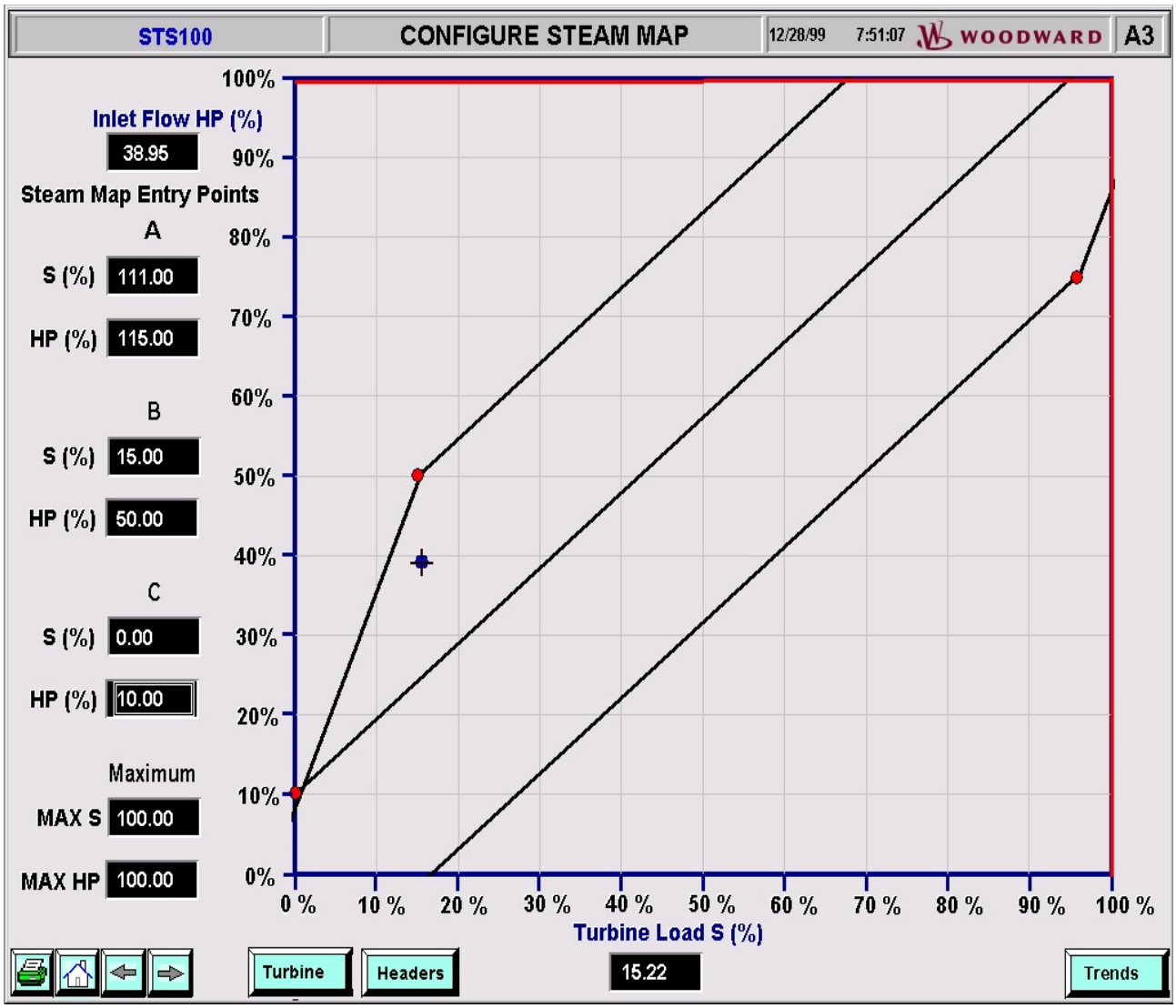
Actuator/Servo Action

This Check Box will select between Direct and Inverting action. Direct implies an increase in current causes an increase in flow, and inverted implies an increase in current causes a decrease in flow.

Flow and Lag Times

This Dialog Box will configure the max flow rates and response times of the valves. The flows can be entered as actual values or in percentages, and each time is given in seconds.

NOTE: There are no differences in functionality from the HP valve settings to the LP valve settings.



CONFIGURE STEAM MAP page

If an Extraction, Admission, or Ext/Adm type of turbine is being simulated select the "**Configure Steam Map**" page to configure the turbine's performance (steam map) data. All data must be entered in the form of a percentage (%). The values are automatically updated when changed, and will be valid only for the type of turbine they were calculated for. Double-click on the desired values/settings to modify them.

Inlet Flow and Turbine Load

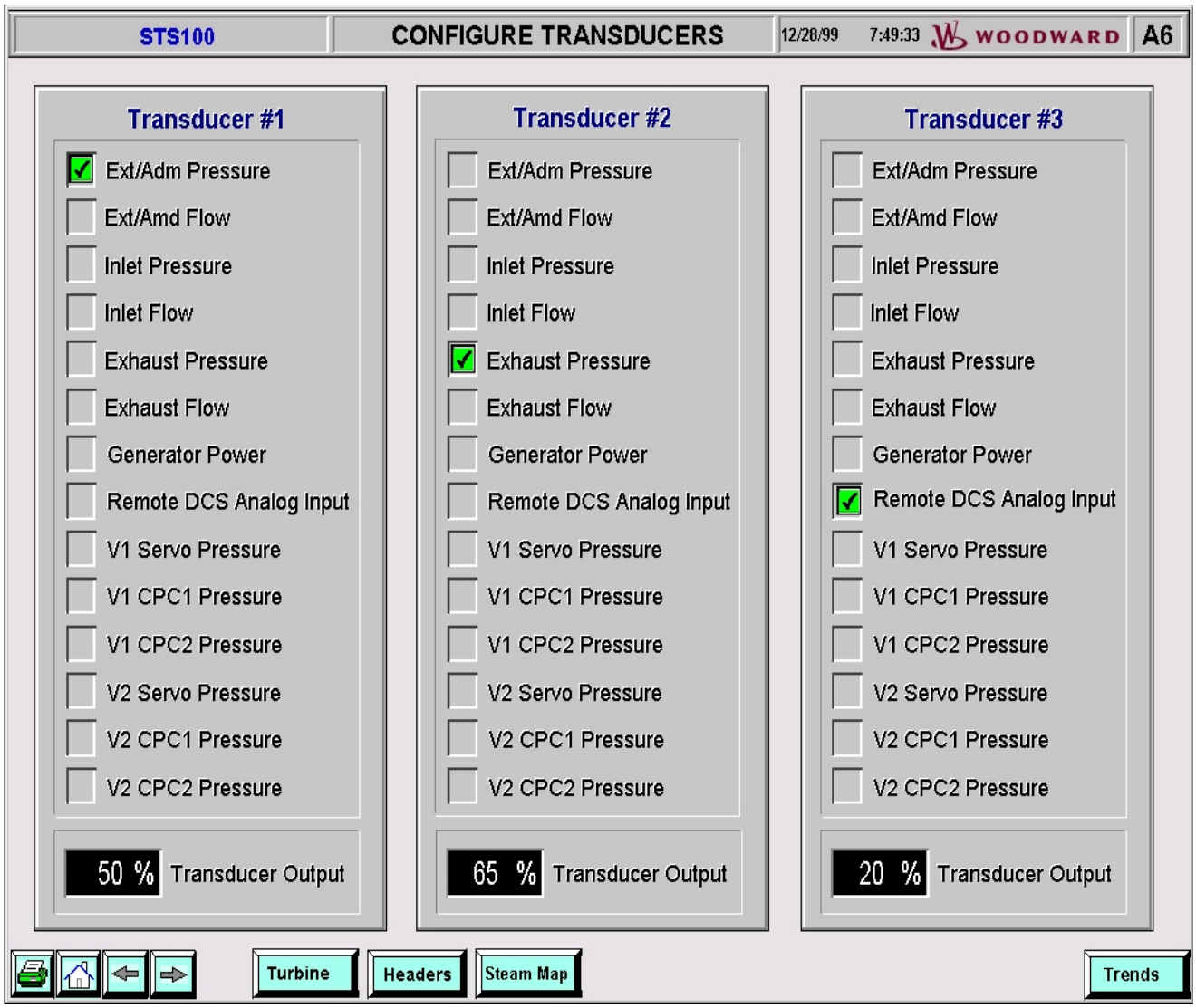
These values will be displayed and used to place the tracking icon on the Steam Map.

S and HP Values

This Dialog Box will configure the A, B, and C points of the Steam Map. Refer to the Woodward controls' manual for information regarding these points.

MAX S and HP

This Dialog Box will configure the maximum flow and power outputs of the turbine. Refer to the Woodward controls' manual for information regarding these points.



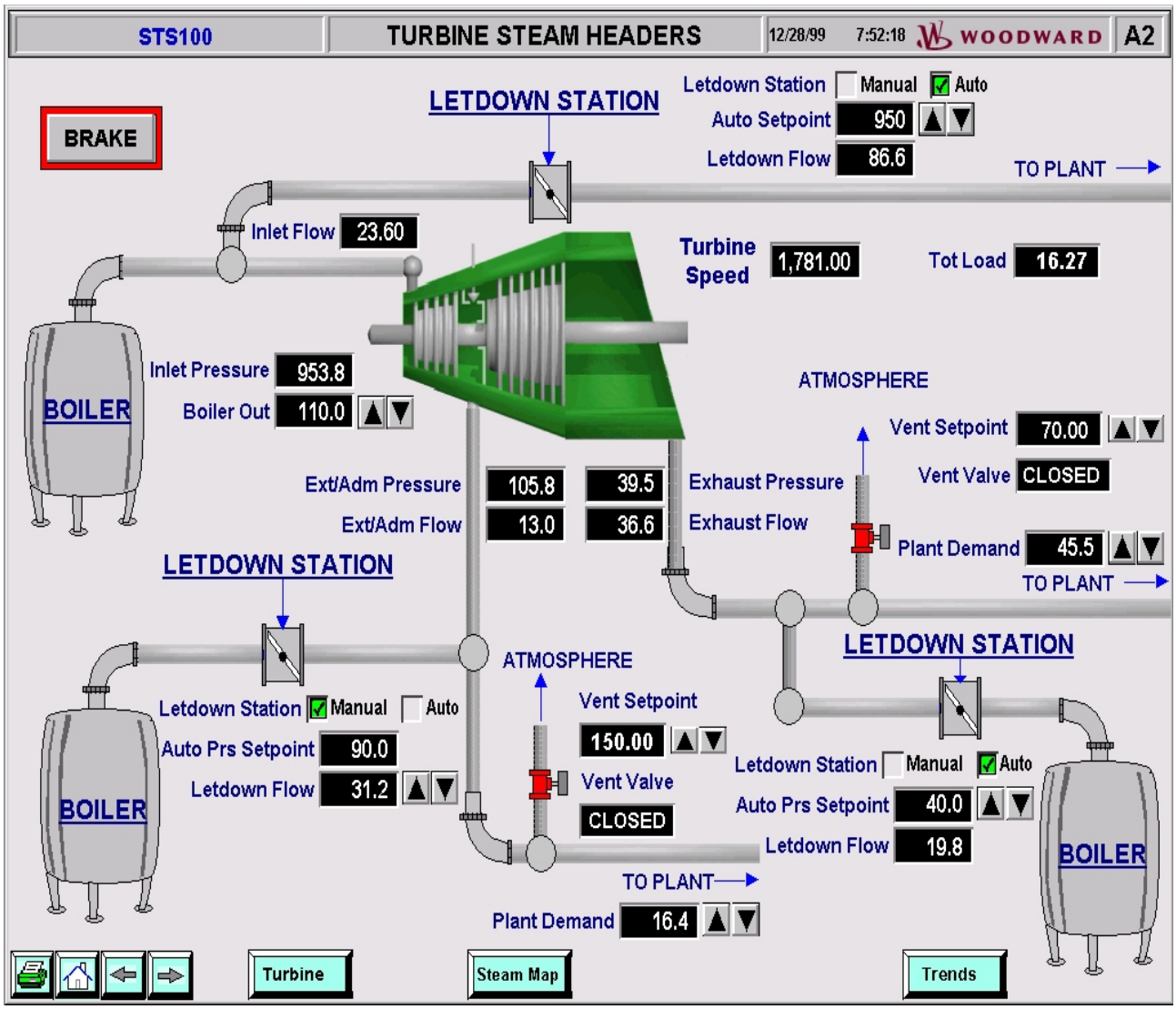
CONFIGURE TRANSDUCERS page

The **CONFIGURE TRANSDUCERS** page is used to configure the three available transducer outputs of the STS100. The Check Box above is used to select between the options shown. The Display Box shown below each transducer displays the transducer output in a percentage (%).

Remote DCS Analog Input

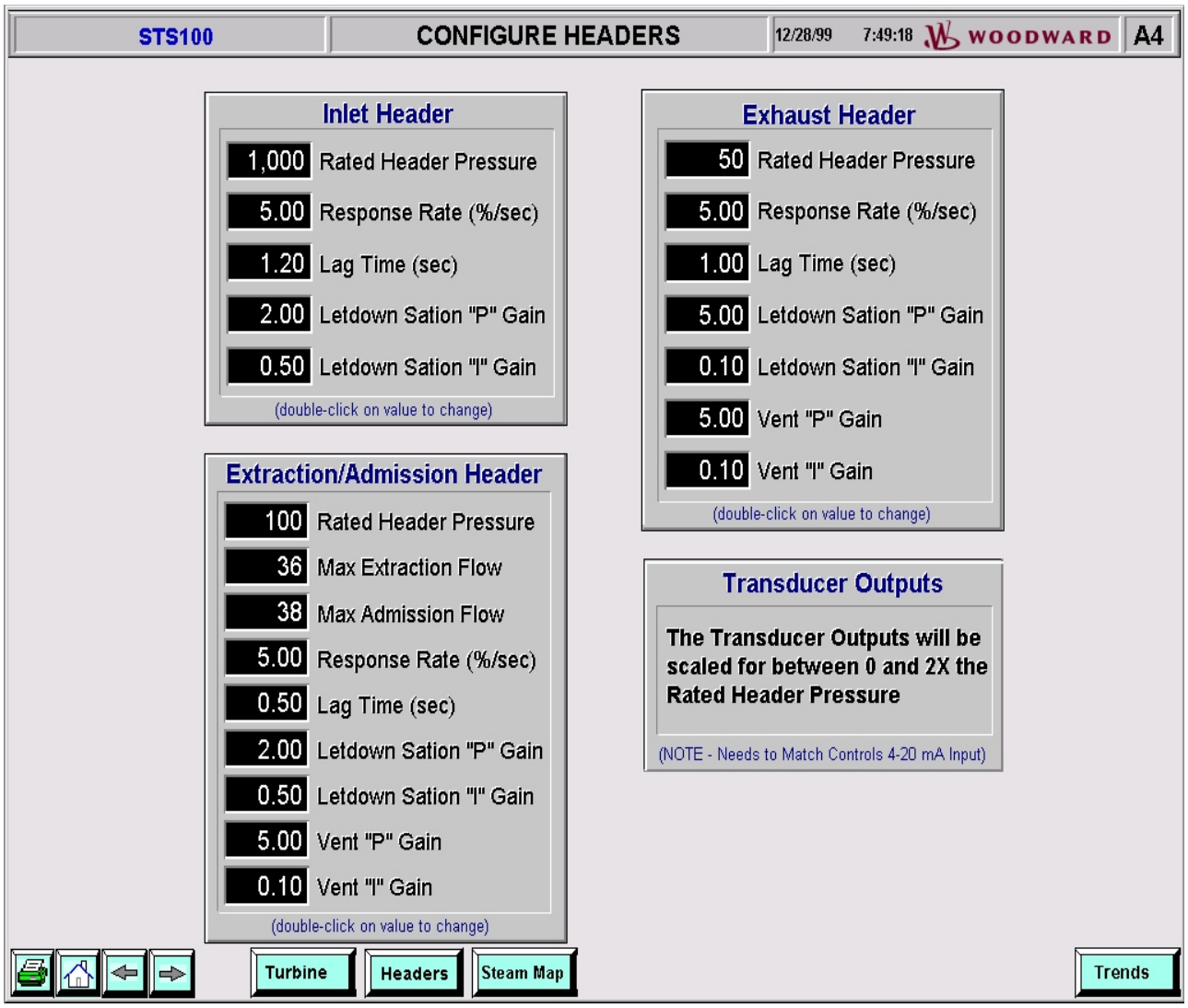
This option allows the user to simulate a 4-20mA signal coming into the control, and have complete control over it's value by the use of up and down arrow boxes shown on the **TURBINE RUN** page.

CONFIGURING THE HEADERS



TURBINE STEAM HEADERS page

The **Turbine Steam Header** page is used to monitor and control the pressures and flows of the Inlet Steam, Exhaust Steam, and if configured, an Extraction, Admission, or Extr/Adm Steam. The **Letdown Stations** and **Letdown Flows** are configurable as well as the **Vent** setpoints. The functionality of this page will be discussed in Chapter 6. To configure all the options and setpoints use the **CONFIGURE HEADERS** page.



CONFIGURE HEADERS page

The **CONFIGURE HEADERS** page is used to configure the responses of each of the three headers. The Dialog Boxes are used to enter numbers for each value. Double-click on the desired values/settings to modify them.

If the pressure or flow of any header is being used as a transducer output, that output will be scaled with respect to the **Rated Header Pressure**. For example, if an extraction turbine is controlling extraction pressure by way of a transducer output, the transducer output will be zero at 0 psi and 20mA at twice the Rated Header Pressure (200 psi in the above page).

Speed Calibration

It is recommended that after the STS100 simulator is configured and before it is initially operated that its Speed output be calibrated. This is done at Woodward and should only be done again if a new simulator application is loaded into the 723 PLUS hardware. Follow the below procedure steps to calibrate the simulator's speed output:

STEP 1: If required, stop Intellution communications.

STEP 2: Connect the PC-to-Simulator RS422 cable to the port J10 of Simulator's. Using ServLink program via J10 connector, RS422, and a 5416-870 download cable.

STEP 3: From the Woodward - program group, Start the Servlink program.

STEP 4: Within the Servlink program click on the New Page icon in the tool bar or select "NEW" under the "File" pull down menu. At this point a menu will appear to set up communications with the control. Select the communication port, that the simulator is connected to, and then click on the "OK" button. Unless otherwise directed by a Woodward representative, do not change any of the other default settings. The Default settings are: Communications Port - COM1, Mode - Point-to-Point, Baud Rate - 19200.
Once the "OK" button has been selected, Servlink will access the control and build the network configuration file. The building of the network definition file may take 5 to 10 minutes. The "Reading Control information" folder will remain active until the Servlink program has finished building the configuration file. In the event that communications between the PC and the control are not working, a message will appear to that effect. Check your cable connections and verify your option selections in the above folder until the "Reading Control information" folder appears.

STEP 5: Once the program has finished building the file, the new network definition file must be saved. Use the **Save As** option in the **File** pull-down menu of the Servlink toolbar to save the new file under the **"C:\Program Files\Woodward\Servlink Server"** directory. The Servlink - Net1 folder shows the new Dflt_Control_ID.NET file that has been created. It is recommended that the new file be named "Net1.net".

STEP 6: At this point the Servlink program is fully installed and the Watch Windows program can be opened. When the Watch Windows program is opened and a network configuration file is requested, select the new file (typically Net1.net).

STEP 7: From the application's category tree, step into category "SPEED_CAL", then into block "ENAB_CALIB". Select and drag the "IN" setting to the Inspector's Sheet1 form. Click on the Value setting to tune the value to "TRUE".

STEP 8: From the application's "SPEED_CAL" category, step into the block "CAL_SPEED". Select and drag the "IN" setting to the Inspector's Sheet1 form. This value is defaulted to 500rpm.

STEP 9: From the application's "SPEED_CAL" category, step into the block "MPU_OUT". Select and drag the "OFFSET" setting to the Inspector's Sheet1 form. Select and drag the "GAIN" setting to the Inspector's Sheet1 form.

STEP 10: With the CAL_SPEED.IN setting at 500rpm, adjust the MPU_OUT.OFFSET value to match the speed sensed by the control to 500rpm. To adjust this setting select the OFFSET value then use the up & down arrows to tune the value. If the adjustment steps made via the arrows are to course, a user can directly enter any value (up to three digits) into this setting.

STEP 11: With the CAL_SPEED.IN setting at "rated turbine speed", adjust the MPU_OUT.GAIN value to match the speed sensed by the control to "rated turbine speed". To adjust this setting select the GAIN value then use the up & down arrows to tune the value. If the adjustment steps made via the arrows are to course, a user can directly enter any value (up to three digits) into this setting.

STEP 12: Repeat steps 10 & 11 as required.

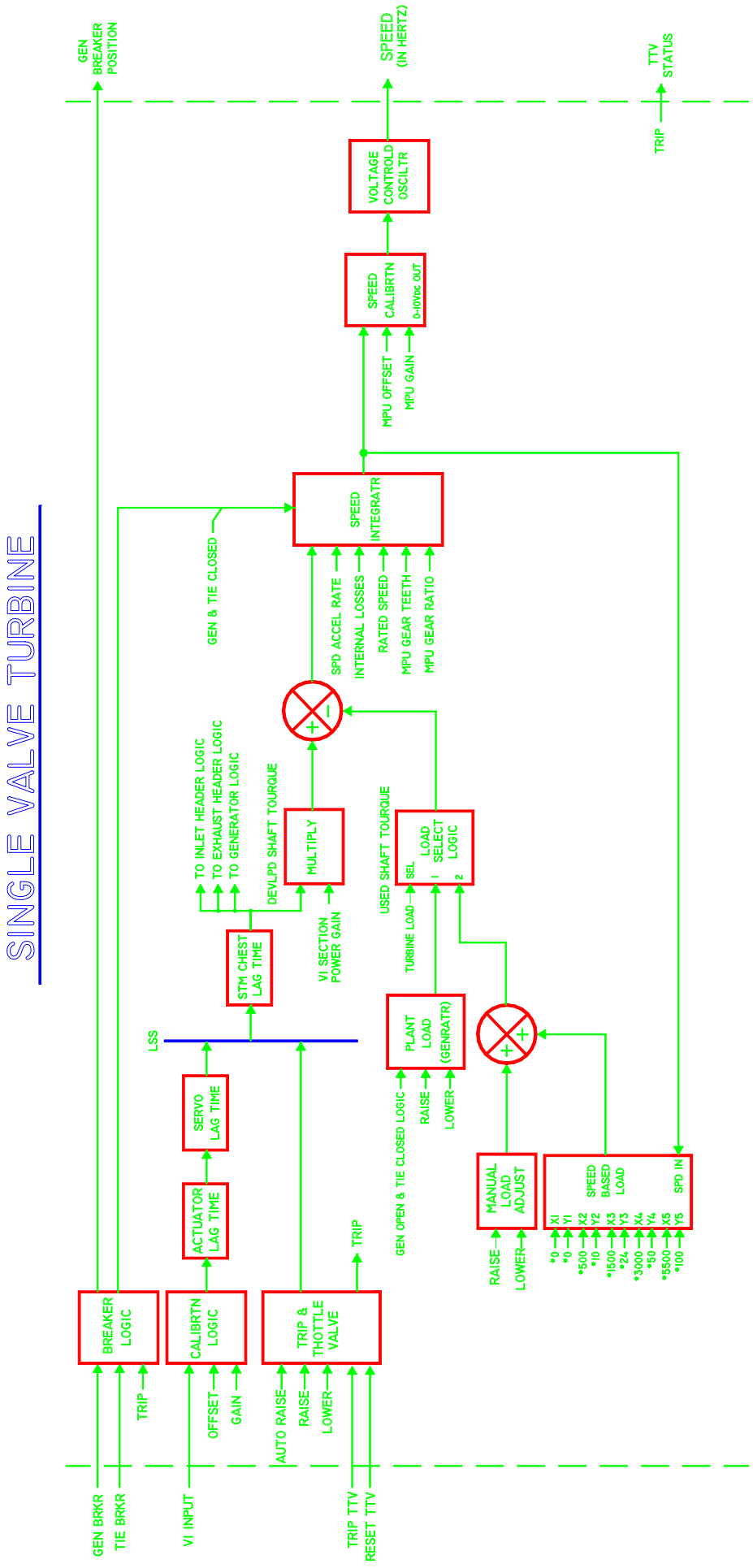
STEP 13: Click on the "SPEED_CAL.ENAB_CALIB" block's value to tune the value to "FALSE".

STEP 14: Right Click on the NET1.net (unidentified) tab in the program's Explorer window, then select "Save Values" to save all changes to EEPROM.

STEP 15: Close the Watch Window and Servlink programs, and move the PC-to-Simulator cable back to port J11.

CHAPTER 4
SIMULATOR FUNCTIONALITY

Refer to bellow block diagrams to understand simulator functionality based on the type of turbine or header parameter used.


SINGLE VALVE TURBINE
GEN BREAKER POSITION
SPEED (IN HERTZ)
TTV STATUS
TRIP
VOLTAGE CONTROLD OSCILTR
SPEED CALIBRTN
0-10Vdc OUT
MPU OFFSET
MPU GAIN
SPEED INTEGRATR
GEN & TIE CLOSED
SPD ACCEL RATE
INTERNAL LOSSES
RATED SPEED
MPU GEAR TEETH
MPU GEAR RATIO
TO INLET HEADER LOGIC
TO EXHAUST HEADER LOGIC
TO GENERATOR LOGIC
DEVLPD SHAFT TOURQUE
MULTIPLY
USED SHAFT TOURQUE
SEL
LOAD SELECT LOGIC
1
2
STM CHEST LAG TIME
VI SECTION POWER GAIN
TURBINE LOAD
LSS
PLANT LOAD (GENRATR)
SERVO LAG TIME
ACTUATOR LAG TIME
GEN OPEN & TIE CLOSED LOGIC
RAISE
LOWER
MANUAL LOAD ADJUST
SPEED BASED LOAD
SPD IN
X1
Y1
X2
Y2
X3
Y3
X4
Y4
X5
Y5
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RAISE
LOWER
TRIP
BREAKER LOGIC
CALIBRTN LOGIC
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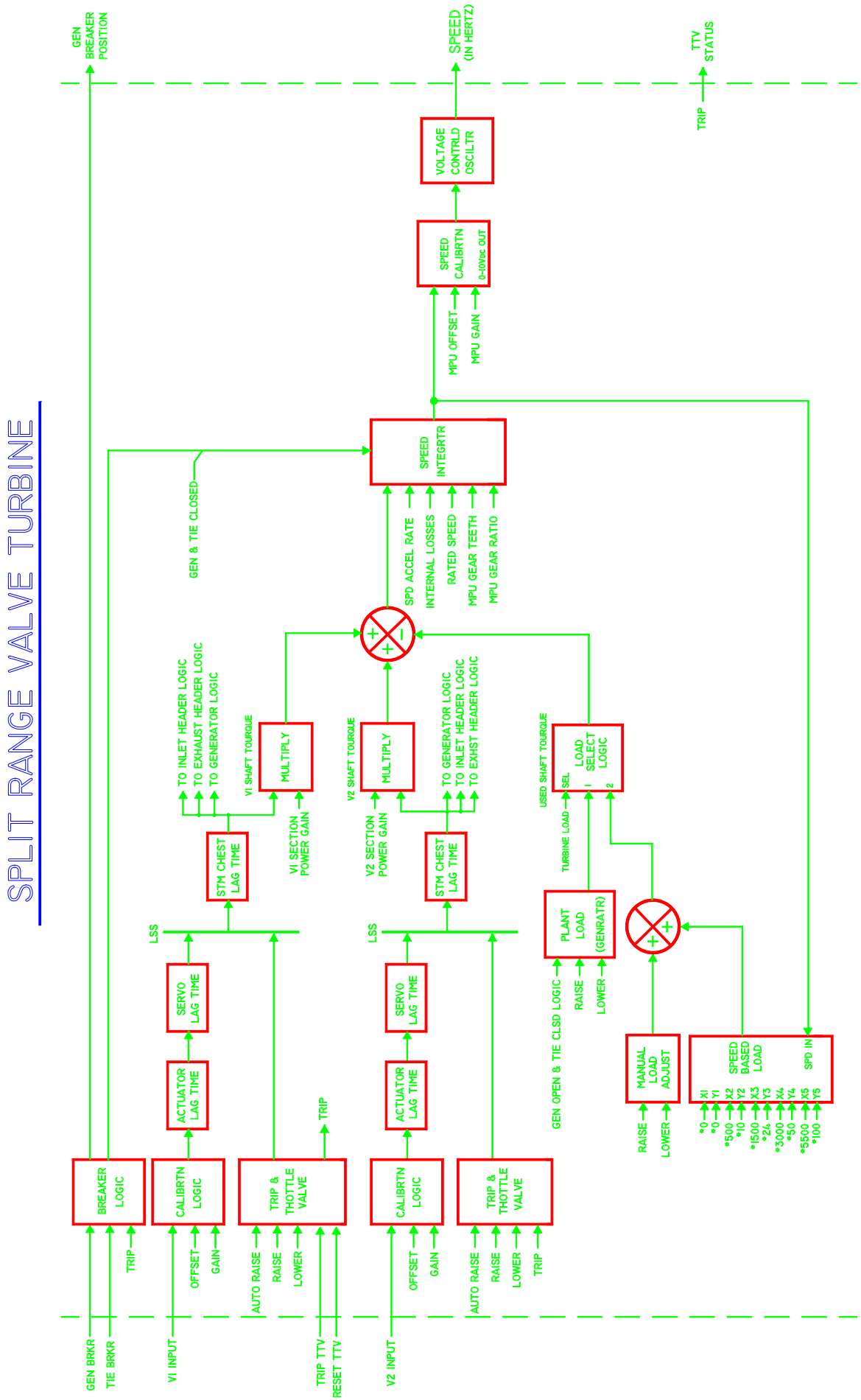
AUTO RAISE
RAISE
LOWER
OFFSET
GAIN
GEN BRKR
TIE BRKR
VI INPUT
TRIP TTV
RESET TTV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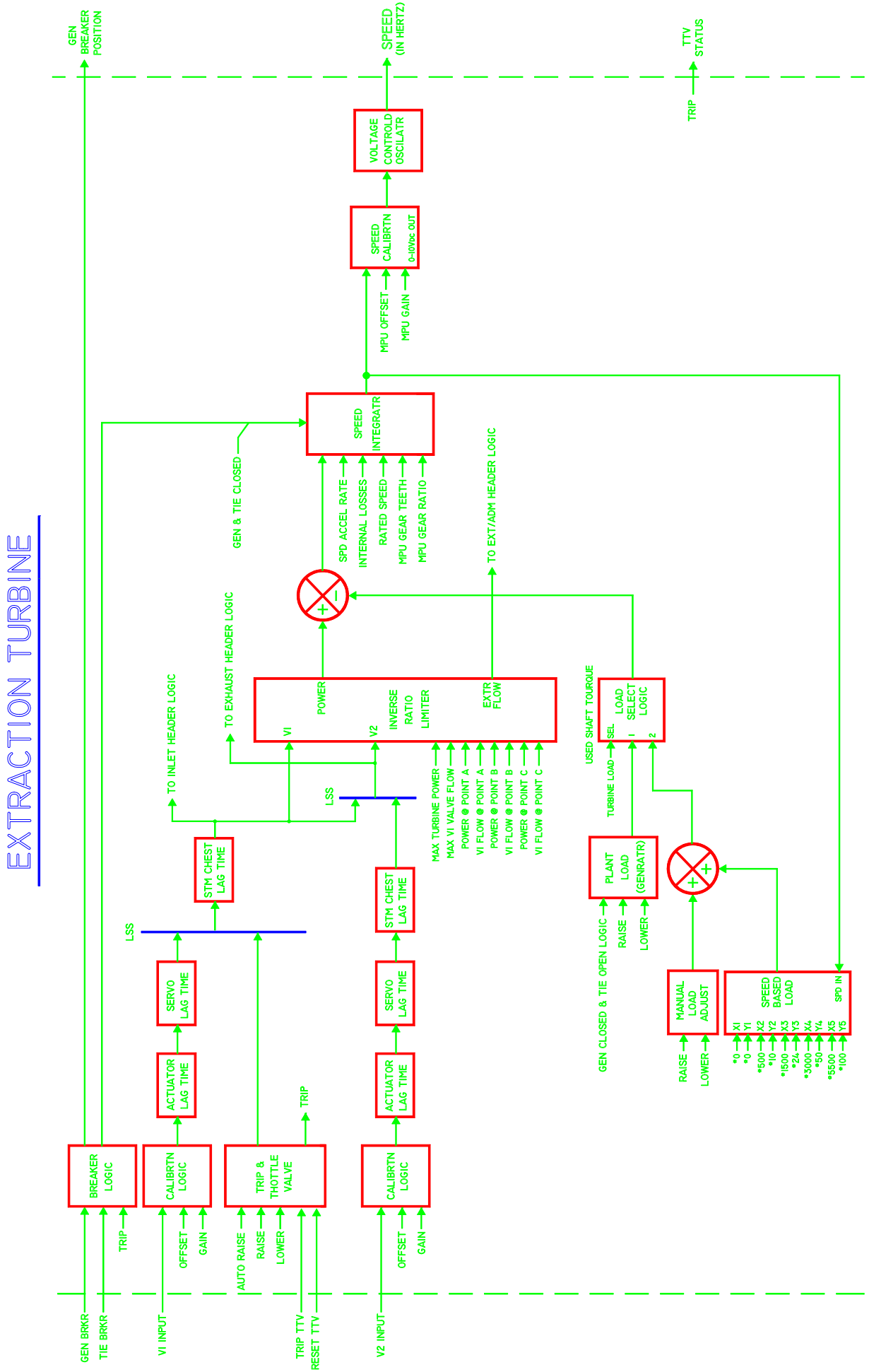
GEN BREAKER POSITION
SPEED (IN HERTZ)
TTV STATUS
TRIP
VOLTAGE CONTRLD OSCILTR
SPEED CALIBRTN
0-10Vdc OUT
MPU OFFSET
MPU GAIN
SPEED INTEGRTR
GEN & TIE CLOSED
SPD ACCEL RATE
INTERNAL LOSSES
RATED SPEED
MPU GEAR TEETH
MPU GEAR RATIO
TO INLET HEADER LOGIC
TO EXHAUST HEADER LOGIC
TO GENERATOR LOGIC
V1 SHAFT TOURQUE
MULTIPLY
V1 SECTION POWER GAIN
STM CHEST LAG TIME
V2 SHAFT TOURQUE
V2 SECTION POWER GAIN
TO GENERATOR LOGIC
TO INLET HEADER LOGIC
TO EXHST HEADER LOGIC
USED SHAFT TOURQUE
SEL
LOAD SELECT LOGIC
TURBINE LOAD
PLANT LOAD (GENRATR)
GEN OPEN & TIE CLSD LOGIC
RAISE
LOWER
LSS
SERVO LAG TIME
ACTUATOR LAG TIME
MANUAL LOAD ADJUST
SPEED BASED LOAD
SPD IN
X1 Y1 X2 Y2 X3 Y3 X4 Y4 X5 Y5
*0 *0 *500 *10 *1500 *24 *3000 *50 *5500 *100
BREAKER LOGIC
CALIBRTN LOGIC
TRIP & THOTTLE VALVE
AUTO RAISE
OFFSET
GAIN
GEN BRKR
TIE BRKR
V1 INPUT
TRIP TTV
RESET TTV
V2 INPUT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TTV STATUS
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VOLTAGE CONTROLD OSCILLATR
SPEED CALIBRTN
0-10Vdc OUT
MPU OFFSET
MPU GAIN
SPEED INTEGRATR
GEN & TIE CLOSED
SPD ACCEL RATE
INTERNAL LOSSES
RATED SPEED
MPU GEAR TEETH
MPU GEAR RATIO
TO EXT/ADM HEADER LOGIC
TO EXHAUST HEADER LOGIC
TO INLET HEADER LOGIC
POWER
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V2
INVERSE RATIO LIMITER
EXTR FLOW
LSS
MAX TURBINE POWER
MAX VI VALVE FLOW
POWER @ POINT A
VI FLOW @ POINT A
POWER @ POINT B
VI FLOW @ POINT B
POWER @ POINT C
VI FLOW @ POINT C
USED SHAFT TOURQUE
LOAD SELECT LOGIC
SEL
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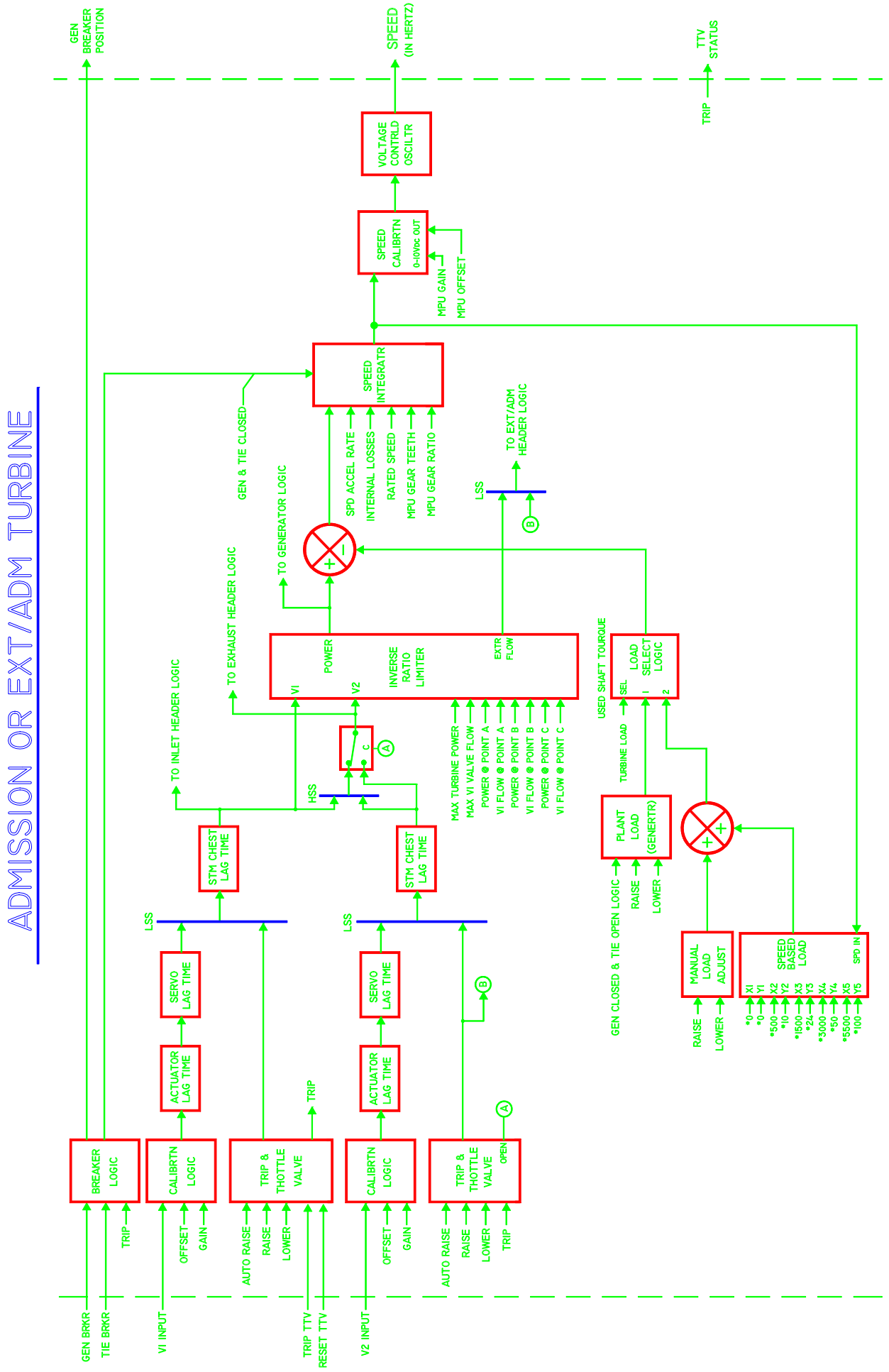
TURBINE LOAD
PLANT LOAD (GENRATR)
GEN CLOSED & TIE OPEN LOGIC
RAISE
LOWER
MANUAL LOAD ADJUST
SPEED BASED LOAD
SPD IN
X1 Y1 X2 Y2 X3 Y3 X4 Y4 X5 Y5
*0 *0 *500 *10 *1500 *24 *3000 *50 *5500 *100
STM CHEST LAG TIME
SERVO LAG TIME
ACTUATOR LAG TIME
BREAKER LOGIC
CALIBRTN LOGIC
TRIP & THOTTLE VALVE
AUTO RAISE
OFFSET
GAIN
GEN BRKR
TIE BRKR
VI INPUT
TRIP TTV
RESET TTV
V2 INPUT


ADMISSION OR EXT/ADM TURBINE
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SPEED (IN HERTZ)
TTV STATUS
TRIP
VOLTAGE CONTRLD OSCILTR
SPEED CALIBRTN
0-10Vdc OUT
MPU GAIN
MPU OFFSET
SPEED INTEGRATR
GEN & TIE CLOSED
SPD ACCEL RATE
INTERNAL LOSSES
RATED SPEED
MPU GEAR TEETH
MPU GEAR RATIO
TO EXT/ADM HEADER LOGIC
LSS
TO GENERATOR LOGIC
TO EXHAUST HEADER LOGIC
POWER
INVERSE RATIO LIMITER
EXTR FLOW
V1
V2
TO INLET HEADER LOGIC
HSS
MAX TURBINE POWER
MAX VI VALVE FLOW
POWER @ POINT A
VI FLOW @ POINT A
POWER @ POINT B
VI FLOW @ POINT B
POWER @ POINT C
VI FLOW @ POINT C
USED SHAFT TOURQUE
LOAD SELECT LOGIC
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PLANT LOAD (GENERTR)
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RAISE
LOWER
STM CHEST LAG TIME
SERVO LAG TIME
ACTUATOR LAG TIME
MANUAL LOAD ADJUST
SPEED BASED LOAD
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*3000
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BREAKER LOGIC
CALIBRTN LOGIC
TRIP & THOTTLE VALVE
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AUTO RAISE
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TIE BRKR
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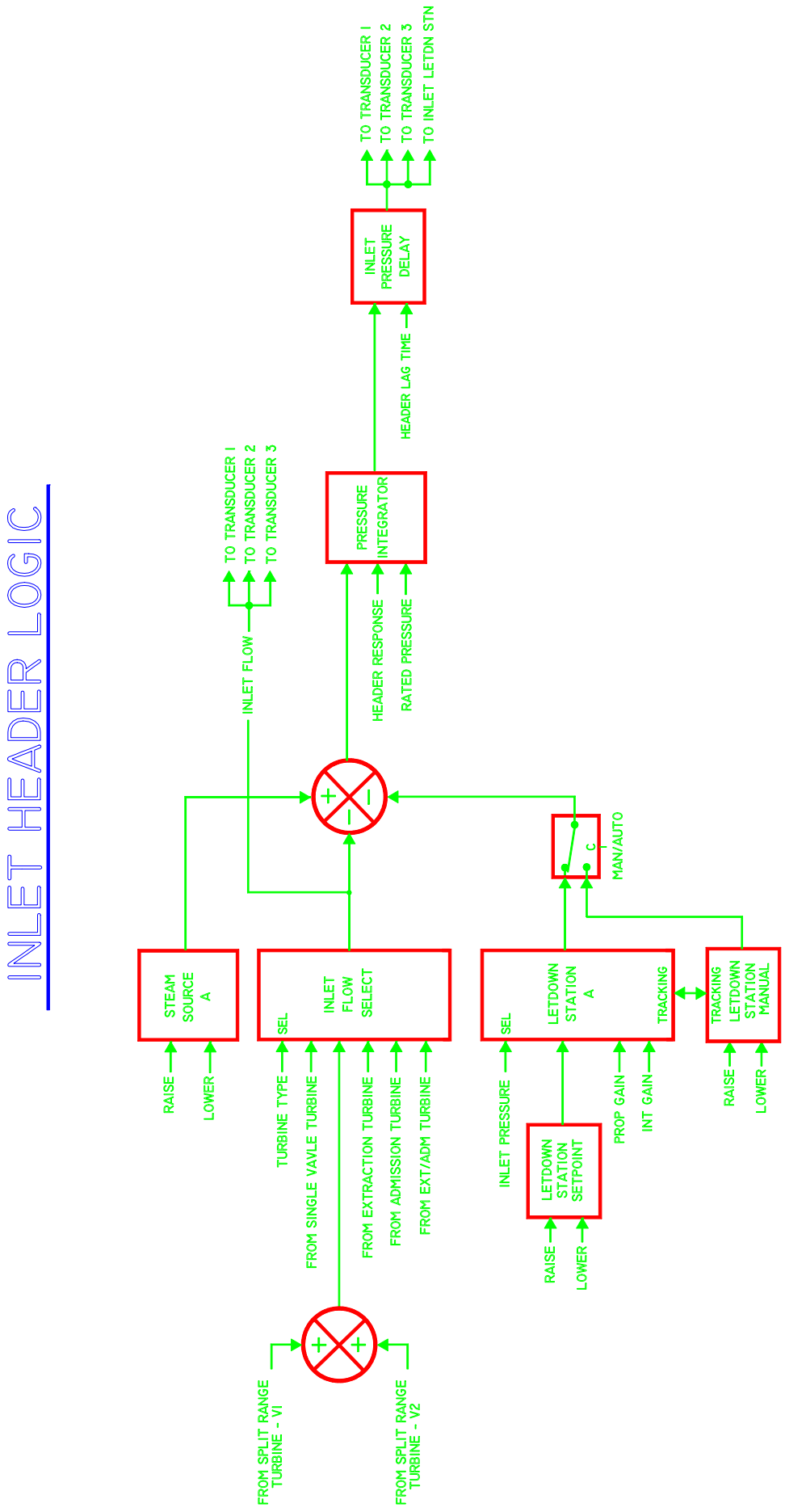
TRIP TTV
RESET TTV
V2 INPUT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TO TRANSDUCER 2
TO TRANSDUCER 3
TO INLET LETDN STN
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HEADER LAG TIME
PRESSURE INTEGRATOR
TO TRANSDUCER 1
TO TRANSDUCER 2
TO TRANSDUCER 3
INLET FLOW
HEADER RESPONSE
RATED PRESSURE
MAN/AUTO
STEAM SOURCE A
INLET FLOW SELECT
SEL
LETDOWN STATION A
SEL
TRACKING
TRACKING LETDOWN STATION MANUAL
RAISE
LOWER
TURBINE TYPE
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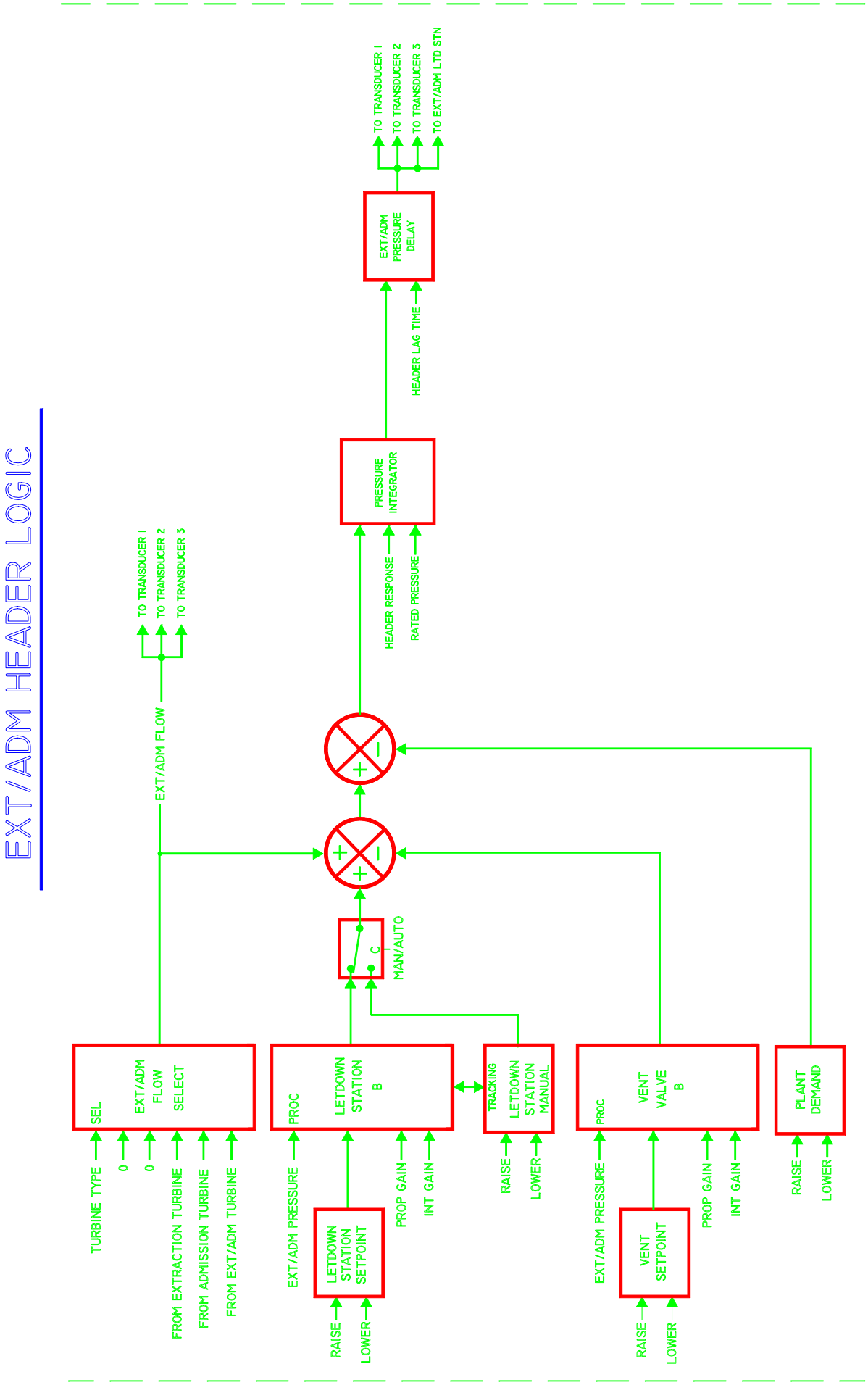
FROM EXTRACTION TURBINE
FROM ADMISSION TURBINE
FROM EXT/ADM TURBINE
INLET PRESSURE
LETDOWN STATION SETPOINT
PROP GAIN
INT GAIN
RAISE
LOWER
RAISE
LOWER
FROM SPLIT RANGE TURBINE - V1
FROM SPLIT RANGE TURBINE - V2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TO TRANSDUCER 3
TO EXT/ADM LTD STN
EXT/ADM PRESSURE DELAY
HEADER LAG TIME
PRESSURE INTEGRATOR
HEADER RESPONSE
RATED PRESSURE
TO TRANSDUCER 1
TO TRANSDUCER 2
TO TRANSDUCER 3
EXT/ADM FLOW
MAN/AUTO
SEL
EXT/ADM FLOW SELECT
TURBINE TYPE
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FROM EXTRACTION TURBINE
FROM ADMISSION TURBINE
FROM EXT/ADM TURBINE
PROC
LETDOWN STATION B
EXT/ADM PRESSURE
LETDOWN STATION SETPOINT
RAISE
LOWER
PROP GAIN
INT GAIN
TRACKING
LETDOWN STATION MANUAL
RAISE
LOWER
PROC
VENT VALVE B
EXT/ADM PRESSURE
VENT SETPOINT
RAISE
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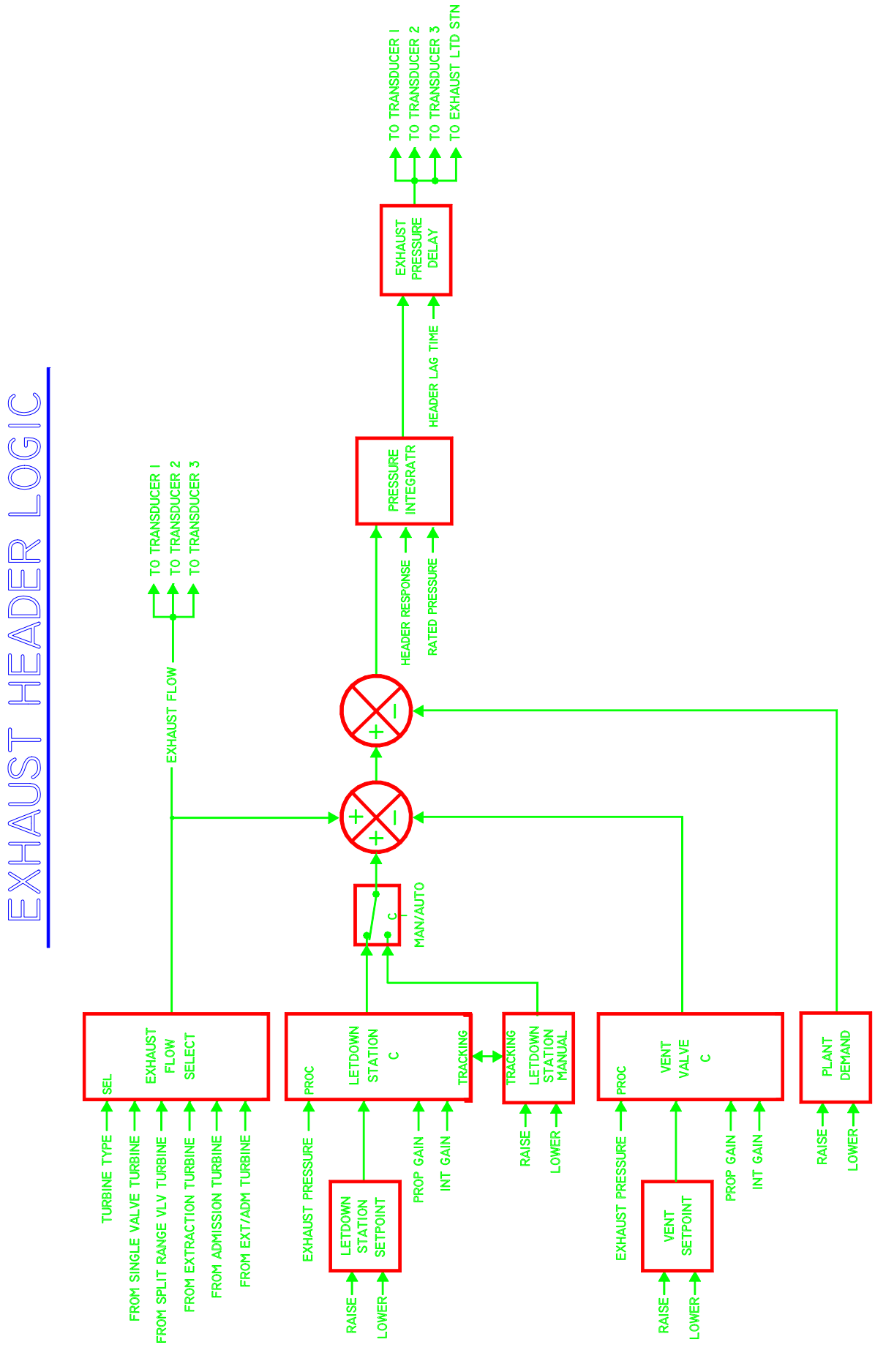
PROP GAIN
INT GAIN
PLANT DEMAND
RAISE
LOWER


EXHAUST HEADER LOGIC
TO TRANSDUCER 1
TO TRANSDUCER 2
TO TRANSDUCER 3
TO EXHAUST LTD STN
EXHAUST PRESSURE DELAY
HEADER LAG TIME
PRESSURE INTEGRATR
HEADER RESPONSE
RATED PRESSURE
EXHAUST FLOW
MAN/AUTO
SEL
EXHAUST FLOW SELECT
PROC
LETDOWN STATION C
TRACKING
TRACKING
LETDOWN STATION MANUAL
PROC
VENT VALVE C
PLANT DEMAND
TURBINE TYPE
FROM SINGLE VALVE TURBINE
FROM SPLIT RANGE VLV TURBINE
FROM EXTRACTION TURBINE
FROM ADMISSION TURBINE
FROM EXT/ADM TURBINE
EXHAUST PRESSURE
LETDOWN STATION SETPOINT
PROP GAIN
INT GAIN
RAISE
LOWER
RAISE
LOWER
EXHAUST PRESSURE
VENT SETPOINT
PROP GAIN
INT GAIN
RAISE
LOWER
RAISE
LOWER

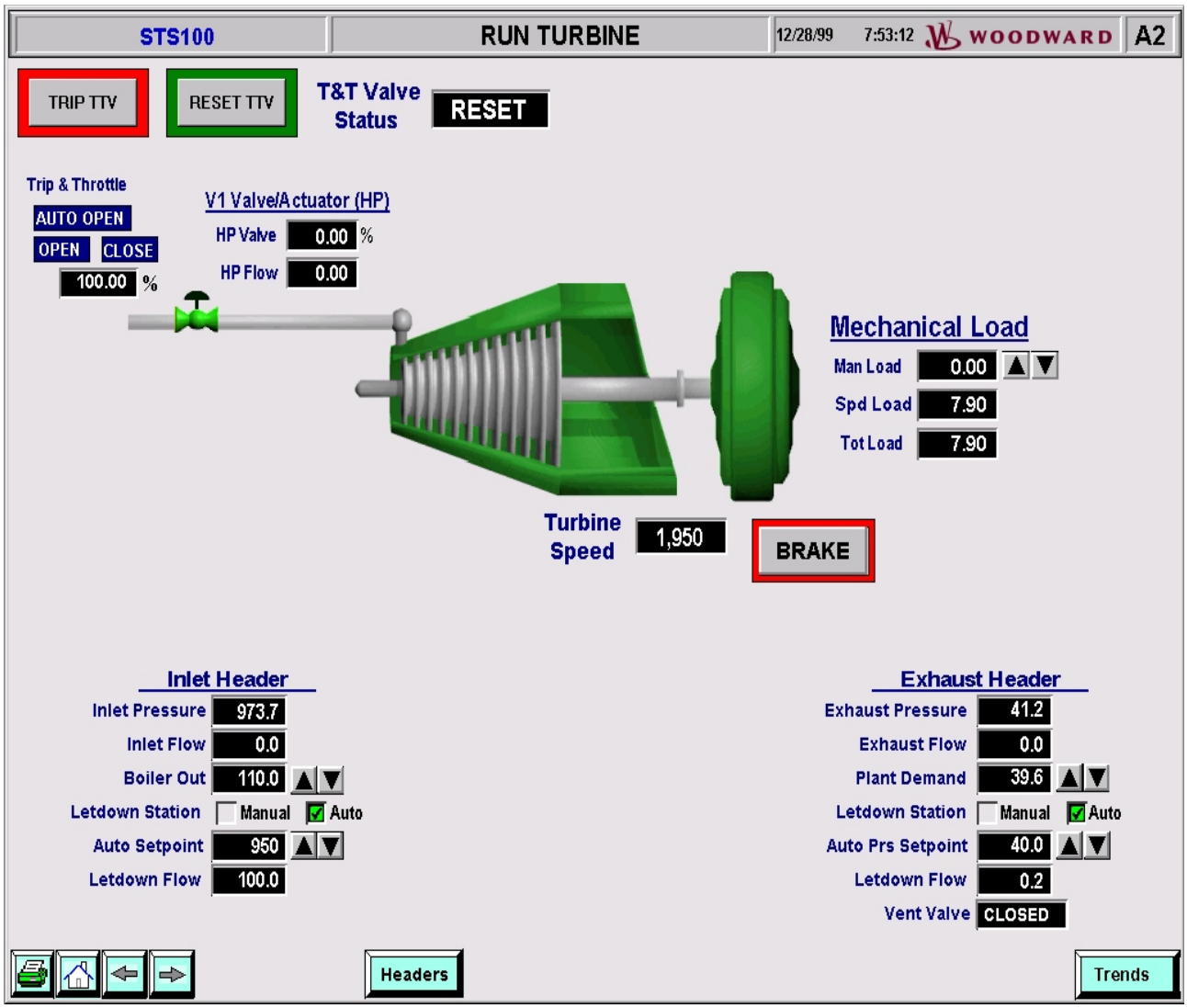
CHAPTER 5
OPERATING THE SIMULATOR

The STS100 simulator is designed to simulate typical steam plant conditions and logic. An overview page is provided to allow an operator to manipulate plant functions. From any page click on the **TURBINE** button to view the **RUN TURBINE** page. Follow the bellow procedures to start each turbine type and manipulate turbine related parameters (power, load, headers).

Starting a Single Valve Turbine

Issue a Reset TTV command via a contact-in or by clicking on the "**RESET TTV**" button. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the Trip and Throttle Valve.

Click on the ▼▲ to raise or lower the manual loading.
Click on the "**BRAKE**" button to cause a momentary loading of the turbine.
Modify either the Inlet or the Exhaust Headers as desired.



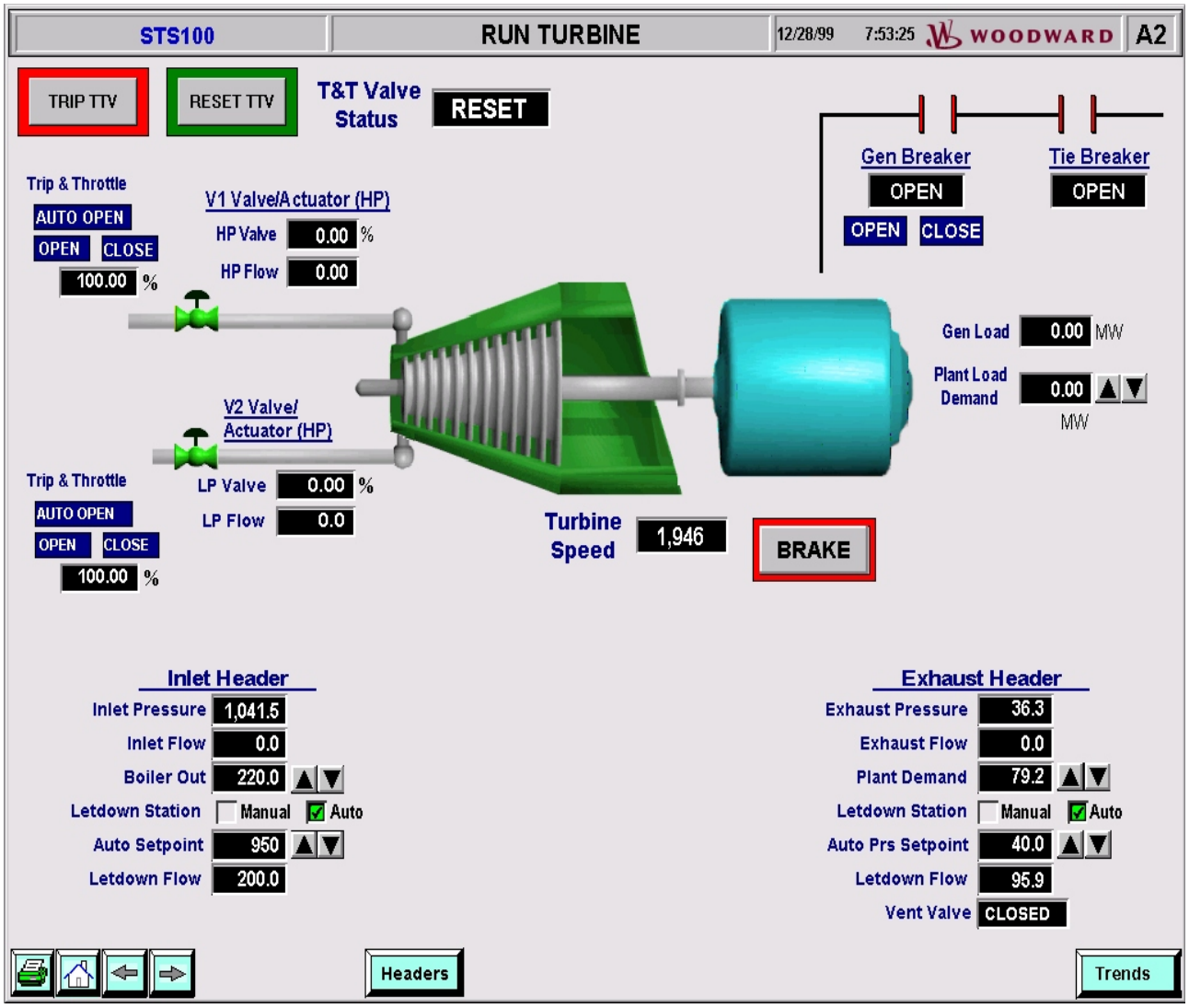
RUN TURBINE page
(Single Valve - Mechanical Load)

Starting a Split Range Valve Turbine

Issue a Reset TTV command via a contact-in or by clicking on the "**RESET TTV**" button. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the V1 Trip and Throttle Valve. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the V2 Trip and Throttle Valve.

Click on the ▼▲ to raise or lower the Plant Load Demand.
Click on the "**BRAKE**" button to cause a momentary loading of the turbine.
Modify either the Inlet or the Exhaust Headers as desired.

NOTE: A generator or mechanical loading can be selected for any of the turbine types.



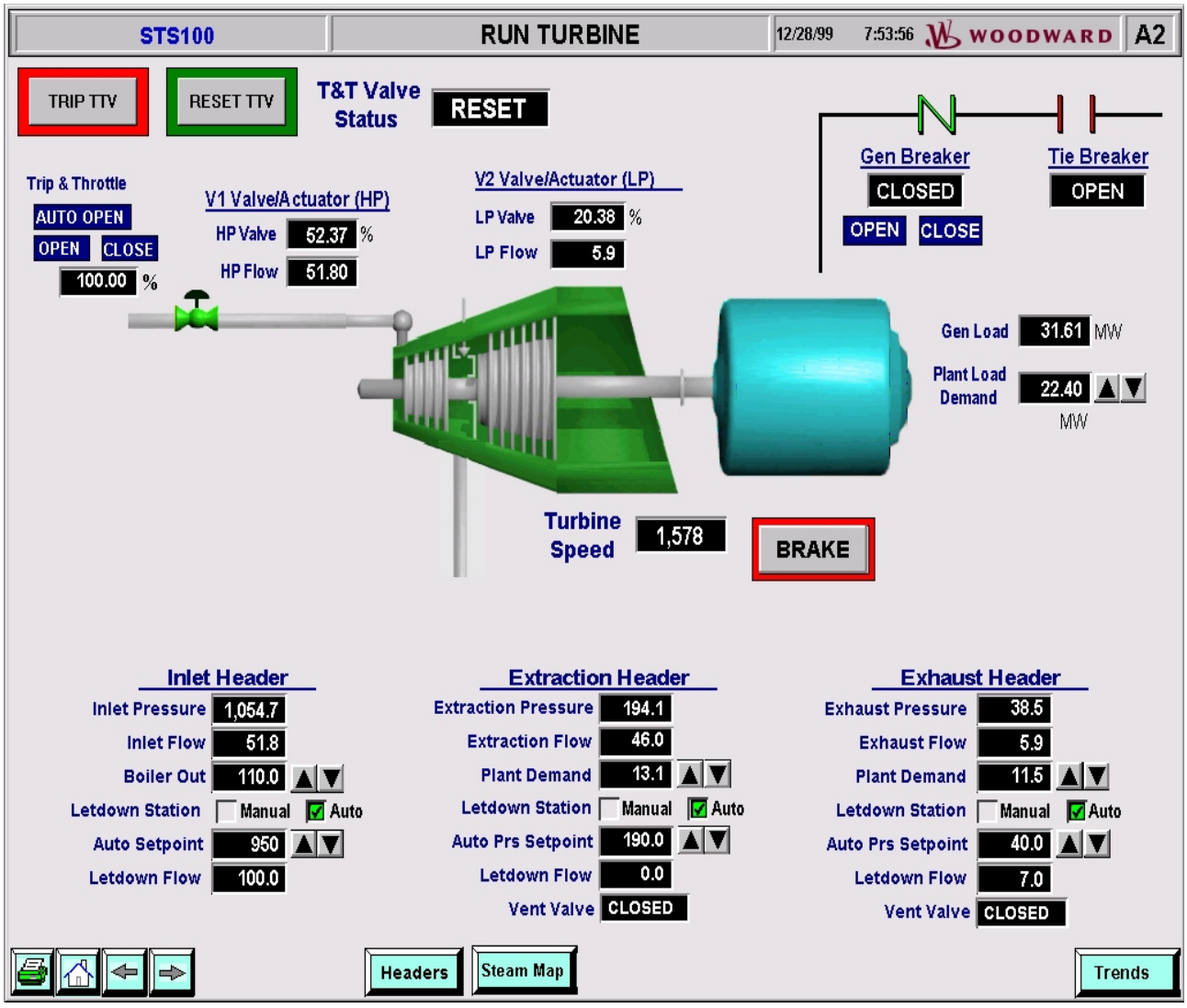
RUN TURBINE page
(Split Valve - Generator Load)

Starting an Extraction Turbine

Issue a Reset TTV command via a contact-in or by clicking on the "**RESET TTV**" button. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the HP Trip and Throttle Valve. With this configuration a simulated check valve is in-line with the turbine's extraction flow to prohibit any admission flow into the turbine from the Extraction header.

Click on the ▼▲ to raise or lower the Plant Load Demand.
Click on the "**BRAKE**" button to cause a momentary loading of the turbine.
Modify the Inlet, Exhaust, or Extraction Headers as desired.

NOTE: A generator or mechanical loading can be selected for any of the turbine types.



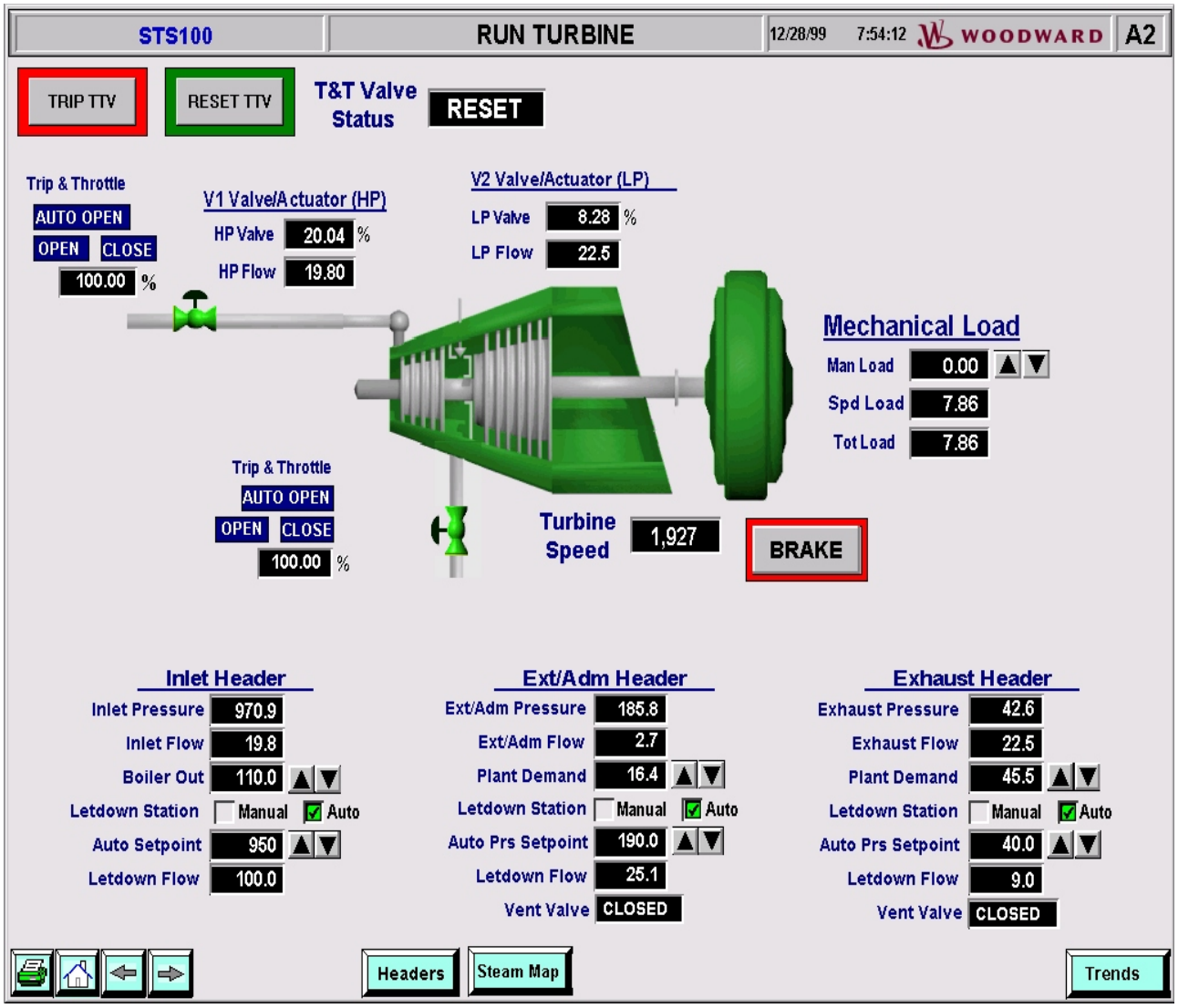
RUN TURBINE page
(Extraction - Generator Load)

Starting an Admission or Extraction/Admission Turbine

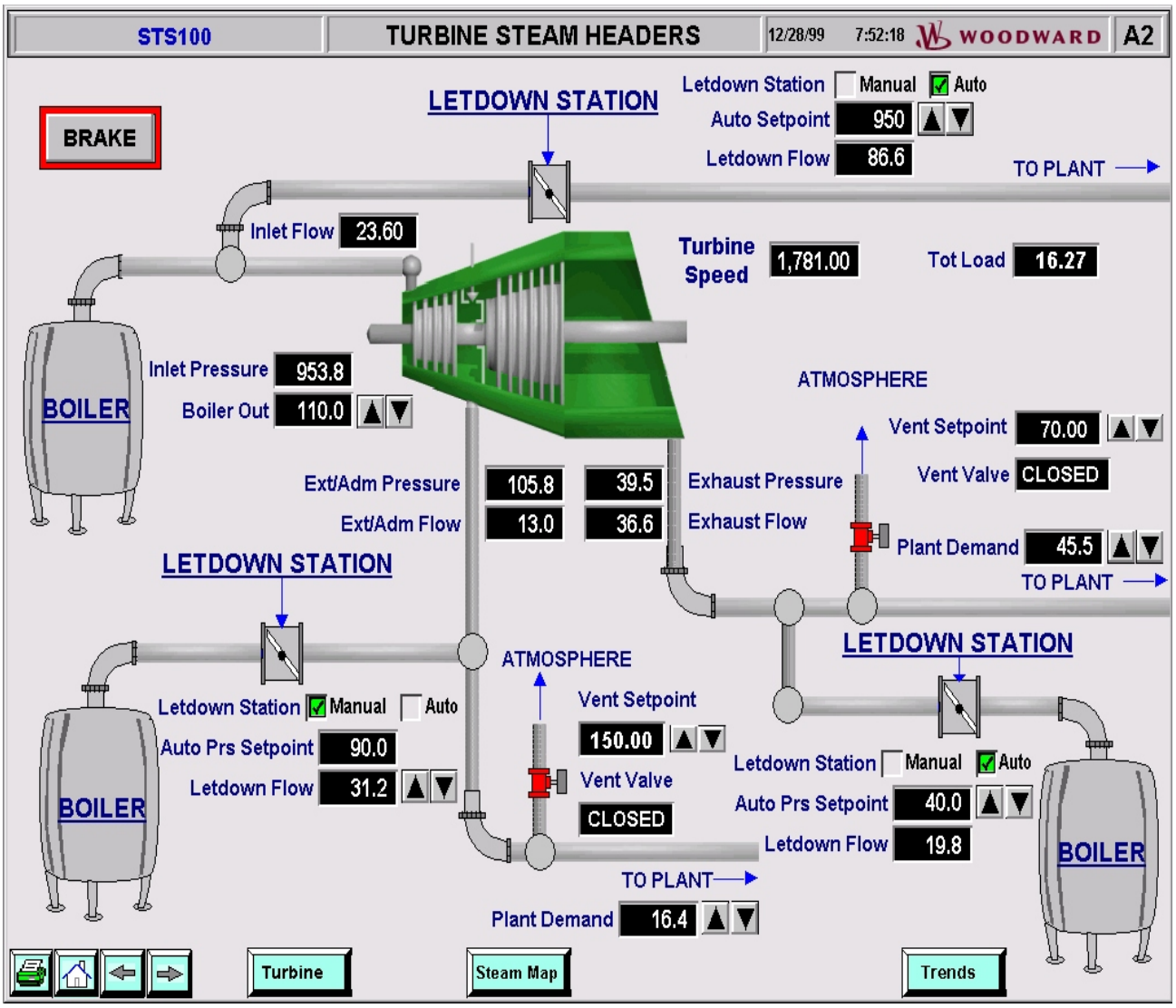
Issue a Reset TTV command via a contact-in or by clicking on the "**RESET TTV**" button. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the HP Trip and Throttle Valve. When appropriate for the type of start routine used by the control, open the Trip & Throttle Valve by clicking on the "**OPEN**" text or select the "**AUTO OPEN"** text next to the LP Trip and Throttle Valve.

Click on the ▼▲ to raise or lower the manual load.
Click on the "**BRAKE**" button to cause a momentary loading of the turbine.
Modify the Inlet, Exhaust, or Extr/Adm Headers as desired.

NOTE: A generator or mechanical loading can be selected for any of the turbine types.



RUN TURBINE page
(Extr/Adm - Mechanical Load)



TURBINE STEAM HEADERS page

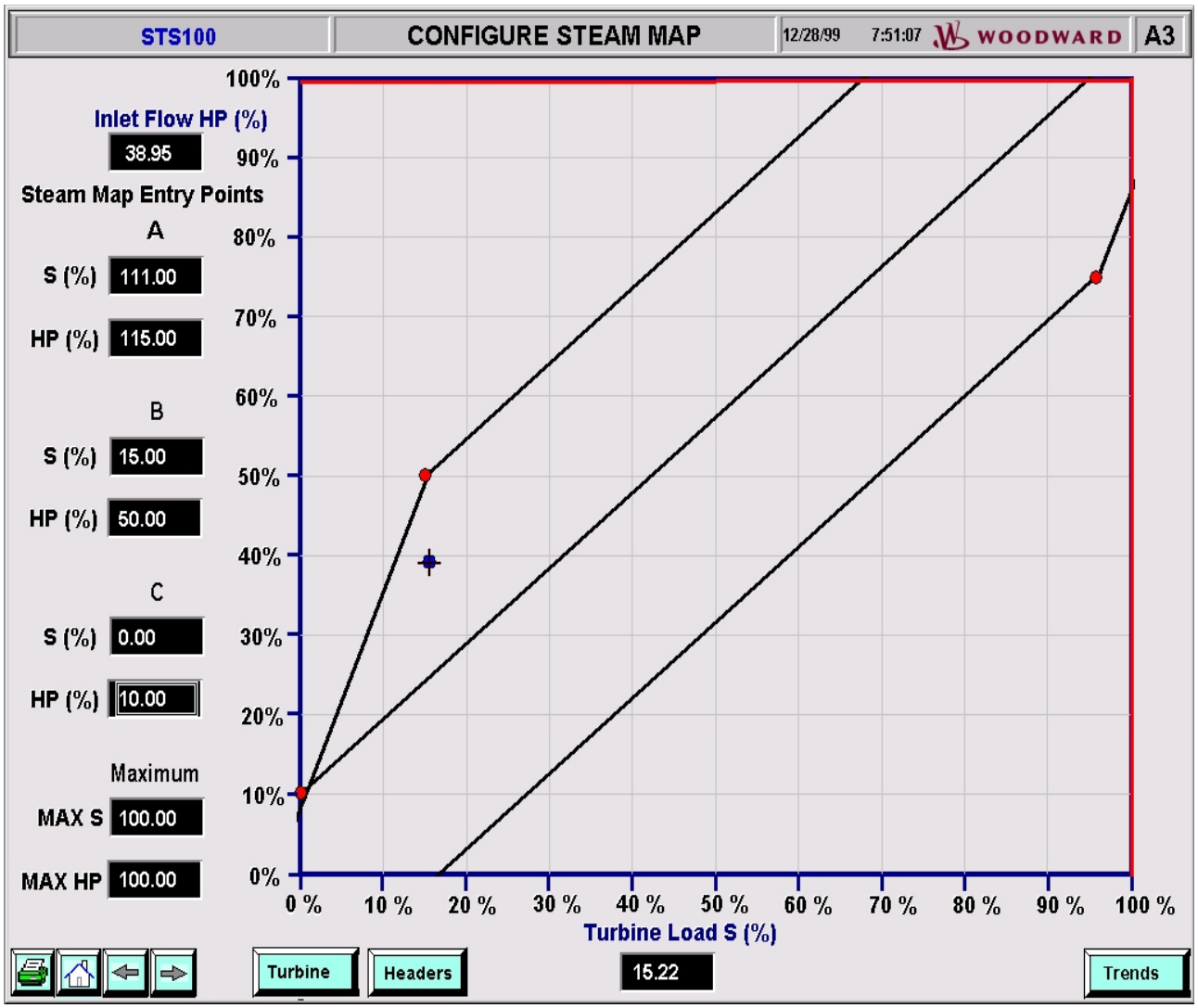
Steam Header Control

The STS100 can simulate all three Steam Headers in and out of the turbine. These headers, through the use of letdown stations, can operate in either an automatic mode or a manual mode. In automatic mode, the letdown station will try to maintain a constant pressure. In manual mode, the letdown station will try to maintain a constant flow. As described earlier, the response times and dynamics of how each header responds and how fast each letdown station reacts can be modified in the **CONFIGURE HEADERS** page.

Control of each Steam Header

Click on the **Letdown Station**'s "**Manual**" or "**Auto**" text to change the operating mode for that station.
Click on the ▼▲ to raise or lower the pressure setpoint in "**Auto**" mode.
Click on the ▼▲ to raise or lower the flow setpoint in "**Manual**" mode.
Click on the ▼▲ to raise or lower the Plants Steam Flow demand, "**Plant Demand**".
Click on the ▼▲ to raise or lower the Vents Steam Pressure setpoint, "**Vent Setpoint**".

Pressures Transducer values (PT) are based off of the configured rated header pressure setting.
Flow values are based off of the configured Max HP Flow setting, Max Extraction value, Max Admission value, or Max HP Flow (E/A) settings depending on the turbine type configured.



CONFIGURE STEAM MAP page

Control of the Steam Map Configuration

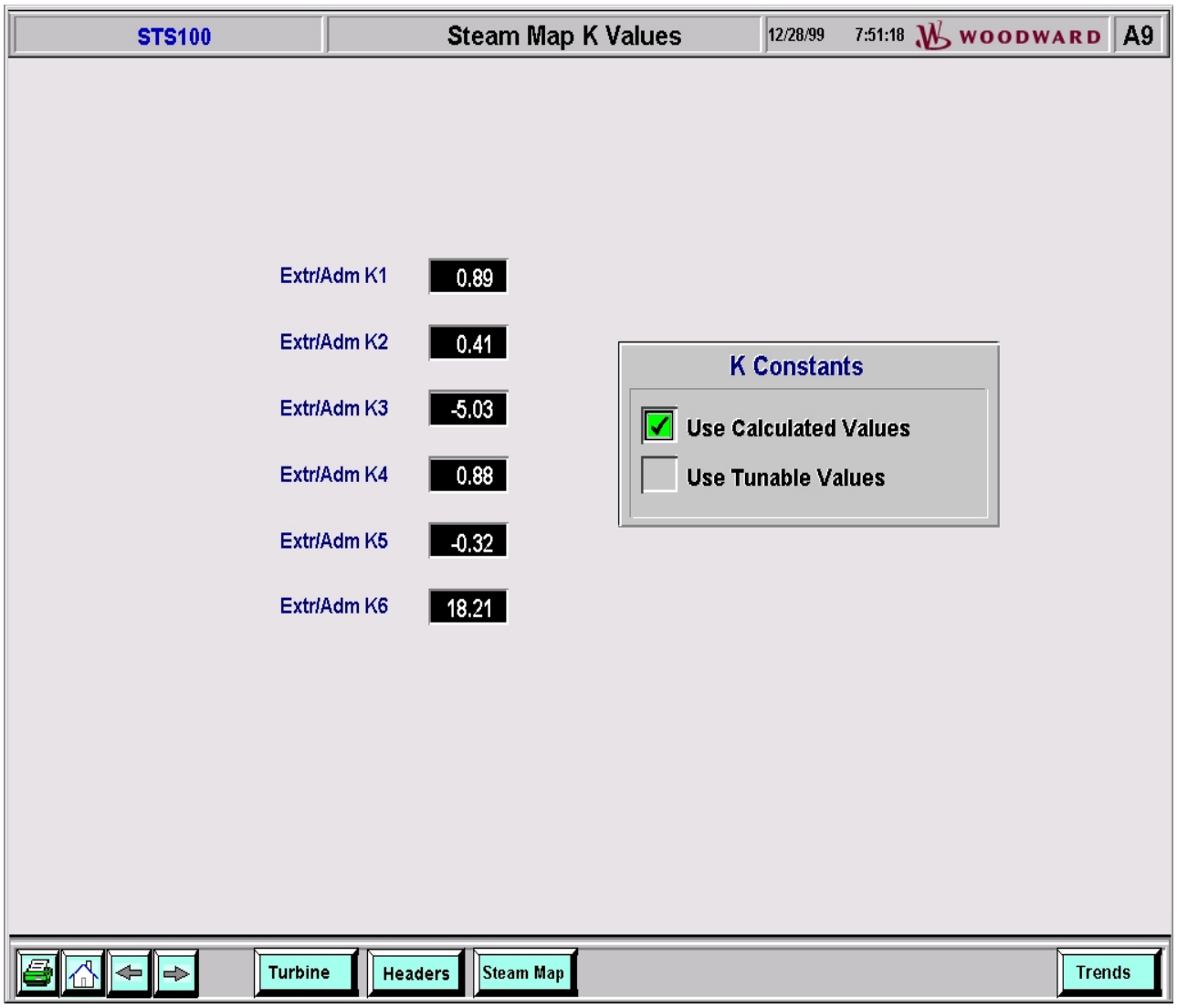
The Steam Map can be configured on-line for any of the custom controls. Simply double click on any of the A, B, C, or MAX values and replace them with the new numbers. The graph will automatically update and display the new Steam Map.

The blue/cross icon that moves with respect to the turbine load and Inlet Flow will display the location of the turbine on the Steam Map.

NOTE: The control system will be responsible for keeping the turbine inside the map. To verify the integrity of the system, the controls map needs to be monitored, **NOT** the simulators.

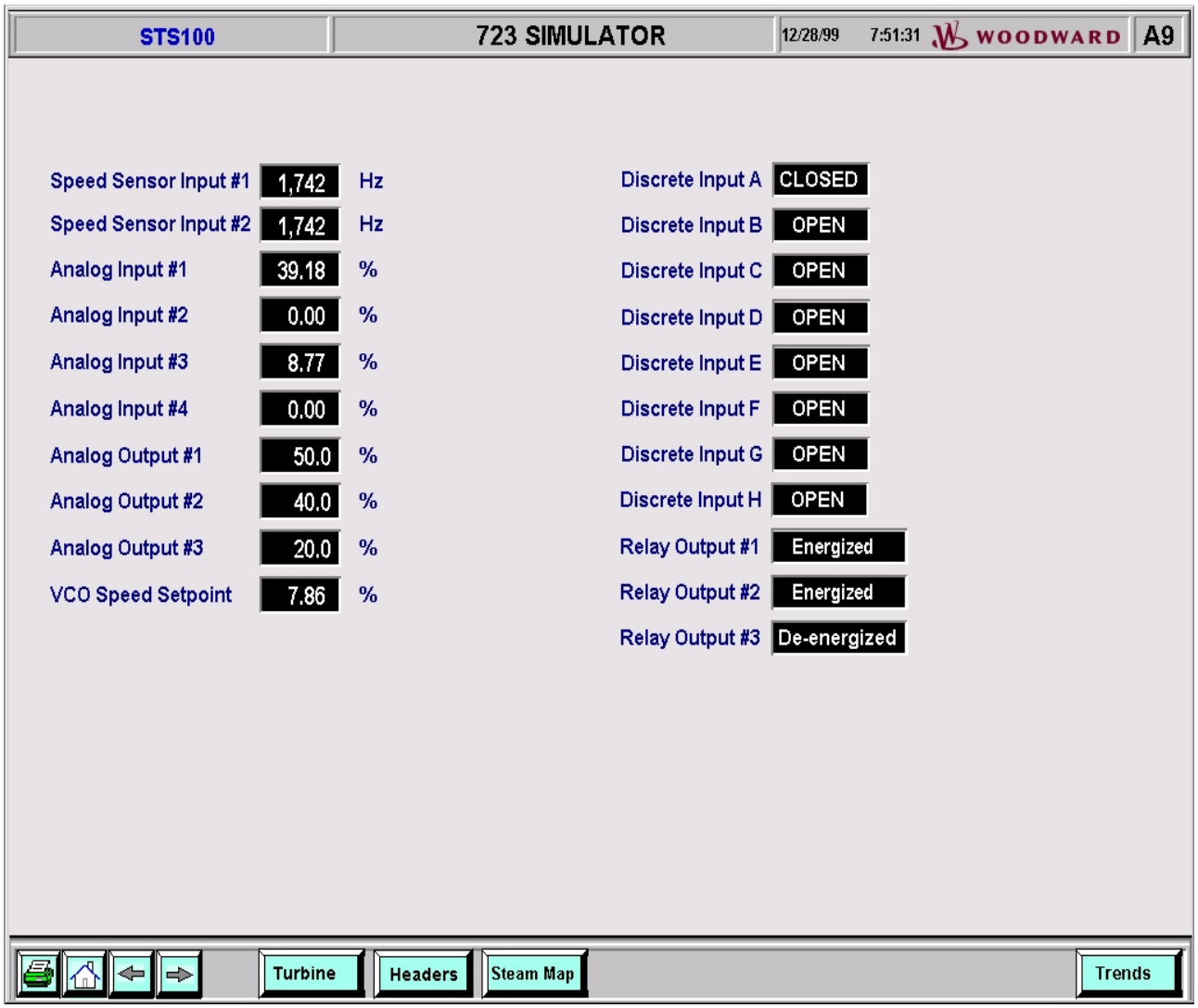
Control of the Steam Map K Values

The STS100 will calculate the Steam Map values (K Values) from the Steam Map entries in the CONFIGURE STEAM MAP page and display them here. If desired, the calculated values can be overridden with a selection of tunable values in the simulator. The Watch Windows program is necessary in order to change those tunable values.



STEAM MAP K VALUES page

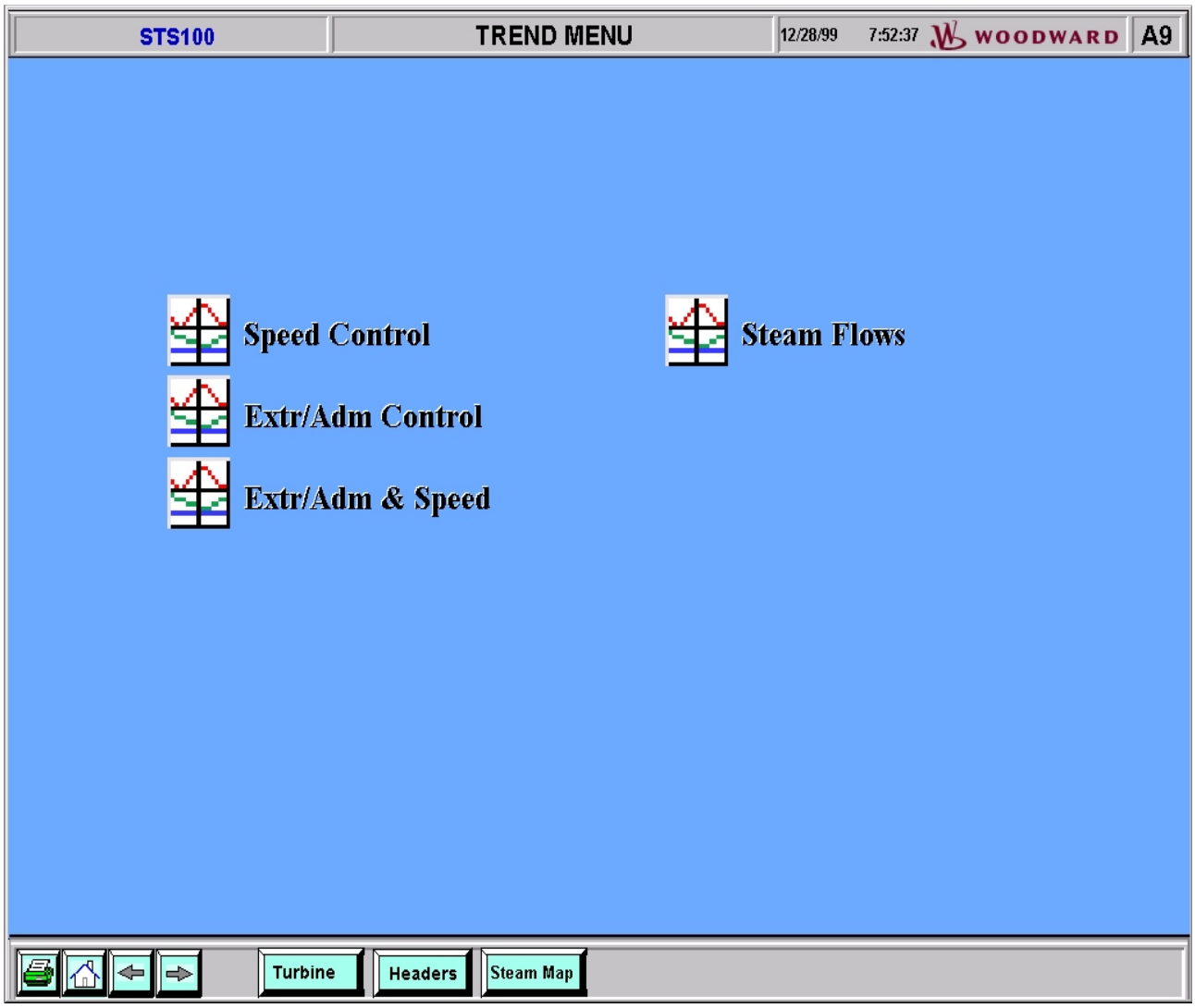
The K Constants Dialog Box above is used to determine which K Values will be used, the calculated values or the tunable values.



723 SIMULATOR page

The **723 SIMULATOR** page is used primarily as a debugging tool. It allows the user to monitor all the inputs and outputs of the 723 PLUS hardware as seen by the simulator.

TRENDING WITH THE SIMULATOR



TREND MENU page

Trends

Four typical trends have been provided on the MENU page. Up to eight analog values can be displayed on each trend page. To change a trend page please reference the Intellution On-Line Help files or the documentation provided by Intellution FIX.

SPEED TREND page

The SPEED TREND page has been shown here for your reference. Trends can be added or modified with the Intellution software. The four that have been pre-generated show the speeds and steam flows on a continuous basis.

CHAPTER 6
WATCH WINDOWS

Watchwindows Program

The Watchwindows program is a troubleshooting and debugging tool that provides a window into the simulator's application. It also is used to program the STS100s five pre-configured turbine applications. Every variable in the simulator is available through the Watchwindows program. The Watchwindows program runs on top of another Woodward program – Servlink. This means that in order for Watchwindows to run, Servlink must be running first. This section will describe the STS100 and Watchwindows interaction. For more details on the Watchwindows program, view the on-line help file.

Servlink Program

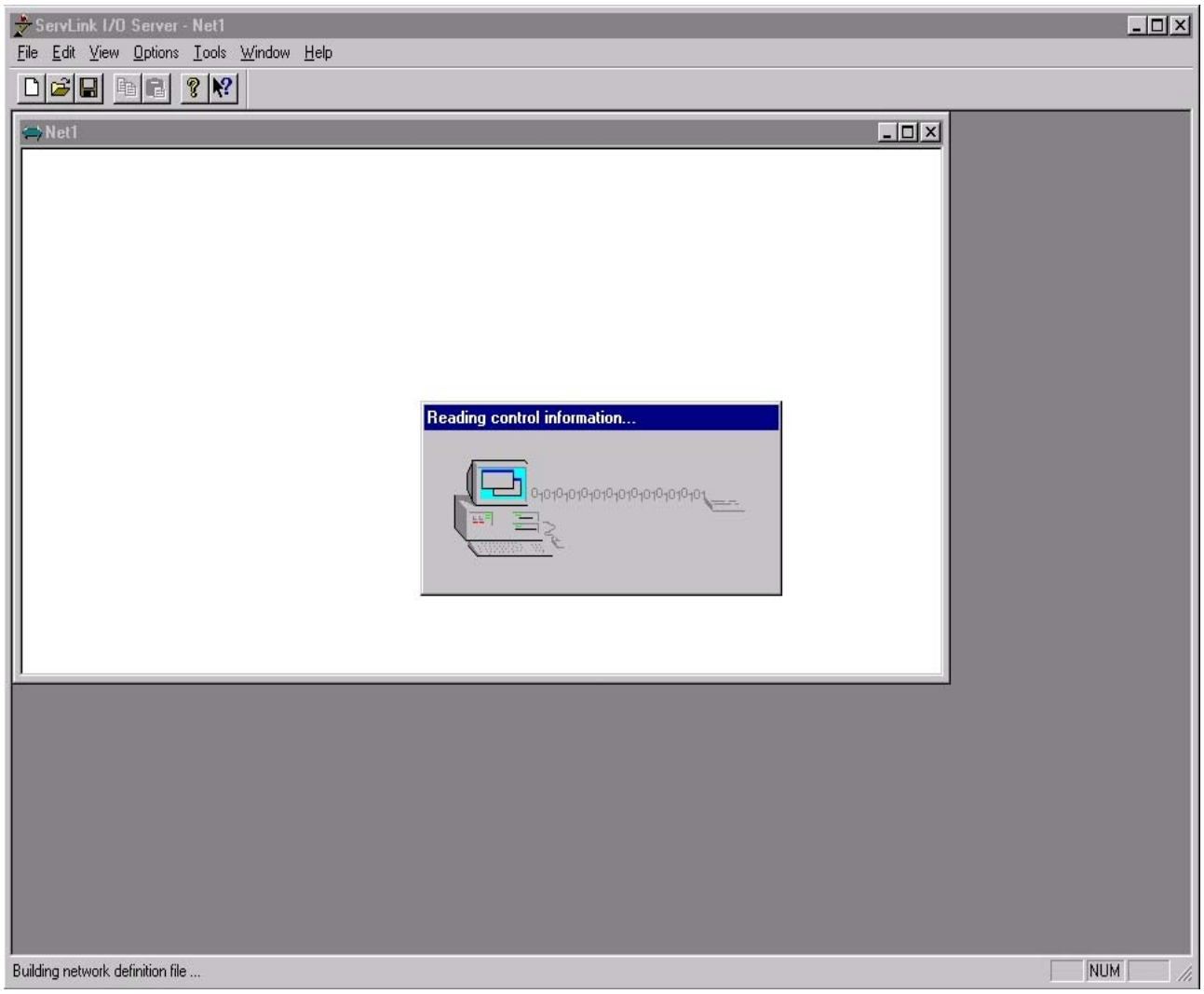
Servlink is an interface program, which directs and manages the transfer of data between the Watch Window program and the STS100 simulator. In order to start Servlink, follow the steps below.

STEP 1: If you will be using the same PC to run Servlink as the Intellution program, stop Intellution communications.

STEP 2: Connect the PC-to-Simulator RS422 cable to the port J10 of Simulator's. Using ServLink program via J10 connector, RS422, and a 5416-870 download cable.

STEP 3: From the Woodward - program group, Start the Servlink program.

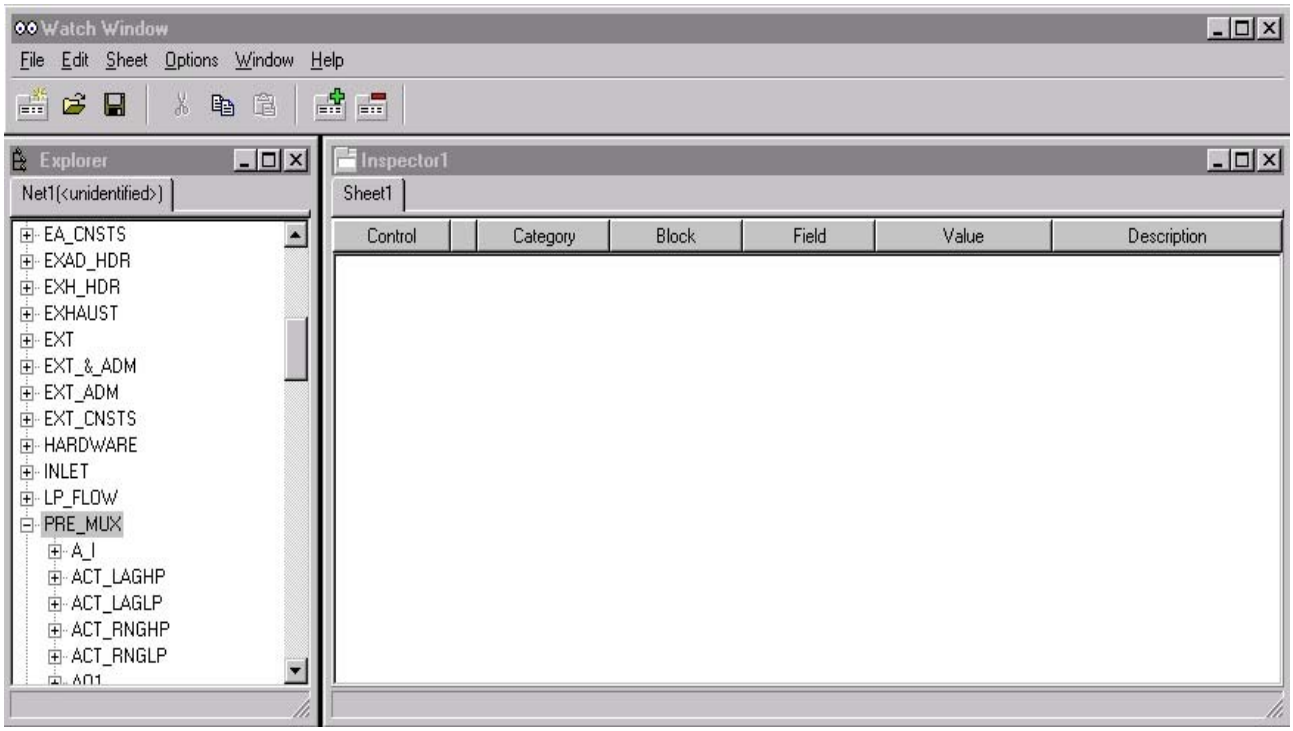
STEP 4: Within the Servlink program click on the New Page icon in the tool bar or select "NEW" under the "File" pull down menu. At this point a menu will appear to set up communications with the control. Select the communication port, that the simulator is connected to, and then click on the "OK" button. Unless otherwise directed by a Woodward representative, do not change any of the other default settings. The Default settings are: Communications Port - COM1, Mode - Point-to-Point, Baud Rate - 19200. Once the "OK" button has been selected, Servlink will access the control and build the network configuration file. The building of the network definition file may take 5 to 10 minutes. The "Reading Control information" folder will remain active until the Servlink program has finished building the configuration file. In the event that communications between the PC and the control are not working, a message will appear to that effect. Check your cable connections and verify your option selections in the above folder until the "Reading Control information" folder appears.



SERVLINK

STEP 5: Once the program has finished building the file, the new network definition file must be saved. Use the **Save As** option in the **File** pull-down menu of the Servlink toolbar to save the new file under the **"C:\Program Files\Woodward\Servlink Server"** directory. The Servlink - Net1 folder shows the new Dflt_Control_ID.NET file that has been created. It is recommended that the new file be named "Net1.net".

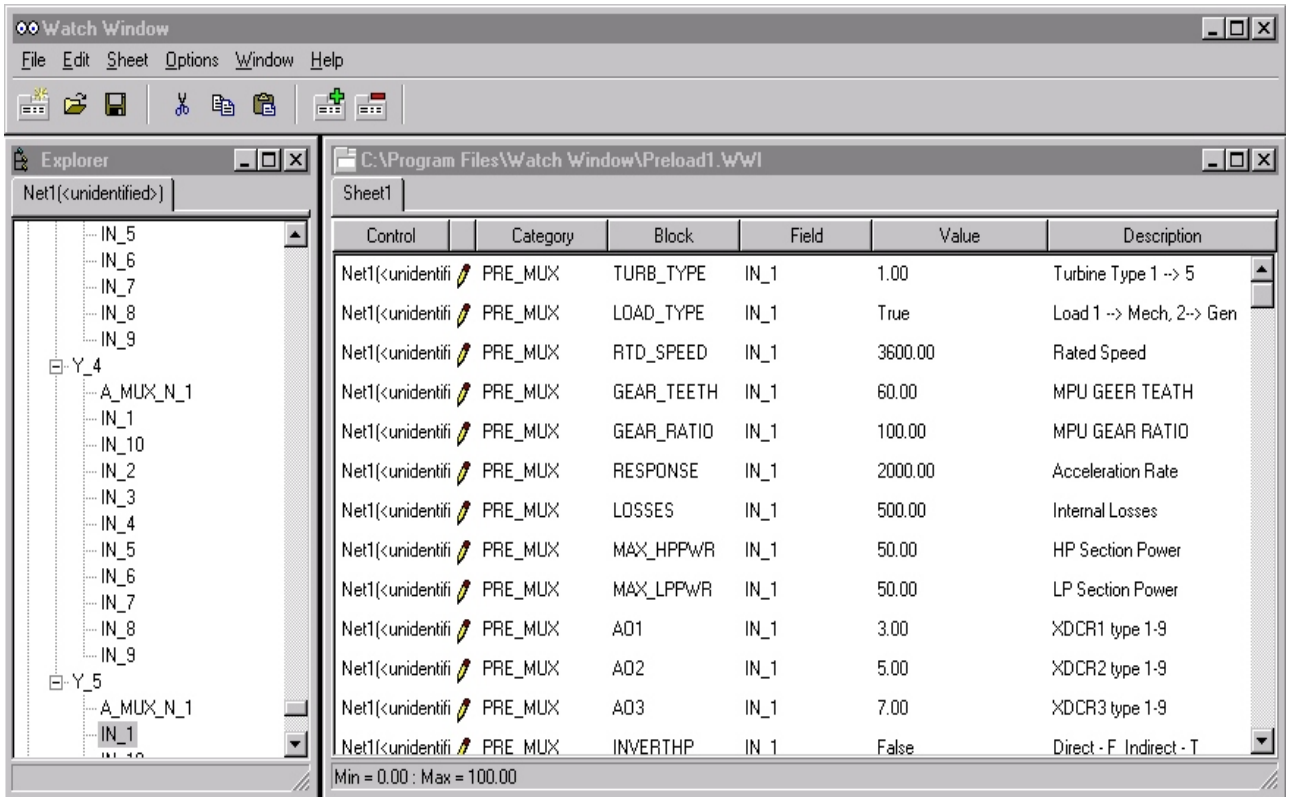
STEP 6: At this point the Servlink program is fully installed and the Watch Windows program can be opened. When the Watch Windows program is opened and a network configuration file is requested, select the new file (typically Net1.net), and the windows below should open.



WATCHWINDOWS

STEP 7: Close out the Inspector1 window by clicking on the X in the upper right hand corner of the inspector window. Do Not Close out the Watch Window window.

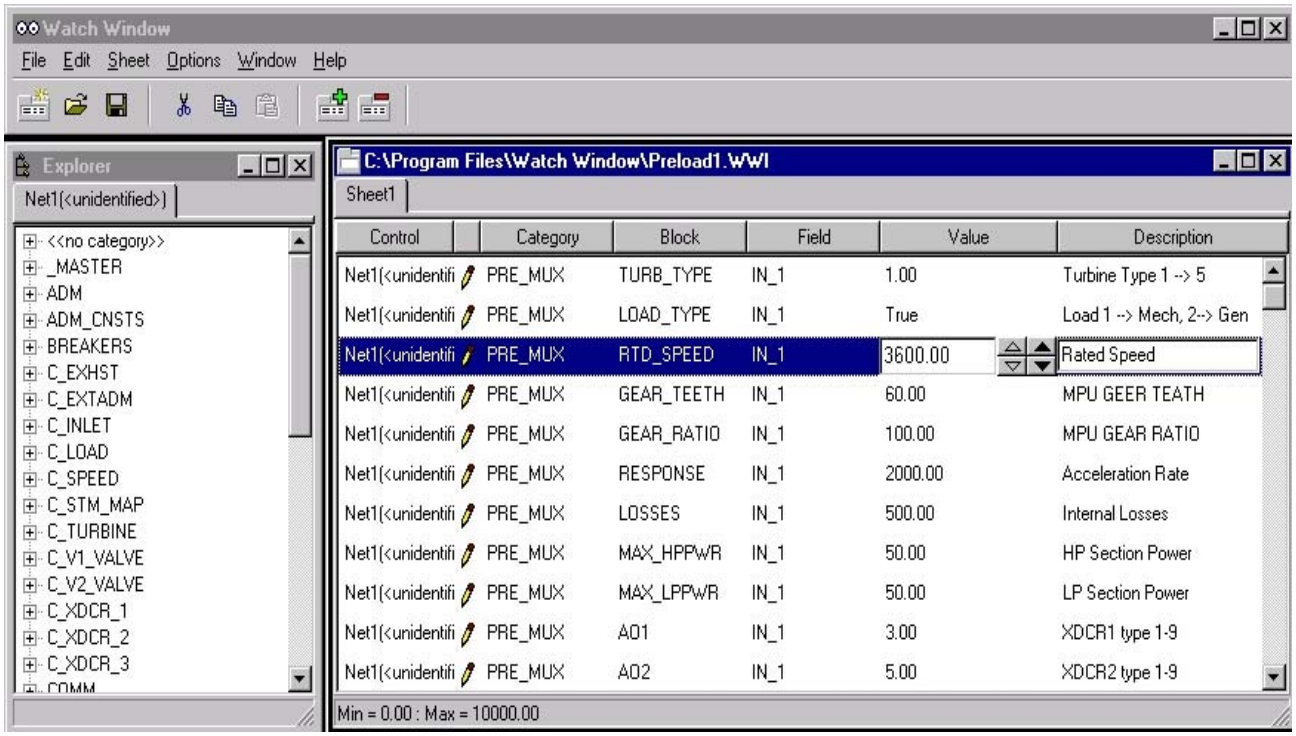
STEP 8: From the Watch Window File-Open menu open the desired pre-loaded configuration. I.e. Preload1.wwi. The window below should open.



PRELOAD TURBINE #1

Preload Calibration

In order to make a change to the pre-configured turbine application, simply select the variable, by clicking on it. And then use the arrow keys to adjust the value to the desired setting, as shown below.



VARIABLES

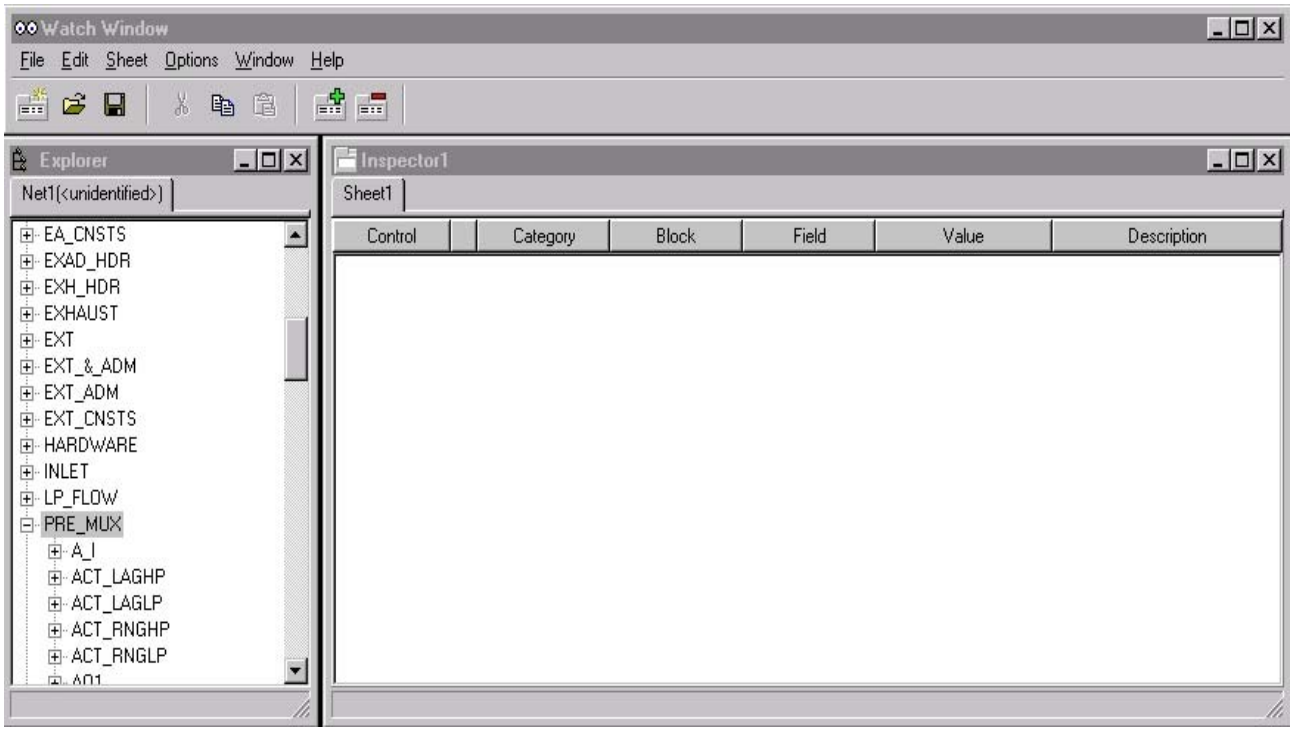
Saving Configuration

Once all changes have been made, they must be permanently saved into the STS100. To do this Watchwindows must right to the EEPROMs in the STS100.

STEP 1: Right Click on the NET1.net (unidentified) tab in the program's Explorer window, then select "Save Values" to save all changes to EEPROM.

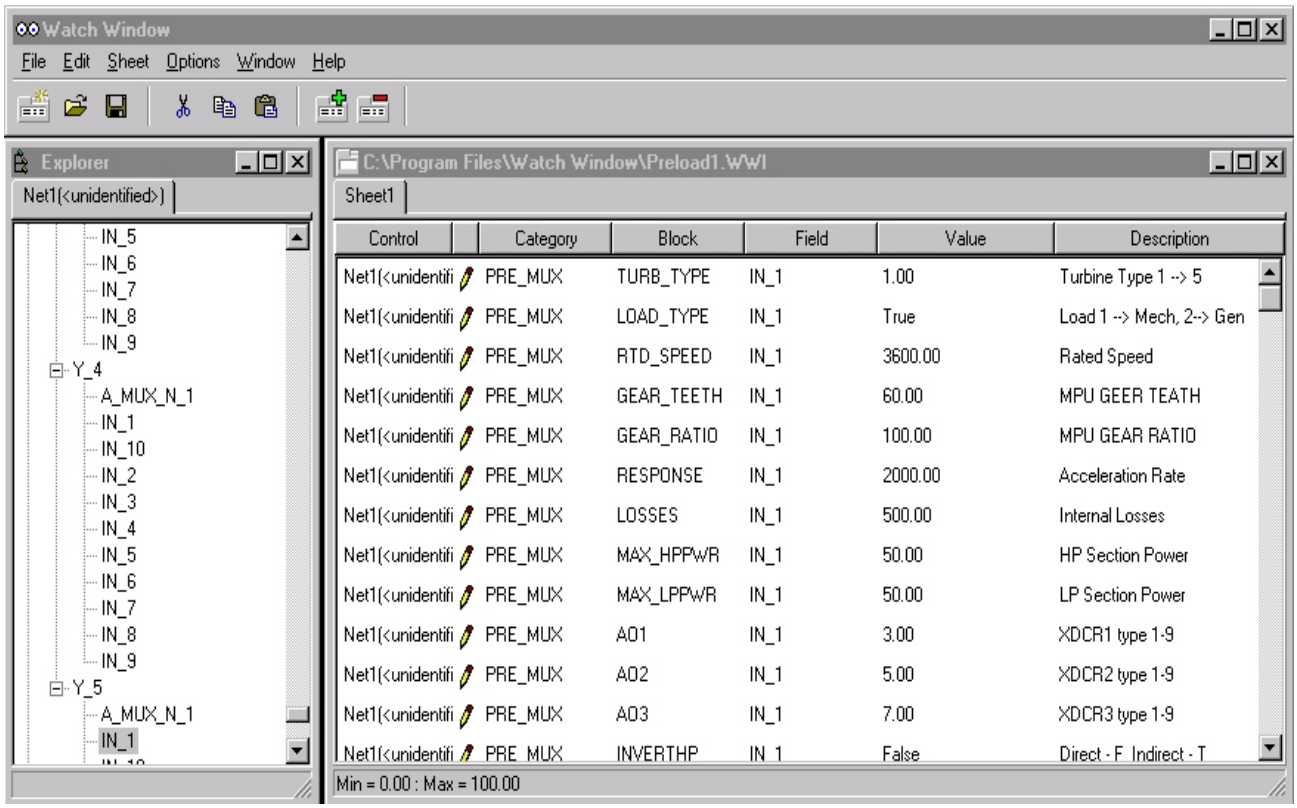
STEP 2: Close the Watch Window and Servlink programs, and move the PC-to-Simulator cable back to port J2.

From now on, whenever the **Preload Turbine #1** is selected, these changes will take effect. Similar changes can be made to the rest of the preloaded turbine applications.



Troubleshooting

Watchwindows can also be used as a troubleshooting aid. The second inspector below was created from the first above. To add variables from the Explorer window on the left, to the inspector window on the right, simply select them with the mouse and drag and drop them into the inspector window. Once all of your variables are in place, save them as your own personal "watch window". To learn more about how it can be used, view the on-line help file in the Watchwindows and GAP applications.



CHAPTER 7
SERVICE OPTIONS

PRODUCT SERVICE OPTIONS

The following are the factory options available for the service of Woodward Governor equipment:
- Replacement/Exchange (3 year warranty) (24 hour service)
- Flat Rate Repair (6 month warranty)
- Flat Rate Remanufacture (3 year warranty)

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available.
- Consult the system troubleshooting guide in this section.
- Contact Woodward technical assistance at 1-800-835-5182 and discuss your problem. In most cases your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

Replacement/Exchange

Replacement/Exchanges is a premium program designed for the user who is in need of immediate service. It allows the user to request and receive a like new replacement unit in minimum time (usually within 24 hours of the request),
providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is also a Flat Rate structured program and includes the full 3-year warranty.

This option allows customers to call in advance of a scheduled outage or an unexpected outage and request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. The customer replaces his field control unit with the like-new replacement and returns the field unit to the Woodward facility as explained later in this chapter.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. The customer is invoiced the flat rate charge at the time the replacement unit is shipped and must return the field unit to Woodward within 30 days. If the unit is not received with that time frame, the customer is invoiced the difference between the flat rate replacement/exchange charge and the current list price of a new unit.

Return Shipment Authorization Label.

To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with each and every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could become delayed and therefore additional charges may be applied.

Flat Rate Repair

Flat Rate Repair is available for the majority of standard products in the field. This program offers the user repair service for their products with the ability of knowing up front what the cost will be. All repair work carries a 180 day warranty on replaced parts and labor.

Flat Rate Manufacture

Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to the user in “like new” condition and carry with it a full 3 year warranty. This option is applicable to mechanical products only.

RETURNING EQUIPMENT FOR REPAIR

WARNING
Explosion Hazard - Do not connect or disconnect while circuit is live, unless area is known to be non-hazardous.

AVERTISSEMENT
Risque D'explosion - Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.

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

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

If any part of the control is to be returned to Woodward Governor Company for repair, attach a tag to the control with the following information:

- Name of company and location where the control is installed
- Contact name and phone number
- Complete Woodward Governor Company part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

CAUTION
To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward Governor Company Manual 82715, Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules. Packing a Complete Control

Use the following materials when returning a complete control:

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

Additional Instructions

To expedite the repair process it is recommended that a purchase order be issued with the item(s) to be repaired. No work will be undertaken until a purchase order is received. It is highly recommended to make arrangements in advance. Contact Woodward Governor Company as (800) 835-5182 for instructions.

Address, Telephone, and FAX Number

Use the following address when shipping or corresponding:
Woodward Governor Company
Industrial Controls Group
PO Box 1519
1000 E. Drake Road
Fort Collins, CO 80522-1519
TELEPHONE: (970) 482-5811 (24 hours a day)
FAX: (970) 498-3058

OTHER SERVICE FACILITIES

Contact the Woodward Governor Company, Customer Service Department for the name of your nearest Woodward distributor or service facility.

ADDITIONAL AFTERMARKET PRODUCT SUPPORT SERVICES

Woodward Governor Company Turbomachinery Aftermarket Services offers the following after sale support for all of Woodward Governor products:

- Customer Training
- Technical Assistance
- Field Service
- Specialized Services

Customer Training is offered either at our facility in Loveland, Colorado, or at the customer's site. This training, conducted by experienced trainers, will assure that customer personnel will be able to maintain system reliability and availability. For information concerning training available, call 1-800-835-5182 and ask for customer training.

Technical Assistance is available using the Woodward toll-free number. The Aftermarket Application engineering group is available to assist customer personnel with technical questions or problem solving during normal business hours or as emergency support 24 hours a day. This group can also provide engineering support for changes or enhancements after the commissioning of customer's systems. For Technical Engineering Assistance, call 1-800-835-5182 and ask for technical assistance.

Field Service engineers are dispatched from the main Woodward facility in Loveland, Colorado, or from one of many regional or worldwide offices located near the customer to provide prompt response. Woodward field engineers are experienced and are continually up-dated on all Woodward products as well as much of the non-Woodward equipment they interface with. The field engineers ensure that all documentation is updated and all field engineers are well informed as to new problems which might arise. Woodward field service engineers are on-call 24 hours a day and may be reached by calling 1-800-835-5182 and ask for field service.

Specialized Services can be tailored to the specific needs of the customer. These services can be based on a particular aspect of a single service or a combination of services and are covered under one low-cost service contract. A contract may be for regularly scheduled training courses or possibly to have a field engineer visit the customer site a pre-determined intervals to provide a system analysis, verify proper operation and make recommendations for maintenance improvements, enhancements, or other needs. These contracts are usually custom and structured to allow ultimate flexibility, thereby allowing the customer to plan and budget more accurately. For more details, contact the Woodward sales representative, or call 1-800-835-5182 and ask for sales support to discuss specific needs. For more information on Woodward aftermarket services access www.woodward.com on the Internet.

We appreciate your comments about the content of our publications.

Please send comments to:

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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.

2008/8/Makuhari