TSx Product Guide

Control solution for stand-alone or distributed turbomachinery applications

TRi-SEN
TURBOMACHINERY CONTROLS

TSx

Turbomachinery Control and Protection System

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Introduction

With unmatched performance and flexibility, the Tri-Sen TSx excels in turbomachinery control and turbomachinery safety applications. The TSx high speed distributed processors and I/O can be configured as simplex, dual redundant and triple modular redundant. Redundant Ethernet networks provide fault tolerant communications with host computers, historians and operator interface workstations.

Our NetSuites engineering toolkit provides an integrated environment for programming and configuring the controls, monitoring the operation, interfacing with operators, recording and trending data, capturing sequence-of-events data, recording high speed event data and troubleshooting system and process problems, all with a unified time base.

Hardware Architecture

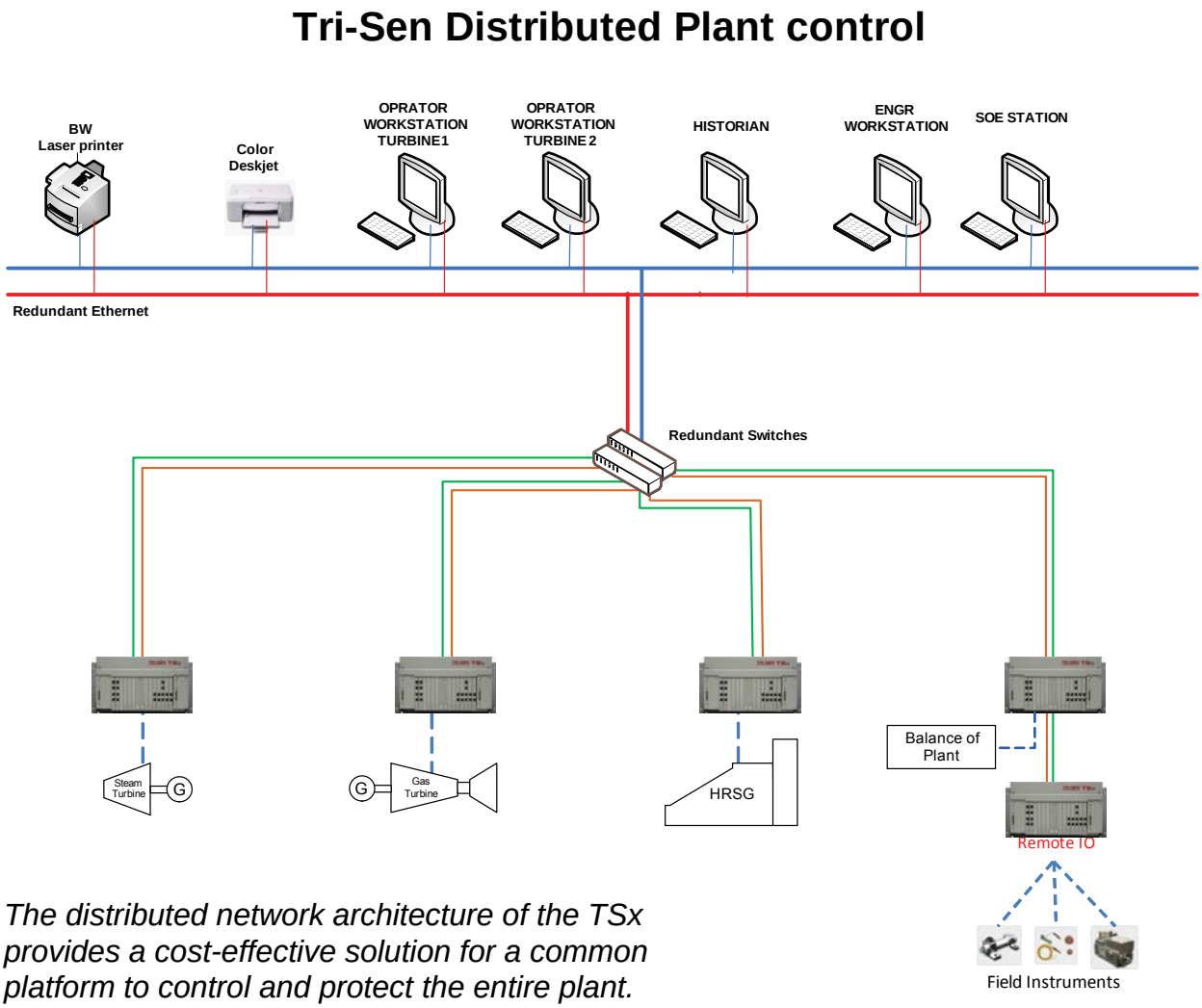
The Tri-Sen TSx employs a card-in-chassis arrangement with external termination assemblies. This arrangement provides the most concise and secure packaging of the control system. Removal and replacement of the I/O and processor modules can be accomplished without the risk of disturbing the field wiring. Chassis power is provided separately from the field power to assure that field faults will not affect operation of the logic system.

A hallmark of the TSx architecture is the ability to repair any redundant active component without interrupting the operation of the turbine or process. Processor modules in redundant systems are self-educating.

Turbomachinery applications require a number of special types of I/O, such as pulse counters, LVDT interface, temperature inputs and various voltage interfaces. The TSx is able to interface with these I/O function directly, eliminating interposing transducers that can create a single point of failure in some of the most important I/O loops of the control system.

Network Architecture

The fundamental characteristic that differentiates the TSx from a PLC-based SCADA system is the reliability of the communications. The Tri-Sen TSx networks are designed to assure that there are no single points of failure in the networks, even for simplex hardware arrangements. Additional network diagnostic features are incorporated to provide a robust network infrastructure.



The distributed network architecture of the TSx provides a cost-effective solution for a common platform to control and protect the entire plant.

I/O Network

The I/O network is managed by the Chassis Processors. Every 1 millisecond, the Chassis Processors scan all the I/O in the chassis and make the data available to the Node Processors. Sequence of Events (SOE) data is also managed by the Chassis Processors. SOE data is available with 1 millisecond resolution and time stamping from both digital *AND* analog inputs for all channels. Input data is never more than 1 ms old when the Node Processors request it from the Chassis processors. And, within 1 ms after the Node Processors deliver output data to the Chassis Processors, the new data is sent to the I/O.

Diagnostics

The very low probability of failure on demand of the TSx is due in part to the extensive level of diagnostics that are performed throughout the system. When the Node Processor is online, built-in comprehensive proof test software runs continuously without interrupting the system, assuring the readiness of the system to detect a failure. I/O bus checking diagnostics are performed for all input data, status and command transfers each time the chassis controller accesses the I/O card. Each transfer is performed twice (all the data bits in the second transfer are inverted). Both transfers are then compared to ensure that no errors exist. I/O bus slot address and control signal contention tests are also performed. Cable detection tests verify that the termination cable is properly connected to the card.

Both analog and digital outputs include independent feedback circuits for each channel to perform validation and verification of each output. For redundant input module configurations, signal validation functions can be used to validate the signal received by the node processors.

Redundancy

No other turbomachinery control system provides the flexibility of redundancy that is available with the Tri-Sen TSx. Processor modules, communication modules, I/O modules, networks and power supplies can all be supplied in the same system with the level of redundancy that suits the application. This includes the ability to freely employ

simplex, dual redundant or triplicated modules for each control or safety function. I/O redundancy can be software-defined on a point-by-point basis. An input or output can be wired to a single input point on a card, to multiple points on the same card or to different points in different chassis. Redundancy is handled by the system and is transparent to the system users.

Redundancy is important for the control and protection of critical turbomachinery and processes, but by itself does not assure success. What is most important is FAULT TOLERANCE. The Tri-Sen TSx not only provides redundancy, it is able to tolerate faults, meaning:

- Faults will be automatically identified by the TSx without the need for any user application programming to identify them.
- The redundant TSx will always continue to operate in a safe manner in the presence of a single fault (and in many cases, in the presence of multiple faults).
- All faults can be repaired without the need to shut down the machine or process that the TSx is controlling or protecting.

		Redundancy Option		
	System Component	Simplex	Dual	Triple
1.	Node Processors	✓	✓	✓
2.	Chassis I/O Processors	✓	✓	
3.	Communication Modules	✓	✓	
4.	I/O Modules	✓	✓	✓
5.	Distributed Processors	✓	✓	✓
6.	I/O Network		✓	✓
7.	Distributed Control Network		✓	✓
8.	Host Network		✓	✓
9.	Power Supplies	✓	✓	

Controller

The TSx Node Processor Card is the core component to the TSx control and protection systems. It provides a central location for communication with host computers, chassis processors, redundant node processors and node processors that are part of a different TSx system.

The node processors utilize a multi-processor (CPU) architecture. The CPU's work in parallel, each performing a specific function. At the core, a 650 MHz Intel processor with integrated floating point unit and synchronous DMA allow a 5 millisecond scan rate. The processor receives and stores the system configuration and user program files in a non-volatile flash memory. Using the data received from the Chassis Processor and the user program files, the Node Processor performs input validation and voting, converts engineering units and solves the logic.

When a new program is downloaded to the TSx or a change is made online to a running program, the NetArrays programming tool will also download a copy of the source files to the flash memory in the Node Processors. Subsequently, this file can be uploaded to the NetArrays PC, assuring that the current version is always available.

Data passed between the Node Processors and Chassis Processors is sent across a redundant I/O network using advanced CRC checking to detect faulty messages. Communication across this network is driven by redundant 100 Mbps full duplex Ethernet processors providing inter-processor and I/O communications.

Special-Function Distributed I/O

The TSx includes special function modules for measuring shaft speed and controlling servo valves. These modules can be used in a simplex arrangement, dual redundant arrangement and triple modular redundant arrangement. These modules do not use the I/O network; they interface directly with their field I/O and the Node Processors. Distributed I/O modules essentially duplicate the redundancy architecture within the cards. Distributed I/O are programmable using the same NetArrays programming tool used for the Node Processors. The distributed I/O modules scan their inputs, execute their logic and send data to their outputs in 1 millisecond. These special I/O can be programmed to perform special functions that would be difficult to accomplish with traditional controller architecture.

Distributed Processor Modules connect directly to the I/O network for interface with the Node Processors. These programmable modules execute their tasks in 1ms. The pulse module measures speed and acceleration and can detect reverse rotation. The servo control module can load share between redundant channels.

Pulse Counter Module

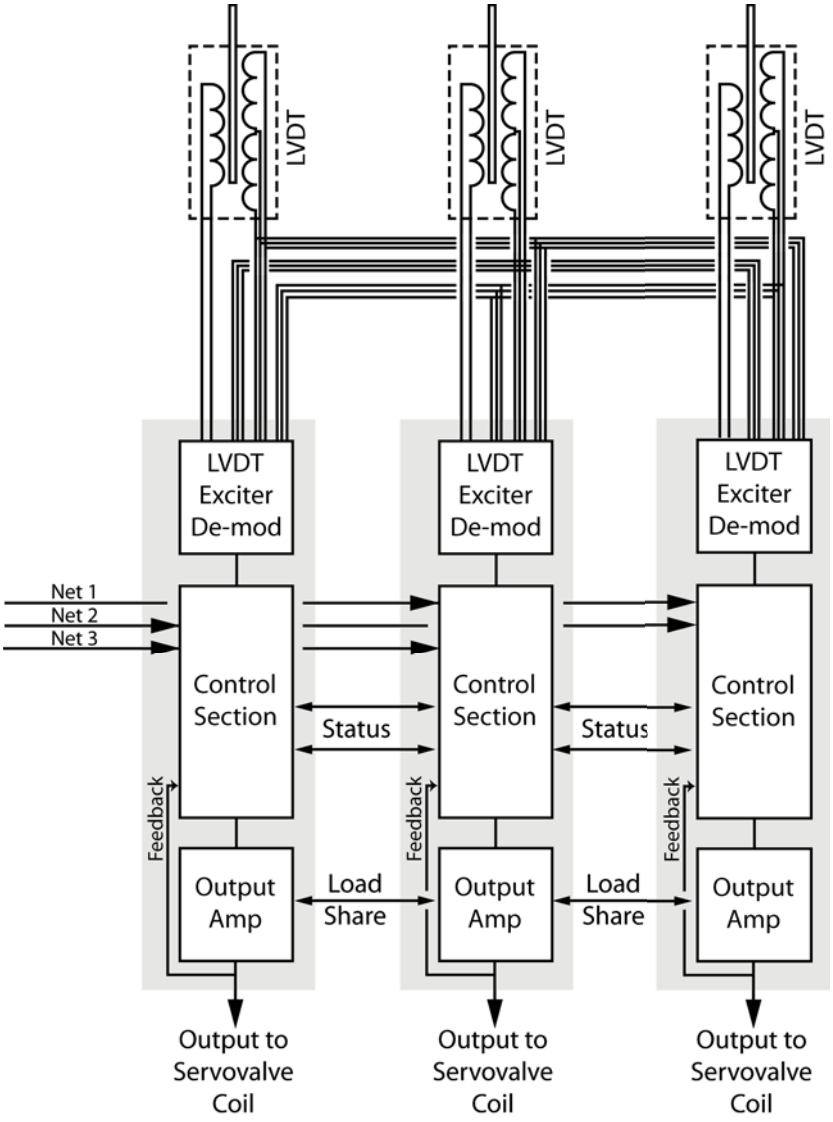
With an update time of 1 ms and 24 bit accuracy, turbine speed can be measured quickly and accurately. The eight-channel programmable module can calculate the first and second derivative of speed (acceleration and jerk), allowing TSx to accurately monitor the acceleration of the turbine and quickly react to load losses before the speed becomes excessive. An Acceleration-Compensated Trip Setpoint (ACTS) allows the turbine input energy to be curtailed well before the traditional trip setpoint is reached, drastically reducing the stresses that result from speed excursions. Eight digital inputs and eight digital output channels are included for high speed interface requirements.

A unique feature of the TSx pulse counter module is the ability to detect reverse rotation. Pump and compressor drive applications are susceptible to reverse rotation if the discharge check valve fails to seat fully when the turbine trips. Reverse rotation can damage shaft end seals and bearing, overheat the turbine and even lead to destructive overspeed if the check valve leakage is excessive. When fitted with active speed probes, the TSx can detect reverse rotation as soon as the shaft begins to turn backwards. This feature can also be used for turning gear engagement interlock logic.

Servo Controller Module

This programmable module has two output channels that can control two different servo valves or two coils in the same servo valve. Integrated feedback LVDT excitation and demodulation is included for two channels. The feedbacks can be used independently or voted to improve the input signal integrity. Outputs can operate in a load sharing arrangement for the same coil or for separate servo coils. And since the servo controller module is programmable, special functions can be included to compensate for servo valve problems, such as null deadband and non-linearities. Eight digital inputs are included on the board to allow fast reaction to load rejection events.

A unique feature of the TSx Servo Controller Module is the method used for handling redundancy. The servo controllers used by other manufactures employ a "fail-over" arrangement to handle system faults. Two or three separate controllers are arranged with independent coils and LVDT's. If any part of the LVDT-controller-coil chain fails, the entire chain is disabled. The TSx uses a "mesh" arrangement and load sharing to maximize the availability of the servo control loop. A single component failure only results in the loss of the failed component. The remaining good components continue to be used in control of the valve.



Communications

While the TSx has all the features and software to handle all aspects of a plant automation system, it is common for our system to need to communicate with external systems, such as vibration monitoring packages, host computers, plant historians and process optimizers. The TSx is available with Modbus serial, Modbus TCP/IP and OPC interfaces.

Modbus Serial Module

Our serial communications module has four ports that can each be configured in a variety of ways to suit a particular installation. Each port can be configured as a Modbus master or slave, full duplex or half duplex and RTU or ASCII mode. The interface can be either RS-232C or RS-485. Data rates can be set from 1200 baud to 115.2 kbaud.

The Modbus Serial Communication card manages all aspects of the protocol and data exchange, including message translating and formatting, message checking, responding to Modbus controllers with proper acknowledgements, error or success codes, and protocol data byte ordering. This built-in intelligence unburdens the TSx controller's processor from the responsibility of managing the Modbus network.

Modbus TCP/IP Module

The TSx Modbus TCP/IP module provides two 100 MHz Ethernet links for communications with Modbus compatible controllers. During each output transfer, the Modbus card performs a 2oo3 output validation test on the data received from the node processor across the redundant I/O communications network. This test ensures integrity of the communications channels. The card can be configured as a Modbus slave or Modbus master. It supports multiple Modbus servers, asynchronous read and write functions, a multiple outstanding read and write request queue and coil and discrete I/O formats.

OPC Server

An integrated OPC server is included to allow secure communications with external systems, such as historians, process optimizers and even Microsoft Excel. Since the OPC server is an integrated application, setup is handled in a fashion that is familiar to the NetSuites user. The tags used for the OPC application can be taken directly from the project tag data base or created directly in the OPC configurator. And any tags used in the OPC server are available for use in the operator interface environment; no special conversions are required.

I/O Types

The TSx control system platform includes a full complement of high speed I/O modules for controlling and protecting turbomachinery and processes. All inputs and outputs are updated in less than 1ms. Most of the modules are also certified for use in SIL 2 and SIL3 safety applications. Analog input and output modules use 16bit D/A and A/D conversions. Analog outputs include read-backs of the final outputs for complete validation.

Sequence of events data is available with 1ms resolution and time stamping for not only the digital inputs but also the analog inputs. Since most plants are moving away from digital inputs in favor of analog inputs, this feature provides operators and maintenance personnel with high resolution data for any upset event. Special turbomachinery I/O are available for speed measurement, reverse rotation detection, servo-valve control, shaft current/voltage detection, and generator synchronization.

I/O Type	Channels	Specifications
Analog Output	4	4-20mA, 0-20mA, -20mA to 20mA, 0-10 VDC, -10 VDC to 10 VDC
Analog Output	16	4-20mA, 0-20mA, -20mA to 20mA, 0-10 VDC, -10 VDC to 10 VDC
Digital Output	8	20VDC to 140VDC, Watchdog timer
Analog Input	8	-10 VDC to 10 VDC
Analog Input	8	-160mVDC to 160mVDC
RTD Input	8	3-wire, 4-wire, 100Ω platinum, -200°C to +850°C
Supervised DO	8	20VDC to 60VDC, output circuit testing, supervised outputs
Thermocouple In	8	Type E, J, K, N, R, S, T and B, point-by-point configurable
Relay Output	12	Non-latching sinking or sourcing relays, 24 VDC/VAC, 24-120VAC
Supervised DI	12	24 VDC, On-off state diagnostics, Proof test diagnostics
Digital Output (AC)	16	120 VAC, 240 VAC
Fault Detecting DO	16	19-30VDC, fuse protected
HART	16	HART communication protocol, non-interfering
Digital Output	24	5VDC to 125VDC, fuse protected
Fault Detecting DO	24	19-30VDC, fuse protected
Relay Output	24	5-30VDC, 24-120VAC, sinking or sourcing
Digital Input	32	24 VDC, 48 VDC, 120 VAC, 240VAC, sink or source
Analog Input	32	0-10VDC, 0-20mA
Servo controller	2	LVDT excite/de-mod, -10 to 10VDC in, -20 ot 20 mA in, +/-100mA out
Pulse Counter	8	0-30kHz, reverse rotation, count accumulator
Vibration	8	Radial displace, axial displace, phase, acceleration, velocity, buffered

Termination Assemblies

In order to provide a safe maintenance environment, the field wiring terminates on remote termination panels. This arrangement provides more efficient packaging of the system, allowing field wiring to be terminated without working around I/O hardware modules. Isolating field power for maintenance is possible with this configuration, assuring the maintenance activities can be done without disturbing the machine or process and without endangering the maintenance technician.

Safety

The TSx hardware has been third-party certified for use in SIL2 and SIL3 safety instrumented functions. This means that the safety system for the turbomachinery and the process will use the identical hardware and software that is used for the control functions, simplifying the engineering and maintenance activities.

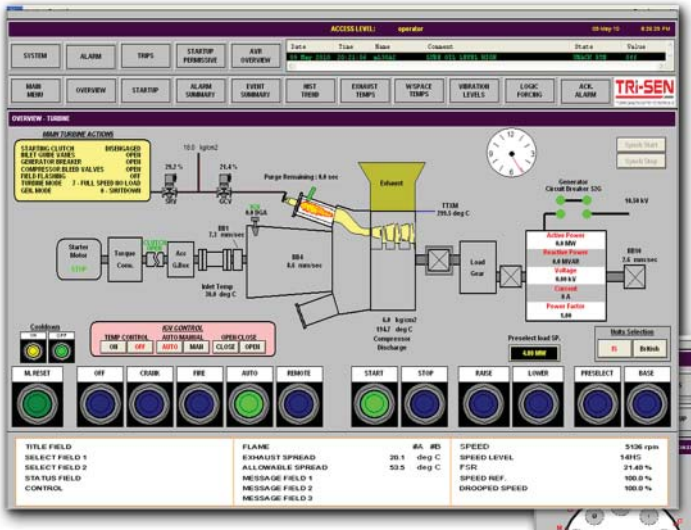
NetSuites Software

A hallmark of the TSx control system is the packaging of the software tools. All the components are included. No additional license fees are charged for the different components, and there are no restrictions on the size of the system or number of computers on which the software is installed.

Security can be managed using multiple roles with specific privileges assigned to each role. Usernames and passwords provide accountability of each user.

Operator Interface

Our View operator interface is fully integrated with the other components of the NetSuites software. The project tag data base used for configuration software (NetArrays) historian, trending package, alarm manager and event recorder is used for the operating interface screens. Building screens can be done quickly using Windows drag and drop techniques for screen objects and database tags.



Comprehensive overview screen provides operator with key operating data for normal operation. Common operator functions can be initiated without excessive navigation.

Detailed operating data are available for troubleshooting and performing special operating and maintenance functions.

Maintenance Tools

NetSuites includes several features that can be used individually for monitoring the system and the process or integrated into the View operator interface software for easy access. Alarm management can be performed using the Alarm and Data Archive (ADA) system or components of ADA can be embedded into View for ease of use. The View pages that are used by maintenance technicians can be managed and protected using the security roles built into NetSuites.

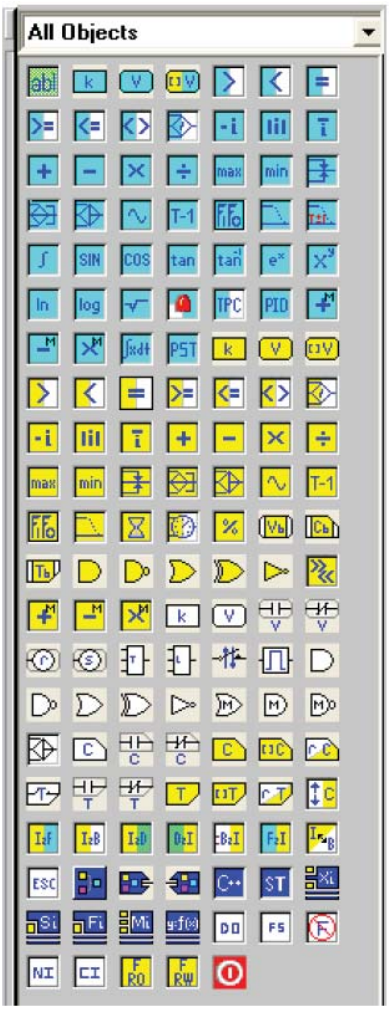
The following maintenance tools are included with all TSx systems:

- ADA – Alarm and Data Archive
- PTDBM – Project Tag Data Base Manager
- SOE – Sequence of Events
- FIFO – First In First Out High Speed Event Logger
- Report – Archive Data Report Generator
- Time Keeper – Time Synchronization for Distributed Control TSx Systems

Software Engineering Tools

NetArrays is the engineering software used for building, testing and troubleshooting application programs. As with other components of the NetSuites package, a common project database is used. The work environment complies with IEC-61131 and includes modules for function block diagrams, ladder logic, sequential flow chart, structured text, C/C+ and fuzzy logic.

A software emulator allows testing the project software without the use of the physical software. Real time instance views of the software allow easy review and troubleshooting of the application.



NetArrays is used to configure the hardware and write the control and safety programs for a new project and making modifications to an existing system. This packaged is used for downloading new applications to the hardware and making changes to an existing system, even while the machinery and process are running.

Building the logic in a NetArrays program is a matter of dragging the module object from the palette onto the program form. Graphical connections are made between the modules and tags to form the logic. Similar techniques are used to build a ladder logic program.

These logic forms are then used with the hardware simulator to run and troubleshoot the logic. When the logic is downloaded to the TSx hardware, these forms can also be used to view the operation of the program and even force values during testing and troubleshooting.

Custom, user-defined function can be created using the Structured Text editor or the C/C+ editor.

About Tri-Sen Systems

Tri-Sen Systems Corporation provides turbomachinery controls to the power and process industries with a focus on supplying high-quality, innovative control for turbines, compressors and generators. Process plants around the world rely on Tri-Sen products for steam and gas turbine mechanical drive applications and compressor anti-surge protection. For more information, please visit www.tri-sen.com.

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