

Trusted TMR Speed Monitor

Product Overview

The Trusted® T8442 TMR Speed Monitor monitors the shaft speed and acceleration of rotating machinery. It provides machine protection for over-speed and over-acceleration shutdown functions. Typical machinery applications include steam and gas turbines driving pumps, compressors and generators. A T8442 Speed Monitor Module within a Trusted System provides the capability to perform turbine speed control independent of the machinery protection functions.

System response times are often critical for these types of application. To minimize processing delays the T8442 operates as a self-contained fault tolerant control sub-system within the Trusted System environment.

Each T8442 has three monitoring and control groups. Each group provides the Speed Monitoring and shutdown control facilities required for one rotating machine. Up to three turbine trains can be handled by a single T8442. A single rotating machine group comprises of three separate Triple Modular Redundant (TMR) speed input channels and two separate quad redundant, fault tolerant output drive structures. Turbines having more than three speed pickups can be accommodated by combining monitoring and control groups.

The speed input channels are designed to interface directly with a Trusted T8846 Speed Input Field Termination Assembly (SIFTA). A single T8846 provides signal conditioning and field cable termination facilities for the nine TMR speed input channels required for three rotating machine groups. Both active and passive speed probes can be accommodated by the T8846. Active probes can be powered from the field cable termination.

The shutdown control outputs are designed to interface directly with three Trusted T8891 Speed Output Field Termination Assemblies (SOFTA). A single T8891 contains the two quad redundant, fault tolerant, volt-free contact structures required for a single rotating machine group.

The inter-connections between the Module and the Field Termination Assemblies (FTAs) are provided by a Trusted TC-801 Cable Assembly.



Features:

- Three rotating machine groups.
- Three Triple Module Redundant (TMR) speed inputs per rotating machine group.
- Active or passive probe speed inputs.
- Two quad redundant, fault tolerant, volt-free shutdown control output structures per rotating machine group.
- 2500 V impulse withstand opto/galvanic isolation barrier.
- Galvanic isolation between field Inputs/Outputs.
- On-board Sequence of Events (SOE) reporting with 1 ms resolution.
- Hot standby module configurations using companion slot.
- Hardware Implemented Fault Tolerance (HIFT).
- Front panel status LEDs indicate module health, operating mode and rotating machine group Input/Output status. Comprehensive automatic diagnostics and self-test.
- TÜV Certified IEC 61508 SIL 3.

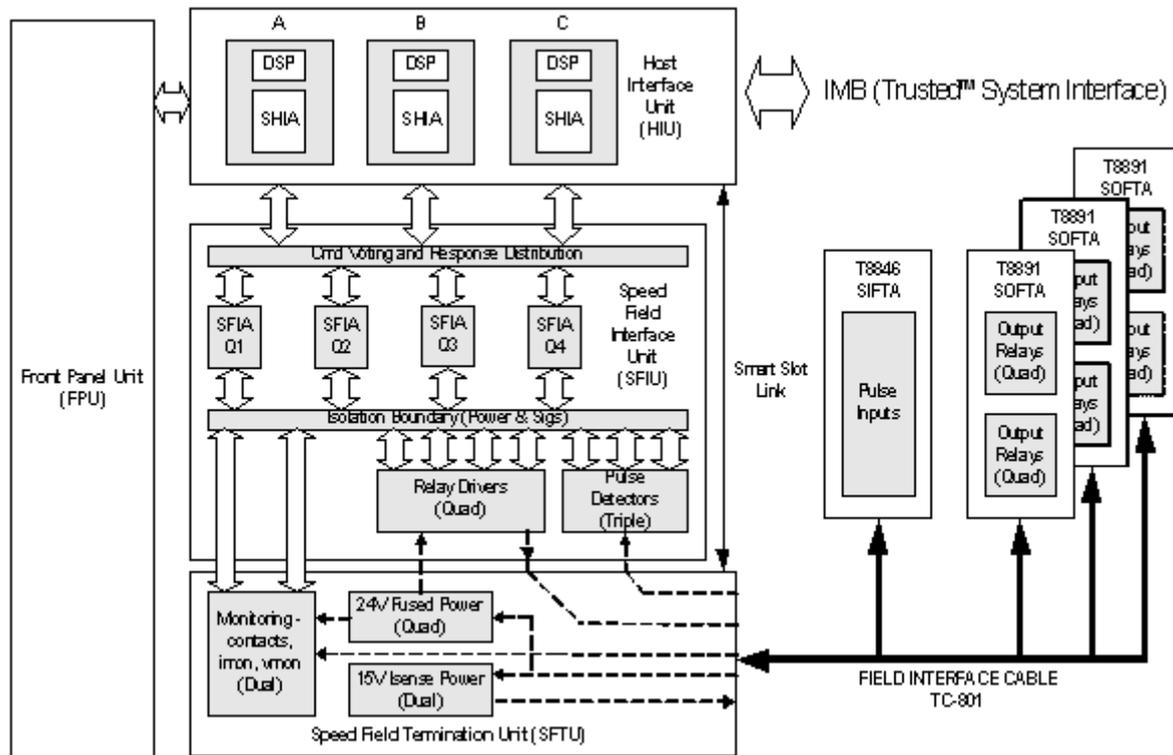


Figure 2 Functional Block Diagram

1.2.1. Host Interface Unit (HIU)

The HIU is a common hardware platform used within all Trusted series 8000 I/O Modules. It provides the fault tolerant communications, control, and processing facilities for the T8442 Module. The HIU is the point access to the Trusted Inter Module Bus (IMB). Each HIU slice is considered a Fault Containment Region (FCR) in that a fault on one slice has no effect on the operation of the other slices. All data sent to the Module from the Trusted System Processor is 2oo3 voted by each HIU slice. The HIU has housekeeping and automatic test functions. The HIU also carries out time stamping of input and output changes for Sequence of Event (SOE) recording.

The two main elements of each HIU slice are the Digital Signal Processor (DSP) and Host Interface ASIC (HIA). The DSP provides the data processing capability while the HIA provides Module specific hardware communication and voting logic between the DSP, FIU and IMB. Each HIU slice is clock asynchronous with respect to the other two slices.

The T8442 Module HIA is referred to as the SHIA (Speed Host Interface ASIC).

1.2.2. Speed Field Interface Unit (SFIU)

The Field Interface Unit (FIU) connects the HIU to the Field Termination Unit (FTU).

The T8442 Module FIU is referred to as the SFIU (Speed Field Interface Unit).

The SFIU utilizes a hybrid redundant architecture with quad-redundancy to achieve fault tolerant output control and triple-redundancy to achieve fault tolerant Speed Monitoring. The Speed Field Interface ASICs (SFIA) provide the interfaces between the HIU and the

quad/triple redundant I/O circuits and dual redundant status monitoring circuits. The SFIA circuits are galvanically isolated from the relay driver and speed input detector circuits. Redundant power supplies are used.

1.2.3. Speed Field Termination Unit (SFTU)

The Field Termination Unit (FTU) connects the FIU to the field.

The T8442 Module FTU is referred to as the SFTU (Speed Field Termination Unit).

The SFTU allows speed input signals and shutdown output signals to be routed from the SFIU to the field connector. It also converts the 24 Vdc field power supply into dual redundant ± 15 Vdc power for the SOFTA relay current sensors and quad 24 Vdc power for the SFIU relay drivers. It provides dual-redundant monitoring circuits for relay status, load status, 24 Vdc power status, and ± 15 Vdc power status. A SmartSlot link connects the SFTU to the HIU and is used to co-ordinate Active and Standby Modules during Module replacement.

1.2.4. FPU Front Panel Unit (FPU)

The FPU is a common hardware platform used within all Trusted 8000 series I/O Modules. It provides voted Front Panel status indication and Module removal detection.

The T8442 Module LED indicators provide status information for the following:

- Slice A healthy
- Slice B healthy
- Slice C healthy
- Module Active/Standby mode
- Module Educated.
- Speed Input Status (x9)
- Over-speed Output Status (x3)
- Over-acceleration Output Status (x3)

1.2.5. T8846 Speed Input Field Termination Assembly (SIFTA)

The T8846 Speed Input Field Termination Assembly (SIFTA) is an integral part of the overall T8442 Speed Monitor System. It is DIN rail mounted, containing passive signal conditioning, power distribution and protection components.

1.2.6. T8891 Speed Output Field Termination Assembly (SOFTA)

The T8891 Speed Output Field Termination Assembly (SOFTA) is an integral part of the overall T8442 Speed Monitor System. It is DIN rail mounted, containing two fault tolerant,

The quad redundant relay architecture provides fault tolerant control of the volt-free output and allows a single relay to be tested without disturbing the load. ISENSE and CONTACT data from the SOFTA is analyzed to determine if each relay is operable and if a load is connected (de-energize to trip only). ISENSE is an analogue signal that represents the load current in each relay leg (of the quad-voted output). CONTACT is a digital signal that pulses during a change of state of any relay within a speed group. ISENSE and CONTACT are processed via dual-redundant circuits. The relay circuits are powered via dual redundant 24 Vdc field power, and dual redundant ± 15 Vdc power is provided to the current sensors on the SOFTA.

The triple redundant speed input architecture provides fault tolerant sensing of rotational speed and acceleration. These circuits receive transformer-coupled power from their associated SFIU quadrant. A test enable from the SFIA causes the speed input to enter self-test mode.

1.3.1. SFIU

The SFIU assembly contains the following circuits:

- **Resistor Isolation**
The interface to the HIU contains resistor isolation to limit the current flow between TMR/QUAD fault containment regions during a power transition or over-voltage fault.
- **SFIA (Speed Field Interface ASIC) & Power Circuits**
The SFIA votes and processes HIU command packets and distributes response packets to all three HIU slices. Decoded coil commands are provided to the relay drive circuits. Relay monitor data and speed input data are processed and provided to the HIU. The power circuits provide fault tolerant ORed HIU power for the SFIA and isolated power for the pulse detectors.
- **Galvanic Isolation**
The SFIU provides a 2500 V impulse withstand galvanic isolation barrier between the SFIA and the field circuits for power and digital signals.
- **Pulse Detectors**
The pulse detectors provide signal conditioning (amplification and threshold detection) for the speed input signals. Each pulse detector is able to replace its speed input signal with a test excitation signal when commanded by the SFIA.
- **Relay Drives**
The relay drive circuits provide the interface between the SFIA and the 24 Vdc relay coils. Each drive circuit provides a diagnostic signal back to the SFIA, indicating the status of the relay coil.

1.3.2. SFTU

The SFTU assembly contains the following circuits.

- **ISENSE Power**
These circuits convert the dual-redundant 24 Vdc field power into dual redundant ± 15 Vdc power for the current sensors on the SOFTA.
- **Fused Power**
These circuits provide independent wire-ORed and fused 24 Vdc power to each of the relay drive quadrants and the two relay monitor quadrants.
- **Relay Monitors**
These circuits provide dual-redundant multiplexing and signal encoding for the ISENSE and CONTACT signals, 24 Vdc field power monitor, and ± 15 Vdc ISENSE power monitor. The encoded data is provided to the SFIA.
- **Field Connector**
The field connector provides the external interface to the SIFTA and SOFTA(s).

1.3.3. SIFTA

Each T8442 Speed Monitor Module hot swap pair requires a single T8846 SIFTA when installed in a Trusted System.

The SIFTA has nine identical speed transducer signal conditioning circuits arranged as three groups of three.

Each of the three groups is an isolated entity, with its own field power and I/O signal interfaces.

A single transducer signal on the SIFTA is taken to three monitoring circuits on the T8442. A fault causes that transducer to fail safe.

Multiple sensors must be employed for SIL 3 applications.

The input transducer fault containment region contains the SIFTA and field cable. It extends from the transducer to the Module/field cable interface.

1.3.4. SOFTA

A single SOFTA assembly provides the relay switching elements for one over-speed output and one over-acceleration output.

A T8442 Speed Monitor Module interfaces with three SOFTA assemblies.

For each output channel, an isolated Hall Effect current sensor is connected in series with each of the two parallel contact switching paths. The outputs from these sensors connect to the T8442 SFTU via the field interface cable and are used for relay contact diagnostic and fault detection purposes.

Force guided contact, safety relays are used on the assembly. The physical properties of these relays verify that welded primary contacts can be detected by monitoring the auxiliary contact status signal. This status signal is passed back to the T8442 SFTU via the field interface cable for diagnostic and fault detection purposes.

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If the 3-2-0 button is selected, the group input degradation will be configured as 3-2-0. In this mode, operation with a single sensor is not possible. The over-speed and over-acceleration outputs will both trip when only one sensor remains available to the group.

If the 3-2-1 button is selected, the group input degradation will be configured as 3-2-1. In this mode, operation with a single sensor is possible. The over-speed and over-acceleration outputs will both operate normally with only one sensor available to the group.

The default mode of operation is for 3-2-0 degradation.

The configuration will appear in the Speed Monitor Configuration Speed Monitor template as:

```
NO_DEGRD <group> <0|1>
```

A value of 0 indicates 3-2-0 degradation mode.

3.1.19. Over-speed Test Timeout

This field can be set globally for the Module. (see also, over-speed test limit 3.1.4)

The input value configures the maximum time period in minutes that a group can remain in over-speed test mode.

If an over-speed test is initiated and an over-speed or zero speed event fails to occur within the configured time limit, the group will be automatically removed from over-speed test mode and the normal over-speed threshold will be restored for that group.

The range of values that can be used for this field are 0 to 120.

The default timeout value is 0 minutes.

The configuration will appear in the Speed Monitor Configuration Speed Monitor template as:

```
OST_TOUT <minutes>
```

3.1.20. Relay Test Selector

This selector field can be set globally for the Module.

The selection in this field configures the behavior of the automatic relay tests.

There are three behavior types:

- Automatic relay testing disabled.
- A test time interval may be selected. Relay contact transition tests are performed on each quadrant of the output structure at the interval specified. Background coil testing is enabled in this mode.

- Only relay coil testing enabled. Relay contact transition tests are not performed in this mode.

Table 4 shows each of the behaviors available for selection.

The time intervals available for selection determine the configured rate at which the output relay quadrants are automatically tested.

The default behavior is for automatic relay testing to be disabled.

Number	Relay Test
0	All automatic relay testing is disabled.
1	Relay quadrant test interval = 37.2 days Relay coil testing is enabled.
2	Relay quadrant test interval = 18.6 days Relay coil testing is enabled.
3	Relay quadrant test interval = 9.30 days Relay coil testing is enabled.
4	Relay quadrant test interval = 4.65 days Relay coil testing is enabled.
5	Relay quadrant test interval = 2.33 days Relay coil testing is enabled.
6	Relay quadrant test interval = 27.9 hrs Relay coil testing is enabled.
7	Relay quadrant test interval = 14.0 hrs Relay coil testing is enabled.
8	Relay quadrant test interval = 6.98 hrs Relay coil testing is enabled.
9	Relay quadrant test interval = 3.48 hrs Relay coil testing is enabled.
10	Relay quadrant test interval = 1.74 hrs Relay coil testing is enabled.
11	Relay quadrant test interval = 52.4 min Relay coil testing is enabled.
12	Relay quadrant test interval = 26.3 min Relay coil testing is enabled.

Number	Relay Test
13	Relay quadrant test interval = 13.1 min Relay coil testing is enabled.
14	Relay quadrant test interval = 6.54 min Relay coil testing is enabled.
15	Relay quadrant test interval = 3.27 min Relay coil testing is enabled.
16	Relay quadrant test interval = 1.64 min Relay coil testing is enabled.
17	Only relay coil testing enabled. The relay contacts will not be exercised.

Table 4 Relay Test Interval

The configuration will appear in the Speed Monitor Configuration Speed Monitor template as:

RLY_T_TIME <number>

See Table 4 for reference to <number>. The default value is 0 (disabled).

3.2. IEC 61131 Toolset Complex Equipment Definition

This section details the Speed Monitor application interface as seen through the IEC 61131 TOOLSET. Figure 6 shows a view of the I/O connection screen with one TMR Processor and one Speed Monitor installed.

As shown in the figure, the T8442 Speed Monitor I/O Complex Equipment Definition includes ten I/O boards, referenced by rack number (See Table 5):