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Automation, Software and Information Technology

**Test report about the approval of the
safety-related automation devices
Trident Version 1.5.1
of Invensys Systems, Inc. - Triconex**

**Report-No.: 968/EZ 101.06/08
Date: 2008-04-25**

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Trident Version 1.5.1
of Invensys Systems, Inc. - Triconex**

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Test object: Trident Version 1.5.1

Customer/Manufacturer: Invensys Systems, Inc. - Triconex
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Order-No./Date: 120661 dated 2007-05-22

Test Institute: TÜV Rheinland Industrie Service GmbH
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Inspector: Dipl.-Ing. Andreas Hesse
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Test location: see Test Institute

Test duration: October 2007 - April 2008

The test results are exclusively related to the test samples.

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Appendix A: Trident Approved Components List

1. **Scope**

Scope of this approval is the safety related programmable system Trident Version 1.5.1, which is related to component changes on existing I/O modules.

This approval shall show that the modified modules are still suitable for risk reduction up to SIL 3 in accordance to IEC 61508 [1].

As a consequence that some standards of the previous type approval [R2] have been withdrawn or superseded the modified I/O modules were approved in accordance to the standards listed in chapter 2.

2. **Standards forming the basis for the requirements**

Functional Safety

- [1] IEC 61508:2000, parts 1 - 7
Functional safety of electrical/electronic/programmable electronic safety related systems

Application specific Standards

- [2] IEC 61511:2004, parts 1 - 3
Functional safety - Safety instrumented systems for the process industry sector
- [3] ANSI/ISA S84.01:2004
Application of safety instrumented systems for the process industry
- [4] EN 50156-1:2004
Electrical Equipment for Furnaces
Part 1: Requirements for Application Design and Installation
- [5] NFPA 85:2007
Boiler and Combustion Systems Hazards Code

Electrical Safety and Resistance Against Environmental Conditions

- [6] EN 50178:1997
Ausrüstung von Starkstromanlagen mit elektronischen Betriebsmitteln
- [7] IEC 1131-2:1992
Programmable Controllers
Part 2: Equipment requirements and tests
- [8] EN 61131-2:1994
Programmierbare Steuerungen
Teil 2: Betriebsmittelforderungen und Prüfungen
- [9] IEC 61131-2:2003
Programmable Controllers
Part 2: Equipment requirements and tests

3. Identification of the test object

Object of this approval is the Trident Version 1.5.1 as described within the Engineering Project Plan [D2]. This Trident version is related to component changes on the following I/O modules:

Name	Model	Description	PCB Rev.		FPGA Rev.		Firmware Rev.
DI	3301	Discrete Digital Input module 24 V DC, 24 points	7400300-020 A	7400297-030 B	0C	16	Build 213
DO	3401	Discrete Digital Output module, 24 V DC, 16 points	7400301-030 A	7400297-040 B	08	16	Build 213
AI	3351	Analog Input module, 24 V DC, 32 points	7400298-010 C	7400297-010 B	02	16	Build 213
AI-DI	3361	Analog Input / Digital Input Combination module 24 V DC, 16 DI, 16 AI points	7400298-020 C	7400297-010 B	02	16	Build 213
RO	3451	Solid State Relay Output module 24 V DC, 32 points	7400302-310 A	7400297-050 B	03	16	Build 213
PI	3381	Pulse Input module, 6 points	7400216-100 B	7400297-060 B	12	16	Build 213
AO	3481	Analog Output module, 4-20 mA, 4 points	7400191-100 C	7400297-020 B	25	16	Build 213
AO	3482	Analog Output module 4-20 mA (2 points) + 4-40 mA (2 points)	7400191-200 C	7400297-020 B	25	16	Build 213

All modules are based on the existing and approved modules [R2]. The modification is related to hardware component changes on the modules without changes to the functionality itself.

The firmware of the system is unchanged to the approved version [R6].

This above listed modules have been tested and verified by the manufacturer to be used within the previous Trident releases v1.2, v1.3, v1.3.1, v1.4, v1.4.1 and v1.5 [D7 - D11].

The above listed firmware build numbers reflect the actual firmware revision of Trident v1.5 release. Earlier Trident builds have different compatible firmware revisions and are listed within [D17].

The compatible version [D18] of the Trident programming tool TriStation 1131, V4.3 (Application Development Workstation) Build 505 and Enhanced Diagnostic Monitor (EnDM) V2.1 Build 153 were already part to the review during the approval [R8].

3.1 Documentation by the manufacturer

The Table 1 contains the documentation plan and top level documentation. The complete development documentation have been delivered by the manufacturer on a CD-ROM [D14] and was archived by the Test Institute.

Table 1: Manufacturer documentation

No.	Document
D1	Documentation plan, Excel-Sheet, (Trident IEC 61508-3 Figure 4.xls), dated March 28, 2008
D2	Trident V1.5.1 Engineering Project Plan, 9100111-004, v1.1, dated July 26, 2007
D3	Trident V1.5.1 Hardware Module Change Description, 9100132-004, v0.2, dated August 27, 2007
D4	Trident V1.5.1 Change and Impact Analysis, 9100180-001, v2.0, dated January 15, 2008
D5	Trident V1.5.1 Test Impact Analysis, 9600209-004, v1.1, dated February 11, 2008
D6	Trident V1.5.1 Verification and Validation Plan, 9600208-003, v1.2, dated September 17, 2007
D7	Trident v1.2 System Release Definition, 6200096-006, v1.1, dated March 12, 2008
D8	Trident v1.3 System Release Definition, 6200096-007, v1.2, dated March 12, 2008
D9	Trident v1.3.1 Software Release Definition, 6200096-012, v1.1, dated March 11, 2008
D10	Trident v1.4.1 Software Release Definition, 6200096-015, v1.1, dated March 12, 2008
D11	Trident v1.5 Software Release Definition, 6200096-014, v1.2, dated March 12, 2008
D12	Trident v1.5.1 System Verification and Validation Test Report, v1.0, dated February 26, 2008
D13	Trident v1.5.1 Documentation CD-ROM, dated March 8, 2008
D14	Trident v1 Safety Consideration Guide, 9720096-002, September 2007
D15	Trident Technical Product Guide, 9791029-006, June 2007
D16	Trident Planning and Installation Guide, 9700070-008, September 2007
D17	Product Release Notice for Trident v1.0-1.5, 9792110-001, v4, dated October 2007
D18	Product Release Notice for TriStation 1131 v4.0-4.4, 9792114-001, v7, dated April 2008

3.2 Documentation by the Test Institute

Previous type approval test reports

No.	Document
R1	Report-No.: 968/EZ 101.00/00 dated 2000-02-17, Type approval of Trident Version 1.0, TÜV Anlagentechnik GmbH
R2	Report-No.: 968/EZ 101.01/02 dated 2002-03-12, Type approval of Trident Version 1.2, TÜV Anlagentechnik GmbH
R3	Report-No.: 968/EZ 101.02/07 dated 2007-03-29, Approval of Trident Version 1.3.1, TÜV Rheinland Industrie Service GmbH
R4	Report-No.: 968/EZ 101.03/07 dated 2007-06-25, Approval of Trident Version 1.4, TÜV Rheinland Industrie Service GmbH
R5	Report-No.: 968/EZ 101.04/07 dated 2007-09-28, Approval of Trident Version 1.4.1, TÜV Rheinland Industrie Service GmbH
R6	Report-No.: 968/EZ 101.05/07 dated 2007-10-23, Approval of Trident Version 1.5, TÜV Rheinland Industrie Service GmbH
R7	Report-No.: 968/EZ 504.00/08 dated 2008-01-25, Environmental and EMC tests of Trident Version 1.5.1, TÜV Rheinland Industrie Service GmbH
R8	Report-No.: 968/EZ 105.11/08 dated 2008-04-01 Approval of Tricon Version 10.4, TÜV Rheinland Industrie Service GmbH

4. Tests and test results

4.1 General

The measuring and test equipment, which has been used by the TÜV Rheinland Group in the tests described in the following, is subject to regular inspection and calibration. Only devices with valid calibration have been used. The devices used in the various tests are recorded in the inspector's documentation.

All considerations concerning uncertainty of the measurements, so far applicable, are stated in the inspector's documentation, too.

In cases where tests have been executed in an external test lab or in the test lab of the manufacturer and where the results of these tests have been used within the here documented approval, this has occurred after a positive assessment of the external test lab and the achieved test results in detail according to the Quality Management procedure QMA 3.310.05.

4.2 Inspection of the safety concept

The safety concept of the Trident system is unchanged compared to the existing type approval. The description and results are listed in [R2] are still valid.

4.3 Inspection of the Functional Safety Management

The inspection of the Functional Safety Management has been carried out on product level. The modifications to I/O modules were made considering the requirements of IEC 61508 [1]. The development was done following the safety lifecycle of IEC 61508 [1].

The development lifecycle follows a well defined and hierarchical process and was assessed by the Test Institute.

Inspections and assessment have been performed during a review meeting within the manufacturer facilities and under consideration of the review results of the provided manufacturer documentation.

Results

The development lifecycle was inspected considering the requirements of Functional Safety Management of IEC 61508 [1]. The assessment has shown that the development was done in compliance of IEC 61508 [1] and was finished with a positive result.

4.4 Inspection of the documentation

The documentation as listed in chapter 3.1 have been reviewed considering completeness, consistency and conformity in accordance to the IEC 61508 [1].

In detail the following items were considered during the inspection of the documentation:

- accuracy and consistency
- comprehensibility
- suit of purpose for the intended topic
- accessibility and maintainability

Results

The inspection of the documentation has been finished with a positive result.

4.5 Inspection of the measures for fault avoidance

The manufacturer has established a quality assurance system, which complies with the safety lifecycle requirements of IEC 61508 [1]. The implemented measures to avoid failures have been inspected during several Functional Safety Assessments (FSA) within the manufacturer facilities in Irvine, USA. The application and effectiveness of the measures to avoid failures during the safety lifecycle have been assessed.

Appropriate measures for failure avoidance have been chosen for Trident Version 1.5.1.

Result

The inspection was finished with a positive result.

4.6 Inspection of the measures to detect and control faults

The measures to detect and control faults implemented in the Trident System components are unchanged from the previous approvals [R2].

The measures to detect and control faults have been reviewed based on the change description [D3, D4].

Result

The results of the previous approval are still valid [R2].

4.7 Review of the hardware changes

The component changes on the modules were analyzed by the manufacturer within a change and impact analysis [D3] and have been part of the review.

A major change common to all modules is the re-design of the IO Controller board which is shared for all I/O modules. These changes are related to the implementation of the field board FPGA functionality into a common FPGA on the IO Controller board of the module. The FPGA on the controller board was already present on the original design [R2] but was exchanged by a new FPGA type .

Due to the modification above the FPGA design has been changed.

The modifications have been tested by automated fault insertion test for each I/O modules. Further the Verification and Validation test have been performed based on the Verification and Validation plan [D6].

The Main Processor module (MP) and the Communication module (CM) are unchanged.

Result

The inspection of the hardware modification was finished with a positive result.

4.8 Review of the software changes

No changes have been carried out to the firmware of the Trident system.

Result

The results of the approval [R6] remain valid.

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4.9 Inspection of the TriStation and EnDM changes

No changes have been carried out to the TriStation programming environment TS1131 and the Enhanced Diagnostic Monitor EnDM V2.1 based on the approval in [R8].

Result

The results of the approval [R7] remain valid.

4.10 FMEA and fault insertion testing

The FMEA and FMECA for each module [D13] were carried out by the manufacturer and are based on the existing analysis performed for the I/O modules.

Automatic Fault Insertion Testing was performed by the manufacturer and the results were provided [D13].

Result

The inspection of the FMEA was finished with a positive result. The results of the fault insertion tests did not show any safety critical deviation.

4.11 Reaction time

System reaction time of the Trident safety system is not affected by the changes on the I/O boards.

4.12 Inspection of the reliability data and PFD calculation

The calculation of the reliability data and PFD values has been performed by the manufacturer based on the FMEA documents [D13]. The basic failure rates were computed using the Parts Count Method of the Bellcore, Issue 6 Model. The results of the PFD calculation of the I/O modules [R2] have been used as a basis and have been updated corresponding to the modification.

Result

The review has shown that the Trident System still fulfils the requirements for risk reduction claiming SIL 3 in accordance to IEC 61508.

4.13 Inspection of the environmental testing and EMC

All tests according to IEC 61131-2 [9] have been performed in the facilities of the Test Institute and are documented in a separate report [R7].

The Main Processor (MP), model 3101 and the Communication Module (CM), model 3201 have not been part of the tests in [R7]. Both modules have been tested in accordance to [7, 8] during the previous type approval [R2]. The result of this approval remains valid.

During and after the environmental and EMC tests some changes occurred to the FPGA code or PCB boards. Those changes have been analyzed by the manufacturer in [D4]. Analysis have been performed and evaluated for impact to the finished Environmental and EMC tests. The review of the minor changes were concluded to have no influence on the performed tests.

Result

All tests have been finished with positive results.

4.14 Inspection of electrical safety

There are no changes to the general architecture of the Trident system which could have an effect on electrical safety. The devices are powered and connected with operating voltages of SELV/PELV (safety class III), electrical hazards to persons can not occur.

Result

The electrical safety is still given.

4.15 Application specific requirements

The compliance to the requirements of the application standards as listed in chapter 2 have been reviewed by the Test Institute.

Requirements according to EN 50156-1

The EN 50156-1 [4] lists beside the application specific requirements also system specific requirements which are in accordance with IEC 61508. Therefore, the system specific requirements are fulfilled.

Requirements according to IEC 61511

The Trident system fulfils the requirements for safety integrity level 3 in accordance with IEC 61508 [1]. Hence, the system can be used within the scope of IEC 61511 [2]. Further it can be used within the scope of ANSI/ISA S84.01 [3].

Requirements according to NFPA 85

The Trident System meets the applicable requirements for logic solvers as defined by the application standard NFPA 85 [5]. The test results were positive and are documented in the inspectors documentation.

Result

The review was finished with positive result and the Trident System is still suitable to be used for applications based on the application specific standards listed in section 2.

5. Summary

The approval of the Trident Version 1.5.1 has shown that the Trident System still can be used in applications up to SIL 3 in accordance to IEC 61508 [1].

For the use of the system the actual Safety and User Guidelines [D14 - D18] released by Triconex must be considered. In addition to the requirements and constraints of this guidelines the related application specific standards have to be taken into account while realizing and commissioning of the application.

The actual valid hardware and software versions should be retrieved from the currently valid module and firmware release list. The list is released together by the manufacturer and the Test Institute.

According to the test results a new certificate No.: 968/EZ 101.06/08 will be issued.

Cologne, 2008-04-25
TIS/ASI/Kst. 968 bu-nie

The inspectors



Dipl.-Ing. Andreas Hesse



Dipl.-Ing. (FH) Oliver Busa