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Automation, Software and Information Technology

**Test report about the type approval of
safety-related automation devices
Tricon Version 10.4
of Invensys Systems Inc. - Triconex**

**Report-No.: 968/EZ 105.11/08
Date: 2008-04-01**

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Tricon Version 10.4
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Test object: Tricon Version 10.4
BiPolar Analog Output Module 3807

Customer/Manufacturer: Invensys Systems, Inc. - Triconex
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United States of America

Order-No./Date: 120655 dated 2007-05-21

Test Institute: TÜV Rheinland Industrie Service GmbH
Automation, Software and Information Technology (ASI)
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TÜV-Offer-No./Date: 968/125/07 dated 2007-05-03

TÜV-Order-No./Date: 9751590 dated 2007-05-24

Inspector: Dipl.Ing. Andreas Hesse
Dipl.-Ing. (FH) Oliver Busa

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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1. Scope

Scope of this type approval is the new BiPolar Analog Output Module 3807 (BPAO) which shall be used as a standard module non-interfering to the safety related Tricon System.

The type approval should demonstrate that the Tricon System Version 10.4 is still suitable for risk reduction in applications up to SIL 3 according to IEC 61508 [1] and IEC 61511 [2] and that the new BPAO module does not interfere with the safety related system.

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

Electrical safety and resistance against environmental conditions

- [2] IEC 61131-2:2003
Programmable Controllers
Part 2: Equipment requirements and tests
- [3] EN 50178:1997
Electronic equipment for the use in power installations

Electromagnetic Compatibility

- [4] EN 61000-6-2:2005
Electromagnetic Compatibility (EMC)
- Generic Standards
- Immunity for Industrial Environments
- [5] EN 61000-6-4:2001
Electromagnetic Compatibility (EMC)
- Generic emission standard
- Residential, commercial, and light industry

Application specific standards

- [6] IEC 61511-1:2003
Functional safety
Safety instrumented systems for the process industry sector
- [7] EN 50156-1:2004
Electrical Equipment for Furnaces
Part1: Requirements for application Design and Installation
- [8] NFPA 85:2007
Boiler and Combustion Systems Hazards Code
- [9] EN 54-2:1997
Fire detection and fire alarm systems
Part 2: Control and indicating equipment
- [10] NFPA 72:2002
National Fire Alarm Code

3. Identification of the test object

Test object of this type approval is the new Tricon BiPolar Analog Output Module, BPAO 3807. This module combines up to 4 bipolar analog input points (-60 mA to +60 mA) and 4 differential input points (-9 V to +9 V), which are used for open load and open coil detection. The BPAO is based on the hardware and software design of the approved Analog Output Module, EAO 3805E. The BPAO module is intended to be used as standard module for Turbomachinery applications and shall be non-interfering to the safety related Tricon system.

Further the changes to the Tricon programming tool "TriStation" (TS1131) and the Enhanced Diagnostic Monitor (EnDM) were reviewed during this approval.

In detail the following versions of the programming environment were part of review:

- TriStation 1131, V4.3 (Application Development Workstation) Build 505
- Enhanced Diagnostic Monitor (EnDM) V2.1 Build 154

Within the manufacturer documentation listed in Table 1 some references are called Servo Control Analog Output Module (SCAO). The initial name of the module was changed during the project to BPAO, keeping the already released documentation unchanged.

3.1 Documentation by the manufacturer

The Table 1 contains the documentation plan and top level documentation. The necessary documentation and software source needed for this approval have been delivered by the manufacturer and was archived by the Test Institute (see Tricon 10.4, CD-ROM, dated 2008-01-17).

Table 1: Manufacturer Documentation

No.	Document
D1	Documentation plan, Excel-Sheet (Tricon V10.4 Doc index.xls)
D2	Documentation plan, Excel-Sheet (TriStation 1131 V4.3 Document Index.xls)
D3	Documentation plan, Excel-Sheet (EnDM V2.1 Document Index.xls)
D4	Servo Control AO (SCAO) Engineering Project Plan, 9100127-001 V1.1, August 20, 2007
D5	Servo Control Analog Output Module Change Impact analysis of Hardware & Software Changes, 9100170-001 V1.2, November 14, 2007
D6	Tricon V10.4 (BPAO) Release, Software Release Definition, 6200003-212 V1.0, January, 2007
D7	TriStation 1131 v4.3.504 Software Release Definition, 6200097-024 V1.0, July 30, 2007
D8	Enhanced Diagnostic Monitor v2.1.153 Software Release Definition, 6200116-019 V1.0, dated July 30, 2007
D9	SCAO Hardware Requirements and Design Specification, 7100299-001 V2.0, September 20, 2007

No.	Document
D10	SCAO Software Functional Specification. 7500299-001, V1.2, August 2007
D11	Tricon v10.4 SCAO 3807 Verification & Validation Plan, 9600217-001 V1.1, August 6, 2007
D12	SCAO Hardware Test Specification, 7600299-100 V2.0, August 21, 2007
D13	Tricon SCAO Manufacturing Test Procedure, 7600299-001 V1.0, September 11, 2007 September, 11 2007
D14	SQA BPAO Functional Validation Procedure Tricon SCAO, 9600229-100 V1.1, August 3, 2007
D15	BPAO Functional Verification Procedure Tricon SCAO, 9600127-004 File: 9600127-004.zip
D16	SCAO Test System Application Programs (TSAPs) Requirements and Design Specification, 9600229-001, Version 1.1
D17	Tricon v10.4 BPAO 3807 Verification and Validation Summary Test Report File: Tricon 10.4 BPAO Summary Test Report.doc, January 2, 2008
D18	Failure Modes & Effects Analysis Tricon BPAO, 7800299-060 V1.0, December 17, 2007
D19	TriStation 1131 V4.3 Engineering Project Plan, 9100133-001, v1.2, dated June 27, 2007
D20	Enhanced Diagnostic Monitor V2.1, 9100134-001, v1.2, dated June 27, 2007
D21	TriStation v4.3 Overview of Changes and Impact Analysis, 9100139-001 v1.0, dated May 16, 2007
D22	TS1131 V4.3 Verification and Validation Report, v0.3, dated August 2007
D23	EnDM V2.1 Verification and Validation Report, v0.4 dated August 2007
D24	Technical Product Guide for Tricon Systems, 9791007-016, December 2007
D25	Planning and Installation Guide for Tricon v9-v10 Systems, 9700077-010, December 2007
D26	Communication Guide for Tricon v9-v10 Systems, 9700088-006, December 2007
D27	Field Terminations Guide for Tricon v9-v10 System, 9700052-016, December 2007
D28	Safety Consideration Guide for Tricon v9-v10 Systems, 9700097-001, March 2007
D29	Developer's Guide TriStation 1131, Version 4.3, 9700100-005, August 2007

3.2 Documentation by the Test Institute

Table 2: Previous test reports

No.	Document
R1	Report-No.: 968/EZ 105.00/00, dated 2000-03-30, Approval of Tricon Version 9.5.1, TÜV Anlagentechnik GmbH
R2	Report-No.: 968/EZ 105.01/01, dated 2001-05-15, Approval of Tricon Version 9.4.2, TÜV Anlagentechnik GmbH

No.	Document
R3	Report-No.: 968/EZ 105.02/01, dated 2001-09-17, Approval of Tricon Version 9.5.3, TÜV Anlagentechnik GmbH
R4	Report-No.: 968/EZ 105.03/01, dated 2001-09-17, Approval of Tricon Version 9.6, TÜV Anlagentechnik GmbH
R5	Report-No.: 968/EZ 105.04/05, dated 2005-08-15, Approval of Tricon Version 10, TÜV Industrie Service GmbH
R6	Report-No.: 968/EZ 105.05/06, dated 2006-10-31, Approval of Tricon Version 10.2, TÜV Rheinland Industrie Service GmbH
R7	Report-No.: 968/EZ 105.06/06, dated 2006-10-31, Approval of Tricon Version 10.2.1, TÜV Rheinland Industrie Service GmbH
R8	Report-No.: 968/EZ 105.07/07, dated 2007-01-08, Approval of Tricon Version 9.5.2, TÜV Rheinland Industrie Service GmbH
R9	Report-No.: 968/EZ 105.08/07, dated 2007-03-30, Approval of Tricon Version 9.10.2, TÜV Rheinland Industrie Service GmbH
R10	Report-No.: 968/EZ 105.09/07, dated 2007-05-14, Approval of Tricon Version 10.3, TÜV Rheinland Industrie Service GmbH
R11	Report-No.: 968/EZ 105.10/07, dated 2007-10-27, Approval of Tricon Version 9.6.5, 9.7.3, 9.8.2, 9.9.4, 10.0.3, 10.1.1, 10.2.2, TÜV Rheinland Industrie Service GmbH

Table 3: Environmental test report

No.	Document
R12	Report-No.: 968/EZ 512.00/08 dated 2008-02-28, 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 tolerance 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 Tricon system is unchanged compared to previous type approvals.

Result

The description and results are listed in [R1, R2] and 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 and extensions to the existing and approved Tricon system were made under consideration of the requirements in accordance to IEC 61508. The development was done following the safety lifecycle and including the appropriate documentation for verification and validation.

The development lifecycle follows a well defined and hierarchical process and was assessed by the Test Institute during the development of the BPAO module under consideration of IEC 61508 according to the requirements of Functional Safety Management.

Inspection and assessment have been performed during a review meeting within the manufacturer facilities in Irvine, USA and under consideration of the review results of the provided manufacturer documentation as listed in chapter 3.1.

Result

The development lifecycle was inspected for compliance with IEC 61508 [1] considering the requirements of Functional Safety Management and was finished with a positive result.

4.4 Inspection of the documentation

Based on the documentation plan [D1] the documentation as listed in chapter 3.1 and the related documentation have been reviewed partly together with the manufacturer 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:

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

Contradiction in the documentation have been discussed with the manufacturer and corrected were necessary.

Result

The inspection of the documentation have 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.

The application and effectiveness of the measures to avoid failures during the safety lifecycle have been assessed. It was demonstrated that the manufacturer complies with the safety lifecycle requirements of IEC 61508.

Appropriate measures for fault avoidance have been chosen for Tricon Version 10.4.

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 according to IEC 61508-2 implemented in the Tricon System components are unchanged from previous approvals [R1 - R11].

The measures implemented in the BPAO module are based on the measures implemented in the approved EAO 3805E module. Detailed inspection of the implemented measures of the BPAO module was not performed as it is a non-safety standard module.

To show interference freeness to the safety related system the manufacturer prepared a Verification and Validation plan [D11] and specified appropriate tests.

The Verification & Validation tests (V&V) for the Tricon Version 10.4 have been successfully completed [D17] and include:

- System functional verification tests
- Module functional verification tests
- Automated Fault Insertion tests for SCAO 3805
- System Level validation tests

Result

The inspection was finished with a positive result.

4.7 Hardware and software inspection of the Tricon Version 10.4

4.7.1 Hardware inspection of the BPAO module

The BPAO 3807 module is based on the EAO 3805E module certified within [R1]. The changes are described within [D5] and have been part of the review.

Both modules shares the general proven in use processor core and shared memory parts [D5]. Further the three channel leg power supplies and DAC outputs are unchanged compared to the other analog output modules from the Tricon system.

The BPAO module monitors its own current outputs and performs an analog output voting using the triple modular redundant architecture. The module operates as a slave to the Tricon system main processor using and is based on its own processor core architecture and does not have direct access to the main processor system (MP).

All information transmissions are checked by the main processor and will be discarded if the messages are malformed. Data compare is voted between the three legs of the system.

No other hardware changes were done to the other parts of the Tricon safety system.

Results

The review was concluded with positive results.

Note:

On application level the user is responsible for correct use of non-safety related data in a safety related application.

4.7.2 Software inspection of the BPAO module

The software for the BPAO was developed using the EAO 3805E firmware as a baseline [D10], there is only one configuration for the BPAO and no configuration information is downloaded from the Tricon operation system ETSX or the control program.

The manufacturer has prepared a verification and validation plan [D11] and defined test specifications [D12 - D15] to verify and validate the correct implementation of the firmware modifications.

The verification, validation and test plans were reviewed under consideration of sufficient test coverage related to the modification and implementation. The final test reports [D1] was reviewed for completeness and accuracy.

No other software related to the Tricon system was part of modification. The new build compared to V10.3 (see Appendix A) does not reflect any functional change to the Tricon firmware or other modules as shown by the same CRCs [D7].

Result

The review of the firmware implementation and modifications was finished with a positive result.

4.7.3 Inspection of the TriStation and EnDM changes

The TriStation programming environment TS1131 Version 4.3 and the Enhanced Diagnostic Monitor EnDM V2.1 were updated to integrate the new AI/DI module and to implement pending modifications [D19, D20].

The modifications are described within a change and impact analysis [D21]. Appropriate verification and validations steps have been planned and performed [D22, D23]. All documentation is compiled and listed in [D2, D3].

Compared to the documentation as listed in 3.1 the change of the build number of both programs results from the renaming of the module to BPAO. No other functional modification was done.

The new BPAO module can be used in conjunction with TriStation 1131 V4.2, Build 505 respectively EnDM V2.1, build 154.

Result

The review has shown that new version of TriStation and EnDM still can be used to program and configure the safety related system Tricon.

4.8 FMEA and fault insertion

The original FMEAs and corresponding fault injection tests were adapted to the modification [D6]. The FMEA have been reviewed and did not identify faults, which could have a negative impact to the safety related Tricon system.

The manufacturer performed automated fault insertion tests to test the diagnostics and possible impacts to the system. The test have been finished with positive results [D17].

Result

The review of the FMEAs and the fault insertion tests were closed with positive results.

4.9 Reaction time

System reaction time of the Tricon safety system is not affected by BPAO communication.

4.10 PFD and PFH calculation

The BPAO module does not affect the PFD or PFH of the Tricon PLC system, because it is considered as a standard module.

4.11 Inspection of the environmental testing and EMC

All test according to IEC 61131-2 [2] and EN 54-2 [9] have been performed in the facilities of the Test Institute and are documented in a separate report [R12].

During the environmental and EMC tests there have been a PCB change from Revision B to C to the layout, which is further described in [D5]. Analysis have been performed and evaluated for impact to the finished Environmental and EMC tests. The changes do not have an influence on the performed tests.

Result

All tests have been finished with positive results.

4.12 Electrical safety

Due to the fact that the BPAO module is powered and connected to devices, which operate with voltages of SELV/PELV (safety class III), electrical hazards to persons can not occur.

Result

The electrical safety is given.

4.13 Application specific requirements

The compliance to the requirements of the application standards as listed in chapter 3.1 are unchanged and the results of the previous type approvals [R1-R11] are still valid.

Result

The review was finished with positive result.

The requirements and constraints of the Safety Consideration Guide [D28], corresponding User Guides [D24 - D27] and the related application specific standards have to be taken into account while realizing and commissioning the application.

5. Summary

The approval of the Tricon Version 10.4 has shown that the results of the previous type approvals are still valid (see Table 2).

The Tricon Version 10.4 can still be used in applications up to SIL 3 as defined in IEC 61508 [1] and IEC 61511 [2].

The carried out tests and analyses have shown that the new BiPolar Analog Output Module 3807 is classified as interference free to the Tricon safety components.

Application programs must be created using the TriStation V4.3 and higher considering the guidelines specified in the Safety Consideration Guide [D28] and the Developer's Guide TriStation 1131 [D29].

All conditions, which the user must comply for a safely use of the products, are described in detail in the corresponding manuals [D24 – D29].

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.

Cologne, 2008-04-01
TIS/ASI/Kst. 968 bu-nie

The inspectors



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