Simulation System for the Wendelstein 7-X
Safety Control System

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Motivation

The superconducting stellarator W7-X needs safety for a safe operation well defined and tested safety system:
I. The W7-X control system allows a safe and flexible control of preparation and conducting of discharges.
II. For every operation phase an enhanced version of the central safety system (cSS) is necessary.
III. The effort for integration tests and validation of the software for the cSS is very high.
IV. A simulation system allows developing and testing the safety software before commissioning and helps to meet the high quality requirements.

A simulation platform for the cSS was introduced for integration tests and validation of the cSS software for the operation phase OP1.2b.

Software versions for safety system

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>Dec 2015</td>
<td>Safety software for commissioning of vacuum system, cryopump and torus hall signalization</td>
</tr>
<tr>
<td></td>
<td>Enhanced safety software for commissioning of superconducting magnet system</td>
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<tr>
<td></td>
<td>Enhanced safety software for radiation protection</td>
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<tr>
<td>Dec 2015</td>
<td>Final software version for operation phase OP1.1</td>
</tr>
<tr>
<td>March 2016</td>
<td>Final software version for operation phase OP1.2</td>
</tr>
<tr>
<td>July 2017</td>
<td>Final software version for operation phase OP1.3</td>
</tr>
<tr>
<td>Dec 2017</td>
<td>Final software version for operation phase OP1.2a</td>
</tr>
<tr>
<td>March 2018</td>
<td>Final software version for operation phase OP1.2b</td>
</tr>
<tr>
<td>April 2018</td>
<td>Final software version for operation phase OP1.2b</td>
</tr>
<tr>
<td>Dec 2018</td>
<td>Final software version for operation phase OP1.2b</td>
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W7-X in operation

Revision of W7-X, Video of the first H₂ plasma discharge (5. February 2016)

Safety-System Overview

Functions of the safety system:
I. Ensures personal safety and investment protection,
II. Supervision of access control into different zones of the radiation protection area,
III. Emergency stop system,
IV. Control of the safety states of W7-X,
V. Signalization (warnings and alarms),
VI. Realization of safety functions:
   - personnel safety,
   - device protection,
VII. Communication interfaces:
   - Central Operation Management (cOPM) (Ethernet),
   - Fast Interlock System (Ethernet),
   - Control components (safety signal interface),
   - Data archive (Ethernet),

Layers of the W7-X control system

Development process

SIMIT based simulation platform for the W7-X safety system

Architectures of SIMIT (Fa. Siemens):
- Modeling system:
  The simulation models are created and the interfaces to the coupled partners are configured in the modeling system.
- Control system:
  The control simulation runs in the control system. The simulation model communicates with the coupled safety program of redundant PLCs of the cSS simulation platform.

Realization:
- Installation of a simulation system, consisting of:
  - 2x PLC S7-417,
  - Profibus safe network and profibus coupling device,
  - Windows PC equipped with SIMIT V9.0
- Processing of about 2000 safety Input/Output signals,
- Implementation of simulation models for:
  - 21 technical components,
  - 5 operation diagnositics (e.g. laser systems),
  - 12 diagnostics,
  - Signalization, access control, gas warning system,

Results:
- W7-X operation and safety software development are possible at the same time,
- Early detection and correction of configuration and software errors,
- Shorter commissioning period due to:
  - a tested configuration,
  - extensively tested software,
  - Significantly reduced on site debugging,
  - Education of the cSS operators,

In operation
- W7-X operational workspace with: Workstation (W7 control room)
- CSS-SIMIT workspace with: Workstation (operator station), SIMIT-operator station

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