FASER DCS

— Specifications —

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1 Overview

The main aims of the FASER Detector Control System (DCS) system are:

- Ensuring the safety of detector
  - Monitoring operation parameters of the detector’s power system
  - Monitoring humidity and temperature for the detector
  - Triggering alarms, and emergency procedures
  - Implementing autonomous integrity checks and diagnostics
  - Provide a user interface to inform FASER users on the state and status of the experiment sub-systems

- Controlling the detector
  - Implement autonomous protocols for transitions between the different operational states
  - Provide a user interface for configuring operational parameters of the power and interlock systems
  - Provide a configuration-DB interface to save and load configurations of the operational parameters of the power and interlock systems

- Archive time-history of detector parameters
  - Keep time series of parameters, states and statuses monitored through the DCS
  - Provide a user interface to access the archived parameters

2 System Architecture

The DCS back-end is implemented in the SIEMENS Simatic WinCC Open Architecture, which is a SCADA system extensively used at CERN, well know by their scalability, multi-platform, open architecture, long-term partnership CERN - ETM.

WinCC OA SCADA works together a layer of software developed at CERN which is known as Joint Controls Projects (JCOP) : it provides supports and maintains a common Framework, that covers :

- Tools and libraries : I/O widgets, trending tools, Access Control, HMI, DB Archiver, Finite State Machine, power supply components.

- Integration of standardised hardware types into WinCC OA SCADA : ELMB, Wiener, CAEN, ISeg, MPOD, S7 PLCs, Schneider PLCs.

- Communications and middleware: DIP and DIM, OPC-UA.

The DCS system has a distributed architecture as depicted in Figure 1. The system hierarchy separates between a low-level device layer handling communication with various hardware components and a high-level supervisory layer, dedicated dedicated to user interactions and combining information from the different parts of the system. The low-level is hosted by two Linux based Local Control Stations (LCS), one dedicated to the interactions with the detector power system, and a second one dedicated to the interactions with other components in the experiment (need to buy a least a Dell R440, 2.5 kCHF). The high level supervisor is hosted within a EP-DT station (its provided by EP-DT team for free to FASER) For convenience and ease of operation, all the DCS servers are located outside of the FASER cavern. Communication between the DCS backend and the controlled and monitored devices is done through the a private network segment.
2.1 Network

The DCS-backend to device communication in FASER run on a small private Sub-network. It is motivated by the fact that experiments are not allowed in the CERN technical network and it cannot be on the general public network (GPN) due to security reasons (several devices with different security levels). The small private network will be protected behind the CERN firewall.

2.1.1 Remotely accessible terminal

FASER DCS will not have a control room application. User interactions with DCS are foreseen through remote access. The DCS provides a remote-terminal accessible through the CERN network for active actions on the DCS.

2.1.2 Communication infrastructure related to DCS in the Cavern

The schema in figure 2 depicts the communication switch usage for the different DCS devices

- 1 Fibre connecting DCS Switch to CERN network
- 1 Gigabit XX port Ethernet 1 Optical switch
- 3 Ethernet cable Switch to Weiner/ISEG PS crates
- 3 Ethernet cable Switch to TIM boards

Figure 1: FASER DCS hierarchy
2.1.3 Web based monitoring

FASER DCS publishes a web-site with snapshots (images of WinCC-OA panels) of the on-line state of FASER, as well as web-access to the detector history.

2.1.4 SMS alert

It is not foreseen to have an on-site shifter for FASER. FASER DCS will alert remote shifters through SMS. The SMS will be sent by the supervisory layer.

2.2 Archiving

All the information relevant from the detector, its voltage and current settings, temperature, humidity, the status of the front-end initialization and so, will be organized an Influx-DB (an ORACLE-DB will be use as backup), allowing any user from the collaboration on-line access the state and status of FASER. This information can be also accessed off-line, to provide a good estimate of the detector conditions during data taking.

2.2.1 OracleDB instance

The FASER Oracle archive can be hosted in the in the PDB instance, due to its small size it can fit in the EP-DT account.

2.2.2 InfluxDB instance

FASER DCS may host its own InfluxDB instance.
2.3 Archiving rate estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>Number of items</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracker and PMT PS</td>
<td>1K items</td>
<td>&lt; 3MB/day</td>
</tr>
<tr>
<td>Interlock</td>
<td>6 items</td>
<td>&lt; 1MB/day</td>
</tr>
<tr>
<td>Temperature / Humidity</td>
<td>200 items</td>
<td>&lt; 1MB/day</td>
</tr>
<tr>
<td>PDU</td>
<td>18 items</td>
<td>&lt; 1MB/day</td>
</tr>
<tr>
<td>Chiller</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

2.4 Archive visualization

For the ORACLE instance, the ATLAS DCS visualization infrastructure can be used. For the InfluxDB Graphana can be used.

2.5 Configuration DB

Need to register an account to the Configuration DB This item needs to be discussed further

2.6 FSM

The DCS provides a Final State Machine to automate the transition between the different operational states in a convenient manner, e.g. Stand-by to Ready, Stand-by to Shutdown, etc. The FSM also serves as a convenient platform for monitoring the status of the detector within each operational state; OK, Transition, WARNING and FATAL. The FSM implementation is hierarchical, this allows an efficient flow of information; at the base-level, single hardware channels are defined as Device Unit with higher level Logical/Control Units acting on set of DU or CU. The DCS also provides a Graphical User Interface (GUI) to interact with the FSM.

3 Tracker and PMT power supplies

The Tracker and PMT power distribution architecture is based on Wiener MPOD system which user Wiener LV modules and ISEG HV modules. Three MPOD crates will be required by the tracker. Two for the LV and one for the HV. Each MPOD crate communicates with the DCS back-end through the FASER sub-network.

The Communication between the crates and the DCS is handled as depicted in Figure 3. A Linux LCS hosts WinCC-OA with an OPC client manager, an SMB server and a Windows VM. Within the Windows VM a WinCC-OA and a OPC-DA server are hosted. The Windows OPC-DA server handles communication between the LCS and the Crates, the communication between the OPC-DA server and the OPC Client is handled through the WinCC-OA (Linux-Windows path) using the SMB server.

The hardware of the PS system specification is:

- 3 × Wiener Crates MPOD-EC for the overall LV/HV system
- 18 × Wiener PMV 8808I, Vcc and Vdd for SCT (144 channels)
- 3 × ISeg EHS 8405p, Vbias HV for SCT (24 channels)
- 1 × ISeg EHS F030n, HV for PMT (16 channels)

3.1 Tracker PS pin-out specification

The pin-out follows the following schema. Due do geometrical reason, the DB37 connectors on patch panel have following pinouts to avoid swap of Vcc and Vdd:
3.2 FSM

The FSM is organized in a: Station $\rightarrow$ Layer $\rightarrow$ Module $\rightarrow$ PS-channel hierarchy. Individual channels are controlled as Device-Units of the FSM. There are three states in the FSM:

- READY: channels at nominal data-taking values
- STANDBY: channels at standby values
- SHUTDOWN: channels off

<table>
<thead>
<tr>
<th>Ch</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch0</td>
<td>Vdd for the 1st module</td>
</tr>
<tr>
<td>Ch1</td>
<td>Vcc for the 1st module</td>
</tr>
<tr>
<td>Ch2</td>
<td>Vcc for the 2nd module</td>
</tr>
<tr>
<td>Ch3</td>
<td>Vdd for the 2nd module</td>
</tr>
<tr>
<td>Ch4</td>
<td>Vdd for the 3rd module</td>
</tr>
<tr>
<td>Ch5</td>
<td>Vcc for the 3rd module</td>
</tr>
<tr>
<td>Ch6</td>
<td>Vcc for the 4th module</td>
</tr>
<tr>
<td>Ch7</td>
<td>Vdd for the 4th module</td>
</tr>
</tbody>
</table>
3.3 Alerts
TBD by tracker experts

3.4 GUI
The GUI is based on the SCT-DCS GUI, it allows configuration of the PS parameters and control of the PS state at the module level.

3.5 Archiving
The DCS will archive monitored values, set-points and states of the PS channels every 30 seconds. Expected data rates are low, less than 3MB per day.

<table>
<thead>
<tr>
<th>Item</th>
<th>Number of items</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracker HV setpoints</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker HV state</td>
<td>72</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker HV monitored</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vcc setpoints</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vcc state</td>
<td>72</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vcc monitored</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vdd setpoints</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vdd state</td>
<td>72</td>
<td>2/min</td>
</tr>
<tr>
<td>Tracker Vdd monitored</td>
<td>72 × 2 (V and I)</td>
<td>2/min</td>
</tr>
<tr>
<td>Total data rate per day</td>
<td>&lt; 3 MB / day</td>
<td></td>
</tr>
</tbody>
</table>

4 Interlocks, temperature and humidity monitoring
The tracker interlock and temperature humidity monitoring is done through the TIM board. The TIM board communicates with the DCS via the MODBUS/TCP protocol. The MODBUS/TCP is an industry standard protocol and is well supported by WinCC-OA. Several CERN groups have experience with MODBUS/TCP devices. The DCS-TIM protocol is described in detail in:
https://indico.cern.ch/event/842296/contributions/3534994/attachments/1894622/3127168/TIMandDCSprotocol.pdf

4.1 FSM
TBD by TIM experts

4.2 Alerts
TBD by tracker experts

4.3 GUI
The GUI will allow for keeping track of the monitored values and their history and corresponding geometry (as possible).
4.4 Archiving

<table>
<thead>
<tr>
<th>Item</th>
<th>Number of items</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interlock setpoint</td>
<td>3</td>
<td>0.1/sec</td>
</tr>
<tr>
<td>Interlock state</td>
<td>3</td>
<td>0.1/sec</td>
</tr>
<tr>
<td>Temperature value</td>
<td>180</td>
<td>0.1/sec</td>
</tr>
<tr>
<td>Humidity value</td>
<td>18</td>
<td>0.1/sec</td>
</tr>
</tbody>
</table>

5 Power Distribution Units (220V/AC)

The NETIO powerpdu-4c is proposed as a controlled 220V/AC power distribution unit. The powering scheme is depicted in Figure 4. This unit can be controlled through WinCC-OA using the MODBUS-TCP protocol. Power consumption and communication can be monitored. To ensure the ability to power the DCS network switch, the PDU for the DCS switch will be controlled via the DAQ network switch.

![Figure 4: Scheme for 220V/AC control and distribution.](image)

5.1 FSM
- READY/STANDBY: PDU on
- SHUTDOWN: PDU off

5.2 Alerts
TBD
5.3 GUI
The GUI should allow for monitoring power consumption and communication with the PDU. Off/On setting is done through FSM commands.

5.4 Archiving
Monitored values and state are archived.

6 Chiller control and monitoring
The Chiller is foreseen to be controlled and monitored by CERN EN-CV. Monitoring information will be available through DIP.

7 DSS alerts
TBD

8 Environment monitoring
Cavern environment will be monitored using an ARDUINO + BME280 via OPC. The application will be taken from the test-bench used for the commissioning of the NSW for ATLAS.

9 VME monitoring
The DCS will monitor voltages and fans for the VME crate.

10 Software organization

11 Repository

12 Deployment