Development of Detector Control System (DCS) for forward hadron calorimeters in the BM@N and the MPD experiments

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Abstract. The BM@N and the MPD experiments at NICA facility (Dubna, Russia) will use the forward hadron calorimeters (FHCal) for centrality and reaction plane determination in the heavy ion collisions. The FHCal is a modular lead/scintillator sampling calorimeter with longitudinal segmentation. The light from each longitudinal section in module is detected with one silicon photomultiplier (MPPC) with sensitive area of 3x3mm\textsuperscript{2}. In total, the FHCal at the BM@N experiment has 438 readout channels, while two MPD calorimeter arms have 616 readout channels. This article shows the DCS design with hardware and software development for these calorimeters. The DCS will be used to control and correct the bias voltages with temperatures of MPPCs. An integration into the main DCS systems for both experiments are discussed.

1. Introduction
The FHCal is a compensating lead-scintillator calorimeter designed to measure the energy distribution of the projectile nuclei fragments (spectators) and forward going particles produced close to the beam rapidity. The proposed modular design of the FHCal covers large transverse area around the beam spot position such that most of the projectile spectator fragments deposit their energy in the FHCal.

The calorimeter at BM@N consists of 34 central modules with 15x15cm\textsuperscript{2} transverse sizes (longitudinal segmentation of 7 sections) and 20 outer modules with 20x20 cm\textsuperscript{2} transverse sizes (longitudinal segmentation of 10 sections). The schematic view of the BM@N [1] experiment setup with the FHCal calorimeter is shown in Figure 1.

The MPD FHCal consists of two identical arms placed at the distance of about 3.2 meters from the interaction point [2]. The schematic design of the FHCAL module, the structure of the FHCAL calorimeters and its position at the MPD setup are shown in Figure 2.

2. Front-end Electronics (FEE)
The Front-end electronics (FEE) for FHCal was produced by HVsys Co. (Dubna) [3] and includes PCBs with MPPCs for light readout with precise HV power supplies, signal amplifiers and calibration LED pulser, managed by two microcontrollers with common serial RS-485 bus (Figures 3 and 4). The HV controller can be controlled with several parameters: status, set and measured channel voltage (up to 10 channels), set or measured common base voltage, HV ramp time, HV ramp status and information from temperature sensor. The LED controller provides
status, the LED pulse frequency, pulse amplitude and allows to perform auto regulation of light pulse brightness.

![Figure 1. BM@N experimental setup.](image1)

![Figure 2. MPD setup.](image2)

![Figure 3. Front view of the FEE board for 7-section FHCal module with 7 MPPC readout channels and LED pulser.](image3)

![Figure 4. Back view of the FEE board with HV regulators, LED and HV microcontrollers.](image4)

### 3. Design of DCS for FHCal

The FHCal electronic boards are connected with a common RS-485 bus to the Control Box Unit (CBU). Since each module has two transceivers one can connect up to 64 electronic boards (FHCal modules) to the CBU. The BM@N setup will use one CBU and the MPD FHCal setup will use two CBUs. The CBUs have a possibility to connect to LAN and be controlled directly by one DCS PC. If more than one application needs to interact with the FHCal, hardware or software proxy can be used. The connection diagram is shown in Figure 5.

The DCS for FHCal should provide fast and stable access to all parameters of the FHCal FEE boards, have extensible architecture for possible hardware upgrades. The DCS functions also include online temperature correction, logging parameters to database, and should have a fast connection with multiple devices. The best solution is a modular structure. All detector parts have capabilities to read or write some controller registers available on the bus. The registers can be described in the configuration files. Then adding a new module means simply creating a new configuration file. The detector parts can be grouped into modules for DCS display. Each module can display controls for all its parts: HV controller, LED controller etc.
4. Performance measurements and integration to common DCS
With a few hundreds of readout channels, the required time to control a single channel or FEE board becomes crucial. The performance bottleneck is a relatively slow common serial bus. Software should fully utilize the bus, and be capable of parallel interaction on two buses (by using 2 CBUs) in case of two-calorimeter MPD setup. The table 1 shows performance measurements for different connection modes for direct one PC DCS system and the new DCS. The “Time” here is given for single request-response in ms (the less the better), and the “Poll sequence per second” is for reading the complete status of a 10-section module (the more the better). The proposed design of the FHCal DCS will be able to send all detector parameters to the experiment-wide tango-based DCS system [4] that will record this information to database. The integration plans are to include ”pytango” module into the FHCal DCS. The module will help to connect the common DCS to FHCal DCS on the software level instead of direct connection to hardware.

| Mode                              | Time, ms | FHCal module poll sequence per second |
|-----------------------------------|----------|----------------------------------------|
| “Legacy”, LAN                     | 150      | 0,33                                   |
| “Legacy”, Moxa Real COM mode      | 50       | 1,00                                   |
| Socket (LAN), single command      | 23       | 2,17                                   |
| Socket (LAN), double command      | 18       | 2,78                                   |
| Moxa Real COM mode                | 25       | 2,00                                   |
| Moxa Real COM mode, double command| 20       | 2,50                                   |
| FTDI serial over USB              | 15 (avg) | 3,33                                   |
5. Conclusion
The proposed hardware and software have been developed to control the parameters of the FHCal detectors. The FHCal DSC provides the required performance for the needs of the calibration and running the FHCal. After the testing and commissioning it will be used in the common DCS systems of BM@N and MPD experiments.

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References
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