DETECTOR CONTROL SYSTEM OF THE ATLAS TILE CALORIMETER

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Abstract

This paper describes the development and implementation of the Detector Control System (DCS) of the Tile Calorimeter detector. The DCS must ensure coherent and safe operation of the Detector. It provides control and monitoring of all parameters of the system and gives to the user a comprehensive picture of the detector behaviour.

INTRODUCTION

The Tile Calorimeter [1] is one of the sub-detectors of the ATLAS experiment [2]. It is a sampling calorimeter made of steel plates (absorber) and scintillating tiles (active material). The design, general features and expected performance of the calorimeter are well described in the "ATLAS Tile Calorimeter Technical Design Report" [3]. The Tile Calorimeter consists of one barrel and two extended barrel parts. All the three sections have a cylindrical structure further sub-divided into 64 independent modules. The calorimeter cells are defined by grouping together sets of optical fibbers into bunches leading to photomultiplier tubes (PMTs). The front-end electronics and PMTs are located in the outer side of the Tile Calorimeter modules, in so-called electronics drawers.

The Detector Control System (DCS) is responsible for safe and coherent detector operation. All ATLAS sub-detectors have their own local DCS, which detailed architecture strongly depends on the structure of the general DCS system of the ATLAS experiment [4] and on electronics architecture and mechanical issues of the sub-detector itself. Each local DCS controls and monitors the operation of a sub-detector and related equipment.

Although each sub-detector is responsible for the implementation and for internal organization of the sub-systems, they must fully comply with the requirements defined by ATLAS central DCS [5]. The DCS of the sub-detectors must follow the general ATLAS DCS system architecture as much as possible unless there are special requirements where the sub-detectors need tailored solutions.

The DCS provides control and monitoring of the main systems of the Tile Calorimeter detector, which are the High Voltage distribution system and the Low Voltage Power Supply (LVPS) system. In addition, DCS is also responsible for interactions with detector calibration and data acquisition systems, and monitoring the detector infrastructure related systems: detector water-cooling and rack control.

TILE CALORIMETER DCS

The commercial Supervisory Control and Data Acquisition (SCADA) package PVSS II has been chosen by the Joint COntrols Project (JCOP) at CERN to implement Back End (BE) software for all LHC experiments [6]. The PVSS II is a commercial product, from Austrian company ETM. It is used to connect to hardware devices, acquire data from them, monitor their behaviour and to initialize, configure and operate them. PVSS II has a highly distributed and flexible architecture, and it allows connection of several autonomous systems through the network.

The BE system of the ATLAS experiment is organized hierarchically in three layers or levels as shown in Figure 1. This hierarchy allows the experiment to be divided into independent partitions, which have the ability to operate in standalone or integrated mode.

At the top layer, there are Global Control Stations (GCS), which are in charge of overall operation of the detector. They provide high level monitoring and control of all sub-detectors, while data processing and command execution are handled at the lower levels. The GCS is able to access all stations in the hierarchy.

The Sub-detector Control Station (SCS) represents the middle level of the hierarchy. The Tile Calorimeter, as a sub-detector of ATLAS, has its own SCS, which allows the complete operation of the sub-detector, by means of dedicated graphical interfaces. At this level of hierarchy, the connection with the TDAQ system, calibration systems and detector infrastructure takes place in order to ensure that detector operation and physics data taking are synchronized.

At the bottom level of the hierarchy are the Local Control Stations (LCS), which handles the low level monitoring and control of LV and HV systems of sub-detector. The LCS executes the commands received from the layers above.

In order to implement the BE system of the Tile Calorimeter DCS, five rack-mounted computers are used, located in USA15 racks. As it is shown in Figure 1, four of those are used as LCS stations (each for one Tile Calorimeter partition) and one as the SCS station. The operating system of those computers is Windows XP and they run PVSS II as a system service.

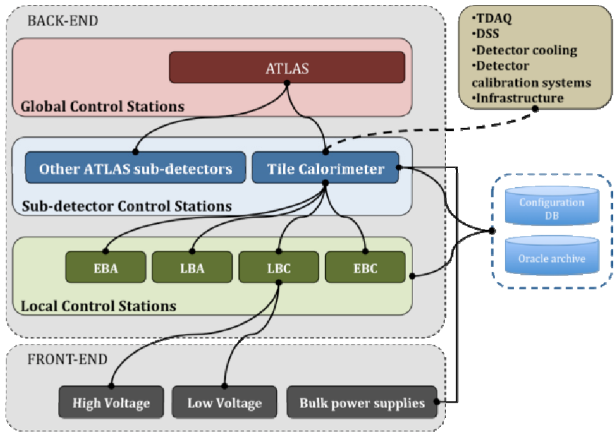

Figure 1: Hierarchy of the DCS of the Tile Calorimeter, as part of the ATLAS control system.

THE LOW VOLTAGE POWER SUPPLIES (LVPS) SYSTEM

The LVPS system is a two stage system: first stage converts 400V AC input into 200V DC output (100 m from the detector in USA15) and then second stage placed on the detector converts 200V DC into 8 independent levels of lower voltages in the range (-15V; +15V). These voltages are used to power the detector Front End (FE) electronics. The Tile Calorimeter FE electronics consists of digital and analog components of the readout system and High Voltage (HV) distributor system. In this section, the hardware entities of LVPS system and their interconnections are briefly described.

The LVPS system is composed by three devices: finger Low Voltage Power Supplies (fLVPS) located at the FE electronics of Tile Calorimeter, auxiliary boards (AUX boards) located in the racks of USA 15 and bulk power supplies providing 200V DC located also in the racks of USA 15.

The fLVPS and AUX board devices make use of Embedded Local Monitoring Board (ELMB) [7], as a general purpose I/O and processing unit for CAN communication [8]. The ELMB fully implements the industry standard of CANbus protocol and it provides minimal functionality of a slave node according to this protocol specifications.

The communication between the fLVPS and the Aux Board devices is made using the ELMB motherboard and the interface of the ELMB with the PVSS is done by an OPC server/client approach [9] where the client is provided by the PVSS manager and the OPC server by a software developed by the ATLAS DCS Central Team, CANopen OPC server. [10]

Figure 2 shows the layout of the ELMB based readout chain, for one Tile Calorimeter partition. In the LVPS system the maximum number of ELMB nodes per CAN branch is 16 and the number of CAN branches per partition is 5. Four of the CAN branches are used for communication with fLVPS devices and one for communication with AUX boards. The CAN Power Supply Unit (CAN PSU) is used to feed the CAN Transceiver part of the ELMB. The length of CAN branches, used to communicate with fLVPS devices is 120-150m and for AUX board devices it is ~10m.

The CAN communication speed for AUX board and fLVPS devices is set to 125KB/sec. Used CAN node addresses are from 1 to 16, as labelled on Figure 2. Branch #0 is used for the communication with AUX board devices and the others (branches #1 - #4) for the fLVPS devices. The numbering of Kvaser card [11] port matches to the branch numbering.

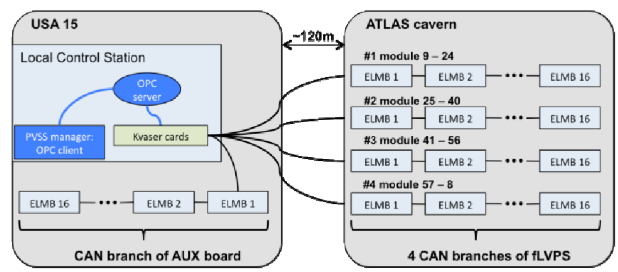

Figure 2: Communication schema with Aux Boards and fLVPS devices, for one Tile Calorimeter partition.

THE HIGH VOLTAGE DISTRIBUTOR SYSTEM

The High Voltage (HV) Distributor system is described in details [1], in the following we provide general information about the system power and communication lines at the ATLAS cavern.

The HV Distribution system consists of two devices: HV Bulk Power Supply (HV Bulk PS) and Super Drawer device. The HV Bulk PS devices are located in the ATLAS electronics cavern, called USA15 and the Super Drawer devices are located at the sub-detector area.

The HV Distributor system uses the HV Bulk PS device channels to provide input high voltage for each Super Drawer device. The HV Bulk PS provides 850 or 930 V, with the maximum DC current of 20mA. To use one input high voltage per Super Drawer, and to distribute and to regulate in-situ voltages of each individual PMT channel, with the precision better than 0.5V. The typical length of supply lines between HV Bulk PS and Super Drawer devices is about 120m.

The communication between the HV Bulk PS that uses ModBus/RTU protocol [12], and the DCS computer running PVSS which can only support ModBus/TCT, is achieved using a Port Server converter [13].

Inside the Super Drawer we have one HV_MICRO card, two HV_OPTO cards, HV internal and external buses, and the Flexible Bus (which links two HV Buses). The HV_MICRO controller card manages the voltages for individual PMTs through the HV_OPTO distributor cards and is used as the I/O and processing unit for CAN communication providing functionality of the slave node according to the specifications of this protocol, as can be seen on Figure 3.

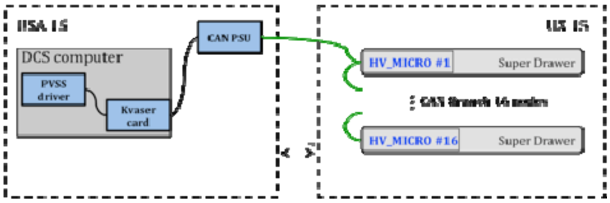

Figure 3: The HVMicro based readout chain.

CONCLUSIONS

The DCS implementation of Tile Calorimeter system follows requirements and suggestions from ATLAS DCS integration guidelines [5]. The DCS of the LVPS system represents comprehensive picture of the system and allows operator to have ability of full control over the system.

This paper provides detailed description of the hardware components of the LVPS system, emphasizes the critical parameters of the system and their monitoring thresholds for ALARM and WARNING. Implemented commands for individual device units of the LVPS system are given in details and time estimates for their execution are provided.

Usage of the Configuration and Conditions DB are also described in this paper. Analysis of the DCS data, from conditions DB showed that daily-recorded data size is in reasonable limit and allows understanding of the LVPS system behaviour. Implementation of the Configuration DB allows storing of the full information about the LVPS system calibration and nominal output voltages.

This paper presents a comprehensive picture of the Tile Calorimeter DCS system, as implemented following the requirements of the ATLAS DCS integration guidelines. The DCS of the LVPS system has been ready on time and proved to be both user-friendly and robust. It was successfully operated in a reliable manner for almost 2 years. A key element in this successful implementation was the correct selection of the building blocks since the beginning of the implementation.

We present the organization of the supervisory level for the LVPS system, information necessary for the operator to have the ability of full control over the system, and a detailed description of the hardware components of the LVPS system with emphasis on the critical parameters of the system and their monitoring thresholds for ALARM and WARNING. Details of the commands implemented for the individual device units of the LVPS system are given as well as time estimates for their execution.

Usage of the Configuration and Conditions DB are also described in this paper. Analysis of the DCS data from the Conditions DB showed that the daily recorded data is reasonable in size and allows understanding of the LVPS system behaviour. Implementation of the Configuration DB allows storing of the full information about the LVPS system calibration and nominal output voltages.

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