A LARGE CHANNEL COUNT MULTI CLIENT DATA ACQUISITION SYSTEM FOR SUPERCONDUCTING MAGNET SYSTEM OF SST-1

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Abstract

The magnet system of the Steady-state Superconducting Tokamak-1 at the Institute for Plasma Research, Gandhinagar, India, consists of sixteen Toroidal field and nine Poloidal field Superconducting coils together with a pair of resistive PF coils, an air core ohmic transformer and a pair of vertical field coils. These coils are instrumented with various cryogenic grade sensors and voltage taps to monitor its operating status and health during different operational scenarios. A VME based data acquisition system with remote system architecture is implemented for data acquisition and control of the complete magnet operation. Client-Server based architecture is implemented with remote hardware configuration and continuous online/ offline monitoring. A JAVA based platform independent client application is developed for data analysis and data plotting. The server has multiple data pipeline architecture to send data to storage database, online plotting application, Numerical display screen, and run time calculation. This paper describes software architecture, design and implementation of the data acquisition system.

INTRODUCTION

The Steady-state Superconducting Tokamak (SST-1) is a medium size fusion device to study the plasma behaviour in steady state operation of 1000s [1]. SST-1 magnet system consists of sixteen Toroidal field (TF) and nine Poloidal field (PF) Superconducting coils, together with a pair of resistive PF coils, an air core ohmic transformer and a pair of vertical field coils [2]. These magnets need to be monitored during all operational scenarios like cool down, ramp up, flat top, plasma breakdown, dumping/ramp down and warm up. More than 500 sensors, like temperature sensors, voltage taps, venturi flow meters, hall probes, pressure sensors, and displacement transducers are mounted on the magnet system and its auxiliaries. These sensors produce very low level signals and so they impose very strict requirements on the signal conditioning and acquisition electronics [3]. Magnet Data Acquisition System (DAS) is required to amplify and filter the signal, digitize the signal, acquire and store it, display the data in engineering units and communicate with other subsystems, all in real time. To satisfy all these requirements, a complete VME bus-based real time data acquisition system is designed and implemented for SST-1 magnet system. The hardware consists of 64 bit backplane VME chassis, SBS-VG4 crate controller with PowerPC-755 processor from SBS technologies, Analog input module IP330 and Analog output module IP 220 from ACROMAG, 6U AVME 9660 carrier board with four daughter card slots from ACROMAG, Digital I/O module VMIVME-2528 from VMIC and a GPS timing module BC635VME from Symmetricom Inc.

PROJECT SCOPE

The VME based DAS is suppose to monitor different sensors mounted on the SST-1 magnets and its auxiliaries, continuously and reliably during different phases of SST-1 magnet operation. The total numbers of required channels are more than 500 in numbers which are required to be monitored continuously over long duration during an experimental campaign. Table 1 shows typical distribution of data acquisition channels for magnet systems with different sensors and its primary application. Sensor signals are coming from the different signal conditioning cards mounted in the instrumentation racks in the magnet control room [4] and are interfaced with VME IOs through signal connection box. Figure 1 shows the functional block diagram of VME DAS with its associated hardware subsystems.

Table 1: Channel distribution for Data Acquisition system

No.	Sensor	Channels	Application
1	Temperature Sensors	150	Cryogenic Temperature Measurement
2	Voltage-tap channels	224	Quench detection and magnet voltages
3	Hall probes	16	Magnetic field direction and intensity measurements
4	Flow meters (Venturi)	32	Flow measurements
5	Absolute Pressure	16	Helium Pressure measurement
6	Displacement transducers	12	Displacement measurement in cold mass
7	Strain gages	8	Stress measurement on magnets
8	Joint Resistance Measurement	102	Inter-pancake and Inter-coil joint resistance measurement

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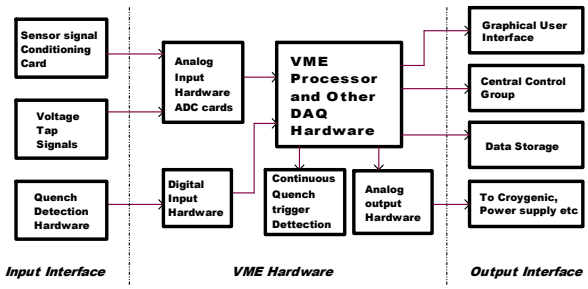

Figure 1: Functional block diagram of the system.

APPLICATION ARCHITECTURE

To cater to the varying need of magnet system, a versatile multi client software application was developed for the VME based hardware. The software application can be divided in three software modules. First module is a target board application which will take care of configuration parameters and data transfer from the data acquisition hardware channels. Second module is a Java server application, which will receive data from the target board application, store data into database and sends data to the client applications. Third module is a Java desktop intranet application, which is a graphical user operator interface used for set configuration, data plotting, data analysis and data monitoring etc. TCP/IP socket programming is used for communication with the data server and user database. One TCP/IP server is required on target side that will communicate with host PC running a TCP/IP client. The server application is developed in JAVA and is ported on freely available sun java / Apache Tomcat web server. This web server communicates over TCP/IP with the dedicated target application as well as multiple client applications. Raw data is archived on host PC while online trends and numerical values are displayed on client applications. Figure 2 shows the application architecture block diagram of the DAS. Following section discuss each module in detail.

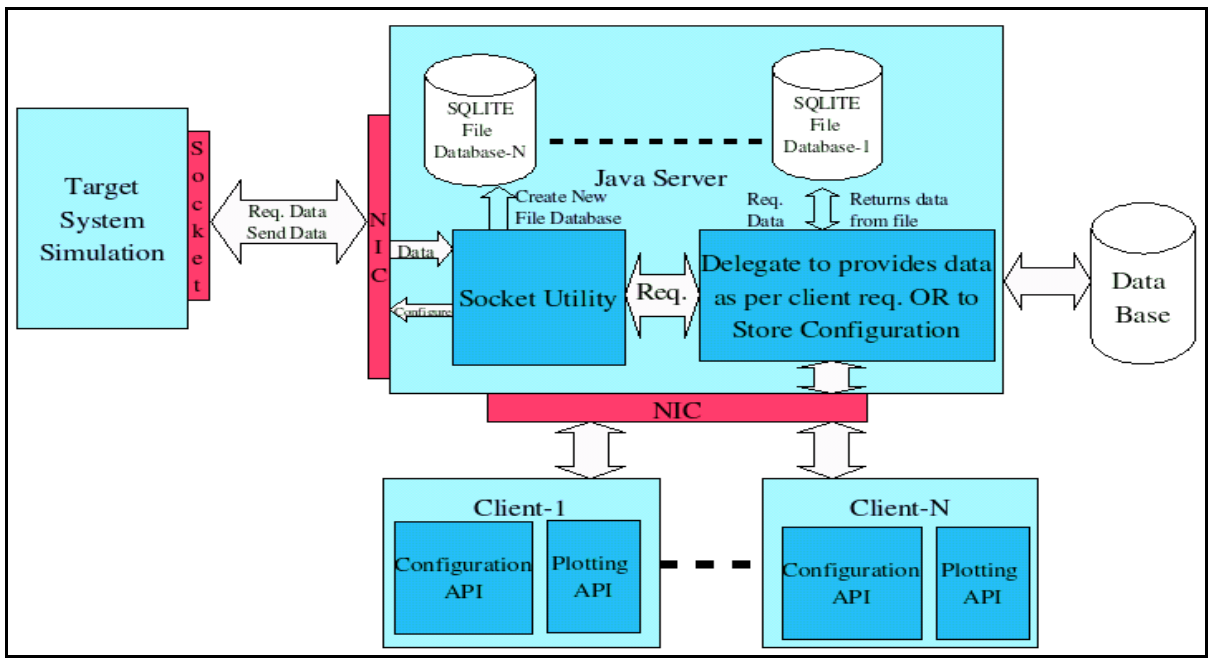

Figure 2: Application architecture of the data acquisition software system.

Target Board Application

Target board application takes care of the configuration parameters of the data acquisition hardware settings like set no. of channels to be used, acquisition mode, scan rate, trigger mode etc. This is a platform dependent application running over VxWorks 5.4 real time operating system (RTOS) platform and is developed in gnu C/C++, with Tornado 2.0.2 as IDE. It acquires the analog signal from the signal conditioning hardware and converts it into digital data using ADC cards, and store into logical memory. Moving average type filter is implemented on raw data which can be configured for selected channels. No. of samples to average is adjustable depending upon signal sampling rate. It has TCP/IP socket API to communicate with the host program running web server software. Using DAC channels, Digital data can be converted into analog form selected by the application server. It also has the VxWorks API for configuring DI/O card to set I/O modes, no. of channels etc to perform the operation of displaying the status of the quench channels or to detect the trigger from the different subsystems to indicate the same to the Application server. Time stamping is implemented with GPS receiver time from the central control room to time synchronize the dtat acquisition with all other subsystems. In the absence of GPS card the application will automatically switch over to the onboard controller RTC time with a ststus update at server and an indication display at client window.

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Application Server

Second module is a Java server application, which will receive data from the target board application, store data into database and forward it to multiple client application as per demand. It contains business logics like Roles, Data management, Authentication, Data storage and analysis. The main aim of this module is to acquire data at high speed and transmit this data over Ethernet intranet network. Along with server the host machine accommodates two databases for the application. One is MYSql database which is used to store user login details, roles, configuration details etc. Whereas other database is H2DB which is the file database used to store the acquired data. This database facilitates offline data analysis as per user requirements at client end through different analysis tab. Here, in this application the file database is used instead of the file because of the performance advantage of the file database over the file in sense of the searching facilities for the off-line data plotting and analysis.

Socket Utility is implemented to receive the set configuration, get configuration, start acquisition, stop acquisition, acquire raw data and acquire calibrate data commands from the client application. It forwards these commands to the target board application, receives the acquired data from the target board application, stores it into the database and forwards acquired data to all clients who had requested it for the on-line plot. Delegate is implemented for activities like authenticate user, user creation and role assignment, provides the configuration details, provides off line data and configuration of the application.

Desktop Client Application

Third module is a JAVA desktop intranet application, which is a rich graphical user interface (GUI) used to set configuration, send commands, data plotting, data analysis and many other functions. Initially, this module was planned to be implemented as a web based interface, but then it was implemented as a desktop application due to its higher speed and better reliability. Set configuration is used to program hardware for the required application setting through a series of pop-up windows. There are two types of users defined for the software operation, Administrator and Normal user. Administrator has all the access rights mainly to configure VME hardware configuration parameters. Normal users have read only permission, he can see current configuration setup and has access to data for analysis and plotting. Only one administrator login is allowed at time. Different tab windows are provided for data monitoring and plot display. As the no. of channels are large, different groups, colours and line styles are provided to show large number of channels at once. Output channel display supports sensor readings in absolute unit (Kelvin, Gauss, mm etc) using internal conversion of raw data with interpolation equation, formula or by reading nonlinear calibration curves. Java client application will provides login facility for the security purpose with defined user rights as per role assignment. GUI provides the facility for the shot comparison, export the data in form of excel, binary and CSV and a scheduler for data backup at predefined interval. A report generation tab is provided for generating report of analyzed data as well as channels configuration.

RESULTS AND DISCUSSION

The DAS was used successfully during the recent SST-1 engineering validation experimental campaign. The VME processor, Server PC and an administrator client were kept in the field at magnet control area. A local intranet network was established using a five port switch with an uplink connection from the central control room SST network. All the user client machines were operated remotely from the central control room. In the event of network problems or failure client will be disconnected but the VME and server will always be running and acquiring the data due to local intranet connection. Client application is made as a desktop application instead of web based application and has worked fine. In case of web application the rich graphic part will take large amount of network bandwidth and can make online plotting slower in case of large data access. Desktop application has a local graphics and only data will be sent over network reducing the bandwidth requirement. Web server and database were integrated in the same machine and has worked uninterruptible fashion.

CONCLUSION

A large channel count multi client DAS was developed for the magnet systems of SST-1. The application has run continuously over several weeks of magnet operation and different modules and features were tested during the execution. The software has shown minor bugs initially and malfunction in data storage sequence and labelling when all the channels were selected simultaneously which were corrected during the usage. The software application will further be modified in client user interface for better visualization and ease of use.

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