STATUS OF THE SARAF CONTROL SYSTEM

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Abstract

The Soreq Applied Research Accelerator Facility (SARAF) is a 5-40 MeV, 0.04-2 mA proton/deuteron RF superconducting linear accelerator, which is under commissioning at Soreq NRC. SARAF will be a multi-user facility, whose main activities will be neutron physics and applications, radio-pharmaceuticals development and production, and basic nuclear physics research.

The SARAF Control System is based mainly on National Instruments and Siemens hardware and software. This paper presents an overview of the design concepts and implementation of the main and auxiliary SARAF control systems.

INTRODUCTION

SARAF is currently under construction at Soreq NRC [1]. It will consist of a medium energy (up to 40 MeV) high current (up to 2 mA, CW, upgradeable to 4 mA) RF superconducting LINAC of protons and deuterons, beam lines and a target hall with several irradiation stations. Due to the technical novelty in the accelerator, the project has been divided to two phases. Phase I includes the ECR ion source, the RFQ, a prototype superconducting module (PSM), a diagnostic plate (D-Plate) and a beam dump (See Fig. 1). Phase I further includes the design of the full accelerator (based on beam dynamics simulations) and the design and risk reduction of foreseen applications. Phase II includes construction of rest of the accelerator and its applications. For more details on SARAF see Ref. 2 and references therein.

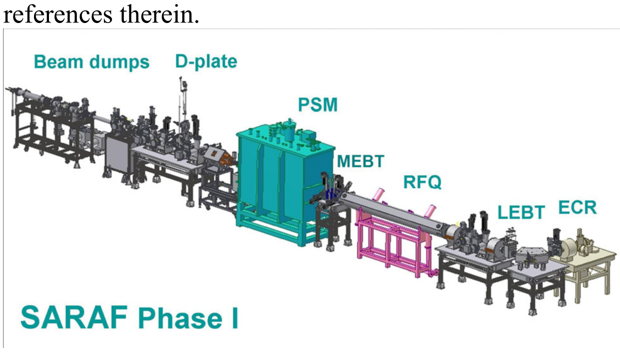

Figure 1: Schematic view of SARAF Phase I.

THE MAIN CONTROL SYSTEM

There were certain guidelines towards the realization of the Main Control System (MCS). We opted for a widely used commercial software package from an established company. The hardware (controllers, data acquisition, hardware, etc.) is also commercial, and incorporates the OPC standard, which is a universal protocol for hardware software interfaces. It is advantageous to choose a company which produces both software and hardware.

There is also a desire to minimize the types of hardware and software in the system. This has to be optimized with constraints that may be imposed by the many subcontractors of the SARAF project, so having several types is acceptable, provided that inter-communication is possible.

The architecture of the MCS was chosen to be 'server-client'. This means that there is a central server whose sole purpose is to manage the hardware controllers and the MCS. The users operate the systems and run additional programs on client computers, which are networked only to the server, and not directly to the hardware. This architecture improves reliability, may provide redundancy and ensures that a crash in a client computer does not affect other clients, the server and the entire facility [3]. The layout of the SARAF control system architecture is shown in Fig. 2.

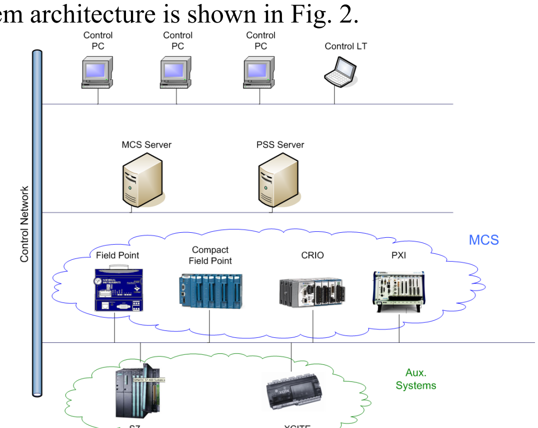

Figure 2: Schematic view of SARAF control system.

HARDWARE

The MCS hardware consists mainly of National Instruments equipment. The type of PLC or DAQ was selected in order to comply with system performance and reliability demands.

Field Point Controllers FP-1601

FP-1601 is a network interface module with event-driven communication, which delivers a high-performance network connection to minimize network traffic. Those 6 modules are used in SARAF for data acquisition of vacuum and magnets power supply control systems.

Compact Field Point cFP-2020/2110

Compact Field Point PLCs are typically used in applications requiring industrial-grade reliability - such as stand-alone data-logging, analog process, and discrete control systems [4]. In the SARAF control system, that type of controller is used for Prototype Superconducting Module process parameters control and Beam Halo measurement control (one controller for each system).

For the Phase I beam lines vacuum control system, it was decided to use a cFP-1804 network interface module to collect the data, where its analysis and control logics run on one of the RT cFP controllers.

CRIO 9014/9002

Compact RIO is a real-time processor for deterministic and reliable real-time applications. It runs the National Instruments LabVIEW Real-Time Module on the Wind River VxWorks real-time operating system (RTOS) for extreme reliability and determinism, which makes the CRIO controller the preferable choice for the SARAF Machine Safety System. In SARAF MCS there are two CRIO controllers to ensure the MSS control system redundancy.

In the beam lines control system, a CRIO controller will be used for MSS in FPGA mode and for magnets power supplies control as a normal RT controller.

PXI 8196

PXI-8196 is a high-performance Pentium M 760-based embedded controller. The new Pentium M architecture provides the highest mobile performance and it is ideal for applications requiring intensive analysis such as the SARAF LLRF control (see Figure 3).

An additional PXI controller will be used for Phase I beam lines diagnostics and motion control.

Motion and Diagnostics PCI 7334/6220

Stepper motors and beam diagnostics control are based on an industrial PC platform, motion control and beam diagnostics PCI cards.

S7- 300/400

A number of stand-alone SARAF subsystems use Siemens SIMATIC S7 controllers. Those controllers are suitable for data-intensive tasks, high processing speeds and deterministic response times that guarantee short machine cycles for applications of Cryogenics (S7-400 controller with two remote modules), Personal Safety System (S7-300-F controllers, which are compatible with the international safety standard EN 954-1, Category 4) and RFQ-RF amplifier control (S7-400).

IQ3 Trend Controllers

Those DDC controllers manufactured by Trend are dedicated to control the SARAF facility HVAC (**H**eating **V**entilation and **A**ir **C**onditioning) and Process Cooling Water for accelerator subsystems. Each of the 7 HVAC/CW control cabinets has an IQ3 controller.

Hardware Location

Most of the SARAF Main Control System components are located in the "RF Hall", which is located above the Beam and Service Corridors.

The cabinet distribution is similar to the LINAC subcomponents location in the Beam Corridor as shown in Figure 3.

CONTROL ROOM

The size, layout and location of the main control room (MCR) in SARAF were designed in order to ensure optimal operation conditions (see Figure 4).

Regarding size and layout, the requirements were:

1) Comfortable size for all monitors and controls,
2) Easy access to all monitors and controls,
3) Housing of two permanent operators + a few more in special occasions,
4) Similar to other facilities of parallel size.

The MCR size is 5×10 m^2, with an adjacent 15 m^2 server's room. It is also adjacent to the RF Hall.

The location of the MCR was dictated by: 1) Proximity to frequently visited systems, 2) Centrality and proximity to main entrance, 3) Possibility for enlargement and, 4) External walls with windows [3].

SOFTWARE

Based on the abovementioned guidelines, it was decided that the MCS software package will be LabVIEW by National Instruments with a DSC module and an OPC server. LabVIEW is widely used, is flexible and scientifically oriented [4]. Most of the engineering personnel in SARAF are familiar with LabVIEW programming and in assistance of being a Rapid Development Software, it helps to design, use and change applications during the commissioning shifts within a short time periods.

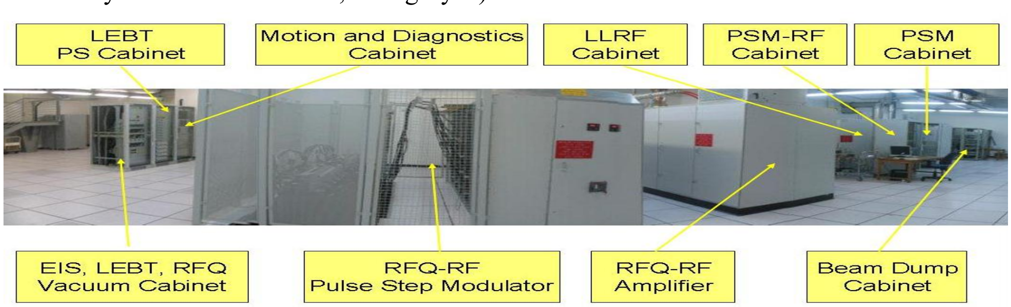

Figure 3: Cabinets location in RF hall.

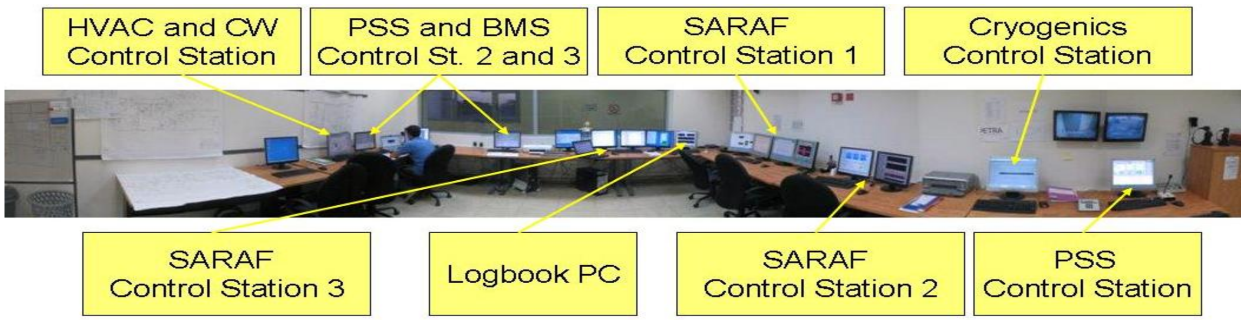

Figure 4: MCR at SARAF.

Since the system is still under commissioning and integration, the applications are designed as stand-alone VI's with full system expert authorization, except for the LLRF application, which is designed in expert/operator architecture (see Figures 5 and 6).

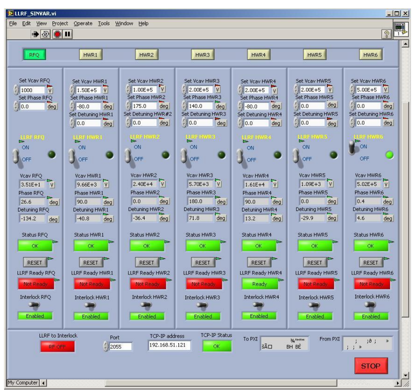

Figure 5: LLRF operator screen.

During Phase I finalization, the applications will be substituted by modular applications consisting of auxiliary and main control subsystems with operating step-by-step sequence and log-on/off procedures. Authorization levels will be defined as "expert", "operator" and "guest".

CONTROL SYSTEM NETWORK

SARAF is using a 100BASE-T Ethernet network for most of the control system devices, except for Cryogenics control that uses PROFIBUS communication. 48 communication points were spread over the facility to provide communication infrastructure to all of the SARAF control subcomponents.

The requirement for additional communication points rose during the commissioning. To resolve it, local fast Ethernet switches are temporarily used, mainly at the SARAF control room. The communication system is planned to be upgraded during Phase II.

During the commissioning period and integration of control subsystems, the flow of data has slowed down. Those issues are currently being investigated by RI and SARAF engineers and the primary results show clearly that clients' request for data/SV updates, variable values change frequency, and measurement dead-bands might be a reason for the network traffic overflow. For instance, one variable application with poor software architecture can demand 0.2% of network capability when there are more than 750 shared variables used for SARAF operation.

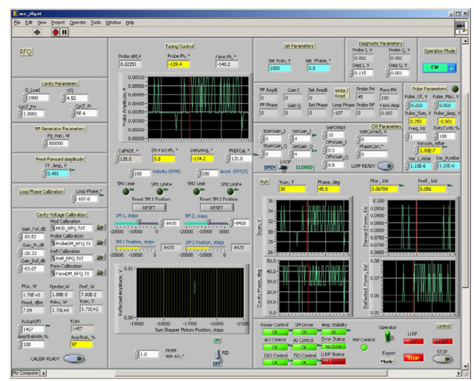

Figure 6: LLRF expert screen.

SUMMARY

In this paper we presented a short overview on the SARAF MCS status. Setting up the Main Control System for this complex accelerator facility is one of the main goals of the SARAF engineering group and will constitute an integral part of SARAF commissioning.

ACKNOLEDGMENTS

We wish to express our acknowledgment to NI Israel and NI Germany for their technical support in setting up and commissioning the SARAF MCS.

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