R.F. Control System For Indus-1

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1 Introduction

Indus-1 is India's first synchrotron radiation source (SRS) nearing completion. It consists of a 20 MeV Microtron injector, a 700 MeV Booster ring and a 450 MeV Storage ring. later, the same booster will inject 700 Mev electrons to a 2 GeV storage ring Indus-2. The R.F. control system for this facility has been operational for more than two years now. This system is integrated into the overall control system for Indus-1.

2 Architecture of indus-1 control system

Indus-1 control system follows a two layer, loosely coupled, modular and distributed architecture as depicted in fig 1. This architecture was chosen for its simplicity; simplicity of the machine and relative inexperience of the designers at that time. Another important consideration was the use of the same system for commissioning as well as for normal machine operation. The top layer or control room layer consists of IBM-PC clones used as operator consoles. These control room computers support the networking environment consisting of Novell Netware as the network operating system and Ethernet communication standard with TCP/ IP as the network protocol. Functional subdivision at this layer has resulted in dedicating one PC for each subsystem like RF, Power Supply, Timing, Vacuum, Beam Diagnostics, Radiation monitoring etc. Each sub-system PC is connected over serial links to Equipment Interface Units (EIU) which are VME crates running inexpensive and powerful 16 bit Motorola 68000 processors. The operating environment at this level consists of basic monitor firmware for the fastest response times. Software development for this VME level (cross development) has been carried out at the control room PC level with the help of cross compilers, cross assemblers and terminal emulation utilities. The machine control software development at the control room layer has been done using C compilers and netware API SDKs.

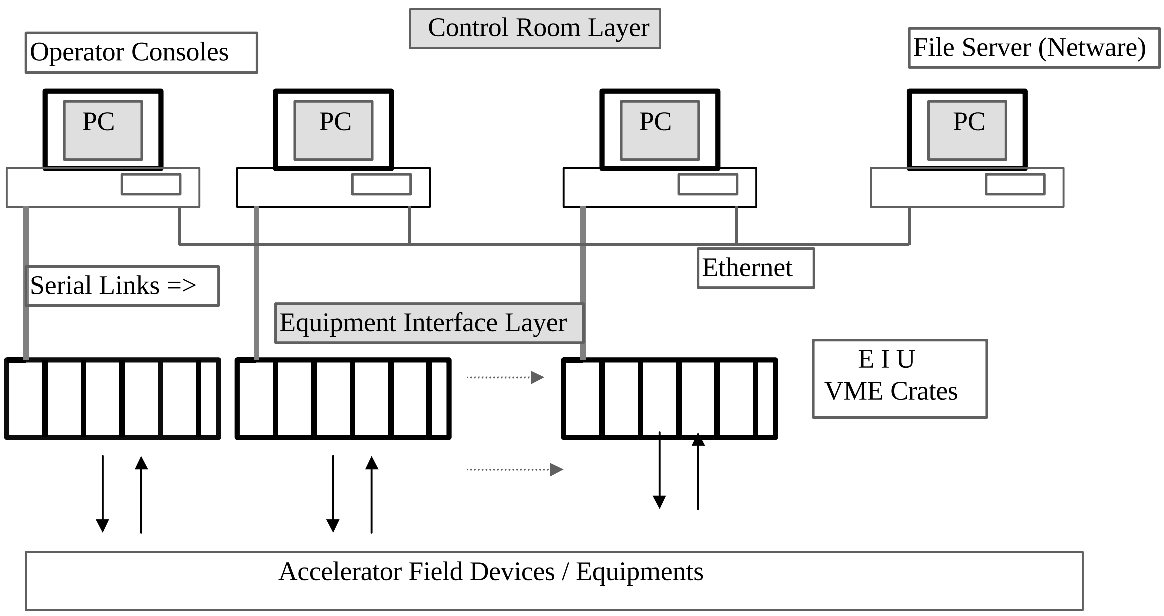

Fig. 1 Schematic Of Indus-1 Control System

3 Overview of R.F. system

The R.F. system has three major components - Booster ring cavity, Storage ring cavity and Ion clearing electrodes for storage ring. Both booster ring and storage ring rf systems are similar except for the power levels.

4.0 KW RF Amplifier for booster ring cavity
10 KW RF Amplifier for storage ring cavity
100 W RF Amplifier for Ion clearing electrodes

Common frequency reference of 31.613 MHz exists for both Booster and storage ring cavities. Fig 2 shows the RF system schematic.

Three analog control loops receive reference SET signals from the control system -

Tuning (Frequency) loop - Compensates for the beam loading effects and temperature changes using motor activated plunger (tuner) and maintains the resonant frequency of the cavity. It is possible to change the resonant frequency of the cavity using a tuning compensation setting from the control interface.

Amplitude loop - Compares the RF Power Set value and the value of the accelerating field in the cavity and corrects the difference if any using the variable attenuator. RF Power Set from controls allows varying of the rf power which consequently changes the cavity gap voltage.

Phase loop - Compares the phase of accelerating voltage in the cavity with the frequency synthesizer output signal and effects corrections if required using the variable phase shifter. Phase Set from controls can be used to change the phases of accelerating fields in booster and storage ring cavities.

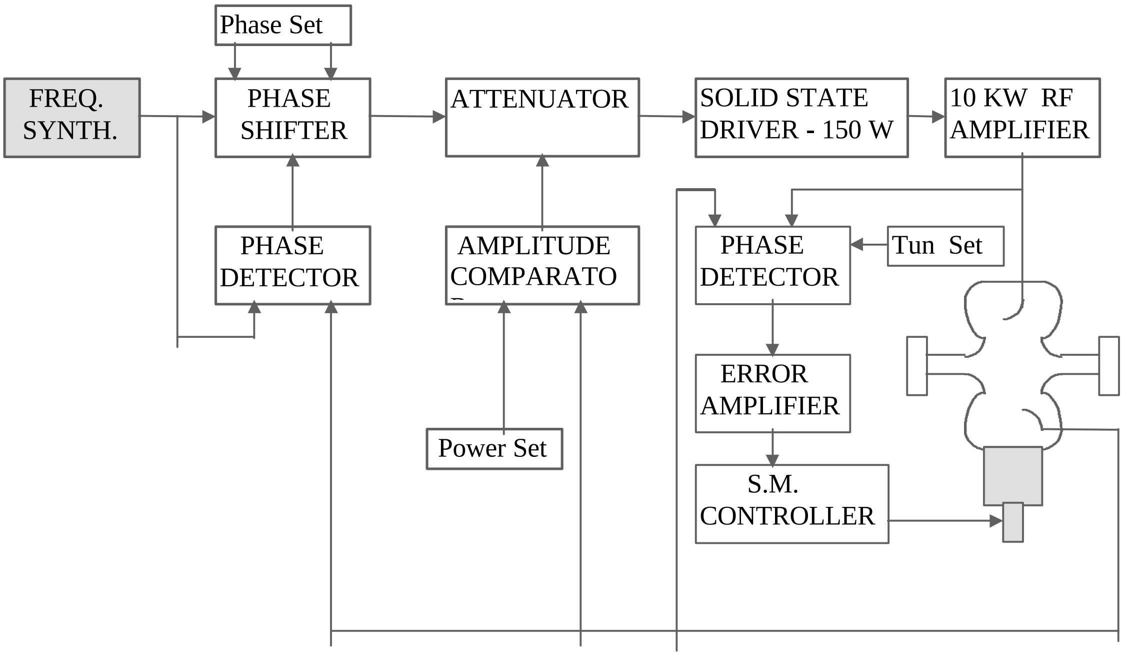

Fig. 2 Schematic of Indus-1 RF System

4 RF control system

In addition to complete control of the rf system of booster and storage rings, the control system also allows control of ion-clearing rf system for storage ring. The various devices/equipments under control regime are two rf cavities and eight ion-clearing electrodes, two high power rf amplifiers of 4.0 and 10 KW, high voltage DC power supplies, pre-amplifiers, phase-shifters, phase-detectors, stepper motor control units, cooling water pumps & chillers, flow switches and temperature sensors etc. The system monitors crucial RF parameters e.g. forward and reflected rf power, rf phase, cavity gap voltage, tuning error etc. Operator interacts with the system from the PC in the main control room. VME crate as the equipment interface unit handles the actual physical connections with the R.F. system.

5 Salient features

- Provides Recommended Start up and Shut down Sequence for RF sub-systems.
- In case of operational problems, the control system provides the operator guidance for troubleshooting and allows for complete manual operation.
- switching off / stopping the control system software and hardware does not affect the state (on / off) of the RF system.
- Local / Remote Mode
  Provides local / remote mode operation for most of the sub-systems. This is activated from equipment / sub-system panel L / R switch. Local mode disables ON / OFF & SET operation of equipment / subsystem from main control room. This is useful for safe system maintenance. Remote mode allows access from main control room only and disables ON / OFF & SET operations from local equipment panel during normal operation.

6 System interlocks

Start up sequence interlocks prevent unsafe (to system) conditions.

* No Cavity Cooling Water Flow - Trip RF
* DC Power Supply Overload (Plate / Screen / Grid) - Trip RF, Driver PS & HV
* Blower Off / HV PS Door - Open / Main Water Flow Off - Trip RF & HV
* Power Supply Fault - Trip RF, HV & Driver PS
* Vacuum Fault - Trip RF

7 Software

The operator interface software is simple, menu driven and has been optimised for minimum operator interaction. Following are the salient features :

- Operator Console (PC) Program - written in C.
- EIU Program - written in 68K assembly lang.
- Distributed Online Database - managed at Console and EIU levels.
- Remote EIU program downloaded at start up.
- Three convenient screens - one each for booster ring, storage ring and common (B.R., S.R. and Ion - clearing).
- Top Menu bar for menu based selection of functions / actions.
- Bottom message bar for operator assistance - ~ 20 messages / screen.
- No direct data entry - Coarse and Fine UP-Down controls for setting RF Power, Phase and Tuning Compensation.
- Vacuum interlock prevents switching ON of RF if required value of vacuum is not achieved.
- Total system shutdown following a recommended sequence.

8 Communication / Protocol

The communication between operator console PC and EIU is command - response type because of the master - slave mode of interaction between them. The PC is the master which regularly sends commands to the slave EIU for sending the latest data and refreshes the same on the screen. Also, operator interaction results in ON / OFF , SET and MODE changes commands which are delivered to the slave EIU. The status of execution of these commands is tracked and operator is informed in case of non-compliance or malfunctioning. The EIU works in the slave mode. It keeps looping, updating the system status, polling for commands from the operator console computer (PC) and when valid commands are received, executes them and sends the relevant data back to PC. Actions on interlock failures and alarm conditions is initiated at the EIU level and the same is conveyed to the PC.

Optically isolated serial communication link between the operator console PC and the equipment interface unit prevents ground loops.

9 Experiences with the system / conclusions

The system’ response and overall operation has been quite satifactory during it’ operation for the last two years. It is realised that the demands for changes / additions are put forth frequently and sometimes entirely new functionalities are demanded. This calls for the features making the system easily extensible and flexible to incorporate extra and new types of inputs / functions.

An Object Oriented approach in software design would help achieve the above with minimum side effects and code reuse to ease the situation.

Porting to different hardware and software platforms is necessitated because the machine life cycle is longer and the technology changes are faster.

International standards in both software and hardware should be followed as far as possible. The concept of software sharing with other labs of the world seems very useful and attractive and needs proper investigation and support.

References

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