Instrumentation and control system architecture of ECRH SST1

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Abstract. The Electron Cyclotron Resonance Heating (ECRH) system is an important heating system for the reliable start-up of tokamak. The 42GHz and 82.6GHz Gyrotron based ECRH systems are used in tokomaks SST-1 and Aditya to carry out ECRH related experiments. The Gyrotrons are high power microwave tubes used as a source for ECRH systems. The Gyrotrons need to be handled with optimum care right from the installation to its Full parameter control operation. The Gyrotrons are associated with the subsystems like: High voltage power supplies (Beam voltage and anode voltage), dedicated crowbar system, magnet, filament and ion pump power supplies and cooling system. The other subsystems are transmission line, launcher and dummy load. A dedicated VME based data acquisition & control (DAC) system is developed to operate and control the Gyrotron and its associated sub system. For the safe operation of Gyrotron, two level interlocks with fail-safe logic are developed. Slow signals that are operated in scale of millisecond range are programmed through software and hardware interlock in scale of microsecond range are designed and developed indigenously. Water-cooling and the associated interlock are monitored and control by data logger with independent human machine interface.

1 Introduction

The electron cyclotron resonance heating (ECRH) is used for plasma start-up to MHD control in various tokamaks [1-4]. The 82.6GHz/200KW and 42GHz/500kW ECRH systems are used in tokamak SST-1 [5-6] to carry out experiments related ECRH assisted breakdown and start-up at fundamental and second harmonic. The operating toroidal magnetic field of SST-1 is 0.75T, 1.5T and 3.0T, however in the beginning phase of tokamak, it is operated at 0.75T and 1.5T magnetic fields. The 42GHz/200KW system is used for starting phase of operation of SST1 [7]. Both ECRH systems 42GHz and 82.6GHz ECRH system consists of Gyrotron, transmission line and a mirror based launcher and other auxiliary power supplies. The 82.6GHz Gyrotron and 42GHz Gyrotron are capable to deliver 200KW/CW and500kW/500ms at 50kV beam voltage respectively.

The system is connected to tokamak using corrugated waveguide based transmission line. The transmission consists of matching optic unit, bends, polarizer, DC break and mirror based launcher. The layout of 42GHz ECRH system and actual system in SST-1 tokamak hall are shown in figure1 and 2 respectively.

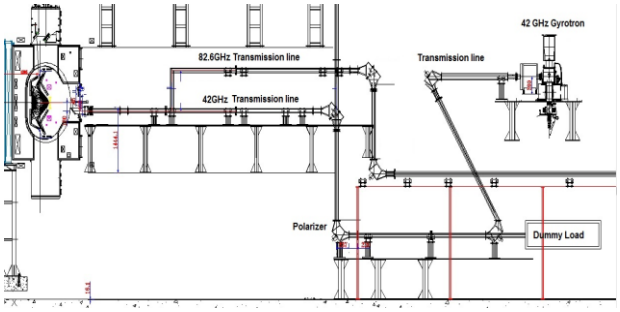

Figure1. 82.6GHz and 42GHz ECRH system on SST1.

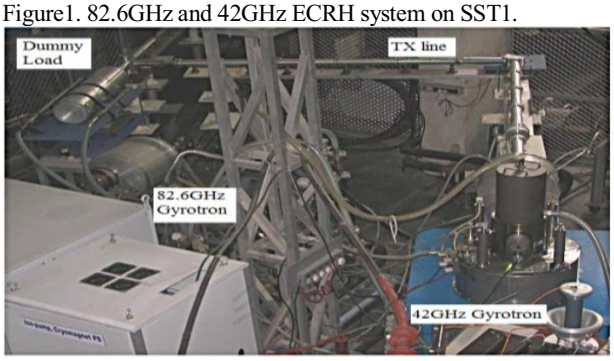

Figure2. ECRH system in SST1 Tokamak

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2 System Requirements

The Gyrotron based ECRH system is associated with many auxiliary power supplies like filaments, high voltage cathode power supply, magnet power supply, anode power supply for generation and control of microwave power. Because of high power generation in Gyrotron microwave tube, sufficient water cooling is provided in component of gyrotron like collecter, body, cavity for heat deposition .The dedicated data acquisition and control (DAC) system is developed to monitor the entire system and perform the automated system tasks [8]. The DAC monitors parameter of axillaries power supplies and controls the according to the system requirements. A dedicated datalogger is used to monitor all cooling parameter of system.The Control system has two parts conditioning instrumentation and interlocks which are discussed in next sections.

3 Conditioning Instruments

The Gyrotron based ECRH system consists auxiliary power supplies, microwave components and cooling system. All the different systems have different control parameters and Different operating range. A single control platform is required to operate whole system automated. The conditioning electronics is developed to convert all parameters to common control range for central control system of DAC. The Conditioning electronics is the common interface between auxiliary system and central control system .The ECRH DAC has VME based central control system, which controls the subsystem.

The Local DAC system of ECRH is interfaced with central control system of tokamak SST1 for various plasma experiments. The optical based Ethernet protocol is used to interface between ECRH and Tokamak control unit. The VME central unit and data logger are connected with Ethernet link with GUI (graphical user interface).

The ECRH DAC control system handles around 80 signals for monitoring and control, which include cooling parameter and interlock signals. The safe operation of Gyrotron requires various Input and Output signals (Analog & Digital). In order to operate the system in High voltage environment, Fiber based input and output interface is used to avoid the transfer of noise with the signal. The VME operate sequential step to interface with local unit of high voltage power supply. The indigenously developed instrumentation and control fulfil the requirements for ECRH operation.

4 Interlock systems

The interlock system operation depends on the hierarchy and critical requirement with different time varies from microsecond to millisecond range. The slow scale interlocks action taken care by VME control unit. This uses software coding and called as soft interlocks. The slow scale interlock associated cooling is operated with Data logger controller unit. The operational window for cooling parameter (Flow & temperature) are decided for safe operation and interfaced with control unit. Topology of interlock unit is shown in figure4.

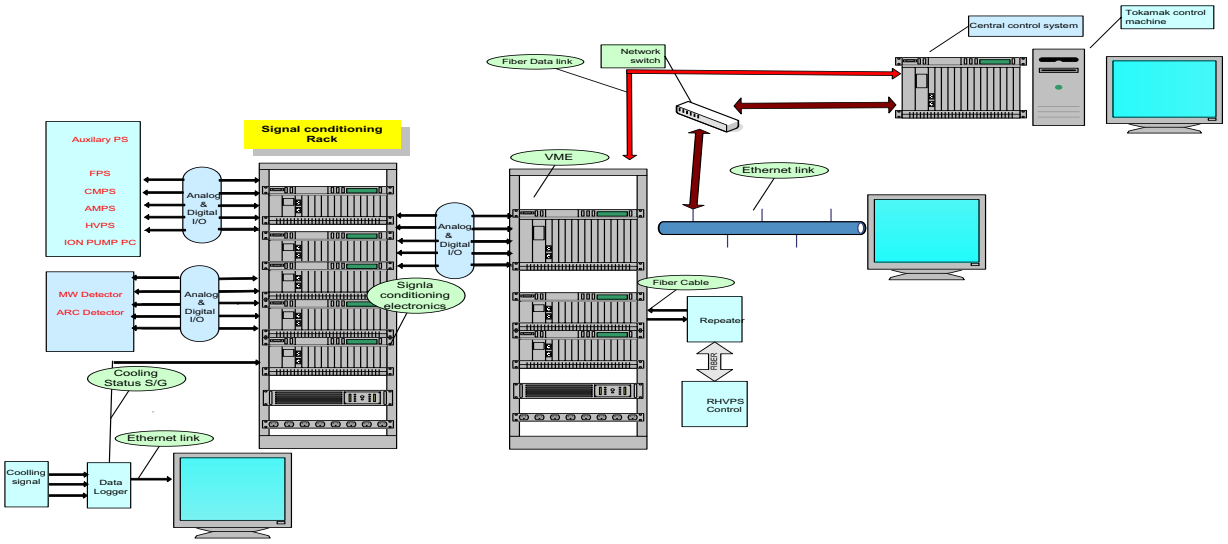

Figure 3. Conditioning instruments of ECRH system.

The Common signal flow diagram of conditioning system is shown in figure 3.In the figure different auxiliary power supplies and cooling control parameters are connected to conditioning electronics.

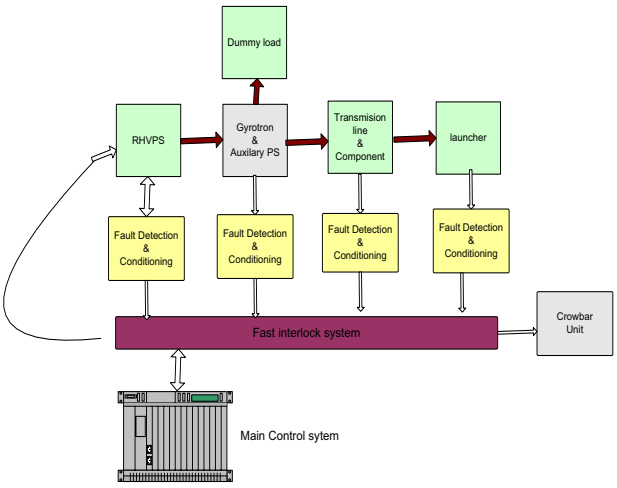

Figure4.fast interlocks processing scheme of ECRH system

The Gyrotron is delicate device and its safe operation demands dedicated fast interlock for the protection of Gyrotron. There are several fast interlock are used for safety of Gyrotron. These are Arc, beam over current, di/dt etc. In case of fast interlock operation, the main high voltage power supply need to be removed within 10µs scale. All ARC detection unit and main power supply parameter like di/dt and beam over current are directly interfaced with dedicated hardwired control system. The fast interlock unit works as an independent control system provides a single trigger to main HV power supply to protect Gyrotron against any damage. Since the time of operation is critical (<10µs) so sensors are directly connected to interlock unit. The optical fiber based communication is used to Interface with interlock and main HV power supply to minimize the delay for reliable and safe operation.

Summary

The VME based control system along with the required conditioning electronics has been successfully implemented in ECRH SST1 system. This is a stable and reliable system operates continuously with Gyrotron. This system is being upgraded with PXI based control system [9]. The fast interlock action will be based on FPGA based processor where the signals would record the sequence of event for post event analysis.

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