§12. Control System of DC Power Supplies for LHD Superconducting Coils

Chikaraishi, H.

The LHD has 6 superconducting coil sets and 6 dc power supplies to excite them in phase I operation. Each power supplies have own local controler but the plasma operation of LHD requires TOUGOU SARETA control for the power system. This paper report about control system of these power supplies to realize it.

Figure 1 shows the structure of the computer control subsystem for the steady state power supplies. This control system has following two functions. One is a coil current regulation and the other is an operating state control of system. This control system has a hierarchy. The lowest is a controller in a rectifier unit. Next is two VME bus computer systems. These VME machines have the coil current regulator for multi-coil system and interface to sequencer in rectifier units and check its state. The highest level is an engineering work station. This machine works as an interface with other control systems, temporary data storage and a total system diagnostic. A reflective memory set using optical fibers links these three computers and it realize the data transfer in real time. Serial lines to transfer the current and voltage data and parallel lines for state signal connect the VME machines and rectifier units.

Current Control The required performances to the regulator are as follows:

1. Current control error in steady state is less than 0.04%.
2. Settling time to the 1% off control error is less than 1 second
3. Load condition changes in wide range.

To sutisfy these, a current regulator based on the state variable control theory is selected. In this control scheme, required control period is less than 20ms because the shortest characteristic time constant of the load is about 0.5 s

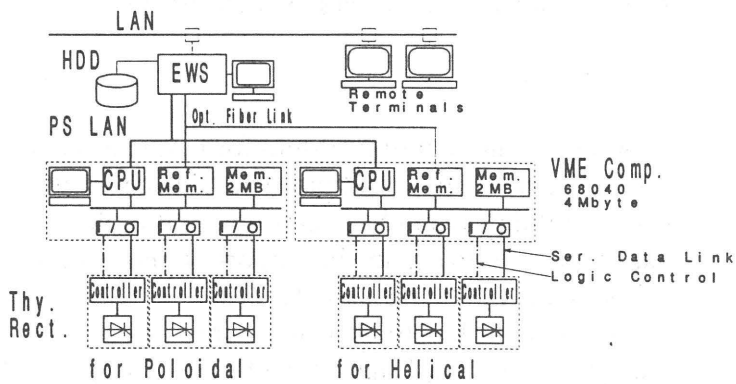

Fig. 1. Structure of Computer Control Subsystem for LHD Power supplies.

and we need more than 10 control steps between this time. The number of state variables is 10 that includes 6 coil currents, 3 currents in structure and a plasma current. We estimated the actual time to perform this regulator with test program. The result shows that the cpu needs only 118 μ s for calculation and 10.8ms for data communication with rectifier units.

Operating Mode of Power System This power system has following states:

Complete stop: All of system is stop.
Stop: Control systems are working but it is not ready to operation.
Standby: After self check, it is ready to excite coils.
Operating: Coils are exciting.
Quench protection: Quench protection is operating.
System fault: Some trouble detected.

First four are normal states and the system moves between these states by a command from LHD experiment control system through a LAN and system conditions. When a system fault is detected, the rectifies try to regenerate stored energy as possible. The main part of this state control is installed in the sequencer built in the rectifier units. Also this sequencer has a quench protection sequence, that starts with hardwired signal, and system fault detectors. The computers run to check the status of rectifiers and report the result to the other system likes as a plasma experiment system. With this structure, each rectifier unit protects itself even if data link or VME machines are down.