ECH Control System for New 1 MW 110 GHz Gyrotrons at DIII–D*

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ABSTRACT

Two new Varian 1 MW 110 GHz gyrotrons are currently being developed and are due to be tested at General Atomics next year. A new cost-effective gyrotron control system to operate multiple gyrotrons simultaneously is being developed. Different systems and combinations that were considered include CAMAC, PLC, VXIbus, and a local computer. This paper will explain the decision making processes used in choosing and implementing the new control system architecture.

INTRODUCTION

The ECH (Electron Cyclotron Heating) gyrotron control system at DIII–D is being upgraded to accommodate simultaneous operation of multiple gyrotrons. The upgrade will provide data acquisition for, and interface to a Russian 110 GHz 1 MW gyrotron and two Varian 110 GHz 1 MW gyrotrons, as well as providing for future expansion. The objective is to develop this upgraded system cost effectively with limited personnel resources and tight schedule constraints.

SYSTEM DESIGN CONSIDERATIONS

The upgrade would require minimizing both cost and schedule, as well as maximizing the use of internal expertise and existing hardware. Different system combinations were considered. Hardware for the ECH control system included PLCs (Programmable Logic Controllers), CAMAC (Computer Automated Measurement and Control), and VXIbus (VMEbus Extensions for Instrumentation) based electronics. LabVIEW and VISTA control software were compared since both software control platforms are currently used at DIII–D. The choice of control software would determine the computer control hardware platform, either a PC or a SUN workstation.

The benefit of a PLC is that it employs the hardware architecture of a computer and relay ladder logic designed specifically for monitoring status, interlocks, alarms, and other 'slow' interlocks. The PLC lends itself to the large amount of I/O among the routinely monitored gyrotron controls. PLC's are used throughout the DIII–D facility, therefore there is readily available expertise within the facility.

ECH control functions include the interfaces between the DIII–D timing and operating parameters, the operator, and the high voltage power supply, as well as mode control and signal monitoring. The two hardware platforms considered to handle the control functions were CAMAC and VXIbus.

The use of a CAMAC system would benefit from a large hardware and software support system since CAMAC is used throughout the DIII–D facility. CAMAC technology has been around for many years with many different vendors providing a large range of module functions. Timing, data acquisition, and other specialized modules have already been developed, tested, and are being used in the facility. Development time and costs are decreased since many of the functions that the ECH control system would require could be copied with minor modification. CAMAC technology is becoming obsolete with several modules no longer in production.

VXIbus is a newer technology and appears to be the future direction of the modular instrument industry. The modules tend to be faster and have more capability. However, since it is a newer technology, the range of functionality still remains behind CAMAC technology. The cost runs about two times that of a comparable CAMAC module. While VXIbus has recently been used in a new control system, the knowledge base in the DIII–D facility remains small. This would mean more development time and cost would be incurred if this system was chosen. After comparing the optional technologies, the choice was made to procure a CAMAC system and a PLC.

Both LabVIEW and VISTA control software are used within the facility, at other institutions, and have third party support. The LabVIEW control software was chosen over the VISTA control software due to existing expertise within the group that would be responsible for most of the development. Another factor in the decision was that most of the development work for a LabVIEW based control system has been completed on the ICRF (Ion Cyclotron RF Heating) control system [1] with much of it directly applicable to the ECH control system. The use of this development work will greatly reduce the time to bring the ECH software control system on-line. Chosing LabVIEW control software will aid in minimizing the cost and schedule constraints in this system upgrade. With the selection of the LabVIEW control software, the hardware platform must be decided upon.

Since the new ICH RF control system was developed with LabVIEW on a SUN SPARCstation 10, this will be the computer platform of choice for the ECH control system. The SUN will be set up to be a multi-tasking, multi-user system. It will be linked to the facility control system for fast data transferring and bulk processing. The SUN provides security on the network and also allows for remote back up as well as file sharing. The SUN has a larger I/O expansion capability for future gyrotron systems.

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With the choice of a SUN platform, we will not only be able to perform data acquisition for the Varian and future gyrotrons, but we will also be able to network the Russian gyrotron controls. We will also be able to copy much of the programming and set up information done on the ICH RF SUN, significantly decreasing several areas where a large portion of development time would have had to been spent.

SYSTEM DESIGN CONCEPT

After analyzing design considerations with respect to the development schedule and budget, the system architecture concept could be identified. LabVIEW control software will be used on a SUN SPARCstation, interface to the gyrotrons with CAMAC and a PLC, and use Ethernet network to DIII–D plasma controls (see Fig. 1). The SUN SPARCstation will interface to the CAMAC crate over a GPIB interface. A serial bus will provide the interface between the PLC and the SUN.

Using the GPIB link, the CAMAC hardware will be accessible by the LabVIEW software developed on the SUN. CAMAC modules with handle fast interlocks and fault logic, timing and modulation information, analog waveform digitization, anode regulation, and water calorimetry. The various modules of the CAMAC hardware will be connected to the high voltage power supply, the gun anode regulator, power monitors, the window arc detection circuitry, as well as to gyrotron current and voltage signals. The hardware and software development will be minimized by utilizing existing development with modifications. For the second and future gyrotrons, designers will only need to copy the developed hardware and software controls.

A serial bus will provide the SUN with an interface to the PLC. The PLC will be programed using relay ladder logic to monitor and respond to analog alarms, digital I/O, and analog I/O. The PLC I/O will be hardwired to control equipment used for access control, the waveguide system, the Vacion power supply, the gyrotron heater power supply, the gyrotron tank interlocks, the water system, and the magnet system. The PLC will also be interfaced with the DIII–D operations PLC to monitor and react to tokamak alarms and for access control. There will be two PLC stations in the control system, the main PLC will be located in the ECH control room and the remote PLC in the electronics rack of the gyrotron vault. The remote PLC, due to its location near the gyrotrons, will handle the majority of the signal inputs.

SUMMARY

The architecture choice satisfies the budget and schedule restraints driving the development of the control system. The potential range of this system allows for utilizing information learned during the control and operation of the 0.5 MW gyrotrons to be incorporated, as well as allowing for future additions in functionality and control.

REFERENCE

[1] W.P. Cary, J.A. Allen, R.I. Pinsker, and C.C. Petty, “ICH RF system data acquisition and real time control using a microcomputer system,” in Proc. 15th IEEE/NPSS Symp. on Fusion Engineering, vol. II, p 547, 1993.

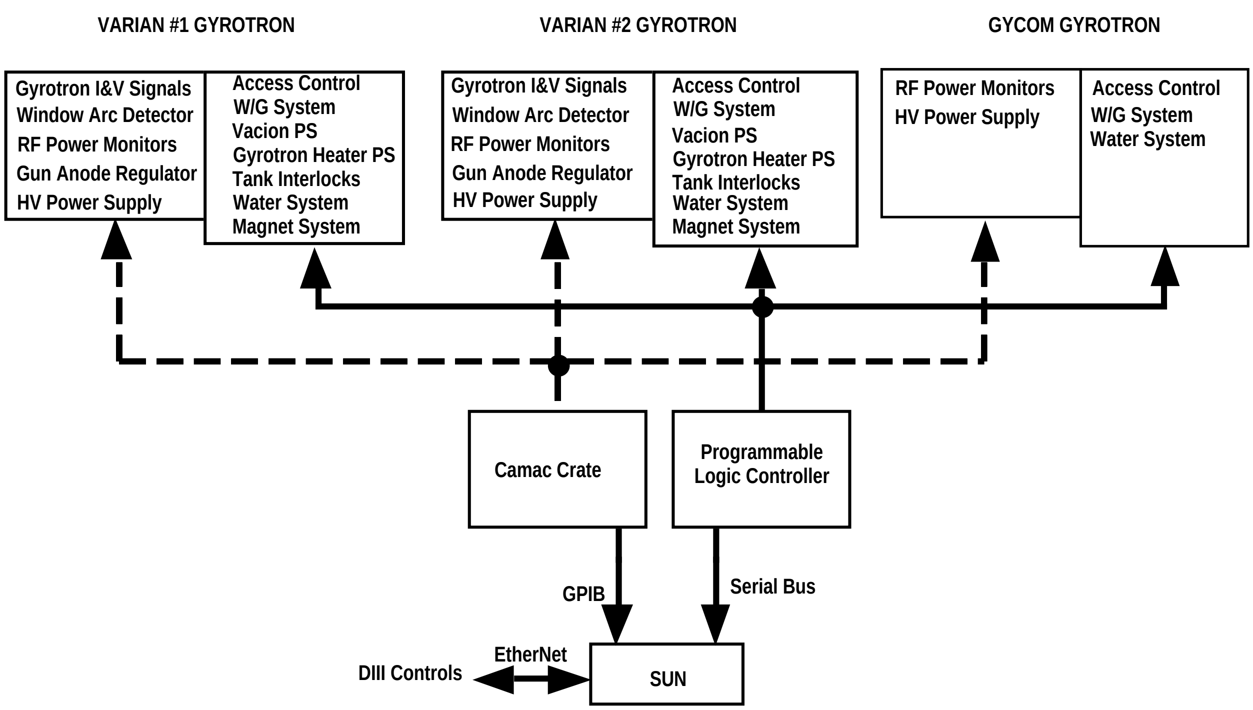

Fig. 1. Gyrotron control system block diagram.