DISTRIBUTED CONTROL AND DA FOR ATLAS*

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Abstract

The control system for the Atlas pulsed power generator being built at Los Alamos National Laboratory will utilize a significant level of distributed control. Other principal design characteristics include noise immunity, modularity and use of commercial products wherever possible. The data acquisition system is tightly coordinated with the control system. Both share a common database server and a fiber-optic ethernet communications backbone.

I. GENERAL ARCHITECTURE

Control of a high voltage pulsed power generator imposes several requirements on a control system. Foremost among these are a need for a high level of noise immunity and high reliability of safety interlocks. Other important considerations for the Atlas control system have been a tightly constrained budget, a desire for ease of use of the system and development tools and a desire for an unusually complete suite of machine performance monitors.

These required and desired characteristics have been well met by a system using commercial programmable logic controllers (PLCs), fiber-optic ethernet, commercial software for human-machine interface, database management and instrument control and a few custom circuits and software elements.

The PLC chosen for this application is SixTrak (TM) by SixNet (TM). This is a modular system mounted on DIN rails and communicating over ethernet. The use of ethernet has the great advantage that it can be run over fiber optics inexpensively. It also has the advantage that instruments using GPIB can be controlled over the same network using National Instruments (TM) ethernet-to-GPIB adapters.

PLCs in sheilded Hoffman (TM) boxes control each maintenance unit, the interlocks and the vacuum system. The maintenance unit and interlock controls will be described in detail. The PLCs in controlled in turn by personal computers running Citect (TM) human-machine interface software.

II. MAINTENANCE UNIT CONTROLS

The largest number of PLCs and control points is controlled from 24 control boxes, one on each of the Marx Maintenance modules (MUs). Each MU has its own positive and negative power supplies, trigger submaster (two MUs share a trigger master), gas distribution, dump system, charge current and voltage monitors. In addition, each MU has time-interval meters to measure the trigger time of each of its eight railgaps and four 40 Msamp/s digitizer channels monitoring the Marx discharge currents.

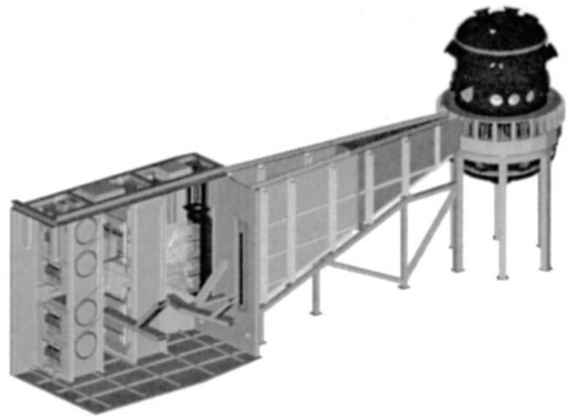

Figure 1. A maintenance unit and transmission line.

Figure 1 shows one of 24 maintenance units and its transmission lines feeding the target chamber. The box on the lid is a Hoffman box containing its controls.

A charge cycle begins with the PLC disconnecting the box from 110 VAC power. A long-throw contactor opens and batteries take over powering all of the local control and DA equipment. The PLC checks gas pressures in the trigger units and railgaps and the oil level, then waits for a go-aheads from the interlock system and master control. Once these are received the PLC enables the trigger system, opens dump switches and commands the power supplies to commence charging. The charge current and voltage are compared with expected waveforms. If any of

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14. ABSTRACT

The control system for the Atlas pulsed power generator being built at Los Alamos National Laboratory will utilize a significant level of distributed control. Other principal design characteristics include noise immunity, modularity and use of commercial products wherever possible. The data acquisition system is tightly coordinated with the control system. Both share a common database server and a fiber-optic ethernet communications backbone

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these stray out of bounds the PLC aborts the charge, informs master control and breaks the interlocks. When charge complete is achieved, master control is notified and high voltage is held up to a preset timeout period. The trigger system is fired directly from the master control system in order to obtain the required simultaneity. Immediately after triggering the PLC opens a flush valve to purge the railgaps. However, this purge must be inhibited if a trigger has not arrived, since dropping pressure on the railgaps could cause a single-channel discharge which can damage them.

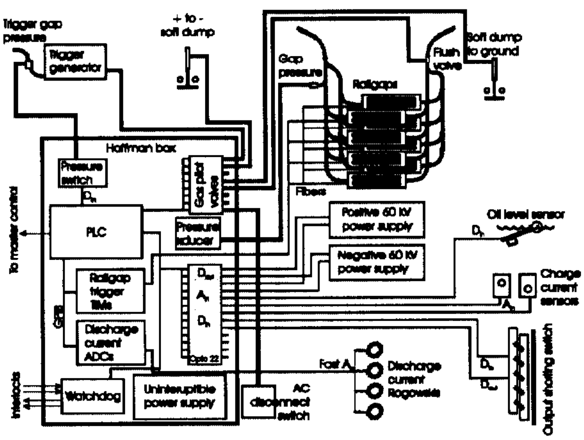

Figure 2. Block diagram of maintenance unit controls.

A novel monitoring system, described in another paper in these proceedings (see M. C. Thompson, et al.), provides a rapidly rising signal from each railgap when its E-field collapses. Each of these signals trips a time-interval meter accurate to ½ ns located in the MU control box. These are read out by the data acquisition system using the same ethernet connection used by the PLC via a GPIB-ethernet adapter. This system can also detect trigger pulses when the Marx banks are not charged, so it supports a pre-shot trigger test.

Each of the four Marx modules in an MU has a Bdot pickup probe mounted on its output header. Four signals from a combination of these probes and a Rogowski coil measuring the total output current are recorded on 40 Msamp/s digitizers in the control box. These have been custom made to a LANL design. They are also read out using the GPIB-ethernet link.

III. INTERLOCKS

High voltage interlock systems have traditionally used robust systems of hardwired sensor loops and relays. This approach is designd to minimize the possiblity of interlock system failures which might lead to exposing workers to life-threatening hazards. Such systems have the disadvantage that they are inflexible and provide little information to the operator. Locating broken interlocks or faults in the system can be difficult. The Atlas interlock system has used a different approach to interlocks designed to take advantage of the great advances in computer and control technology while attempting to maintain the same standards of reliability.

Two principles have been followed to overcome the hazards associated with allowing too much silicon in the interlock chain. First, the system is completely redundant. Two sensors at each interlock location feed signals to independent control centers, each with a PLC. Each interlock PLC provides an output to any hazardous system to enable it to energize, and absence of either of these signals shuts it down.

The second principle is to continually sense the health of every PLC involved in energizing hazardous systems and to shut down the hazard if any PLC shows signs of ill health.

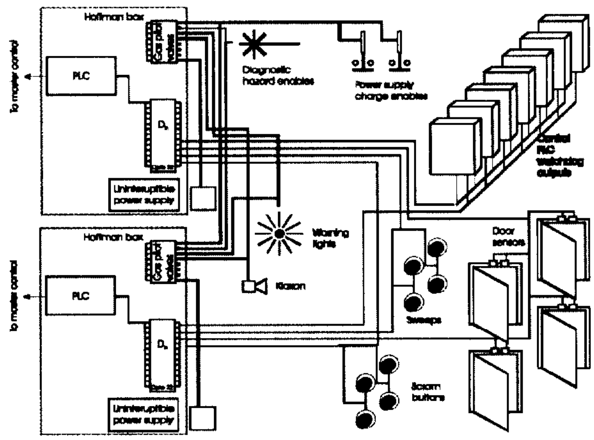

Figure 3. Redundant interlock systems.

This is accomplished by communicating interlock-related signals via periodic transitions rather than DC voltage levels. If any signal fails to make a transition within a preset time-out period, then dedicated circuitry shuts down the hazard(without PLC intervention). Thus a

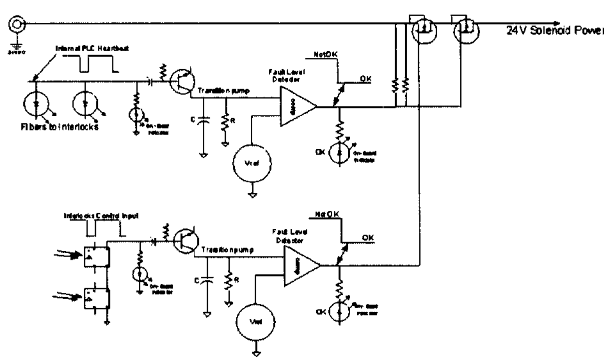

Figure 4. Watchdog circuit monitoring an MU PLC and signals from both the interlock systems. This circuit shuts down hazardous systems if any of the three inputs fails to make a transition in its time-out period.

PLC "hanging" with its outputs in an arbitrary state will force an interlock shutdown. These circuits are called "watchdog" circuits.

IV. DATA ACQUISITION

Data acquisition (DA) will be more tightly linked to the control system on Atlas than is common for this type of machine. This takes two forms. Controls and DA share the same ethernet subnet. This allows us to put recorders in section II as well as a number of diagnostics on the inside ends of the vertical transmission lines and in the powerflow channel. These latter diagnostics will be recorded in a small screenroom located near the center of the machine. Communication with this screenroom will be via ethernet to GPIB, just like the MU control box diagnostics. These will be controlled and read out by a dedicated DA computer in the main control room running National Instruments (TM) LabVIEW (TM) software for instrument control.

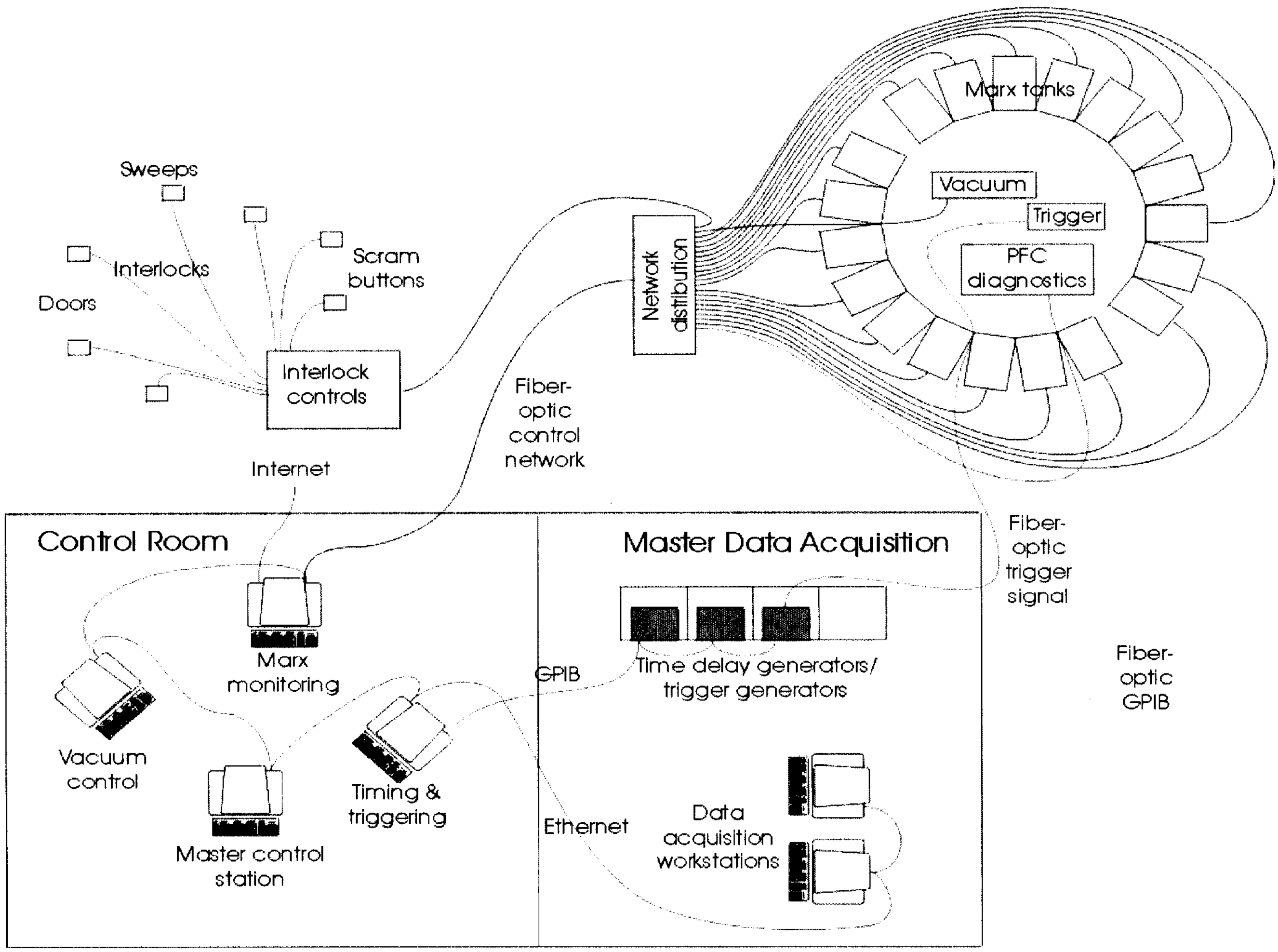

Figure 5. Atlas data networks.

in the control boxes on each maintenance unit with little additional overhead cost.

The control system and DA also share a Sybase (TM) database which is maintained on two server computers separate from the dedicated control computers and DA computers. This database thus contains all of the machine configuration and setup data, machine diagnostics data and much of the experimental diagnostic data. From one of these servers this data can be published on the World Wide Web.

Machine diagnostics include the time interval meters looking at each railgap and MU current probes described

User diagnostics can use the same approach as the machine diagnostics. Experimenters with dedicated recording systems will be integrated into this system to whatever degree is appropriate. The main control screenroom is partitioned into to rooms, one of which will be available to experimenters to setup DA and diagnostic control computers.

Analysis of the data will be performed using Research Systems, Inc. IDL (TM) software package, via a WWW graphing package or with a user's favorite tools.

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