Magnet Power Supply as a Network Object

S. Cohen and R. Stuewe
Los Alamos National Laboratory
Los Alamos, NM USA 87545

Abstract

Magnet power supplies with embedded microprocessor controls are being installed in the beam-lines of the linear accelerator and proton storage ring at LAMPF. Using an RS422 link they communicate with the accelerator control system through a terminal server connected to the site-wide DECnet backbone. Each supply is, for all intents and purposes, a network object. The controller has a command set of over seventy-five three-character ASCII control and read-back instructions. Strategies for choosing the appropriate control protocol and the process of integrating these devices into a large accelerator control system will be presented.

I. INTRODUCTION

Magnet power supplies with embedded microprocessor controls are being installed at the Clinton P. Anderson Meson Physics Facility (LAMPF). The LAMPF Control System (LCS)[1] interface for the supplies must be designed so that all existing applications that need to access power supply control channels remain unchanged. Control information to the units can originate from three sources; the front panel of the supply, a remote panel which can be mounted thousands of feet from the supply and an RS-422 ASCII uplink. Connection to the accelerator control system is through the uplink. Power supply control protocol consists of seventy-five ASCII commands. Only a handful of these instructions need be known to the LCS for routine adjustments and control. The remainder are intended for power supply set-up and troubleshooting.

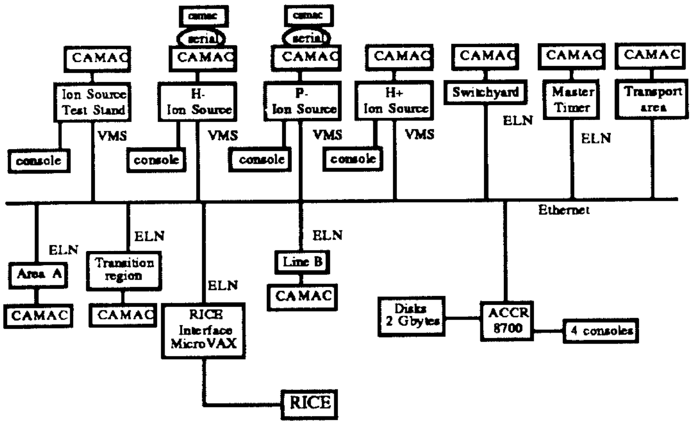

Figure 1. The topology of the LAMPF control system.

These supplies are more appropriately termed magnet controllers. They appear to the LCS as an integrated current source and electromagnet combination. In fact, key interlocks from the magnet themselves are attached to and monitored by the supply. For example, a water over-temperature trip from the magnet will cause the supply to ramp off with no intervention from the accelerator control system. Some supplies that we are installing provide a current of 1000 Amperes at 500 Volts into a one Henry inductive load. Regulation is one part in 10^4. Power supply control is significantly more complex than just "on" and "off."

II. RS-422 INTERFACE TO THE LAMPF CONTROL SYSTEM

In the past we have interfaced serial communication devices to the LCS using either a CAMAC serial communications module or a connection to terminal server. We chose the latter for this latest serial device.

Asynchronous serial communications using CAMAC is a compromise, at best. Using CAMAC modules for serial communication involves another layer of in-house software that must be developed. Serial communications modules of different types cannot, in general, be interchanged without software modifications. If the location of the supply requires a CAMAC crate to be located some distance from its control computer then a serial highway needs to be used to extend the CAMAC bus. This adds another data bus that must be maintained.

Terminal server protocol is already integrated into the LCS computers' VMS or VAXELN operating system[2]; no additional drivers or other special interface software need be written. Terminal servers can be attached anywhere along the existing control system's ethernet backbone that runs the linear accelerator's half-mile length. Our experience using the terminal servers has shown that they are reliable and are straightforward to program.

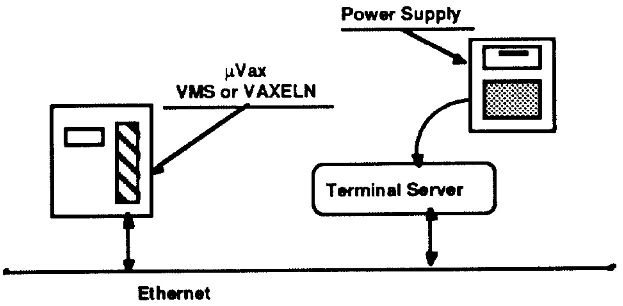

Figure 2. Power supply as a network object.

Work supported by the US Department of Energy

0-7803-0135-8/91$01.00 ©IEEE

III. EMBEDDED CONTROLLER SOFTWARE DEVELOPMENT

The software for the embedded controller was designed and written by the power supply vendor[3] using our detailed specifications. Our contract required delivery of a software emulation of the power supply for our testing and evaluation months before the first prototype power supply was to arrive on-site. We were able to provide feedback to the vendor early in the development cycle. The emulator runs on an MS-DOS computer and uplink communication is provided through its serial communications port. A number of modifications and additions were prompted by our experimentation.

The emulator PC is connected to a terminal server. Diagnostic codes, running on a networked LCS computer, simulate the command environment in which the actual supplies will exist. The supply controller is required to respond to commands at a rate of no less than 10 Hz.

The supply's command repertoire was expanded and modified as result of our experimentation with the emulator. Control commands for setting limit points and a new response mode are examples of items that were added.

A. Limit Points

Current and voltage limit point commands were added to supplement the power supply's trip point instructions. The limit point settings should prevent excessive overcurrent and overvoltage shutdowns that result from mistakes in entering new set point values. The device will not attempt to seek a set point that exceeds its limit point. If a set point request exceeds the limit point, the supply will remain in its present state and reply with an error code. In contrast, if the power supply's output voltage or current exceeds its trip point it will ramp off.

B. Verification modes

There are a number of reply formats to which the controller can be set. The supply has four response modes, Complete Verification (CVN)[4], Complete Verification Off (CVF), Short Verification (SVN) and Numeric Verification (NVN). In every case except CVF, an end of line, <EOL>, character or characters are appended to the controller's reply[5]. A terse two-digit-number response is ideal for computer control, but not particularly convenient for the human technician doing troubleshooting. The variety of response modes allow one to obtain a good match between the user and the supply controller.

Examples of the response formats to an ON command, after an interlock fault is detected, is illustrated in Table 1.

Table 1
Comparison of power supply response formats. The response is to an "ON" command after an interlock has tripped.

Verification Mode	Controller response
CVN:	ON Ok Error Bad State <EOL>
CVF:	*nothing*
SVN:	Error 06<EOL>
NVN:	06<EOL>

The NVN mode, most natural for computer-to-power-supply communication, was added a as a direct result of our emulator testing. Note that the CVF mode, the original mode supplied by the vendor for external computer control, provides no response to any command that it understands. There are obvious problems with using this mode for computer control.

IV. ACCELERATOR CONTROL SYSTEM INTERFACE

The existing control system provides a hook into which we were able to attach these new intelligent supplies the *pseudo device*. The pseudo device mechanism is actually a generic interface to the LCS run-time database[6,7]. The job of the *pseudo device* software is to allow database access calls used by all of the existing control system applications to access and control any piece of hardware without knowing its operating details. The *pseudo device* must take care of all details, including any differences in the operational model of the target device and the LCS.

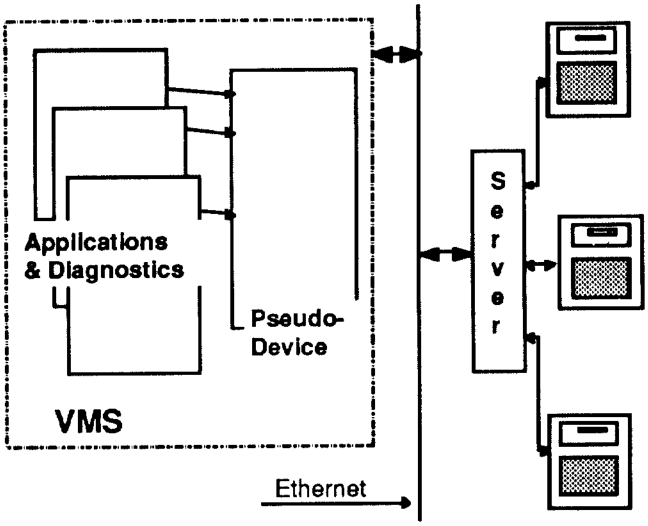

Figure 3. The pseudo device interface.

For historical reasons, analog control in the LCS is assumed to be incremental. That is any command value requested is assumed to be an increment to be added to the present setting of the device. This puts it clearly at odds with our new supplies' set point control philosophy. *Pseudo device* software must compensate for this. All analog data received from the supply is coded as a set of ASCII characters. It must be parsed and converted to REAL*4 format before being sent to the control system.

Each terminal server connection requires its own VMS I/O queue. The *pseudo device* acts as a terminal server port manager and maintain dialogs with multiple supplies. It decides what threshold of inactivity will trigger a port disconnect. Each queue uses some of the precious VAX CPU cycles.

Diagnostic programs will be able to access all of the power supply command set through a special diagnostic pass-through channel for each supply. Commands, not just those known by the run-time database, will be accessible though a simple terminal interface for remote troubleshooting.

V. POWER SUPPLY INITIALIZATION

Each supply's operational parameters must be protected from unauthorized modification, i.e. values such as the trip point settings, interlock fault parameters and ground current trip points. Commands that effect sensitive parameters will be accepted only if the supply is placed in the password-protected super-user mode. The controller reverts to the normal user mode after a time-out period has been exceeded. There are additional set-up values such as the definitions of the twenty-four interlock faults. Initially these need to be entered interactively by a human user. Once this is done the entire set of values can be downloaded to the control system computer. In the future the power supply can be reconfigured by uploading the stored block of values to the controller. The block is protected by a checksum so that file "spoilage" can be detected. The block-load command is not a super-user command, but the checksum scheme prevents tampering with the file. We have not addressed the issues of version management of the magnet block files. A workable scheme to keep track of hundreds or thousands of these parameter files must be devised.

VI. CONCLUSIONS

We feel that the additional time and effort that is being spent now on a generic power supply interface will be well worth it. The requirement for the vendor to supply an emulator for a new device early in the design cycle proved invaluable. In addition to revealing unforeseen flaws in the original controller design, it allowed us to confidently start work on the LCS control interface before any hardware existed. We are planning to put the supplies in service during the 1992 LAMPF run cycle.

VII. REFERENCES

---

[1] S.C. Schaller and E.A. Bjorklund, "Distributed Data Access in the LAMPF Control System". Particle Accelerator Conference, Washington, DC USA (1987)

[2] Digital Equipment Corporation LAT protocol

[3] Alpha Scientific Electronics, Inc., Hayward, CA 94545

[4] For a full description of the controller and its command set see:
R.S. Rumrill and D.J. Reinagel, "Intelligent Power Supply Controller", in this conference proceedings.

[5] The following characters can be selected as an end of line character sequence: LF (ASCII 10), CR (ASCII 13), CR and LF or LF and CR.

[6] S.C. Schaller and P.A Rose "Data Acquisition Software for the LAMPF Control System", Particle Accelerator Conference, Santa Fe, NM USA (1983)

[7] S.C. Schaller, J.K. Corley and P.A Rose, "Optimizing Data Access in the LAMPF Control System", IEEE Trans. Nuclear Science., **NS-32**, 5, (1985)