Control System for the MLI Model 1.2-400 Synchrotron Light Source

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Abstract

The control system for the MLI Model 1.2-400 Synchrotron Light Source is now being assembled and checked out. This system controls the injection of 200 MeV electrons from the linear accelerator into the storage ring, and the acceleration of the beam to 1.2 GeV, after accumulating current of 400 mA. The ring consists of 8 bending magnets, 20 quadrupoles, 16 sextupoles, an rf cavity driven at 500 MHz, and miscellaneous vacuum and utility support equipment. The control system also supports a transport line that consists of 2 dipoles, 11 quadrupoles, and 5 fast injection magnets. The storage ring is a synchrotron radiation source for research applications including development of x-ray lithography techniques. A detailed discussion of the approach, hardware and software implementation, and preliminary performance data are presented.

I. Description

The control system for the MLI Model 1.2-400 Synchrotron Light Source is designed for customers who plan to use the light source as a tool, rather than as an experiment. This emphasis on practicality implies an operator interface that is friendly to the operator. Many of the higher level operations are automated.

To make the control system economically attractive, development was minimized. Commercially available software has been used as much as possible. Hardware to support the chosen software was also selected to minimize development.

A. Software

MLI has selected a commercially available control system development platform (VISTA) that has a complete facility for user interface and a structure set up to handle the interface between hardware and user. It presents control and readback to the user via graphical screens; examples are shown in section II. The software has been described in an earlier paper [1].

The following have been developed inhouse by MLI:

- the database representing the real hardware connections has been defined.
- graphics interfaces connecting the user to the hardware control and readback have been drawn; these include:
  - — magnet control and readback
  - — vacuum control and readback
  - — rf control and readback
  - — injection timing control
  - — diagnostic control and readback
  - — diagnostic screen control, video digitizing, signal processing, and other beam monitoring systems
- the software drivers that the original system lacked have been written; these include:
  - — individual CAMAC card handler
  - — stepper motor drivers
  - — PLC scanner handler
  - — GPIB handler
- the higher level application software required to enable the operator to commission the machine has been written; this includes:
  - — coordinated magnet ramping
  - — automatic ramping data from accelerator physics parameters
  - — orbit calculation correction
  - — smooth restoring of settings for magnets that cannot tolerate any step change

B. Hardware

The hardware has been discussed in an earlier paper [2]; a short recap is presented here.

- Computing hardware:
  - — Vaxstation 3100, as the user interface
  - — MicroVax 3400, as the hardware connection to some of the interfacing electronics:
    - — GPIB controller
    - — video digitizing
    - — industrial programmable logic controller (PLC) scanner interface
    - — CAMAC controller

Because it is the higher performance machine, the MicroVax is also used as the machine to maintain the realtime data base.

- Interfacing electronics:
  - — CAMAC: because of the support already provided by the commercial package, this handles most of the magnet controls and diagnostics
  - — GPIB interface: injection timer control
  - — commercial PLC, for controlling the following:
    - — vacuum interlock logic, control, and status (see Ref. [3])
    - — dipole power supply protection logic, control, and status
    - — injection magnet control and status
  - — direct plug in card to the "Q bus" of the MicroVax: video digitizing

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II. Status

A. Completed Development

The control system is now largely complete. First-cut menus are now available for all I/O points (approximately 600 points). The Video Monitoring menu (figure 1) is a typical graphics menu that makes use of the physical location of the unit to help the operator identify the device being controlled. The fluorescent screen at each location can be activated (inserted into the path of the electrons) by moving the cursor to the appropriate camera symbol and "clicking" on it with the mouse. The color of the camera indicates whether the screen reached its intended location. For analog readback to the operator, both graphics and text are used in the display wherever possible. An example is the Beam Slits box in the Video Monitoring menu. Here the graphics display is also the control command; by "dragging" the end of the graphical slit with the mouse, the actual slit will be moved in the corresponding direction.

By activating the appropriate "button" on the menu, the Optical Monitoring Station menu will appear (figure 2). This is an example of a menu where the color and position of the symbol itself are part of the status indication. The video multiplexer will also be set up by the selection of the particular camera and will direct the signal to the TV monitor and the video-digitizer. By activating the appropriate "buttons" on the

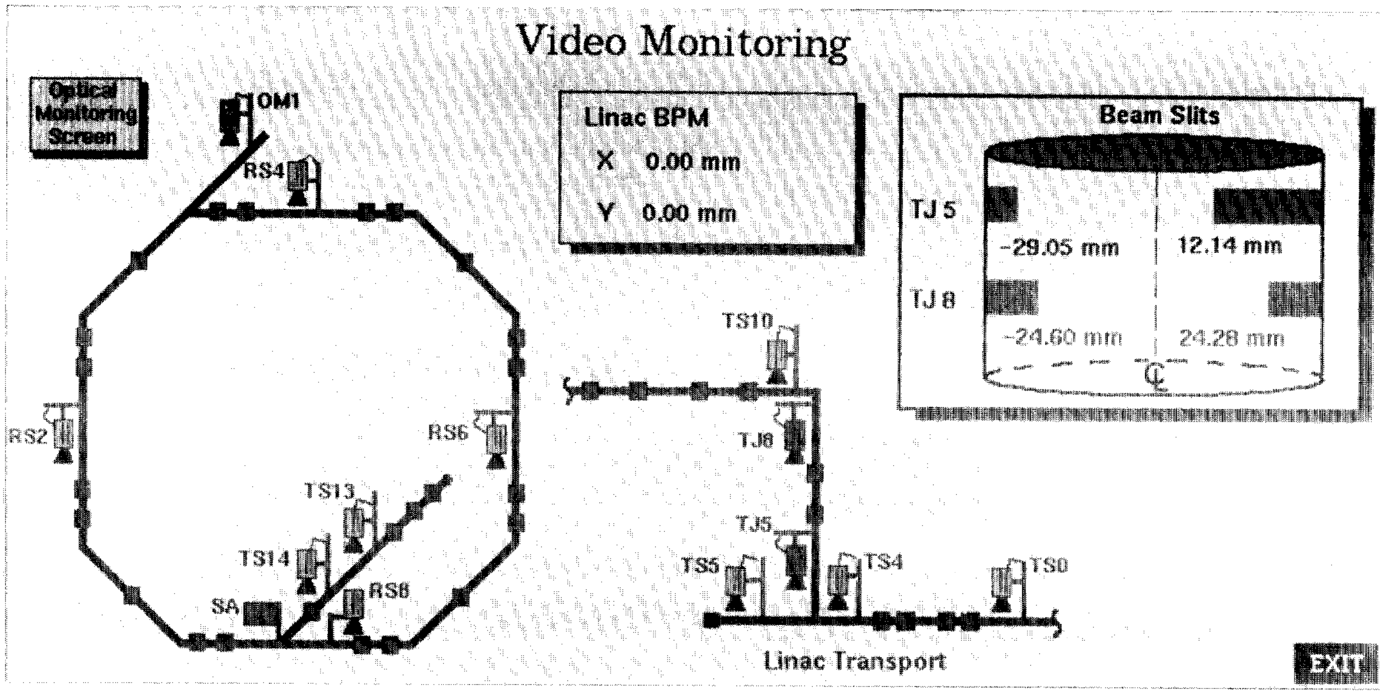

Figure 1. Video Monitoring menu.

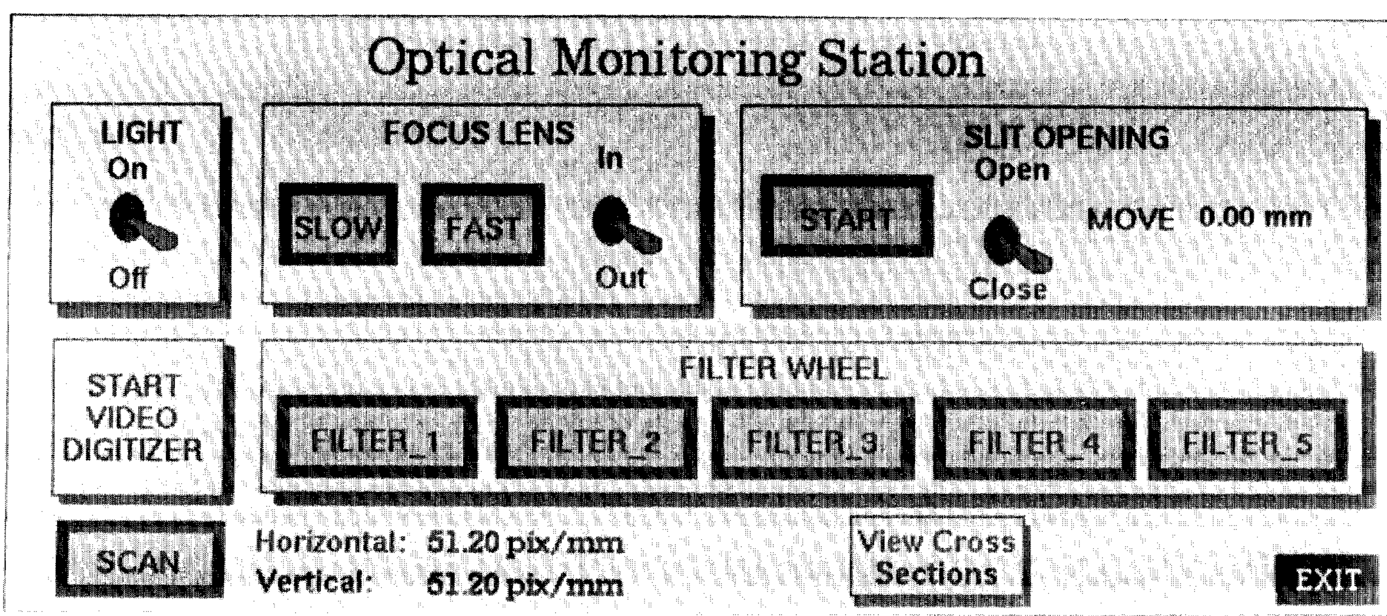

Figure 2. Optical Monitoring Station menu.

menu, the video digitizing process will be started and the video signal from the camera will be analyzed.

Significant mathematical calculation is required by some of the signals. Automatic beam monitor scanning, position calculation, and display is one example; the diagnostic screen TV signal is another. The digitizing of the TV signal is done by hardware. The image enhancement and the beam profile cross-section analysis (width, intensity, etc.) are done by software. An example of such signal processing is the pair of beam cross sections (horizontal, vertical) shown in figure 3. This kind of information will be used in the emittance calculation of the electron beam.

All interfaces to the outside world have been tested to the connector of the I/O cards. Software development is slightly ahead of the hardware development because not all the cable to connect the hardware to the computer interface is available yet. Although this has prevented us from moving on to the next step of testing, we do not expect any delay in the shipping schedule.

In terms of application software, the magnet power supplies can be ramped in a coordinated fashion from a list of predefined data points. A means to generate the magnet control ramping data from a list of estimated energy, horizontal and vertical tunes, and chromaticities stable points has been developed, but not yet fully tested.

B. Remaining Development

Testing to the final control devices via the intended cable will be completed before shipping, to check for noise and signal levels. The ramping data generation program will be completed. Work is underway on orbit correction calculation and an operator initiated automatic correction program.

III. Performance

It is difficult to gauge the performance of a still unfinished control system. However, two statistics give some indication of what we may be able to expect. The first is the readback bandwidth of a typical set of display data. On the magnet control readback menu (the most important information for controlling a synchrotron), the maximum readback rate was tested to be 8 times per second. The second statistic is the time required to restore a complete set of control output (a total of 106 channels of data) to all the magnet power supplies; this is required after a shutdown. Complete restoration has been timed at 2.81 seconds. Both tests represent unoptimized results, and further improvement is still possible.

IV. References

[1] B. Robinson and P. Clout, "Modularization and standardization of accelerator control systems," *Nucl. Inst. & Meth.*, Vol. A293, pp.316–320, 1990.

[2] B. Robinson et al., "The LSU electron storage ring control system," *Proc. 11th Int'l Conf. on the Application of Accelerators in Research & Industry*, Denton, Texas, Nov. 1990.

[3] S. Pugh and Brian Ng, "Vacuum control system for the MLI Model 1.2-400 Synchrotron Light Source," IEEE 1991 Particle Accelerator Conference, San Francisco, May 1991.

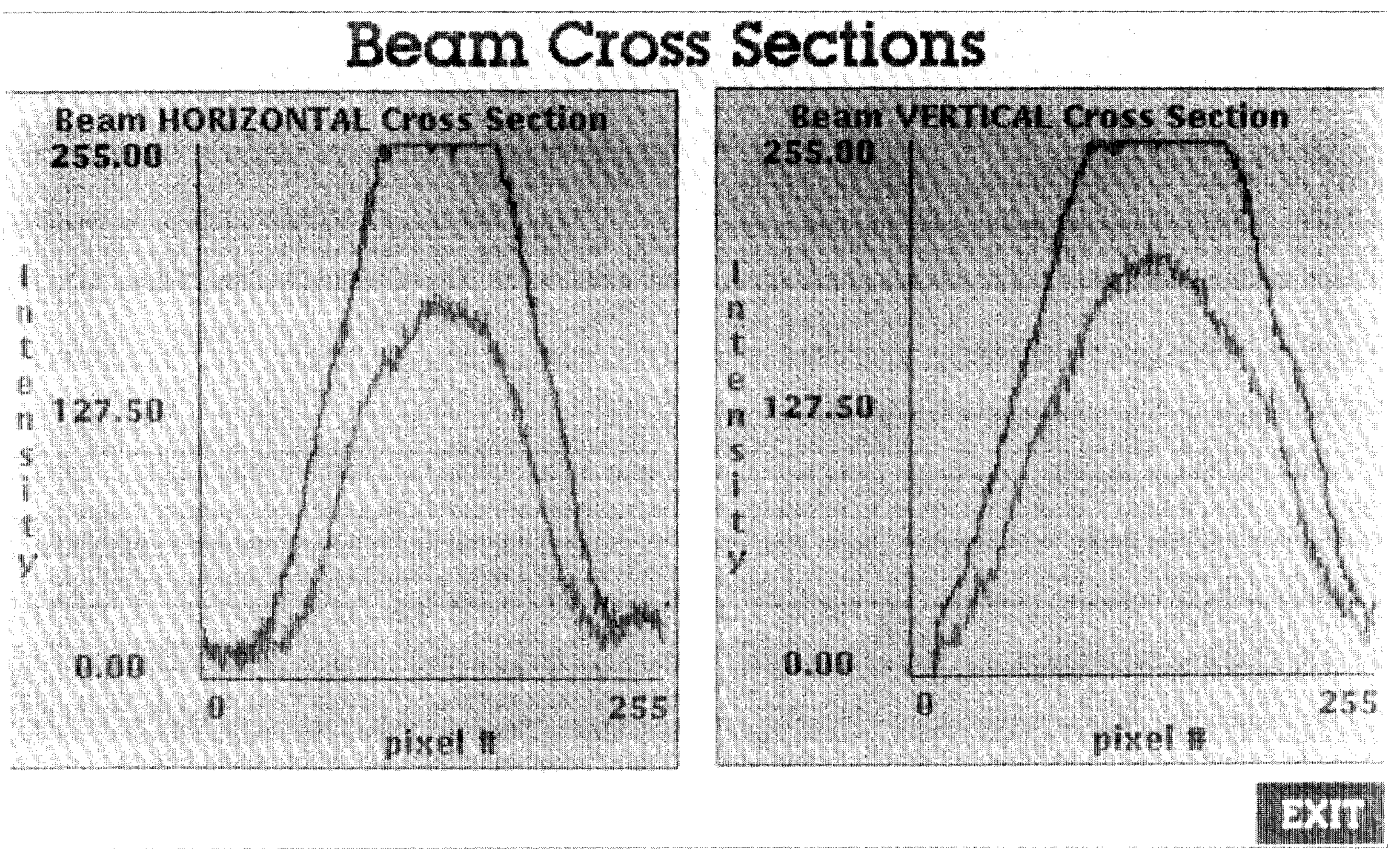

Figure 3. Beam cross-section data.