NETWORKING REMOTE INSTRUMENTATION FOR THE ADVANCED LIGHT SOURCE*

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Abstract

The Advanced Light Source (ALS) control system[1] instrumentation includes high data rate instruments such as digital oscilloscopes, sending 5000-10,000 bytes/s, and low data rate instruments such as network analyzers, digital multimeters and frequency counters sending < 1000 bytes/s. These instruments monitor signals in racks at distances up to 80m from the control room (Fig 1).

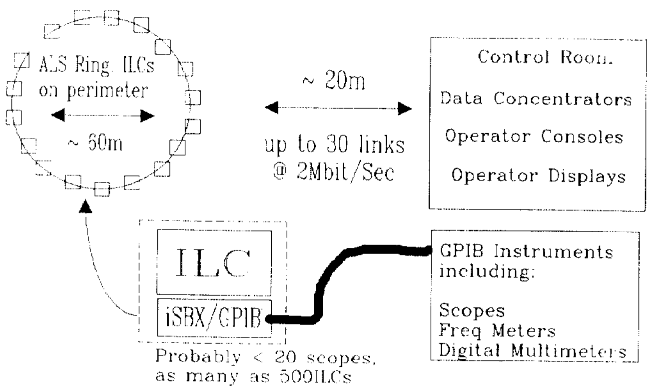

Figure 1. Block Diagram

Digitization of Instrument Data

To maximize signal fidelity while minimizing analog cabling, an instrument with digitizing capabilities is located near the racks, with the digitized data collected by an Intelligent Local Controller (ILC). The ILC, an in-house designed single-board computer (Photo 1) based on an i80C186, provides serial communication back to the operator workstation and an iSBX/GPIB interface port for instrumentation.

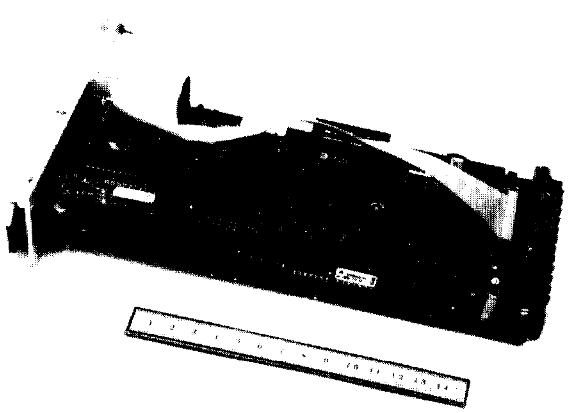

Photo 1. ILC Circuit Board

Signal Referenced in Machine Database

Data collected by the ILC is then networked into the machine database, maximizing flexibility of display formats for operator workstations. Having instrument data inserted directly into the machine database allows operators to "logon" a trace for display (Photo 2) by name instead of having to cross reference a scope input to a waveform. Database referenced signals also provide for engineering units on the display, and allow multiple views of the same data by different workstations.

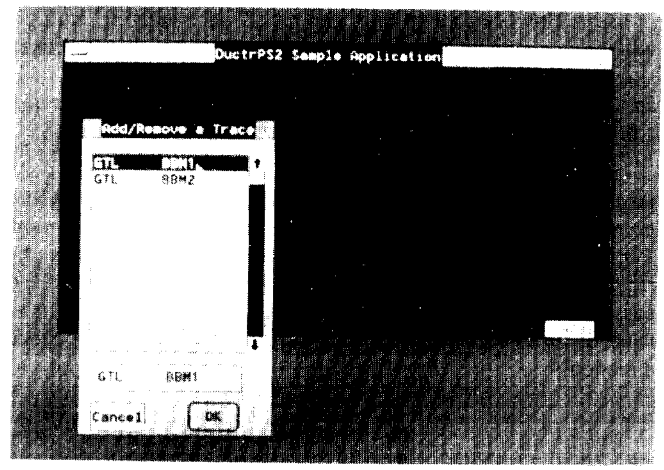

Photo 2. Logon of Signal "GTL BBM1:"

"Realtime Response" for Operators

Providing "realtime response" means that an operator should be able to change the gain of a scope trace and see the resulting effect "promptly" (at least on a human perception level). The performance goal is four oscilloscope traces per operator workstation(s) refreshed at >= 5Hz. Upto 12 workstations may be active in the ALS control room.

Scope Front Panels

Compared to simple waveform digitizers, digital scopes offer the traditional scope's front panel flexibility in sampling speed, gain, input coupling, and triggering (Fig 2). Like traditional scopes, they can do double duty as standalone instrumentation for in-field debugging.

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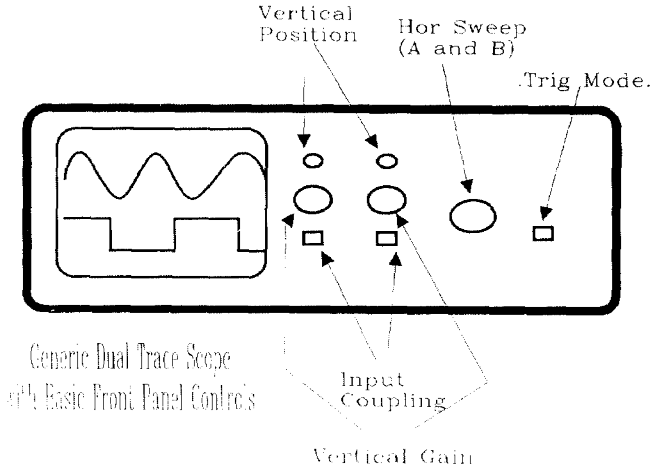

Figure 2. Commonly-Used Scope Front Panel Controls

Because of the potential complexity of front panel settings, a "windows-type" of user interface for remote scope control is appropriate (Photo 3).

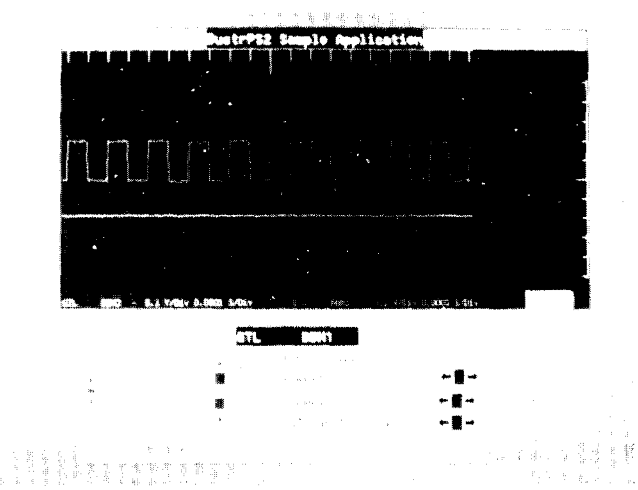

Photo 3. Dialog Box Implementation of Common Scope Controls

Scope Data Rates

Compared to other GPIB instrumentation in the ALS, scopes put the greatest requirements on the data networking and graphics performance. A typical scope trace will consists of 1024 points of 8 bits each, although some scopes may have higher or lower resolution with fewer points. Assuming a refresh of 10Hz the operator workstation has only a (100/*N*)us to process each point from the scope, where (*N*) is the number of traces being displayed.

Other GPIB Instruments

Instruments such as digital multimeters and frequency counters generally have less complicated front panels, and in most cases can be controlled by a command-line interface. These instruments also return far less data than scopes. For example, in response to the user sending a "?", a frequency counter responds with 19 bytes of information (Photo 4). Typically, these readings will be updated a few times per second. Spectrum and network analyzers will have complicated front panels, and data update rates on the order of hundreds of bytes/s.

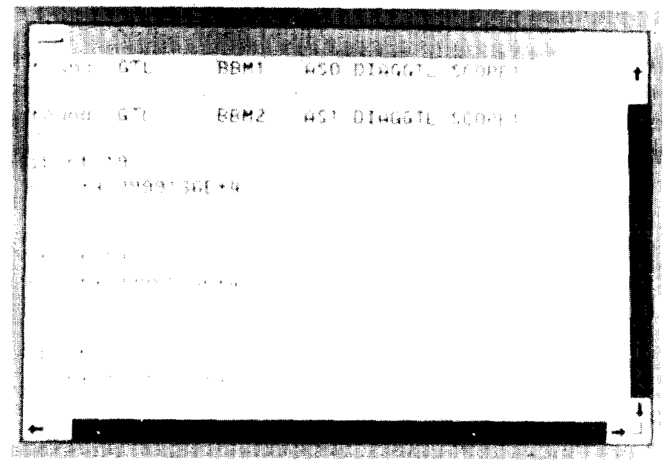

Photo 4. Command Line Interface to Frequency Counter

Multiple Applications with Different User Interfaces

In the current implementation under Microsoft Windows, multiple applications can be running on the workstation. For example, control and viewing of a scope through dialog boxes and pulldown menus can proceed while simultaneously providing a command-line interface to control a frequency counter (Photo 5).

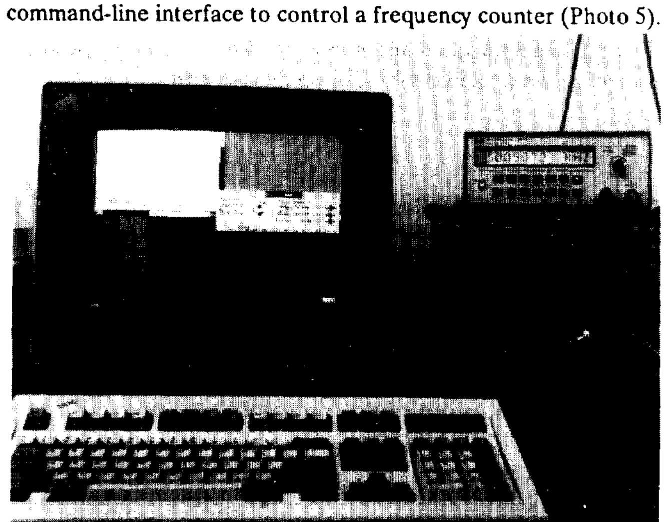

Photo 5. Scope and Frequency Counter Displays

Generating a Windows-based User Interface

Since the networking of the actual instrument data is not dependent on providing the operator display and interface, most of the initial development is done with the workstation connected directly to the instrument through a commercial GPIB interface card from National Instruments. Various libraries of GPIB calls allow the card to be programmed in different languages. The user interface, including graphics displays, pull-down menus, and dialog boxes are developed at this point.

Generating a Network Protocol

A tally is then made of the GPIB-specific calls that were used from the vendor-supplied library. For example, scope control uses the National Instrument library calls IBRD, IBWRT, IBCLR, IBSRE, and IBEOS. A network driver on the workstation side then replaces these calls with message passing calls to the ILC. Corresponding code is written on the ILC that interprets these messages, and then duplicates the original library call action through its iSBX/GPIB interface (Fig 3).

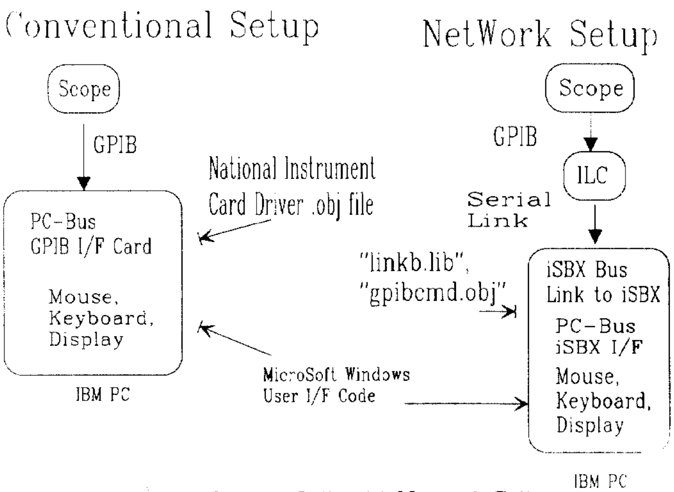

Figure 3. Replacing Library Calls with Network Calls

Between the networked and non-networked version of the scope control program, about 3/4 of the code is shared.

Basic Time Budget

Performance may be limited by the time it takes the ILC to extract GPIB data across its iSBX/GPIB interface (30 Kbytes/s) and by the plotting speed of the workstation (24 Kbytes/s for a quarter-screen size window). However, these two operations can proceed in parallel, so the limit should be the cumulative delay of plotting plus the 10us/byte required to get data across the network (Fig 4).

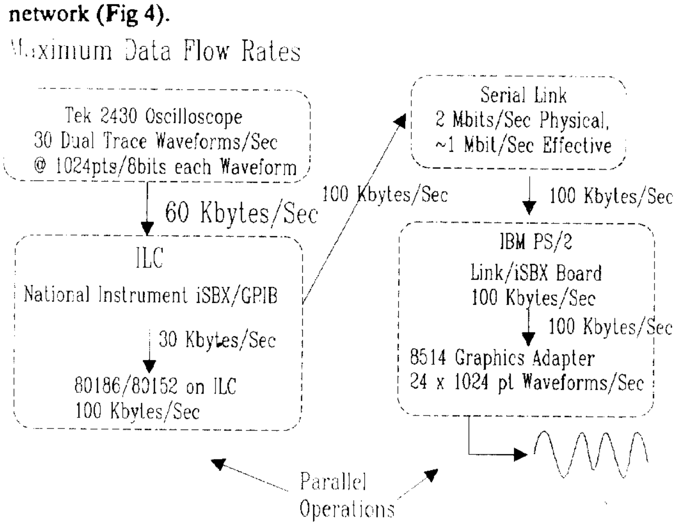

Figure 4. Time Budget

Effects of Window Shape and Size on Throughput

Since the scope window display can be resized and the drawing mode changed by the user, it is possible to choose between a large window for detail or a small window for drawing speed. For example, a fullwidth 1024 length plot in "envelope" drawing mode has about half the graphics throughput (Photo 6) as a quarter-screen since it has twice as many points to plot.

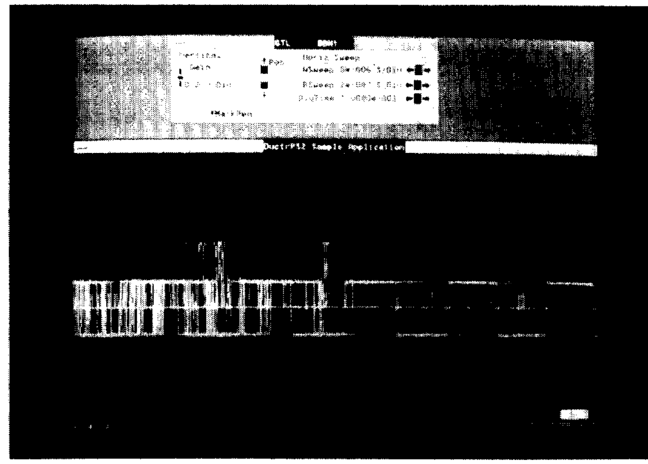

Photo 6. Full Width Window in Envelope Mode

Preprocessing of Data to Improve Throughput

Data reduction (scaling, decimation for smaller displays) could take place before data is transferred to the workstation. For example, the data concentrators (Display Micro Module, or DMM[1]) might send up only as many points as were appropriate for a given workstations display window.

Conclusion

Remote instrumentation will reduce cabling to the control room and possibly provide for better signal measurment. Inclusion of remote instrumentation data into the machine database will provide flexible access, display, and control from multiple operator workstations. Currently available instrumentation and computers have sufficient performance to provide "realtime" response in a network configuration.

References

[1] S. Magyary, "Advanced Light Source (ALS) Control Systems," in Proceedings of the Particle Accelerator Conference, 1989.