Distributed and Networked Real-Time, Control and Data Acquisition System for Wyle Laboratories' Thermal Vacuum Chamber

The Challenge:

Develop a distributed real-time control and data acquisition system that integrates hundreds of transducers and actuators with secure system access, configurable data logging, data extraction, and display features.

The Solution:

Using off-the-shelf hardware from National Instruments, including PXI real-time controllers and I/O modules, combined with powerful software tools, LabVIEW, LabVIEW RT, and the Datalogging and Supervisory Control (DSC) Toolkit, to implement a fully integrated and user configurable real-time control solution.

Products Used:

Software	TV25 Control System	LN2/PID Control System
LabVIEW™ 7.1	(1) PXI-1000 8 slot chassis	PXI-1010 PXI/SCXI 12-slot chassis
LabVIEW RT 7.1	(1) PXI-8186 RT controller	(1) PXI-8175 RT controller
DSC Toolkit	(1) PXI-6031 64-channel analog input	(1) PXI-6031 64-ch analog input
	(2) PXI-6704 64-channel analog output	(1) AMUX-64T 64-ch analog mux
	(1) PXI-6508 96-channel digital IO	(1) PXI-8421/2 RS-485 serial
	(1) PXI-6509 96-channel digital IO	(8) SCXI-1102 128-ch thermocouple

Use of Flexible Technologies

Wyle Laboratories needed networked, distributed operation along with real-time control and flexible configuration capabilities. We realized that we could address all of the system requirements with cost-effective and flexible technologies including:

- PXI I/O modules for real-time acquisition and control
- SCXI I/O modules for distributed signal conditioning and acquisition of a variety of analog and digital signals
- Datalogging and Supervisory Control (DSC) Toolkit for user login, control and data logging supported by Citadel database
- LabVIEW Real-Time for implementing an embedded, easy-to-design control and data acquisition engine
- LabVIEW for implementing a flexible user interface for system configuration and data viewing
- Support technologies, such as DataSocket, VI Server, and ActiveX for ease of integration and information exchange between several different sub-applications running on the Windows platforms in a networked environment

Implementation

The design of the data acquisition and control systems is shown in **Figure 2: TV25 Functional Block Diagram**. The chamber data acquisition and control system was designed to collect and display up to 256 channels of real-time data from thermocouples, vacuum gauges as well as control and monitor up to 192 digital I/O channels for controlling compressors, valves, and pumps. The system also communicates with third party controllers such as the Omega CYD218 temperature controller and a variety of liquid Nitrogen (LN2) control systems. The control logic is a self contained queued state machine used to provide safety monitoring of the thermal vacuum chamber and test specimens. The interlock control logic is based on using the control valve, motor, and pump states in conjunction with pressures and temperatures. The state machine architecture allows for easy modification of the interlock control states during the test and assembly of the chamber.

The PID control system simultaneously controls and displays 64 analog output controlled PID temperature control loops and 12 digitally controlled LN2 PID temperature control loops while allowing real-time changes to the setpoints and control parameters. The system is also responsible for monitoring an additional 100 thermocouples attached to the customers specimen under test.

The real-time and host applications are based on the state machine architecture. This architecture allows for the main program logic to be easily modified in the future supporting the addition of new software features or changes to the hardware. The design goal was to decompose a complex, event-driven application into a set of *states* connected by *queues*. This design decouples event and thread scheduling from application logic. Decomposing services into a set of states also enables modularity and code reuse. The state machine for the real-time computer is shown in Figure 1: State Machine Architecture. Real-time code in the PXI modules handles deterministic system control. The code also provides the transducer data to an acquisition application running on the server machine. The server collects data from serial devices and updates the panels prior to logging the data to the Citadel database.

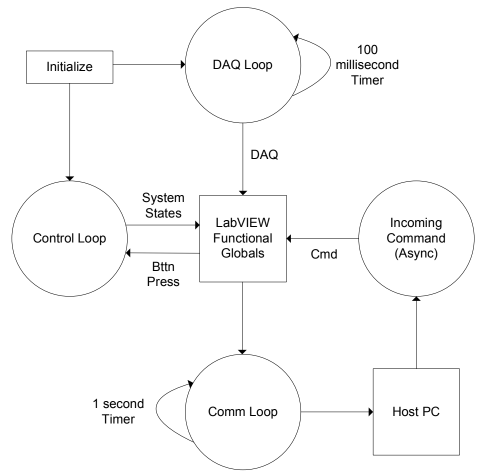

Figure 1: State Machine Architecture

The host application(s) were implemented using National Instruments LabVIEW with the DSC Toolkit on networked personal computers running Windows XP. A redundant network was implemented using switches, routers, multi-route cabling, and use of the TCP/IP protocol to broadcast messages and data to all attached computers.

The DSC toolkit was used to leverage its built-in abilities to perform user access security and was also utilized to allow for rapid and easy storage and display of the data acquired by the real-time controller.

We built multiple operator consoles using LabVIEW. Our customer can deploy the consoles anywhere on the local network. Internet and intranet users gain access to the application data by running LabVIEW applications that connect to the DataSocket server publishing the data for remote viewing.

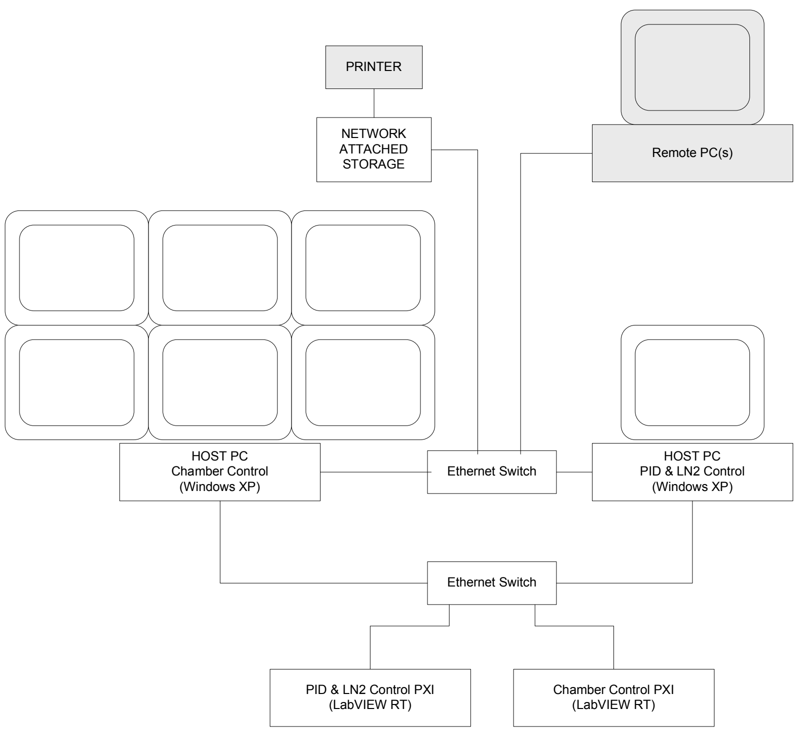

Figure 2: TV25 Functional Block Diagram

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