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The DIII–D Neutral Beam Supervisory Control and Data Acquisition Workstation Upgrade

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***Abstract*—The DIII–D Neutral Beam Supervisory Control and Data Acquisition (NB SCADA) system is responsible for data and status communication between remote system devices. Some years ago, it was operated and controlled on a 486 PC with Microsoft Windows 3.1. A 16-bit software package called FIXDMACS was used to interface and communicate with Siemens programmable logic controllers (PLCs). Due to the ever-changing operation requirements, this system became antiquated and failed to adequately support new process conditions and meet the NB operational demands. It was, therefore, inevitable that a system upgrade would be needed to satisfy efficiency and performance. This project required a comprehensive survey of available hardware and software currently offered by the leading industries. The best solution was a complete replacement of the entire workstation. A new Dell Pentium III PC, equipped with Windows NT, was acquired to replace the old SCADA system. FIXDMACS was replaced by scalable iFIX, which was also developed by Intellution. In addition, data migration and conversion was performed to enable forward compatibility of all existing software and system configurations. Besides delivering an excellent solution to monitoring the neutral beam system operations, iFIX is able to accept Microsoft Visual Basic scripts and programs to automate routine or repetitive tasks, allowing system administrators to execute these tasks and controls quickly. This added feature provides flexibility and simplicity for maintaining and troubleshooting purposes. Although additional improvements are always possible as with all other software products, iFIX has proven to be a valuable tool in supporting the operations. Packaged with essential enhancements, new capabilities and powerful tools, Intellution has developed an application that certainly surpasses its predecessor. Today, the upgraded DIII–D Neutral Beam SCADA system is fully operational. Both hardware and software upgrades were a cost effective and necessary approach toward achieving the goals of mazimizing system performance, improving efficiency and reliability, and providing better control of the neutral beam operational processes.**

I. INTRODUCTION

The NB SCADA workstation primarily receives and transmits data between remote system devices in order to obtain up-to-date device status or to command status changes. It requires efficient data transmission with high reliability as well as timely system control and response. As system requirements increased, the system became increasingly sluggish and unreliable. Failures occurred frequently when reliability and accuracy were most needed. The activities of concern were the real-time interactive user interface, real-time process monitoring, supervisory control and data acquisition, data communication control, and process control. In order to effectively replace an aging system that was performing poorly, the search for a complete hardware and software replacement began in September 2000. The main objective was to provide an efficient and economical solution. The project was completed successfully in November 2000. Presented here are the facts, findings and overall results of this project. In addition, sample screen displays of the iFIX software will be shown to illustrate its simple use and yet powerful capability.

II. UPGRADE PROCESS OF THE NEUTRAL BEAM SCADA WORKSTATION

A. Hardware

As mentioned, a 486 PC with Windows 3.1 operating system running at 100 MHz was used as the original NB SCADA workstation. A complete system replacement was determined to be the best solution to satisfy the operation requirements. In order to make an effective evaluation, the criteria used in consideration were overall design, durability, warranty, and technical support. The selected upgrade computer was a new Dell Pentium III PC with Windows NT operating system running at 450 MHz. It has 128 megabytes of memory and 6.4 gigabytes of disk space. Included in the system was a 19-inch SVGA display monitor. A separate sound card was purchased due to a PC system interrupt request (IRQ) conflict that will be discussed later. The system was also configured to operate on the current local area network. Fig. 1 shows a complete system setup and its network connectivity.

B. Software

The FIX family of software is composed of individual 32-bit applications that together provide solutions to many of the challenges faced by process control engineers. As mentioned, FIXDMACS was an outdated 16-bit application that needed to be replaced with new state-of-the-art software. Developed by the same company, Intellution, iFIX is a new 32-bit automation software package that takes advantage of the powerful capabilities in Windows 95 and Windows NT. This upgrade was considered reasonable since iFIX allows our custom-designed system configuration to be preserved and conveniently transferred via its data migration capability. The DIII–D NB system consists of four beamlines. They are located at 30°, 150°, 210° and 330° with respect to the DIII–D tokamak vessel. At each beamline location, there is a left side and a right side ion source system (i.e., 30°L and 30°R). iFIX provides total access to each of these locations via a comprehensive main menu screen. When requested, a detailed information page including current status for the location of interest is displayed in a pop-up window. Fig. 2 shows an actual screen display of the iFIX main page. It provides a general assessment of all beamline locations via assigned

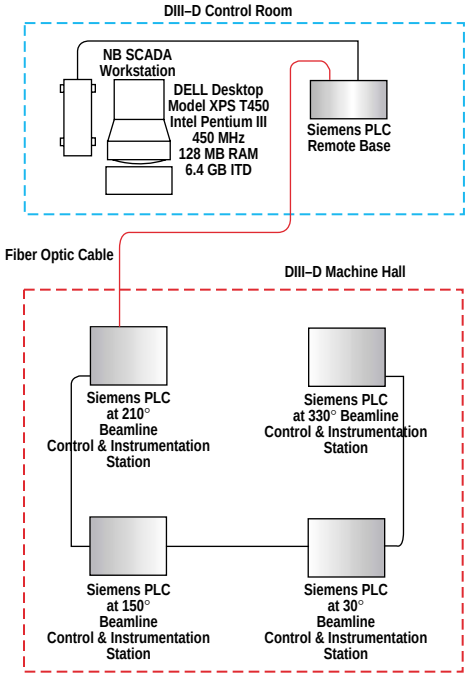

Fig. 1. The upgraded NB SCADA workstation with iFIX software.

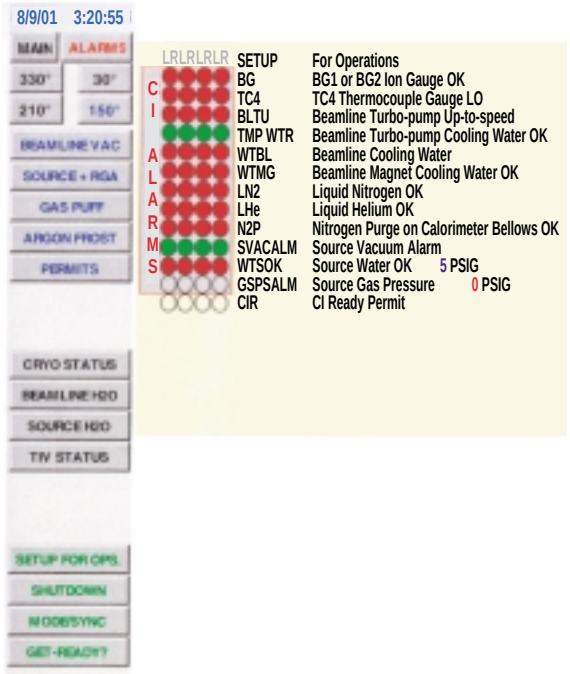

Fig. 2. iFIX main menu providing access to all locations of the beamlines.

color (i.e., red and green) indicators. Other information and functions such as system status, setup and shutdown can be accessed and controlled directly on this main menu. One of the many useful features that make this product vital is its ability to facilitate users in creating complicated graphical user interfaces. As shown in Fig. 3, a network of components can be graphically presented which enables operators to visually grasp the complex interconnectivity of all major and minor components. Also available on the display is the big picture of status changes that make process monitoring less laborious. Status indicators are intuitively displayed in either green or red color. Those shown in green indicate good operating condition. On the other hand, indicators that appear in red suggest there might be problems at that specific location and require prompt attention. Another highlight of iFIX is real-time monitoring. It allows all processes to be monitored and appropriately controlled in a timely manner. In addition, alarm and event reporting provides convenience for system control and maintenance.

C. FIX to iFIX Migration

The difference in data structures and formats between the new and the old application was significant enough to require conversion and manipulation. In order to make full use of the existing data and setup configurations, all data files were successfully converted using Microsoft Visual Basic. Scripts written in Visual Basic were utilized to automate the data conversion process. The task of data migration was greatly simplified because of iFIX's ability to understand and execute these scripts effortlessly. As a consequence, this feature has made the application flexible and versatile. Most of the change over was completed in a matter of days, not weeks as originally anticipated. The new upgraded SCADA workstation was back in operation quickly. As a fine-tuning measure, miscellaneous adjustments and system configuration modifications were made to ensure maximum performance.

D. Technical Issues

iFIX was designed to automatically utilize system interrupt request #5 (IRQ5) regardless of system availability. This is a default which cannot be modified. Having a system interrupt preset that is not configurable is one of the limitations of this software. It makes installation more difficult than it should have been. IRQ conflict occured in our particular system since IRQ5 was already allocated for the system sound. This problem was resolved by using a plug-and-play sound card that automatically detects and uses another available IRQ. Another improvement that could be made in iFIX is better documentation. Although a voice help desk is available, software installation would have been much easier if there had been detailed discussions of system specifications and requirements. Additional documentation and a better built-in help utility would certainly improve the user-friendly aspect of this application and ultimately increase its value. This would help prepare users for a smooth installation and provide a positive experience in using the product. Despite some shortcomings, iFIX is overall a well-developed 32-bit application.

III. Features and Capabilities of the New Neutral Beam SCADA Workstation Made Possible by iFIX

A. Local and Remote Alarm Management

Identifying exact locations of faulty components or connections has been greatly simplified by this useful feature. It enables operators to pinpoint, diagnose and take appropriate

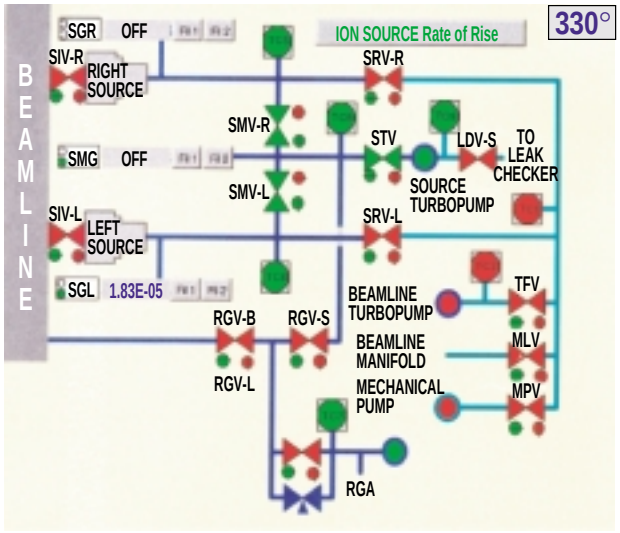

Fig. 3. A flow diagram in iFIX providing operators an excellent visual aid.

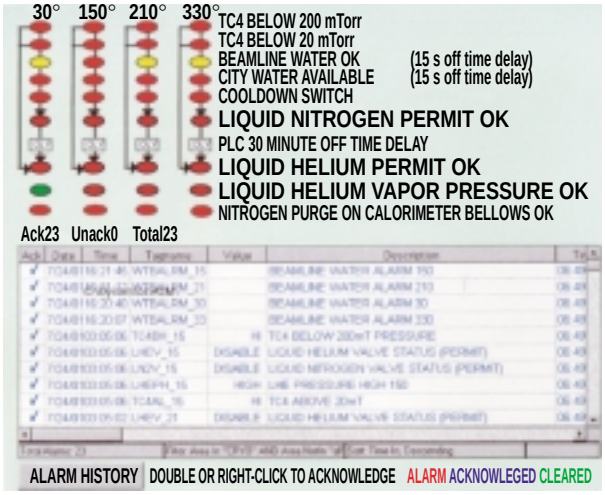

Fig. 4. A Cryostatus page displaying all alarm events.

actions quickly. Fig. 4 shows the alarm page that contains signals for all locations and associated meaningful messages indicating or explaining the cause for alarm.

B. Water and Gas Pressures Monitoring

Monitoring real-time changes in water and gas flow pressures is a very important task that gets scrutinized during operation. Therefore, as shown in Fig. 5, a table listing and updating all current pressure levels allows for immediate detection of any abnormal activity. Appropriate adjustments can then be made to prevent disruptions of operations.

C. Real-time Process Monitoring

This powerful capability provides operators total control of the real-time operation processes. Any command execution and/or order of status changes are made quickly without jeopardizing data and system integrity. Working in conjunction with an efficient graphical user interface, much of the process coordination has been simplified, ensuring productive and successful operation.

D. Data Logs with Date and Time Stamps

With date and time stamps recorded in the data logs, troubleshooting and monitoring the operations have been made easier and much more efficient. A chronological profile of all activities can be created based on this readily available information when problems occur and require investigation.

E. Automated System Setup and Shutdown

As part of the day-to-day operations, routine tasks have been automated and have resulted in better productivity and efficiency since common errors are prevented from reoccurring.

F. Additional New Capabilities

The following are other features that contribute to the success of iFIX:

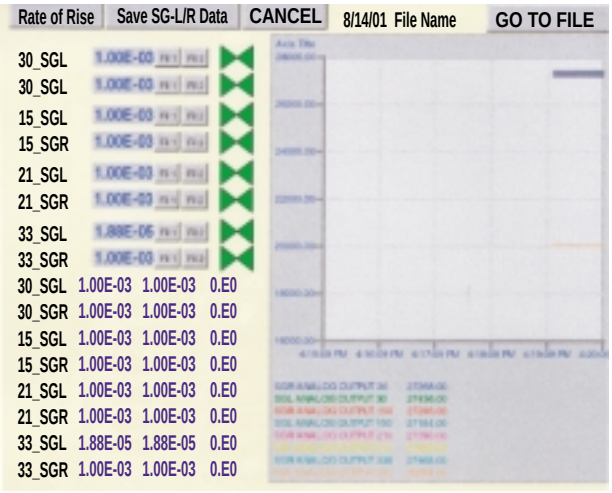

Fig. 5. A display of analog measurements to monitor gas and water pressure.

- Multi tasking, multi functions capabilities
- Real-time and historical trending
- SQL servers/ODBC drivers relational database connectivity
- Comprehensive, accurate reporting
- Statistical process control

IV. PERFORMANCE EVALUATION OF THE NEW NEUTRAL BEAM SCADA WORKSTATION

Significant improvements in data transmission speed and system stability have been noted. Prompt delivery of information enables supervisors, lead operators and managers to make decisions that prevent or reduce system downtime. With the new workstation in place, failures and system hang-up problems have been reduced from 50% to approximately 10% during operations. As a result, the frustration that plagued operators prior to the upgrade has been greatly reduced. Time taken to navigate through control pages has significantly decreased with fast and seamless transition.

Furthermore, the system reliability has been greatly improved, consequently increasing the availability of neutral beam operations in supporting the plasma physics experiments.

V. DISCUSSION AND CONCLUSIONS

Provided here are historical backgrounds of the DIII–D Neutral Beam SCADA system and an explanation of why the upgrade was critically needed to maintain efficiency and reliability. Hardware and software components of the entire replacement system were examined and associated technical issues were discussed. Moreover, system performance was evaluated and compared and new features as well as capabilities were presented. Some hardware and software conflicts were encountered during the transition. This was expected because problems commonly occur where there are changes made to a system. Despite the technical hurdles, this upgrade project has proven to be a wise investment and a logical solution. As technology evolves, it is important to remain objective in maintaining an up-to-date and efficient NB SCADA workstation. The ultimate goal is to secure optimum performance and reliability in all neutral beam operations.

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