Development and Application of General Purpose Data Acquisition Shell (GPDAS) at Advanced Photon Source*

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Abstract

An operating system shell GPDAS (General Purpose Data Acquisition Shell) on MS-DOS-based microcomputers has been developed to provide flexibility in data acquisition and device control for magnet measurements at the Advanced Photon Source. GPDAS is both a command interpreter and an integrated script-based programming environment. It also incorporates the MS-DOS shell to make use of the existing utility programs for file manipulation and data analysis. Features include: alias definition, virtual memory, windows, graphics, data and procedure backup, background operation, script programming language, and script level debugging. Data acquisition system devices can be controlled through IEEE488 board, multifunction I/O board, digital I/O board and Gespac crate via Euro G-64 bus. GPDAS is now being used for diagnostics R&D and accelerator physics studies as well as for magnet measurements. Their hardware configurations will also be discussed.

I. INTRODUCTION

GPDAS (General Purpose Data Acquisition Shell) has grown out of a concept of a command interpreter and a programming environment for streamlined data acquisition and analysis in a flexible laboratory measurement setting. Even though most operating systems on various platforms provide a command interpreter and certain levels of programmability, they are not specifically designed for laboratory environments for data acquisition, analysis and device control. These require command flow control, communication with external devices, storage and archival of the data. Conventionally, a dedicated stand-alone application would be developed for these purposes. The drawback of this approach, however, is that such applications are inflexible in their scope of capabilities and therefore cannot be easily modified to adapt to different laboratory environments or different configurations of devices, especially in the R&D phase which calls for frequent changes in the measurement procedures.

GPDAS was originally developed for the magnet measurement systems at the Advanced Photon Source. A standardized method using a rotating coil probe will be employed for multipole measurement. On the other hand, various schemes were being considered for dipole measurement. This flexible situation warranted the development of a data acquisition and analysis software that allowed for high-level user programming to simplify hardware debugging.

II. SYSTEM AND SOFTWARE

The current version of GPDAS runs on MS-DOS-based microcomputers. The computer system for magnet measurement at APS consists of a Compaq 386/20e computer equipped with 4 Mb RAM, a 40 Mb hard drive, a 44 Mb removable hard drive, a 5.25 inch 1.2 Mb floppy drive, a 3.5 inch 1.44 Mb floppy drive and a VGA monitor. The system is linked to other computers through Ethernet for data transfer and communication. Text and PostScript graphics files are downloaded to laser printers using AppleTalk connection.

The software package consists of a shell, utilities and script programs. Residing on top of the MS-DOS shell, it also incorporates the MS-DOS shell and takes advantage of existing utility programs for file manipulation and data analysis.

The shell can be directly interfaced with PC boards and control the data acquisition system devices. In conjunction with the magnet measurement system, software drivers for IEEE488, a digital I/O board and an ADC/DAC are built in the shell. The shell can be interfaced to other types of boards through source level modification. Developed with such possibilities in mind, the internal structure of the shell is highly modularized to facilitate such changes.

III. PROGRAMMING IN GPDAS

The shell can be programmed to perform desired tasks either interactively or non-interactively. In the interactive mode, commands are entered through the keyboard, while in the non-interactive mode the shell reads in commands from a script and serially executes them. The shell may also run in a mixed mode by embedding certain commands in the script.

The syntax of the commands must conform to DASL (Data Acquisition Shell Language), a high-level language developed for GPDAS. Commands that are not understood by the shell are passed to MS-DOS shell for further processing. Script programming is relatively easier than developing new

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applications, therefore, debugging of hardware and testing of measurement procedures are simplified.

Design objectives of the shell include:

- Interactive mode for user command input
- Non-interactive mode for script execution
- Definition of command aliases
- History of commands
- Assignment of variables and arrays (integer, long, float, double, and string) in RAM and virtual memory
- Backup of aliases, history and variables in script format
- Mathematical, logical and text string operations
- Input and output
- Command flow control
- Device interface
- Windowing capability
- Graphics capability

Other utility applications have also been developed as integral parts of the software package. These include: PostScript graphics, graphical monitoring, file management, background printing and device control.

IV. APPLICATIONS

In this section, we will focus on the application of GPDAS to magnet measurement [1] at APS, which was the primary motivation for its development. Applications to the measurement of synchrotron BPM characteristic [2] and closed loop feedback for orbit stabilization [3] will also be discussed.

A. Harmonic Analysis of Quadrupole Magnet

National Instrument 16 bit digital I/O board for AT Bus is used as a communication bridge between the computer and a Gespac crate. Gespac devices include: encoder-motor controller, digital integrator, integrator trigger, time base trigger, power supply controller, ADC (current/voltage reader) and stepper motor controller. The encoder-motor controller is used to control the motion of the rotating search-coil and generates triggering signals for digital integrators. National Instrument 16 bit IEEE488 interface board for AT Bus is installed to control the devices equipped with IEEE488 interface.

The harmonic analysis of quadrupole magnets is accomplished with a GPDAS script and a few modularized utility programs which are called from the script. The entire process of data acquisition and analysis can thus be streamlined. This modular approach facilitates software debugging and helps overcome the 640 KB memory limitation imposed by MS-DOS.

Figure 1 shows the schematic of the quadrupole magnet measurement system. Both the radial and tangential winding type rotating coil probes have been tested. The script calls the data acquisition program to take raw data from integrators and then calls the harmonic analysis program to analyze the data. The results are then used to realign the magnet. The script saves the data and the analysis results in text, binary, and PostScript graphics files. Data base management and hard-copy printing are also done by the script. Figure 2 shows a sample PostScript graphics output from harmonic analysis of the quadrupole magnet using a radial winding coil.

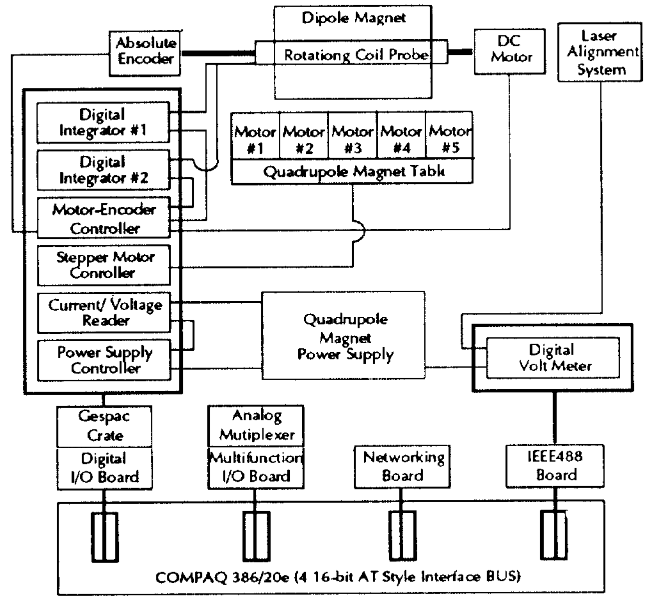

Figure 1. Schematic of quadrupole magnet measurement system.

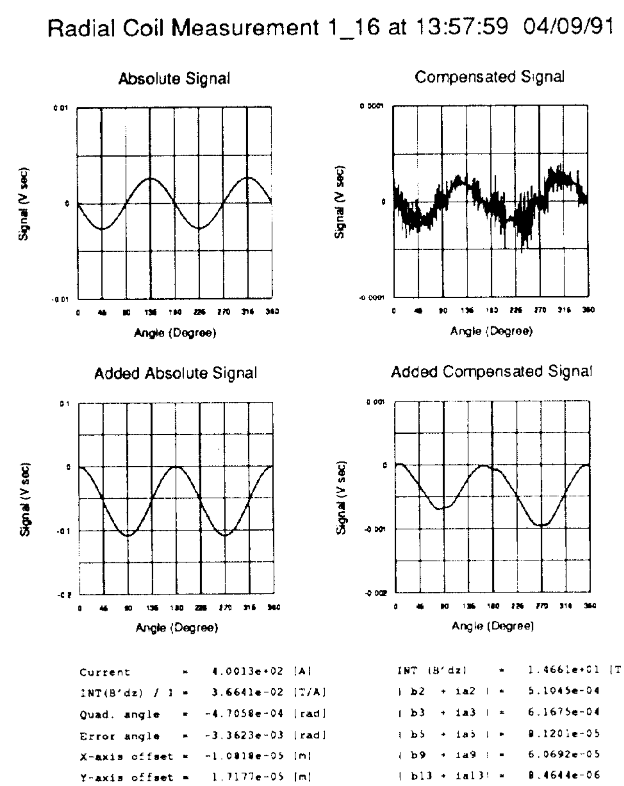

Figure 2. A sample PostScript graphics output from harmonic analysis measurement.

B. Mapping of Dipole Magnet

Two methods of mapping dipole magnets have been tested, one using a Hall probe and the other using a long coil. The schematic of these measurements is shown in Fig. 3. The 3-D mapping table is controlled by 3 stepper motors with encoders and an IEEE488-interfaced motor indexer. The Hall probe #1 is used for mapping and the Hall probe #2 and the NMR probe are used as reference. The digital output of the Hall probe #1 is transferred to the computer via IEEE488 interface and the analog output of the Hall probe #1 is connected to the digital voltmeter.

Two dimensional least square fitting of mapping data has been done for each mapping plane. Integral mapping using a long coil has been tested by moving the coil or ramping the current. Other measurements have been tried for coil manufacturing test, noise measurement, soldering effect, zero-Gauss chamber test and power supply fluctuation test. End field measurement using a short coil and a rotating coil probe will also be tested. At the final stage, integral mapping will be carried out by bucking the signals from the reference magnet and the magnet being measured.

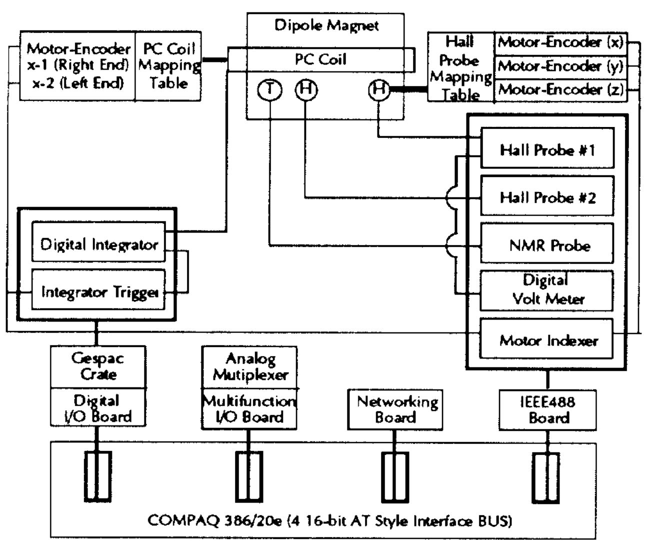

Figure 3. Schematic of dipole mapping system using Hall probes and a coil.

C. BPM Test Stand Measurement

GPDAS has been used to characterize the synchrotron beam position monitor (BPM) test stand. Four button-type pickups are mounted on a BPM unit made of stainless steel. A thin fixed wire of 0.012" diameter is suspended through the elliptic bore under tension in order to maintain straightness. The transverse position of the BPM unit relative to the wire is controlled by two stepper motors and a controller in a CAMAC crate. The buttons are multiplexed by a 4-throw-1-pull mechanical RF switch, and measurements are done using a network analyzer and a digital sampling scope.

The stepper motor controller, the switch driver, the network analyzer and the sampling scope are interfaced to the computer via IEEE488 bus. As in the case of the magnet measurement system, data acquisition and analysis are done by GPDAS scripts and accompanying utility programs. The scripts also format the measurement data and the analysis results for further processing on other computers.

D. Closed Loop Feedback Measurement

The APS will use a large number of correction magnets to create local bumps and to achieve global orbit stabilization. Efforts have been made to counter the effect due to the finite inductance of the magnet and the eddy current in the 1/2"-thick aluminum storage ring vacuum chamber. Significant amplitude attenuation and phase shift of the correction magnet field were anticipated. Measurements and compensation of this eddy current effect have been done using GPDAS.

The data acquisition was done primarily using an ADC, which registered the reference signal, the field inside the vacuum chamber and the control signal to the magnet power supply. Compensation was done by an analogue circuit, and data acquisition and analysis were done by a script and a few utility programs as discussed in previous cases.

V. CONCLUSION

GPDAS provides an integrated script-based environment for data acquisition and analysis. It has been successfully applied to the magnet measurement system, synchrotron BPM test stand and closed loop feedback measurement at the APS. It proved particularly useful for test measurements, such as equipment test, manufacturing technique development, and feasibility tests for measurement methods. Though it currently runs only on MS-DOS-based computers, it can be ported to other platforms, such as SUN or VAX workstations with modifications on the user command interface.

VI. REFERENCES

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