WOODWARD

Application Note 83405

Original Instructions

Advanced Software System lets Control Engineers Concentrate on Control

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Introduction

When designing and commissioning a new turbine control system, much time is often spent rewriting, retesting, and redrawing documentation for software that has already been proven in a similar application. An application software generator system is needed that will allow a control systems engineer to efficiently reuse existing software with a minimum of rewriting, retesting, and regenerating documentation. This system should be self-documenting so that the engineer who generated the application will not be the only person who can efficiently modify the software. Woodward has developed a Graphical Application Programmer (GAP™) system to help solve these problems.

The GAP software provides flexibility as well as the robustness and self-documentation needed to meet today's changing requirements for control system software. The application programmer is the result of decades of experience controlling thousands of turbines for turbomachinery OEMs as well as end user customers. The GAP software allows a user to design his or her control system logic on an integrated drawing package that runs on a PC in the Windows® environment. Once the control logic has been graphically entered, the GAP/PC system automatically generates code that is loaded into the governor to control of the turbine.

All changes or additions to the application programmer are generated, tested, and documented by an integrated team of software experts, so that the improvement of the GAP software is an ongoing process. This process minimizes the amount of time spent rewriting specific control functions. In the past, application programmers have provided little flexibility for design changes or special requirements. Because the GAP software was written specifically for turbine control applications, and because of the many years of experience Woodward has in the marketplace, the GAP software is both flexible and robust.

The GAP software saves time and money during all three phases of control system operation: system design and commissioning, run-time, and system support and modification.

System Design and Commissioning

One of the biggest advantages of the GAP software is that it allows control engineers to actually program the control. Software Engineering has become an ever more specialized field. Requiring a control systems engineer who must be a turbine control expert to also be very efficient at writing and verifying real-time computer operating systems is impractical if not unfeasible. A control engineer using the GAP software doesn't need to know about data structures, C++, multitasking, or data skew. Specialists who do know the intricacies of digital closed loop control have designed an application programmer that allows the control engineer to concentrate on his/her specialty, the control system requirements and logic.

The GAP software block diagram entry screen has the look and feel of many software simulator interfaces that may already be familiar to the control engineer. Blocks much like the blocks used to enter models into MATLAB® or MatrixX™ are entered into the GAP software.

Once the control logic is entered, the GAP software generates code that runs the control. The GAP software blocks are written in C, which is a transportable language. This means that it can be used on different hardware platforms. Because of this feature, the same proven blocks that have been utilized by Woodward for ten years will also be used on Woodward's next generation controller, whatever that may be, without introducing system bugs.

Just as the same blocks are reused, the control engineer using the GAP software builds on a Woodward library of GAP software functions that may be reused from controller to controller with little code generation and testing time, and again, without introducing errors. Because of the system's transportability, the GAP software provides an efficient means for producing error-free control software, not just control acceptability.

The GAP software produces control code that incorporates several important operating modes that greatly facilitate system configuration and checkout. These modes are configuration, service, and system debug mode. Configuration mode guides a user through completely setting up any application specific parameters, or tunables, the first time the system is powered up. Service mode allows an operator to step through and observe important control parameters in a logical fashion to facilitate system troubleshooting. System debug mode offers the user the most flexibility with the fewest restraints. In debug mode, the operator may observe the output of any block, or change any tunable in the system. All three levels of operator interface are password protected so that inadvertent or unwanted access to control parameters is not permitted.

While the GAP software system has proved to be an extremely efficient means of programming a turbine controller, some users still require that their existing sequencing logic will run on their new control. For these users, an industry standard ladder logic programming interface has been provided in the GAP software. The ladder logic interface gives the user a very quick way to make minor program changes, because the ladder logic is on-line programmable. The ladder logic program may be altered while the rest of the control system remains running.

Run-Time Performance

When more and more complex algorithms are implemented on a digital control, the result can be a less than robust controller. One of the main advantages of the GAP software is that all the blocks have been written as efficiently as possible without jeopardizing code stability. Blocks are written in one standard language, and the interface between blocks is well defined. Unwanted interactions between unrelated pieces of software, while common in many other control systems, have virtually been eliminated with the GAP software.

The timing requirements of the code generated by the GAP software have also been rigidly defined and adhered to. Variable execution time blocks have been avoided. The non-variability in the execution times of the blocks means that a control that runs efficiently on a test stand is currently exercising the entire control program. The user does not have to worry that under an unanticipated set of conditions, the processor will become overburdened, and will not have enough time to complete its assigned tasks. Only with predictable execution times can a multitasking operating system have a guaranteed update rate. Software tasks may be programmed to run every 5 ms, 10 ms , 20 ms, 40 ms, etc., and all the tasks seem to run simultaneously. The GAP software guarantees that a task programmed to run every 5 milliseconds will run exactly every 5 milliseconds, no matter what other functions the control system is presently exercising. Systems based on PLCs cannot do this.

Because of Woodward's long-standing relationship with turbine OEMs, special software algorithms have been written and verified through years of use in the field. A sample list of these special blocks includes:

- A unique PID algorithm with special provisions for disturbance handling and noise rejection
- Anti-reset wind up low signal select and high signal select blocks
- OEM-specific extraction/de-coupling algorithms
- Special acceleration controls for precise turbine start-ups
- Special algorithms that allow parallel or series valve transfers with minimal bumping
- Compressor surge control algorithms
- Several modes available for bumpless transfer between control modes
- Special disturbance rejection algorithms for step load changes
- Model reference controls for special turbine system problems
- Precise flow control algorithms for dry-low emissions applications

Many man-years of development time have been invested in the design and testing of these features. Using a standard block diagram language, wherein the blocks don't change over time, allows new applications to take advantage of the knowledge gained in the past. In this way, a collection of blocks used to control a given turbine can be used to control a different turbine, with a different control platform, in a consistent, repeatable fashion.

A final run-time advantage of the application generator is that the same code produced by the GAP software is used to control Woodward's NetCon® F/T fault-tolerant control system. The NetCon F/T system will remain in control of the turbine in the presence of a single-point hardware failure. The majority of the software used in the fault-tolerant system consists of the very same software blocks used to run all of Woodward's other controls. This makes the conversion of an application from a simplex to a fault-tolerant control a straight forward task with a very predictable outcome.

System Support and Modification

During system support and modification the advantages of the GAP software become readily apparent. Because of the structure of the GAP software, and because it generates its own documentation, user changes to the control software can be supported by field service personnel. If the control system software were written with only the aid of a software compiler like C or Pascal, any errors introduced in this code by users might be almost impossible to identify and repair. The GAP system generates its own documentation that is guaranteed to match the control code generated. Only with a tool like this can user modified software be supported by anyone other than that user.

Another important control attribute provided by the code generated by the GAP software is system security. All operator interfaces are password protected with multiple levels of user access so that unwanted tampering with the control is prohibited.

The GAP system, because of its rigidly defined nature, allows Woodward to exercise the same engineering change and revision control system procedures used to control the manufacture of any control system part. This ISO 9001 approved engineering change system guarantees software compatibility, as well as documentation that makes it possible to reproduce, diagnose, and repair control logic bugs. If any bugs do escape, they will be well documented, and the affected systems will be readily located and fixed.

Summary

Woodward's GAP software system makes use of tested, refined, and proven software routines. Because these routines have accumulated so much run-time, and have been tested under so many different circumstances, solutions not readily apparent to a control engineer using a different application generator may be straightforward to an application specialist using the GAP software. The amount of time saved by using the GAP software, and the quality of the code generated makes this application programmer one the most efficient, lowest risk methods available for generating control system software and documentation.

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