POWER PMAC - Motion Control Innovation

Controlling the Advanced Technology Solar Telescope

The largest solar telescope in the world, with unprecedented abilities to view details of the sun, needed to have the most sophisticated control system available.

The Advanced Technology Solar Telescope (ATST) project is expected to provide the sharpest views ever taken of the solar surface. Through the use of the ATST, scientists expect to learn how cosmic magnetic fields are generated and destroyed, and learn what role the fields play in the organization of plasma structures and the impulsive releases of energy found everywhere in the universe. But more importantly, researchers are interested in the mechanisms responsible for solar variability that eventually affects the Earth.

The Telescope's optic support structure, which includes the mirror assemblies, is expected to weigh nearly 75 tons, the mount base nearly 90 tons, and the Coude rotator 160 tons. The 84-foot diameter enclosure will be thermally controlled, highly ventilated, and will be a co-rotating hybrid that has independent rotation when the telescope is positioned at zenith. The enclosure is where the controllers and much of the instrumentation will be located.

Control and Instrumentation Needs

Overall, the instrumentation would incorporate over one hundred motion actuators at the beginning—that number will grow as instruments are added to the system. While each individual actuator will have minimal impact on the ATST Coudé environment by itself, all of the motion control hardware taken together will be a dominant factor in the generation of heat and EMI inside the telescope enclosure.

One critical area of consideration for motion control in the ATST was the expertise required to maintain multiple systems. If each area of control chose to use a different vendor for their motion controller, a tremendous burden would be placed on both the hardware and software maintenance personnel with respect to documentation, spare parts, periodic upgrades, maintenance of software code, and expertise in each of the systems.

The ATST motion control requirements had to flow down from the General Requirements & Specifications for the Design and Fabrication of ATST SPEC-0070. A rough distillation of SPEC-0070 requirements that applied directly to the motion control hardware design and selection included a design solution that simplified components and ensured the lowest cost and highest reliability without sacrificing performance; provided an ease of removal, installation, servicing, alignment, and adjustment; and met full life expectancy of the telescope (40 years) if possible. Finally, the controllers had to comply with NEC, minimize and offer immunity to EMI, comply with FCC reg Part 15 class B (class A for computer room), provide ESD immunity IEC 1000-4-2, and RFI immunity IEC 1000-4-3, IEC 1000-4-6, as well as provide power-line disturbance immunity per IEC 1000-4-9, IEC 1000-4-13.

Controller Selection

ATST engineering team identified vendors based on their ability to provide a product line that could run the gamut from 30+ axes of control to a simple only 2 axes of control, which would span the needs of all the instrumentation packages being used. The priority was to identify a family of motion controllers with a common Linux friendly socket-based software interface. Another interest was to find a solution that would minimize the ATST software development effort required to communicate through the socket-based interface.

All of the vendors considered used a Windows interface whereas the ATST software framework was Linux based. Each manufacturer had a different method to solve the challenge, but in each case additional development time would be required. The extra layer of software needed to interface to the controllers also required maintenance and documentation, which would require the software team to maintain another software layer.

No vendor emerged that provided everything desired for ATST instrumentation, so the vendors were judged on criteria such as company viability, price, physical size, integration capabilities, encoder options, and the elegance of the overall solution. The ATST instrument partners weighed in on the study and unanimously expressed concern over the price of the high-end options that were being evaluated, as their budgets were constrained. Since one purpose of the study was to determine a standard system that the software team would use to develop sample code (in an effort to ease instrument partner development efforts), this caused an expansion in the scope of the investigation with the addition of a few smaller-system vendors — primarily to see if the price point and development effort could be reduced.

The ATST first light instruments (see Pic-2: Multiple Instrument Configurations) would all contain over 20 axes of motion each with the exception of the Visual

Broadband Imager (VBI), which would contain at least 8 axis. For this reason, the 30-axes controllers were selected as the best over-all solution for comparisons. The best-value choice came down to minor differences between the vendor offerings.

After a complete analysis, Delta Tau's new controller, Power PMAC, won ahead of the competition meeting most of the requirements defined by the ATST engineering team. Power PMAC not only supported the required price, physical size, integration capabilities, and feedback options, it also provided an elegant solution for a Linux friendly socket based interface since the controller itself is based upon a Linux OS with real time kernel. This allows use of well-defined SSH and Telnet communication protocols between the controller and other devices at ATST.

Power PMAC is equipped with a dedicated motion engine which can be used to perform a wide variety of motion profiles at all levels of complexity starting at independent and simple trajectories to coordinated and sophisticated for as many as 256 motors defined in as many as 128 independent coordinate systems. Also using a task scheduler, Power PMAC provides unrivaled access to all levels of process, which enables the user to customize the controller/computer as required by project definitions. Power PMAC can be simultaneously programmed in several programming language/environments such as script language and IEC-61131 for high level and synchronized code and ANSI C for low level programming. In Addition, Power PMAC can use the unique capabilities of MATLAB®/Simulink® and LabView® software packages which are highly desirable for scientific/academic use. Power PMAC can be used directly as a platform for executing custom designed Phase/Servo routine auto-generated code from Simulink® Realtime workshop engine and it can communicate with LabView for process control and data acquisition purposes.

Summary and Conclusion

Besides winning out over other controllers, Delta Tau's system was also price competitive, highly capable, and offered the simplest Linux interface solution. Delta Tau also offered lower-end solutions with much lower price points putting it only slightly more expensive than the small controller that was considered.

After Delta Tau won the comparison, informal inquires were made with existing telescopes that use Delta Tau control systems. It was found that the company was generally liked and well accepted in the telescope community. It was also found that mature and well-tested Linux interfaces to Delta Tau systems were available to ATST from other users. Delta Tau customer service was reported to be good, and a forum was available with a large and very active user community. There were also consultants who specialized in developing control systems design with Delta Tau controllers. All of these reasons gave the ATST team a high degree of confidence that Delta Tau was the solution offering the best value for instrument control.

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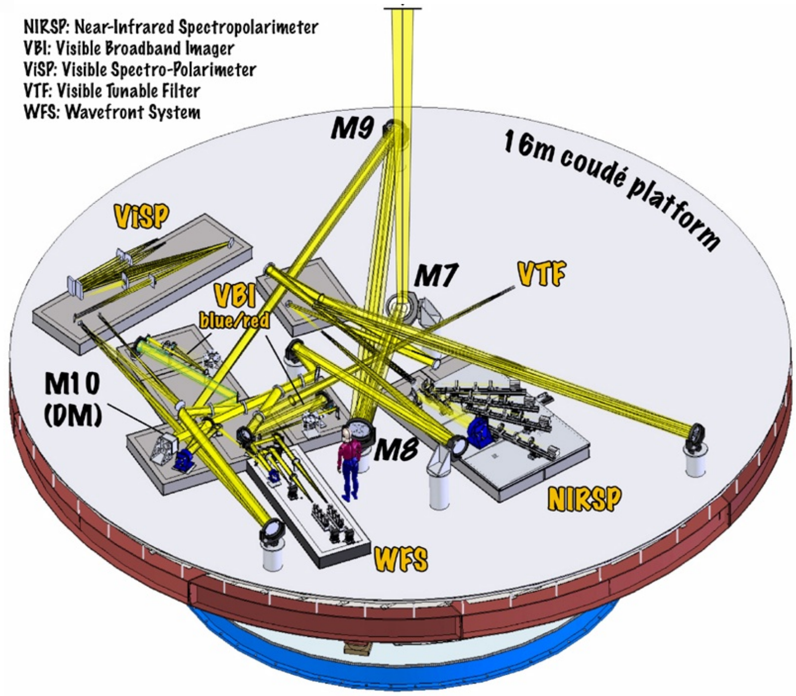
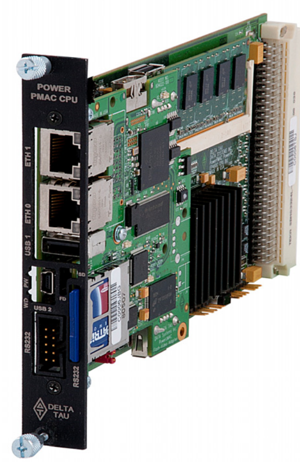
CAPTIONS:

Pic-1: ATST Cutaway Model: This model shows the ATST observatory facility as well as the enclosure area where the instrumentation would be housed.



Pic-2: Multiple Instrument Configurations: The Coude Lab optical arrangement shows the capability of the unit to observe simultaneously with multiple instruments.



Pic-3: PMAC Controller: Delta Tau's controllers can be found around the world in a wide variety of applications. When accurate and repeatable control is needed for critical operations, Delta Tau provides cost effective solutions.