THE CONTROLS SYSTEM FOR THE SUPERCONDUCTING MODULE TEST FACILITY

D. J. Nicklaus

Fermi National Accelerator Laboratory, Batavia, IL 60510, U.S.A

ABSTRACT

The Superconducting Module Test Facility (SMTF) is being established at Fermilab as a centerpiece of the US efforts in high gradient superconducting RF (SCRF). The SMTF is an international collaboration involving several major laboratories and universities which will provide a facility where different module types can be tested, including tests with beam. This paper discusses the selection and development of the controls system software for the SMTF. The current status of the software is reported.

INTRODUCTION

SMTF at Fermilab was proposed in response to several ambitious SCRF accelerator projects being planned in the US, including the International Linear Collider (ILC), Free Electron Lasers, and RIA (the Rare Isotope Accelerator). Its main goal is to develop U.S. capabilities in high gradient and high Q superconducting accelerating structures in support of the International Linear Collider.

SMTF will enable scientists to pursue the potential of SCRF and take advantage of advances in technology to extend science goals. SMTF will have a large impact on testing and planning for the ILC. A key ILC feasibility demonstration requires that a complete acceleration cavity cryomodule (modulator to cavity) be assembled and tested at the ILC design gradient of 35 MV/m.

Long term plans (by 2009) call for moving and upgrading the photoinjector of the NICADD Photoinjector Laboratory at Fermilab and using this as a high quality pulsed electron beam for SMTF.

PLANNING

In early 2005, an evaluation panel was convened at Fermilab to consider the choices for a control system for SMTF. Three systems were seriously considered, EPICS, ACNET (the control system for the existing Fermilab accelerator complex), and DOOCS (the DESY Object Oriented Control System). Other commercial systems were not really explored or considered. The panel concluded that any of the three systems would meet the requirements of the controls for SMTF. Some of the considerations were: existing ACNET infrastructure already in place for Fermi Accelerator controls; relatively limited (but some) expertise in EPICS at Fermilab; very little knowledge of ACNET among collaborators outside of Fermilab; no expertise or support for DOOCS outside of DESY; and DOOCS support for hardware at the Fermilab photoinjector.

Due to the collaborative nature of SMTF, the panel recommended that SMTF choose one control system architecture. The panel also pointed out that there is EPICS expertise widely available at many of the SMTF collaborating institutions. However, due to short term SMTF goals, the panel recognized that the SMTF controls would be a mix of components from several different systems for the short term.

REALITY

To meet near term goals, the controls system is indeed including components utilizing several

different controls systems. The SMTF project established a short term goal of a RF cavity test in October, 2005, in the Meson area building at Fermilab. The cavity to be tested is referred to as Capture Cavity 2 (CC2). The CC2 is a 1.3 GHz 9-cell TESLA cavity, similar to the NICADD Photoinjector Lab Capture Cavity 1 (CC1) in use at Fermilab. CC2 will be cooled to cryogenic temperatures for the October test. Additionally, a LLRF (Low Level RF) system for a single 3.9 GHz cavity will be needed at the Meson area in 2006.

High level controls software is needed for many different subsystems for the CC2 tests, including LLRF control, cryogenics, modulator, and klystron interlocks.

LLRF Control

The CC2 LLRF system design is based on the proven FPGA-based, single-cavity Simcon 2.1 LLRF controller card from DESY. However, much additional work is needed to provide all the components that are needed for a stand-alone LLRF system, and to integrate these components with the DESY DOOCS control system to provide a complete LLRF solution for a single cavity test. A complete Simcon 2.1 module has been in operation with a Matlab interface at Fermilab since March 2005. The DOOCS interface for this card has been recently completed at DESY has been transferred to Fermilab. The DOOCS interface to the Simcon card runs on a VME-based, Sparc CPU single board computer running Solaris.

DESY has also provided SMTF with 8-channel Digital to Analog Converter (DAC) cards for use as function generators for testing the system and high speed Analog to Digital cards for general signal processing. They have also transferred DOOCS interfaces for these additional cards.

DESY is now working on the multiple-cavity Simcon 3.1 LLRF system, which is a higher performance system capable of controlling multiple cavities fed from a single Klystron. Fermilab will not require a multiple-cavity LLRF system for at least another year and a half, when the first cryomodule becomes available for testing.

Cryogenics

The cryogenics equipment is controlled by Programmable Logic Controllers (PLCs). There is currently some control over the SMTF cryogenic plant provided through ACNET via fully custom libraries to the PLCs. For SMTF, cryogenic control and monitoring is needed via EPICS. Support for the PLCs is supplied by the vendor's applications and hardware. One application provided by the vendor is an OPC server for access to other systems. OPC is a series of standards specifications commonly used to move real-time data from PLCs. Drivers for an EPICS interface to OPC have been developed in the EPICS community and we have integrated this software into our control system. We are running a software EPICS IOC on the PC that hosts the OPC server and developed EPICS displays using the EPICS "EDM" GUI (graphical user interface) builder to replicate and extend the existing ACNET user interfaces to the cryo system.

Modulator

A system based on a PC/104 computer card is used for controlling the modulator. This computer card has been used for other projects in the ACNET system at Fermilab running the eCos operating system. There was no existing EPICS support for eCos but the engineer using this card ported EPICS to eCos on the card, so this part of the system will be under EPICS control.

Klystron Interlocks

New VME cards are being built for the interlocks and hardware protection of the Klystron systems. This will be controlled by a conventional EPICS system running under vxWorks on a standard VME processor card. The new hardware will not be ready for an October, 2005 test, however, so an existing Klystron interlock system from an earlier Fermilab experiment has been picked up for the October test. This existing system uses ACNET related software (Internet Rack Monitors and their parameter pages), but is able to run completely independently of the rest of the Fermilab accelerator complex. We expect to only use this system temporarily and to soon replace it with the EPICS controlled system.

Timing

The hardware clock timing for the SMTF controls system is provided by an Industry Pack IP-177 eight channel delay timer. This is built on a commercially available IP module with an FPGA, RAM, two receivers for incoming clock signals, 40 bits of digital I/O, and two interrupt lines to interrupt the host processor. The IP-177 is a common design used in many other control system timing applications at Fermilab and elsewhere. For SMTF, a 9MHz clock signal is the input to the IP-177.

CONCLUSION

As expected, due to tight schedule constraints, we have had to set aside the goal of having one integrated control system for all the SMTF components, temporarily, at least. Development will probably continue in both EPICS and DOOCS for the foreseeable future. This is not as bad as it might sound, because DOOCS is able to communicate with EPICS nodes using the EPICS channel access protocol. Thus, we can build higher level interfaces in DOOCS which can interact with both EPICS and DOOCS subsystems. The DESY contributions to the SMTF controls system including the software for the LLRF Simcon card and of course all the hardware are too large and valuable a part of the system to be able to quickly plan on replacing DOOCS with EPICS. Since DESY's systems use DOOCS, any further advancements made at DESY will be more easily integrated into SMTF if we continue to use DOOCS. DOOCS is the control system for the photoinjector experiment at Fermilab.

ACKNOWLEDGEMENTS

REFERENCES

[1] OPC Device Support - Information and Download
 http://www-csr.bessy.de/control/SoftDist/OPCsupport/
[2] G. Cancelo, R. Carcagno, B. Chase, Capture Cavity 2 LLRF System Project Definition, September, 2005.
[3] M. Kucera. IP-177 Eight Channel Delay

Timer for SMTF. August, 2005.