The Fermilab SSR1 and HB650 Synoptic and EPICS remote cryogenic control system

L Pei, B Hansen, M White, J Makara, S Ranpariya, M Barba

Fermi National Accelerator Laboratory
Batavia, IL, 60510, USA

Abstract- The 325MHz Single Spoke Resonator 1 (SSR1) Cryomodule (CM) has a 5.3-meter length, and it has 288-liter liquid helium @ 4.5K mode. The High Beta 650 MHz (HB650) CM contains six elliptical cavity cryomodules, has a 9.9-meter overall length and it has 530-liter liquid helium. The SSR1 and HB650 CM had been tested at Fermilab Cryomodule Test Facility (CMTF). Their cryogenic control system includes the Siemens Process Control System S7-400, Automation Direct DL205 PLC, and remote synoptic HMI/EPICS Phoebus GUI. This paper presents a method which has been successfully used by Fermilab PIP2 IT cryogenic remote on-line, real-time control systems.
Keywords: PIP-II, SSR1 CM, HB650 CM, cryogenic control system, synoptic HMI/EPICS IOC OPC UA
CEC/ICMC session ID: C1Po1F-02
Fermilab Report number: FERMILAB-CONF-23-351-TD

INTRODUCTION

Fermilab CMTF is the test facility that houses two test caves that are capable of testing various styles of cryomodules (CM) at 162.5 MHz, 325 MHz, 650 MHz, and 1.3 GHz, in pulsed and continuous wave (CW) modes of operation. The test stands have been used to commission and assess the cryomodule performance prior to their operation in the future Proton Improvement Plan II, (PIP-II) accelerator, the current Linac Coherent Light Source (LCLS) II accelerator, and the LCLSII HE upgrades. A layout of the entire CMTF complex is shown in Figure 1.

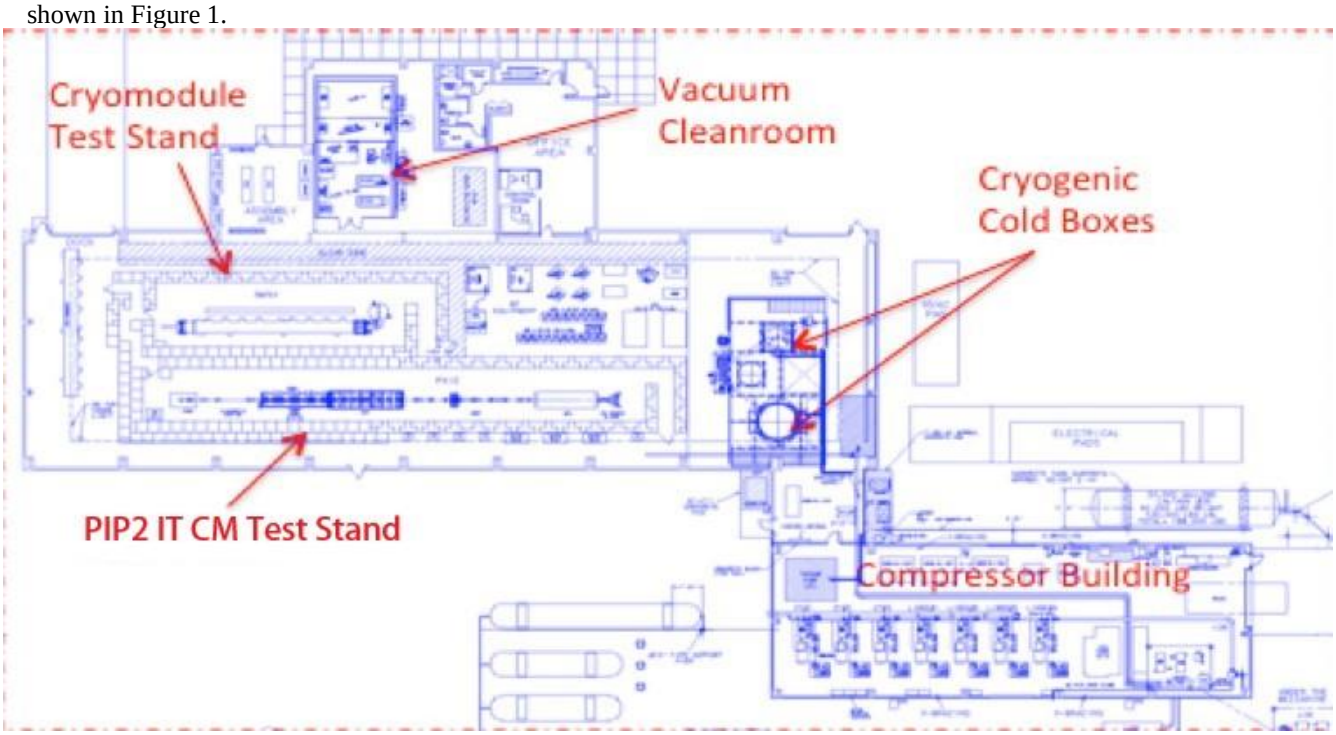

Figure 1. Layout of Cryogenic Module Test Facility

TEST FACILITY DESCRIPTION

The CMTF warm compressors are the MYCOM brand 300 KW screw compressors, with four compressors for the SCP plus one compressor serving as a purifier compressor as shown on the Figure 2. The Superfluid Cryogenic Plant (SCP) of Linde is shown on the Figure 3, it supplies gas and liquid helium to various styles of cryomodules. The CMTF is to house two test stands. One stand is to test LCLS-II (Light coherent light source) CMs and the other stand PIP-II Injector Test (PIP2IT) is to test HWR, SSR1 and HB650 CMs for the PIP-II Project and will test SSR2 and LB650 CMs in the future. Five types of PIP2 IT SRF CMs are shown on the Figure 4.

Figure 2. CMTF Warm Compressor building

Figure 3. CMTF Linde SCP Cryogenic plant

Figure 4. Five types of the PIP2 IT SRF Cryomodules

CRYOGENIC CONTROL SYSTEM

The cryogenic control system at CMTF includes the Siemens Process Control System SIMATIC PCS7-400. The simplified schematics for the CMTF cryogenic controls system is shown on Figure 5.

The Siemens Engineering Station (ES) is used for programing and local operation. The SIMATIC OPC Scout is designed for OPC DCOM communication. The Synoptic HMI and EPICS GUI are used for operations and monitoring. Fermilab ACNET (Accelerator Control Network) is used to archive, monitor and alarm on all parts of the CMTF cryogenic system. ACNET is also used for control on all parts of the CMTF cryogenic distribution

system except the HB650 CM. The Siemens S7-410 CPU is its central cryogenic control that controls ten remote I/O cabinets including 74 ET200M I/O Modules. The cryogenic control system also has eight DL205 PLCs used as the local sub-control system, and one is used as the gateway PLC. The S7-410 central control system processes all PID loop control, signal conversion and logic control as well as communication with ACNET

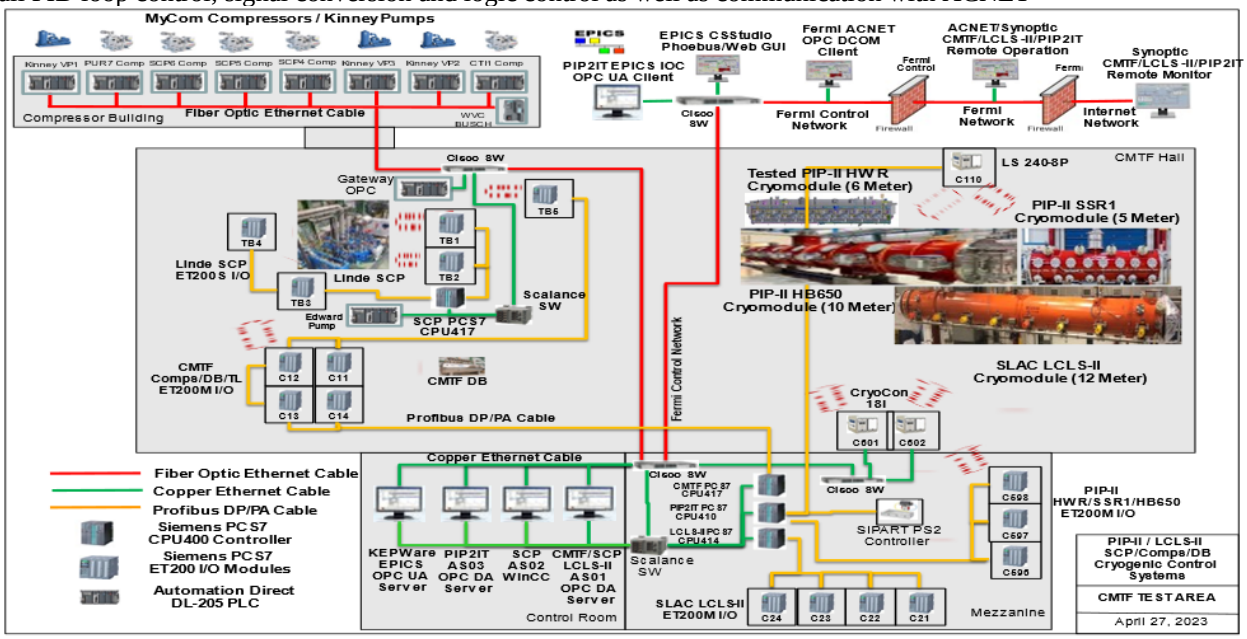

Figure 5. CMTF Cryogenic Control System Outline

The Experimental Physics and Industrial Control System (EPICS) is a set of open-source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems. The EPICS is used to control HB650 CM control valves and heaters. The KEPServerEX OPC is the connectivity platform that provides a single source OPC DA/UA converter server to link the Siemens S7-410 PLC and the EPICS IOC application. The EPICS Phoebus GUI display, monitor and control the HB650 CM. The EPICS HB650 PVJT valve control page is shown in Figure 6, the EPICS HB650 cavity monitor page is shown in Figure 7. The EPICS GUI HB650 control system is shown on Figure 8.

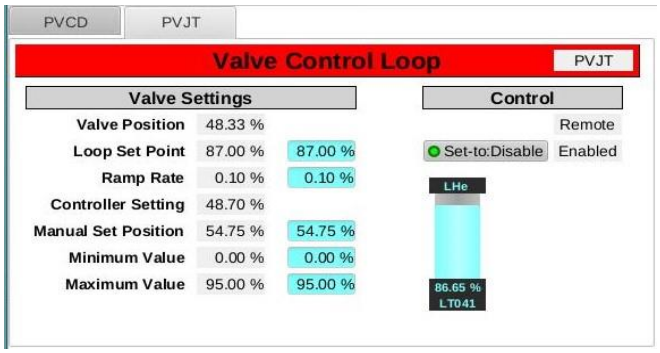

Figure 6. EPICS HB650 PVJT valve control page

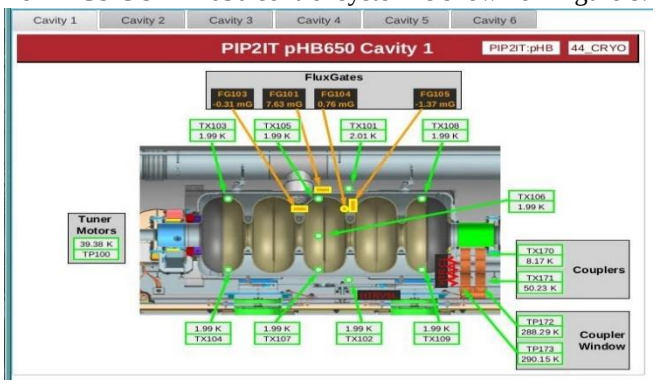

Figure 7. EPICS HB650 cavity monitor page

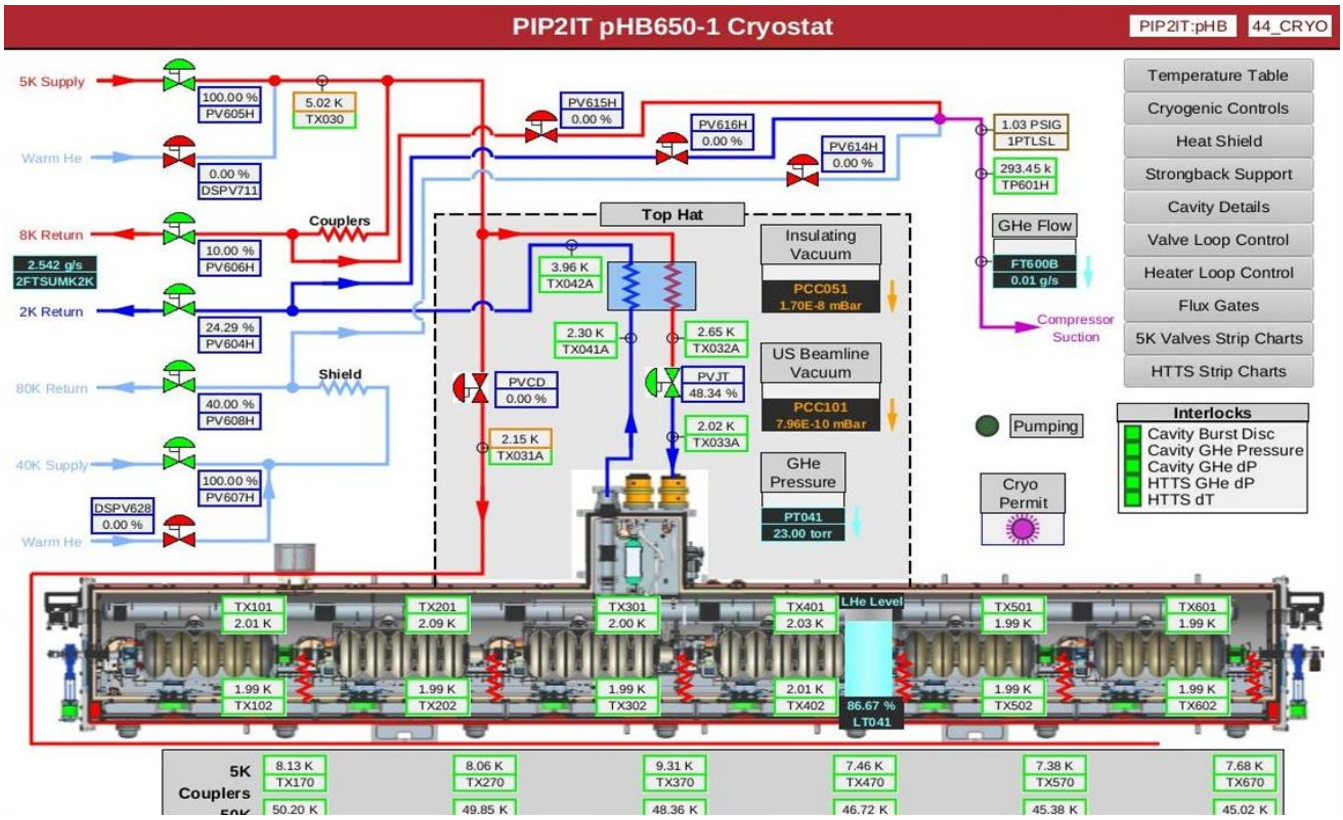

Figure 8. EPICS HB650 Cryogenic control system

The top layer HMI used for the CMTF Cryogenic system is the Synoptic viewer application, which is an implemented in Java. The Synoptic system is a graphical interface between the S7-410 PLC and the end user which uses graphical tools to display and control the cryogenic process. The SSR1 and HWR Synoptic HMI controls are shown on Figure 9 and the HB650 Synoptic control is shown on Figure 10

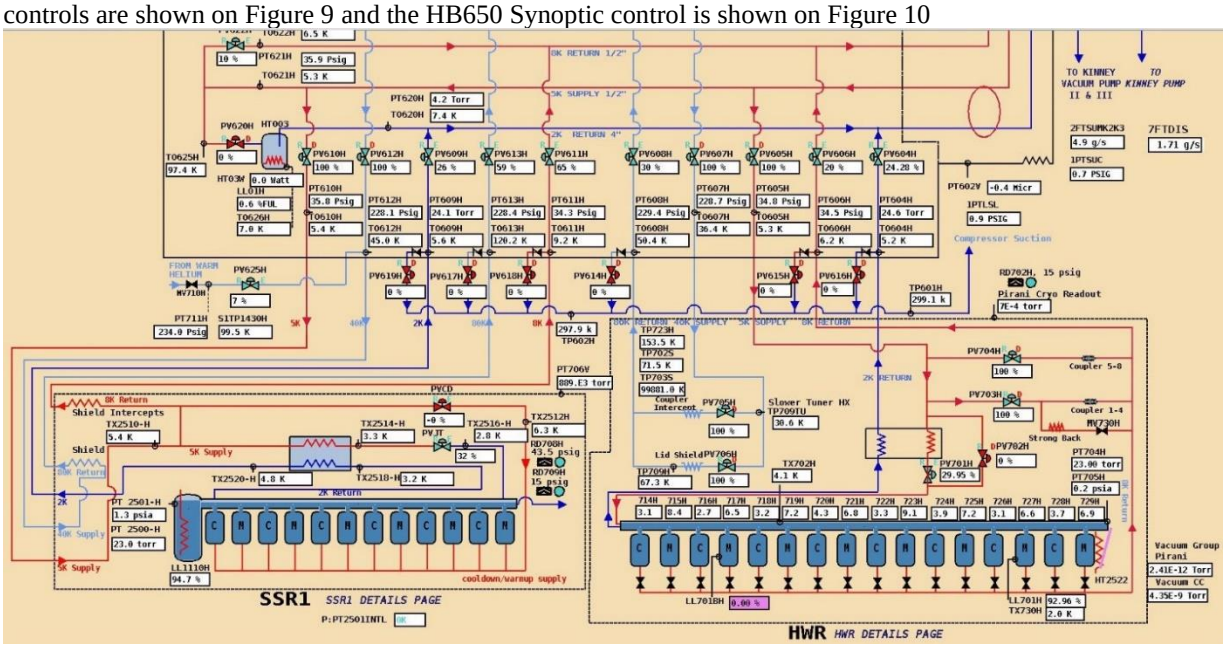

Figure 9. Synoptic HWR and SSR1 cryogenic control system

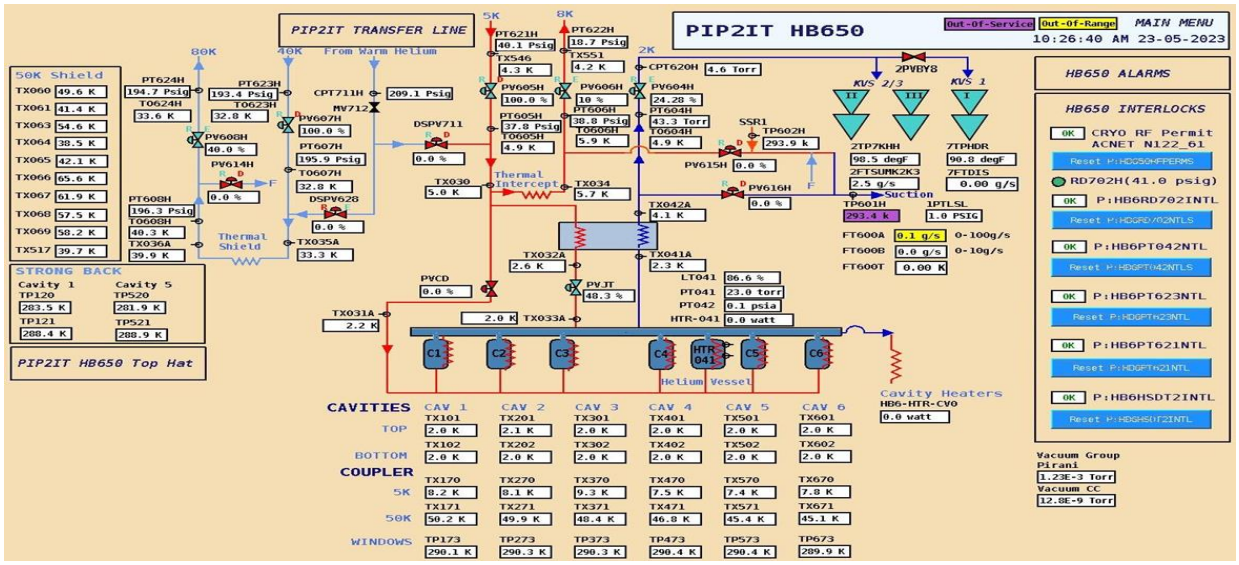

Figure 10. Synoptic HB650 cryogenic control system

CONCLUSION

The HWR, SSR1 and HB650 Cryomodules (CM) have been successfully tested in the CMTF PIP2 IT test stand. For the HB650 larger volume CM, its high volumetric flow rate and high helium vapor velocity of Joule-Thomson (JT) valve contributed to some PID operational difficulties in controlling liquid level in the cryomodule's pipe and end dewar. The HB650 VELAN pneumatic PVJT valve control is shown in Figure 11.

The Figure 11 shows HB650 was pumped down from 4.5K to 2.0K (3,065 Pa). During the pump down, the PVJT valve was controlling the dewar helium liquid level LT041 at around 87%, and the PV-604 valve was controlling bath pressure PT041 to 3,065 Pa (23 torr) by venting into the Kinney Skid inlet header. One additional instrument air buffer for the VELAN pneumatic PVJT valve was added to keep the valve position stable with a leaking positioner valve.

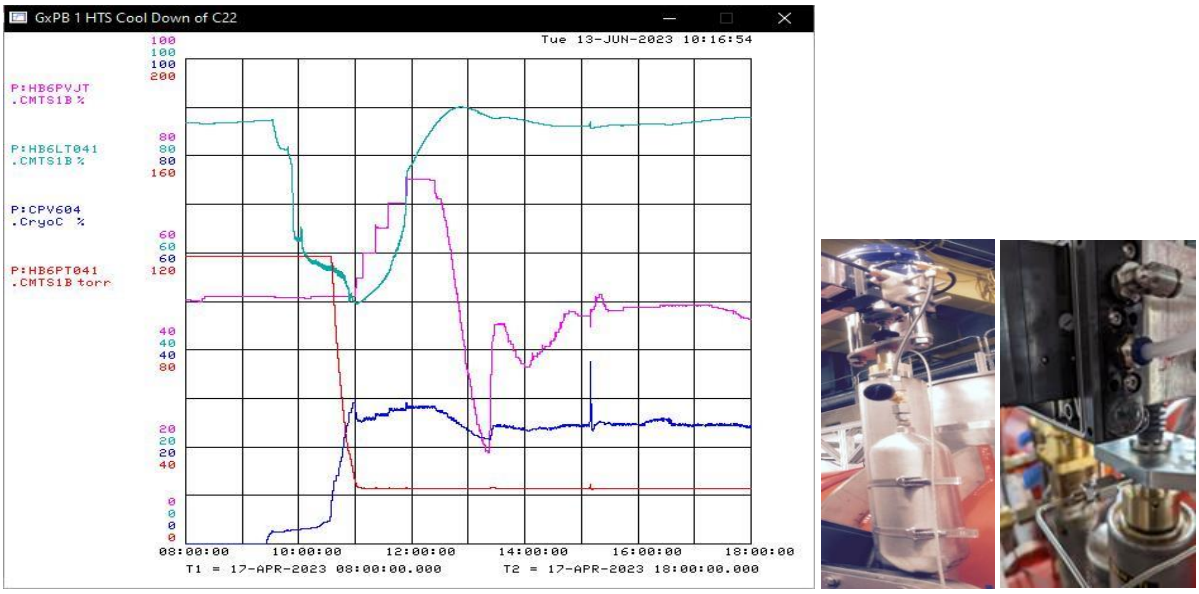

Figure 11. The HB650 VELAN pneumatic PVJT valve control

ACKNOWLEDGMENTS

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics. The authors wish to recognize the dedication and skills of APS-TD Cryogenic Technology Division personnel involved in the installation and operation of this system.

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