FERMILAB CMTF CRYOGENIC DISTRIBUTION REMOTE CONTROL SYSTEM

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ABSTRACT

The Cryomodule Test Facility (CMTF) is able to provide the necessary test bed for measuring the performance of SRF cavities in a cryomodule (CM). The CMTF have seven 300 KW screw compressors, two liquid helium refrigerators, and two Cryomodule Test Stands (CMTS). CMTS1 is designed for 1.3 GHz cryomodule operating in a pulsed mode (PM) and CMTS2 is for 650 MHz cryomodule operating in Continuous Wave (CW) mode.

Based on the design requirement, each subsystem has to be far away from each other and be placed in distant locations. Therefore choosing Siemens Process Control System 7-400, DL205 PLC, Synoptic and Fermilab ACNET are the ideal choices for CMTF cryogenic distribution Real-Time remote control system.

This paper presents a method which has been successfully used by many Fermilab distribution cryogenic Real-Time remote control systems.

KEYWORDS: Cryomodule test facility, Distribution, Real-Time Remote control.

INTRODUCTION

Fermilab's Cryomodule Test Facility (CMTF) will house the new cryogenics plant as well as multiple stand-alone SRF cryomodule test stands. One of the buildings will house the noisy vibrating equipment (seven compressors, pumps, etc.) needed to operate the cryoplant. The other building will contain: the cryogenic plants, cold box, cryomodule test stands, RF systems, a vacuum clean room, and an office area.

The current plan is for the test facility to house two test caves that are capable of testing various styles of cryomodules at 325 MHz, 650 MHz and 1.3 GHz, in pulsed and continuous wave (CW) modes of operation. The test stands will be used to assess the cryomodule performance prior to their commissioning. A layout of the entire CMTF SRF Accelerator Test Facility complex is shown in Figure 1.

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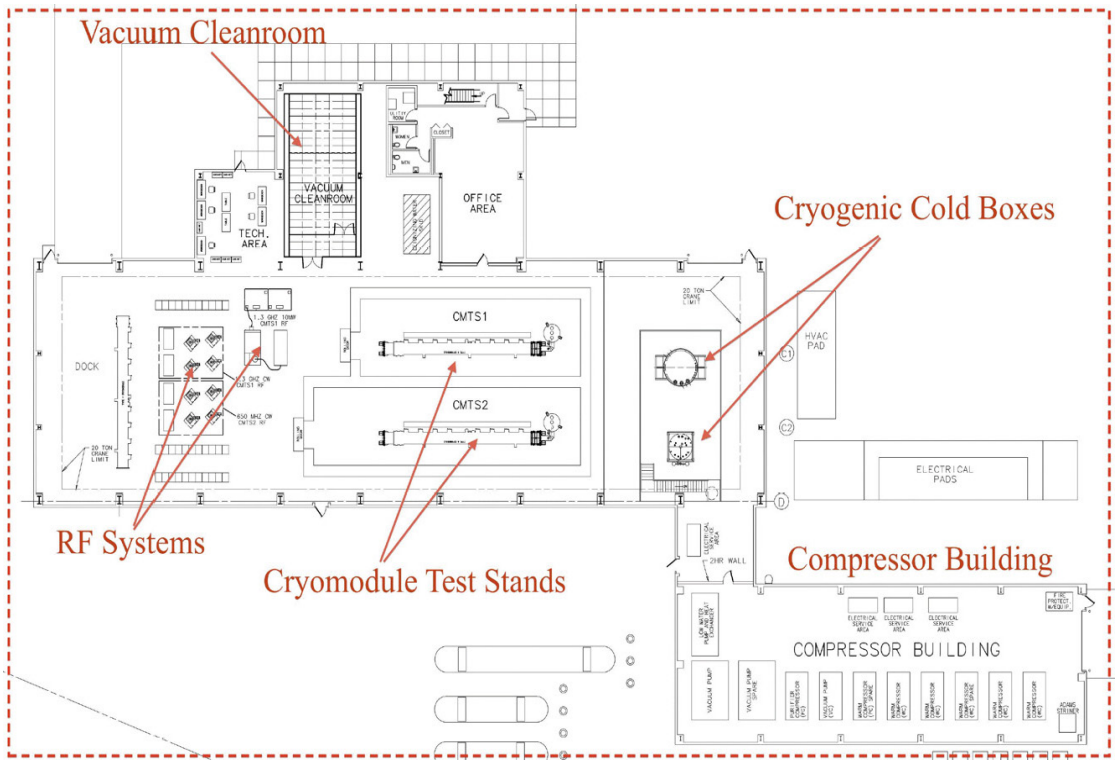

Figure 1. Layout of CMTF SRF Accelerator Test Facility

TEST FACILITY DESCRIPTION

The cryogenic test facility is composed of compressor room and helium refrigeration, which is provided by an onsite cryoplant. The warm compressors are the MyCom 300KW compressors #1 through #6, plus compressor #7 serving as a purifier compressor as shown on the Figure 2. The goal of the seven compressors is to demonstrate stability of operations up to four compressors in parallel between typical suction @ 15.5 psia +/- 0.1 psi and discharge @ 290 psia +/- 3 psi.


Figure 2. CMTF Warm Compressor Room

There are two cryogenic helium plants as shown on the Figure 3; one is Superfluid Cryogenic Plant (2K @ 250W by Linde) and another is CTI4000 cryogenic refrigerator (20K @ 1kW by SLAC). They will supply liquid helium to various styles of cryomodules. Half-Wave (HW) Cryomodule for the Project X Injector Experiment (PXIE) includes two Super Conducting (SC) cryomodules. The first one HW includes 8 SC half-wave cavities operating at 162.5 MHz; and the second one Single Spoke Resonators 1 (SSR1 by CryoMagnetic, Inc) includes 8 spoke cavities operating at 325 MHz as shown on the Figure 4. Another one is CMTS cryomodule.

Figure 3.CMTF SCP and CTI4000 Cryogenic plant

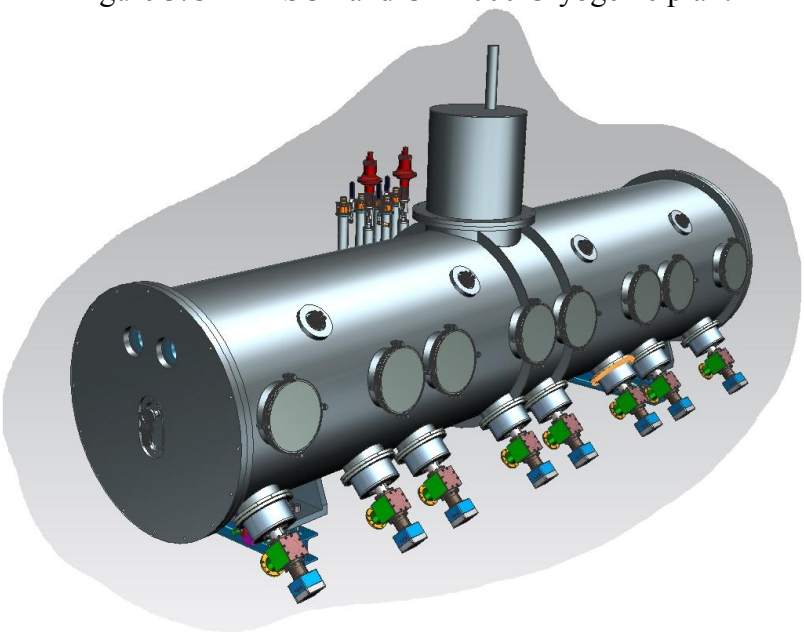

Figure 4.CMTF PXIE SSR1 Cryomodule

CRYOGENIC CONTROL SYSTEM

The main control system at CMTF consists of the Siemens Process Control System SIMATIC PCS 7 which is an integral component of Totally Integrated Automation (TIA); TIA is a unique platform for unified and customer-specific automation system. The similar system (APACS) has been successfully used for many years at Fermilab to control other cryogenic systems. Simplified schematics for the CMTF controls system is shown on Figure 5.

The multi-level distribution control system uses Siemens Engineering Station (ES) as its operation level; SIMATIC NET IE as its OPC server; Fermilab Synoptic HMI system as its Web operation and monitor level; Fermilab ACNET as its archive, monitor and alarm level; PCS7-400 as its central control level; eleven ET200Ms as its remote data acquisition and I/O control field level; nine DL205 PLCs as its remote independent sub-control field system and one gateway GWPLC as its media communication between PCS 7-400 and field sub-control systems.PCS7-400 central control system handles all PID LOOP control, signal conversion and logic control as well as communication between Fermilab ACNET and PCS7-400and DL205s.

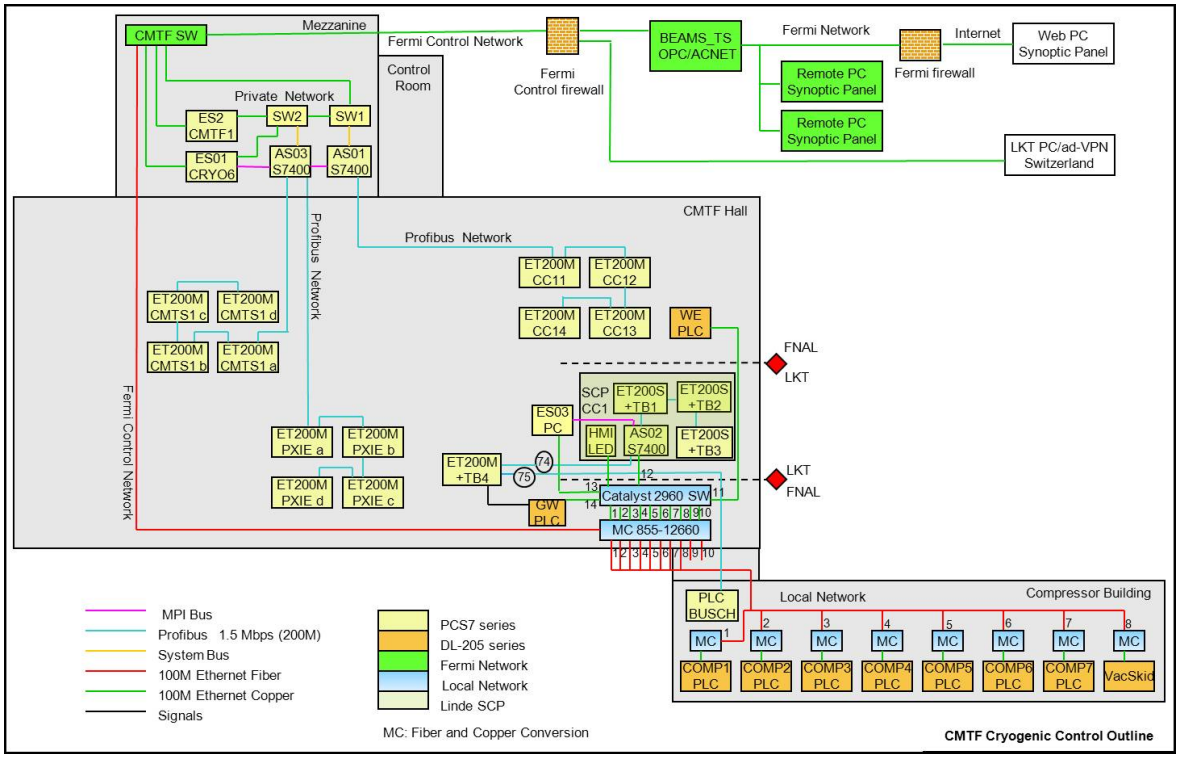

Figure 5.CMTF Cryogenic Control System Outline

The control of the localized equipment such as the main 300 KW MyCom compressors, expansion engines and purifier compressor are done using localized, self-contained, and PLC based sub-controls system, (Automation Direct DL-205 PLCs by KOYO®) which communicate directly with the PCS7 system using a fiber optic line. The localized PLCs interface with the equipment motor controller and manage the machine local interlocks. The start/stop/reset features, the remote/local control as well as a limited amount of input and output channels are also managed by this PLC Locally, a local touch panel display allows for manipulation and control of these systems and parameters.

The top layer human machine interface used for the CMTF Cryogenic system is Synoptic graphic user interface from Sun-Microsystem JAVA. The Synoptic system is a graphical interface between the PCS 7 system and the end user which uses graphical tools to display the cryogenic process. Control of the system can also be done using those tools by simply clicking on graphical components and manipulating the output. The displays are created using the Synoptic graphical builder. Synoptic also supports alarm handling and plotting packages.

Many of the I/O devices are also sent to the Fermilab ACNET control system from PCS 7 using a SIMATIC NET IE OPC server. This flexibility gives experimenters access to data from various systems in one platform for ease of plotting and data management.

WARM COMPRESSORS INITIAL COMMISSIONING

Over the last month some key components of the CMTF cryogenic system have been successfully commissioned, it includes the warm and purifier compressors as well as the inventory control system. During the commissioning, three 300KW MyCom compressors are operating as show on Figure 6. The inventory WEKA pneumatic control valves PVHSL, PVLSL, PVLBL, as well as bypass valve EVBP are shown on the Figure 7 is available to maintain pressure while compressor' flow will be changed with loading valve. We used PCS 7-400 PID LOOP control to regular discharge pressure PTLHP at 250 psig and suction pressure PTLSL at 1.5 psig. All high sliders and low sliders of compressor #4, #5 and #6 are set up at 100% by Synoptic HMI manual setting while compressor running.

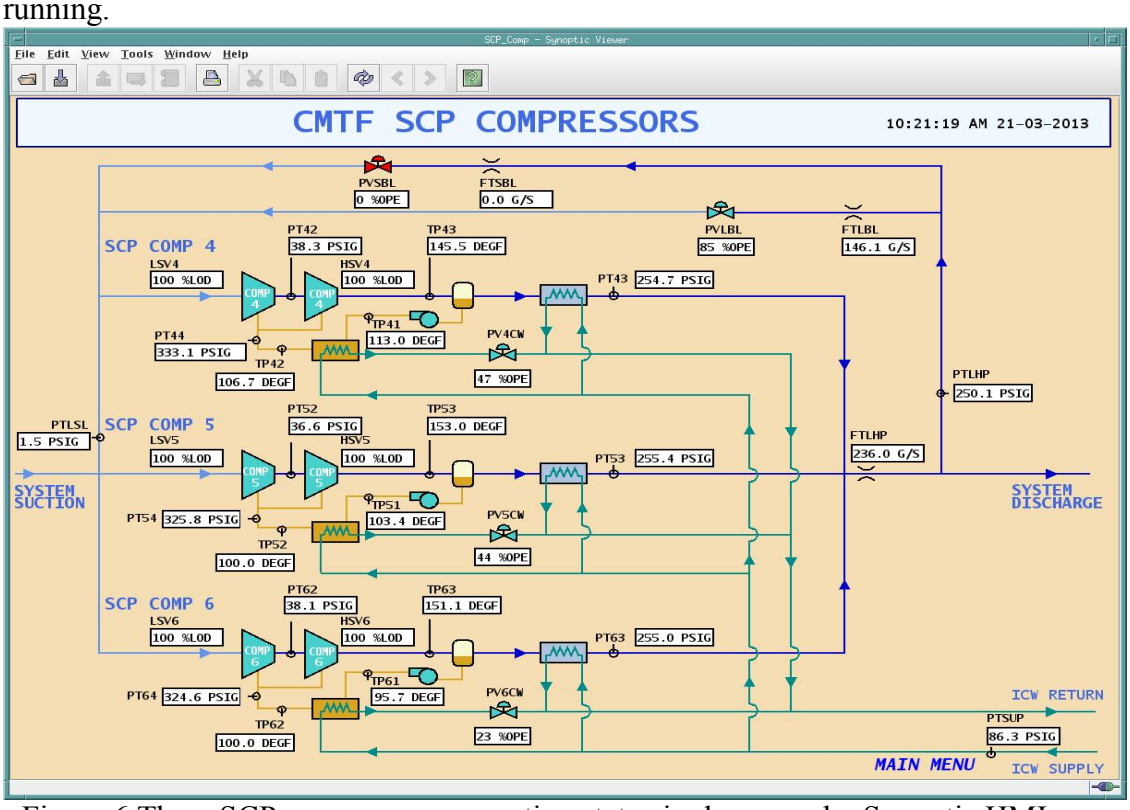

Figure 6.Three SCP compressors operation status is shown up by Synoptic HMI

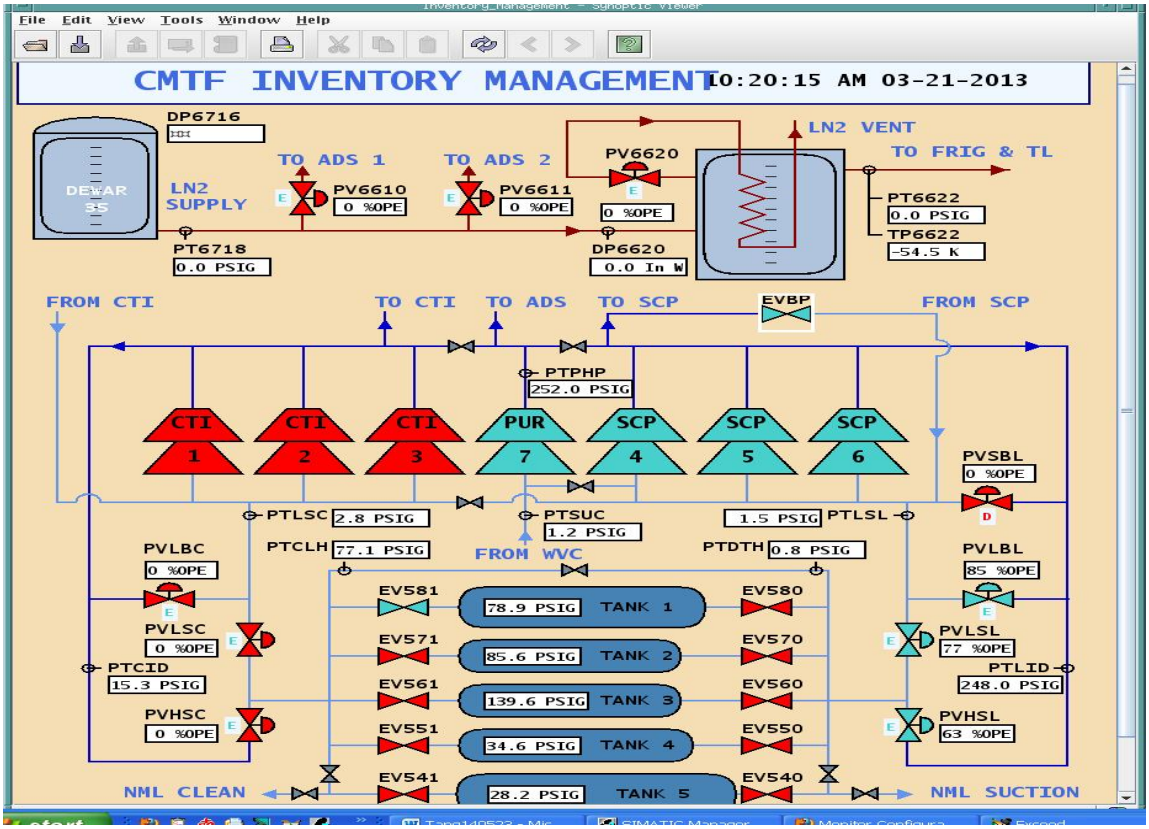

Figure 7.CMTF Inventory management is shown up by Synoptic HMI

To satisfy commissioning requirement for the compressor system, the high suction valve PVHSL is setting at 250 psig and following up PTLHP; the low suction valve PVLSL is setting at 1.5 psig and following up PTLSL; and the bypass valve PVLBL is setting at 0.5 psig and following up PTLSL.

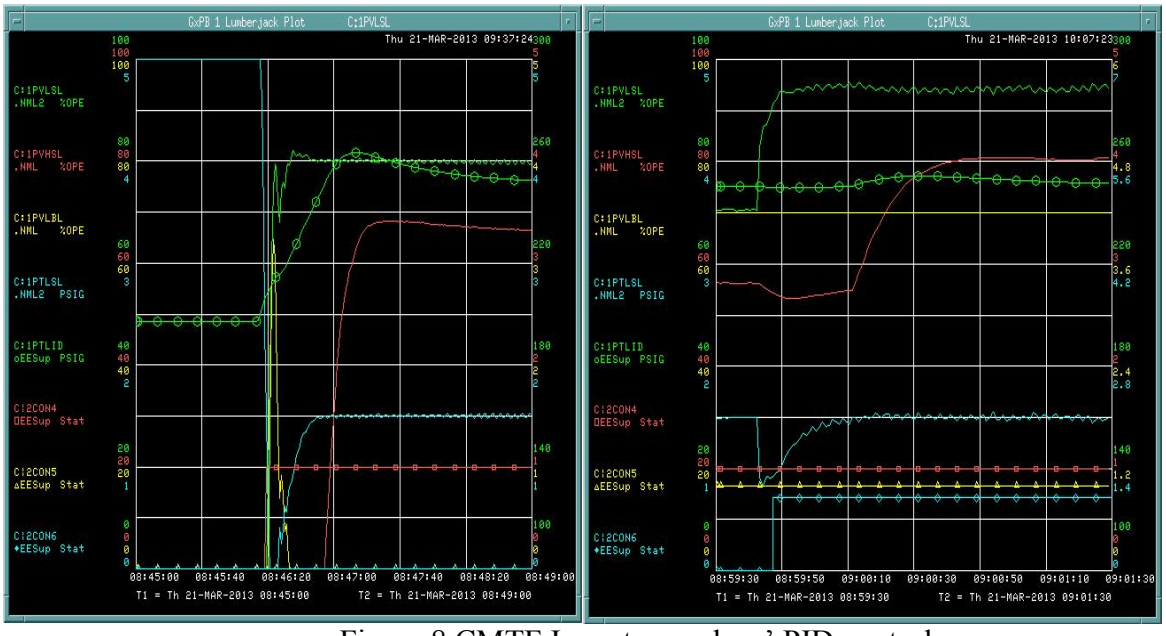

Figure 8.CMTF Inventory valves' PID control

After first compressor #4 starting, these inventory PID control valves response are quiet fast and stable to keep PTLHP and PTLSL up requirement value, then continuously starting compressor #5 and compressor #6 and lock PVLBL valve at 70% opening, these inventory PID control valve's action are still very well as shown on Figure 8.

The next phase of commissioning will include cooling down the installing Linde' Superfluid Cryogenic Plant (2K @ 250W) and SLAC CTI4000 cryogenic refrigerator (20K @ 1kW) helium distribution system leading to the test caves. The test load will consist of the two PXIE SC HW and SSR1 cryomodules and one CMTS cryomodule. PXIE is the integrated systems test for the Fermilab Project X frontend.

CONCLUSION

The CMTF cryogenic system is working on its schedule with the successful commissioning of several subsystems, including the Warm compressor systems, inventory control system and PCS 7-400 distribution cryogenic control system. The commissioning of the cryogenic distribution system leading to the new cryoplants test using the Linde's SCP and SLAC's CTI4000 will soon be underway followed by full caves commissioning of the PXIE system. The major goal of the PXIE project is a validation of the Fermilab Project X concept and elimination of technical risks

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