

PROPOSED IMPROVEMENTS TO THE TEMPERATURE MAPPING SYSTEM OF SINGLE-CELL SUPERCONDUCTING RADIO FREQUENCY CAVITIES AT CORNELL UNIVERSITY

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Abstract

Single-cell Superconducting Radio Frequency (SRF) cavities, made of niobium, are manufactured at Cornell University. The primary purpose of these cavities is to further the understanding of SRF. With this better understanding, improved cavities can be manufactured for particles accelerators such as the Cornell Energy Recovery Linear-accelerator (ERL). A temperature mapping system (T-Map) has been developed that can detect temperature changes on the surface of the cavity to give a full temperature profile of the cavity during operation. This paper details ideas to improve the T-Map at Newman Lab such as using LabVIEW for data acquisition and designs of a new testing insert to move from the center testing pit to the west testing pit.

INTRODUCTION

SRF cavities made of Niobium are used in particle accelerators around the world. Niobium enters a superconductive state at 9.2K. Liquid helium is used as a cryogen because it is in its liquid state at 4.2K. When a cavity transitions from superconducting to normal conducting under RF operation it is known as quenching. [1] If a cavity were to quench during operation in a particle accelerator, the beam could be lost. Quenches are caused by the exceeding the critical temperature or critical magnetic field. By taking a full temperature profile of the cavity under different conditions such as changing temperatures and E_{acc} , the cause of the quench can be located. Newman lab has three test pits to accommodate cavity tests of various sizes. Single-cell temperature maps tests are conducted in the center testing pit.

Temperature Mapping System

The current temperature mapping system (T-Map) consists of 646 Allen-Bradley resistors (see figure 1) on 38 boards positioned around the entire cavity. There are additional Allen-Bradley resistors mounted on the sides of a few boards to measure the bath temperature for comparison and offset. The voltages across the resistors

are read by a National Instruments (NI) DAQ PCI-6229 which is connected to two NI SCXI-1001 that are daisy chained together. Each NI SCXI-1001 has 12 NI SCXI-1100 modules that have 32 channels on each module resulting in 768 channels total. There is a layout file that relates the resistors by board to the module/channel layout. In addition to the Allen-Bradley resistors, Cernox temperature sensors are placed on the cavity and in the bath. The Cernox sensors are read using a LakeShore 370.

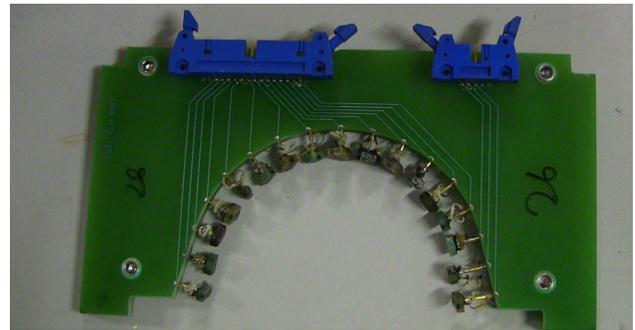


Figure 1: T-Map Board with 17 Allen-Bradley resistors

The data has been acquired and compiled into usable results in a MATLAB program. On average the MATLAB program takes 160 seconds to complete one data acquisition cycle. The majority of this time occurs switching between channels. A single data acquisition cycle consists of reading 1000 samples per channel and averages those samples for each of the 768 channels; then stores the averages. For each channel average that is stored, one Cernox temperature is taken and stored. Testing time is limited because the testing pit is filled completely with liquid helium and tests are conducted as the liquid helium evaporates. Because of this time limiting factor, it would be beneficial if the data acquisition took less time. LabVIEW is made by NI and does not have the latency that occurs in MATLAB when switching between channels.

This paper addresses using LabVIEW as a data acquisition tool to reduce the data acquisition cycle time while keeping the existing MATLAB program to compile data into usable results.

Transition to the West Pit

Newman laboratory has three testing pits: the east pit, center pit, and west pit. The center pit is the smallest of the three and holds a 17.5” cryogenic testing dewar. The west pit can accommodate a 22” dewar. Since both dewars are the same height, the 22” has a greater volume to be filled with liquid helium. Each test starts by filling the dewar with liquid helium and testing until the cavity is no longer covered. With the larger dewar it is possible to test for longer amounts of time.

With the center pit test insert, the T-Map boards have to be turned into place. This puts undesirable stress on the resistors and boards due to space restrictions. Additionally, the cables have to be wrapped in plastic, adding stress to the cables. The added space in the west pit would eliminate the need to rotate the boards into place while the resistors are touching the cavity. There would also be room for an all-metal valve to be added to the insert. The all-metal valve is an important addition to the insert because it allows the cavity to be assembled in the clean room without being attached to the entire test insert. This provides for a cleaner and quicker transfer between different cavities to be tested.

The center pit insert will be modified to go into the west pit with new vacuum tubes and an upgraded viking horn setup. This paper details these designs.

METHODS

LabVIEW for Data Acquisition

A data acquisition program was written using LabVIEW in order to better interface with the NI hardware. Running the LabVIEW program prompts the user to select between scanning all the channels and scanning only the channels that have resistors wired

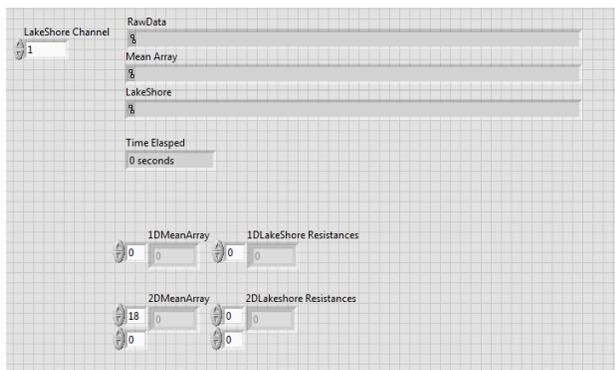


Figure 2: LabVIEW Program Front Panel

according to the layout file. The program takes 1000 readings on one channel, averages those samples and one reading from the LakeShore simultaneously. It does this for all 768 channels. It then saves the raw voltages listed by channel, the averages in a 24 by 32 array, and the LakeShore readings to separate files and displays that file location. The program front panel also displays the time it took to complete the data acquisition (see figure 2).

Testing Insert for West Pit

The new viking horn set-up will have two 90 degree elbows on the non-pumping side, and an all-metal valve with a 90 degree elbow on the vacuum pumping side (see figure 3). The vacuum tubes were designed so that there would be 0.5” of clearance on all sides between the test insert and the dewar. Additionally the vacuum tubes were designed to provide as much space as possible for the T-Map boards.

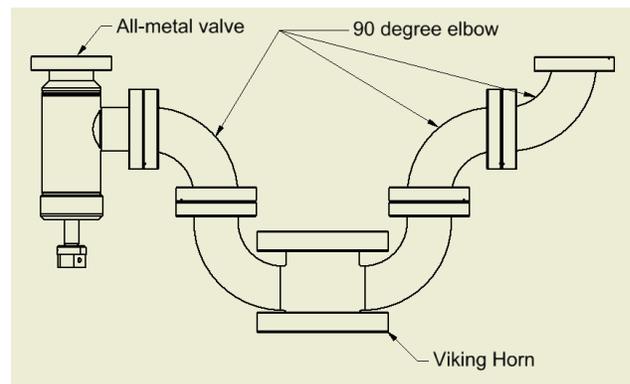


Figure 3: Lower Insert Assembly

RESULTS

LabVIEW Program

The LabVIEW program was able to complete data acquisition in 46 seconds which is a significant improvement over the MATLAB program. At the present, the LabVIEW program can't be called by the MATLAB program, nor can the LabVIEW program send the data directly into MATLAB rather it exports it as a text file.

Due to the complications connecting LabVIEW to MATLAB, an alternative time reduction method was

implemented using the current MATLAB program. During data collection, graphing the temperature was reduced from all 768 temperatures that are recorded to only graphing 76 of the temperatures. This speeds up the process by 52 seconds allowing more data to be collected.

Additional time reduction may be accomplished by reducing the number of data points collected for each resistor. However, further data analysis would need to be done to assess if the number of data points can be reduced without being detrimental to the signal-to-noise ratio of the system.

Vacuum Tubes for West Pit

The vacuum tubes are designed and in the drawing stage with two alternate designs (see figure 4). One that has flattened pipes on the long vertical pipes, and the other that uses a regular unflattened pipe. The advantages to the unflattened pipe design is there is less stress on the pipe and takes less time to manufacture; but the flattened pipe provides more room for T-Map assembly. Next step will be to have the vacuum tubes manufactured in house and to purchase an all-metal valve and 90 degree elbows. Once produced, the tubes can be implemented into the testing configuration.

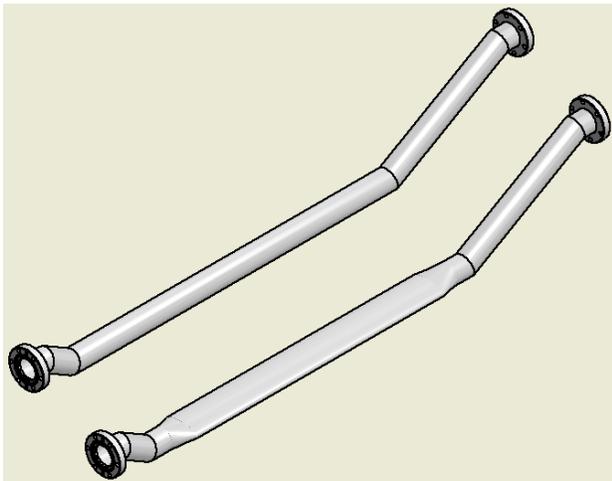


Figure 4: Final Vacuum Pipe Designs

CONCLUSION

Several approaches have been made to increase the efficiency of the T-Map system for single-cell SRF cavities. It is important to be able to collect as much

data as possible during one fill of liquid helium. Although at the current time the LabVIEW program doesn't interface with the MATLAB T-Map software, when fully implemented it will save significant time during the testing process. The west pit has a larger capacity for holding liquid helium, and therefore, can allow a longer testing session. The re-design of the vacuum pipe setup to fit in the west pit will facilitate testing capabilities in the west pit.

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- [1] H. Padamsee, J. Knobloch, and T. Hays, RF Superconductivity for Accelerators, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, (2008).