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Design of a Temperature Mapping System for Superconducting RF Cavities

Introduction

The purpose of the project was to design a temperature mapping system for superconducting RF cavities. The system was to have the ability to take input from over 646 sensors that would be distributed over the surface of a cavity. As each board would have a maximum of 32 channels, 21 boards would ultimately be needed. The purpose of designing a new revision was to increase the sensitivity of the data acquisition system, reduce noise, and to significantly improve the data rate it can handle.

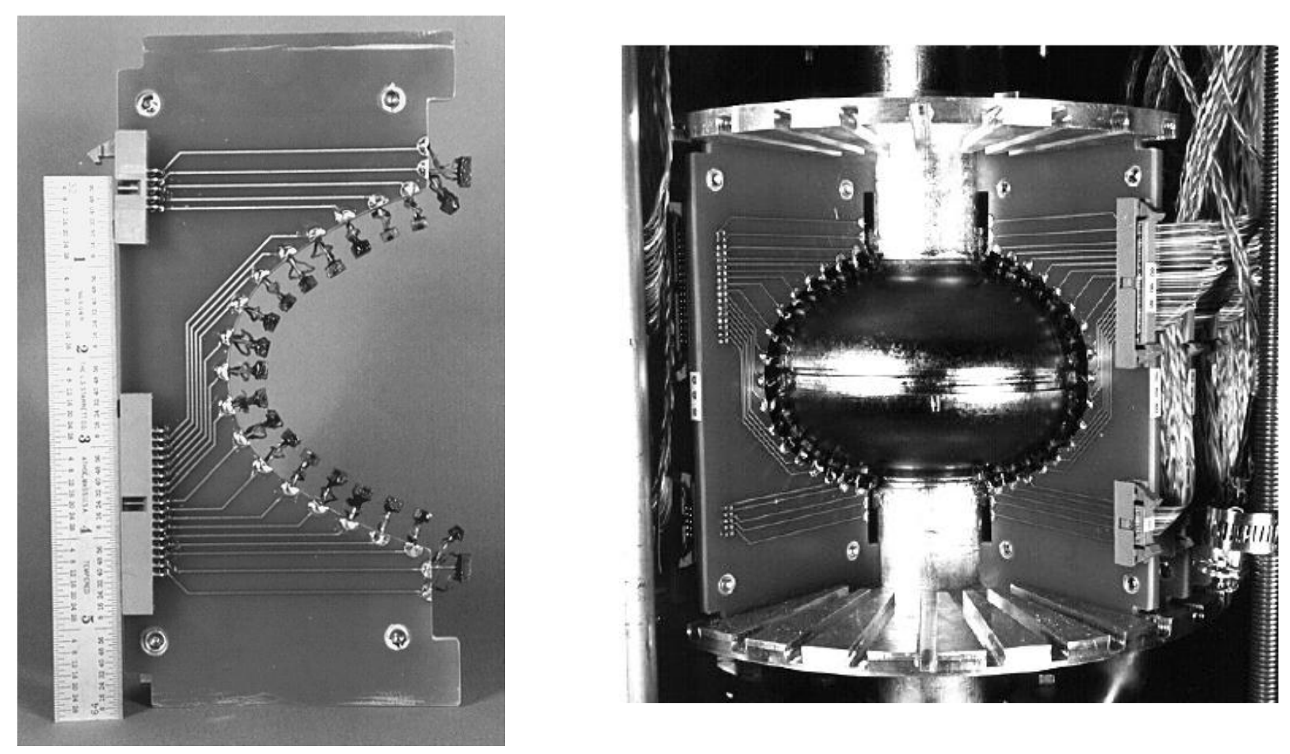
Background Information

The sensors used to measure the surface temperature of the superconducting RF cavities exploit the semiconductor properties of carbon-based resistors. In particular, their resistance increases exponentially with decreasing temperature. By taking advantage of this property, extremely small temperature changes, in the mK range, can be detected.

As these sensor signals are extremely small, they must be amplified through the use of instrumentation amplifiers, which are highly accurate devices that are very useful in keeping signal noise to a minimum. From here, these amplified signals are fed into analog-to-digital converters, all running in tandem with respect to a single clock, where they are digitized and can then be operated on in a computer environment.

Figure 1: The Physical System

The actual physical system utilizes modified 100 Ohm Allen-Bradley carbon-composition resistors. G-10 board is then machined to match the contour of a superconducting RF cavity. These boards are then distributed around a cavity, which allows a temperature map to be obtained.



Acknowledgements

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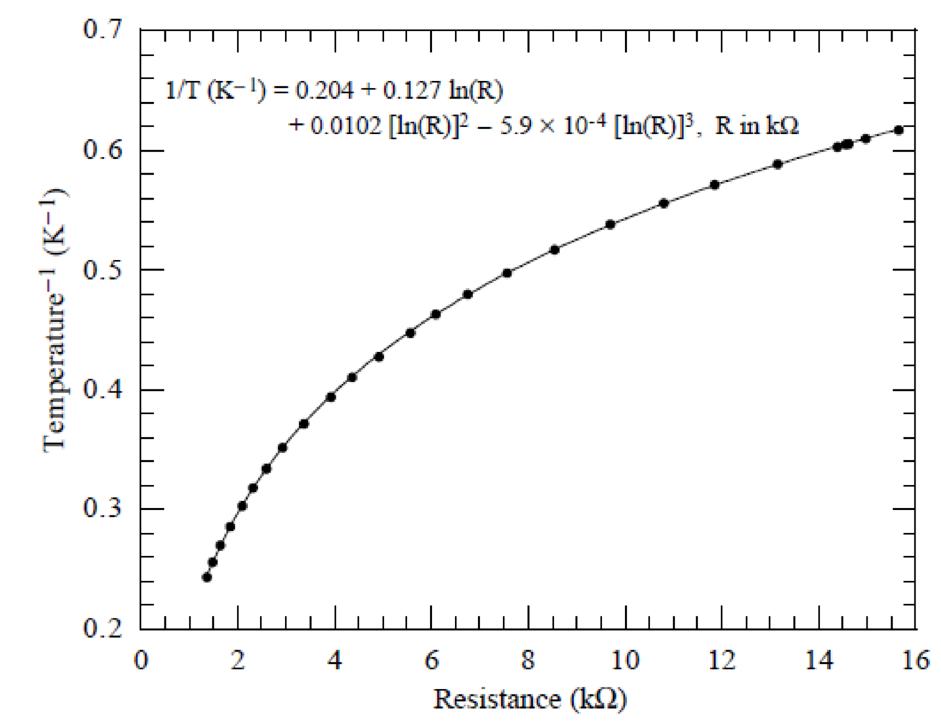
Figure 2: The Relationship Between Temperature and Resistance

As can be seen in the following graph, the resistance of a carbon-composition resistor increases exponentially with decreasing temperature. This is the characteristic that ultimately allows the temperature measurements to be made.



Results

Though there is still plenty of work to be done, some critical decisions were ultimately made. In particular, either the MAX11040K or MAX11060 digital-to-analog converters can be used, allowing either 24-bit or 16-bit systems to be built without difficulty. In addition, the AD8421 was chosen as the instrumentation amplifier, which gives high precision with minimal noise. The power rails required to run these devices utilize TPS7A30 and TPS799 linear regulars. Finally, the system clock signal is distributed by using a CDCLVC1108 fan-out clock buffer.