RF Test Station Data Acquisition System Upgrade

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Fermilab has numerous RF power devices and amplifiers that are used to accelerate particles in its accelerator complex. It is essential that the RF power amplifiers be highly reliable since a failure necessitates a shutdown of the accelerators for repair in the tunnels. To ensure reliability after repairs, each amplifier is tested on an automated test station prior to being placed back into service. The existing test station data acquisition was originally built more than 10 years ago on a PC platform using LabVIEW 6.1 and various A/D and D/A cards along with GPIB control of some hardware component. This project aims to update the entire acquisition system to modern hardware using the most recent version of LabVIEW. Additional control and I/O components will also be added to take advantage of the newer, more robust RF-related components.

I. INTRODUCTION

This paper describes the ongoing update of the data acquisition system for the RF test station. The specific RF devices used in accelerators will be described in section II. The description of the test station will be discussed in section III, and the upgrade of the test station will be described in section IV followed by a conclusion, acknowledgements, and references.

II. RF DEVICES

In the Main Ring and Booster accelerators, a 100–125 kW RF amplifier gives the RF power for an accelerator station. This RF power amplifier provides energy to the cavity structure, which accelerates the proton beam. The power tetrode tube within the RF power amplifier contains four elements that combine the high-voltage direct current from the modulator with the RF drive from the driver rack to produce RF power as high as 125 kW. The driver rack provides 4 kW of RF power to the cathode of the power tube which amplifies it to the high power level. The frequency of this device sweeps from 37 MHz to 53 MHz depending on the requirements of the experiment. The modulator provides direct current from 0 to 23 kV with current up to 20 A. To support this power structure, there are a few other

hardware requirements to keep the RF amplifiers, tubes, and modulators running optimally. These requirements include a filament supply of 15 V at 200 A, a screen grid power supply of 1 kV, and a water supply for anode cooling of 20 gallons per minute. There is also a control grid power supply of variable basis from -400 V to 0 V. Without this, the tube would be unable to effectively conduct and amplify the RF power. The distributed input level stays the same despite possible variations in the power output. The Booster accelerator operates between 30–53 MHz. The Main Ring operates between 52.8–53.1 MHz. The cavities are tuned to operate within these frequencies.

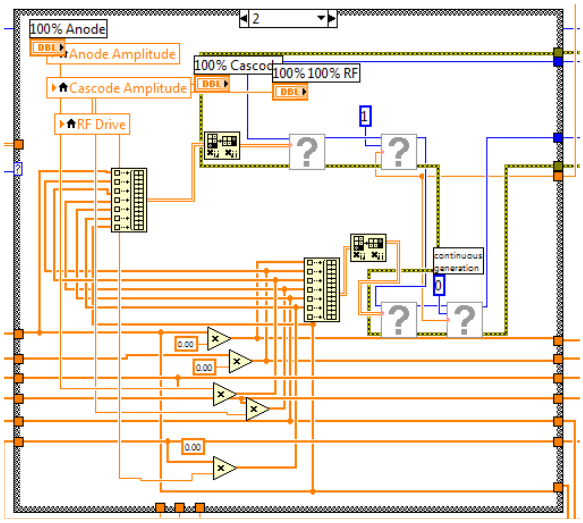
III. TEST STATION DESCRIPTION

The RF test station is a system containing multiple parts. It includes the analog-to-digital converters (A/Ds) used to measure various incoming signals, several digital-to-analog convertors (D/As); the desktop computer running LabVIEW 13.0 for data processing and control; the RF driver rack, which provides RF power to the cathode of the power tube; the modulator, which provides a high-voltage direct current; the RF power amplifier, which contains the tetrode tube that produces 125 kW of RF power; and the 100 kW water-cooled RF load. The existing RF test station in place includes an HP desktop computer. It runs on the Windows 2000 operating system.

IV. TEST STATION UPGRADE

The existing RF test station in place includes a desktop computer. It runs on the Windows 2000 operating system. It uses computer boards PCI 6071E, PCI 6713, and PCI GPIB. The three previous computer boards will be replaced with these two boards: PCIe-6353 and PCIe-GPIB. The new boards have higher resolutions, more input and output channels, and higher bit counters. In addition, a Dell Precision T3600 will replace the old computer.

The initial program was written using LabVIEW 6.1 software. It uses traditional data acquisition (DAQ) acquired from National Instruments to analyze the signals from the test stand. The existing system is more than ten years old and it must be updated so new software and hardware can be used. The upgrade of the RF test station includes replacing the outdated hardware and updating the LabVIEW 6.1 program to LabVIEW 13.0. LabVIEW 13.0 uses different drivers called DAQmx. The new DAQmx drivers have different output levels than the old traditional DAQ drivers. Also, the DAQmx driver provides a wider range of output types to function properly. Hence, the program must be redesigned to fit the specific hardware requirements. This involved changing input types from cluster to arrays, creating varying inputs, and programming around subVIs among other things. This is an example of the program prior to updates:



The three previous computer boards will be replaced with these two boards: PCIe-6353 and PCIe-GPIB. This is a comparison of an old board to a new board being installed:

PCI 6017E (Old)	PCIE 6353 (New)
1.25 MS/s	1.25 MS/s
12-bit resolution	16-bit resolution
2 AO	4 AO
8 DIO	48 DIO
2 24-bit counters	2 32-bit counters
Up to 64 analog inputs	Up to 80 analog inputs
12-bit AI resolution	16-bit AI resolution

The new boards have higher resolutions, more input and output channels, and higher bit counters. This allows more data to be acquired at faster rates.

In addition, a Dell Precision T3600 will replace the old computer. The overall upgrade will allow for higher processing power, more sample inputs and outputs, and a higher sample rate; it will be able to test some of the newer developed RF cavities.

V. Conclusion

An update of the data acquisition program for the RF test station was necessary to allow for further upgrades and increased reliability in measurement and data analysis. This is being achieved through hardware and software upgrades. Once the system is fully operational and in place, the RF test amplifiers and modulators will be tested using this station to determine whether they can be used in the Booster or Main Ring.

VI. Acknowledgements

The entire Accelerator Division was extremely helpful and supportive throughout this process. I would especially like to thank my mentor, Arden Warner, for being very kind, understanding, and informative during my ten weeks at Fermilab. I would also like to thank Mitch Adamus and David Slimmer. They were always willing to spend time troubleshooting and answering any questions I had.

VI. References

[1] Mark S. Champion, “A New Data Acquisition and Control System for the Power Amplifier Test Station,” Fermilab, May 1991.

[2] Wells, Travis, “LabVIEW for Everyone,” 1997.

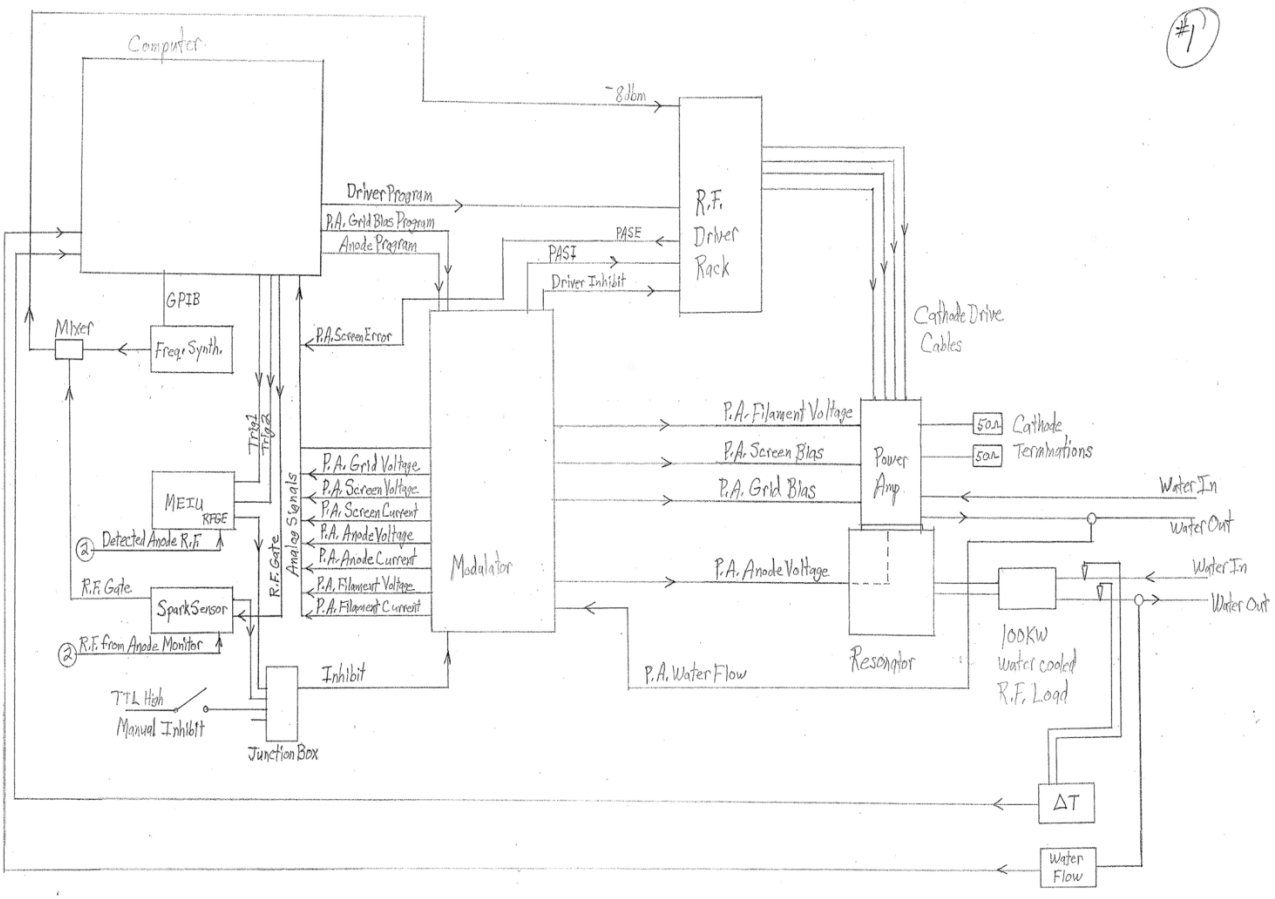


Figure 1: Block diagram of RF test station.