RF Test Station Data Acquisition Upgrade

Arindam Mukherjee
Mentor: Arden Warner
Fermilab, Batavia, IL

Abstract

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.

RF Test Station Description

The RF test station is a system containing multiple parts. The data acquisition part includes the analog-to-digital converters (A/Ds) used to measure various incoming signals, several digital-to-analog converters (D/As), the desktop computer running LabVIEW 13.0 for data processing and control. The drive system includes 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. There are a few other connecting parts shown in the block diagram that contribute to the structure of the RF test station. They are the filament supply of 15 V at 200 A; a screen grid power supply of 1 kV; a control grid power supply of variable bias from -400 V to 0 V; and a water supply for anode cooling of 20 gallons per minute.

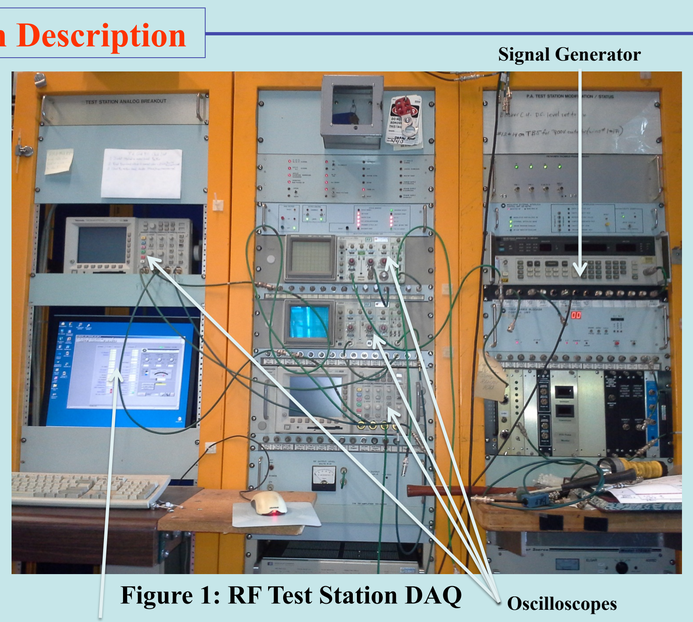


Figure 1: RF Test Station DAQ

Example RF Test Station Data

To the right is an example of what would appear on an oscilloscope of the RF test station. These lines represent outputs from the modulator and devices inside the modulator. The pink signal represents the P.A. anode voltage. The dark blue line represents the P.A. grid voltage. The teal color represents the P.A. anode current.

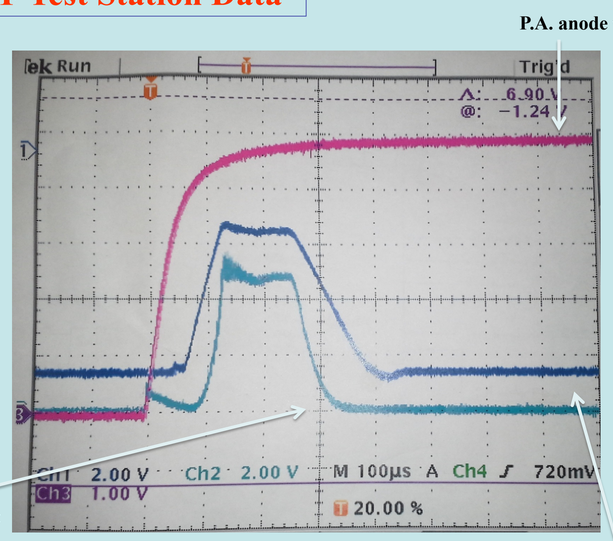
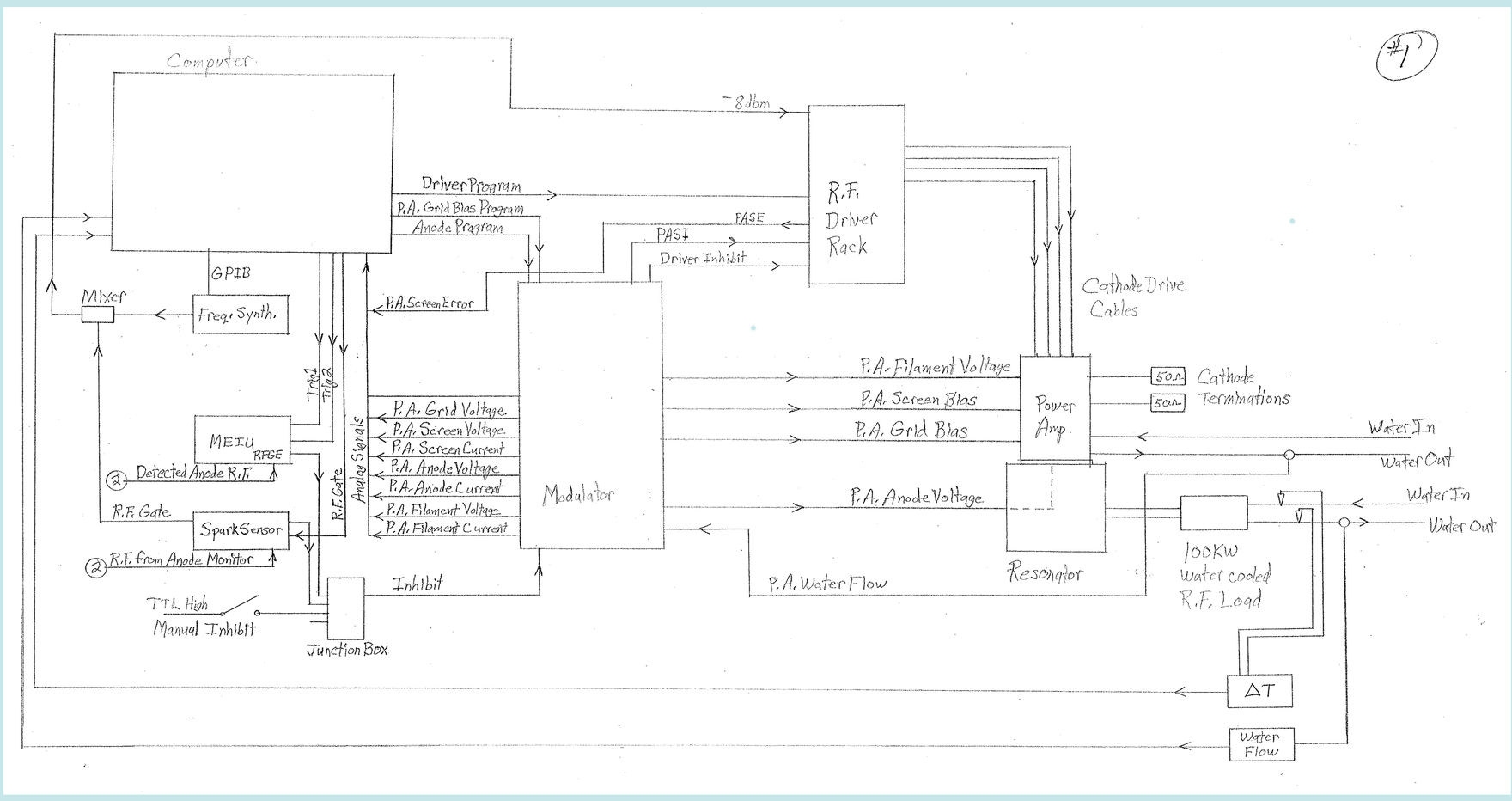


Figure 2: Modulator Output Signals

Block Diagram



RF Power Amplifier

Figure 3: RF Power Amplifier

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.

Figure 4: Modulator

Hardware

The existing RF test station in place includes an HP desktop computer. It runs on the Windows 2000 operating system. It uses computer boards PCI 6071E, PCI 6713, and PCI GPIB. The three previous computers 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.

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

Software

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 almost fifteen 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. LabVIEW 13 uses different drivers called DAQmx. The new DAQmx drivers deliver slightly different outputs 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 slightly redesigned to fit the specific hardware requirements.

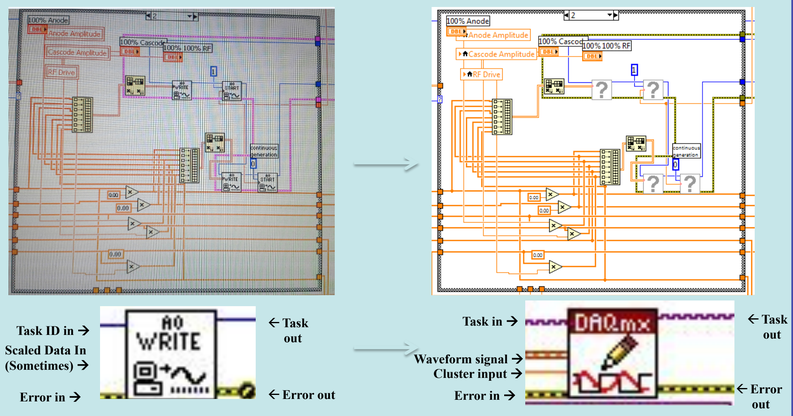


Figure 5: Traditional DAQ to DAQmx

My Contribution

Due to the update of the software from LabVIEW 6.1 to LabVIEW 13, there were many broken wires and compile errors in the program. It was my responsibility to debug and compile the program. I also installed and tested the new computer boards into the Dell Precision T3600. After successful installation, I tested the PCIe board using an analog input box and a 9 V battery as the voltage input. I also tested the GPIB board using an HP signal generator as the input. A signal was received and the computer was able to turn the pulse from the generator on and off.

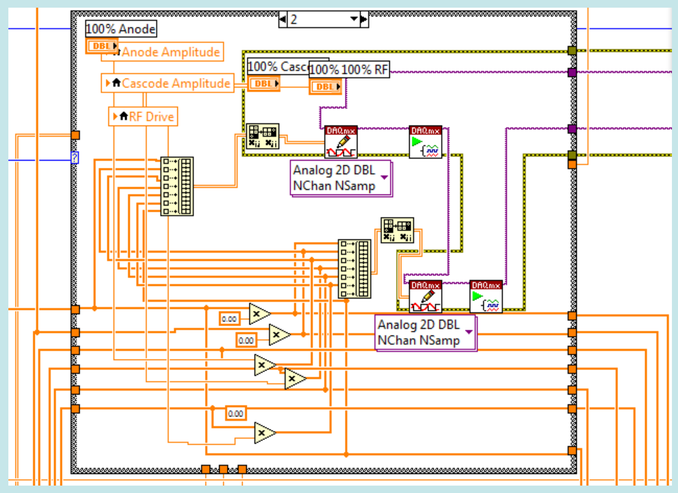


Figure 6: Debugged and Compiled LabVIEW Program

Summary

The RF test station data acquisition upgrade allowed an update of the system. Once the system is fully operational and in place, the RF power amplifiers and modulators will be tested to determine their reliability.

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.