Warm Front End Upgrade for the PIP-II Linac

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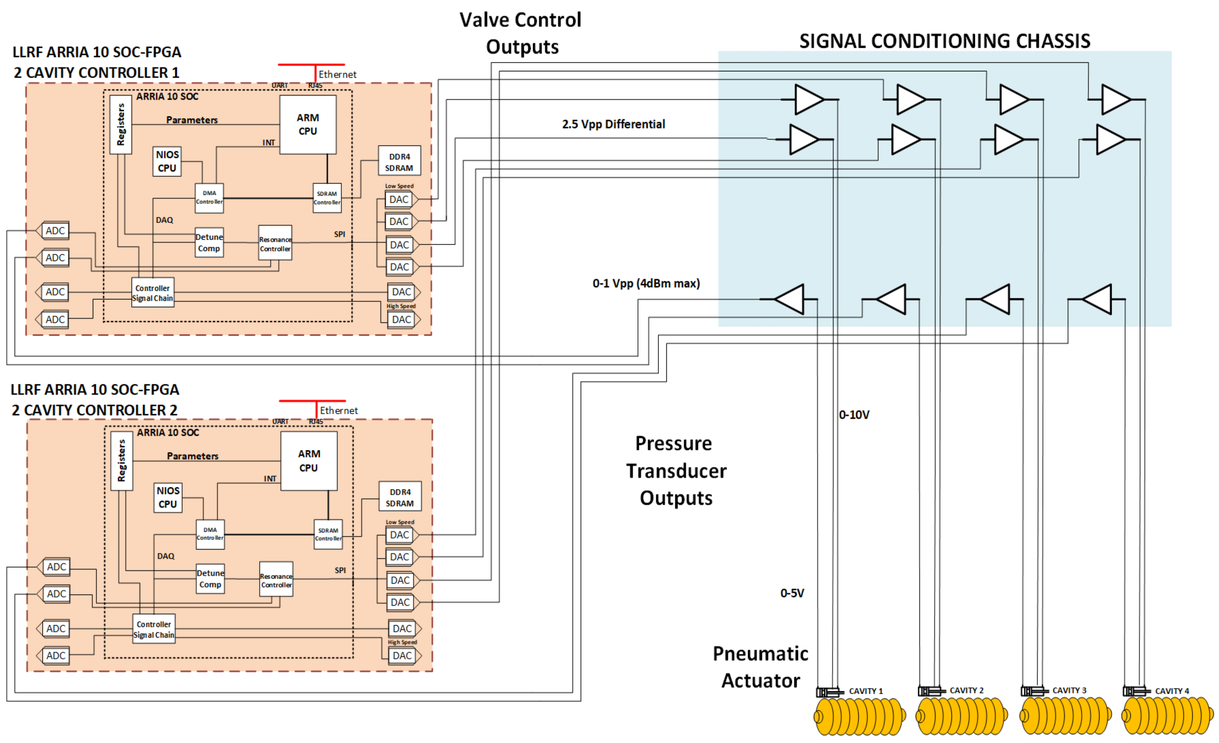
Introduction

The LLRF systems for the PIP-II Linac's Warm Front End, which includes an Ion-source, a RFQ, and four buncher cavities are being upgraded. Developed over a decade ago, the original LLRF systems were based on VXI crates and early FPGAs with limited resources.

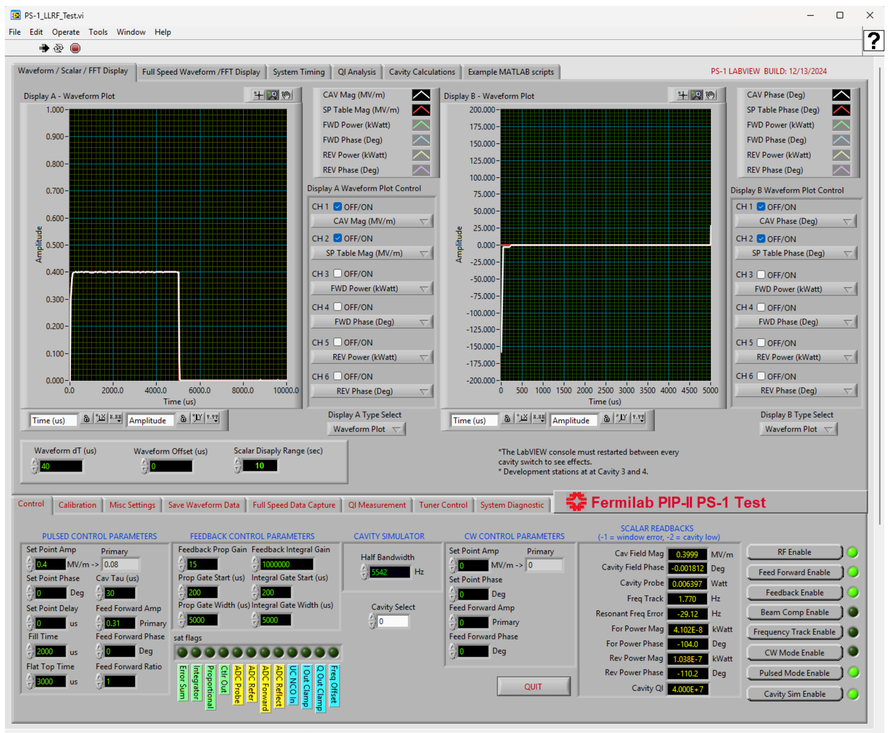
These systems, as well as the one for the first superconducting cryomodule, the HWR, will be upgraded with the ARRIA 10 SoC-FPGA chassis with EPICS interfaces. Aligning with the rest of the PIP-II Linac. The RFQ and the HWR have unique resonance control systems integrated into the LLRF controller hardware.

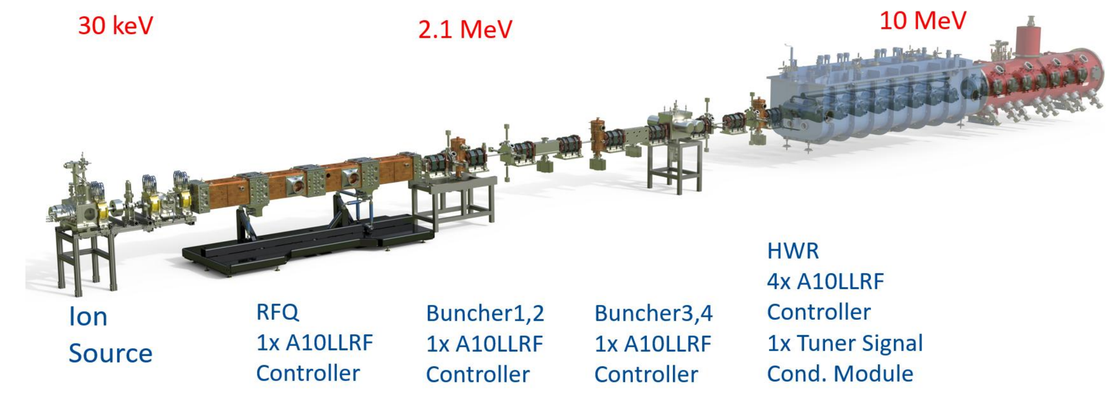
HWR Resonance Control System

Resonance control is achieved by using a pneumatically operated slow tuner that compresses the cavity at the beam ports. Helium gas is controlled by solenoid valves on both the pressure and vacuum sides. A pressure transducer provides feedback for monitoring and control.



RFQ in Pulse Mode Operation



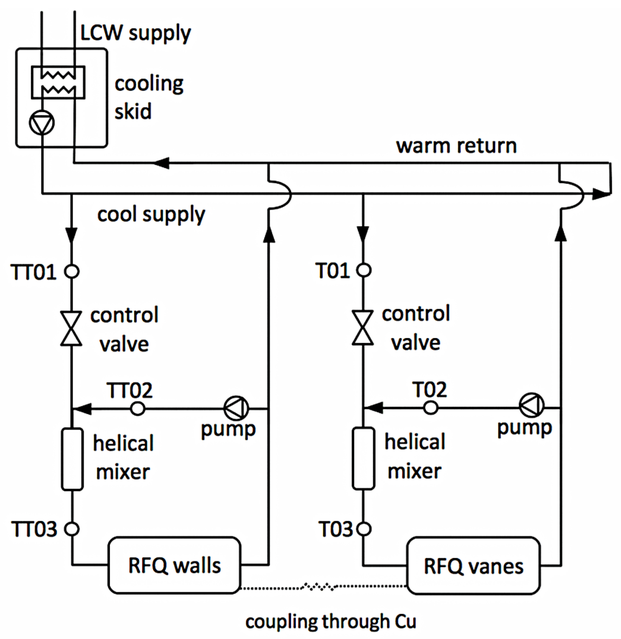


ARRIA 10 SoC-FPGA Chassis

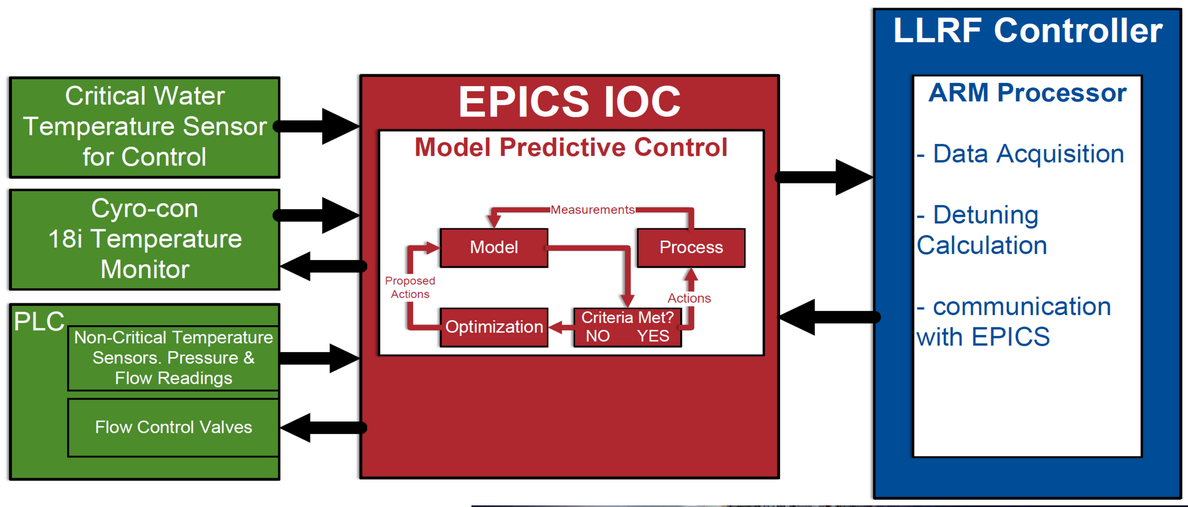
RFQ Resonance Control

Resonance control is achieved by regulating the temperature of the RFQ. A neural network models the RFQ's frequency response to variations in both the water cooling and RF system. This model is embedded within a model predictive control (MPC) framework to allow dynamic frequency tuning.

Water Cooling System Diagram



RFQ Resonance Control Block Diagram



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