Resonance Control System for the Fermilab PIP-II IT HWR Cryomodule
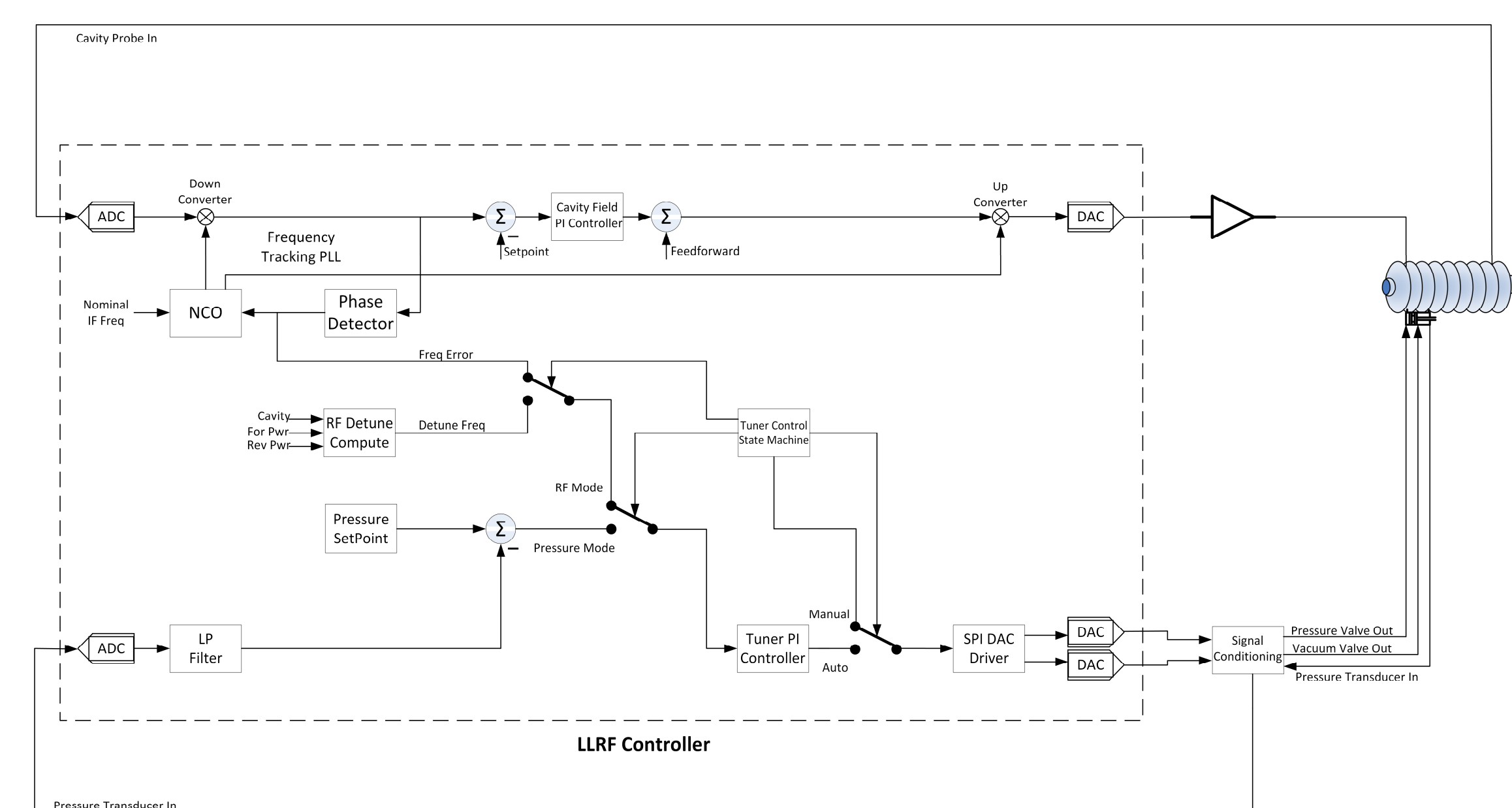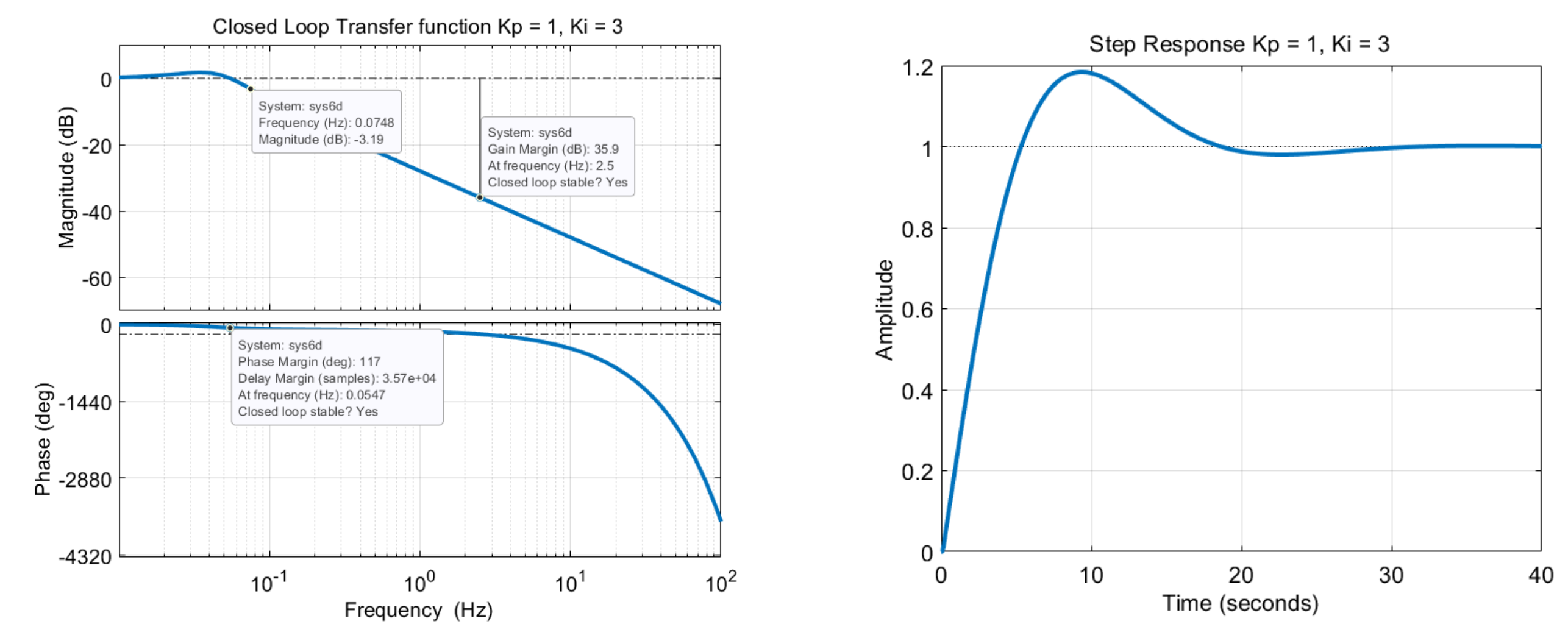
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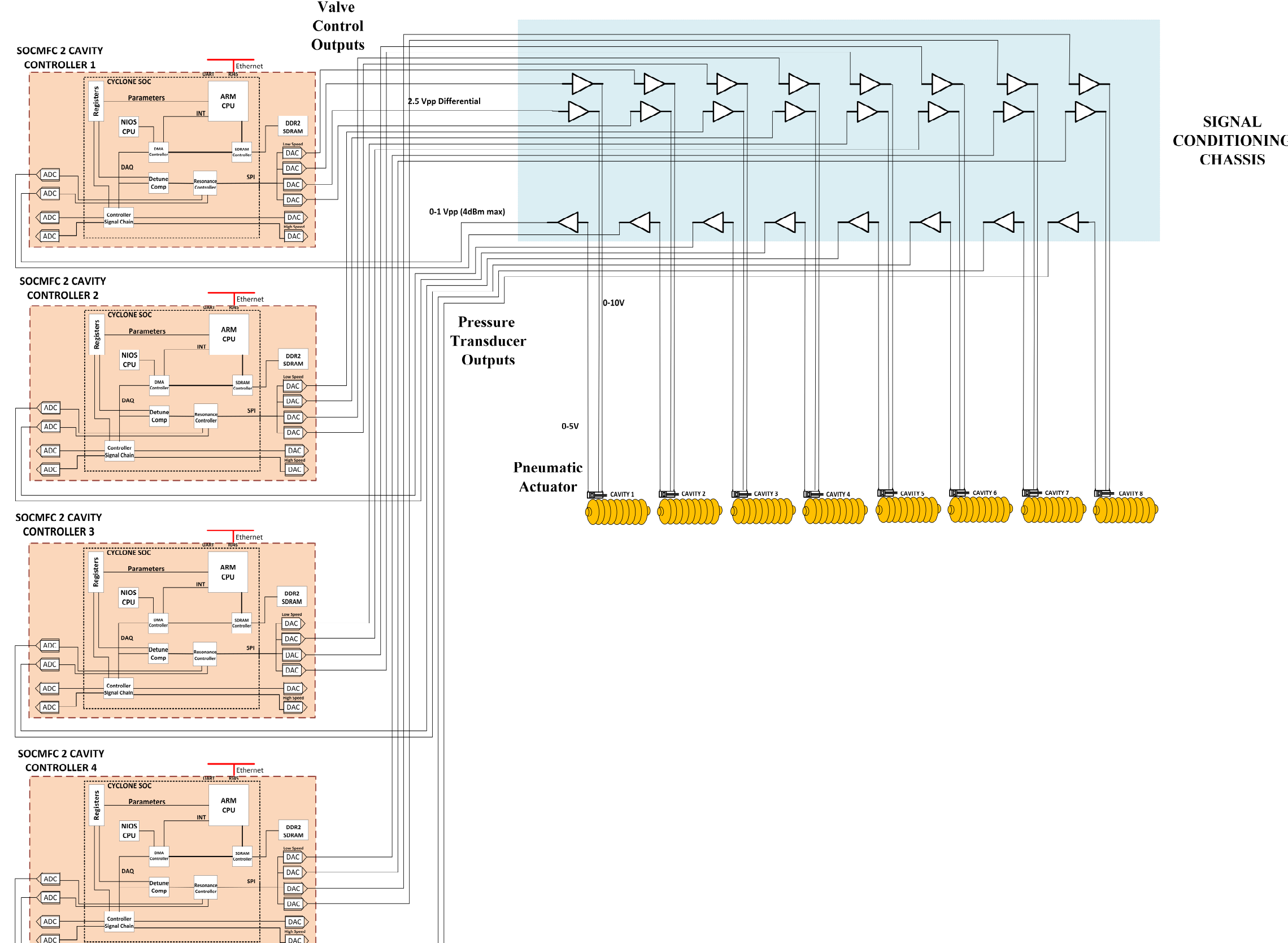
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Introduction

- The HWR (half-wave-resonator) cryomodule is the first one in the superconducting section of the PIP-II LINAC project at Fermilab.
- The HWR cryomodule comprises of 8 cavities operating at a frequency of 162.5 MHz and accelerating beam upto 10 MeV.
- Resonance control of the cavities is performed with a pneumatically operated slow tuner which compresses the cavity at the beam ports.
- Helium gas pressure in a bellows mounted to an end wall of the cavity is controlled by two solenoid valves, one on the pressure side and one on the vacuum side.
- A pressure feedback control loop can hold the cavity tuner pressure at a fixed value for the desired resonant frequency. Alternately, the feedback loop can regulate the cavity tuner pressure to bring the RF detuning error to zero.
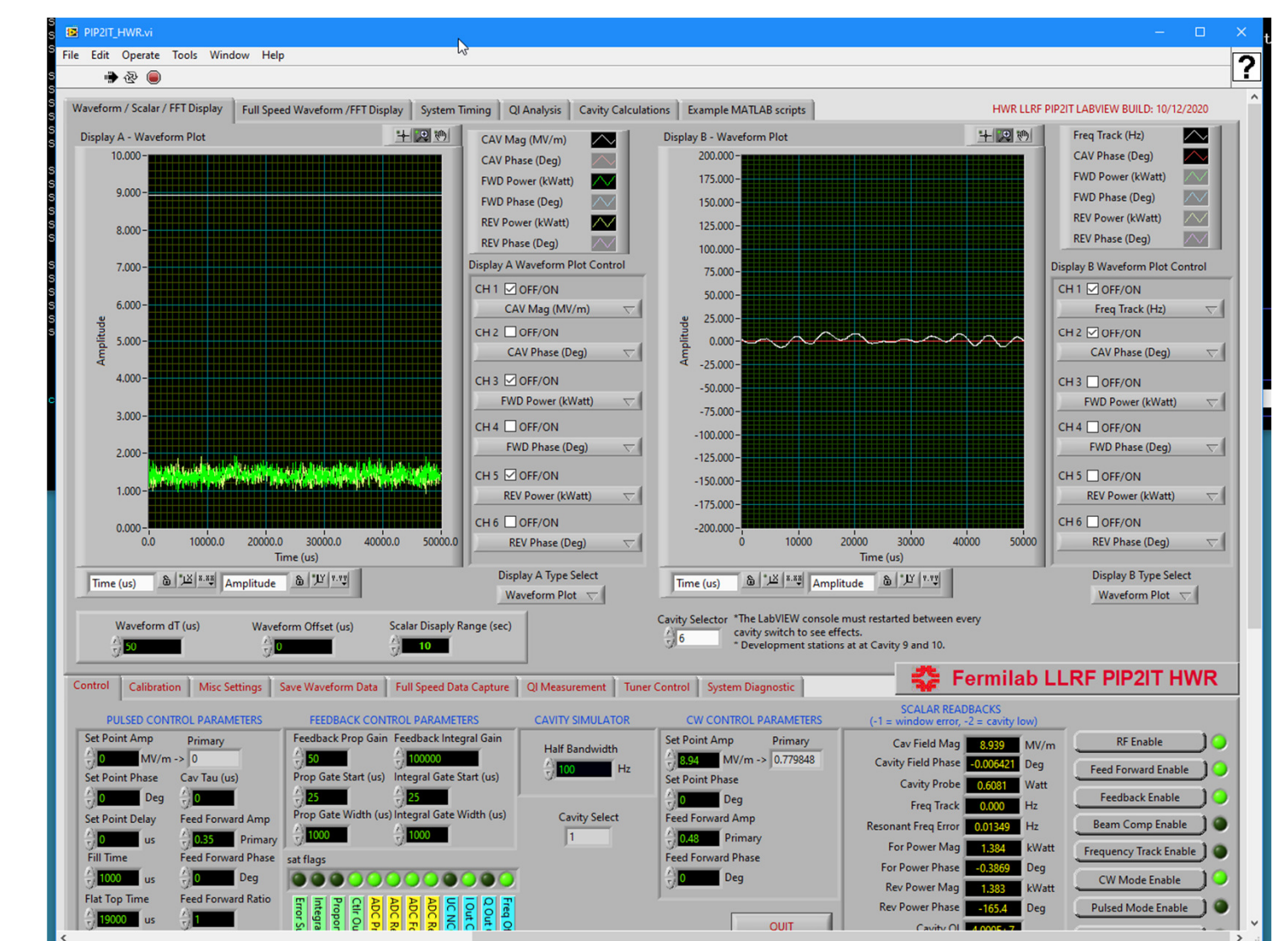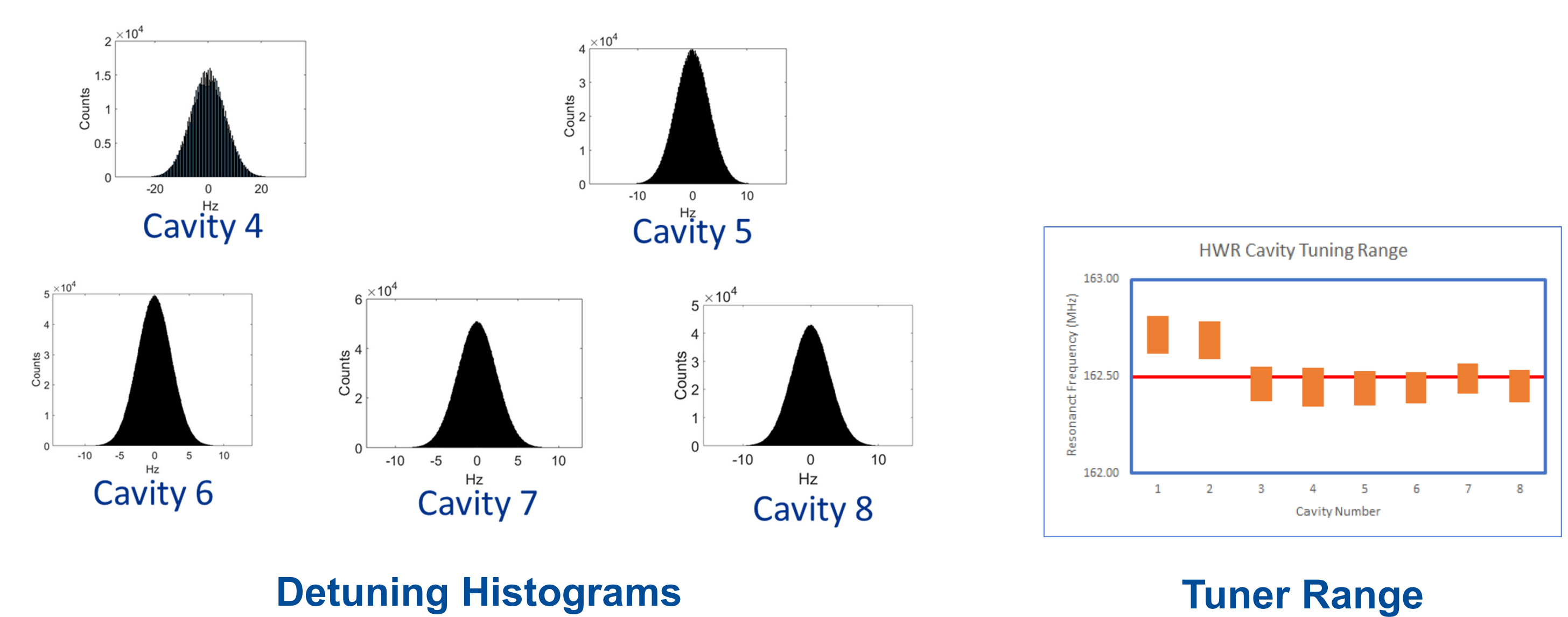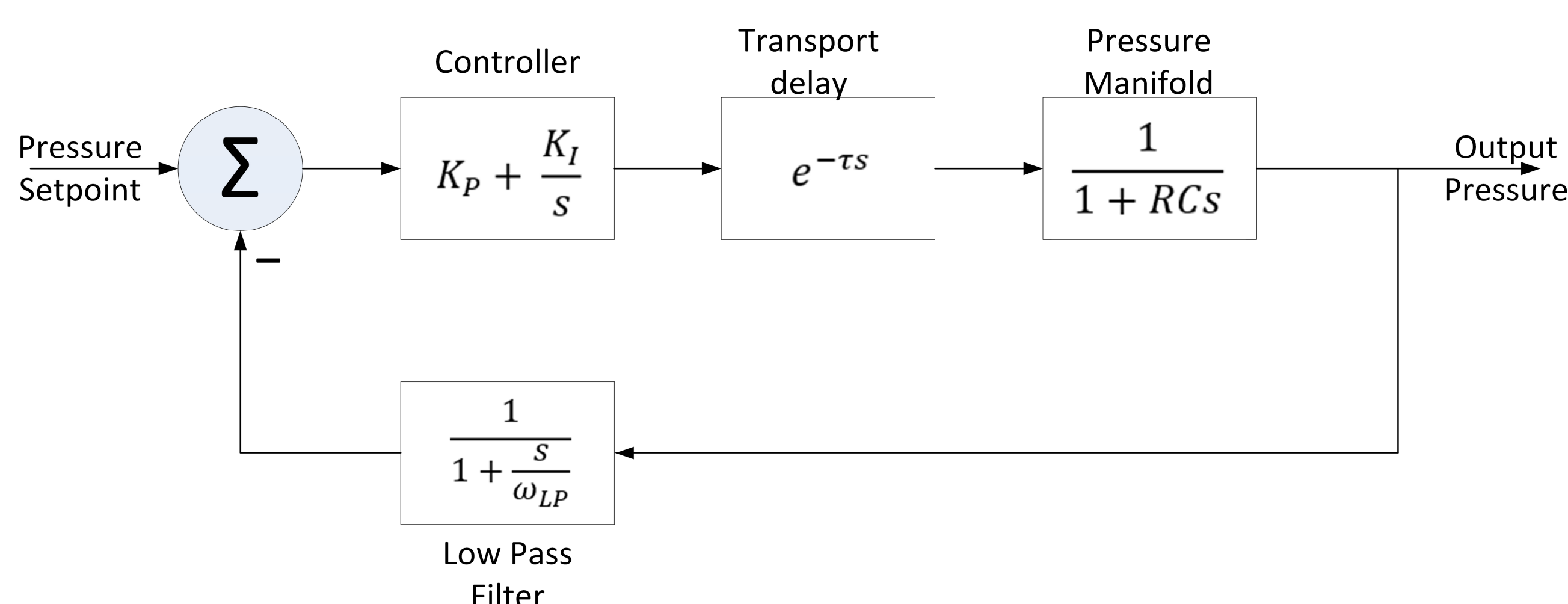
HWR Resonance Control System

Pneumatic Tuner Control System Model

Tuner Control Design

Tuner Performance

Pressure Loop Step Response

Cavity Detuning

Cavity 4

Cavity 5

Cavity 6

Cavity 7

Cavity 8

Detuning Histograms

Tuner Range

Summary

- A tuner control system for the pneumatic tuner was integrated into the LLRF controller which is implemented with an SOCFPGA.
- The cavity detuning computation in GDR mode is obtained from the cavity probe and forward power inputs.
- Cavity detuning was held to the <20 Hz max excursions specified by the PIP-II requirements

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