SRF 2021

28 June 2021 – 02 July 2021

THPTEV002

Enhanced Pneumatic Tuner Control for FRIB Half-Wave Resonators

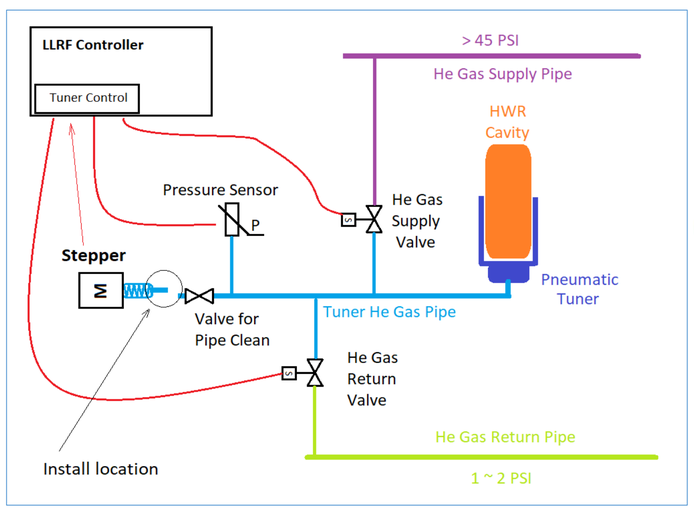
Wei Chang, Shen Zhao, Ting Xu, John Thomas Popielarski, Sang-Hoon Kim, Walter Hartung and Cong Zhang

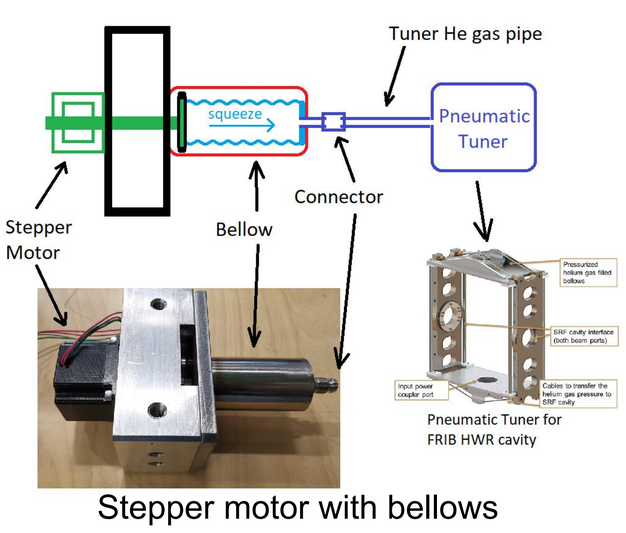
Facility for Rare Isotope Beams, Michigan State University, East Lansing, MI 48824, USA

Abstract

The superconducting driver linac for the Facility for Rare Isotope Beams (FRIB) includes a total of 46 cryomodules; 31 cryomodules contain half-wave resonators (HWRs) with pneumatic tuners. Pneumatic tuner control is via solenoid valves connecting the tuner to a helium gas supply manifold and a gas return line. For precise compensation of cavity detuning over a small range, the control voltage for the solenoid valves must be calibrated. Some valves have hysteresis in the gas flow rate as a function of control voltage, such that their response may be nonlinear and not repeatable—this makes the control algorithm challenging. To improve the system performance, a new pneumatic tuner control system was developed which regulates the position of one stepper motor instead of the two solenoid valves.

Pneumatic Tuner Control Using a Stepper Motor and Bellows





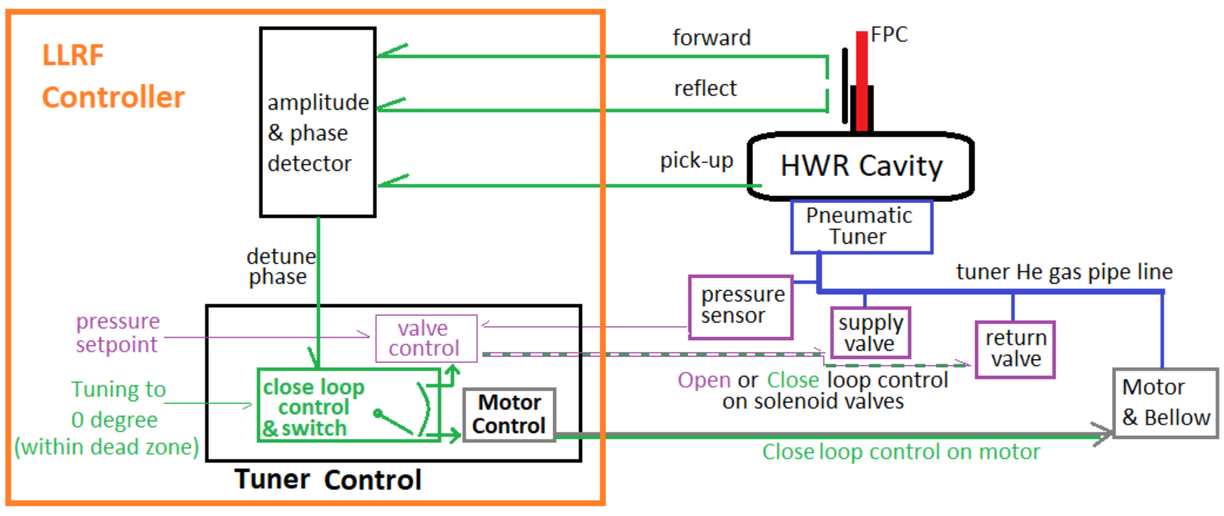
Stepper motor with bellows

Existing System

The pneumatic tuner is connected to a helium gas space. There are two solenoid valves, one connected to the gas supply pipe, the other connected to the gas return. The LLRF system controls these valves by roughly setting the voltage or precisely controlling them with feedback from the cavity frequency detune.

New System

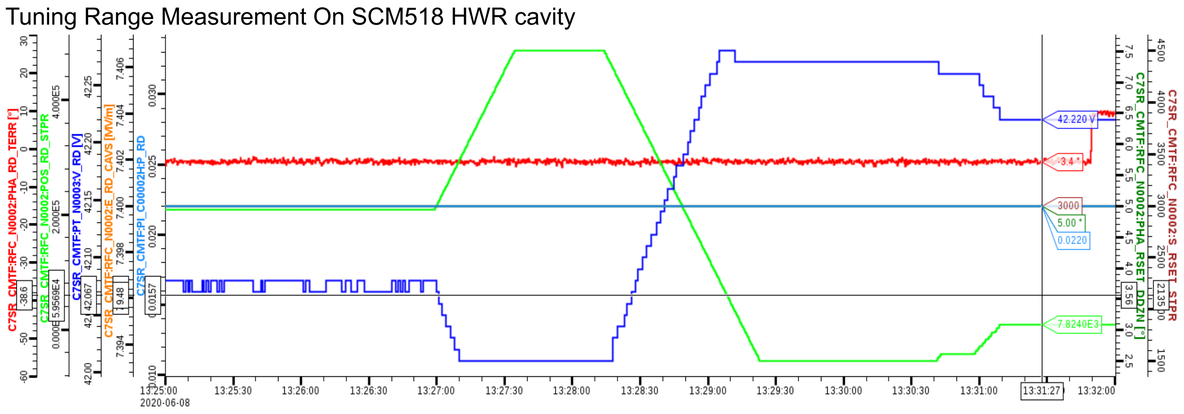
The solenoid valves remain closed and the volume of the helium gas space is adjusted to control the tuner pressure precisely. To implement this, a stepper motor with a bellows is installed on a spare valve (used for cleaning the system). The tuner is controlled via the stepper motor.



Pneumatic tuner control

Testing

Tuning Range Measurement On SCM518 HWR cavity

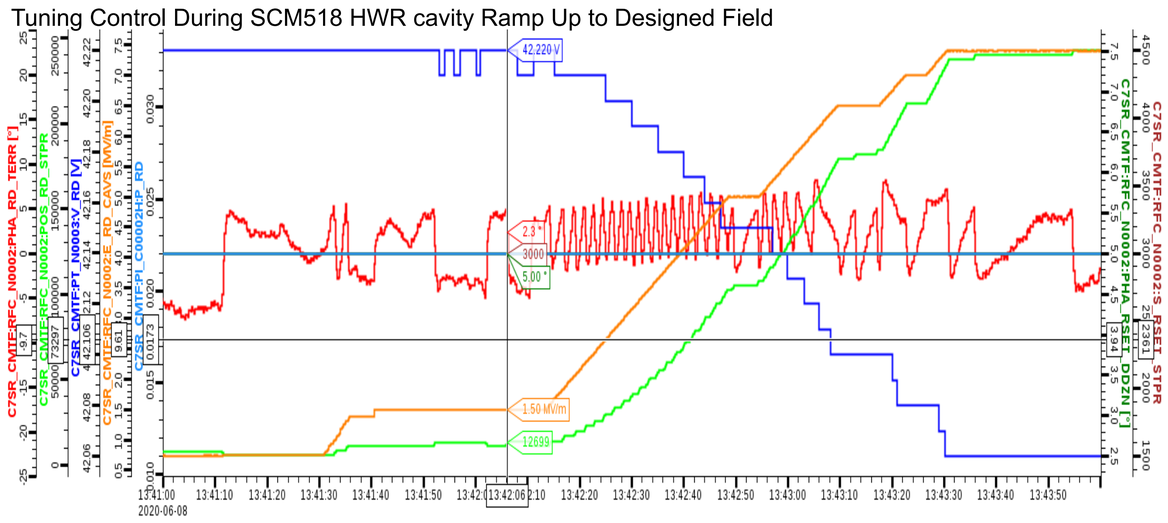


The stepper motor and bellows were installed on an HWR tuner in the cryomodule test bunker for testing (during SCM518 certification test). The new method can obtain 0.2 PSI tuning range (blue curve reading unit “V” is actually “PSIa”, green curve is stepper position)

Tuning Range	Pressure (psi)	Stepper Position (counts)
High Limit	42.27	0.85E+5
Low Limit	42.01	4.86E+5

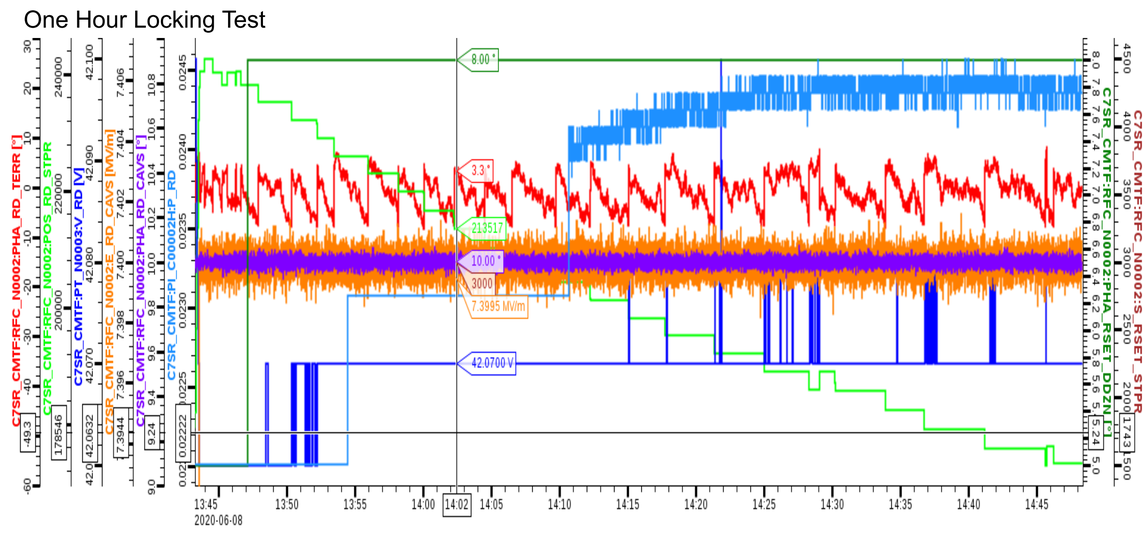
df/*dP* ~1 kHz/psi
Tuning range ~260 Hz
New system: *df* ~6.5e-4 Hz/step (1.5e+6 steps/psi)
The enhanced method can easily achieve 0.1 Hz tuning resolution, which is almost impossible with the existing system.

Tuning Control During SCM518 HWR cavity Ramp Up to Designed Field



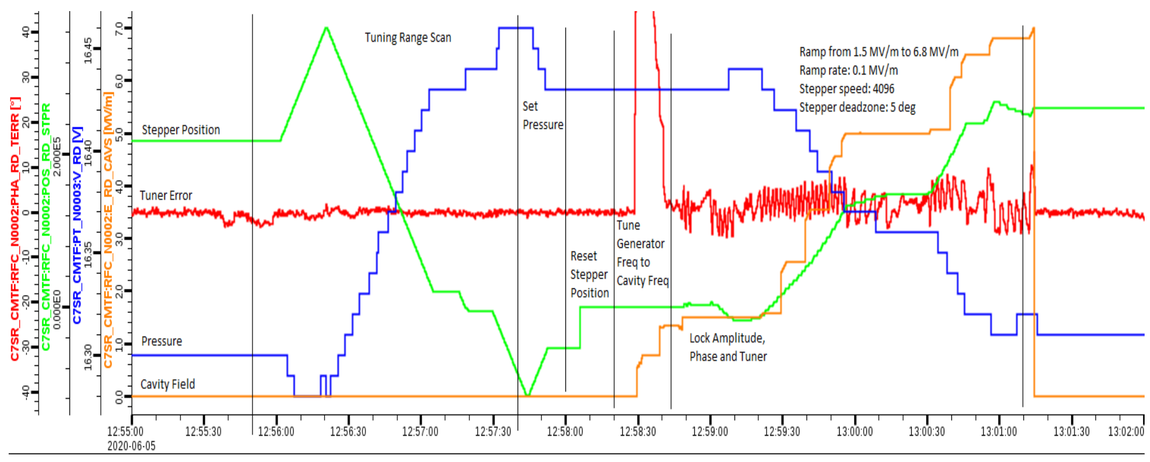
New tuner control method applied during ramp-up to 7.4 MV/m (operating gradient): red = cavity detuning in degrees. Detuning is within ±5° with the new method.

One Hour Locking Test



Stability test with the new method: locked amplitude and phase for one hour. Cavity detuning (red) is within ±5° ; amplitude and phase stability are the same as before.

Procedure



Procedure for testing control with new method

1) Adjust solenoid valves to roughly set the tuner pressure
2) Run stepper motor to measure tuning range
3) Cavity RF on and tuner control on; ramp up to operating gradient
4) Lock amplitude and phase for stability test

Facility for Rare Isotope Beams
at Michigan State University

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661. Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.