MICROPHONICS COMPENSATION FOR A 325 MHZ SPOKE CAVITY AT FERMILAB

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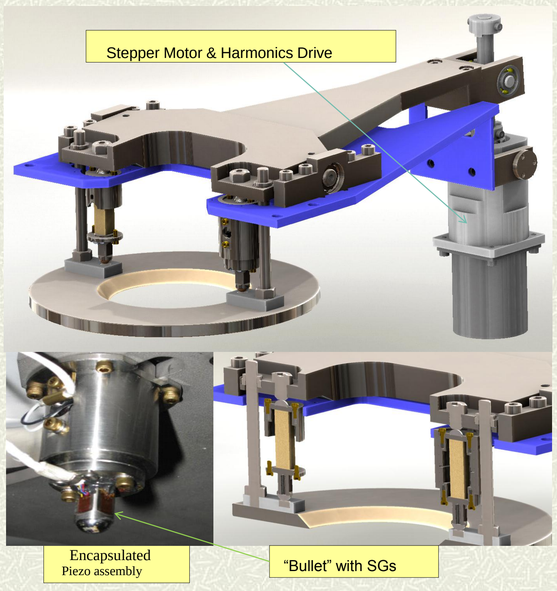
Abstract

Fermilab is developing 325MHz CW narrow-bandwidth spoke cavities for the proposed Project X. The first results of active microphonics compensation for these cavities are presented.

325MHz Single Spoke SRF Resonator

SSR1 –originally designed for HINS.
RF- pulsed operation at 4.5K.

Slow/Fast tuner requirements:
Compact size (in-beam-line axis);
250kHz slow tuning range
Fast tuner: 4 piezo to compensate LFD & dF/dP =140kHz/torr



SOURCE OF DETUNIN

Cavity detuning can be driven by a variety of sources including:

- Pressure variations of the helium bath;
- Vibrations from external equipment such as pumps;
- Geophysical noise; and
- the Lorentz force;

dF/dP compensation SSR1 with Narrow Bandwidth Coupler

Initial cold tests of SSR1 using CW provided an opportunity to gain experience with a very narrow bandwidth cavity

Test Conditions

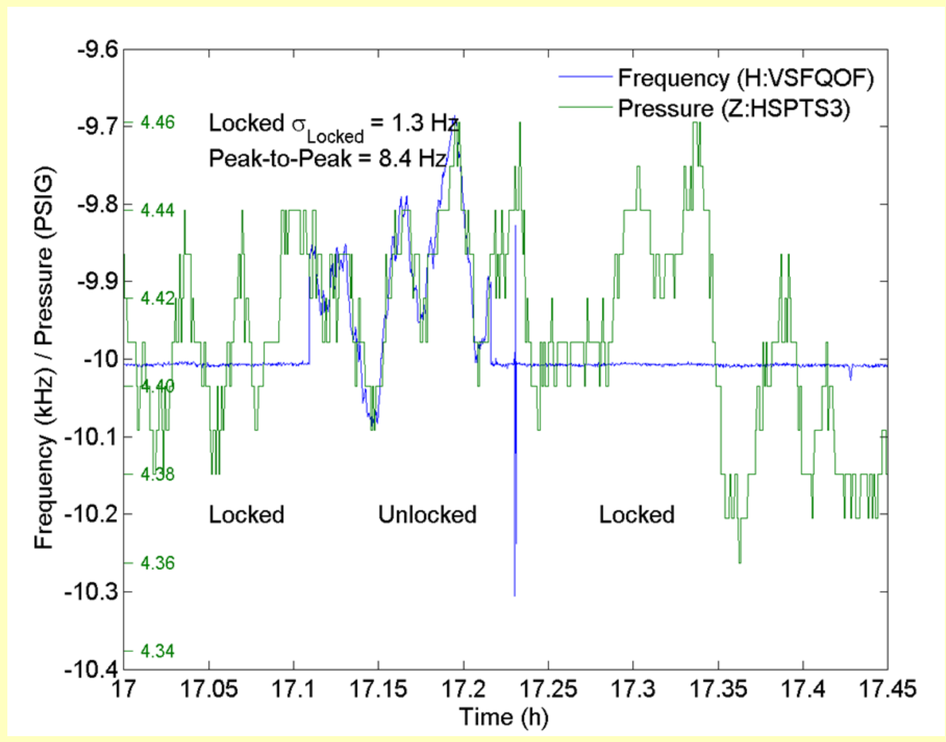
- 4.5K
- Cavity bandwidth of about 1.5 Hz
- df/dP ~= 140 Hz/torr
- dPp-to-p~=5 torr
- LLRF tracking resonant frequency of cavity

Detuning control system

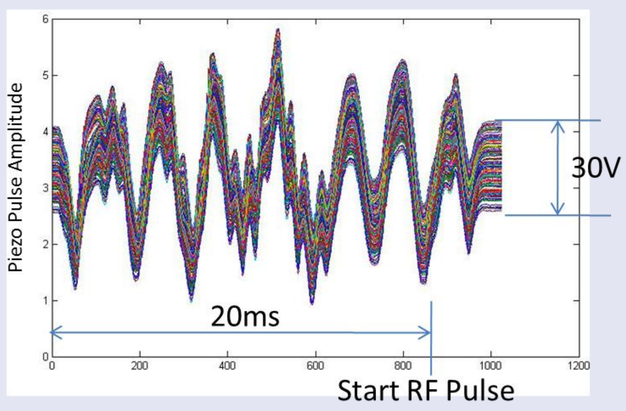
- 100 kHz digitizer measured RF frequency offset from an arbitrary set point
- FPGA fed Δf back to fast tuner

Reduced pressure related variations in cavity frequency from several hundreds Hz to

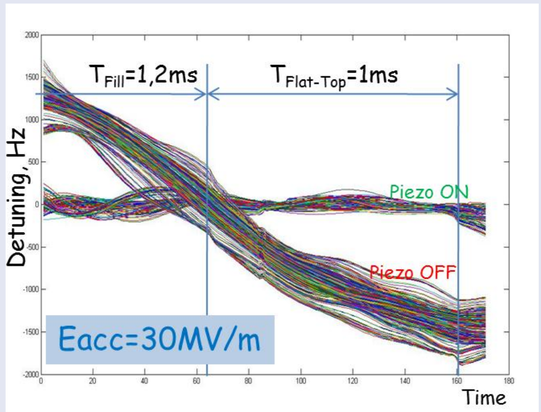
Δf <= 1.3 Hz RMS



RF pulse mode of operation LFD & 4K fluctuation compensation



Piezo Drive Stimulus Pulse
4K LiqHe pressure compensation
E_{acc}=30MV/m
during 180sec operation
Bias changed on 30V
(dV=30V → dF=600Hz)



Second round of CW tests provided an opportunity to gain experience with a wider bandwidth cavity and fixed RF drive frequency

Test Conditions

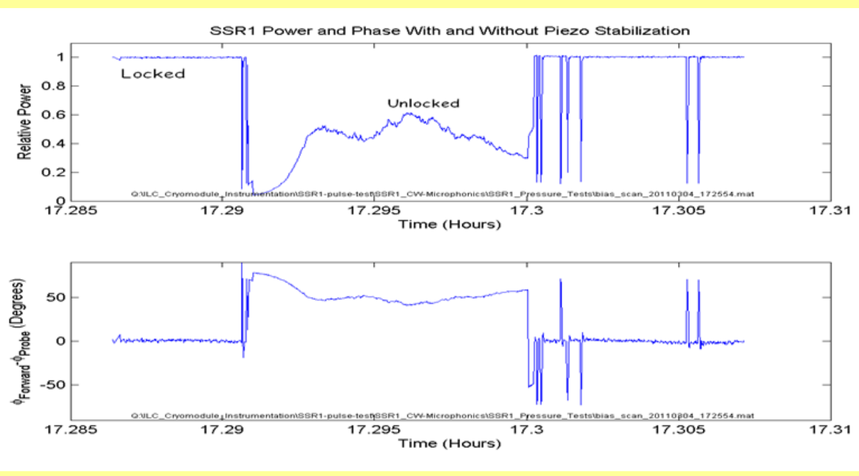
- 4.5K
- Cavity bandwidth ~100 Hz
- RF drive frequency fixed ~325 MHz

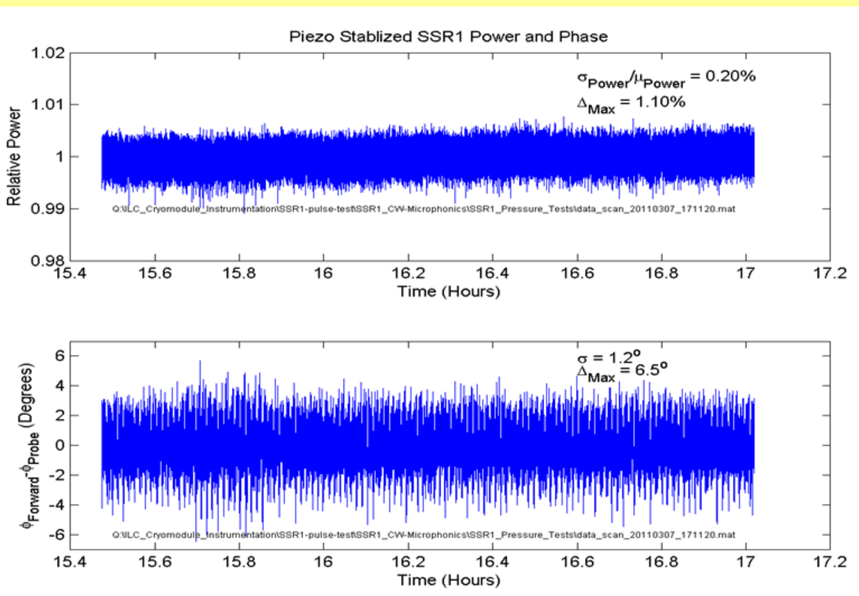
Detuning control system

-104 MHz digitizer measured RF phase difference between forward and probe signals
- CPU fed $\Delta\phi$ back to fast tuner

Able to limit pressure related variations

Gradient <= 0.2% RMS
Phase <= 1.2° RMS





CONCLUSION

Possible to stabilize cavity resonant frequency to several Hz or better even at 4.5K using relatively simple closed loop

Substantial performance improvements may be possible using a more sophisticated controller

Plan to use SSR1 to gain experience and more fully understand factors that limit active control