SIMULATED LORENTZ FORCE DETUNING COMPENSATION WITH A DOUBLE LEVER TUNER ON A DREASSED ILC/1.3 GHz CAVITY AT ROOM TEMPERATURE

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Introduction

- Pulsed SRF linacs with high accelerating gradients experience large frequency shifts caused by Lorentz force detuning (LFD)
- A piezoelectric actuator with a resonance control algorithm can maintain the cavity frequency at the nominal level thus reducing the RF power.
- This study uses a double lever tuner (LCLS-II type) with a piezoelectric actuator for compensation and another piezoelectric actuator to simulate the effects of the Lorentz force pulse, see Fig. 1
- A double lever tuner has an advantage by increasing the stiffness of the cavity-tuner system thus reducing the effects of LFD. The tests are conducted at room temperature and with a dressed 1.3 GHz 9-cell cavity

Experimental Setup

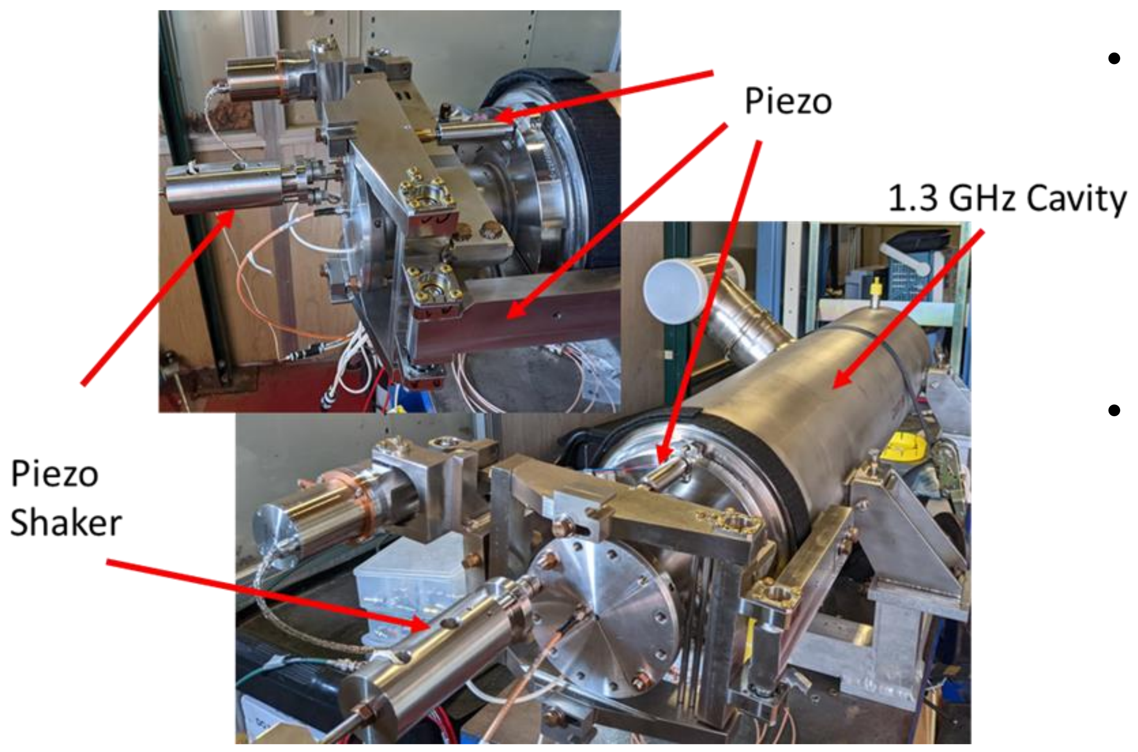

Figure 1: Setup of LFD simulation with 1.3 GHz cavity. Two piezo capsules are used for resonance control and a piezo (denoted as shaker) is used to simulate the LFD.

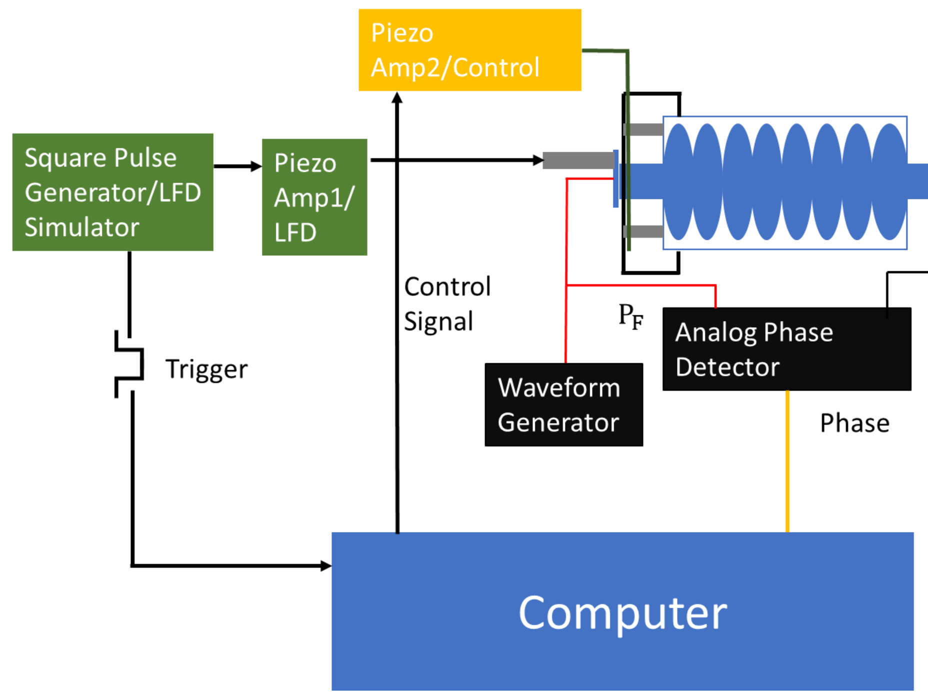

Figure 2: Schematic of signals used to measure the cavity frequency and for resonance control. A square wave pulse generator was used to simulate the LFD pulse and to trigger the control.

- A schematic of the hardware and signal topology the cavity frequency and for resonance control is shown in Fig. 2.
- An RF analog signal generator is used to produce the input signal to excite the cavity in the π mode which occurs at 1298.838 MHz at room temperature.
- The forward power coupled through a directional coupler is fed to input A of the AD8032 Analog Phase Detector (APD) .
- The transmitted power of the cavity is sent to input B of APD.
- The output signal of the APD is proportional to the phase shift between forward and transmitted power
- The phase of the forward and transmitted power can then be related to the cavity detuning. This was digitized with NI-PXI-4472 14-bit ADC.

LFD Resonance Control

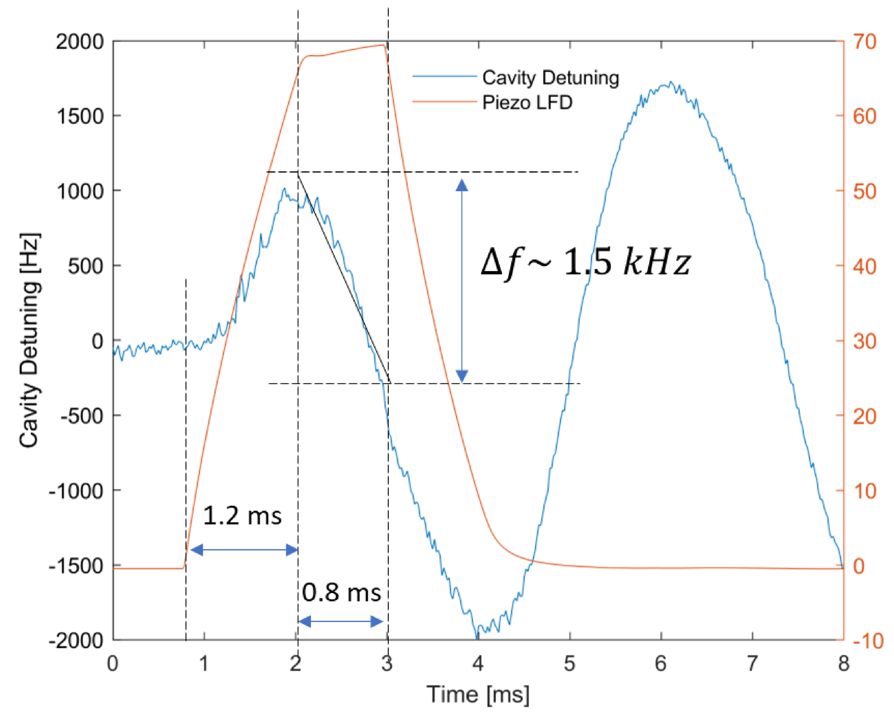

Figure 3: Simulated LFD pulse with a square wave pulse on the shaker piezo.

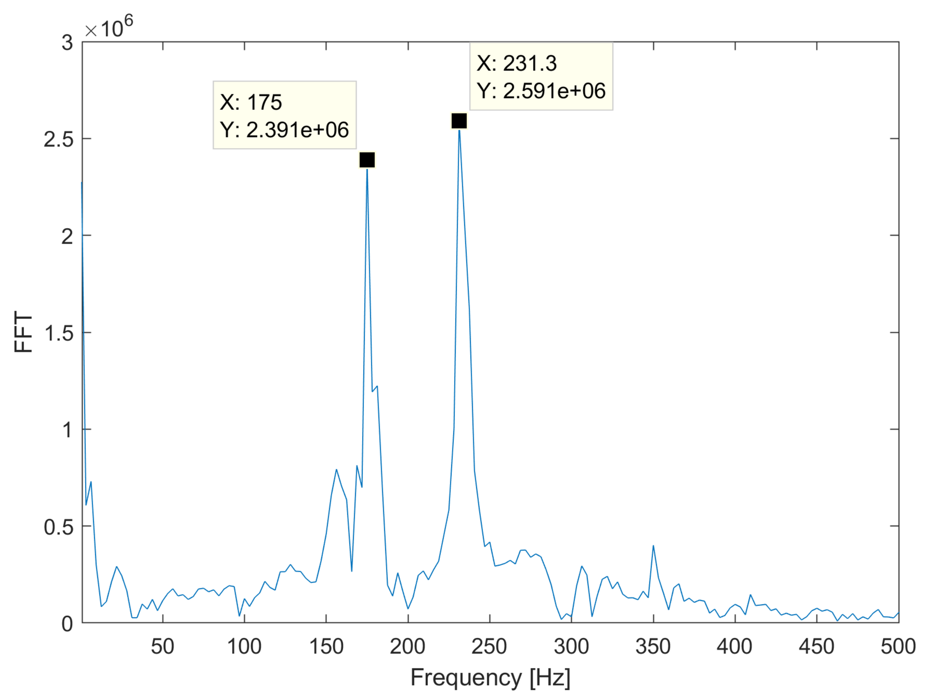

Figure 4: FFT of the cavity detuning from the simulated LFD pulse

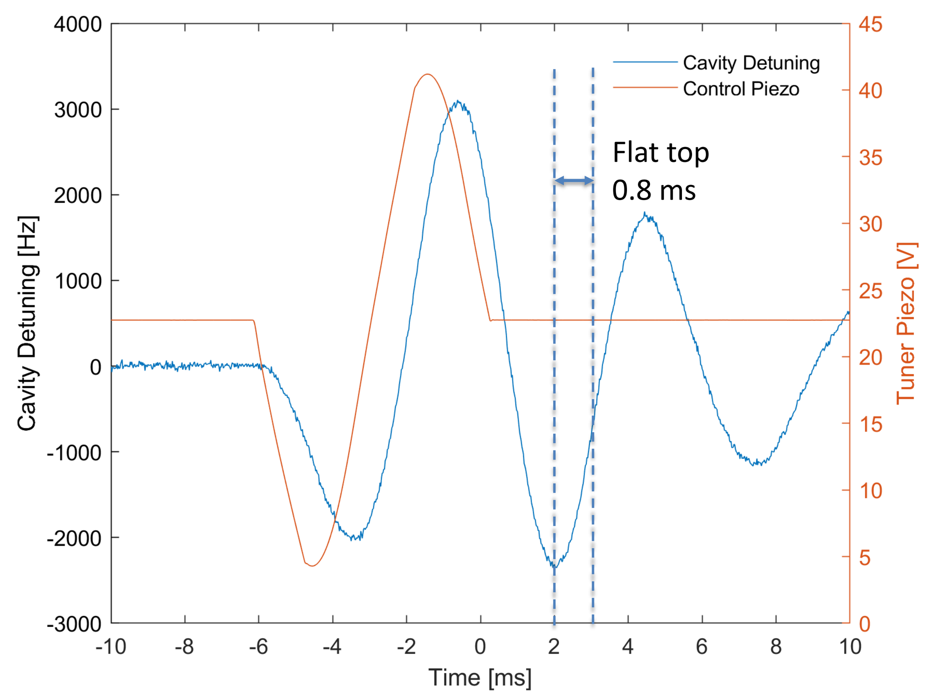

Figure 5: 160 Hz single cycle sine wave and the cavity detuning response.

- The simulated LFD pulse is done with a square wave pulse on the shaker piezo as shown in Fig. 3
- The voltage on the shaker piezo was ~ 70 V
- The rise time is 1.2 ms and the flat-top is 0.8 ms
- The LFD during the flat-top is ~1.5 kHz
- The goal of the LFD resonance control to decrease the detuning to 0 Hz
- This was done by using a sine wave with a frequency which will cause destructive interference with the LFD pulse
- Three parameters need to be optimized for the sine wave: the frequency, the amplitude, and the delay from the flat-top
- These three parameters were changed by brute force on LabVIEW
- The right frequency can found by taking the FFT of the step response from Fig. 3, the result is shown in Fig 4.
- The largest frequencies excited are 175 Hz and 231 Hz
- When both these frequencies were implemented the results were not good. The amplitude and delay were also changed
- A sine wave of 160 Hz resulted in a flat detuning line

Results

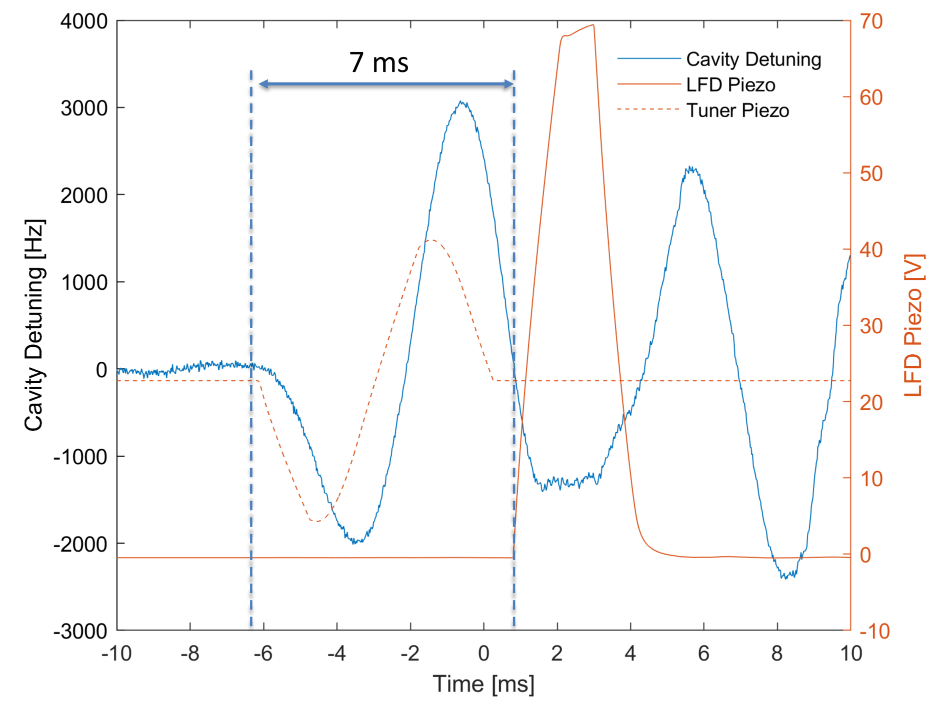

Figure 6: Control pulse which results in a flat cavity detuning. A sine wave of 160 Hz with a delay of 7 ms was used.

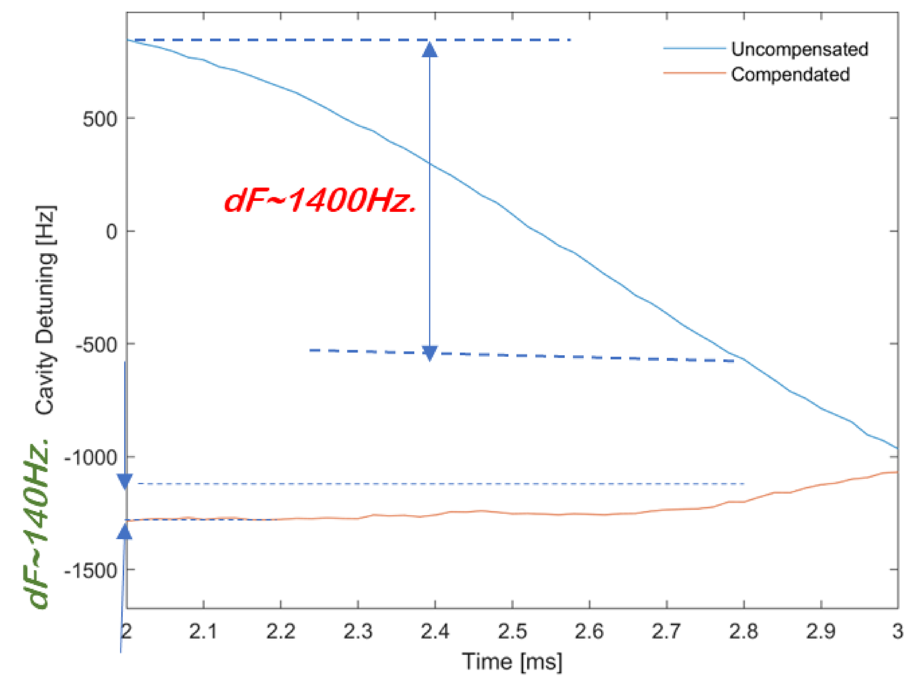

Figure 7: Comparison of cavity detuning with piezo control on and off. The results show that when the LFD pulse is compensated the cavity detuning is decreased by a factor of 10.

- The single cycle sine wave was delayed by 7 ms from the LFD pulse. This delay produced the best results.
- The optimal voltage for the control piezo was 35 V peak-to-peak.
- The detuning at the flat-top dropped from 1.4 kHz to 140 Hz. **The detuning was reduced by a factor of 10.**
- Note that the compensated detuning is not at 0 Hz detuning
- This was likely due to not optimizing the offset voltage of the piezo control
- In future iterations this will also need to be optimized.

Conclusion

- A double lever tuner was used for LFD resonance control
- A sine wave was used to cause destructive interference with the resulting detuning from the simulated LFD pulse.
- The results show that the detuning is decreased from 1.4 kHz to 140 Hz
- Further studies are planned to make the program automatic and produce results where the detuning is set to 0 Hz

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