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

- 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 1298.836 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

- 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 be 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

- 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