WEPH010

STATUS OF MICROPHONICS ON CERL NINE-CELL CAVITIES

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Abstract

In the main linac (ML) of the compact energy recovery linac at KEK, two 1.3 GHz nine-cell superconducting cavities (ML1 and ML2) with high loaded Q (QL > 1 × 107) are operated in continuous wave mode. Because of the narrow bandwidth of these cavities, the microphonics detuning have a significant impact on the achievable RF field stability. In this paper, we have analysed the microphonics performance of the two ML cavities. According to our study, a “field level dependence microphonics” phenomenon is observed on the ML1 cavity. Several frequency components higher than 500 Hz were suddenly excited if the cavity field is above an onset field (~3 MV/m). Although the mechanism for the phenomenon remains obscure, the onset field is probably related with the cavity quench limits. Finally, we confirmed that the deteriorated RF stabilities (due to the deteriorated microphonics) can be improved by applying a disturbance observer based control approach.

Introduction

The cERL is a 1.3 GHz superconducting (SC) machine operated in the continuous-wave mode. In the main linac (ML) of the cERL, two nine-cell cavities (ML1 and ML2) with a high loaded Q of more than 1×10^7 were installed [1-2].

- Before 2015, a 50 Hz vibration (from the scroll pump) is the dominant microphonics. Resolved by inserting a rubber sheet under the scroll pumps.
- After 2016, microphonics in ML1 deteriorated. ML2 is okay.
- At 2019, high frequency components at 680 Hz and 890 Hz are excited in ML1.
- From 2016-2019, the performance of RF stability in ML1 deteriorated due to the deteriorated microphonics.

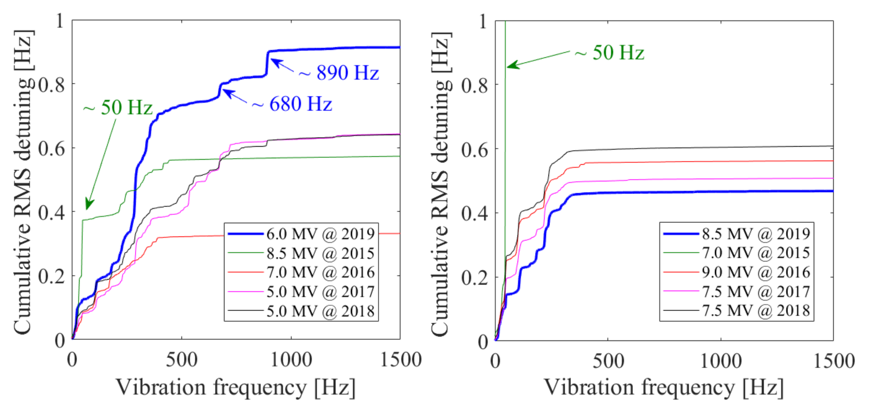

Figure 1: The Cumulative RMS detuning as a function of the vibration frequency of the ML cavities. Left: ML1. Right: ML2.

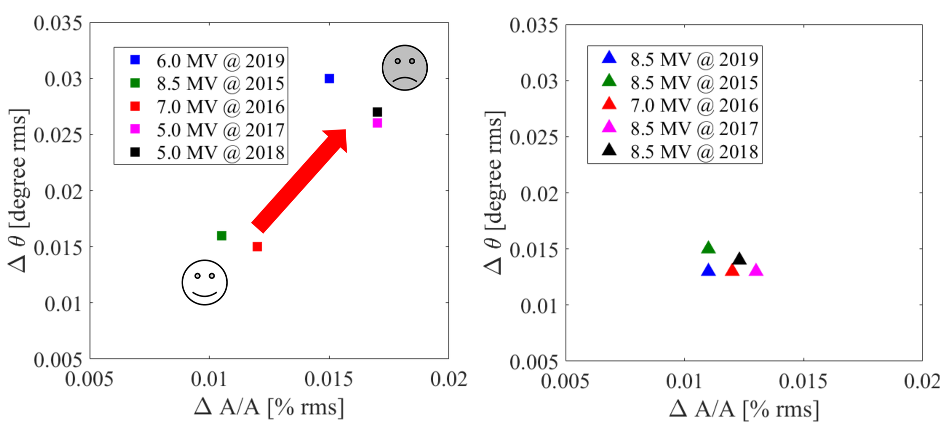

Figure 2: Amplitude and phase stabilities of ML1 cavity (left) and ML2 cavity (right) under FB operation in the past five years. .

Microphonics detuning vs. Cavity field (cont’d)

- For ML1 cavity, the RMS detuning is increased if the cavity field exceeds the onset field. ML2 is okay.

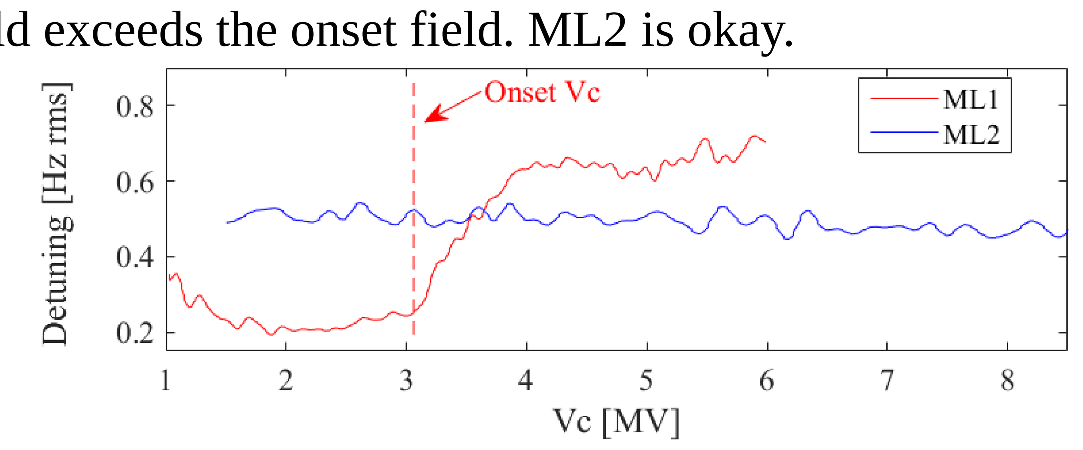

Figure 5: RMS detuning of ML cavities as a function of their Vc.

Microphonics spectrum near the onset voltage

- Higher frequency components suddenly appeared (very fast).

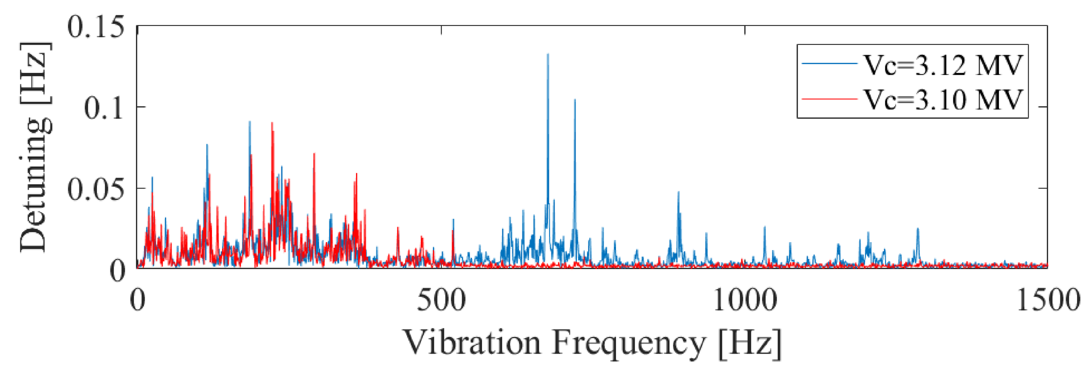

Figure 6: Microphonics spectrum comparison near the onset Vc.

LLRF

- Field control: LLRF feedback (FB) system.
  Resonance frequency control: Tuner FB system.
- The phase differences ($\Delta\varphi$) between cavity pick-up signal and feedforward (P_f) signal signals are calculated by LLRF system.
- Detuning is calibrated by $\Delta\varphi$.

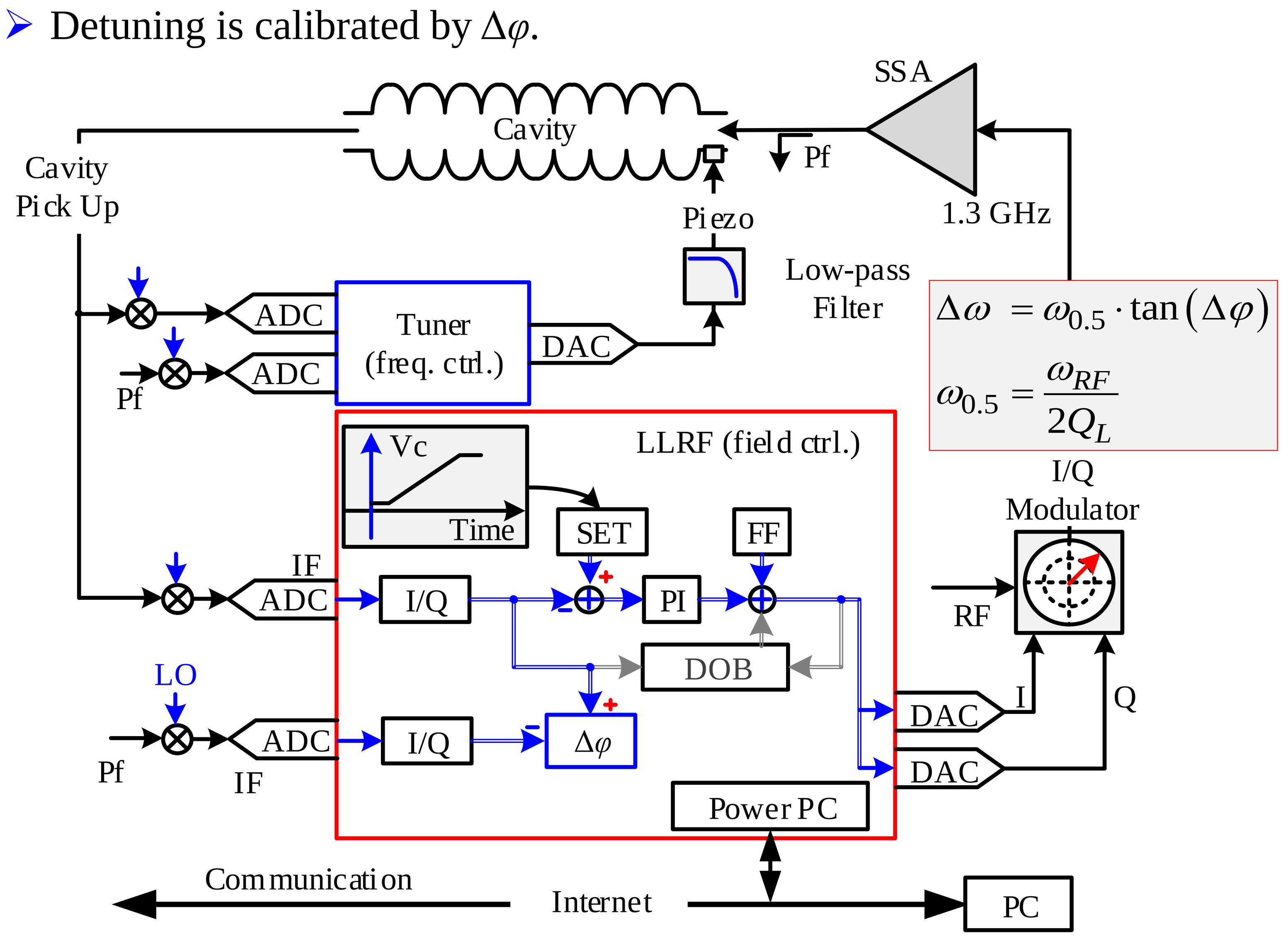

Figure 3: Schematic of digital LLRF and frequency tuner system.

Onset Vc vs. Quench Threshold Voltage

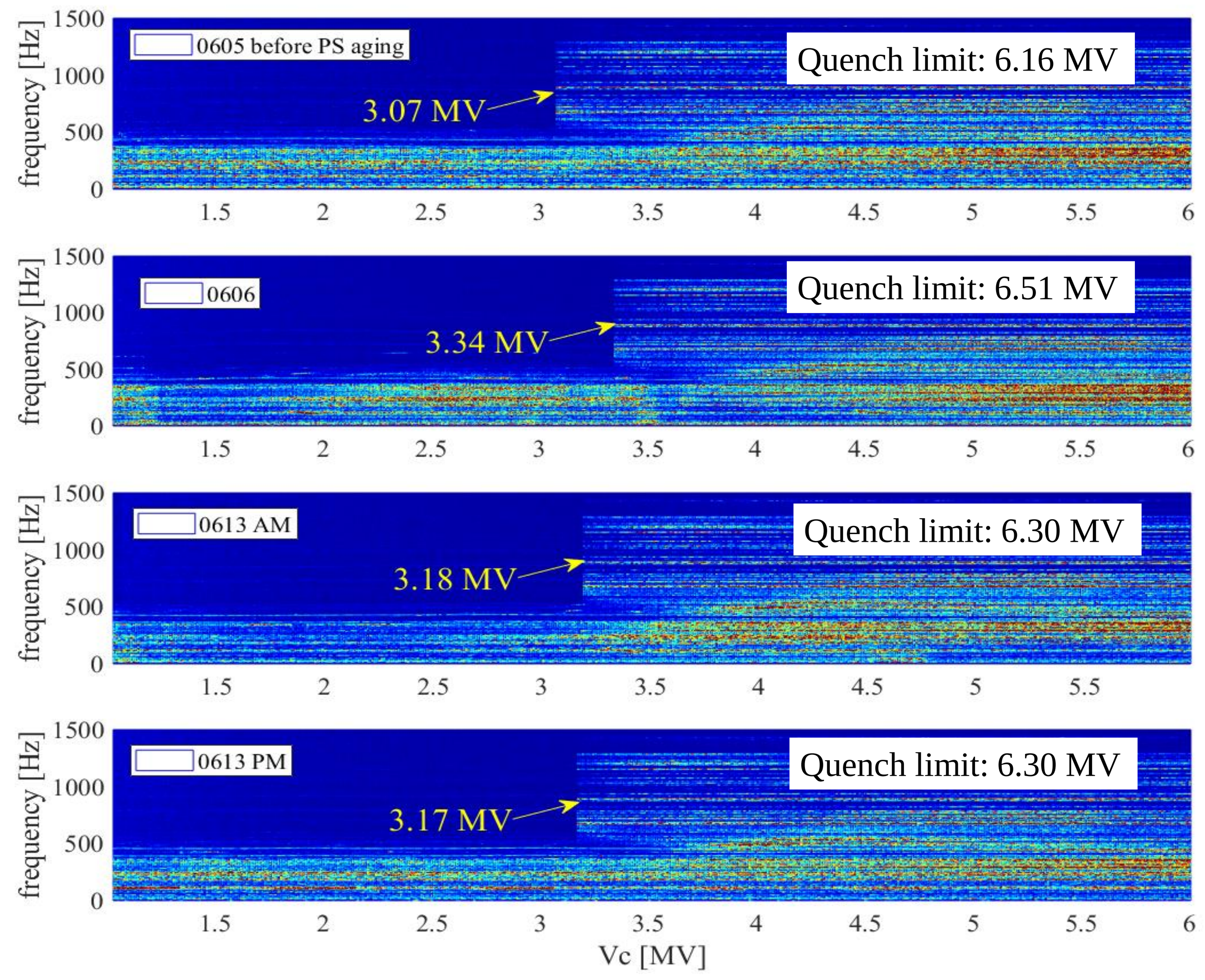

Figure 7: Onset Vc varied according to the different quench threshold voltage.

Microphonics detuning vs. Cavity field

- For ML cavity, the high frequency components is excited if the cavity voltage is above the onset voltage (~3.1 MV, or ~3.0 MV/m).
- No field dependency in ML2.

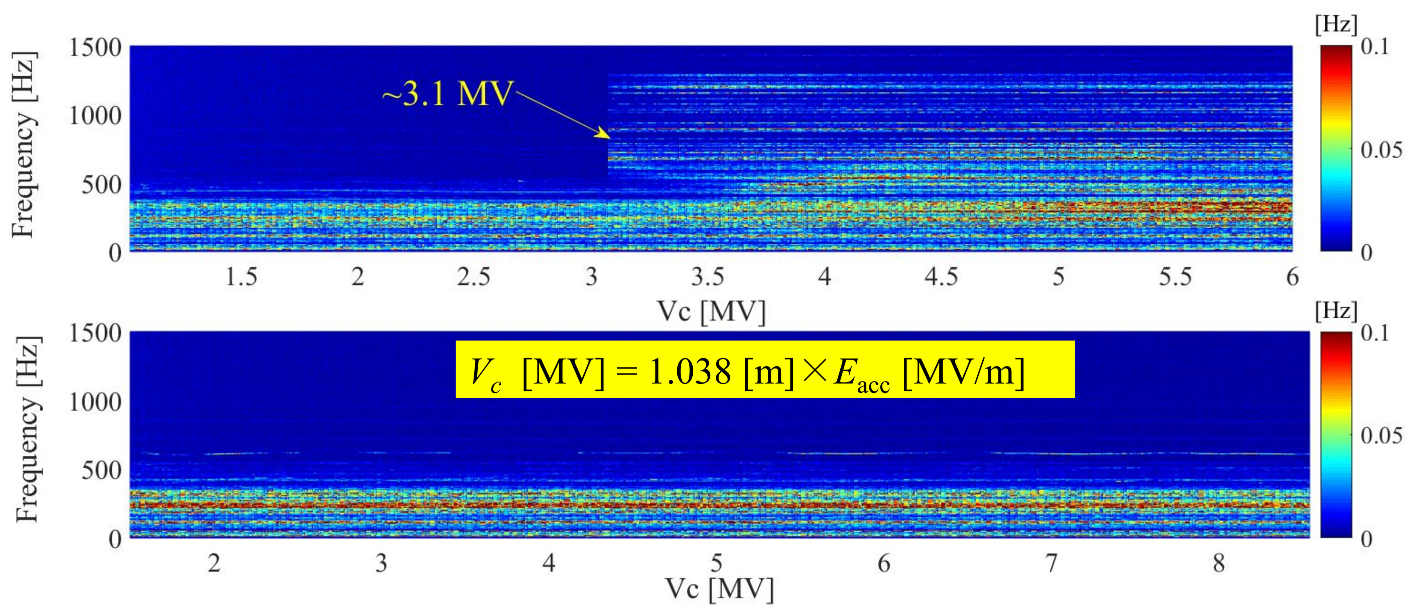

Figure 4: Field-detuning maps of ML1 (upper) and ML2 (lower) cavity. The color in the figure presents the intensity of the microphonics detuning.

DOB control

- The RF stabilities of the ML1 cavity can be improved with DOB control even under deteriorated microphonics [2].

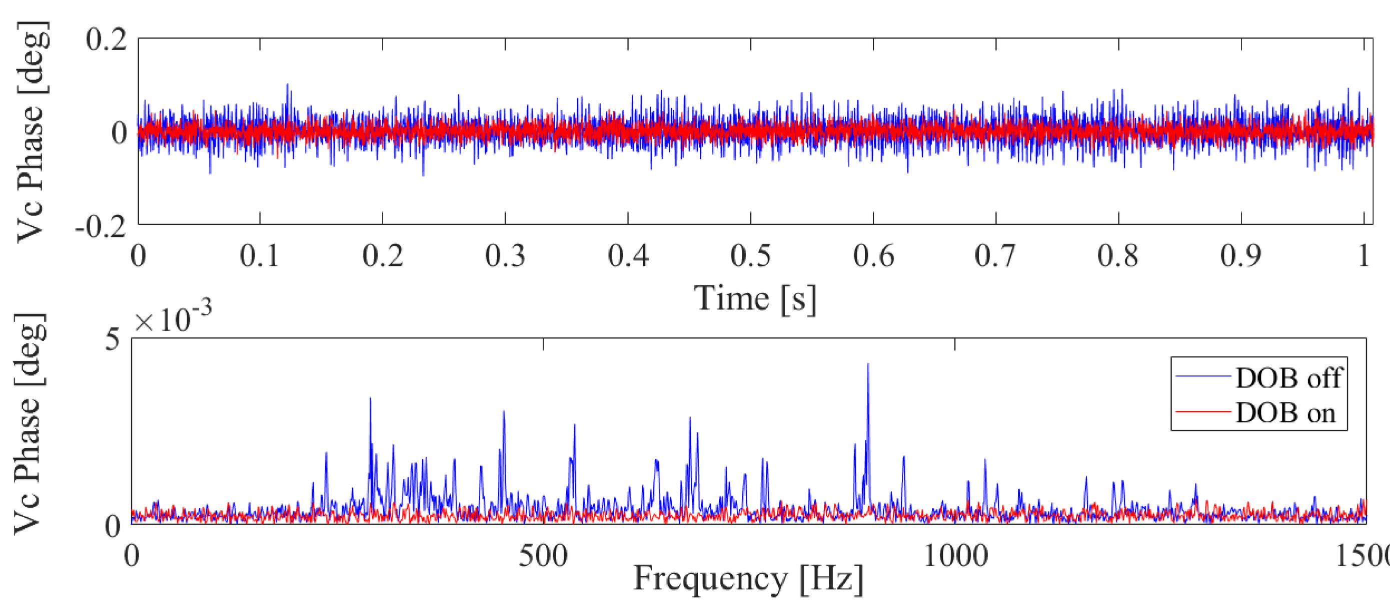

Figure 8: Measured ML1 V_c phase in the case of with and without DOB control.

Reference

[1] H. Sakai *et al*., “Long-term 0peration with Beam and Cavity Performance Degradation in Compact-ERL Main Linac at KEK”, in *Proc. LINAC’18*, Beijing, China, Sep. 2018, pp. 695-698.

[2] F. Qiu *et al*., “Application of disturbance observer-based control in low-level radio-frequency system in a compact energy recovery linac at KEK”, *Phys. Rev. ST Accel. Beams*, vol. 18, p. 092801, Sep. 2015.