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Steady-state response matrix of radio-frequency cavity voltage in storage rings

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The study of beam-cavity interaction is an essential step towards achieving the design objectives of high-intensity storage rings, particularly in the rapidly advancing fourth generation of synchrotron light sources, which rely on the strategy of bunch lengthening with harmonic cavities. Assessing the effectiveness of harmonic cavities typically requires self-consistently solving bunch equilibrium distributions, accounting for beam-loading voltages. This paper introduces a novel concept of the steady-state response matrix (SSRM) of radio-frequency (RF) cavity voltage: the steady-state beam-loading voltages are expressed as a product of the SSRM and an array containing only the information in bunch charge density distributions. Notably, the SSRM depends solely on RF cavity parameters such as R/Q, loaded Q, and resonant frequency. We demonstrate that the SSRM can significantly simplify and accelerate the self-consistent calculation of bunch equilibrium in double RF systems. Additionally, the SSRM can also facilitate the calculation for transient beam-loading feedforward compensation and the evaluation of thresholds for periodic transient beam-loading effect.

Footnotes

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