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Improving Beam-Based Regulation with Disturbance Model-Based Design for Continuous-Wave Linear Accelerators

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Regulating the arrival time of electron bunches is a crucial step to improve the temporal resolution of accelerator-based time-resolved experiments. Nowadays, a regulation method, called beam-based feedback, has been shown to work well for stabilizing the arrival time on pulsed accelerator machines. Essentially, this method resembles a typical design of a simple proportional regulator, where the plant is represented by an electron beam response matrix, and where the inversion of such matrix produces the regulator.

In recent years, however, linear accelerators that operate in a continuous-wave mode have received increasing attention. One of the key features of such machines is the improved statistics of measured data, which enables a high-resolution spectral analysis of the noise acting on the electron beam. This new insight allows to reinterpret the electron beam regulation as a disturbance rejection goal, where the disturbance is based on measured frequency data.

In this contribution, we show that the proportional beam-based feedback method has a principal performance limitation that becomes apparent by analyzing continuous-wave data. To improve this situation, we propose a regulator design that incorporates a dynamical disturbance model formulated in the context of a so-called H2 mixed-sensitivity problem. With the help of measurement data, we demonstrate that a single regulation stage, which is installed in a continuous-wave linear accelerator and features a disturbance model-based beam-based regulator, has a potential to outperform the commonly used proportional regulator, without compromising the plant stability.

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