An Intra-pulse Fast Feedback System for a Future Linear Collider

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Abstract

An intra-pulse Interaction Point fast feedback system (IPFB) has been designed for the Next Linear Collider (NLC), to correct relative beam-beam misalignments at the Interaction Point (IP). This system will utilise the large beam-beam kick that results from the beam-beam interaction and apply a rapid correction to the beam misalignment at the IP within a single bunch train. A detailed examination of the IPFB system is given, including a discussion of the necessary electronics, and the results of extensive simulations based on the IPFB concept for fast beam correction are presented. A recovery of the nominal luminosity of the NLC is predicted well within the NLC bunch train of 266 ns.

The FONT experiment — Feedback On Nanosecond Timescales — was proposed as a direct test of the IPFB concept and was realised at the NLC Test Accelerator at SLAC. As part of FONT, a novel X-band BPM was designed and tested at the NLCTA. The results of these tests with the NLCTA short and long-pulse beam are presented, demonstrating a linear response to the position of the 180 ns long-pulse beam: measurements show a time constant of $\sim$1.5 ns and a precision of better than 20 μm. A novel BPM processor for use at X-band, making use of the difference-over-sum processing technique, is also presented in detail, with results given for both short and long-pulse beams.

The FONT design concepts and modification of the IPFB system for use at the NLCTA are described. The design of a fast charge normalisation circuit, to process the difference and sum signals produced by the BPM processor, forming part of the FONT feedback circuit, is detailed extensively. Bench tests of the feedback electronics demonstrate the effectiveness of the normalisation and feedback stages, for which a signal latency of 11 ns was measured. These bench tests also show the correct operation of the normalisation and feedback principles. Finally, the results of a full beam test of the FONT system are presented, during which a system latency of 70 ns was measured. These rigorous tests establish the soundness of the IPFB scheme and show correction of a mis-steered bunch train within the full NLCTA pulse length of 180 ns.