Development of a Low-Latency, High-Precision, Beam-Based Feedback System Based on Cavity BPMs at the KEK ATF2

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Abstract

A low-latency, intra-train feedback system employing cavity beam position monitors (BPMs) has been developed and tested at the Accelerator Test Facility (ATF2) at KEK. The feedback system can be operated with either position information from a single BPM to provide local beam stabilisation, or by using position information from two BPMs to stabilise the beam at an intermediate location. The correction is implemented using a stripline kicker and a custom power amplifier, with the feedback calculations being performed on a digital board built around a Field Programmable Gate Array (FPGA). The addition of zitter scaling to the BPMs to increase the cavities’ Q-values has led to improvements in the feedback performance with beam trains of two bunches, separated by 280 ns and with a charge of 1 nC. For single (two-BPM feedback, stabilisation of the beam has been demonstrated to below 50 nm (41 nm). Ongoing work to improve the feedback performance further will be discussed.

Introduction

The Accelerator Test Facility (ATF2), KEK, is a test-bed for the ILC, with a prototype for the ILC final focus [1].

Cavity BPMs

The IP feedback system has three dipole cavity BPMs, and one reference (monopole) cavity BPM. The signals from these BPMs are processed with a two-stage system and used by a FONTSA digital board to compute a correction signal [2].

Signal Processing

First stage: 6.4 GHz monopole and dipole modes are down-mixed using a common 5.7 GHz Local Oscillator (LO) signal to 714 MHz, thus, retaining their relative phases.

Second stage: the monopole and dipole modes are mixed both in-phase and in-quadrature to produce orthogonal baseband signals and Q.

Fontsa Board

The I and Q signals are digitised at 357 MHz and the bunch correction, V, is computed from these signals on a Field Programmable Gate Array (FPGA). The feedback performance was tested with beam trains of two bunches, separated by 280 ns and with a charge of 1 nC. For single (two-BPM feedback, stabilisation of the beam has been demonstrated to below 50 nm (41 nm). Ongoing work to improve the feedback performance further will be discussed.

1-BPM & 2-BPM Feedback Configuration

Beam stabilisation to 50 nm was demonstrated with 1-BPM feedback at IPC, by integrating over 10 samples. Given the incoming bunch jitter and bunch-to-bunch correlation, the expected stabilisation was 65 nm. The feedback exceeds the prediction, suggesting the measured incoming correlation is considerably lower than the true correlation.

1-BPM Feedback Results

Beam stabilisation to 41 nm was demonstrated at IPB with 2-BPM feedback, by integrating over 5 samples. Given the incoming bunch jitter and bunch-to-bunch correlation, the predicted stabilisation was 40 nm, in excellent agreement with the measurement. The correlation has not been fully removed, suggesting the feedback gain, G, was set too low.

References