A new Front-End electronics, based on Logarithmic Amplifiers, is currently being developed for the CERN SPS Multi Orbit Position System (MOPOS). The aim is to resolve the multi-batch structure of the beams and cope with their large intensity range (> 70 dB). Position and intensity signals are digitized in the Front-End electronics installed in the tunnel. The data are then transmitted over a serial fibre-optic link to a VME Digital Acquisition board located in surface buildings. A first prototype, equipped with a calibration system, has been successfully tested on the SPS under different beam conditions, including single bunch, 25 ns and 50 ns bunch trains. The system architecture and the first beam measurements are shown in this poster.

Abstract

The MOPOS comprises 216 Beam Position Monitors (BPMs) installed in the beam pipe of the SPS accelerator. They are mostly single-plane shoe-electrostatic pick-ups, but some of them are two-plane strip-line monitors. The signals, which are induced on the electrodes by single-bunch and multi-bunch proton and lead-ion beams, are processed by Logarithmic-Amplifier (Log-Amp) modules to measure the position of the beam.

Position Measurement Principle for New MOPOS System

Logarithmic derivation of normalized position

\[
x = \frac{A - B}{A + B} = \frac{A}{B} \left(1 - \frac{1}{x}ight)
\]

Log Conformance Error

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MOPOS Front-End Architecture

An impedance matching adapter with low-pass filtering is connected directly to each pick-up electrode to limit the bandwidth of the BPM signal. A beam-based calibrator with further low-pass filtering is then used to deliver suitable signals to the Front-End chassis for centred-beam calibration. The Front-End chassis, which sits in the tunnel, contains two Log-Amp boards, a Diode Detector for even more accurate orbit measurements and the acquisition board that serializes the data prior to transmitting the optical signals to a VME acquisition system located in surface buildings.

MOPOS Front-End Prototype

The MOPOS comprises 216 Beam Position Monitors (BPMs) installed in the beam pipe of the SPS accelerator. They are mostly single-plane shoe-electrostatic pick-ups, but some of them are two-plane strip-line monitors. The signals, which are induced on the electrodes by single-bunch and multi-bunch proton and lead-ion beams, are processed by Logarithmic-Amplifier (Log-Amp) modules to measure the position of the beam.

Log-Amp Board

The new MOPOS system needs to measure the multi-batch structure of the BPM signals with a resolution of 0.1 mm in orbit mode and 0.4 mm in trajectory mode. Bunch intensities range from $1 \times 10^9$ to $5 \times 10^{10}$ for proton beams and from $1 \times 10^6$ to $2 \times 10^{10}$ for lead-ion beams. Bunch spacing can extend from 5 ns up to 23 µs. The nominal number of batches $N_b$ can vary between 1 and 4 for protons and up to 13 for ion-beams.

Bunch and Multi-Bunch Injection Oscillations

Single-Bunch and Multi-Bunch Oscillations

Proton beam injections were measured during consecutive turns on a single bunch (left) and during the injection of the fourth bunch (right), which is off-centre. The LHC multi-bunch beam consisted of 36 bunches per batch with 50 ns bunch-spacing and $1.4 \times 10^{11}$ protons/bunch.

First Beam Measurements

To characterize the sensitivity of the system, magnetic correctors are used to generate local beam displacements of ±1 mm up to ±5 mm in the vicinity of selected BPMs. These results show that the sensitivity is about 1.7µm/bin for the strip-line BPM and 2.5µm/bin for the shoe-box BPM.

The estimated resolution (limited by noise and beam position jitter) is about 375 µm in trajectory mode and 80 µm in orbit mode, which agrees with the specifications. Some optimization is still needed to improve the sensitivity on the 40MHz High-Sensitivity channel for low charge beams.

Local Beam Bumps

Single bunch (left) and multi-bunch (right) injection oscillations.