IOTA BPM Technical Review

January 3, 2019

Review Charge

The charge to the reviewers is to evaluate and make recommendations to how the following are being addressed and should be addressed going forward.

1. Understanding and documenting the requirements for the beam position measurement and the expected beam intensity, structure, and timing.

2. Providing detector, electronics, and signal processing designs and equipment adequate to satisfy the needs of the IOTA research program this year.

3. Documenting the remaining design and commissioning steps and expected schedule needed to reach the measurement performance outlined in the requirements?

Requirements

I find that the provided documentation adequately addresses expected beam intensity, structure and timing. There seems to be confusion over how many bunch position measurements are made per turn. The initial operating scenario for IOTA has only one populated bucket. The original requirements document asked for a single bunch measurement per turn and have that measurement timing adjustable to each bucket. This timing adjustment may best be done external to the BPM system as long as the BPM system accepts an external trigger.

There was some discussion of multiple bunches (position measurements) per turn. IOTA needs to clarify the necessity of this type of measurement as this heavily impacts resulting design specifications.

The IOTA experimental program, after some machine operations experience, has provided an additional requirement for the BPM system to be robust against synchrotron motion.

Current Detector

The current detector design does not provide turn-by-turn data for a single bunch at the requested resolution. Several problems which are intrinsic to the signal processing design have been identified.

- RF Envelope detector is the primary source of system noise.
- DC coupling makes measurements for lower beam intensities difficult to impossible.
- RF Envelope detector has an uncorrected non-linear response.
- DSP is susceptible to synchrotron oscillations.
- The system response is dependent on the linear charge density of the beam.

Path Forward

Any new design of the analog signal conditioning must take into account the added requirements of the proton beam in IOTA. There is unlikely to be a single solution for both electrons and protons, but provision for robustly changing from one beam to the other needs to be formulated. Close collaboration with IOTA and continued external oversight is needed to make any new design successful.

The non-linear response of the RF envelope detector can possibly be corrected to improve the turn-by-turn position resolution. The BPM system response depends on the linear charge density of the beam. Unless a linear charge density can be teased from the sum signal after correcting the non-linear response of the RF envelope detector, there is little that can be done to remove this problematic feature.

Research into better DSP could remove the dependence on synchrotron oscillations.