STORAGE RING TUNE MEASUREMENTS USING HIGH-SPEED METAL-SEMICONDUCTOR-METAL PHOTODETECTOR

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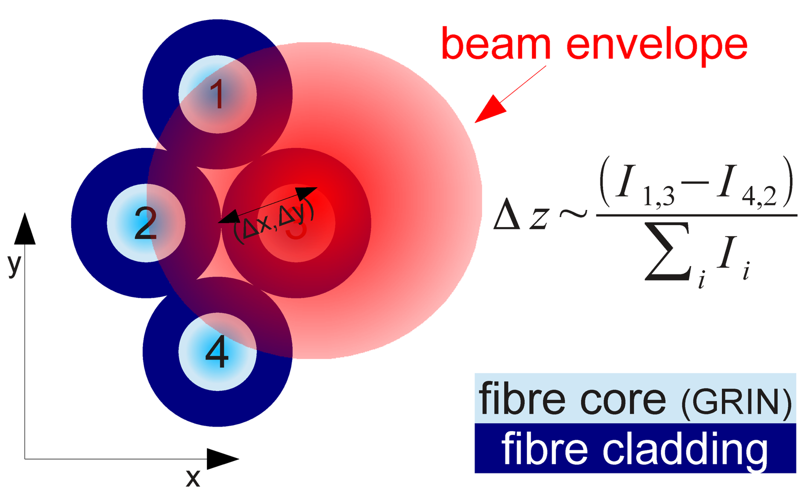
Abstract

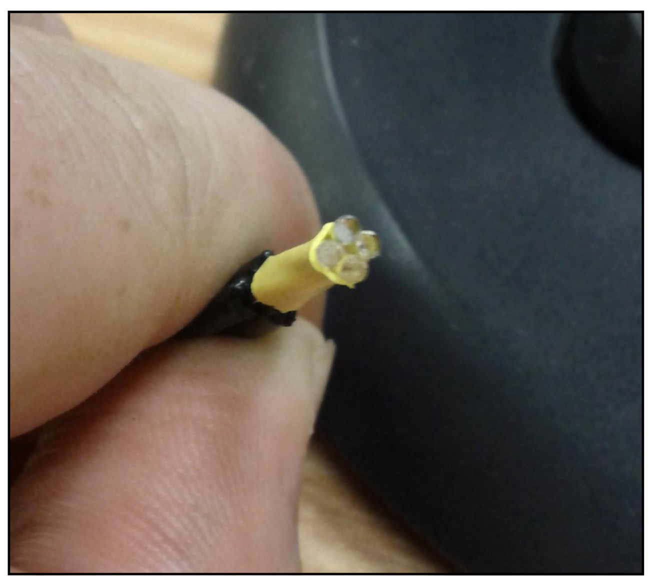
In any storage ring, the measurement and control of betatron tunes is an integral part of optimising the stability and lifetime of the stored particle beam. This contribution presents a novel relative beam position measurement system relying on a direct synchrotron-light detection using fibre-coupled, high-speed Metal-Semiconductor-Metal(MSM) Photodetectors (PD) in a custom-made balanced RF biasing circuit.The system will be described along with its first results measuring the tunes for the storage ring at the Australian Synchrotron. The results are compared to the existing electro-magnetic BPM-based tune measurements taken.

Introduction

Tune diagnostics systems, typically integrated into the beam position monitoring (BPM) or transverse feedback subsystems, are essential for any synchrotron and are used to control the actual tune working point to prevent the onset of instabilities that can occur if the fractional tune approaches low-order resonances of the accelerator lattice.



a) The fiber diamond arrangement with respect to the synchrotron photon beam spot size.



b) A prototype fiber diamond utilising large core PMMA multimode fibers.

Figure 1. For the nominal SL-BPM system, the light is focussed onto a set of length-matched optical fibres that are grouped to a diamond-type structure as illustrated in Figure 1, and each being individually fibre-coupled to its own MSM-PD.

For most systems, a small amount of excitation is required to separate the tune signal from the measurement noise, therefore tune measurements often cannot be performed during user time. A high-bandwidth, low-noise BPM utilising visible synchrotron radiation has recently been successfully tested at the Australian

Experimental Setup

The synchrotron-light based beam position monitor system (SL-BPM) described in this paper is built on the original Fill Pattern Monitor (FPM), which is based on a single high-speed MSM Photodetector (MSM-PD) to measure the electron beam density in real time [1,2]. Figure 1 shows how for the nominal SL-BPM system, the optical pickup is comprised of four optical fibers in a diamond configuration. As the beam moves the individual fibers recieve varying light intensity proportional to the beam position.

A specialised balanced biasing tee circuit (Figure 2) has been constructed for the PDs to compute the incoherent sum or difference in the analogue domain before being further processed or directly digitised.

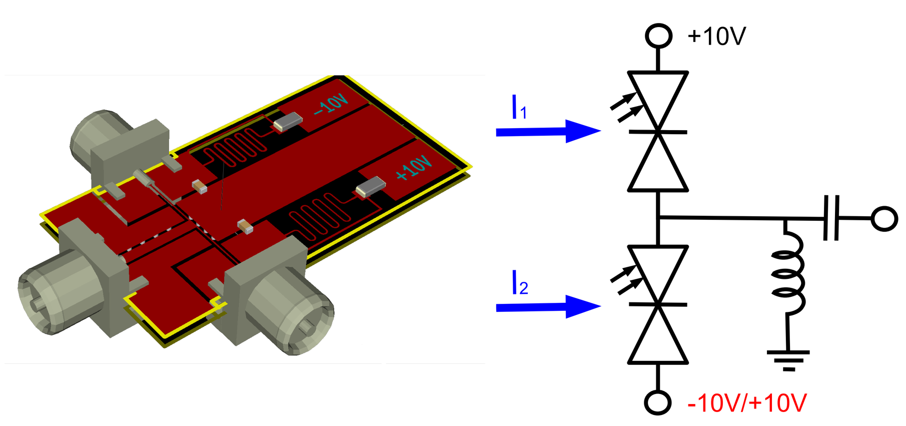


Figure 2. The specialty balanced bias-tee designed for the SP-BPM system. It can operate in two modes, differential or sum of the two signals from the MSM-PDs.

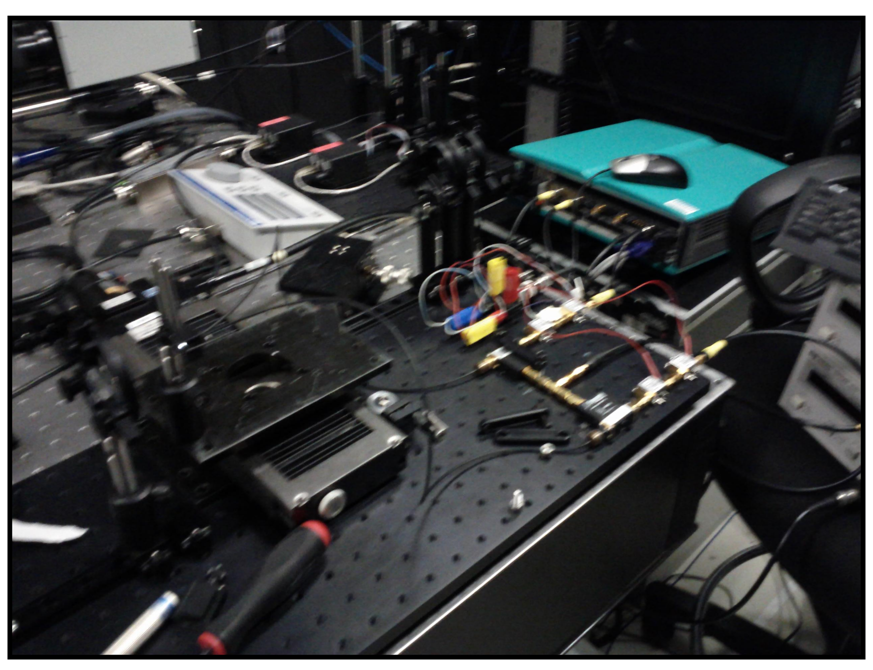
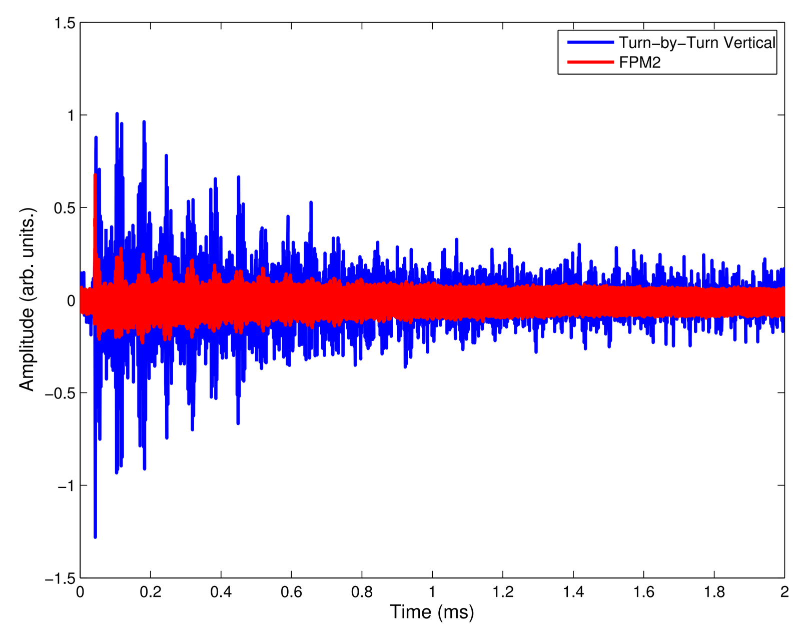


Figure 3. The experimental setup at the optical diagnostic beamline (ODB) at the Australian Synchrotron.

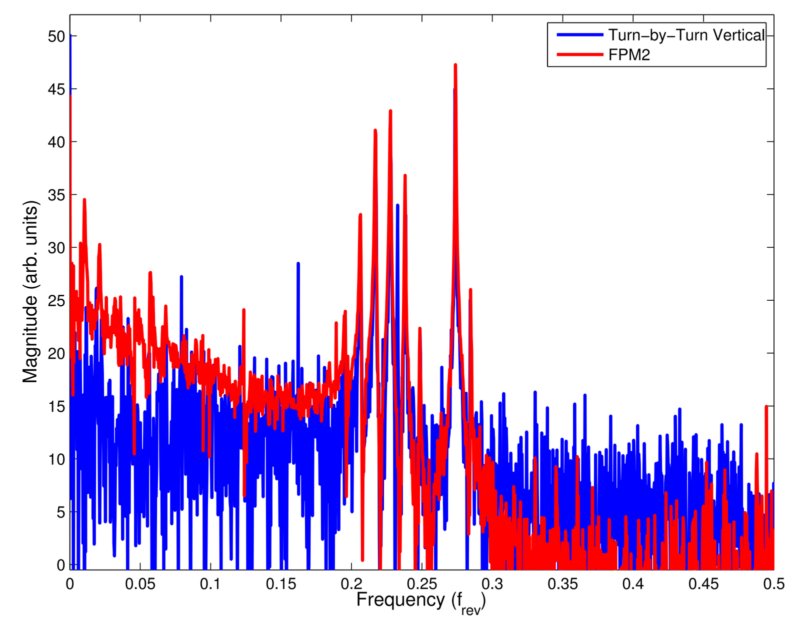
Results

Using this set-up, the tunes for the storage ring at the Australian Synchrotron have been measured and compared to the existing tune measurement system. At the Australian Synchrotron, the data for tune measurements is typically acquired using turn-by-turn data from the storage ring button BPMs while the beam is excited by a combination of four injection kicker magnets [3].

A comparison between the traditional button BPM-based system and SL-BPM system is shown in Figure 4. The balanced bias tee was replaced with a Broad-Band Tune (BBQ) front end [4]. Figure 5 is an overlay of two sets of data taken with the prototype SL-BPM system, utilising the balanced bias tee configuration.



a) Turn-by-turn position data, taken simultaneously with the standard BPMs and the SL-BPM system.



b) The position data transformed into the frequency domain. High chromaticity induces a splitting of the vertical tune lines.

Figure 4. A comparison between the optical tune measurement system and the existing turn-by-turn BPM system. Clear agreement between the different methods is evident. The fractional tunes for this measurement are (Qx, Qy) = (0.273, 0.227)

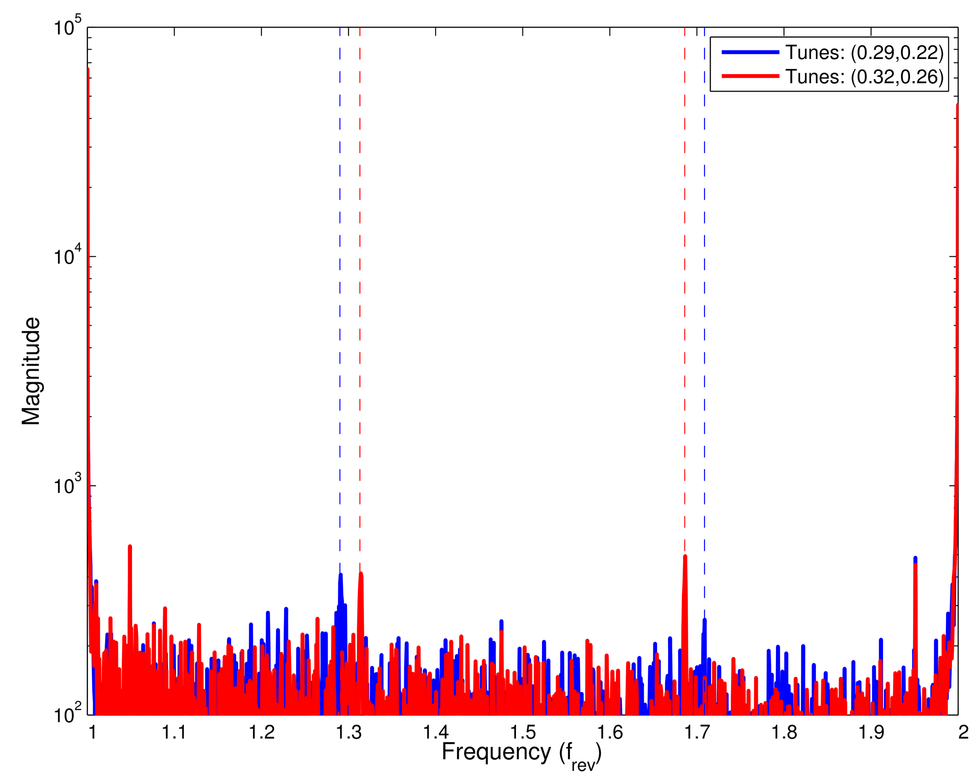


Figure 5. Two tune measurements utilising the SL-BPM BPM system. Between the two measurements the storage ring tunes shifted from (Qx, Qy) = (0.29,0.22) to (0.32,0.26)

Conclusions

Preliminary results from the prototype optical beam position measurement device described above are promising. The system has demonstrated the ability to track the temporal evolution of the tune and is in good agreement with the existing BPM diagnostics. Future improvements will include a more refined post-processing and higher-resolution digitisation of the available analogue signal to fully exploit the achievable signal-to-noise ratio of the MSM-PD.

References

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