New method for reducing the contribution of the beam position in the quadrupole signal *

Joel Alain Tsemo Kamga[1], *Wolfgang F.O. Müller*[1], *and Thomas Weiland*[1]
[1]Technische Universität Darmstadt, Institut für Theorie Elektromagnetischer Felder (TEMF), Schlogartenstrasse 8, 64289 Darmstadt, Germany

Introduction

Quadrupole pickups are of particular importance in the accelerator physics because they allow the measurement of some parameters like the transverse extent of the beam, that can be obtained by measuring the quadrupole moment of the beam. However, this quadrupole moment is not only dependent on the r.m.s beam dimensions $(\sigma_x^2 - \sigma_y^2)$, which is the information we need, but also on the beam position $(\overline{x}^2 - \overline{y}^2)$ [1]. Therefore, the beam dimensions cannot be obtained directly from a traditional pickup, but by extracting from the quadrupole signal the contribution of the beam position. However a reasonable accuracy can be obtained only if the beam displacement from the center is small compared to the beam size. The goal of this work consists in developing a new method for calculating the quadrupole signal that will be much less sensitive to the beam position.

Methods to pickup $\sigma_x^2 - \sigma_y^2$

Known methods

The design used in this work is an electrostatic pickup with four plates as shown in Fig. (2a). The main goal of this work described in the introduction can be achieved by starting from the so called *Log-ratio method*, because this method compared for instance to the *difference/sum method* provides a quadrupole signal that is less sensitive to the beam position [2].

New method

The proposed method is described in Fig. (1). For more details about the *Log-ratio method*, see [2]. The quadrupole signal coming from the new structure is given by:

$$\Xi = \frac{160}{\ln(10)} \frac{\sin(\alpha)}{\alpha} \left[\left(1 - (1+2c)^2 \frac{\tan(\alpha/2)}{\alpha} \right) \cdot \frac{\overline{x}^2 - \overline{y}^2}{b^2} + \frac{\sigma_x^2 - \sigma_y^2}{b^2} \right] + O\left(\frac{1}{b^4}\right)$$

where α and b stand for the angular width of each electrode and the pickup radius, respectively. From the above Equation, while omit 4^{rd} order, an appropriate factor c can be found to eliminate the square term of the beam position.

* Work supported by GSI.

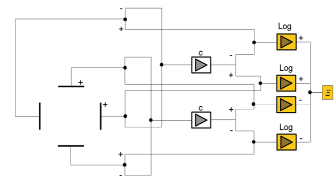
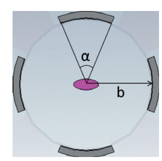


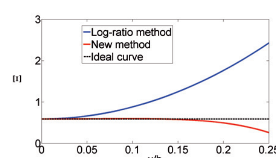
Figure 1: Pickup design for the new method

Simulation results

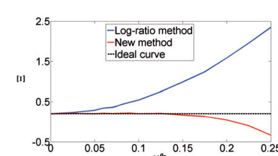
CST Particle Studio (PIC Solver) was used for the simulation. The transverse beam extent σ_x, σ_y was assumed to be less than $0.2b$ and the normalized beam velocity β was 0.5.



(a) Pickup design



(b) Analytical results



(c) Simulation results at 50 MHz

Figure 2: Quadrupole signal when $\overline{y} = 0$, $\alpha = 45^o$, $b = 50$ mm, σ_x/b = 0.1, σ_y/b = 0.025

Conclusions

In this work we have presented a new method to considerably reduce the effect of the beam position on the quadrupole signal. Looking at Fig. (2b) and (2c), we can see a good agreement between the analytical results and the simulations. The future work consists in testing the method to the other pickup types.

References

[1] A. Jansson, D.J. Williams "A new optimised quadrupole pickup design using magnet coupling".

[2] P. Li, B. G. Sun, Q. Luo, X. H. Wang, H. L. Xu "New Methods of measuring Emittance Using Beam Position Monitors".

[3] CST GmbH, "CST PARTICLE STUDIO".