THE DESIGN OF THE STRIPLINE KICKER FOR THE BEPCII TRANSVERSE FEEDBACK SYSTEM

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Abstract

The strong beam current (0.9 A) and the large number of bunches (93 bunches) may cause the coupled bunch instabilities (CBI) in BEPCII [1]. Active feedback systems are required to suppress CBI. The BEPCII transverse feedback system mainly includes three parts that are the signal detection, the signal process, and the kicker. The magnitude of feedback power is very important parameter that is intimately related to the design of the kicker. The kicker is a key part in the transverse feedback system. The strip line electrodes will be used as the kicker in BEPCII. In this paper the numeric modelling and the simulation result of the kicker is given. The electromagnetic design has been carried out mainly by means of the Hewlett&Packard high frequency structure simulation code. The results provide a base on the mechanical design.

INTRODUCTION

In the storage ring, beam feedback system can damp the coupled-bunch instability, so the beam lifetime will be increased. In this transverse bunch-by-bunch feedback system, two BPMs whose phases difference is about 90 degrees are used to pick up the beam signals. The pick up signals are then sent to the front-end electronics by low loss cables, where the beam position oscillation information can be detected. The phase of the beam position oscillation signal should be changed 90 degrees through the signal processing system in order to damp the transverse dipole oscillation. The power amplifier is used to amplify the damp signal and then to drive the kicker. The kicker gives a net electromagnetic force to the beam and damps the coupled bunch instability.

The important parameter for the beam feedback system is the power. It has an intimate relation to the design of kickers.

ELECTROMAGNETIC DESIGN

The common transverse kicker is based on the strip line pair in the most accelerators, see Fig.1. As shown in Fig. 2, each electrode and vacuum pipe forms a transmission line with 50-Ohm characteristic impedance. Two standard coaxial cables are used as ports where the power is transformed. In order to feed back all possible CB modes, the system bandwidth is 250MHz, and then the 300mm length stripline, the quarter of the 250MHz wavelength, is required. The opening angle of the electrode is 88 degrees. The thickness of the electrode is 2 mm. The radius of the stripline is 48 mm, and the radius of pipe is 75 mm. The taper is 50 mm long.

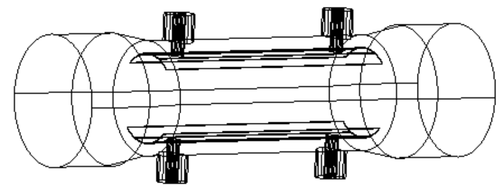

Figure 1: The kicker model.

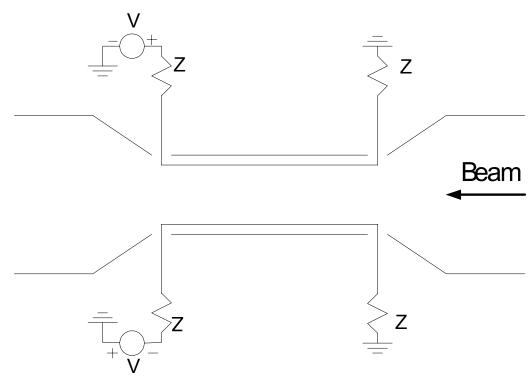

Figure 2: Transverse kicker.

The power coupled to the beam can be induced by two ways. One is the even mode that means the same polarity voltages drive to the downstream port of the beam direction, with the upstream ports terminated to matched loads. The longitudinal electric field is produced on the beam line, and the kicker can be used as the longitudinal kicker, see Fig.3.1. The other is the odd mode, in this mode the kicker can be used as the transverse kicker, see Fig.2; two opposite polarity voltages drive the port, and then the transverse electromagnetic field formed in the beam pipe can give a net deflecting force, see Fig.3.2.

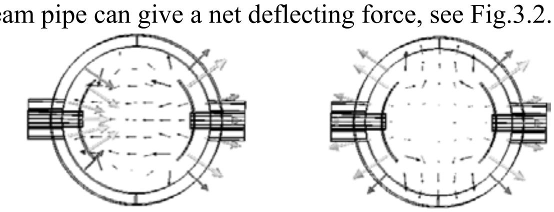

Figure 3.1: E-field distribution on a middle transverse plane in case of even mode (left) and odd mode (right) excitation.

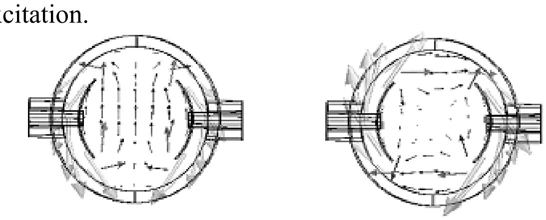

Figure 3.2: B-field distribution on a middle transverse plane in case of even mode (left) and odd mode (right) excitation.

SIMULATION

The reflection coefficient vs. frequency

In order to transform the maximum power to the stripline and reduce the reflected power, it is necessary to match each stripline to the 50 Ohms external transmission line. So changing theposition of the transition can get good results.

The reflection coefficient vs. frequency at the input ports is shown in Fig.4.

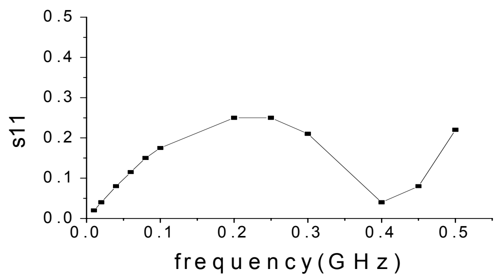

Figure 4: Reflection coefficient vs. frequency

3.2 Shunt impedance

The effectiveness of the kicker is defined by shunt impedance R_S

$$R_S = V_\perp^2 / 2P \quad , \tag{1}$$

where $V_\perp$ denotes the integration of the Lorentz force received by the unit charge along z-axis.

$$\mathrm{v}_\perp = \int_0^l (\vec{E} + \vec{\mathrm{v}} \times \vec{B})_\perp dz \, . \tag{2}$$

As for the strip line, the shunt impedance can be calculated by this formula too [4]

$$R_s = 2Z_c \left(\frac{g_{trans}}{kh}\right)^2 \sin^2(kl) \tag{3}$$

where Z_C (50Ohm) is the characteristic impedance of transmission line. The shunt impedance may be acquired by the way of integrating the Lorenz force along the *z*-axis. In HFSS code, the following way [2] is taken to get the electromagnetic data at any specified frequency.

If

$$E_y(x=0, y=0, \omega t=0) = E'(z) \, ,$$

$$B_x(x=0, y=0, \omega t=0) = B'(z) \, ,$$

$$E_y(x=0, y=0, \omega t=\pi/2) = E''(z) \, ,$$

$$B_x(x=0, y=0, \omega t=\pi/2) = B''(z) \, , \tag{4}$$

then we can define:

$$E_y(z) = [E'^2(z) + E''^2(z)]^{1/2} ,$$

$$B_x(z) = [B'^2(z) + B''^2(z)]^{1/2} ,$$

$$\Phi_E(z) = \arctan\left[\frac{E''(z)}{E'(z)}\right],$$

$$\Phi_B(z) = \arctan\left[\frac{B''(z)}{B'(z)}\right]. \tag{5}$$

The electric field in y direction and magnetic field in x direction can then be represented by two phasors

$$\mathrm{E}_y(z,t) = \mathrm{Re}\{E_y(z) e^{j[\omega t - \Phi_E(z)]}\} \, ,$$

$$\mathrm{B}_x(z,t) = \mathrm{Re}\{B_x(z) e^{j[\omega t - \Phi_B(z)]}\} \, . \tag{6}$$

The maximum transverse deflecting voltage received by the beam at a given frequency is

$$V_\perp(\omega) = \left| \int_0^l [E_y(z) e^{j[\frac{\omega z}{c} - \Phi_E(z)]} + cB_x(z) e^{j[\frac{\omega z}{c} - \Phi_B(z)]}] dz \right| \tag{7}$$

where l is the length of the electrode, $\omega z / c$ represents the transition factor, that means the beam will receive the maximum electric field when the beam move to the middle of the kicker.

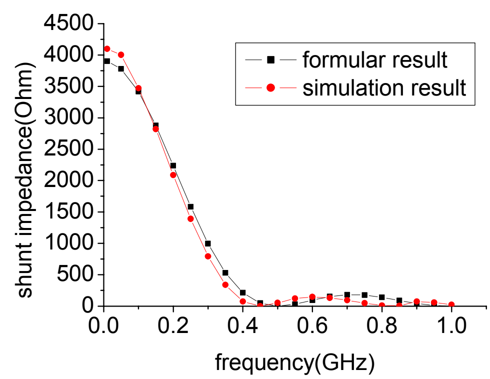

Figure 5: Transverse shunt impedance

CONCLUSION

The 1300 Ohm shunt impedance at 250 MHz has been acquired. The reflection, at the port where the power couples to the stripline, is good. On this condition, the power of 123 Watts is enough to damping the coupled bunch instability. But the design of the kicker for BEPCII should be continued. This paper may provide a base for the mechanical design.

REFERENCE

[1] BEPCII Design Report Last Revised, Sep. 23, 2003.

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[4] D. A. Goldberg and G. R. Lambertson, "Dynamic Devices: A Primer On Pickups and Kickers", LBL-31664, November 1991.