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DEVELOPMENT OF KICKER FOR TRANSVERSE FEEDBACK SYSTEM IN BEPCII

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Abstract

This paper introduces the necessary design parameters of transverse feedback system. Meanwhile, it mainly contains the design of stripline as feedback system kicker. The transverse kicker has 4 striplines, so that it can work in vertical and horizontal area. In the experiment, the shunt impedance is 1500 Ω which is simulated by HFSS and the system only needs 120 W to suppress the coupled beam bunch instabilities. According to the results of parameter S (1, 1) and S (2, 1), power loss and reflection is convenient. Recently, the prototype is calibrated.

INTRODUCTION

In order to receive more specific beam position instances and suppress beam instability as much as possible, we need to develop the kicker for BEPCII transverse bunch-by-bunch feedback system in storage ring. Comparing with the current transverse kicker, the new one provides superior dipole oscillation damping and detects the electrical field signal more sensitively [1]. According to calculation and simulation results, the amplitude reflection rate parameter is lower than 1% and a shunt impedance of 1500 Ω at 250 MHz working bandwidth can be reached. It needs 120 W power to suppress all unstable coupled bunch modes and the transmission efficiency is more than 99%. Meanwhile, this design aims to increase the space utilization rate in the storage ring, so the four-stripline-type kicker is adopted. This kicker tube consists of 2 striplines in horizontal and another 2 striplines in vertical direction. The important dimensions include the stripline length of 300 mm and the total length of the transverse kicker which is less than 500 mm. The innovation of this development is improving the beam intensity and lifetime, and the analysis and diagnosis ability of the beam detection system.

PARAMETER SIMULATION

Relevant Parameters Deduction

BEPCII has collide mode and synchrotron mode. At the beginning of the design of the transverse kicker, physics analysis needs to refer to some details of BEPCII in two different mode [2]. Table 1 shows the main parameters which play an important role in this work.

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Table 1: Main Parameters of BEPCII

Parameters	Collide mode	Synchrotron mode
Energy E_0 (GeV)	1~2.1	2.5
Circumference (m)	234.53	241.13
RF frequency (MHz)	499.8	499.8
Harmonic number	396	402
Revolution frequency (MHz)	1.264	1.243
Revolution period (ns)	792	804

Table 2 shows the main parameters of the new transverse kicker, which is based on the relevant parameters in Table 1. The other part of this paper concerns the details of the design. Because of synchronous mode in BEPCII, the bucket will be filled by beam bunch one by one. So the system bandwidth is a half of RF frequency. The maximum output voltage is calculated by the Eq. (1):

$$V_{FB\perp} = 2\frac{T_0}{\tau_{FB}}\cdot\frac{E}{e}\cdot\frac{\Delta x}{\sqrt{\beta_m\beta_k}} \quad (1)$$

According to shunt impedance and maximum output voltage, the maximum power needed by this system is 120 W, and Eq. (2) shows how to calculate it

$$P = \frac{1}{2}\frac{\Delta V_{FB}^2}{R_k} \quad (2)$$

Table 2: Main Parameters Transverse Kicker

Parameters	Transverse Kicker
System Bandwidth (MHz)	250
Shunt Impedance (Ω)	1500
Maximum Feedback Voltage (V)	600
Maximum Output Power (W)	120
Stripline Length (mm)	305
Tube Inner Radius (mm)	50
Stripline Flare Angle	60°

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The shunt impedance of the kicker's stripline is calculated by Eq. (3)

$$R_k = 2Z_c\left(g_{\perp}\frac{l}{a}\cdot\frac{\sin kl}{kl}\right)^2 \qquad (3)$$

In this equation, Z_c= 50 Ω, stripline radius is a = 38 mm, the number of wave k = ω/c, the length of stripline l = 300 mm. According to the chart, the approximate solution of shunt impedance is 1.5 kΩ while the frequency is 250 MHz. $g_{\perp} \approx 1$. Figure 1 shows the shunt impedance at different frequencies (calculated from 50 MHz to 500 MHz).

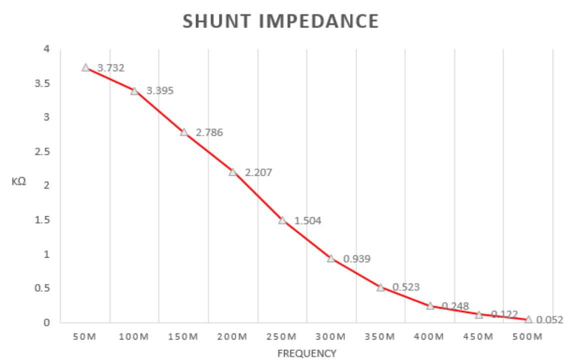

Figure 1: The shunt impedance at different frequencies.

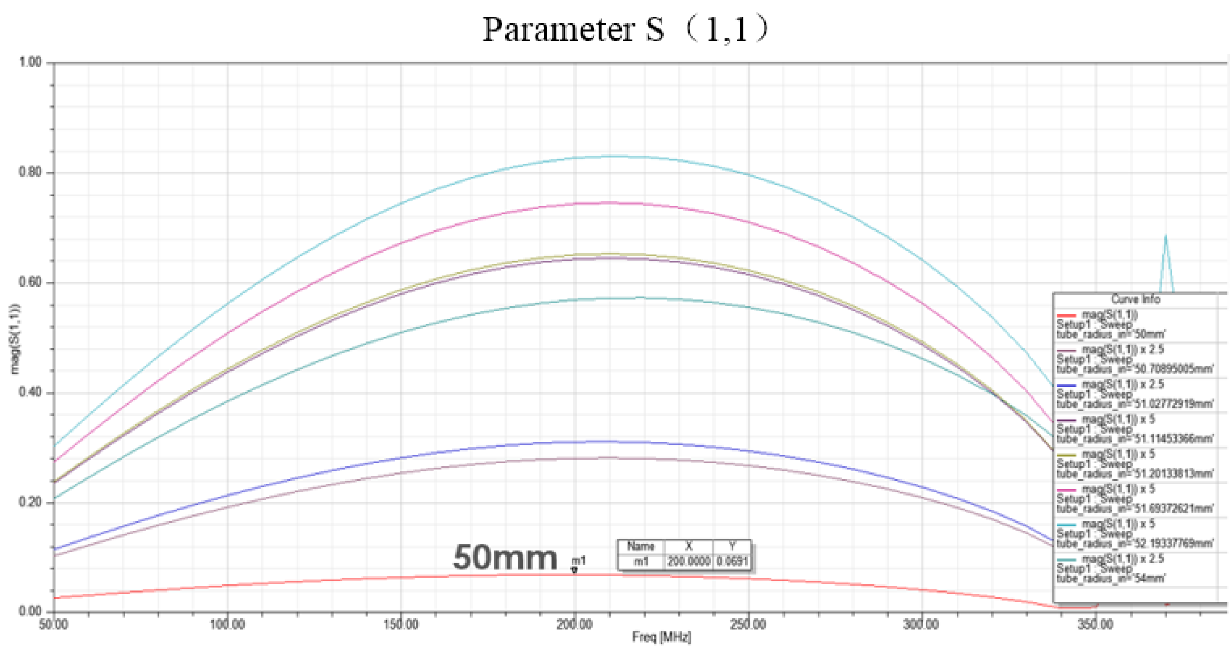

Figure 2: The results of S (1, 1) for different internal radii.

S Parameter Results

Figure 2 is the coefficient of power input port at different frequencies. Parameter S (1, 1) is the ratio of reflected wave voltage in power feed point to incident wave voltage [2]. In order to transmit the maximum power to stripline (which is from amplifier) and reduce the reflected power, the stripline needs to be impedance matched with external port and transmission cable. The thickness of the cavity internal wall is adjusted so that the reflection of wave range is lower than 10% and reflected power is less than 1%.

Figure 3 can be regarded as the efficiency of power transmission with power through the stripline at different frequencies. As we can see, when the cavity internal radius is 50 mm, transmission efficiency is 99.76% and the power reflecting factor is lower than 1%.

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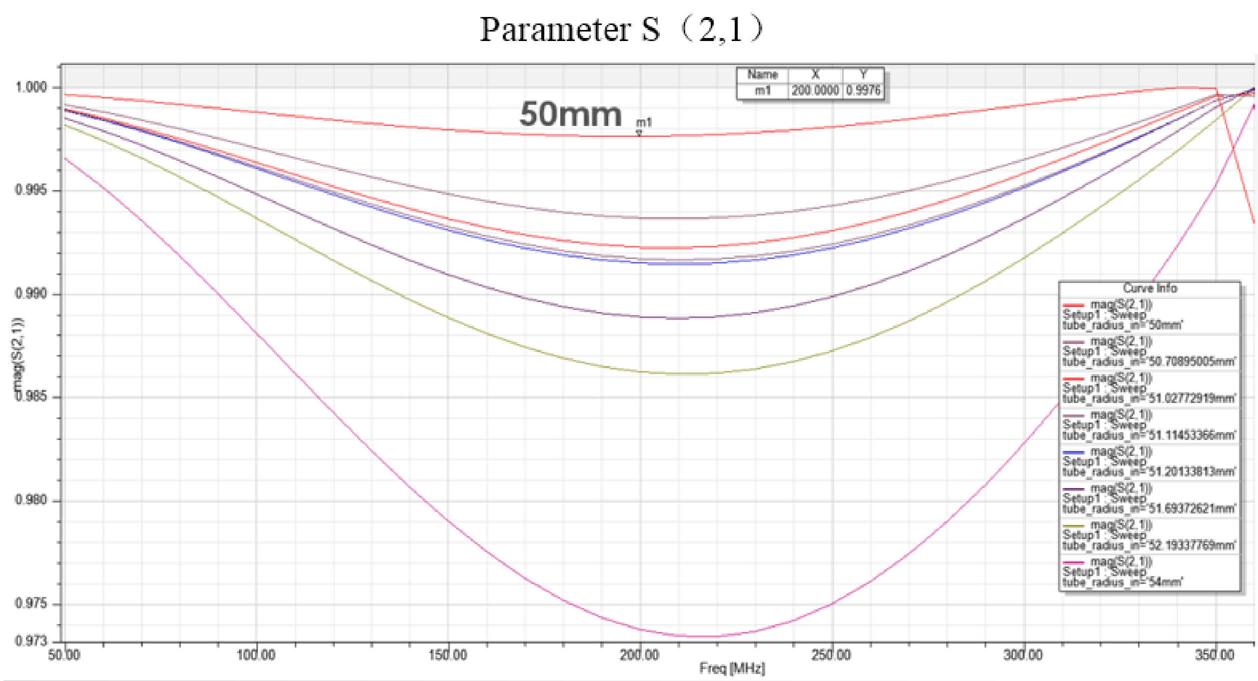

Figure 3: The results of power transmission parameter for different internal radii.

CONCLUSION

In this article we have illustrated the design of the development of transverse kicker for BEPCII and emphatically introduced important parameter, such as shunt impedance, power reflecting factor and power transmission efficiency. In simulating experiment, we designed the transverse kicker as a four striplines type so that it is able to operate in x and y direction at the same time. We finally calculated the shunt impedance is 1500 Ω by the use of HFSS while the length of stripline is 300 mm. Then we could easily calculate that the beam bunch instability can be suppressed if the power is 120 W. In transmission simulation, power reflecting factor was lower than 1% and power transmission efficiency was more than 99%.

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