THE OPTIMIZATION OF TRANSVERSE STRIPLINE KICKER

H. P. Hsueh#, Y. P. Chang, Y. C. Yang, C. C. Chang, Y. T. Cheng, G. Y. Hsiung, NSRRC, Hsinchu, Taiwan, ROC
J. R. Chen, NSRRC, Hsinchu, Taiwan, ROC / NTHU, Hsinchu, Taiwan, ROC

Abstract

The construction of a new 3 GeV synchrotron facility, Taiwan Photon Source (TPS), is ongoing. It is required to install stripline kickers to suppress instability generated by mismatch between injection kickers or imperfect installation of vacuum components all around. First, the design philosophy will be described for transverse stripline kickers. HFSS electromagnetic simulation software is used to optimize structure parameters like electrode dimensions, electrode distance from vacuum chambers etc. to make transverse stripline kicker working more efficiently and effectively. Simulation results will be presented in this paper and all structure dimension choices will be discussed.

INTRODUCTION

Since the transverse stripline kicker was introduced in 1993[1], it has been used extensively in all synchrotron light sources. With shorter bunch and lower emittance, it is necessary to optimize the design of transverse stripline kicker to reduce wake field heating on kicker, and also to maintain low insertion loss and high return loss. Also to simplify the design with more space in straight section to spare, we separate the kicking in vertical and horizontal direction into two independent transverse stripline kickers. First, the equivalent circuit will be introduced. Second, the design considerations will also be introduced. Finally, the simulated results will be presented and discussed.

EQUIVALENT CIRCUIT

The uni-directional transverse stripline kicker can be seen as coupled line directional couplers[2]. The coupled line directional couplers have many different types. The uni-directional transverse stripline kicker is just the stacked coupled stripline type[3]. This stacked coupled stripline is operated in the arbitrary combination of even mode and odd mode. The impedance of even mode and odd mode are as follows[3]:

$$Z_{0e} = \sqrt{\frac{\mu_0}{\varepsilon_0}}\frac{b^2 - S^2}{4bW}\frac{1}{\sqrt{\varepsilon_r}} \quad (1)$$

$$Z_{0o} = \sqrt{\frac{\mu_0}{\varepsilon_0}}\frac{1}{2W\sqrt{\varepsilon_r}\left[\frac{2b}{b^2 - S^2} + \frac{1}{S}\right]} \quad (2)$$

$$Z_0 = \sqrt{Z_{0e} \cdot Z_{0o}} \quad (3)$$

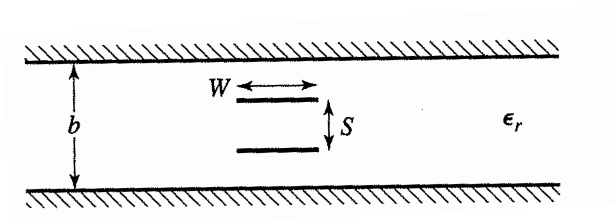


Figure 1: Coupled line directional couplers structure for transverse stripline kickers[3].

With above equations, proper dimensions can be decided before any HFSS simulation started. Since the inner dimensions of TPS straight section vacuum system is 20x68mm racetrack shape. S has been determined to be 20mm. As for electrodes width and chamber height, the initial values were chosen to be W=40mm and b=114.24mm. The electrode length is also determined to be 300mm as all people used.

DESIGN CONSIDERATIONS

Reduce Wake Field Heating

To reduce wake field heating, it is necessary to reduce the coupling impedance. The most effective way is to decrease the gap between electrode and nearby grounded vacuum chamber especially in the beam direction[4]. Since the targeted bunch length is 2.86mm for TPS, the gap much smaller than this number is desired. We have chosen 1mm as the starting gap size for HFSS simulation.

Transmission Line Transitions

The power will be input from coaxial cables into stripline kickers. It is essential to have low insertion loss and high return loss to have more power into working and less power reflected. It is essential to have insertion loss less than 0.25dB and return loss higher than 15dB near working frequency range (499.67MHz as our RF frequency)[5]. Otherwise, most power will be reflected even before it enters the electrode. Both edge-mounted transitions and vertical mounted transitions have been used in HFSS simulations.

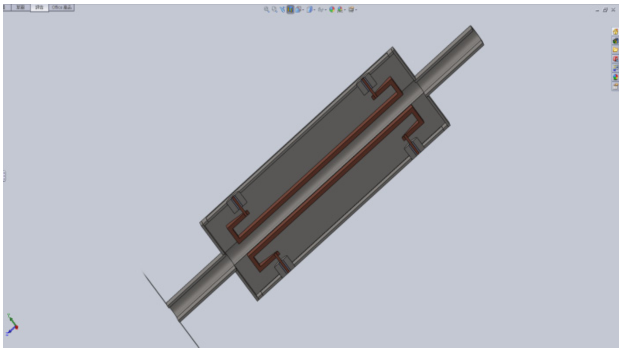
SIMULATION RESULTS

Initial Structure Results

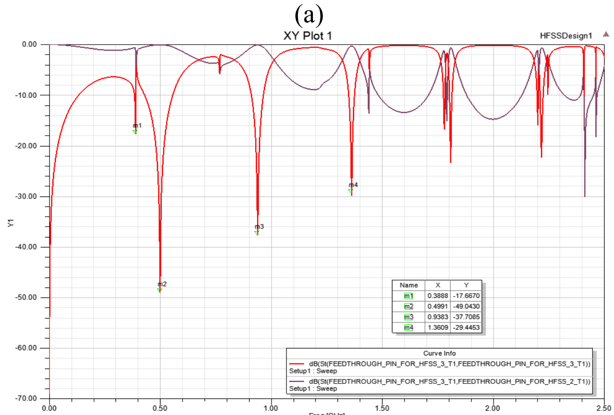
Initially, the electrode structure and chamber structure are both designed to be simple and similar to other

#hxh167@nsrrc.org.tw

synchrotrons. Just made some simple change to adapt to TPS chamber shape and size (Figure 2.). HFSS 15.0 has been used for all simulation results.



(a)

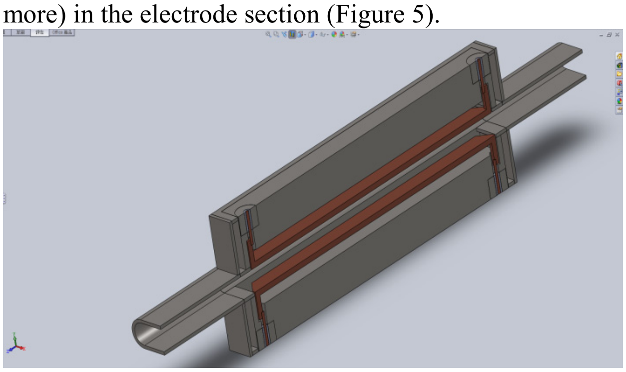


(b)

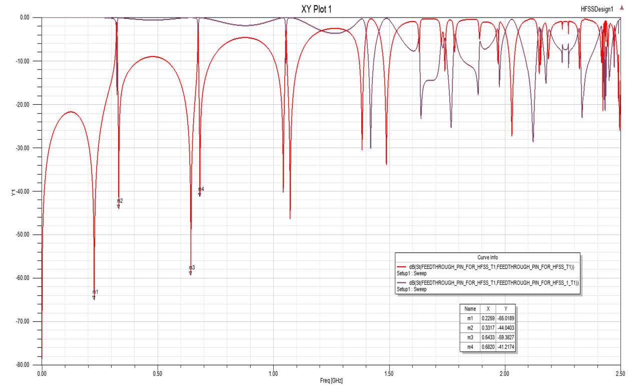
Figure 2: (a) Simple transverse stripline kicker structure. (b) HFSS result for S11 and S21.

Change Transmission Line Transitions

Since the power transmitted didn't look good in above case in most frequency range, it is desired to have a better transmission line transition. It is then changed from vertical mounted transitions to edge mounted transitions (Figure 3). To further improve the transitions, a cone is added to the pin of feedthrough to further smooth the transition (Figure 4). To this stage, it is very obvious from the simulated TDR results that the signal travelled at 80% of light in coaxial section and near speed of light (95% or more) in the electrode section (Figure 5).

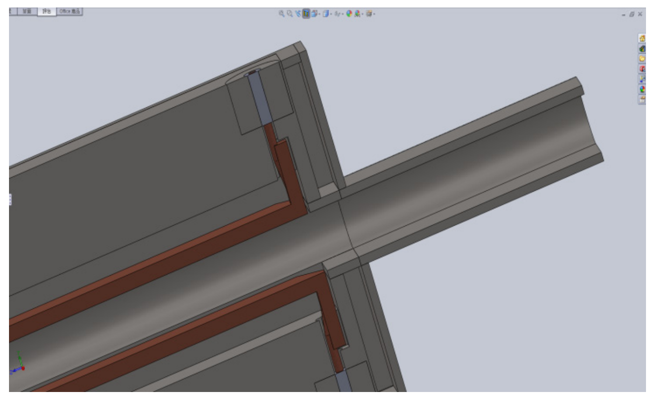


(a)

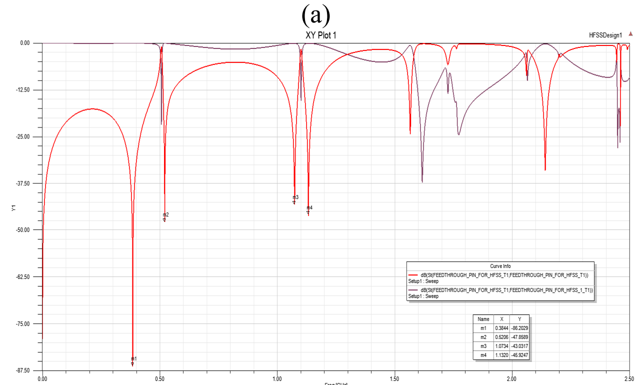


(b)

Figure 3: (a) A more complicated structure with distance estimated from Eq. (1)-(3) and edge mounted transitions. (b) HFSS result for S11 and S21.



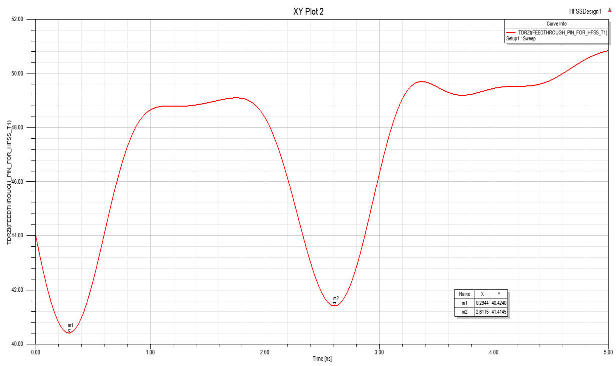
(a)



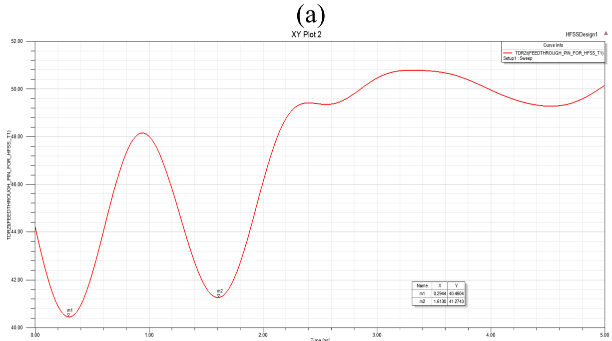
(b)

Figure 4: (a) A more complicated structure with distance estimated from Eq. (1)-(3) and edge mounted transitions. (b) HFSS result for S11 and S21. A cone was added here.

ISBN 978-3-95450-122-9



(a)



(b)

Figure 5: (a) HFSS result for TDR with 300mm electrode. (b) HFSS result for TDR with 150mm electrode. The impedance mismatch dip happened at the transition from coaxial feedthrough to electrode.

DISCUSSION

The results of HFSS simulation on vertical stripline kicker have been presented. The results are very similar to the cases predicted in regular microwave engineering textbooks. The next step is to build actual test pieces just as the design presented here and compare the TDR and network analyzer measurements with the simulated results.

REFERENCES

[1] J. N. Corlett et al., "Logitudinal and Transverse Feedback Kickers for the ALS," EPAC'94, p. 1625 (1994); http://www.JACoW.org

[2] C. Deibele, "Synthesis and Considerations for Optimally Matching to a Beam Position Monitor Circuit Impedance," SNS-NOTE-DIAG-31, 2002, http://it.sns.ornl.gov/asd/public/pdf/sns0031/sns0031.pdf ; see also sns0010, 42, 79.

[3] D. M. Pozar, *Microwave Engineering*, (Hoboken, NJ: John Wiley & Sons, Inc., 2005 3rd Edition), p. 337.

[4] U. Iriso et al., "Design of The Stripline and Kickers for ALBA", DIPAC'09, Basel, Switzerland, 2009, MOPD18, p. 86 (2009); http://www.JACoW.org

[5] E. Holzman, *Essentials of RF and Microwave Grounding*, (Artech House, 2005), p. 85.