A DESIGN OF INPUT COUPLER FOR RF-CAVITY

T. Nagatsuka, T. Koseki, Y. Kamiya, M. Izawa[A] and Y. Terada[B]

Institute for Solid State Physcis (ISSP), The University of Tokyo
3-2-1, Midori-cho, Tanashi, Tokyo 188, Japan

[A]Photon Factory, National Laboratory for High Energy Physics (KEK)
1-1 Oho, Tsukuba, Ibaraki 305, Japan

Technical Research Institute, Hitachi-Zosen Corporation
2-2-11, Funa-machi, Taisho, Osaka 551, Japan

I. INTRODUCTION

Characteristics of a newly designed input coupler are presented. The coupler was designed for a 500 Mhz damped cavity [1] to be installed in the high-brilliant VUV and soft X-ray synchrotron radiation ring planned at ISSP [2] and in the Photon Factory (PF) storage ring with a high brilliant configuration [3]. The design study of the coupler has been done mainly using the computer code, High Frequency Structure Simulator (HFSS, HP85180A), which can calculate the S-parameters of high frequency structures.

II. CHECK OF APPLICABILITY OF HFSS

At first, we compared the results of HFSS with experimental results in order to examine how HFSS realizes the rf characteristics of the structure such as input coupler. We simulated the microwave transmission in a cold model of coupler for 714 Mhz cavity to be installed in ATF (Accelerator Test Facility) at KEK [4]. The model coupler was fabricated by TOSHIBA Corp. Figure 1 shows the frequency dependence of VSWR of the coupler. Both results of calculation by HFSS and measurement by TOSHIBA are plotted in the figure. Though a small difference between them is seen, it can be inerpreted as due to the reflection at the transformers; a coaxial-rectangle transformer and D - N transformer were used in the measurement and both of them had VSWR of about 1.05. We may conclude from the above that HFSS is well suited to a design of an input coupler.

III. CALCULATION OF VSWR OF APS COUPLER

Figure 2 shows a schematic view of the input coupler which is used for the 508 Mhz alternating periodic structure (APS) cavity of the TRISTAN ring at KEK [5]. We chose the APS coupler as a starting point of our design study. The APS coupler consists of a coaxial line with a loop antenna, a cylindrical ceramic window and a rectangular waveguide. We calculated the transmission response of APS coupler without the loop antenna.

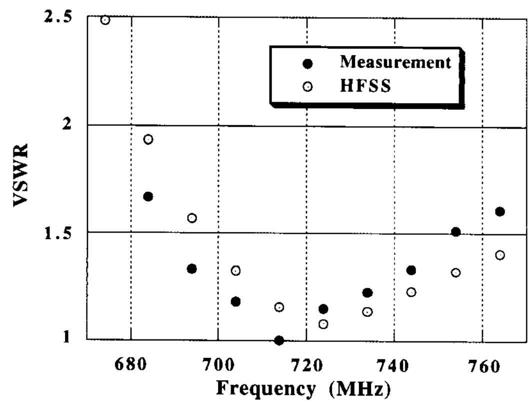

Figure 1: VSWR of the cold model of ATF input coupler.

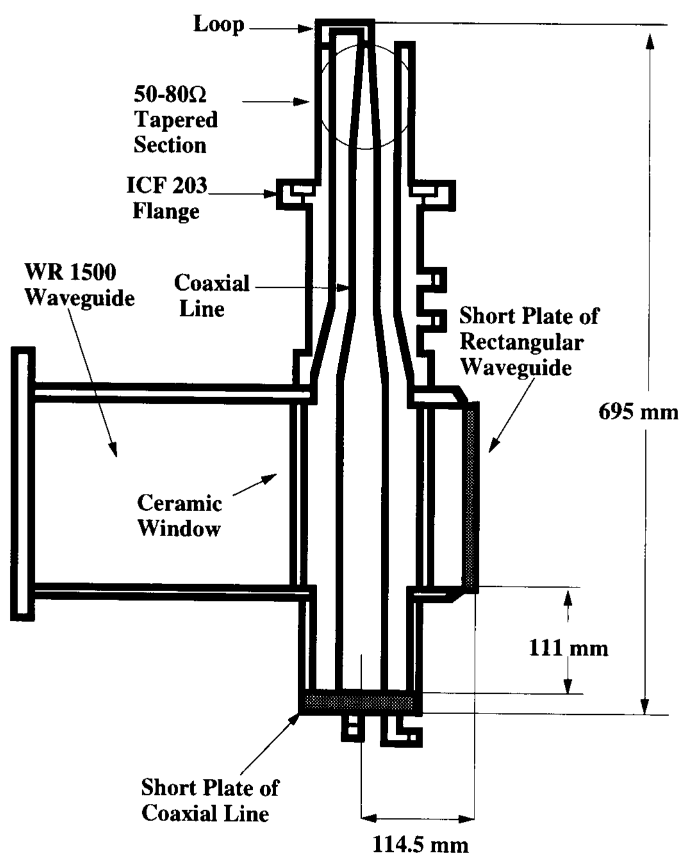

Figure 2: APS input coupler

The closed circles in Fig. 3 show the calculated values of VSWR. As shown in the figure, the VSWR at the operating frequency of 508 Mhz is not close to unity but rather large. This coupler has a tapered section at the end of coaxial line (see Fig. 2), which transforms the characteristic impedance Z from 50 to 80Ω. This impedance transformation thus causes reflection: an approximation of discontinuous change in impedance gives VSWR ≅ 1.6, while another approximation of smooth change gives VSWR ≅ 1.48 very close to the calculated value at 515 Mhz, where without tapered section there is almost no reflection (see the open circles in Fig. 3). In the latter approximation, the reflection coefficient is expressed as,

$$\Gamma = \frac{1}{2}\int e^{-2j\beta z}\frac{d}{dz}\log Z(z)dz \quad ,$$

which gives $|\Gamma| \cong 0.194$.

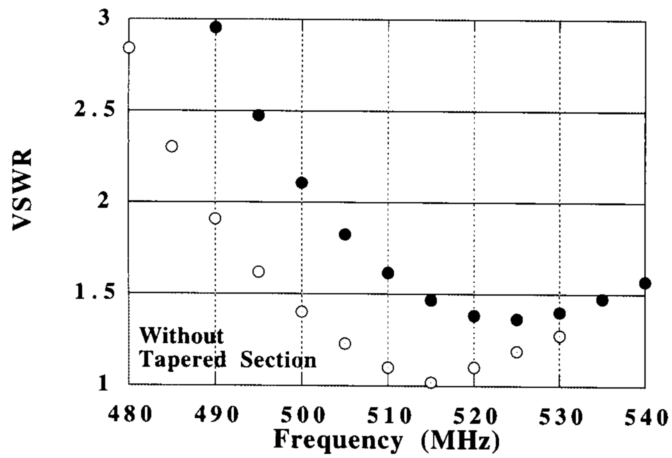

Figure 3: VSWR of APS coupler with and without tapered section.

IV. MEASUREMENT OF COUPLING COEFFICENT FOR TWO TYPES OF LOOP USING A PROTOTYPE CAVITY

In order to experimentally examine the effect of the tapered part on coupling coefficient, we made two types of coupling loop model. Figure 4 schematically shows the loop models; (a) has a straight coaxial wave guide and (b) has a tapered coaxial wave guide. We attached each type of model to the coupler port of a prototype cavity as described in Ref. [1] and measured the coupling coefficient β with a Network analyzer (HP8510C). Figure 5 shows the dependence of loop position on β. The tapered type has a smaller value of β than the straight type, though the former has aparently a larger cross-section for coupling to the magnetic field in the cavity. therefore we may conclude that the striaght type (Fig. 4(a)) is better suited to an input coupler than the tapered one.

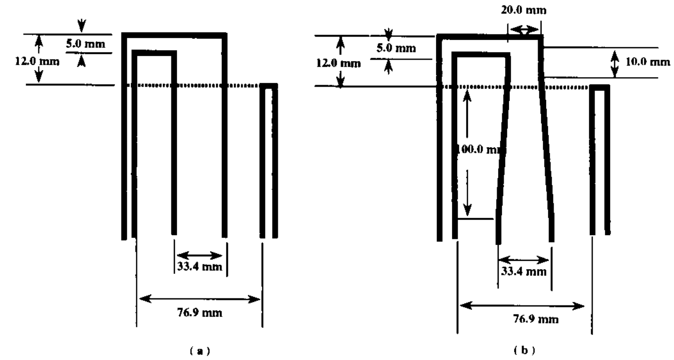

Figure 4: the model loops.

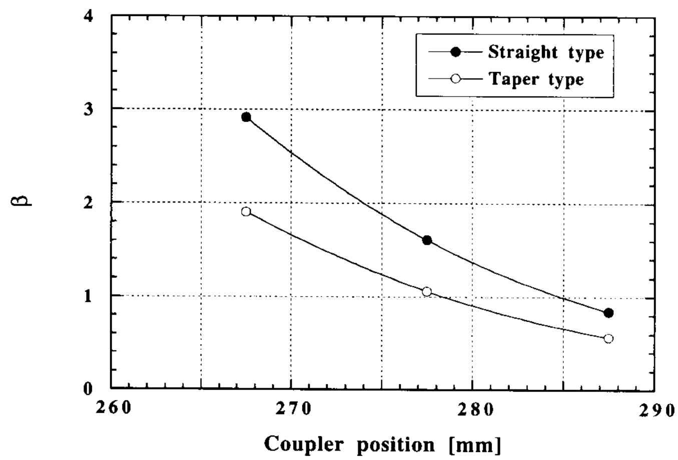

Figure 5: The dependence of loop position on β. the abscissa is the distance between the center of cavity and the broken lines indicated in Fig. 4.

V. FINAL DESIGN OF THE INPUT COUPLER

In order to obtain low-loss transmission of 500 Mhz microwave through the input coupler, we adjusted the positions of the short plates of rectangular waveguide and coaxial line by using HFSS (see fig. 2). The frequency at a minimum value of VSWR tends to change with the position of the short plate of coaxial line (Fig. 6), while the minimum value itself does with the position of the short plate of rectangular waveguide (Fig. 7). the lowest value of VSWR at the frequency of 500 Mhz was obtained with both short plates located at 4.5 mm outside their original position of the APS coupler. The VSWR at the operating frequency of 500 Mhz is almost unity (Fig. 8).

A cold model of our new coupler has been fabricated and attached to a prototype cavity made of aluminum. the coupling loop was mounted at the position of 280 mm away from the center of cavity. The low power test showed that β is 1.35. it is equivalent to 2.27 for the cavity made of Cu. Recently, we fabricated the high power models of cavity and coupler (Fig. 9). the value of β was measured to 2.35 for the set of high power models.

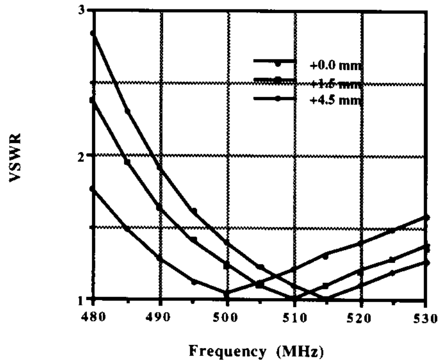

Figure 6: VSWR versus the position of short plate of coaxial line.

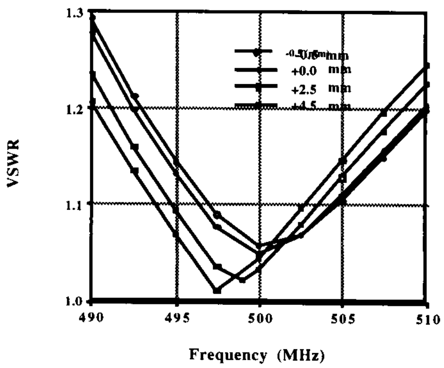

Figure 7: VSWR versus the position of short plate of rectangular waveguide. The position of short plate of coaxial line is fixed at 5.25 mm outside the position of APS coupler.

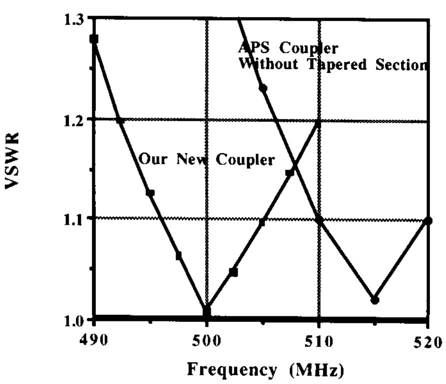

Figure 8: VSWR of our new coupler and that of APS coupler without its tapered section.

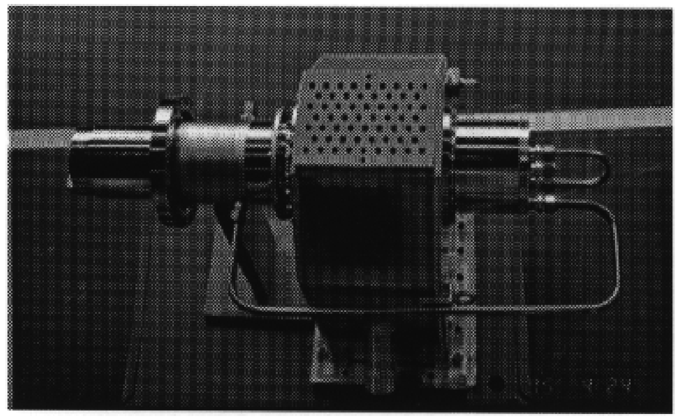

Figure 9: Our new coupler.

VII. REFERENCES

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