HOM COUPLER DEVELOPMENT
FOR SC LINAC OF JAERI/KEK JOINT PROJECT

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Abstract

A HOM (Higher Order Mode) coupler for a 600MHz superconducting linac of the JAERI/KEK Joint Project is described. Design of the coupler is based on coaxial line technique. The filter characteristics of the HOM coupler are calculated by using the HFSS code. The test results of the model HOM coupler are reported.

1 INTRODUCTION

JAERI is proposing the JAERI/KEK Joint Project [1] of a high intensity proton accelerator. Development of the SC(superconducting) linac has been carried out for this Joint Project. The driving frequency of the SC linac was chosen 600MHz. This paper describes the HOM coupler for the 600MHz SC linac. This HOM coupler is based on coaxial line technique used in the TTF(TESLA Test Facility)[2].

2 DEGISN OF HOM COUPLER

The equivalent circuit to the fundamental mode filter of the HOM coupler is shown in Figure 1 [3]. The filtering frequency f_e of this circuit corresponds to the fundamental frequency of the superconducting cavity so that it works for the band elimination filter (B.E.F). This frequency is given as a formula, $f_e = 1/\sqrt{L_f C_f}$. This frequency is varied by changing a length "d" of the coaxial line or a distance "g" of the gap (in Figure 2). The wider gap, i.e. the smaller capacitance C_f results in the higher resonant frequency. The shorter "d", i.e. the smaller inductance L_e also results in the high resonant frequency.

The frequency of a model coaxial line resonator is calculated with the SUPERFISH code. The result is

shown in Figure 2. The resonant frequency of the coaxial line resonator is 600MHz and corresponds to the fundamental frequency of the SC cavity.

A model HOM coupler shown in Figure 3 was designed referring this calculation result. This HOM coupler has the structure where a coaxial line length "d" and a gap length "g" are variable parameters.

The filter characteristics and the external Q-values were measured by using this HOM coupler.
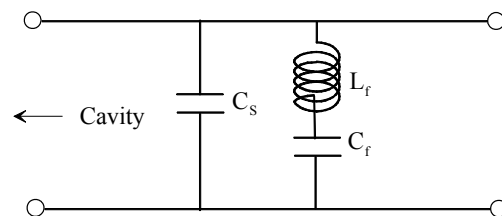

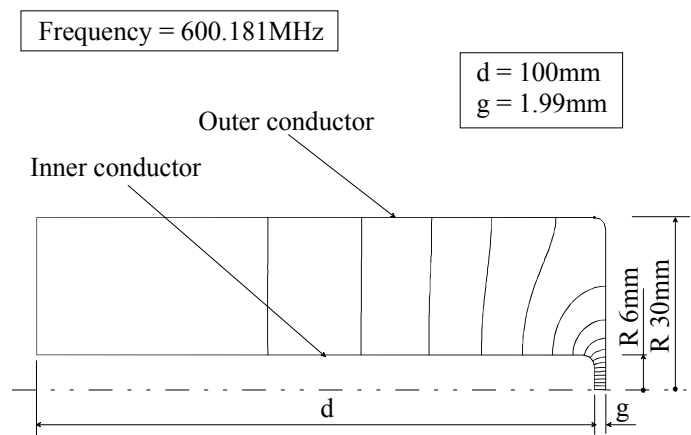Figure 1: Circuit model of fundamental mode filter

Figure 2: Resonant frequency of coaxial line

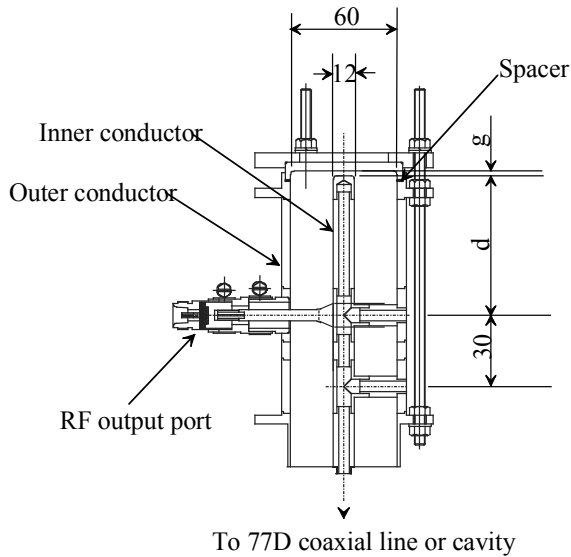[#] E-mail ; matsuoka@linac.tokai.jaeri.go.jp

Figure 3: Shape of model HOM coupler

3 EXPERIMENT

3.1 Filter Characteristics of HOM Coupler

The HOM coupler was measured using a network analyzer as shown in Figure 4. RF power is fed from the PORT 1 through a coaxial reducer. Transmitted power is picked up from the output port of HOM coupler (PORT 2). A photograph of measuring filter characteristics is shown in Figure 5.
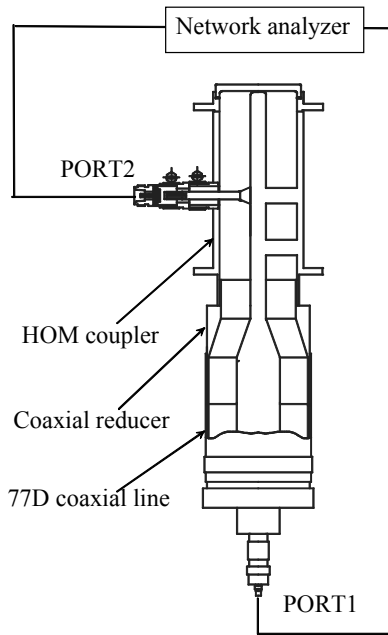

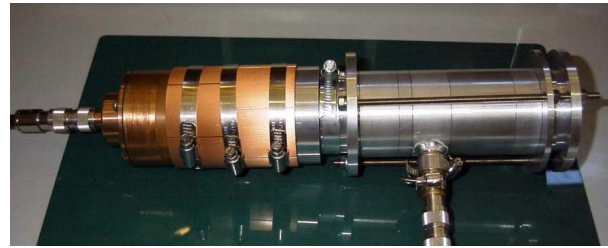Figure 4: Set up for measurements of filter characteristics

Figure 5: Measuring filter characteristics

The measured S_{21} parameter is shown in Figure 6. In this case, a coaxial line length "d" is 100mm and a gap length "g" is 2mm. The simulation with the HFSS code was carried out in the same condition as the measurement.

The model of this simulation is shown in Figure 7. The boundary condition of perfect conductor is chosen in the simulation. The result of this simulation is indicated in Figure 8. The filtering frequency of experimental result 596MHz is reasonable agreement with the simulated result 600MHz of which accuracy is about 5MHz.
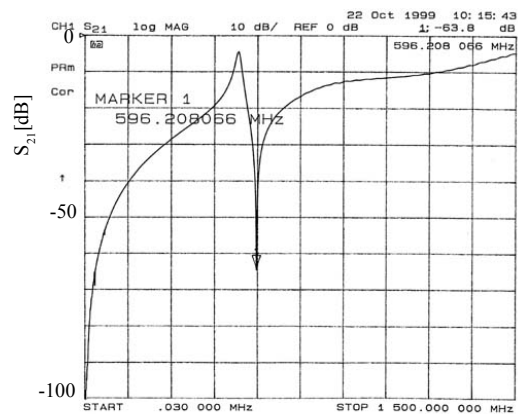

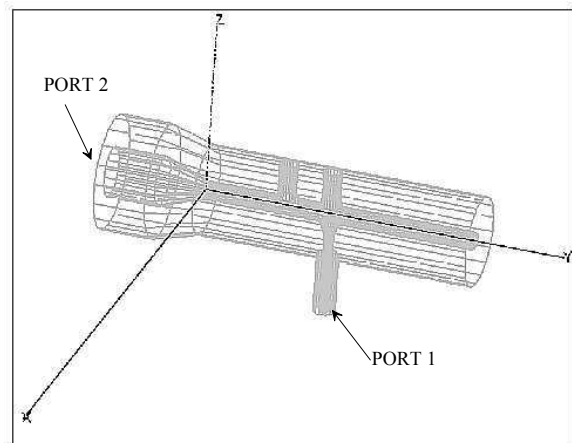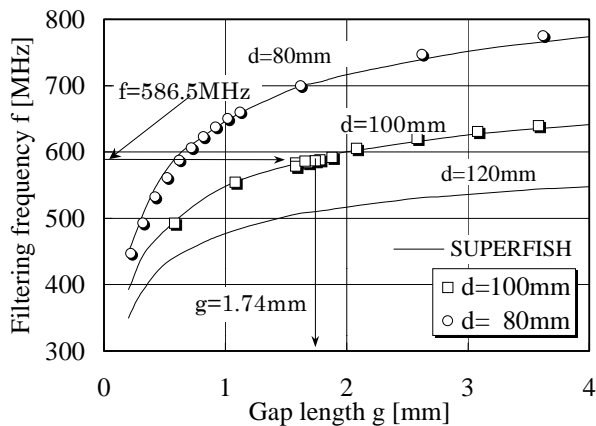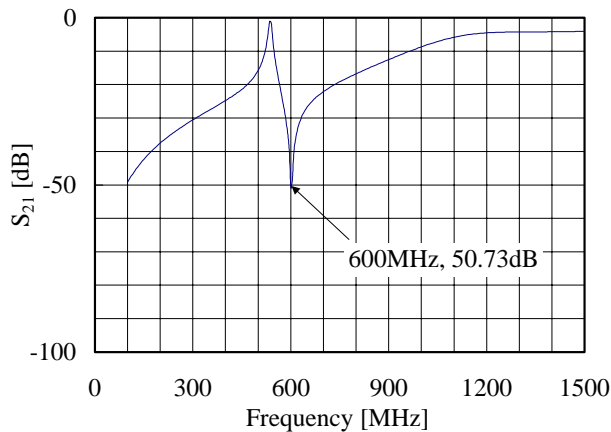Figure 6: Measured S_{21} parameter using the net work analyzer

Figure 7: Simulation model of HOM coupler for HFSS

Figure 8: Filter characteristics of HOM coupler

(graph showing 600MHz, 50.73dB)

(calculated with HFSS)

Figure 9: Measured filtering frequency of HOM coupler

The gap length dependence of the filtering frequency is plotted in Figure 9. In this figure, the solid lines indicate the results of calculation by using the SUPERFISH code. The measured data are consistent with the calculated curves.

The length of coaxial line d=100mm was chosen because the frequency sensitivity for the gap length "g" is moderate compared to that of d=80mm at 600MHz.

3.2 External Q-value of HOM

A single cell cavity made of copper was used to measure the external Q-values of the HOM coupler. The geometry of the single cell cavity is shown in Figure 10. The higher order modes of this cavity are calculated by using the MAFIA code.

The resonant frequencies are listed in Table 1.

The HOM coupler is connected to the beam pipe of the

single cell cavity as shown in Figure 11. The external Q-value was measured by using a network analyzer.

The photograph is shown in Figure 12. RF power was fed into the cavity from the RF input coupler, and transmitted power was picked up from the HOM coupler in the mono-pole mode (TM010). In case of di-pole modes, RF power was fed through the HOM coupler and the external Q-values were derived from the S_{11} parameters.

The gap length "g" of 1.74mm was selected properly referring to the result of the filter characteristics (Figure 9). However, to attain the maximum external Q-value, the fine-tuning of the gap length was needed because of the effect of the additional stray capacitance C_s shown in Figure 1. A fluctuation of gap length dependence of the external Q-value is shown in Figure 13. The external Q-value of the fundamental mode was sufficiently lower than that of HOM (TM110 or TE111) as shown in Table 2. Other modes are not measured here because resonant frequencies of them are higher than the cutoff frequency of the beam pipe. Their experimental Q-values depend on the beam pipe length strongly.
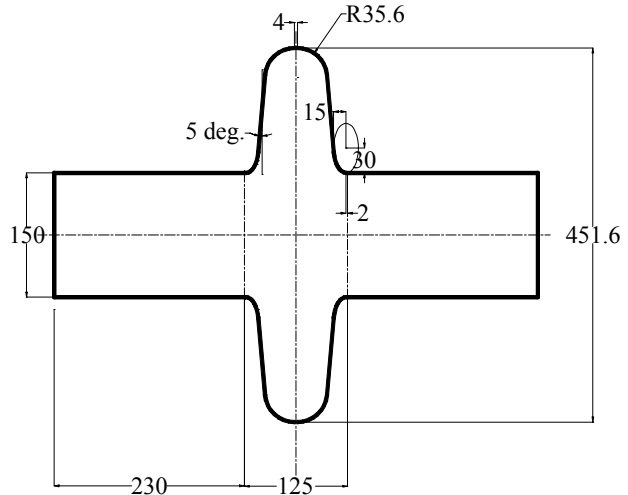

Figure 10: Geometry of single cell cavity

Table 1: Higher order modes of single cell cavity
(Calculated with the MAFIA code)

Unit :MHz

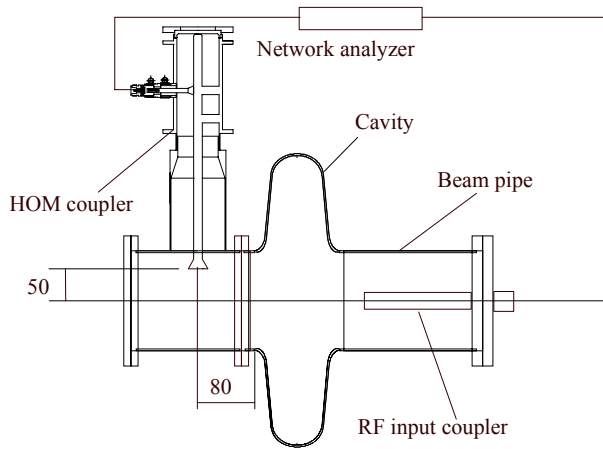| Mode	Frequency	Mode	Frequency
TM010	594.5	TM030	1868.5
TM110	813.0	TE112	1900.8
TE111	1046.9	TM021	2043.2
TM020	1267.4	TE121	2044.1
TM120	1594.6	TM130	2170.2
TM112	1810.4	TM021	2211.3
TM011	1849.1	TE122	2335.3

Figure 11: Set up for measuring external Q-values

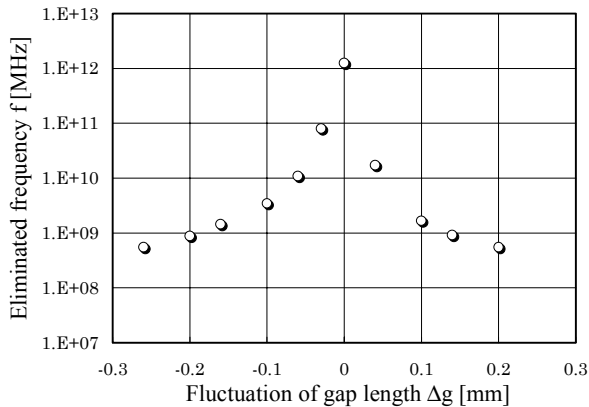

Figure 12: Measuring the external Q-values

Figure 13: Gap length fluctuation dependence of external
Q-values

Table 2: Experimental results of the external Q-values

Mode	Frequency	External Q
TM010	586.5MHz	1.6E11
TM110	815.2MHz	2.0E4
TE111	1098.1MHz	7.2E3

4 CONCLUSION

A HOM coupler model was designed by using the SUPERFISH code and fabricated. We obtained the RF characteristics of the HOM coupler that were consistent with the calculation results. The measured external Q-value of the fundamental mode is sufficiently lower than those of the HOMs.

The simulation of filter characteristics by using the HFSS code is useful in designing of HOM coupler with reasonable accuracy.

The HOM coupler based on the coaxial line has good adjustable feature for filtering frequency.

5 ACKNOWLEDGEMENT

6 REFERENCES

[1] The Joint Project Team of JAERI and KEK, "The Joint Project for High-Intensity Proton Accelerators", JAERI-Tech, 99-056,KEK Report99-4(1999).

[2] Jacek Sekutowicz, "Higher Order Mode Coupler for TESLA", Proc. of the 6th Workshop on RF Superconductivity, 1993, pp.426-439.

[3] E.Haebel, "Coupler, Tutorial and Update", Proc. of the 5th Workshop on RF Superconductivity, 1991, pp.334-353.