DAMPING OF HIGHER ORDER MODES BY HERA COAXIAL LINE TYPE COUPLER APPLIED TO 1.5 GHz ACCELERATING STRUCTURE

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Abstract HOM couplers for 500 MHz 4-cell sc HERA cavity have been developed and successfully tested at DESY. In this work, we describe a HOM coupler which is a simplified and rescaled version of these couplers suitable for accelerating structures with fundamental mode frequency in the range of 1.5 GHz. We present a basic design as well as results of RF measurement of a 5-cell 1.5 GHz cavity equipped with this coupler.

INTRODUCTION

HOM couplers for the 500 MHz 4-cell sc HERA cavity have been developed and tested at DESY. These couplers are based on coaxial line technique. We used two different types of couplers to reach the required strong damping for the high beam current of 60 mA. For application with less damping necessity only one type of broad band coupler might be needed.

It is clear that one can use a scaled version of the HERA couplers at lower fundamental mode (FM) frequencies. At higher frequencies, however, one might expect problems with mechanical tolerances. In this paper we describe a HOM-coupler for higher fundamental mode frequencies (1.5 GHz) based on the HERA coupler design. Advantages of this coupler are:

- easy cooling of inner conductor through two inductive stubs
- simple after machining adjustment by tuning of two capacitors,
- thermal isolation of inner conductor and output line
- small over all size.

COMPUTATION

We have computed the frequency spectrum up to 5 GHz of a 5-cell cavity of CORNELL/CEBAF design by URMEL (2). This helps us to select resonant modes with significant value of R/Q. We concentrated on damping of these modes. The first three columns

of Table 1 present type, frequency and R/Q of computed parasitic modes.
The computation showed that the 5-cell cavity has several trapped modes which have no electromagnetic fields in the beam tubes, therefore they cannot be damped by couplers placed at this location. Two members of the dipole passband TE_{121} (f_0 = 3480.8 MHz, f_0 = 3486.11 MHz) and one of passband TE_{112} (f_0 = 3488.38 MHz) have no field in the beam tube. Then Q_{ext} of these modes caused by any coupler mounted on the beam tube must be high.

THE CAVITY MODEL

To test the coupler model we have used the copper model of 1.5 GHz, 5-cell structure. Because of machining errors the cavity had a fundamental mode frequency f_{FM} = 1480.5 MHz. We have tuned the cavity to flatten the field distribution of FM, but it was mechanically impossible to get f_{FM} = 1.5 GHz. The cavity model had 4 ports for mounting HOM coupler at different distances from end cells. We will present here results obtained for the smallest distance 10 mm (Fig. 1). Column 4 of Table 1 contains frequencies of parasitic modes as measured for the copper model.

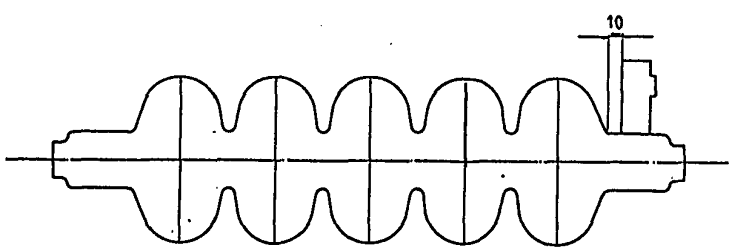

Fig. 1 5-cell cavity with HOM coupler

THE COUPLER DESIGN AND MEASUREMENT DATA

The tested version of the coupler is schematicly given in Fig. 2. The basic idea is similar to the 500 MHz design, however, it is not a simple rescaling of the HOM coupler, because as it was mentioned above we replaced the two types of HERA coupler (TM and TE coupler) by one type. The proposed design gives the settlement between damping of HOM and required mechanical tolerances. We have tested the FM filter sensitivity to machining or tuning errors in the case when coupler is mounted at the nearest to the end cell port. For the best tuned filter we have got FM Q_{ext} = $3*10^{12}$ and within ± 0.05 mm change of distance between the filter capacitor plates, Q_{ext} was still higher than $7*10^{9}$. One

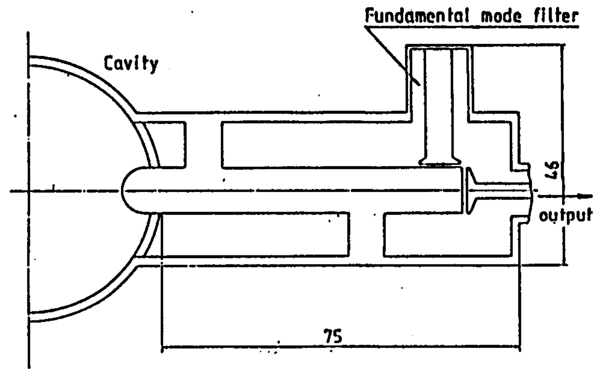

Fig.2 The outline of the HOM coupler.

should keep in mind that final tuning of the FM filter can be done when coupler is welded to the cavity (it is usual procedure with 500 MHz couplers, which allows us to reach FM $Q_{ext} > 2*10^{10}$). In the scope of this work only one coupler was built and attached to the cavity. The azimuthal position of the coupler was not optimized in respect to the polarization of the dipol modes. As consequence this one coupler cannot always effect both polarizations (see Table 1). Column 6 gives the product of computed R/Q and measured Q_{ext}. To get effective damping of both polarization of dipole modes one should equip the cavity with two couplers. It seems better to mount one coupler on each beam tube to avoid problems with modes which do not have flat field profile.

The measured transfer function of the coupler in the frequency range from 1 to 8.5 GHz is presented in Fig. 3. The transfer

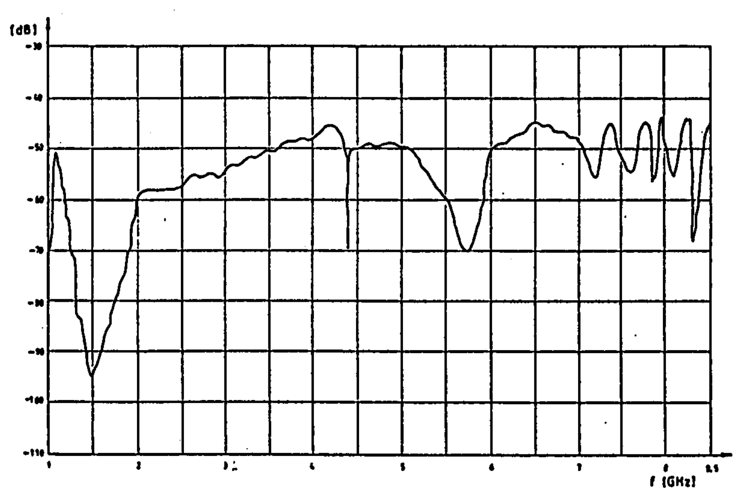

Fig.3 Transfer function of HOM coupler.

curve has two notches below 5 GHz. The first is the FM notch and causes high Q_{ext} for the fundamental mode. The second notch in vicinity of 4.425 GHz is not very deep and all HOMs in this region are well damped e.g. mode TM_{022}. The next notch is between 5.55 GHz and 5.8 GHz but modes in this range propagate well in beam tube and thus produce high enough fields at the HOM coupler port.

TABLE 1.HOM spectrum of 5-cell 1.5GHz cavity equipped with one HOM coupler.

MODE	Computed * (by URMEL-T)		Measured **		Impedance ***
	f_0(MHz)	R/Q (Ω)	f_0(MHz)	Q_{ext}	R/Q*Q_{ext} (KΩ)
TM_{011}	2730.59	3.68	2725.96	3.4×10^4	125.1
	2777.27	1.47	2753.44	7.7×10^3	11.3
	2817.59	20.37	2803.80	6.6×10^4	1344.4
	2864.84	97.19	2847.30	3.5×10^4	3401.7
TM_{020}	2990.99	35.08	2962.47	1.7×10^4	596.4
TM_{021}	3915.39	6.93	3908.00	3.4×10^3	23.6
	3957.35	2.47	3930.00	1.3×10^3	3.2
TM_{012}	4375.73	1.20	4366.00	3.1×10^5	368.9
	4385.36	29.43	4379.00	6.7×10^4	1971.8
TM_{022}	4440.37	3.59	4418.00	4.7×10^3	16.9
	4534.38	2.66	4479.00	3.0×10^3	8.1
TE_{111}	1826.14	14.61	1812.27 —	4.2×10^4 —	613.6 —
	1893.81	50.05	1883.67 —	8.3×10^3 —	415.4 —
TM_{110}	2079.74	19.39	2059.81 2061.09	1.3×10^4 2.8×10^4	252.1 542.9
	2102.37	25.40	2084.89 2086.92	1.4×10^4 1.2×10^4	355.6 304.8
	2124.83	6.48	2097.65 —	2.7×10^4 —	175.0 —
	2126.56	1.74	2103.99 2104.39	4.2×10^5 1.7×10^5	730.8 295.8
TM_{111}	2685.28	2.05	2678.62 2680.11	4.5×10^3 8.2×10^2	9.2 1.7
	2884.03	1.52	2822.08 2827.60	5.5×10^3 2.4×10^3	8.4 3.6
TM_{121}	2952.73	47.42	2898.70 2900.00	9.0×10^3 6.4×10^3	455.2 303.5
	3213.14	6.50	3060.30 3067.30	6.0×10^2 6.0×10^2	3.9 3.9
	3397.01	3.13	3383.80 —	6.8×10^3 —	21.3 —
TE_{121}	3433.20	16.77	3385.00 —	3.8×10^4 —	637.3 —
	3482.26	1.77	3461.82 3462.54	1.1×10^7 1.4×10^6	19470.0 2478.0
	3482.70	1.37	3468.01 —	2.2×10^8 —	301400 —
	3500.76	2.01	3474.31 3475.90	2.1×10^6 4.2×10^6	4221.0 8442.0
TM_{112}	4381.15	2.66	4331.08 —	1.2×10^4 —	31.9 —
	4399.20	2.26	4392.66 4393.34	2.2×10^6 3.7×10^4	5016.0 84.4

NOTE : * Computed by URMEL-T. For the Dipole Mode R/Q is calculated 22.8mm off axis.
** Measured on Copper Model Equipped with a HOM Coupler.
*** Resulting Impedance: R/Q*Q_{ext}

CONCLUSION

The measurements results have shown that the coaxial line type coupler can provide good damping of HOM resonances also for cavities with higher FM frequency. The mechanical tolerances seem to be not critical for the coupler design. We can also conclude that in case of higher damping requirements rescaling of both HERA HOM coupler should be possible.

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