QUADRUPOLE COUNTER MIXING CHOKE STRUCTURE FOR THE KEKB ARES CAVITY

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Abstract

The KEKB ARES cavity employs the choke-mode cavity as its accelerating part. The choke keeps the fundamental RF energy from absorbed by the HOM damper when the cavity is made axially symmetric. If there are multipole components in the cavity, they would pass through the choke and degrade the Q value of the cavity. In the case of ARES, dipole and quadrupole components are the problem since higher multipole components cannot propagate through the coaxial line to the damper because of their cutoff frequency. The choke-mode cavity of ARES necessarily has a coupling slot to the coupling cavity. Although another slot for counter-balancing is attached so that the field inside the cavity does not have a dipole component, quadrupole component still remains. In order to avoid the degradation in Q value from the quadrupole component, the choke is deformed to have twofold symmetry. Part of the monopole component is converted to quadrupole by the deformation, with which the quadrupole field propagating to the HOM absorber is cancelled. The performance of this choke was confirmed by measurement.

1 INTRODUCTION

ARES is a normal conducting cavity which is now under development for KEKB[1-7]. It consists of three simple cavities: an accelerating (a-) cavity, an energy storage (s-) cavity and a coupling (c-) cavity. These three cavities are coupled in series through irises (Fig. 1). The a-cavity is a chokemode cavity[8]. It is a damped cavity in which the power from the klystron is confined in the cavity by the choke while the field of higher order modes excited by the beam passes the choke and are absorbed by the SiC HOM damper.

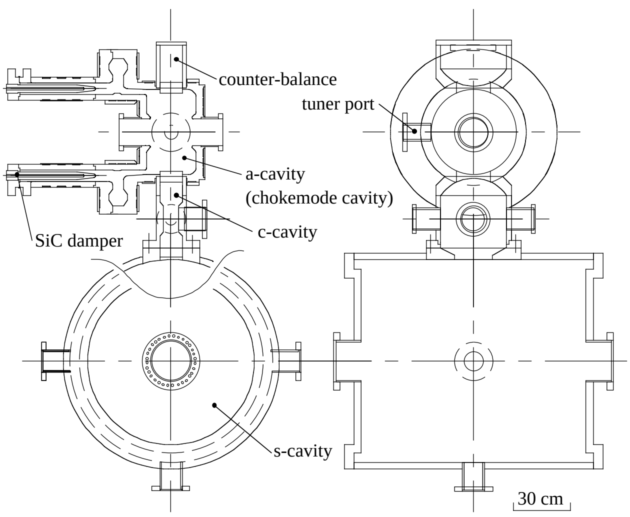

Fig. 1 ARES cavity for KEKB.

Although the chokemode cavity itself is axially symmetric, the coupling iris between the a- and c-cavity generates multipole components in the accelerating $\pi/2$ mode. These multipole components are not stopped by the choke and degrade the Q value since the notch frequency for multipole modes is different from that of the monopole mode. The counter-balance is attached on the wall of the a-cavity on the opposite side of the c-cavity in order to cancel the dipole component in the $\pi/2$ mode. Then the transverse gradient of the accelerating voltage at the beam centre is cancelled. The multipole components higher than quadrupole do not propagate in the coaxial line connecting the main cell of the a-cavity with the HOM damper, since the cutoff frequency is higher than the RF frequency for these components. Thus the problem only arises from the quadrupole component. There are some possible solutions to this:

i) Increase the number of counter-balance to 2 so that dipole and quadrupole components be cancelled in the a-cavity at the same time.

ii) Reduce the radial size of the coaxial line to shift the cutoff frequency of the quadrupole mode to higher than the RF frequency.

iii) Deform some other part of the cavity so that the quadrupole component vanishes before it reaches the HOM damper.

For the ARES cavity the solution (iii) is employed. The drawback of solution (i) is that it would make the fabrication more complicated and the wall current between the three irises more concentrated. The next solution (ii) would increase the external Q to the coaxial line for higher order modes and their impedance also.

The principle and the design procedure is described in sections 2 and 3. The measurement of the Al 1/5 scale cold model and the ARES a-cavity is reported in the section 4.

2 PRINCIPLE OF QCM

The QCM choke is shown in Fig. 2. Two grooves of quarter circle are made on the side wall of the choke. The phase of the grooves around the beam axis is in quadrature from the counter-balance and the c-cavity, i.e., they are equally

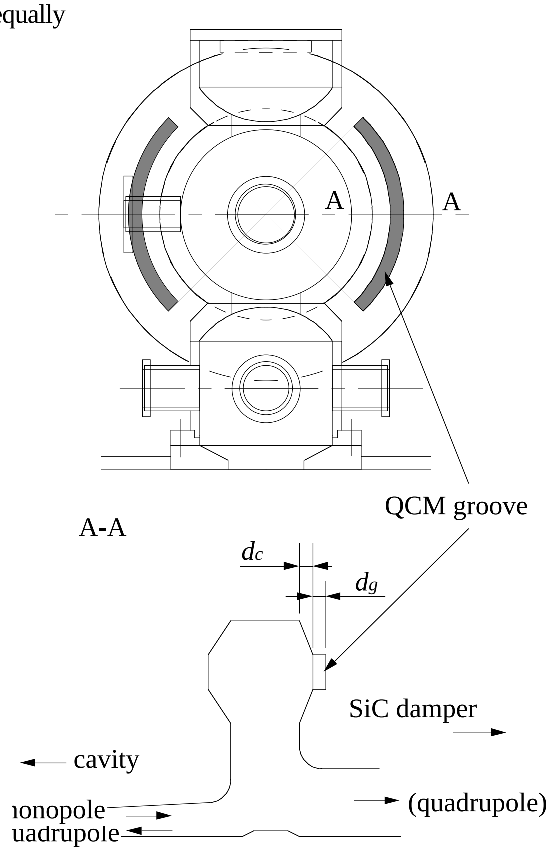

Fig. 2 QCM choke. Two grooves are on the side wall of the choke.

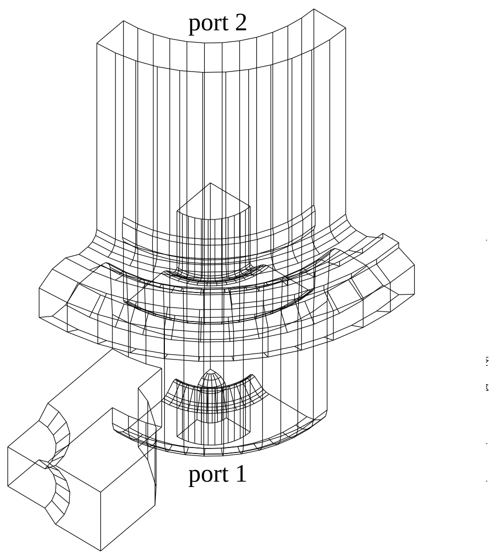

Fig. 3 HFSS model used in the design of the QCM choke.

spaced around the axis. As the incident monopole field passes by the grooves, it generates quadrupole (and octupole, etc.) component. Part of the generated quadrupole field propagates to the HOM damper. If the amplitude of this quadrupole component is the same as the quadrupole component that passes through the choke and if their phase is opposite to each other, there is no quadrupole field absorbed by the HOM damper.

3 DESIGN

The dimensions of QCM choke was designed with HFSS (High Frequency Structure Simulator from HP). The model used in designing is shown in Fig. 3. Only a quarter of the a-cavity is modelled utilising the fact that the $\pi/2$ mode of ARES is almost unchanged even if there is a short plane at the centre of the c-cavity. Two parameters were adjusted so that the transmission from the monopole field in port 1 to both the monopole and quadrupole field in port 2 at the operating frequency be minimum. One is the depth of the shallow annular groove d_c, by which the notch frequency for monopole mode can be adjusted mainly. The other is the depth of the two grooves d_g, which changes both the notch frequency for monopole mode and the amplitude of quadrupole generation. The tuning process is several cycles of i) adjusting d_g to minimise the quadrupole component, and then ii) adjusting d_c to minimise the monopole component.

4 MEASUREMENT

4.1 1/5 scale Al cold model

A 1/5 scale Al cold model with two counter-balance was fabricated to confirm the basic function of the QCM

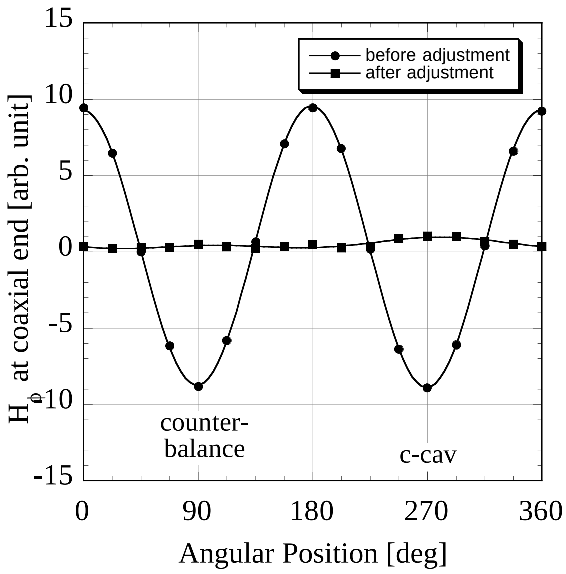

Fig. 4 Measured field that passed through the QCM choke in the middle of its adjusting stage (1/5 Al cold model).

Table 1 QCM dimensions by HFSS calculation and 1/5 cold model. The values for 1/5 scale cold model are multiplied by a factor of 5.

	d_c [mm]	d_g [mm]
HFSS calculation	12.9	23.2
1/5 cold model	12.0	22.5

choke and to determine its dimension precisely. It is detachable at the middle of the choke. First, a choke without QCM grooves is attached. The Q value with HOM damper, which was rubber-type ferrite sheet in this measurement, was 4.5×10^3 while it was 7.5×10^3 without the damper. This shows that the choke mode cavity is not usable for ARES without any remedy. Next, a QCM choke was attached. Its d_c and d_g are smaller than calculated value described above to allow fine adjustment by machining. The adjustment was done carefully increasing d_c and d_g. The transmission from the end wall of the main cell to the end of the coaxial line was measured without damper as a function of the angular position of the 2nd pickup loop. The amplitude of multipole components changes as the tuner at the side wall of the main cell moves. The dimensions d_c and d_g were adjusted to make the monopole and quadrupole components minimum when the tuner is at the expected operational position. The result is shown in Fig. 4. The amplitude and phase of multipole modes is determined by fitting the measured data to the form

$$a_0 + a_1 \cos(\theta - \theta_1) + a_2 \cos(2\theta - \theta_2) ,$$

which is shown as the solid curves in the figure. The final

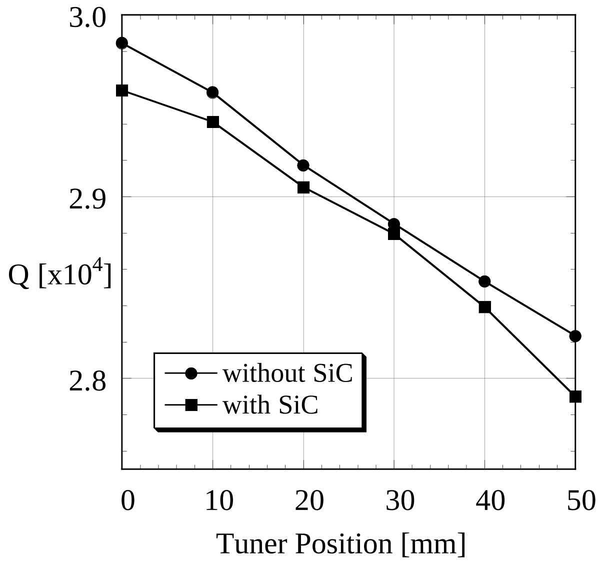

Fig. 5 Measured Q value of the first ARES high-power model with and without SiC damper in the chokemode cavity.

value of d_c and d_g are listed in Table 1 together with the calculated value. The Q value with or without the ferrite damper were the same within the precision of the measurement.

4.2 ARES a-cavity

The QCM choke of the first high-power model of ARES was fabricated according to the dimensions of the cold model above. The RF characteristics of the QCM choke was measured with the a-cavity to which the counter balance and 3/4 of the c-cavity are attached by brazing to form one component. The s-cavity and remaining 1/4 of the c-cavity is connected to the a-cavity component by flanges.

For the measurement of the QCM choke, the opening of the c-cavity was closed by a metal plate and a metal bar with a thickness of 150 mm was fixed at the centre of the c-cavity so that the c-cavity is detuned. The measured Q value is plotted as a function of the position of the tuner in Fig. 5. The circles and squares in Fig. 5 represents the Q value with and without the SiC damper, respectively. The degradation of the Q value is minimum when the tuner top is about 2~30 mm from the inner surface of a-cavity as we intended.

CONCLUSION

The choke of the chokemode cavity of KEKB ARES cavity is modified to the QCM choke to prevent the quadrupole component from absorbed by the HOM damper. The measurementshowed that the QCM choke works as expected.

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