FERRITE TEST CAVITY FOR MUSES

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Abstract

A ferrite test cavity was designed and manufactured for investigating the permeability, magnetic Q-value and the high loss limit of a ferrite with the size of 5 inch (I.D), 8 inch (O.D) and 1 inch (thickness) at high RF input power in the frequency range 20MHz to 60MHz. The test cavity consists of three arms: one with a ferrite, one with a variable capacitor, and one with a fixed stub. These three arms are connected by one box, from which RF power (3kW maximum) is fed into cavity. The bias current (2500A maximum) hollow conductor is wound ten times around the ring of the ferrite and the upper parts of the conductor are removable for exchanging ferrite. The transmission line calculation shows that this test cavity has the resonance for the ferrite with permeability 2 to 20 and magmetic Q-value 5 to 200 by tuning the variable capacitor with 600pF in maximum. We measured the permeability and Q-value of a ferrite in this test cavity.

1 INTRODUCTION

A Booster Synchrotron Ring (BSR) is proposed for a storage ring system named MUSES (Multi-Use Experimental Storage rings) in RI beam factory project in Institute of Physical and Chemical Research (RIKEN). It is urgent to develop a ferrite cavity with the frequency range 25MHz to 53MHz, the voltage 25kV per one cavity (two cavities are to be placed in BSR), and the repetition frequency 1Hz.

We designed the ferrite cavity with these specifications in the drift tube type in the conceptual design of BSR and we need the ferrite with low RF loss and high threshold level of high loss phenomena [1]. We proposed the ferrite cavity with the size 5 inch (I.D), 8 inch (O.D) in ferrite.

There are a few types of ferrite which is expected to be used in a data book, but the data is not sufficient. It is necerrary to clear the following data, i.e. the relation between permeability and bias current, magnetic power density and a sweep rate in which the high loss effect appears, magnetic Q-value (Q_m) dependence on the power density in ferrite and the effect of ferrite temperature. Moreover these measurement have to be done in the ferrite with the size in its use. So we designed and manufactured a test cavity for investigating the RF properties of a ferrite. Table shows the parameters of the test cavity.

2 FERRITE TEST CAVITY

Fig.1 shows the schematic drawing of the ferrite test cavity. It consists of three coaxial arms: F, S, and C-arm. F and S-arms are aligned in line and form a $\lambda/2$ resonator loaded with tuning capacitance in C-arm. To cover the above frequency range in high power operation over the high loss threshold, a water cooled vacuume variable capacitor (30-650pF) was employed. Ferrite is tightly contacted with

Table Parameters of the ferrite test cavity

Cavity type	capacitor loaded $\lambda/2$ coaxial resonator
Frequency	20MHz - 60MHz
Ferrite size	5 inch (I.D) 8 inch (O.D) 1 inch (thick)
	400mm maxmun in O.D.
Tuning element	bias current and variable capacitor
Bias conductor	10 turns water cooled 235mm^2 hollow conductor
Cooling of ferrite	water in cooling plate
RF source	3kW solid state wide band amplifier
Bias current	2500A
Impedance matching	single variable capacitor in series

the cavity wall on both sides and cooled through the wall by water. The bias winding of ten turns are passing through inside the inner pipe and the upper parts of the conductor are removable for exchanging ferrite. Maximum bias current is set to be 2500A. Thus RF power is confined in the cavity and does not affect measurement system and biasing system. The overall picture is shown in Fig.2.

The desgin is analyzed based on a transmission line model. In this model, each part of the cavity is represented with equivalent coaxial line except a ferrite ring and a lumped capacitance. Ferrite ring is reperesented with radial mode transmission line. A few dimensional parameters are adjusted to match with the result of the high frequency structure simulation program.

The ferrite size is fixed to be 5 inches in inner diameter, 8 inches in outer diameter and 1 inch in thickness. We can measure another size of ferrite up to about 400mm O.D by replacing the ferrite vessel. The material of this cavity including fixed stub is almost aluminum except cooling parts.

3 IMPEDANCE MATCHING

Impedance matching between 50 Ω RF source and input impedance of the cavity is necessary to make test in high RF power level. Impedance conversion with single variable capacitor (6 - 500pF) in series was adopted. It is simple and practical but the demerit is that the tuning and the impedance matching interfere each other. The tuning and the impedance matching capacitance calculated as a function of frequency are shown in Fig.3 for μ=2 and μ=17. It is shown that the impedance matching can be obtained for a wide range of μ and Q_m. A current transformer and a voltage divider are installed at the entrance of the matching section to monitor the input impedance and the input RF power.

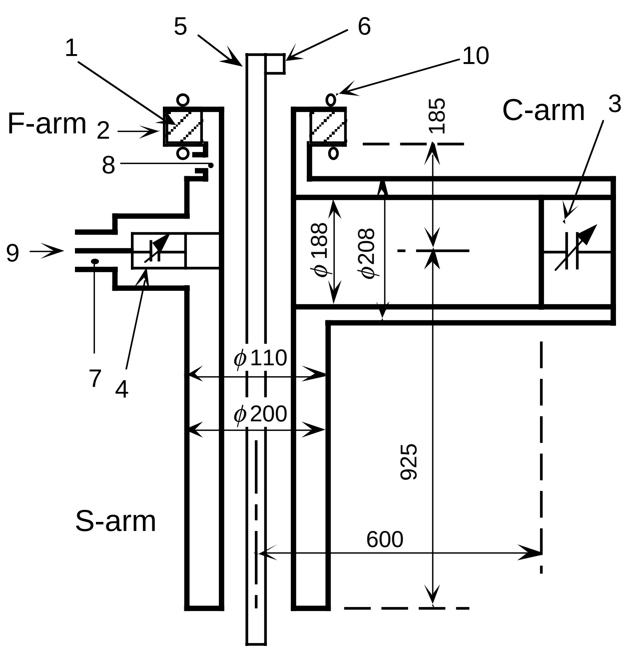

Figure 1: Schematic drawing of ferrite test cavity
1-ferrite ring; 2-ferrite vessel; 3-tuning capacitor; 4-impedance matching section; 5-bias current; 6-removable cross bar; 7-voltage and current monitor; 8-voltage monitor; 9-RF input terminal, 10-water cooling pipe

4 RESONANCE FREQUENCY AND Q-VALUE OF THE CAVITY

We measured resonance frequency and Q-value of this cavity with the empty ferrite vessel and without the impedance matching section. Figures 4 and 5 show the results. The markers represent the experiments and the solid line represents the calculation with ε=1 and μ=1 in the above model. The agreement is fairly good in Fig.4, but

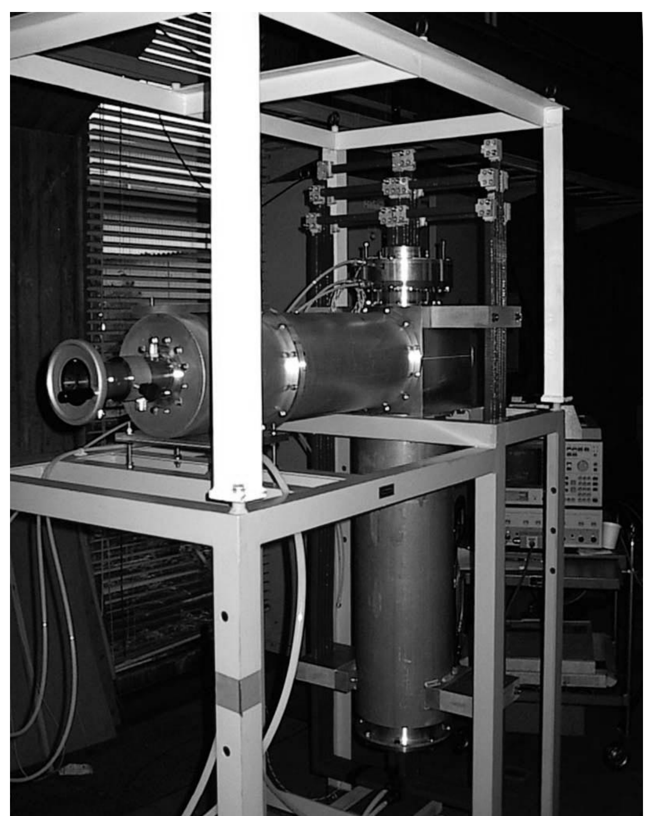

Figure 2: Overall picture

there is a little difference in Fig.5. In Fig.4 the calculated resonance frequencies for variout μ are also shown. We can see that the test cavity covers the required range in frequency and permiability.

5 TEST MEASUREMENT OF FERRITE

We measured resonance frequencies and Q-value of the test cavity loaded with a ferrite of M11E by TDK. The measurement was carried out at 10mW power level without the matching section and bias current. Q-values from 262 at 19MHz to 221 at 34MHz were obtained. From these data, mu and Qm of the ferrite was calculated by using the above model. The result is shown in Fig.6. The experiments with high RF input power and bias current are scheduled.

REFERENCES

[1] J.E. Griffin and G. Nicholls, "A review of Some Dynamic Loss Properties of Ni-Zn Accelerator RF System Ferrite", IEEE Trans. Nucl. Sci, NS-26, 3965 (1979).

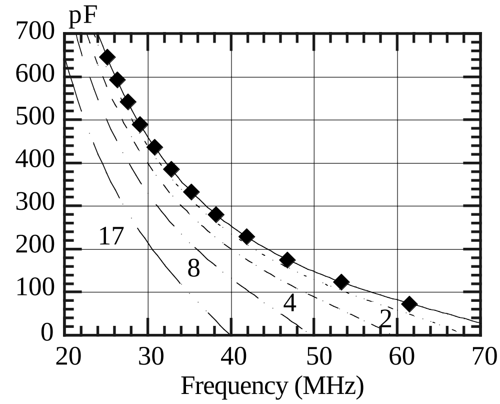

Figure 4: Tuning capacitance and frequency at resonance. Markers represent the experiment and solid line is obtained by calculation without ferrite. Dashed lines are by calculation with ferrite for various μ, which are represented in figure.

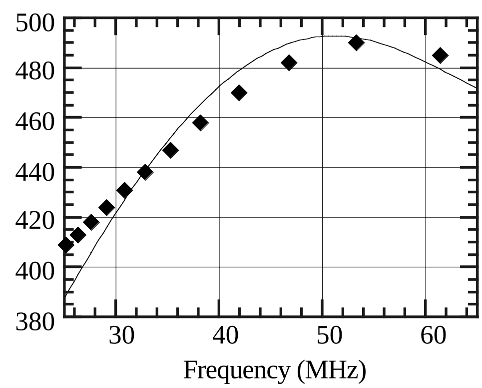

Figure 5: Resonance frequency and Q-value of the cavity without ferrite. Markes represent the experiment and the line is obtained by calculation.

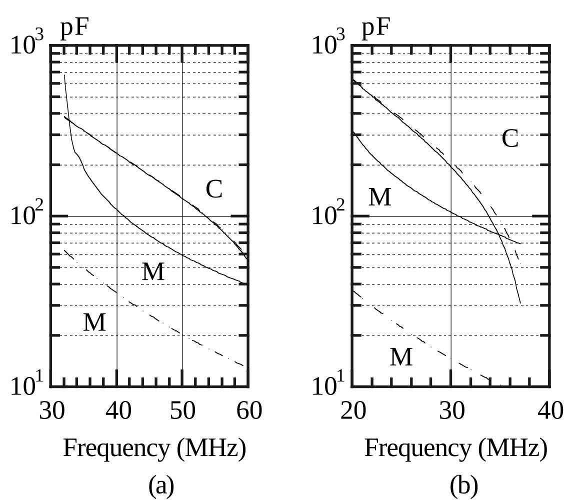

Figure 3: Tuning and impedance matching capacitance for μ=2 (a) and μ=17 (b). C means tuning and M matching capacitor. Solid lines are Q_m=20 (a), Q_m =10 (b) and dashed lines are Q_m=1000 for both cases. Tuning capacitances are almost same in Q_m=20 and Q_m =1000 for μ=2

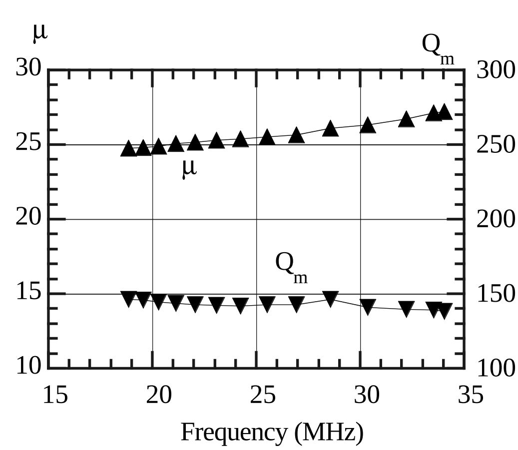

Figure 6: Measured μ and Q_m for a ferrite