HOM CHARACTERISTICS MEASUREMENT OF MINI-LIA CAVITY*

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Abstract

Mini-LIA[1] is a miniature linear induction accelerator designed and manufactured by China Academy of Engineering Physics and Tsinghua University in 2007. To investigate the higher order modes (HOM) of Mini-LIA cavity, especially the frequency and quality factor Q of the TM_{110} and TM_{120} in it, both numerical simulation and experiments were performed. Several models of the cavity were established and calculated by using E module of MAFIA code. Network analyzer was applied to measure the frequency and Q in cavity. Both the simulation results and the experiment results are presented in this paper. The results of the experiments were coincident with the calculated results. Finally, The HOM characteristic of Mini-LIA cavity with metglas core in it was explored, and some interesting results was obtained.

INTRODUCTION

Usually, there are tens of accelerating modules and several kilo amperes electron beam in a linear induction accelerator (LIA). Well controlled electron beam parameters are important in LIA because of its high current performance. The transport of high current electron beam through the entire accelerator requires low transverse wake potentials and therefore well damped higher order modes in the accelerating structures[2]. The HOM voltage which may drive the beam instability is proportional to the beam current and depends on the quality factor Q and the mode specific impedance R/Q. While R/Q for each mode can be calculated, the reliable value of Qs and frequencies can be obtained only from measurements[3]. To obtain this information for the Mini-LIA cavity, both numerical simulation and experimental measurements has been performed.

NUMERICAL SIMULATIONS AND HOM IDENTIFICATION

The Mini-LIA system consists of two induction accelerating cavities. Both of them were designed and manufactured in similar size. In order to get mode frequency and Q-value in the cavity, we used E module of MAFIA code to do numerical simulations. Fig. 1 is a cavity model established by MAFIA according to the size of Mini-LIA cavity. The MAFIA calculations were done for the single cavity.

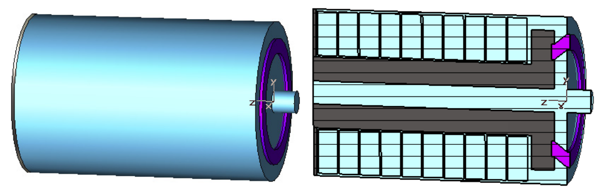

Figure 1: Cavity model of Mini-LIA

Table 1: Mode characteristics in an empty cavity model

Mode	Mode frequency (GHz)	Q-value
TM_{010}	1.239	1764.6
TM_{110}	1.790	2465.3
TM_{120}	2.194	4375.9
TM_{130}	3.009	4664.6

Table 1 shows the calculated characteristics of longitudinal and dipole modes in an empty cavity model found by MAFIA in the frequency range from 0.5GHz to 3.5GHz. It contains frequencies and Q-values which were obtained by setting the property parameters of inner surface material. In order to identify HOM from the simulation results, some HOM which we are interested in were specified by analyzing the distribution and shape of their E-field and H-field.

HOM MEASUREMENTS

There are four field probes sensitive to the voltage in the cell mounted in the cavity. Three are E-probes, one is H-probe. Fig. 2 is a picture of them.

We performed the direct HOM measurements of the cavity using a network analyzer. To excite resonant modes in the cavity one E-probe was used as port a of the network analyzer. Signals from one of the other three probes were input the network analyzer as port b. The spectrum contains all harmonics of the revolution frequency by measuring the S_{21} function.

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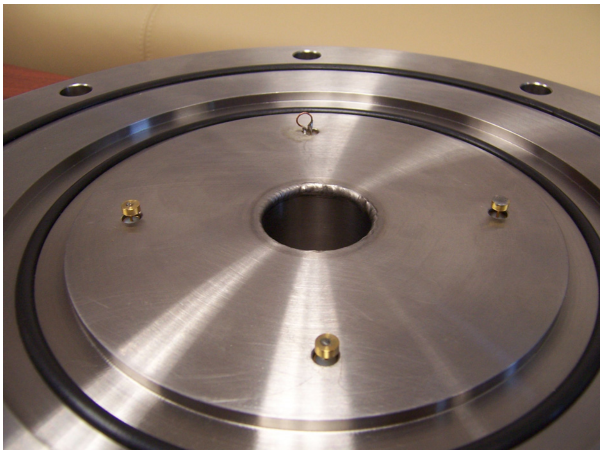

Figure 2: Field probes of Mini-LIA cavity

Note that the field probe sensitivity is different for different modes. It depends on the probe location and on the mode field pattern. The mode with the higher voltage may give the peak with smaller amplitude than the other one with the lower voltage. So, it would be wrong to compare measured peaks amplitude with calculated R/Q. Fig. 3 shows spectra of a signal picked from the E-field probe of the empty cavity. There is no doubt that the peaks in the spectra are related to the higher order modes. It was easily to identify peaks seen in spectra with calculated HOM. So we can say with certain which mode is responsible for the appearance of which peak. The frequency correlation between peaks and calculated HOM is able to be seen in Table 2.

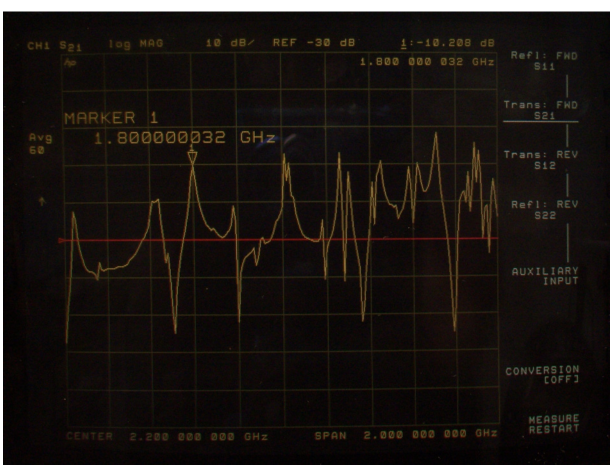

Figure 3: Spectra of the empty cavity

Table 2: Comparison between calculated and measured frequency in an empty cavity

Mode	Calculated frequency (GHz)	Peak frequency (GHz)
TM_{110}	1.790	1.800
TM_{120}	2.194	2.202
TM_{130}	3.009	3.015

By measuring the S_{21} function we also found the Q-values of some HOM. Table 3 shows the results of some modes. These results are not in a good agreement with those calculated by E module of MAFIA. Measurements were done repeatedly by selecting different field probes (E-probe or H-probe), and the results were similar with each other. The disagreement may be explained by the differences between the property parameters of inner surface material set by MAFIA and actuality of cavity surface material.

Table 3: Comparison between calculated and measured Q-values in an empty cavity

Mode	Calculated Q-value	Peak Q-value
TM_{110}	2465.3	235
TM_{120}	4375.9	924
TM_{130}	4664.6	1335

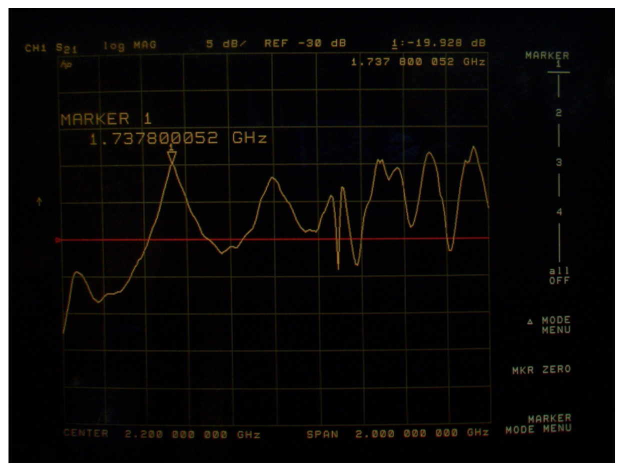

Figure 4: Spectra of the metglas cavity

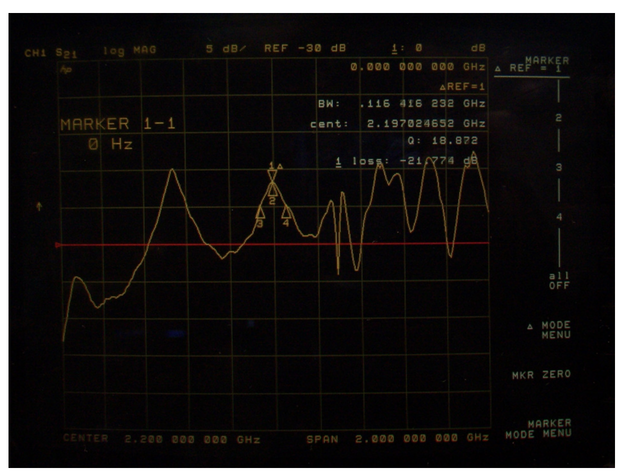

Figure 5: Q-value measurement of TM_{120} mode

Because there are not reasonable parameters of metglas required by MAFIA code, The MAFIA calculation was not able to be done for the cavity with metglas core. We performed the measurement for the cavity with metglas core in the same procedure as before. Figure 4 shows spectra of a signal picked from the E-field probe. Figure 5 shows the Q-value measurement of TM_{120} mode at frequency 2.197 GHz. Table 4 shows Q-values of some HOM. The frequencies of HOM have slightly difference compared with the spectra before, but the peak positions are almost the same. The Q-values have more decrease than those of the empty cavity.

Table 4: Comparison of characteristics between an empty cavity and a metglas cavity

Mode	**Mode frequency (GHz)**		**Q-value**	
	Empty cavity	**Metglas cavity**	**Empty cavity**	**Metglas cavity**
TM_{110}	1.800	1.738	235	23
TM_{120}	2.202	2.197	924	19
TM_{130}	3.015	2.990	1335	62

CONCLUSIONS

The frequencies of HOM in an empty Mini-LIA cavity simulated by computer are in a good agreement with the measurement results done by network analyzer. The Q-values of HOM calculated by MAFIA code are all bigger than those of measurement. The cavity with metglas core in it has much smaller Q-values than the empty cavity. It indicates that the cavity with metglas core is helpful to decrease the Q-values of HOM and suppress the beam breakup instability.

REFERENCES

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