

HOM CHARACTERISTICS OF THE ARES CAVITY

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Abstract

The ARES (Accelerator Resonantly coupled with an Energy Storage) cavity, which consists of three cells, has been developed for the KEK B-Factory, and two types of the ARES cavity have been constructed for the beam test. Both the types were installed in the KEK TRISTAN Accumulation Ring and beam-tested. The accelerating cell of the ARES has a HOM-damped structure to lower the impedance of HOM's in order to store a high current beam. The spectra excited by the beam (single bunch, 100mA) were measured for both the cavities with scanning of the resonant frequency. Basically these results are consistent with those of calculations. The HOM's appear to be damped as expected. But the actual spectra for three cells are more complicated than only the accelerating cell. During this experiment, however, any beam instabilities due to the impedance of the cavities were not observed. This paper describes only the "ARES95"- one of the two types of the ARES.

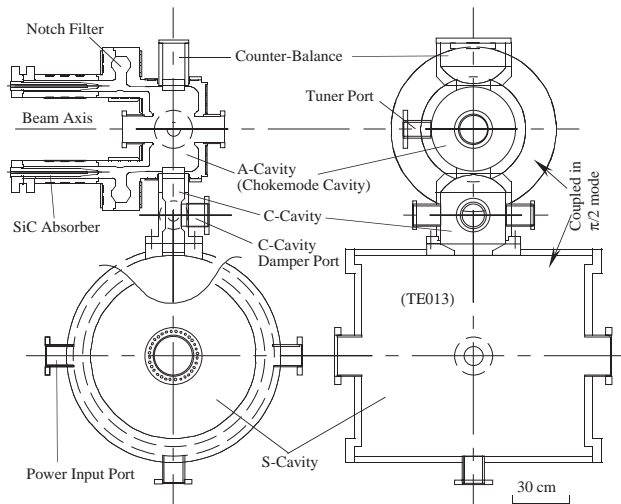


Figure 1 : A schematic drawing of the "ARES95."

1 INTRODUCTION

A new system of a normal conducting RF cavity, called "ARES[1]", has been developed for KEKB accelerator which has to store high current beam. This cavity system(See Fig.1), which consists of three cells of an accelerating cavity(A-cavity), a coupling cavity(C-cavity) and a storage cavity(S-cavity), suppresses the coupled-bunch instability associated with the accelerating mode. The accelerating mode is operated in the $\pi/2$ mode of the three cells at 508MHz. The 0 and π modes are damped with a "coupling cavity damper[2]" which has a choke

filter to block the $\pi/2$ mode. For more details of the ARES system, refer to Ref.[1], and for more of the accelerating mode, refer to Ref.[3].

Last year, two types of the ARES, which are named "ARES95" and "ARES96[4]" respectively, have been designed and constructed. The difference between the two types is the structure to damp the HOM's of the accelerating cavity. For the "ARES95", the accelerating cavity is loaded with a coaxial waveguide, which is equipped with a notch filter of a radial-waveguide type(Fig.1). The filter reflects back the TEM wave coupled with the accelerating mode, the frequency of which is located at the first stop frequency of the filter. The RF waves passing through the filter are absorbed by sixteen bullet-shape sintered SiC absorbers inserted from the waveguide end[5]. Both the types were installed in the TRISTAN Accumulation Ring(AR) and beam-tested. This paper describes the HOM's of the "ARES95". For the details of the "ARES96", refer to Ref.[4].

2 HOM CHARACTERISTICS

The system of the A-cavity(without C,S-cavity) has been already beam-tested, and its HOM characteristics were reported in Ref.[6]. Basically the three-cell system, ARES95, has similar HOM characteristics as those of the A-Cavity, but it has more complicated HOM's with the S,C-cavity. Table 1 summarizes the HOM's, which has been observed only in the "ARES95." Figure 2 shows the HOM spectra which were measured at the AR beam-test. The longitudinal coupling impedance and the HOM spectrum calculated by using the electromagnetic field simulation code "MAFIA [7]", are shown in Figure 3 and 4 respectively. The low power measurement was performed for the distinguished peaks in the HOM spectra.

2.1 AR Beam Test

The two types of the ARES, high-power tested and beam-tested were installed in the AR(See Table 2 for the machine parameters). These cavities were placed in the straight section, the beam-bore diameter of which is 150mm. Both ends of the straight section are tapered down to the standard vacuum chamber. The HOM's that propagate through the beam pipe are damped by the cylindrical SiC absorbers attached to the walls of the vacuum chamber of both sides of the cavity.

In the beam test, the HOM spectra which were excited by the beam(single bunch, 100mA) in the cavity were measured with scanning of the resonant frequency of the accelerating mode by moving the tuner of the S and A-cavity. The results superimposed for four tuner positions are shown in Figure 2. The accelerating mode resonant frequency at each tuner position is separated by

300 kHz from the other. Among various peaks, two high peaks around 3.4GHz are distinguished. A mode at 807MHz has been only observed in the ARES (not in the A-cavity only).

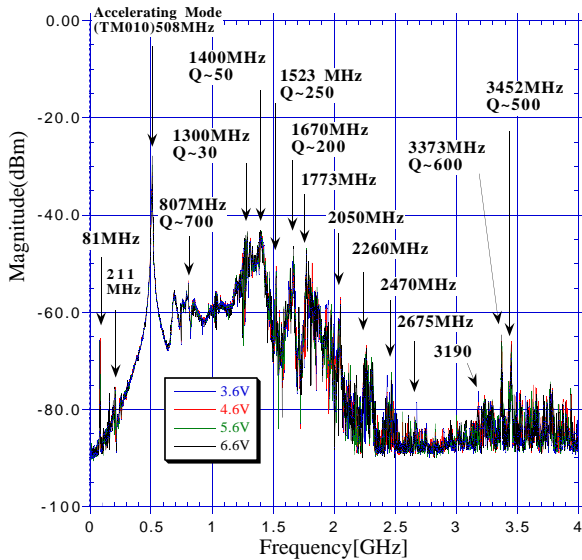


Figure 2: The HOM spectra excited by the beam (single bunch,100mA) in the “ARES95.”

2.2 Calculation

The HOM properties were calculated by using the “MAFIA” 3D time domain solver (MAFIA-T3). Figure 3 shows the structure used for the calculation. This structure includes only the A and C-cavity(and the counter balance).

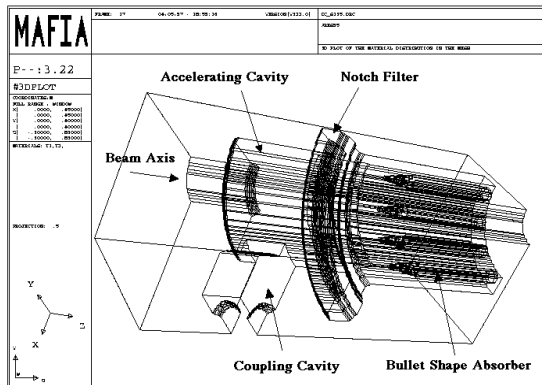


Figure 3: The structure of the “ARES95” used for the calculation of the wake potential.

Figure 4 shows the longitudinal coupling impedance obtained by the Fourier transformation of the wake potential which was calculated for the bunched beam passing through the cavity along the beam axis. The curve in Figure 4 represents the threshold impedance per cavity for the instability. The spectrum shown in Figure 5 is the Fourier transformation of the calculated time-dependent field at the position of the antenna used in the beam-test measurement. This spectrum corresponds to Figure 2. See Ref. [6] for the details of the calculations.

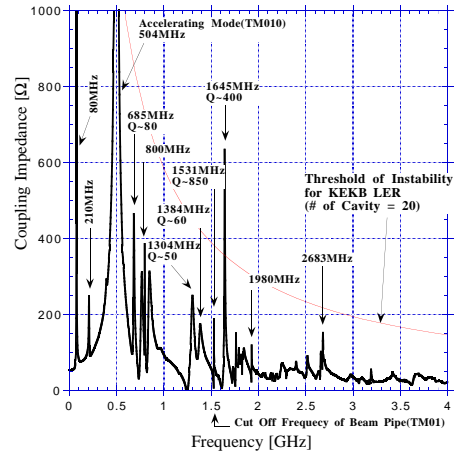


Figure 4: The longitudinal coupling impedance obtained by the Fourier transformation of the wake potential ($0 < s < 132m$) calculated by using the MAFIA-T3.

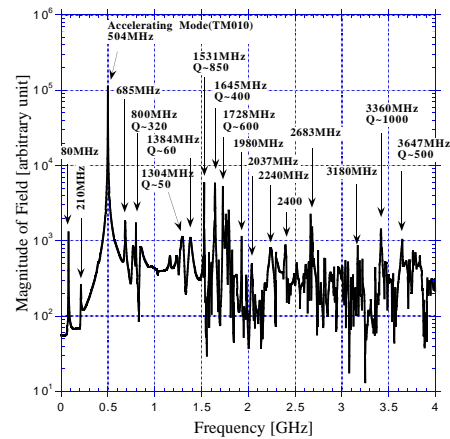


Figure 5: The HOM spectrum calculated by using MAFIA-T3.

2.3 Low Power Measurement

For the distinguished peaks obtained by the beam-test, the low power measurement was performed. The transmission spectrum was measured by using the network analyzer. The shunt impedance of the 807MHz could be measured with bead measurement method[8]. The results are also shown in Table 1.

3 RESULT AND DISCUSSION

During the beam test any beam instabilities due to the impedance of the cavity were not observed even in the case of the multi-bunch, 700mA beam. The summary of the HOM’s which only appeared in the “ARES95” is shown in Table 2. For most of the modes, the Q-values obtained by the beam-test, by the calculation and by the low power measurement are largely different from each other. In the beam test the frequency resolution is limited by the revolution frequency of the beam, while in the calculation it is limited by the time duration of the wake potential calculation. Therefore, the results of the low power measurement are most reliable for high Q-value modes.

The peak at 807MHz was observed in both the spectra of the two types of the ARES - "ARES95" and "ARES96", although their A-cavities are different. This is a dipole mode of the C-cavity, being coupled with the counter balance in the $\pi/2$ mode. The magnetic field pattern calculated by using the MAFIA eigen mode solver (MAFIA-E) is shown in Figure 6. It can not be damped by the "coupling cavity damper," which needs longitudinal electric field there. The coupling impedance of this mode was about 500Ω ($=R/Q \times Q / 2$) as determined by the bead-pull measurement. However, this impedance is not dangerously high in comparison with the threshold in Figure 4. Since we could not exclude the possibility that the similar modes can have a higher impedance at higher frequencies, we are improving the "coupling cavity damper" in order to damp this kind of mode[4]. The improvement is also necessary in order to damp the two peaks at 1.3GHz and 1.4GHz, which are located at the second stop band of the choke filter of the "coupling cavity damper."

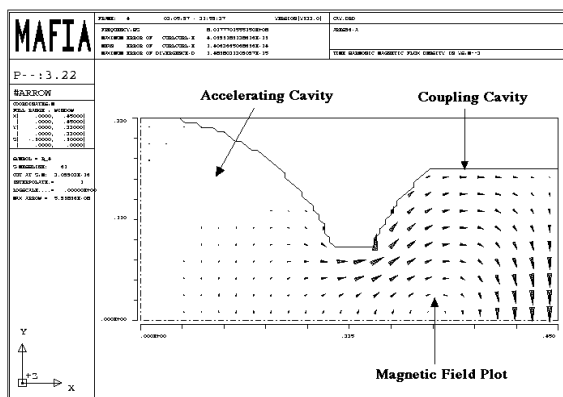


Figure 6: The magnetic field pattern of the mode at the 807MHz

Two more high peaks are seen in Figure 2 around 3.4GHz, where no high peak was found in the calculation without the S-cavity. Thus it is natural to assume that they are associated with the S-cavity. However, no distinguished peaks were observed in the low power measurement either.

The calculated impedance in Figure 4 has a higher peak than the threshold at 1.65GHz which corresponds to 1.67GHz in Figure 2. This mode is located at the second stop band of the notch filter of the A-cavity [6]. The calculation of the wake potential with the longer time duration makes this peak higher. This indicates that it has actually even higher Q-value or that the calculation is not accurate (already two times as high as measured), because it is located in the vicinity of the cut-off frequency of the beam pipe. So further investigation is needed.

The transverse impedance modes are not observed partly because they are hard to distinguish on account of the complication of the HOM spectrum of the three-cell system, and partly because the threshold impedance for the transverse instability of the AR is about ten times as large as that of the KEKB.

4 SUMMARY

During the beam-test any beam instabilities due to the impedance of the cavity were not observed. The HOM spectra excited by the beam were measured. Basically these results are consistent with those of calculations which exclude the Storage cavity. The HOM's appear to be damped as expected. Since we cannot exclude the possibility that the beam is strongly coupled with a special kind of C-cavity mode, it is preferable to further improve the "coupling cavity damper". The two high peaks around 3.4GHz and the peak at 1.67GHz require further investigation.

Beam Test Spectrum		Calculated(MAFIA) (3D TD, s < 132m)			Low Power Measurement (Bead Measurement)		
Freq. [MHz]	Q_L	Freq. [MHz]	Q	R_{sh}/Q [Ω]	Freq. [MHz]	Q_L	R_{sh}/Q [Ω]
807	700	800	320		807	10000	0.1
1300	30	1304	50		1300	50	
1400	50	1384	60		1400	100	
1523	250	1531	850		?		
1670	200	1645	400		1670	200	
1773	450	1728	600		1773	2500	
2050	500	2037	200		2054	8700	
3373	600	3360	1000		?		
3452	500	?			?		

Table 1 : The summary of the HOM's peculiar to the "ARES95." For definition of the shunt impedance, see Ref.[8].

RF Frequency	508.5808 MHz
Harmonic Number (h)	640
Revolution Frequency	794.6575 kHz
Beam Energy	2.5 GeV
RF Voltage	0.4~2.0MV
Momentum Compaction factor (a)	0.01250
Tune (H,V)	10.14, 10.25
Synchrotron Tune	0.017~0.032

Table 2: The machine parameters of the TRISTAN Accumulation Ring (AR)

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