

MEASUREMENTS OF LOSS PARAMETER AND ITS FREQUENCY CHARACTERISTICS IN VACUUM COMPONENTS

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ABSTRACT

A loss parameter in vacuum components used for the TRISTAN is measured with a current pulse method proposed by Sands.¹⁾ An induced field on a wire stretched along the center axis of the component is analysed in frequency-domain using a fast Fourier transform (FFT). A fundamental frequency measured of a bellows agrees with a calculated value.

INTRODUCTION

When a stored bunch traverses an irregularities of a wall in a vacuum chamber, induced fields at the wall are changed and new secondary fields are produced. These secondary fields referred to as wake fields are oscillating at the wall with a large number of modes. The energy of the oscillations is transformed eventually into heat as the oscillating fields decay. The bunch has an energy loss due to such wall and this energy loss gives serious problems to a storage ring and a stored bunch.

A loss parameter is defined as

$$k = \frac{1}{q^2} \sum_i U_i \quad (1)$$

where U_i is an energy loss in the i th mode and q is a charge of a bunch.

The loss parameter can be measured on a bench set-up. A thin wire is stretched along the center axis of a chamber with an irregularity. The chamber forms a coaxial transmission line. A bunch simulated by a current pulse is fed to the wire via a tapered matching section. A transmitted current pulse is memorized as $i_m(t)$. For the interpretation of data, a pulse through a chamber without an irregularity is also memorized as $i_o(t)$. A difference between $i_o(t)$ and $i_m(t)$ is a secondary current ($\Delta i(t)$) which is generated by the secondary fields due to an irregularity. The loss parameter having dimension of volts per pico-coulomb is given by

$$k = \frac{2 R_0}{q^2} \int i_o(t) \cdot \Delta i(t) dt \quad (2)$$

where R_0 is characteristic impedance of a coaxial chamber. This measurement has been carried out in various storage rings.^{2,5)}

APPARATUS

A schematic of the apparatus is shown in Fig. 1. An accuracy of this measurement is dependent on a stability of the simulated pulse. In order to minimize time jitter and drift of the pulse, a frequency synthesizer for triggering and an averaging method for sampling data are used.

MEASUREMENTS

The loss parameter for two cylindrical cavities is measured to compare with the calculated value obtained by using the KN7C program.⁶⁾ In each case, the radius of the beam port is 6.7 cm and the gap length of the cavity is 11.5 cm. These results are shown in Fig. 2.

The k value for a bellows⁷⁾ used in the Accumulation Ring is measured to be 0.004 volts per pico-coulomb at $\sigma = 2.4$ cm, where σ is r.m.s. bunch length. This value is comparable with the one for a bellows in the PEP.⁸⁾ A difference signal induced on a wire, $\Delta i(t)$, is considered to be a reflection of wake fields from the bellows. A FFT of the signal shows us a resonance frequency of the component. A resonance occurs near 3.2 GHz as shown in Fig. 3. It is

known that a bellows resonates at the following frequencies⁹⁾

$$f_k = \frac{1 + 2k}{4\pi} \frac{c}{\tau} \quad (3)$$

with

- k = 0, 1, 2, ...
- c: velocity of light
- τ : amplitude of bellows

The lowest frequency given by using eq. (3) is 3.2 GHz, and agrees with the measured one.

DISCUSSION

A loss parameter is given as an integral of a power loss in time-domain from eq. (2). The loss is also given as a sum of a large number of modes from eq. (1).

The frequency characteristics provide a better understanding about the energy loss. However, there is an assumption in the measurement that the characteristics of the fields are not grossly modified by the presence of the wire. A frequency shift is checked for the cylindrical cavities with and without a wire. It turns out that fundamental frequency agrees with each other less than 10 %. There is a difference in higher modes by the presence of a wire. The FFT has a very rough resolution of about 200 MHz.

REFERENCES

- 1) M. Sands and J. Rees: PEP-95 '74.
- 2) J.N. Weaver et al.: IEEE Trans. NS-26 ('79) 3872.
- 3) M.G. Billing et al.: IEEE Trans. NS-26 ('79) 3583.
- 4) J. Peter: IEEE Trans. NS-24 ('77) 1446.
- 5) G. Gavallari et al.: CERN/EF/RF 82-2.
- 6) E. Keil: Nucl. Instr. Meth. 100 ('72) 419.
- 7) H. Ishimaru et al.: IEEE Trans. NS-28 ('81) 3320.
- 8) J.N. Weaver: PEP-NOTE-342 '81.
- 9) A.G. Ruggiero: KEK 80-16.

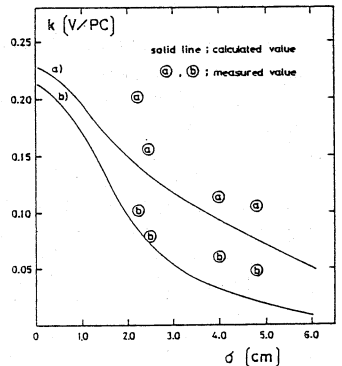


Fig. 2 Loss parameter as a function of r.m.s. bunch length.
 a) outer radius of cavity is 14.7 cm.
 b) outer radius of cavity is 9.7 cm.

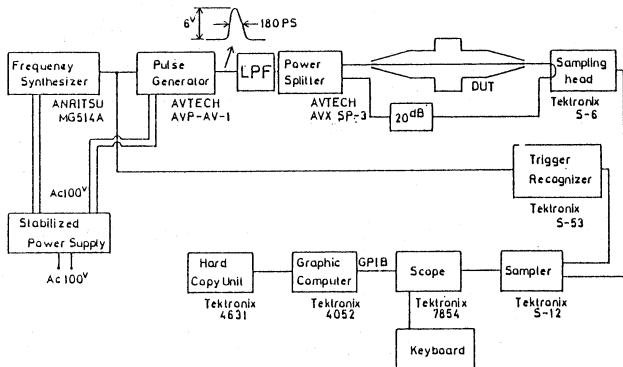


Fig. 1 Schematic of the apparatus.

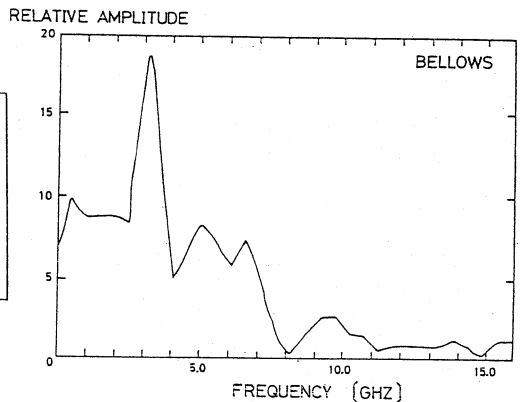


Fig. 3 FFT of induced voltage on a wire by bellows.