

ELECTRON BEAM MONITOR BASED ON WAVEGUIDE WITH THIN IMPEDANCE FILMS

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Abstract

The wave propagation in a waveguide with thin impedance films is investigated. An application of the cavity with thin impedance walls as a bunch parameter pickup based on the transition radiation in the cavity is considered. The cavity-pickup model is investigated experimentally

1 INTRODUCTION

It becomes to be an actual one the nondestruction control of the beam parameters of the investigations of the bicylindrical accelerating module. The waveguide and cavity beam monitors have maximum sensitivity in the number of the transparent ones [1]. The low inertness of such beam monitors and the accordance of their frequency characteristics to the spectrum structure of the beam permit one to define the high frequency (HF) structure of the beam, in particular, the pulse length shape and the change of the electrons number in the bunch in the pulse duration. However the most types of the transparent beam monitors (cavity one, waveguide one and so on) are under high-vacuum, when this beam monitors are installed into the tract and are separated from it by the dielectric tube. The electrostatic space charge remove problem arises from the surfaces of the dielectric. To solve this problem the possibility of creating beam monitors with super thin metallic walls was investigated. This walls provide radio transparency to take-off the energy transition radiation [2]. Here the transition radiation of the relativistic particles is modeled by the radiation of the probe and its mirror image on the opposite walls of the waveguide.

2 THE CAVITY WITH SUPERTHIN WALLS

It was shown, that the transition radiation energy is determined from the expression [2]

$$W = \int \frac{f(\omega)}{|M_{mn}|^2} d\omega; \quad (1)$$

which at $|M_{mn}|=1$ coincides with the expression for the transition radiation energy of the particle traversing an infinite waveguide perpendicularly to its axis [3].

For the film thickness less than the skin-layer both for E and H types of waves we have

$$|M_{mn}|^2 = 1 + 2\sqrt{2}\alpha \cdot \sqrt{|\epsilon''|} \cos^2\left(\frac{2\pi}{\lambda_g}d\right),$$

where λ_g is the wavelength in the waveguide,

$\alpha = \text{Re}(\gamma\Delta)$, $\gamma = \frac{\omega}{c} \sqrt{|\epsilon''|} \cdot e^{-i\frac{\pi}{4}}$; Δ is the plate thickness (the walls of the cavity).

The factor $|M_{mn}|$ -is stipulated by the presence of two impedance walls with relative position $2d$ between which a charged particle is flying (a probe is placed there to simulate the particle flight).

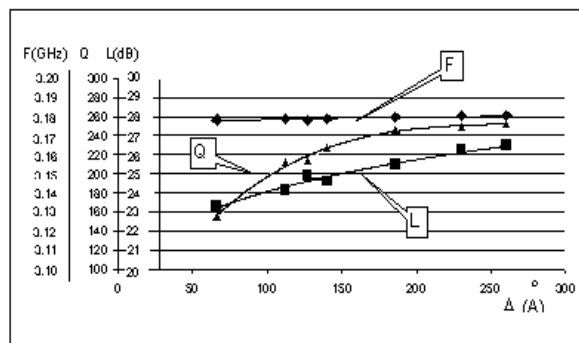


Figure.1. The dependence of the losses (L), resonance frequency (F), and Q-factor of the cavity on the thickness (Δ) of the impedance walls of the pickup.

The values of measured signals in the experiment performed by using the radiating probe will correspond to the quantity

$$\frac{dW}{d\omega} \Delta\omega_{reg} = \frac{f(\omega)}{|M_{mn}|^2} \Delta\omega_{reg} \quad (2)$$

where $\Delta\omega_{reg} = \frac{\Delta\omega}{Q}$ - is the registration frequency band

which is narrowing in inverse proportion to the Q -factor of the cavity beam monitor. If we normalize the value of (2) to the energy emitted in the infinite waveguide in the

band $\Delta\omega$, then for the normalized values of loss L we will have the expression

$$L = \frac{1}{|M_{mn}|^2 Q} \quad (3)$$

The measurements (Fig.1) are in good agreement with the calculated values obtained by formula (3) and show the usefulness and applicability of such a beam monitor [2].

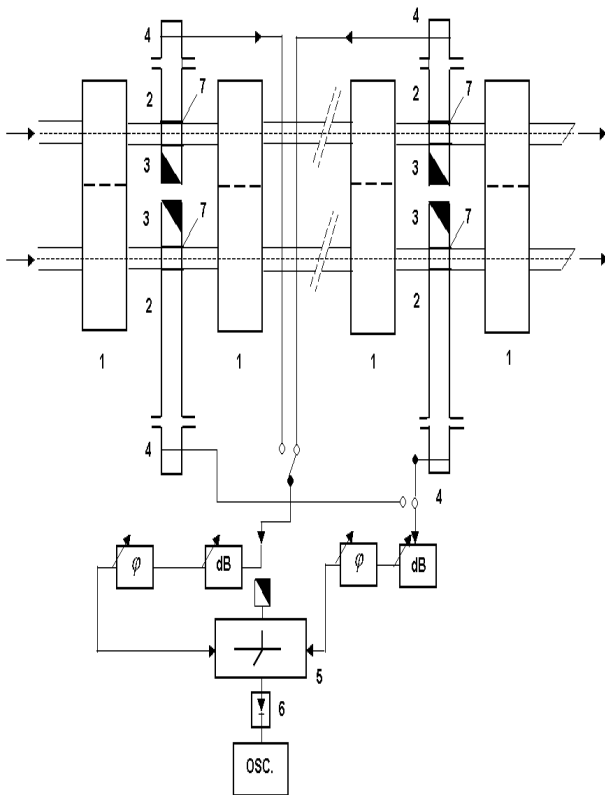


Figure.2. The beam parameter control scheme in two beam accelerator. 1 - bicycindrical cavity, 2 - waveguide beam monitor, 3 - waveguide matched load, 4 - adapter, 5 - waveguide hybrid T - bridge, 6 - detector, 7 - ceramic tube with the impedance walls

3 THE WAVEGUIDE BEAM MONITOR IN TWO-BEAM ACCELERATOR SCHEME.

It is supposed that the beam monitors are installed into the circuit of the accelerating module. The scheme of the beam monitor arrangement is added in Fig.2. The main type of the oscillation which is being excited in the cavity 1 is the second symmetrical E-mode for the case being considered. The phase of the field which is excited by the high current beam is shifted to π in relatively to the accelerating field. It means that leading and accelerated bunches will be flying into the cavity simultaneously. However during the accelerator tuning a necessity may arise in shifting the bunches concerning one another

because of the defining transition processes in the cavity, as well as the change of the cavity characteristics, which is connected with the cavity shunting by the high current beam. Therefore, setting the beam monitor at an equal distance from the cavity walls one will be able to control the beam parameters and the efficiency of the interaction between the beams by the phase shift. The signal (Fig.2) of the beam monitors 2,3,7 acts to the hybrid T-bridge 5 through the attenuators dB and the phase - shifter φ , waveguide-to-coaxial adapter 4 and then the sum signal enters into the detector 6 and oscillograph as well. The scheme of the signals interference permits one to tune and follow the characteristics of accelerator by choosing the optimum relationships between the phases of the electron bunches. An adding control can be realized by the amplitude detecting, excluding the heterodine canal (Fig.3,a,b). The expected oscillograms are added in Fig.3,c.

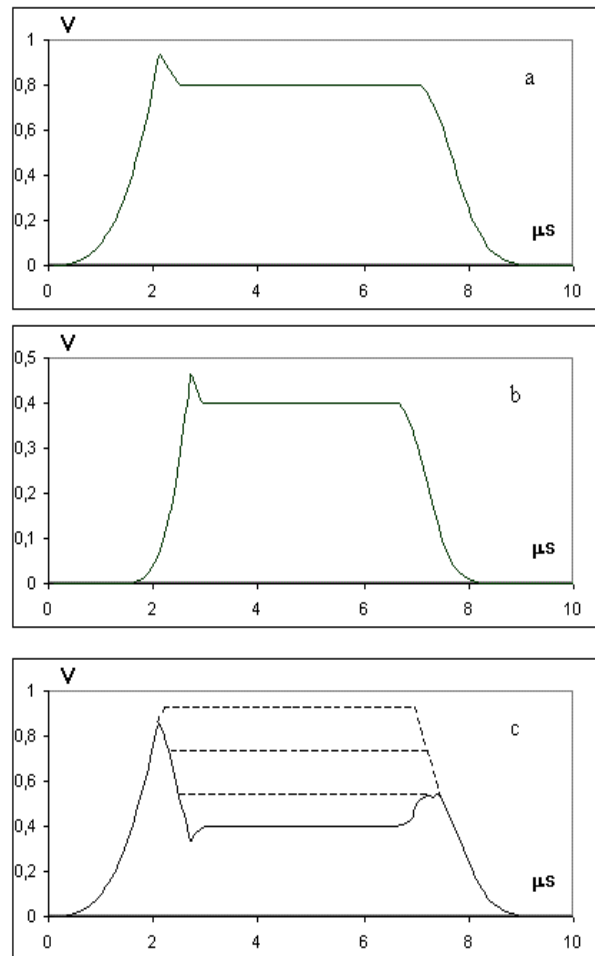


Figure.3. The oscillograms: a) of the leading beam; b) of the accelerated beam; c) of the sum signal. The summing results for the different phase are added by dot.

One should notice that these beam monitors permit to check not only the proper beam "setting" (with the cavity loading effect by the high current beam), but also to discover the other effects, in particular, the shifting of the

beam from the trajectory, the scattering of the beam and so on. The developed system permits one to realize not only the pair control but the cross control at the tuning of the electrical lengths of the HF signal to the receiver as well. The special phasemeter may be introduced in the base circuit (Fig.2) to make the control of the acceleration processes operative.

One may have noticed the other opportunities of this beam monitors. For example: placing this beam monitor close to the cavity, one will fix the exponent attenuation of the cavity field in the drift tubes which, owing to the high sensitivity, are the limit waveguides for the frequency of the cavity. Therefore one may observe two signals: the first - with the big amplitude at the beam flying and the next - the weak one which is defined by the Q - factor of the acceleration cavity and by its couple value with the beam monitor.

In this case the spectrum distorting of the oscillations is a minimum one because $Q_{bm}/Q_c \ll 1$ ($\approx 10^{-4}$), where Q_{bm} is the Q -factor of the beam monitor (the cavity with the thin walls) and Q_c is the Q -factor of the accelerating cavity.

4 CONCLUSION

One may use the beam monitor to receive a maximum accelerated field in the cavity at the accelerator tuning.

For example, by putting off the accelerated beam but leaving the high current beam unchanged, then choosing the parameters of this beam one may tune the cavity on the maximum field in the second part of the cavity with the help of the readings of this beam monitor. After this processes one puts on the acceleration beam. Therefore the proposed beam monitor permits one to execute the continuous control of the two beam accelerator and to support its optimum performance.

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