ALTERNATING PERIODIC STRUCTURE WITH THE COUPLING CAVITY OF AN EXTREMELY LOW QUALITY FACTOR

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The accelerating structure made up of coupled resonators has usually high Q factors not only for the accelerating mode but also for the other higher order modes. The latter causes the beam blow up effects in case of an electron linac and both the transverse and longitudinal instabilities in an electron storage ring. The threshold currents for these instabilities are proportional to Q of the corresponding higher mode. One method of degradation of Q is to attach an absorbing ferrite antenna which does not affect the accelerating mode(1). Here another possibility is considered by using an alternating periodic structure (APS)(2). In this APS Q of the coupling cavity is made quite low.

The coupled resonator equations give the following relations for $\pi/2$ mode of an APS with two excited cavities

$$Q = Q_a[\,1 - (\,1 - x\,)(\alpha x)^{-1}]$$

$$|X_0/X_2| = [\,1 - (\,2\alpha x\,)^{-1}] \quad \text{so long as } \alpha x \gg 1,$$

where $\alpha = (\,kQ_a/2\,)^2$, $x = Q_c/\,Q_a$, with Q_a and Q_c being Q of the excited and coupling cavity respectively, X_{2n} the field amplitude in the 2n-th cavity(3). The external drive is assumed in the 4-th cavity. For example, when k = 0.01 and $Q_a = 3\times10^4$, we have $Q/Q_a = 0.995$ and $|X_0/X_2| = 0.998$ even for x = 0.01. This implies the lowering of Q_c has only a minor effect on the $\pi/2$ mode. Next we must consider how much damping of the other higher modes can be expected by this method(4). When the structure is compensated with respect to the fundamental pass band, the other modes in this band would have a factor of about pQ_c where p is the ratio of lengths of the excited and coupling cavity respectively, because the field is rather uniformly distributed along the structure. For the higher pass bands, however, the structure is generally uncompensated and each pass band splits into two groups, namely, the main cavity mode group and the coupling cavity mode group. As the modes of the former group have small field intensities in the coupling cavity, the lowering of Q is not expected to be large.

A S-band disk loaded APS made of brass is tested (5). The cavity number is five with the main cavities at the both ends being half ended and hence the total length is 10.5cm. The ratio p of the cavity lengths is 2 : 1 , the aperture in the 5 mm thick disk is 20 mmϕ , and the fundamental $\pi/2$ mode is at 2854 MHz with a coupling coefficient k of 1.1%. The cylindrical part of the coupling cavity is replaced by a martensitic steel SUS 403. Then the Q of the $\pi/2$ mode in the fundamental pass band is slightly changed from 4400 to 4200. The Q's of $\pi/4$ and $3\pi/4$ mode are however changed from 3500 to 1000, and those of the 0 and π mode are reduced to 500 from an initial value of 3800. With regard to the TM_{11} mode we find the coupling cavity mode group at around 4250 MHz and main cavity mode group at 4400 MHz. The Q's of the former modes are reduced to 1000 from 4000, but those of the latter are reduced only to 3000 from 4400.

In order to obtain better damping of higher modes, the disk and washer structure(6) is promising, as the main and coupling cavity are merged into one cell and hence the field distribution of any mode would be more uniform.

References

(1) N. Lehnart, H. Petersen: DESY int. rep. H2-77/12(1977)
(2) T. Nishikawa et al: R.S.I. vol.37 (1966) 652
(3) E.A.Knapp: Linear accelerators, North-holland(1970) 601
(4) K. Takata: Japanese Patent 720509 (1974)
(5) T. Kikuchi, K.Takata: J.J.A.P. vol.9 (1970) 679
(6) V.G.Andreev: J. Tekhnicheskoy Fiziki vol. 41(1971) 788