# COMPUTATIONAL METHODS FOR ANALYZING ELECTRON MULTIPACTING IN RF STRUCTURES

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Electron multipacting is a major problem in rf structures like in high energy particle accelerators, especially those with superconducting cavities. The problem is also met in satellite communication antennas. Analyzing and suppressing multipacting accordingly have industrial interest for accelerator construction and for space industry.

Multipacting occurs when free electrons, accelerated by the rf field, strike the surface of the cavity and release secondary electrons, which repeat the process and, rapidly cause an electron avalanche. This electron discharge absorbs the rf energy and may cause quenching and breakdown of high power rf components like couplers and windows. The phenomenon starts if certain resonant conditions for electron trajectories are fulfilled and if the impacted surface has a secondary electron yield larger than one.

Basically two different multipacting mechanisms are described in literature [1-4]. In the first one, the model case consists of two parallel electrodes with oscillating voltage drop. The resonant electron trajectories bounce from one electrode to another and back in a flight time roughly equal to an integer number of rf cycles. In the second one, the shape of the electron trajectories is mostly due to the magnetic field.

In this talk, we describe a systematic computational way to analyze electron multipacting in rf structures. The first step, in the given geometry, is to recognize those rf power levels that are able to multipact. The second step is to locate and identify the possible multipacting processes. The basis of the analysis consists of trajectory calculations in relativistic dynamics. The novel feature here is to analyze the general nearly periodic structures of the resonant trajectories by using a special distance function defined in a multidimensional phase space and other ideas arising from the theory of dynamical systems.

The approach is applied numerically to analyze multipacting in coaxial structures. We consider straight coaxial lines as well as tapered lines and certain (cold) ceramic window configuration. In the straight lines, both the standing wave and traveling wave operations as well as a combination of the standing and traveling wave operations, so called mixed wave operation, are considered. For the more

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complicated structures, we have developed our own codes for computing the electromagnetic fields. In the structures without the windows we have used a code based on the boundary integral method, and in the window structures we have used another code, which is based on the finite volume element method.

A general cure against multipacting is to avoid the resonant conditions. Therefore, we investigated the dynamics of the electron trajectories in order to find rules for these resonances and, thereafter, we suppress the multipacting by an appropriate cavity design and field perturbations. For plain coaxial lines, our algorithm enables us to find simple scaling laws for the multipacting power bands with respect to the dimensions, frequency and impedance of the line. By these laws, one can shift the multipacting bands by appropriately altering the design of the line. Furthermore, we studied the effect of grooving to multipacting as well as DC biasing and static magnetic perturbations of the rf field. With our present multipacting analysis method, it is possible to optimize the perturbations and suppress the multipacting to acceptably low levels.

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