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Quasi-Analytical Derivation of Parallel-Plate Multipactor Trajectories in the Presence of Higher-Order Mode Perturbations

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Multipactor [1] is a resonant phenomenon in which an electromagnetic field causes a free electron to impact a surface, resulting in the surface emitting one or more secondary electrons. If the surface geometry and electromagnetic fields are appropriately arranged, the secondary electrons can then be accelerated and again impact a surface in the bounding geometry. If the net number of secondary electrons participating in multipactor is non-decreasing, then the process can repeat indefinitely. This phenomenon is of considerable practical interest in the design and operation of radio frequency (RF) resonant structures, windows, and supporting structures.

Multipactor is frequently studied either experimentally or via numerical simulations. In the case of numerical simulations, frequently the particle trajectories are determined by calculating the force on a particle at any given step in time, and stepping the particle through many time steps. In this work, the particle position is expressed as a linear time-dependent system of equations, and the equations are solved for the case of a multi-mode time-harmonic excitation. The resulting solution is expressed in terms of an explicitly-defined integrand which in practice must be evaluated numerically. This quasi-analytical method could in principle provide an explicit integrand for any excitation in which certain intermediate quantities in the time-invariant system are analytically integrable.

This work provides an additional way of examining how various parameters affect multipactor trajectories, and could be used for further perturbation analysis. Some comparisons in a parallel-plate geometry are shown between results using this method and results from a full numerical solver that was previously used by the authors in the context of coaxial-geometry multipactor simulations [2], [3].

[1] Padamsee et. al, "Multipacting"in RF Superconductivity for Accelerators, Weinheim, Germany: Wiley-VCH, 2008, Chapter 10, pp. 182-197

[2] Rice and Verboncoeur, "Multipactor Current Modelling Using an Averaged Version of Furman's SEY Model" , 41st IEEE International Conference on Plasma Science (ICOPS 2014), Washington, DC, May 25-29, 2014

[3] Rice and Verboncoeur, "Multipactor Current Growth Modelling Using an Averaged Version of Furman's SEY Model", International Particle Accelerator Conference (IPAC'15), Richmond, VA, May 3-8, 2015

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