ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-MOPME025

NEW POSSIBILITIES OF MULTP-M CODE

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Abstract

Implementation and Testing of the new module package for geometry import of the MultP-M 3D code for multipacting prediction was performed. The results of simulations for the coaxial line specimen using this new module are presented. These results are compared with analytical calculations and experimental data.

INTRODUCTION

Multipactor can be a limiting factor to achieve of designed parameters of various RF devices. This phenomenon takes place in such regions of RF units with which have low surface electromagnetic fields. Multipactor discharge appears due to the secondary electron emission and resonant conditions of a transit time of electrons between two plates and RF field oscillation periods number. multiplicity. Such This kind of discharge can lead to RF power losses, structure overheating and following breakdown and in certain cases it causes failure of device performance. Multipacting is especially presents special danger for superconducting devices because of quench possibility.

The MultP–M code [1] is a tool developed for that allows the analysis of multipacting in fully 3-dimensional RF structures. It is based on solving solves the non-relativistic motion equation of electrons in time harmonic RF fields. MultP–M does not contain a field solver, but it provides an interface to import the field map from a text-file. The external field solver must be able to export field maps to text files, and it is strongly recommended that it uses a conformal mesh (mesh points coincide with the boundary). MultP-M takes into account the RF device operation mode and allows simulation both for standing and traveling waves.

The resulting trajectories can be analysed by means of electron counter function and various statistics. All other parameters used in the calculation (field level ranges, SEY, initial energy of electron, electron emission phases, initial number of particles, minimal collision number, frequency and limitation of field periods number for calculation) are to be specified assigned by user. The final decision whether multipacting is possible or not is up to the user.

Geometry plotting in last versions of the code was implemented by addition or and subtraction of basic primitives like cylinder, sphere etc. This fact made simulations in the program more complicated and made it unsuitable for some structures. New module which allowing import of geometry from other codes in *.STL format was developed to solve this problem.

New version of MultP-M code allows two kinds of the geometry plotting: import from CST MWS (*.STL file) and using basic primitives.

TESTING OF NEW MODULE MULTP-M

The main goals of the upgraded code testing are to validate correctness of the developed module during simulations and to obtain and fix possible errors. Correctness analysis of the module performance was estimated by comparison with experimental results, analytical calculations and simulation results obtained using by similar codes for multipacting prediction.

Analytical Solution for Coax Line

Coaxial lines are widely used in accelerator technique for power and signal transmittion as a power transmitting units. Unfortunately, possibility of multipactor discharge is a serious problem for the performance of such structures.

The simulations were carried out for a part of the coaxial line with following parameters: inner radius R_{in} = 2 mm, outer radius R_{out} = 4 mm, line length of the specimen L = 50 mm, operating frequency f = 2.45 GHz.

According to [2], multipactor in this structure was experimentally obtained at transmitted power levels above 1 kW and these observations were validated by authors of this article using COAXMUL code.

Analytical simulations provides estimations of the threshold power levels at which multipactor discharge can appear and allows to determine an order of multipacting.

Calculations were done for the two-plane approximation using equations from [3] and [4].

According to [3]:

$$V_{min} = \frac{m\omega^2 d^2}{e}\frac{1}{\sqrt{4+(2n+1)^2\pi^2}}$$

According to [4]:

$$V_{min} = \frac{m}{e}\frac{4\pi f^2}{2n-1}$$

m and e – electron mass and charge respectively, $\omega = 2\pi f$ – operating frequency of the device, n – order of multipactor discharge.

Corresponding level of transmitted power was determined as follows:

$$P = \frac{\pi V_{min}^2}{Z}\frac{1}{\ln({R_{out}}/{R_{in}})}$$

Additionally we used diagram [3] and Multipactor Calculator code [5] which can be qualified as an analytical type of calculations.

The results of calculations are presented on the generalized plot (Fig. 1).

One can see on Fig.1 that all analytical methods listed above give values of the threshold power levels which are close to each other. The results obtained by Multipactor Calculator show the biggest difference in comparison with other ways of calculation because of the following program feature: this code takes into account material properties of the device walls while equations do not include parameters of a material.

It can be seen that first stable 5th order trajectories are obtained at power level of about 1kW and this level is in a good agreement with experimental data [2].

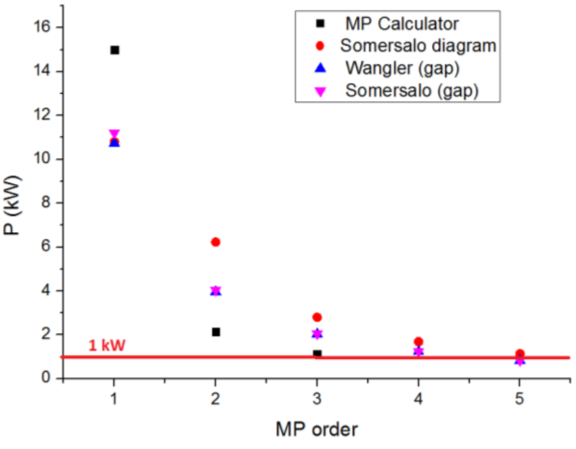

Figure 1: Generalized plot of analytical results.

CST PS Solution for Coax Line

The next stage of our investigations was multipacting simulation by CST PS code [6].

Secondary Emission Yield curve for copper used for these simulations is shown in Fig. 2.

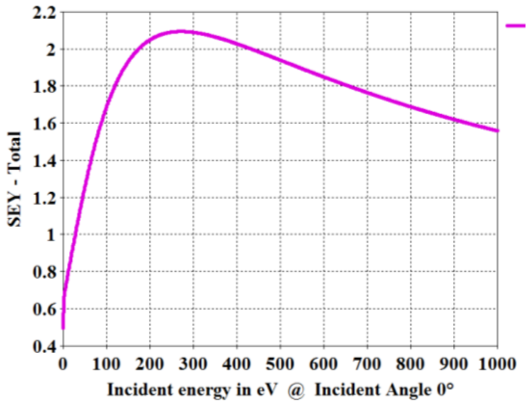

Figure 2: SEY curve for copper.

An exponential increase in particles number within the coaxial line was obtained at various levels of transmitted power. The results for several cases are shown on Fig. 3. (in logarithmic scale). Linear growth at these graphs indicates resonant conditions presence which can cause mutipacting at power levels above 1 kW.

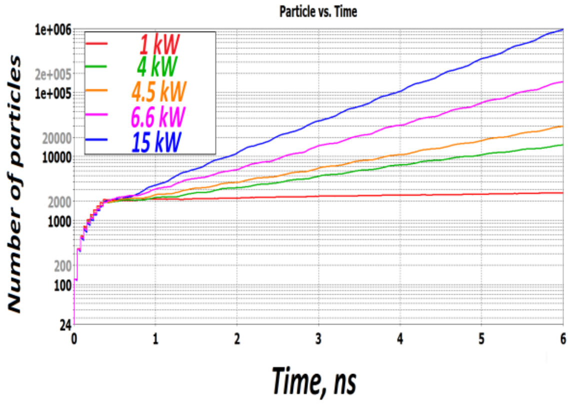

Figure 3: Particles number vs. Time for various levels of transmitted power.

MultP-M Solution for Coax Line

Further step of multipactor prediction for the coaxial line specimen was simulation by MultP-M using both primitives and new module of geometry import.

First of all we determined threshold levels of transmitted power at which significant particle growth within the coaxial line is obtained. Fig. 4 shows percentage particle growth vs. transmitted power for both ways of geometry plotting.

One can see from Fig. 4 that graphs obtained by using basic primitives and new module are close to each other and this accuracy is quite enough for estimations of threshold power levels.

The results of multipacting simuations by MultP-M show a presence of strong resonant conditions for the discharge in a wide range of transmitted power – from 2.5 to 60 kW. Detailed investigations of several trajectories obtained from Phase/Field diagram indicate that there are stable multipactor trajectories of 1-5 orders.

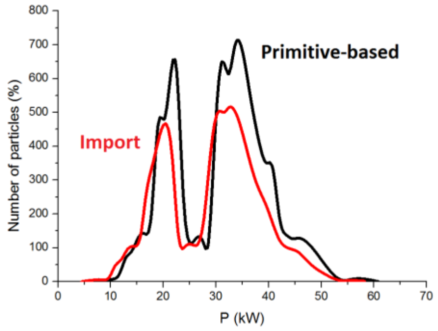

Figure 4: Number of particles vs. Transmitted power.

Comparison of the experimental, analytical and numerical results obtained by various codes validates correctness of the developed module.

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CONCLUSION

Comparison of experimental results, analytical calculations and the results of simulations by various codes proves that new module for geometry import operates preforms correctly and can be used without accuracy degradation.

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