MULTP-M CODE UPGRADE

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Abstract

It is obvious that for all new RF devices all issues potentially influencing on their performance and operation must be considered at design stage. Multipacting discharge is known to be one of such phenomena. This discharge occurs in vacuum areas of RF devices in case resonant conditions for electrons are met and the secondary electron emission is strong enough. The problem of effective design of multipactor-free RF devices can be solved using powerful 3D numeric simulation tool Multp-M developed at MEPhI and INR. [1].

In this paper new features of this code are presented and illustrated by several common tasks solved. Multp-M code was upgraded so it is able to simulate the external magnetic and electric fields influence on discharge behavior and transient mode simulation. Code became more user-friendly thanks to new 3D interface.

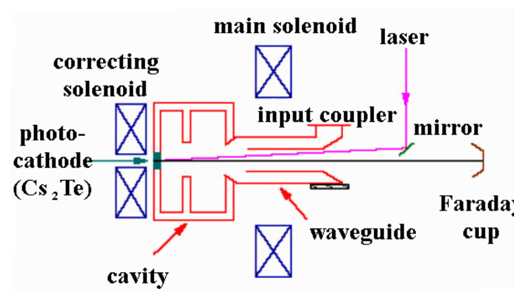
INFLUENCE OF THE EXTERNAL FIELDS

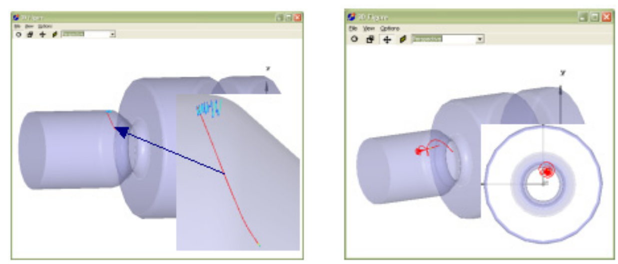
There are a lot of ways for multipactor suppression known and used in microwave techniques. Use of external magnetic or electric field is one of the most widely implemented. Besides that a lot of RF devices like electron guns and injectors operate with magnetic field applied for beam focusing. This leads to sufficient change in multipactor properties. In order to simulate these conditions at early design stage Multp-M was expanded with new modules introducing static fields in model.

Algorithms added were tested and proved to yield correct results. As the initial test single electron dynamics was simulated in simple electric and magnetic fields pattern. More comprehensive research were done and their results compared to known data.

New features were used to evaluate external focusing magnetic field in PITZ photoinjector cavity and electric bias applied in “warm” coaxial line area commonly used in high power input couplers [2]. For instance latter having inner conductor radius equals to 14.4 mm and outer of 31 mm is used in Energy Recovery Linac.

Sample results obtained for PITZ photoinjector cavity illustrating Multp-M code simulation and visualization capabilities are presented on Fig.1. For research details refer to [3]. Multipactor trajectories in cell to circular waveguide transition area were found at 27.25 MV/m on-axis field strength.





a b

Figure 1: Sample multipactor electron trajectories

a – without external field, b – with focussing magnetic field.

Multipactor could be a severe problem for coaxial lines operation. Its suppression could be done by applying DC high voltage bias between conductors. As an example the simulated multipactor in coaxial line used in ERL high power input coupler warm part [2] is shown on Fig. 2. Coaxial line model used for simulation has inner conductor radius equal to 14.4 vv and outer one 31 mm. Fig.2 illustrates raise of electrons number vs. transmitted power for different bias applied. RF power on charts is normalized: 1 unit equals to 33 MW.

One could see that applying 3...4 KV DC lead to multipactor suppression for transmitted power up to 250 KW CW. It covers full operating range for this coupler.

Thus new computation module implemented in Multp-M code allows to make correct simulation for devices with static magnetic or electric fields and to choose of bias parameters.

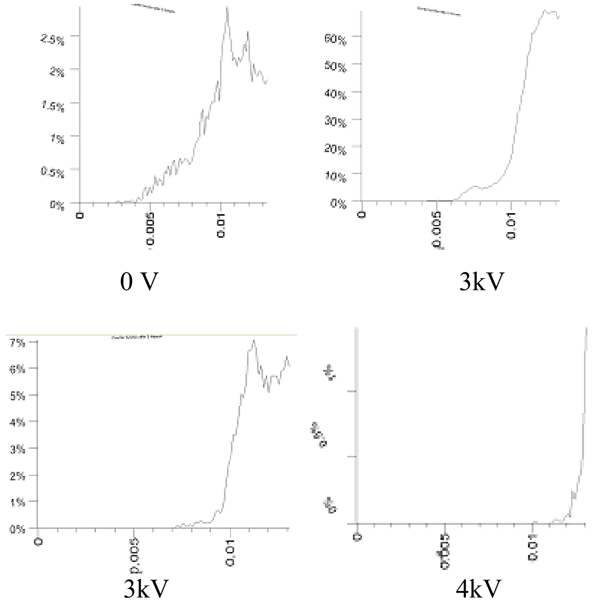


Figure 2: Multipactor electrons number in coaxial line for different DC bias applied to inner conductor.

3D – INTERFACE

Initially MultP-M had only 2D visualization mode. Both model and simulation results showed via three planes aligned to coordinate axes (see Fig. 3).

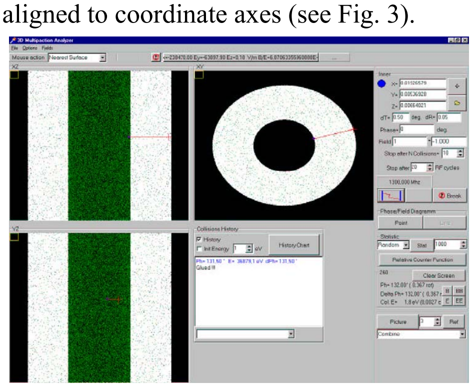


Figure 3: MultP-M: 2D interface.

However, electron trajectories analysis is very important for multipactor study. For complex models multipactor localization and its features is hard to find without true 3D figures and corresponding tools. For this reason Multp-M code was upgraded with 3D visualization module.

Code itself operates in MS Windows environment, so 3D graphics was made using OpenGL library. Fig. 4 illustrates Multp-M snapshot for disk loaded waveguide model and simulated multipactor electron trajectories.

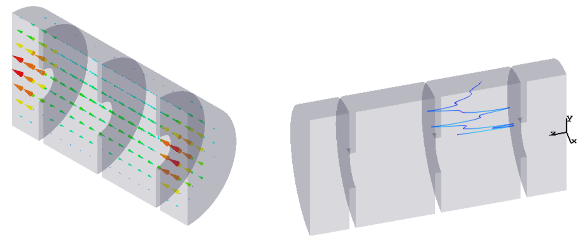


Figure 4: MultP-M: multipactor in DLW simulation results (left - electric field distribution, right – electron trajectory)

New 3D interface allows full visualization of model, electromagnetic field distributions and found electron trajectories. Panning, zoom, rotation, cut-off plane placing, transparency control and other functions are available.

TRANSIENT MODE

New simulation module for transient case development became an important code upgrade. This feature allows one to study multipactor in RF devices operating not only in steady state but also for different transient conditions occurring for example at power-on. New module for pre-calculated time-dependant fields using general purpose electromagnetic solver import was created. Transient fields distribution is interpolated using set of field matrices at different discrete time steps.

Both single and group multipacting electron trajectories simulation in transient mode made ready for use. Sample model for transient solver demonstration is rectangular waveguide of 20x40 mm cross section operating on 5712 MHz. Input signal waveform used in simulation is shown on Fig. 6. Electromagnetic field distribution along the waveguiede for 2 ns after pulse launch is shown on Fig. 6.

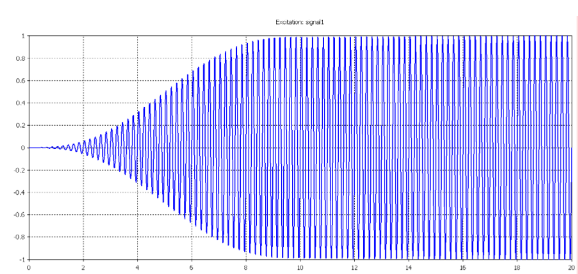


Figure 5: Transient signal waveform

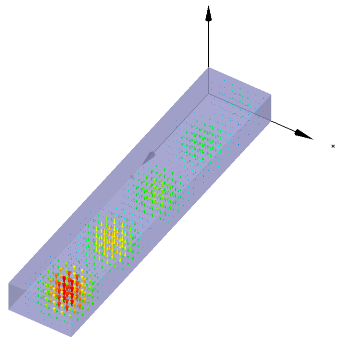


Figure 6: Electric field in waveguide distribution 2 ns after pulse rise (MultP-M).

Fig. 7 presents the rectangular wavegude operating on 5712 MHz example test simulation results. Multipacting electrons trajectories are shown along with overall electron number vs. time.

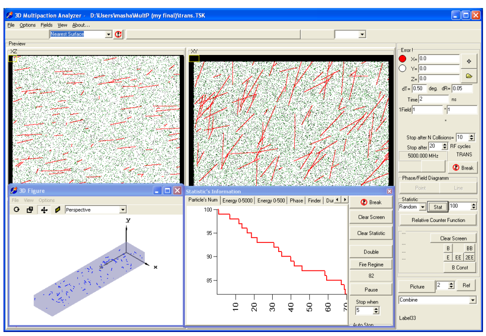


Figure 7: Multipactor electrons trajectories and overall electron number vs. time for transient mode

CONCLUSIONS

New modules for multipactor simulation Multp-M code upgrade were developed and tested. Series of examples were presented to show code capabilities for simulation of devices with static fields and in transient conditions. 3D interface developed for this code is also.

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