Simulation of Indirect Effects of Lightning on Aircraft Engine

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***Abstract*— This paper presents a new approach for simulating the indirect effects of a lightning impact on an aircraft engine. Based on macro modelling, it performs a model reduction, in a similar way as "stick models", but using a patch support instead. This new macro element allows for fast resolution of the quasi-static lightning injection problem.**

Keywords—Lightning Simulation; Macro Modelling; Patch Finite Elements.

I. Introduction

Numerical simulation plays a major role from the specification to the certification of an aircraft engine regarding lightning indirect effects [1]. On the one hand, 3D solvers, based on the resolution of discretized Maxwell's equations, can be used to predict precisely the constraints to be applied to equipments in a complex system, and therefore be part of lightning certification process. However, they involve heavy tools which are inappropriate for parameters optimization or measurements analysis. On the other hand, much lighter models such as "stick models" have gained a lot of interest [2][3]. Based on the PEEC (Partial Element Equivalent Circuit) method, they have shown to be faster and sufficiently accurate in some aeronautical applications. One drawback though is the poor estimation of the current distribution at higher frequencies as current is constrained to follow the stick path. A new model, based on macro modelling, has been implemented to overcome this problem.

II. Stick model analysis

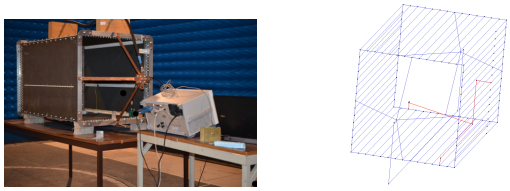

Figure 1. Left: EADS IW composite box. Right: stick model implementation (GiD)

We consider a configuration with a cable inside a composite box (Fig. 1), originating from EADS-IW and simulated in the frame of the French Industry Project called PREFACE [4]. We apply a first model in which the box is meshed with wires the radius of which is determined by the Equal Area Rule (EAR) and with a conductivity extracted from measurements. The simulated current flowing over the cable from a lightning injection differs from measurement beyond 10 kHz, as depicted in Fig. 2.

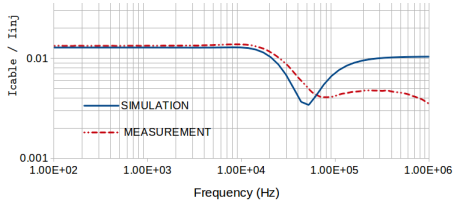

Figure 2. CW analysis of normalized current over a branch of a cable inside the box. continuous: simulation with LiRiC (Onera), dashed: measurement

III. Patch implementation

A new macro finite element has been implemented. Its support, called "patch", results from the segmentation of wires and triangulated surfaces using the Fiedler vector of the corresponding Laplacian matrix.

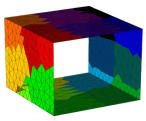

Figure 3. Surface segmentation of the composite box

A quasi-static solution of the lightning injection problem can be approximated using two methods: one takes a static current distribution over the system to represent the macro finite element in the micro element basis and provides a reduced inductance matrix over patches; the other one defines for each patch of the system an adapted number of degrees of freedom. The oral presentation will show the improvement obtained with this new approach.

References

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