A MULTIPHYSICS CO-SIMULATION FOR A WIDE BAND GAP POWER MODULE FATIGUE-RELATED PERFORMANCE ASSESSMENT

Benjamin Boulbene[1], Toni Youssef[2], Donatien Martineau[2], David Balland[1], Régis Meuret[2]

[1] Chiastek

[2] Labinal Power Systems

benjamin.boulbene@chiastek.com

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ABSTRACT

Fatigue-related performance testing remains a costly endeavor for aeronautical equipment. They must endure a huge number of cycles representative of the operating environment. Moreover, a finite number of destructive tests can be carried out in specific facilities for a fairly low number of configurations.

The purpose of this study is to show how multi-physics cosimulation can offer more confidence to several engineer teams at an early stage of the component design.

Here is investigated the performance of power electronic components working under a harsh avionics environment. In aircraft applications, electronic components are subject to severe thermal loadings due to both electrical power operations and flight temperature profiles. Great amplitude for numerous temperature cycles tends to damage the structure of the component; this integrity loss has a significant influence on the module electrical power performance. Three physical problems are strongly coupled with a non-trivial behavior. Multi-physics modeling was seen as the best solution to investigate the electro-thermo-mechanical behavior of the electronic component in such environments at the predesign stage.

CosiMate's open architecture enabled to create a specific component to connect Ansys MAPDL to other simulators through a cosimulation bus. This method empowered the design team to create an open platform

matching their skills and current software configuration. Regarding this case, Synopsys's Saber, for 1D power electronics simulation, and Ansys MAPDL, for 3D thermal and mechanical modelling, have been coupled over the CosiMate bus. The open architecture workflow associated to 1D/3D coupling helps saving a significant amount of resources compared to a new complete software solution.

Moreover, every physical phenomenon has its own characteristic time. Using CosiMate, one can use each simulator with its dedicated time-step. Orders of magnitude are 10ms for the electrical model, 1s for the thermal model, and few minutes for the mechanical model. Setting carefully the cosimulation synchronization time-step enables one to make the best trade-off between those time-steps and investigate different failure scenarios with a time evolution. Also, it helps reaching a small global simulation time compared to a monolithic or strongly coupled platform while preserving a sufficient accuracy.

Multi-physics transient modelling is performed by a double-coupling method, both involving the thermal analysis. On the one hand, the ANSYS thermal model and the Saber electrical model are coupled over the CosiMate bus. Coupling parameters are a temperature computed by ANSYS thermal and the power losses output from the Saber solver.

The thermal-mechanical coupling analysis was set thanks to ANSYS Parametric Design Language (APDL) scripting capability, illustrating the dependency between crack-propagation and temperature variation. From the mechanical simulation is computed the Strain Energy Density (SED) over the time. The lifetime of the power module is computed according to this SED variation, integrating all electrical, thermal and mechanical phenomena.

This application show how practical cosimulation can be when it comes to creating new workflows involving several physical phenomena at different abstraction levels. The versatility of CosiMate is an asset to integrate new software solutions or versions, as well as new or updated sub-models in a perspective of continual improvement. This study of a single power module is not an end in itself; a broader purpose is to carry out reliability studies, including then a statistical approach. This approach will help to decrease drastically the number of experimental tests and shorten the certification process by testing many configurations in a short amount of time.