APPLICATION BRIEF

Achieving Meaningful Results with an Unusual Winding Setup in Ansys Maxwell

The winding settings within Ansys Maxwell's 3D transient T-Omega solver are widely known. This application note will focus on an unusual winding setup, where different windings share the same conduction path, and will offer tips and tricks needed to achieve meaningful results.

Products Used:

Ansys Maxwell

/ Different windings sharing the same conduction path in Ansys Maxwell's 3D T-Omega solver

The case of different windings sharing the same conduction path was not considered in Ansys Maxwell development when the winding feature was designed and implemented. Nevertheless, under certain conditions and constraints, this setup is doable and delivers good results. Maxwell can typically be applied in wye-connected busbars and power loss studies of power electronics modules. The usual way to address these applications is by using either Q3D Extractor or the recently implemented A-Phi solver within Maxwell. The added value of the present approach with respect to Q3D is that we solve all fields, and with respect to the A-Phi solver, we can also use it in applications where moving parts are present.

The layout of this application note will discuss a typical case study concerning busbars short circuit analysis.

/ Case study: Busbars short circuit Geometry

The geometry is shown in Figure 1. It is taken from a typical example and has been simplified.

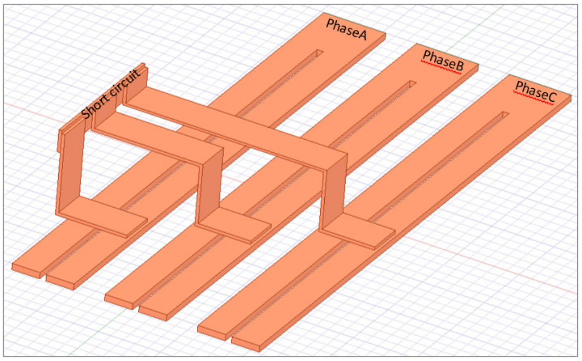


Figure 1. Geometry

Phase Currents

The three short circuit currents in the three busbars are reported in Figure 2.

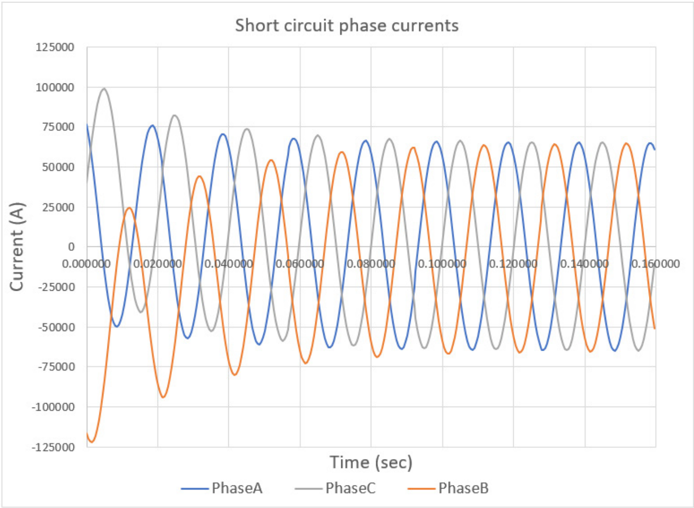


Figure 2. Phase currents

It is easy to see how the three currents are recognized by Maxwell as belonging to the same (and unique) conduction path. Addressing this kind of setup within Maxwell has been a challenge. At present, we have a nice solution using the relatively new A-Phi solver, but the following figures show how to analyze it within the transient T-Omega solver.

Model Setup

The simulation region must have a face tangential to the side faces of the three busbars (Figure 3)

Let's also suppose we have already created suitable datasets for phase currents. We need only two datasets since the third current is calculated using Kirchhoff's first law (Figures 4 and 5)

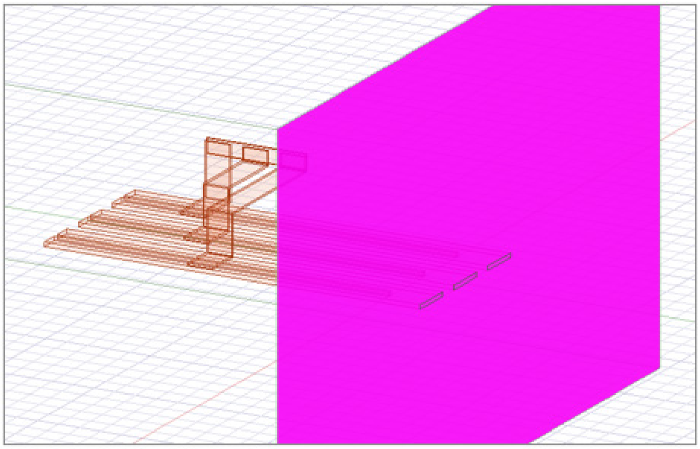


Figure 3. Simulation region's face tangential to the busbars' side faces

The datasets for Phase A and Phase C currents are:

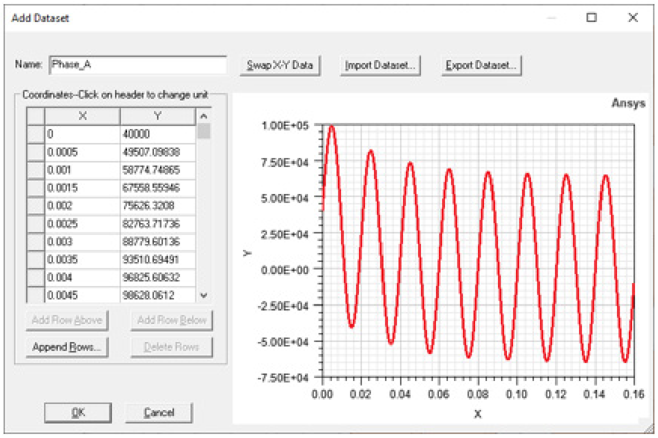


Figure 4. Phase A current dataset

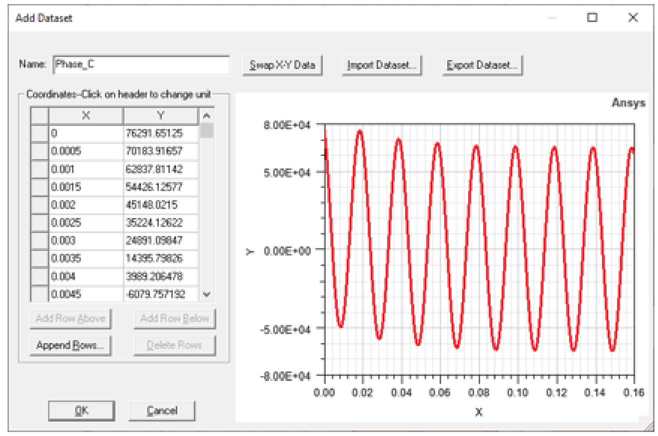


Figure 5. Phase C current dataset

Concerning the coil terminals assignment, for Phase A we use the three busbars' side faces tangential to the simulation region. The assignment needs to be set up as follows (Figures 6-8):

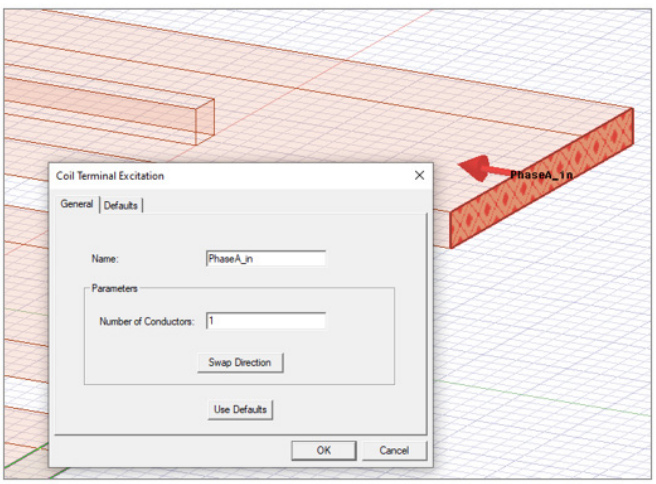


Figure 6. Phase A input coil terminal

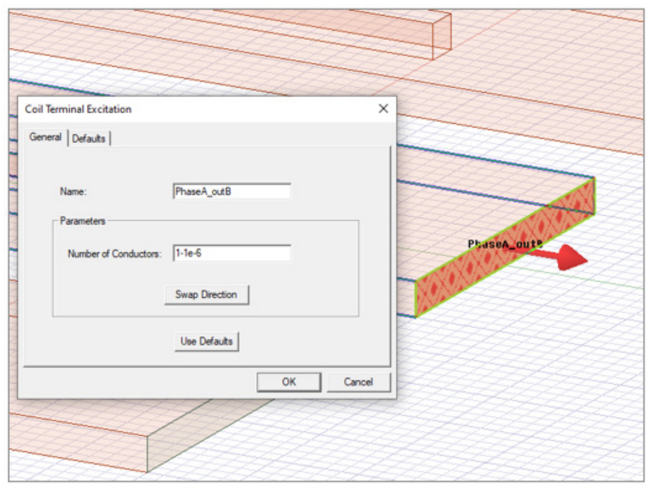


Figure 7. Phase A output coil terminal on Phase B

Please note the number of conductors: **1-1e-6=0.999999**.

Please note the number of conductors: **1e-6**. With such a setup, we force the Phase A current to flow almost totally through Phase B busbar in the opposite direction.

Concerning coil terminals belonging to Phase C, we need to select the same faces we assigned Phase A coil terminals to and use the command "Create object from faces." This way, we create three sheets (2D entities) where we can assign coil terminals. We need to do this preliminary operation because it is not possible to assign multiple coil terminals to the same faces (Figures 9-11).

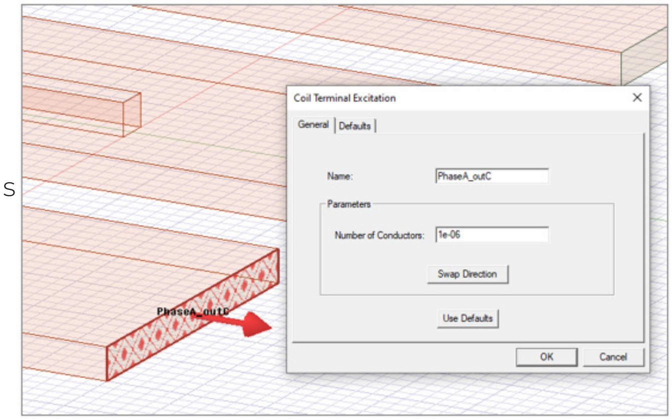


Figure 8. Phase A output coil terminal on Phase C

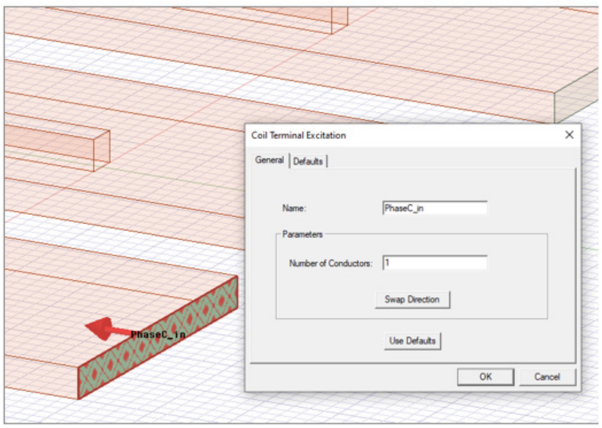


Figure 9. Phase C input coil terminal

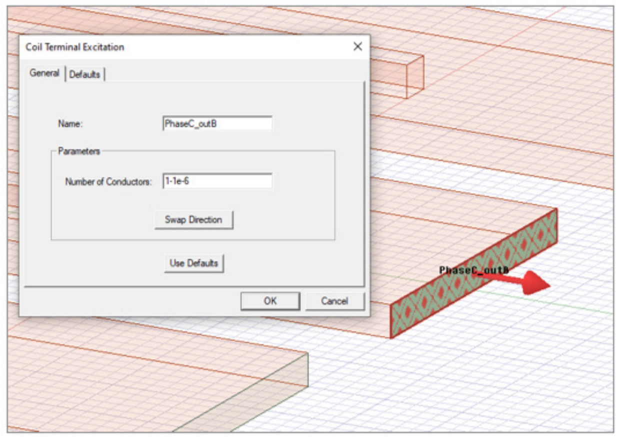


Figure 10. Phase C output coil terminal on Phase B

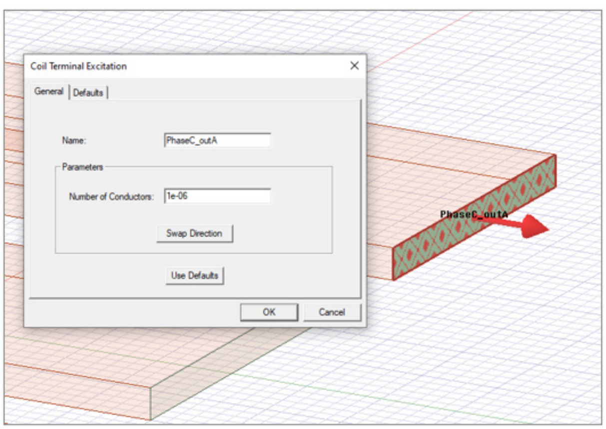


Figure 11. Phase C output coil terminal on Phase A

Once we have created the six coil terminals, we need to assign them to two windings, as in Figure 12:

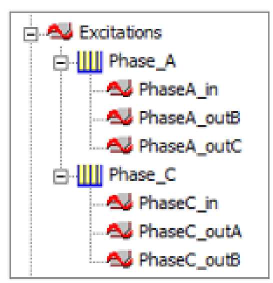


Figure 12. Winding setup

The two windings' properties are shown in Figure 13, where we have taken advantage of the built-in piecewise linear (pwl) function.

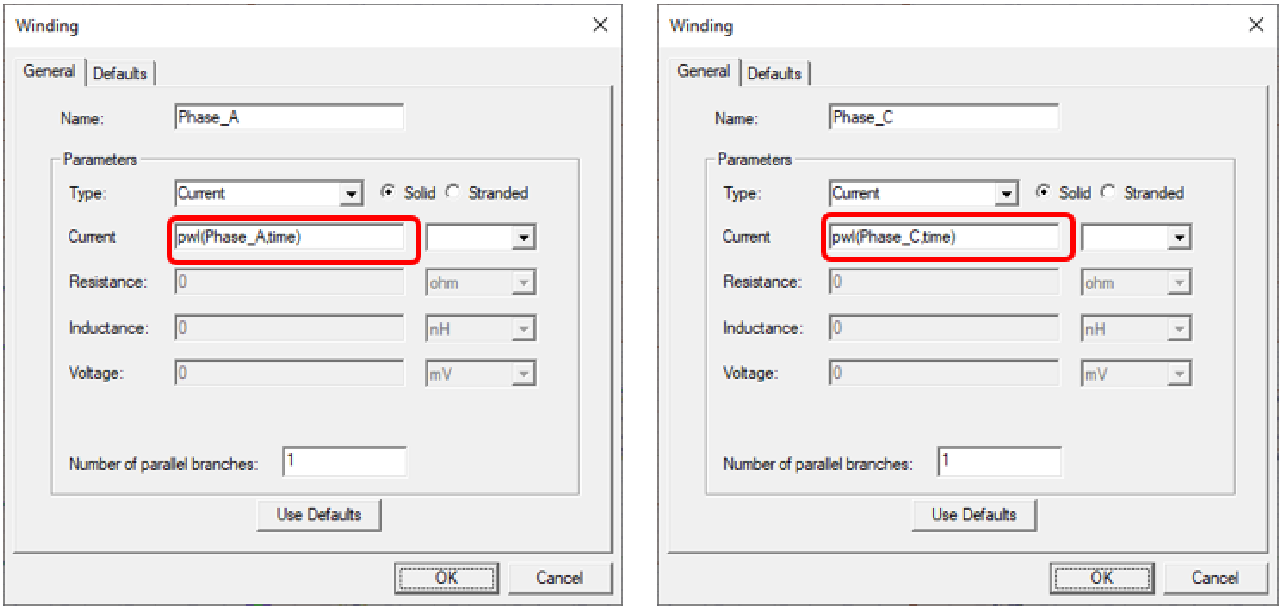


Figure 13. Phase A and Phase C winding properties

To avoid possible issues, it is recommended to select "Perform minimal validation," as the above setup could not pass the user interface (UI) validity check (Figure 14).

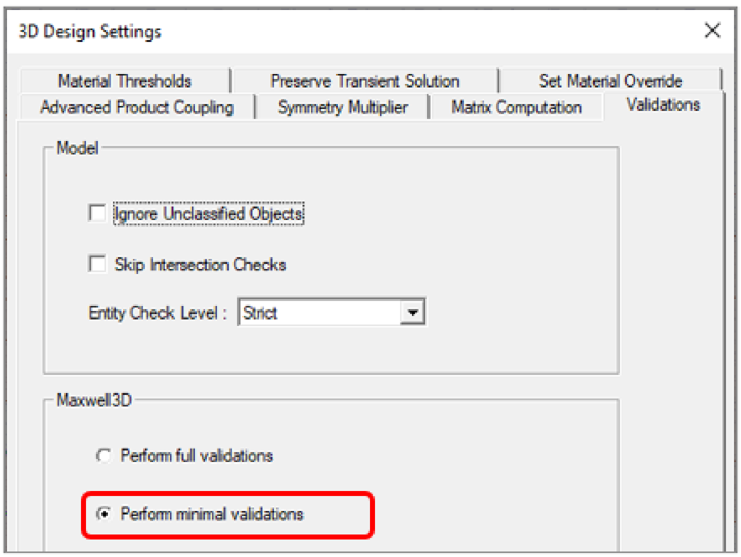


Figure 14. Validation settings

In the simulation setup, the time step has been set to **5e-4 sec**.

/ Results and Comparison with Ansys Maxwell's A-phi Solver

The used mesh is displayed in Figure 15.

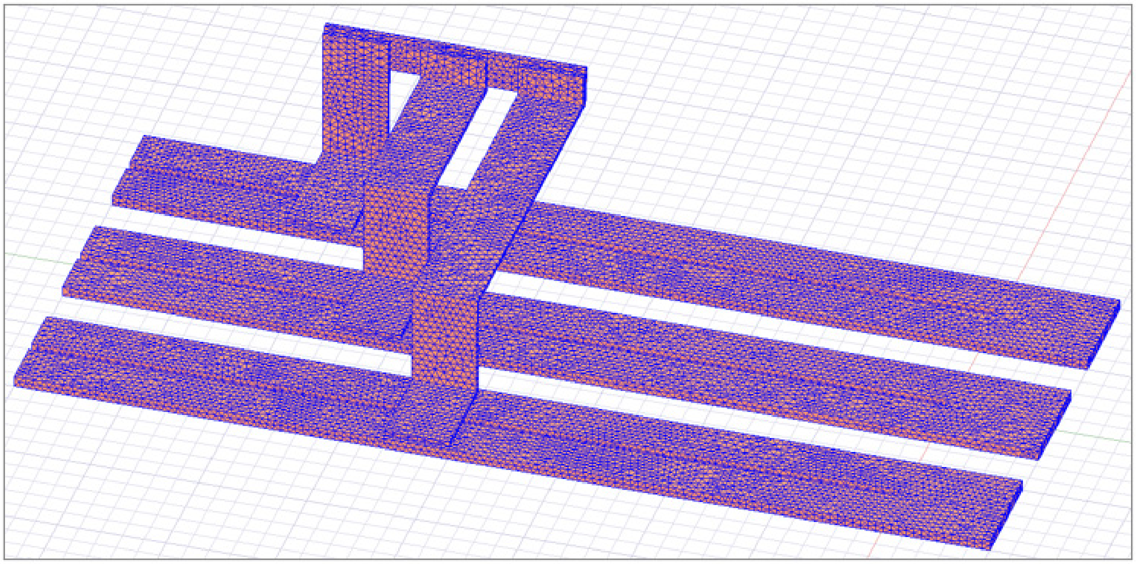


Figure 15. Mesh on the busbars

The two input currents are reported in Figure 16.

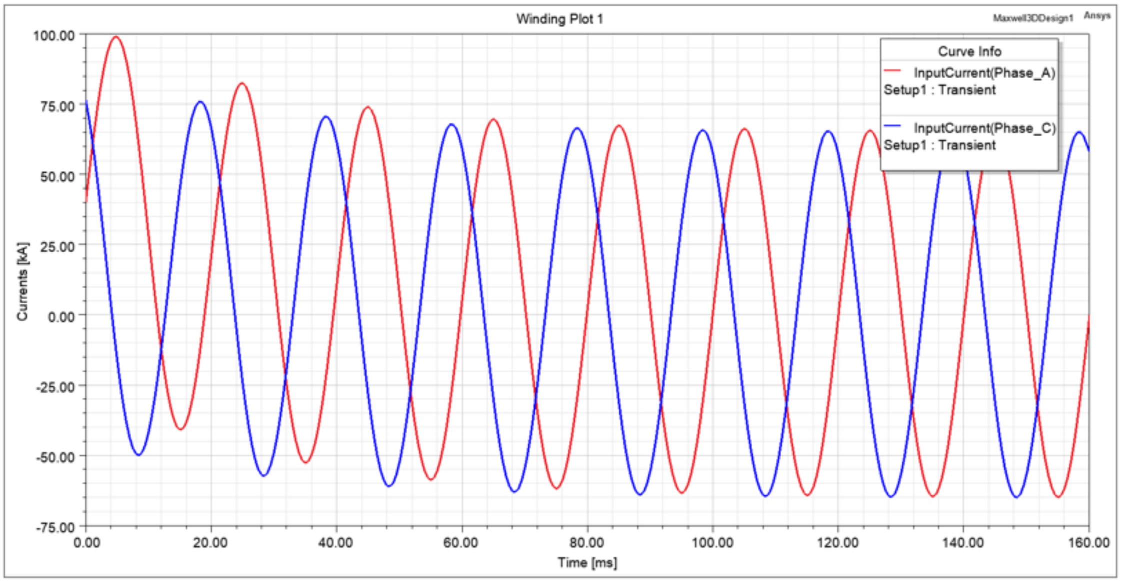


Figure 16. Simulated input currents

The current flowing through Phase B can be calculated as **I_phaseB = -I_phaseA-I_phaseC**, or through integration of J-field distribution over the Phase B busbar cross section. Figure 17 reports the comparison between the two aforementioned approaches. It is easy to see how the two ways for calculating Phase B current produce identical results.

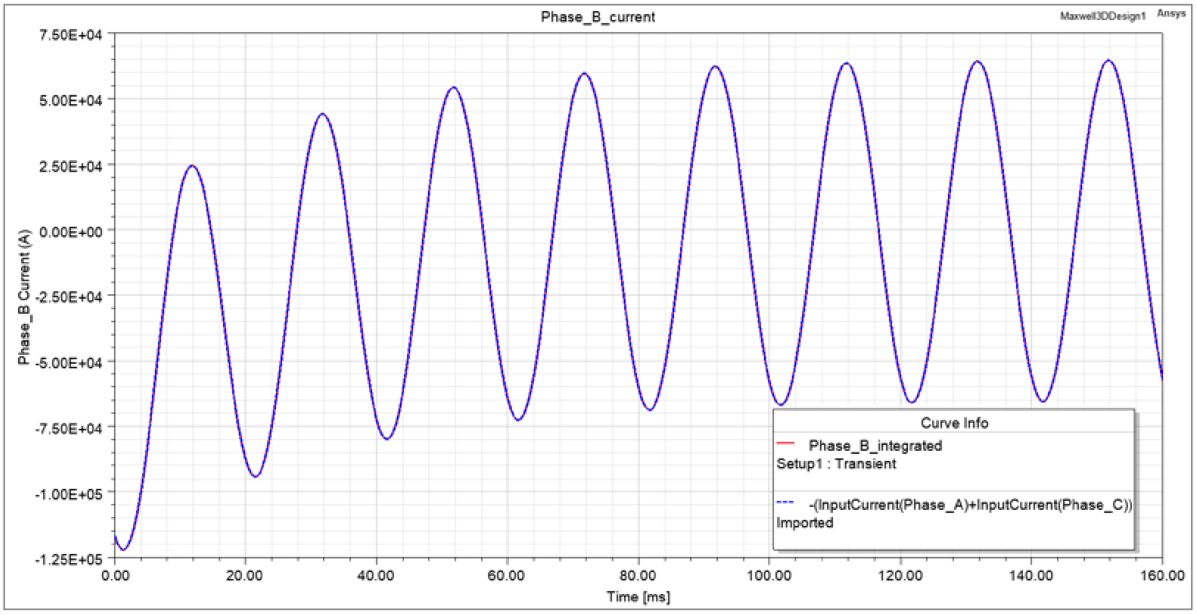


Figure 17. Phase B current calculated both by integration of J-field and by sum of Phase A and Phase C currents

The calculated behavior of J-field after 3 ms is shown in Figure 18.

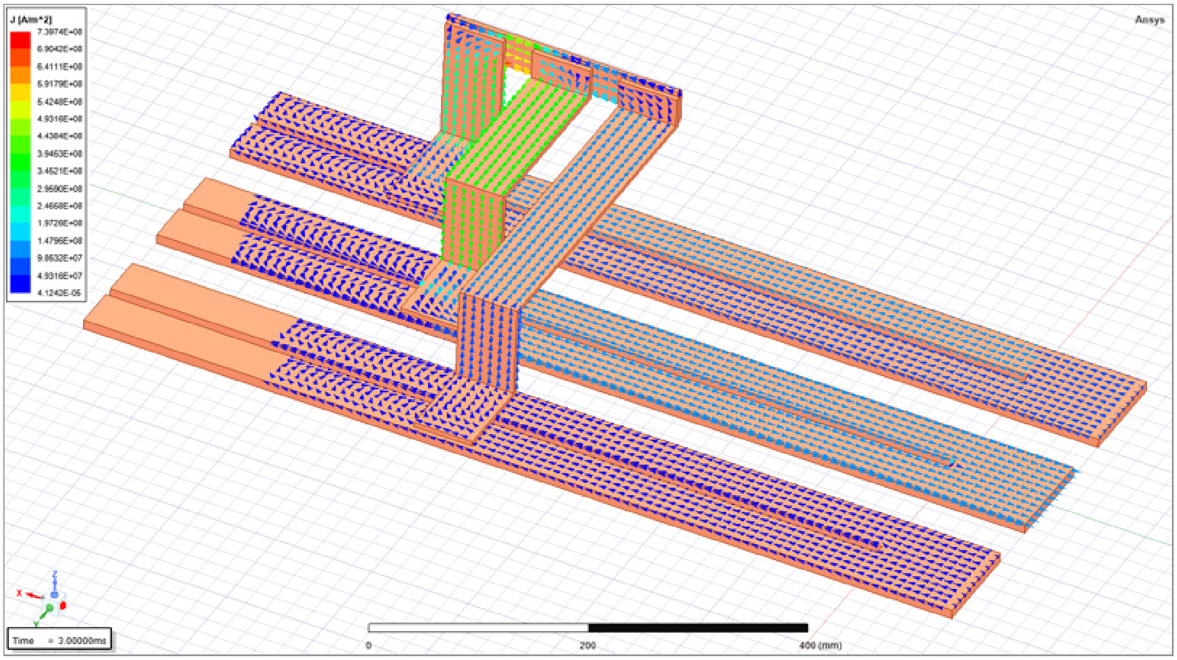


Figure 18. J-field distribution on the busbars after 3 ms

For validating the obtained results, the same geometry has been used to simulate a second design, taking advantage of the A-Phi solver.

Now the windings have been removed and Phase A and Phase C currents have been directly applied on the busbar side faces using datasets. On the Phase B side face, a **Voltage=0** excitation has been assigned (Figure 19).

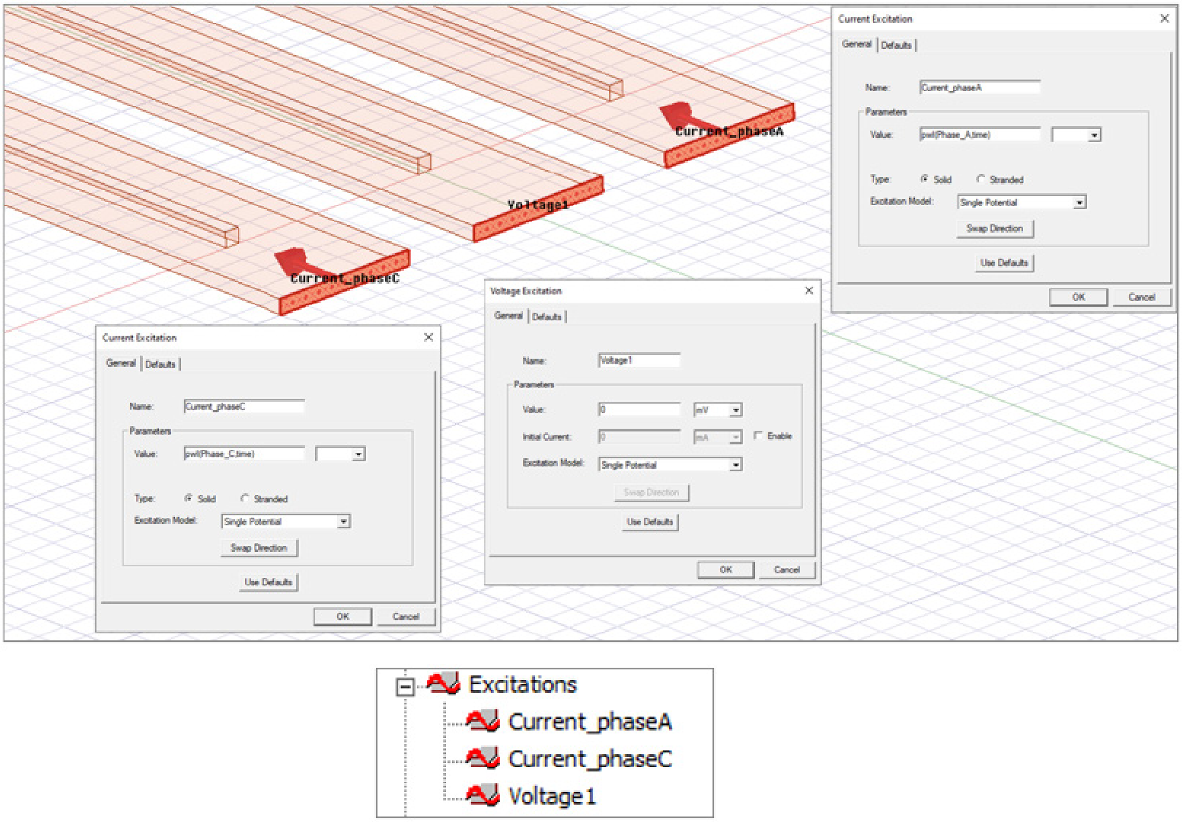


Figure 19. A-Phi solver excitation setup

The results are shown in Figures 20-22.

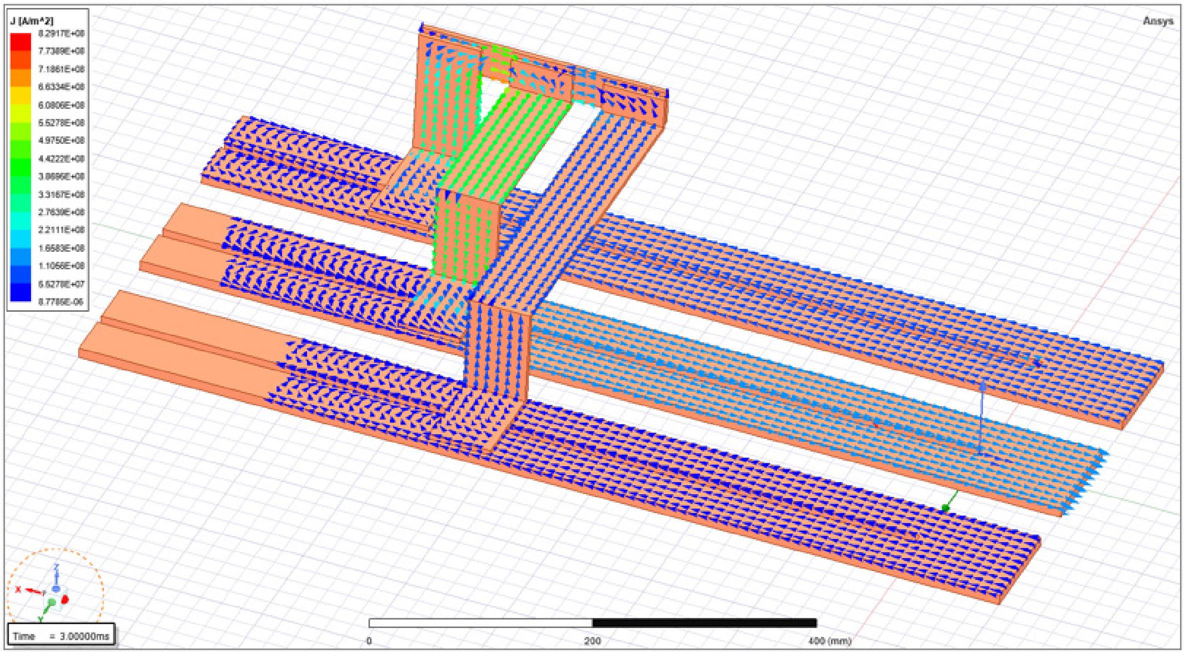
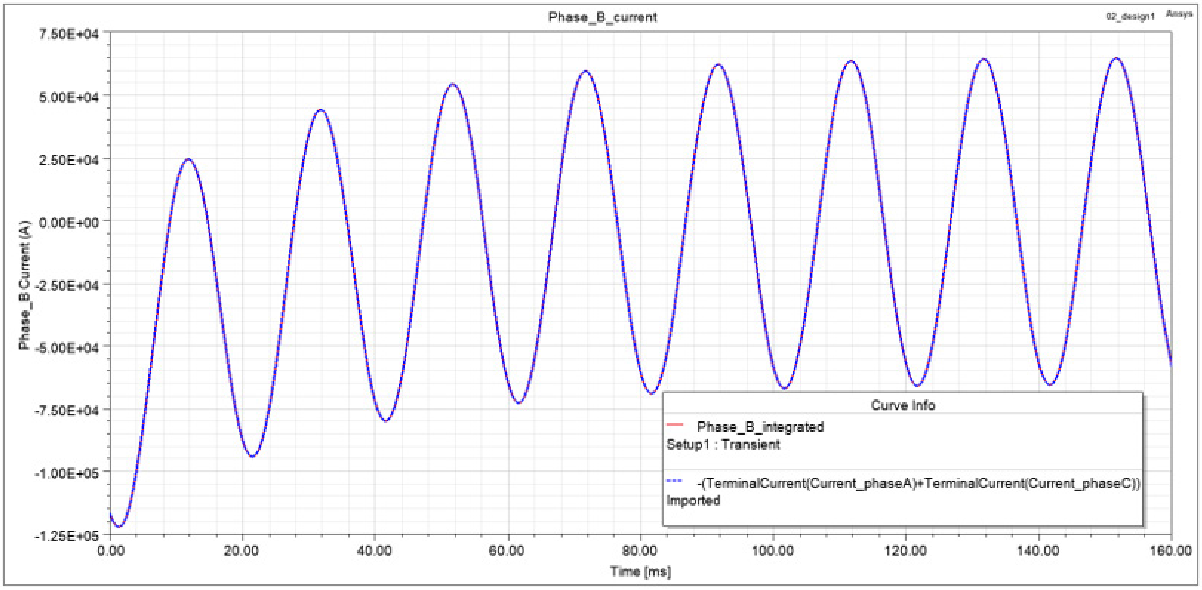


Figure 20. J-field distribution on the busbars after 3 ms, calculated using the A-Phi solver



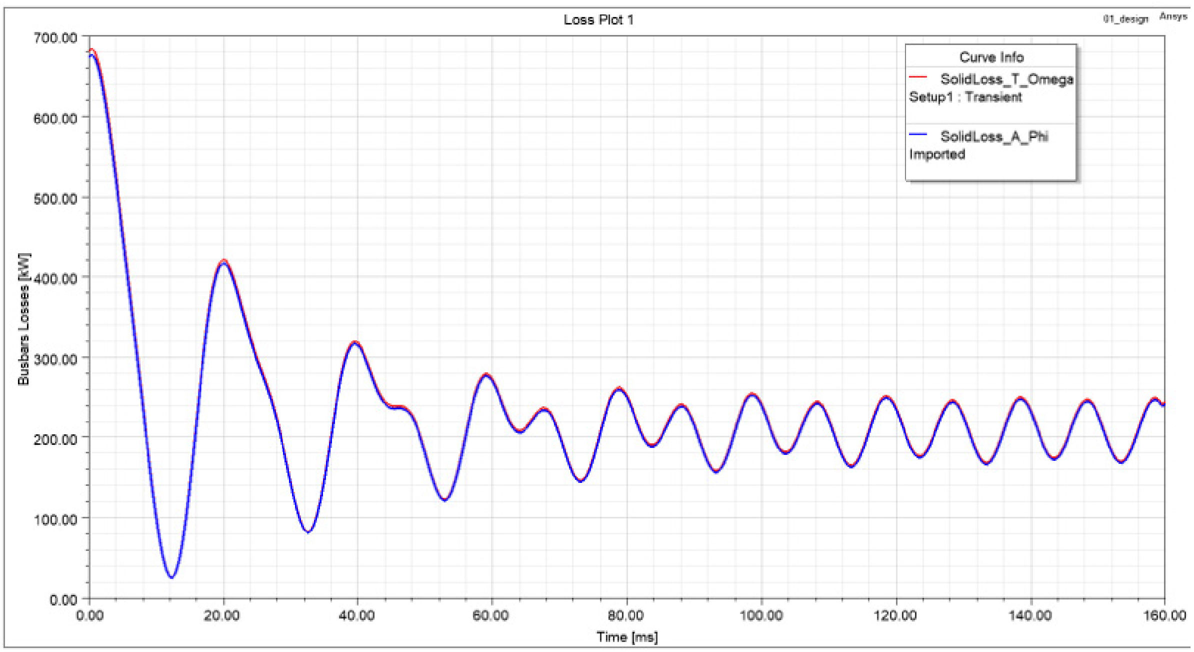


Figure 22. Comparison between losses calculated using the T-Omega and A-Phi solvers

The obtained results match the ones we obtained using the T-Omega solver almost perfectly.

/ Summary

In the present application note, an unusual winding setup in Maxwell's 3D transient T-Omega solver has been implemented and discussed. The peculiarity of the presented winding arrangement is that different windings share the same conduction path. A comparison with an equivalent model based on Maxwell's A-Phi transient solver has been carried out and discussed.

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