Accurate Simulation of a Marchand Balun at 2.4 GHz

Marchand Balun

Explore our simulation of a Marchand balun, operational at 2.4 GHz with a 1 GHz bandwidth, verified through S-Parameter analysis in HFWorks. The simulation results highlight the balun's capability for equal power distribution and a 180° phase shift between two outputs.
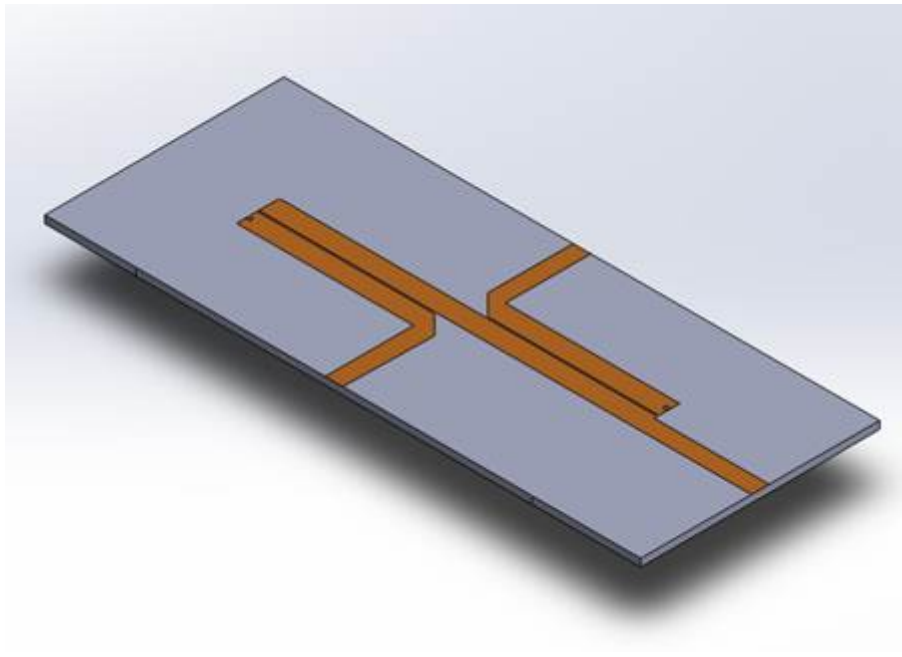

Figure 1: the structure's 3D view in SolidWorks

Simulation

The Scattering Parameters solver excels in analyzing structures by delivering key metrics like Return Loss, Insertion Loss, and Phase Shift between inputs and outputs. Optimal mesh refinement is crucial on conductors, ground slots, and vias to ensure precise frequency response analysis.

Loads/ Restraints

The conductor, placed on a 0.8 mm RO4003 substrate (Er=3.38), uses a zero thickness approach with small vias at output ports for connectivity. An encompassing air box models radiation effects, extending both above and below the substrate.

HFWorks allows impedance analysis variations by enabling a "Skip 3D solution" option for quick impedance checks without full simulation. It requires defining integral lines on the port's surface for precise Zpv and Zvi calculations, optimizing electric field orientation with a calibration path for accurate port mode analysis.
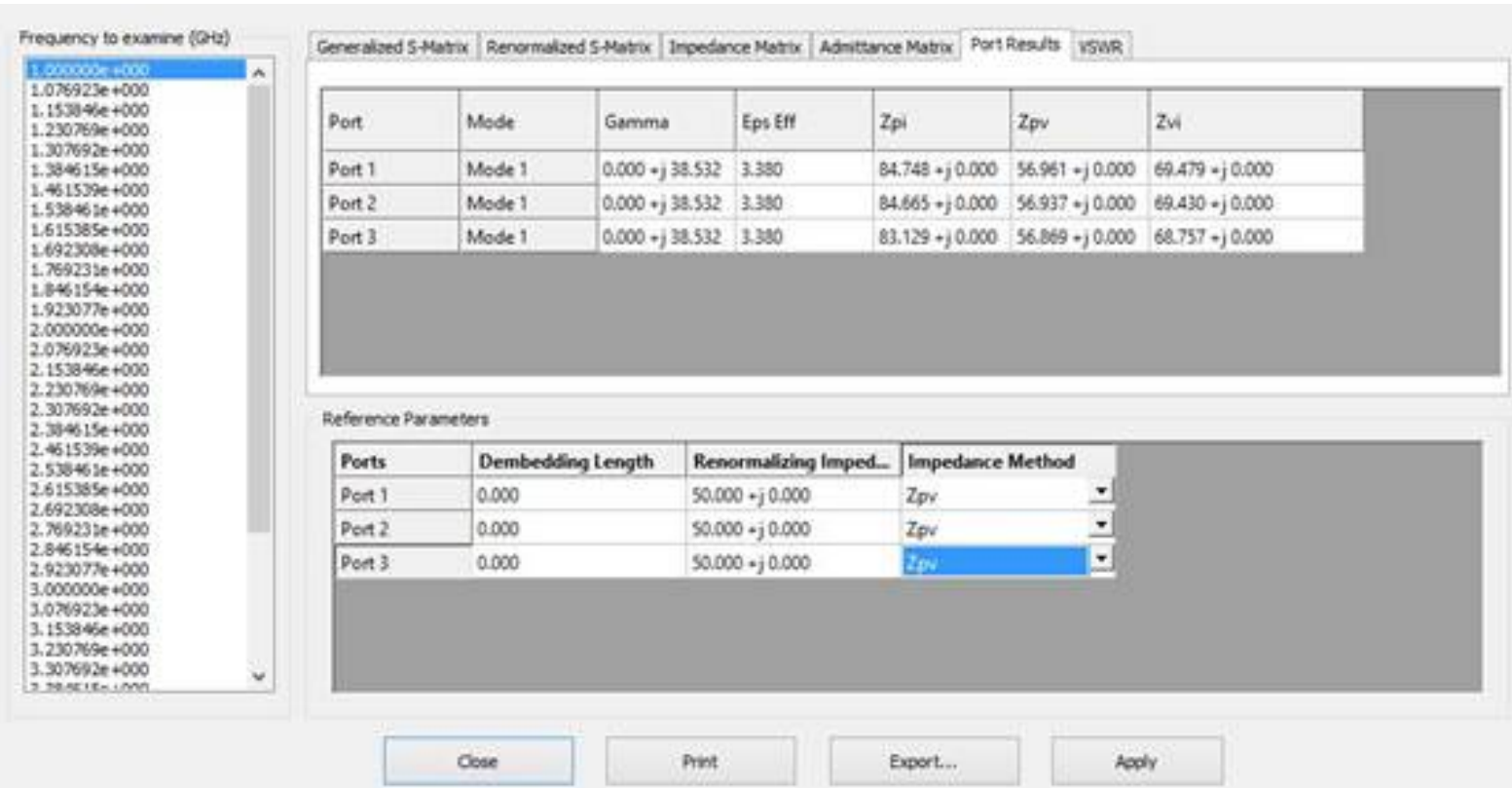

Figure 2: Impedances of the port

Results

To ensure the HFWorks simulator's accuracy, it's vital to compare simulation outcomes with actual measurements. The provided figures demonstrate the structure's insertion and return losses across the 1 to 4 GHz frequency range.
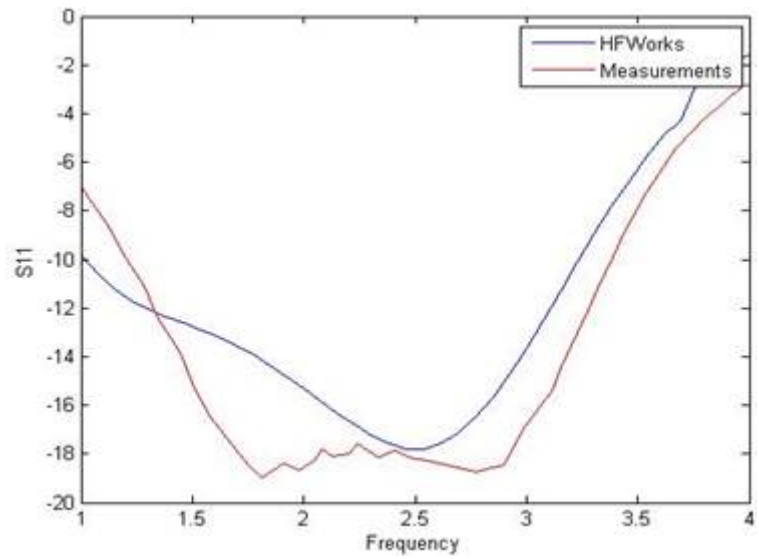
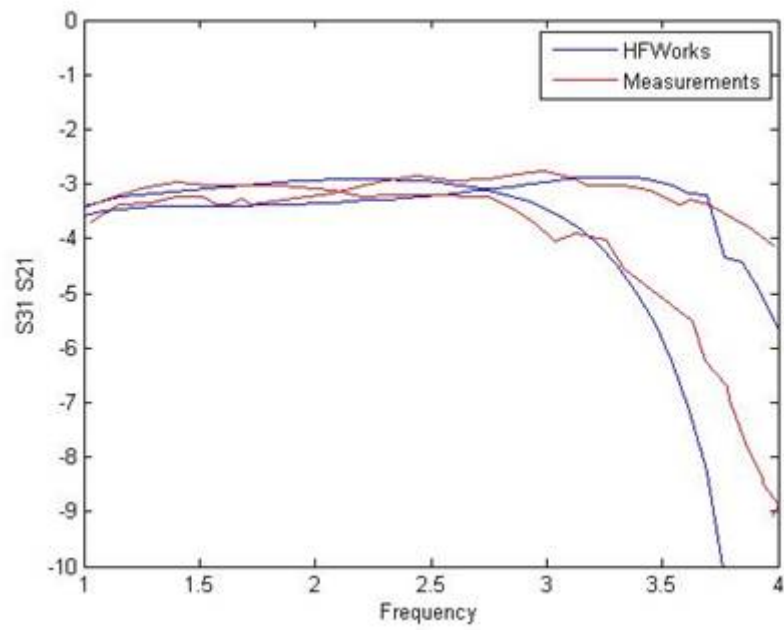Figure 3: Reflection coefficient at the balun's input port

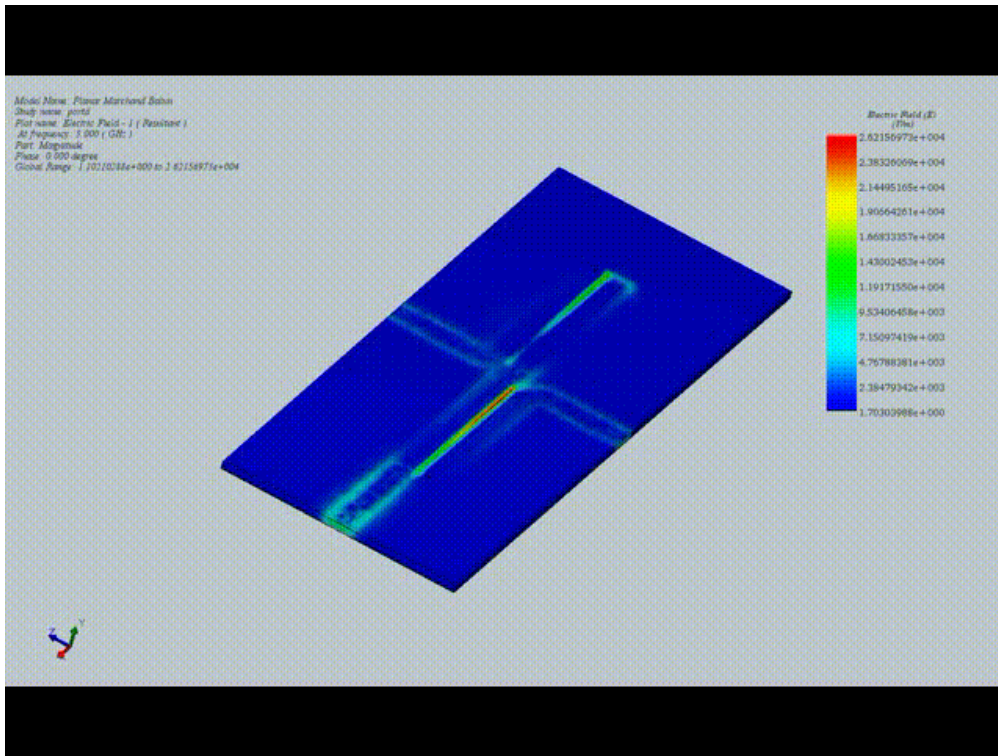Figure 4: Insertion losses at the balun's output ports

Figure 5: 3D Electric Field Distribution at 3 GHz

Conclusion

This application note explores the simulation of a Marchand balun, designed to operate at 2.4 GHz with a bandwidth of 1 GHz, using HFWorks for S-Parameter analysis. The simulation validates the balun's ability to distribute power equally and achieve a 180° phase shift between its two outputs. The Scattering Parameters solver is utilized to provide essential metrics such as Return Loss, Insertion Loss, and Phase Shift, with careful mesh refinement around conductors, ground slots, and vias to accurately capture the frequency response. The simulation incorporates a zero-thickness conductor on a 0.8 mm RO4003 substrate and models radiation effects with an encompassing air box. Additionally, HFWorks facilitates impedance analysis variations and electric field orientation optimization for precise port mode analysis. The results, including the balun's insertion and return losses across a 1 to 4 GHz frequency range and the 3D electric field distribution at 3 GHz, confirm the accuracy of the HFWorks simulator, aligning closely with actual measurements and demonstrating the effectiveness of virtual prototyping in RF design.

References

[1] A New Planar Marchand Balun Zhen-Yu Zhang, Yong-Xin Guo, L.C. Ong, and M.Y.W. Chia 2005 IEEE