Optimisation of a 10-Way Conical Power Combiner

A ten-way conical power combiner was designed and constructed in a project at the Department of Electrical and Electronic Engineering of the University of Stellenbosch, South Africa [1]. This device is an example of an axially symmetric power combiner, commonly used in the space and airborne industries due to their compact and lightweight nature, their excellent wideband performance as well as their low losses. CST MICROWAVE STUDIO® (CST MWS) was instrumental in the optimisation of the geometry of the power combiner, a photograph of which is shown in Figure 1.

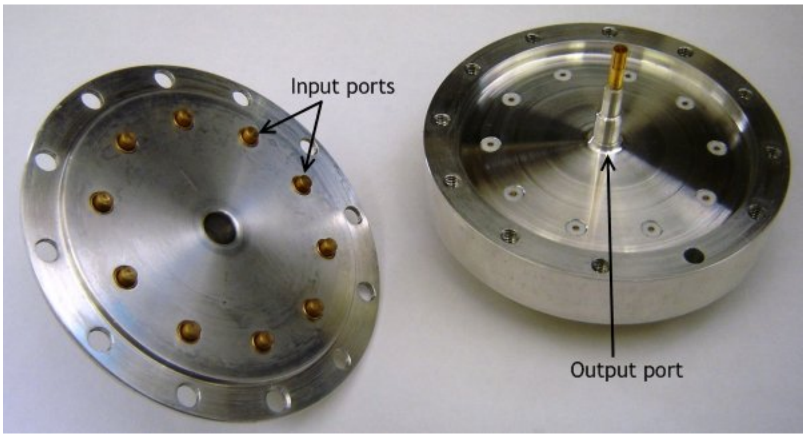

Figure 1: View of the 10-way conical combining structure showing the input and output ports.

Axially symmetric power combiners offer substantial advantages - lower loss, smaller size - over corporate or chain-type combiners, especially when many combining ports are involved. Within this class of power combiners (which includes the ubiquitous radial power combiner), conical line combiners have the desirable characteristic of having a constant characteristic line impedance over a varying radial distance. The transient solver of CST MWS proved to be very useful in the optimisation of the power combiner's performance, allowing the rapid design of a combiner with better than -14.5 dB return loss over a 6.5-14.1 GHz frequency range.

The CST model of the combiner is shown in Figure 2. It is constructed by placing the vacuum and dielectric parts of the structure within a PEC background material. A stepped impedance coaxial airline is used to match the 50 Ohm input port impedance to the 5 Ohm impedance the conical transmission line. The positioning of the input ports relative to the outer wall of the combiner, shown by the "back-short" distance in Figure 2, was optimised using CST MWS. The rotationally symmetric positioning of the input ports around the central output port allows CST's S-parameter symmetry functionality to be used to reduce the number of simulations needed to determine the full S-parameter matrix. Two planes of magnetic symmetry were also used to reduce the total simulation time by a factor of four.

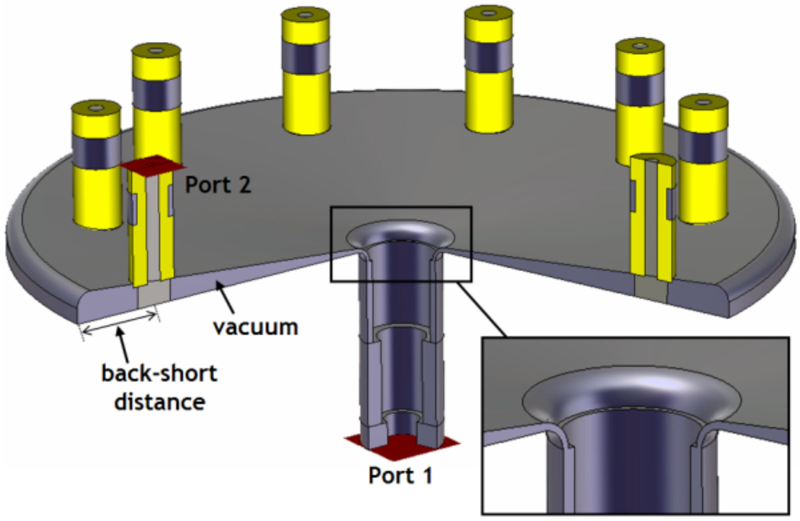

Figure 2: A cut-away view of the CST MWS model of the conical combiner. The inset shows a more detailed view of the coaxial-to-conical line transition.

A comparison of simulated and measured results is shown in Figure 3. Given the difficulty in accurately constructing and simulating such a large structure (about 65 mm diameter) with such small gaps (only 0.28 mm at the coaxial-to-conical transition), the agreement is generally good, though some deviation is seen in the reflection coefficient of the output port at the higher cut-off frequency. A view of the electric field propagation through the device at 10 GHz may be seen in Figure 4.

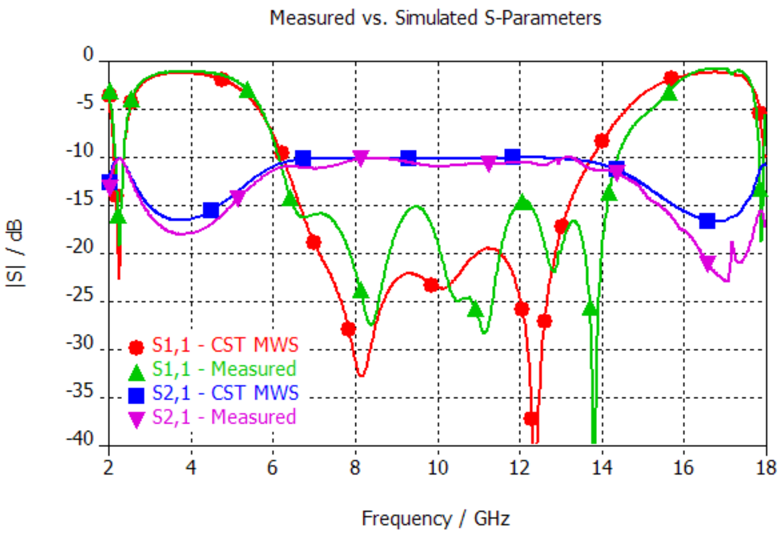

Figure 3: A comparison of the simulated and measured reflection coefficients at the central output port, and of the transmission from an input port to the output port.

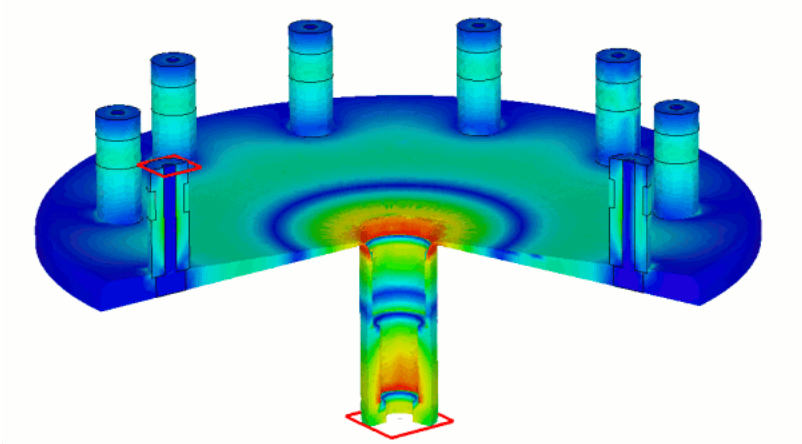

Figure 4: An animation of the electric fields at 10 GHz. In this scenario the combiner is being used in reverse mode as a splitter.

CST MICROWAVE STUDIO® was successfully used in this project as part of the procedure for designing a state of the art compact and lightweight conical power combiner which displayed a matched bandwidth of 74%. CST's PERFECT BOUNDARY APPROXIMATION (PBA)® allows rounded structures such as this one to be modelled with great accuracy. At the same time, the speed of simulation - this structure contained over 16 million mesh cells but simulated in less than 4.5 hours on a standard desktop server - allows parametric studies and optimisations to be carried out in reasonable time frames.

CST would like to thank Dr. Dirk de Villiers and Prof. Petrie Meyer of the University of Stellenbosch for providing the CST model and measured results for this application note.

[1] D. I. L. de Villiers, P. W. van der Walt and P. Meyer, "Design of a Ten-Way Conical Transmission Line Power Combiner," IEEE Trans. Microwave Theory Tech., Vol. 55, No. 2, pp. 302-308, Feb. 2007.

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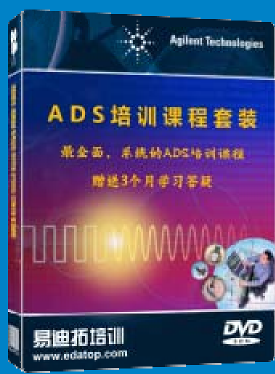

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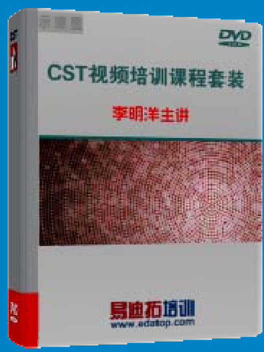

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