Modeling and Simulation of DRF in WIPL-D

The aim of this white paper is to present the possibilities for modeling, simulation and adjusting of a dielectric resonator filter in WIPL-D software environment. Using a variety of WIPL-D features, rather complex model of the DRF can be easily designed and efficiently simulated.

This paper describes the realization of a 2.3 GHz band filter using dual-mode dielectric resonators for cellular communications. These filters are a new and exciting technology in the microwave filter industry. The filters capitalize on the inherent property of dual-mode dielectric resonators to exhibit two resonances. Dual-mode DR filters are superior to single-mode DR filters, but they are more complex and harder to simulate, design and implement.

The property of having two modes can be exploited to develop filters that have the same advantages of single-mode dielectric filters while also exhibit better performances, as well as small size and mass with fewer components and, therefore, they are less expensive to manufacture.

Dielectric resonator

At the resonant frequency most of the electromagnetic energy is stored within the dielectric resonator. The support is used to ensure that there is no contact between the puck and the enclosure. The enclosure acts as a shield to prevent radiation and due to the puck's remoteness the resonant frequency is controlled by its cross sectional area and permittivity constant. The shape of puck used in this example is shown on Figure 1.

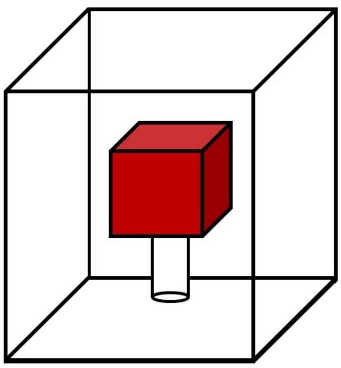

Figure 1. Shape of dielectric puck.

Filter Model

An example used to fully expose the wide variety of WIPL-D unique features is a dielectric resonator filter with 2 separate cavities, which are coupled in a rather specific way. Thus, this filter is a four-section, two-cavity filter. Filter layout is presented in Figure 2.

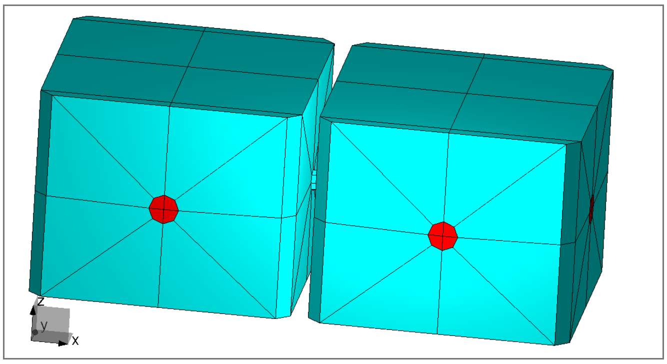

Figure 2. Layout of dielectric resonator filter.

The dimensions of the cavities are 50 mm x 50 mm x 40 mm. The resonating frequency should be about 3 GHz.

Transformer is used to replace the wire probe. The transformer is a rod made of metal, smaller than the length of the cavity, with a hole at the bottom to enable fixing to the cavity. It is placed vertically in cavities to couple to the electric field of the dual-mode resonance. The details of the feeding are presented in Figure 3.

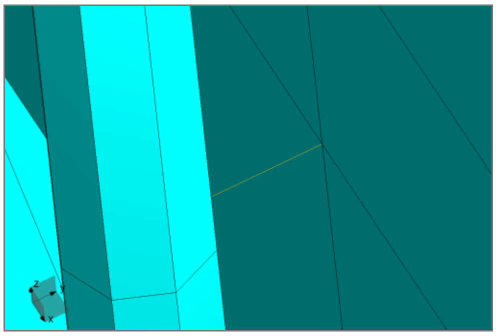

Figure 3. Transformer used for feeding of the structure.

Two dielectric tuners are used in each cavity to control the resonant frequency. They are cubes (19 mm x 19 mm x 19 mm) made on high quality ceramics with Er = 44 and TgD = 10^{-5}. Support for the dielectric tuners is made from alumina (Er = 9.8 and TgD = 10^{-4}). The interior of the filter is presented in Figure 4.

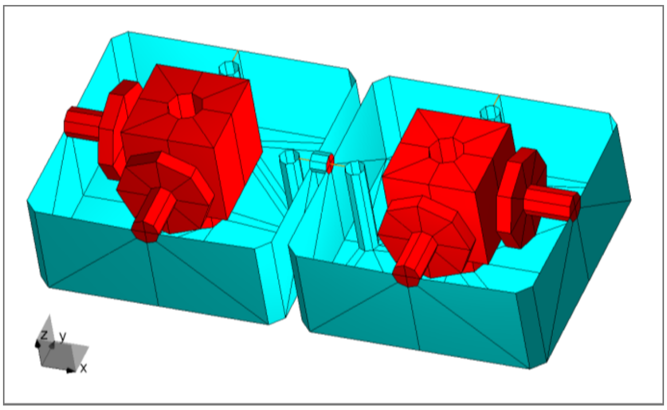

Figure 4. Interior of dielectric resonator filter.

The filter is modeled as symmetrical and the distance between dielectric tuner and the dielectric puck is the main factor used to control the filter response (Figure 5).

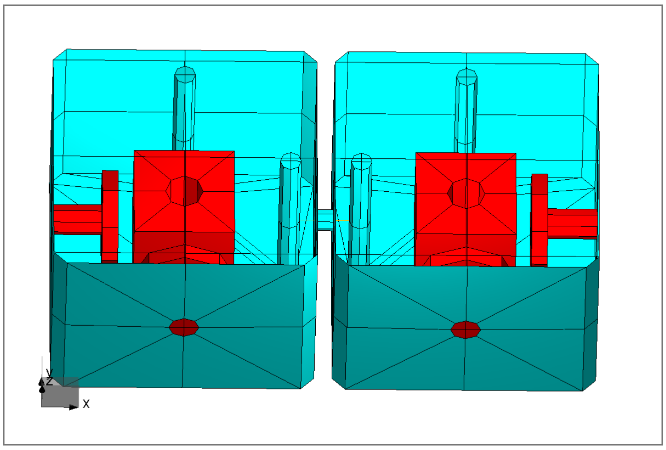

Figure 5. Coupling distance between dielectric objects.

The actual model (prototype) of the filter that was designed in WIPL-D is presented in Figure 6.

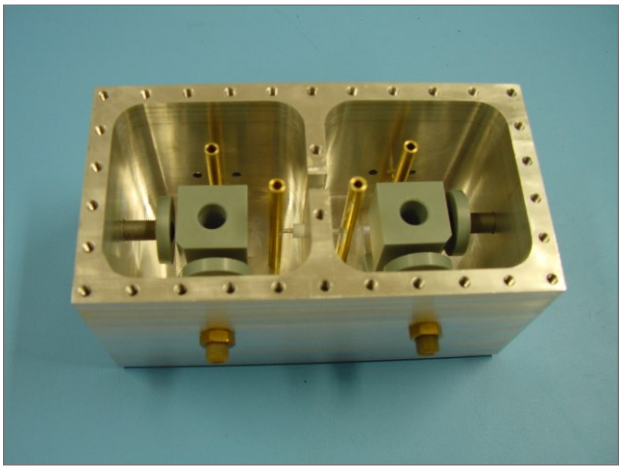

Figure 6. Prototype of the filter.

“Goal-post” inter-cavity coupling design was implemented below (Figure 7). A piece of wire was inserted into a tube of Teflon and set up across the two transformers in the different cavities.

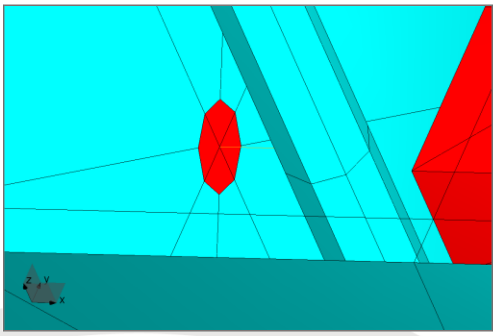

Figure 7. “Goal-post” coupling between the cavities.

The complete filter arrangement has two identical mirrored cavities joined by a narrow, short iris with the “goal-post” transformers (Figures 5-6). The model was created using WIPL-D objects:

- *BoR*s and *Circle*s for transformers, pucks and transformers
- *BoCG*s for the walls of the cavities.

The complete model is parameterized. Hence, the power of WIPL-D Optimizer can be used to tune the filter.

Simulation and Results

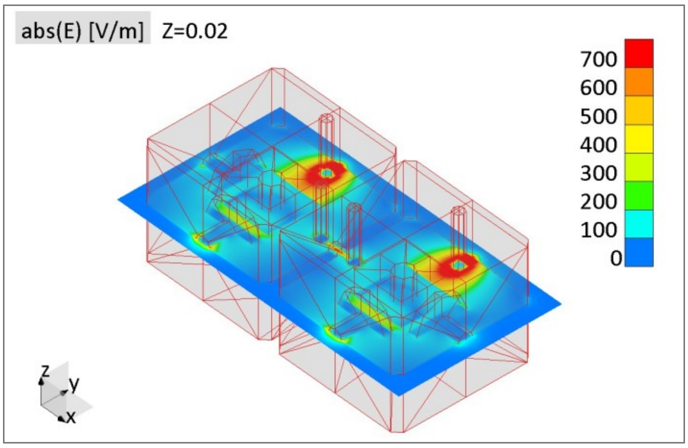

Figure 8. The strength of the electric field.

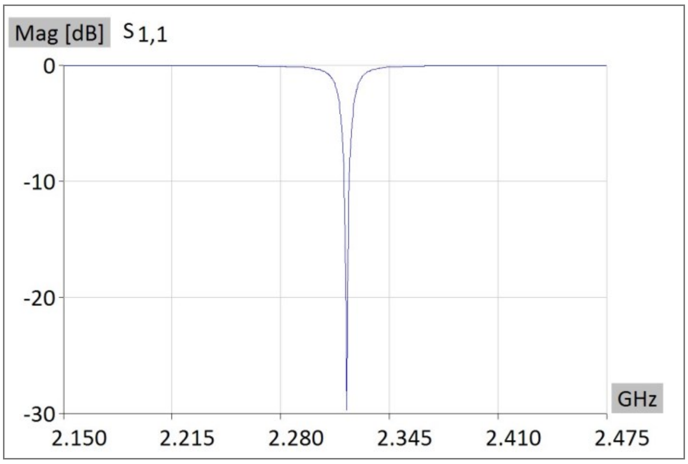

Figure 9. Return loss in frequency band around resonance.

Near field and return loss calculation are presented in Figures 8-9. The model requires approximately 4,000 unknowns and around 3 minutes per frequency to be simulated.