

## Rectangular Waveguide Interdigital Filter

This application note describes simulation of a band-pass, interdigital filter. In general, an interdigital filter represents a coupled-line filter where each section of line is about  $\lambda/4$  long. One end of a section is short-circuited while the other end is open-circuited. The short-open orientation alternates from one port of the filter to the other.

In this application note, a particular case of an interdigital filter with conductors suspended in air and enclosed within a metallic box will be considered.

### A Model of the Interdigital Filter

The interdigital filter was modeled using WIPL-D Pro CAD software where a model of EM structure can be either imported from various CAD formats, or created from the scratch in WIPL-D Pro CAD native editor using built-in primitives. The later approach has been adopted for the particular case of interdigital filter considered here.

Beside basic primitives used to draw the filter structure, a symmetry plane has been utilized to reduce the complexity of the structure and two *Waveguide Ports* were used as feeders. The losses in metal conductors are represented with skin effect, where  $\sigma = 19 \text{ MS/m}$ .

The WIPL-D Pro CAD model of the interdigital filter is shown using *Contours* render mode, in Figure 1.

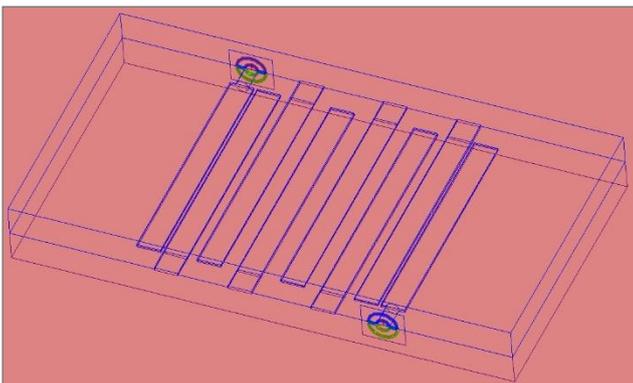


Figure 1. Interdigital Filter in WIPL-D Pro CAD

The half of the interdigital filter is shown using *Shaded with Line* render mode, in Figure 2.

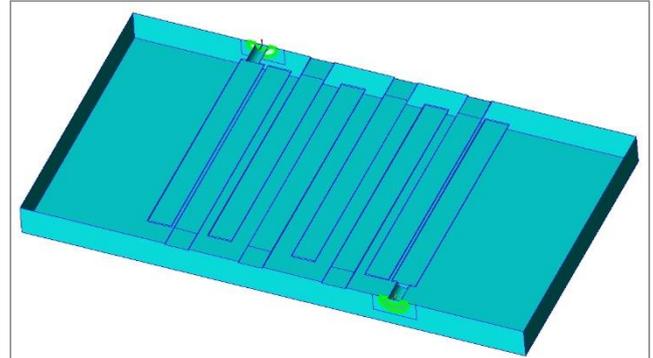


Figure 2. Half of the interdigital filter in WIPL-D Pro CAD

### Simulations and Dimensions

The model of interdigital filter was simulated from 5 GHz to 14 GHz in 26 frequency points. To ensure high accuracy, the convergence of the results has been checked. It has been concluded that the convergence was satisfactory with *Reference frequency* of 20 GHz and *Max Patch Size* of  $0.075 \cdot \lambda$ . After the convergence has been confirmed, dimensions of the filter were adjusted to set values of  $S_{11}$  in the pass-band (8.30 GHz to 10.86 GHz) below -20 dB.

Computer used for these simulations is Intel® Core™ i7 CPU 7700@ 3.60 GHz. Number of elements, number of unknowns, computer memory required and simulation time per frequency are presented in Table 1. The simulation (with ports) was performed in, so called, *S-Parameter Mode*.

Simulation time per frequency was calculated as total simulation time (simulation of two ports and total filter network) divided with number of frequencies.

Table 1. Number of elements, number of unknowns, computer memory and simulation time per frequency

Number of elements	Number of unknowns	Memory [MB]	Simulation time per frequency [sec]
1663	1540	18.1	5

Meshed model of the half of the interdigital filter with indicated dimensions of interest is shown in Figure 3. The dimensions are: length of sections, spacing between the sections, and half of the metallic case height. In Figure 3, we can also see port extensions automatically added in the simulation to model coaxial ports.

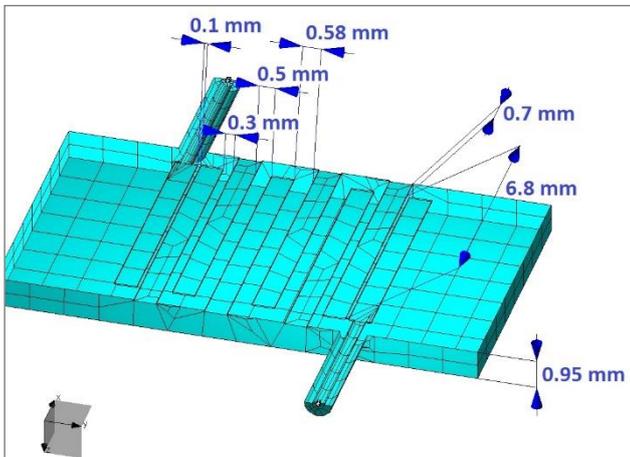


Figure 3. Meshed model of the half of the interdigital filter

## Results

$S_{11}$  and  $S_{21}$  parameters of the simulated interdigital filter presented in Figure 4 indicate that the filter has the performance as required. The passband is 8.30 GHz to 10.86 GHz with the return loss higher than 20 dB.

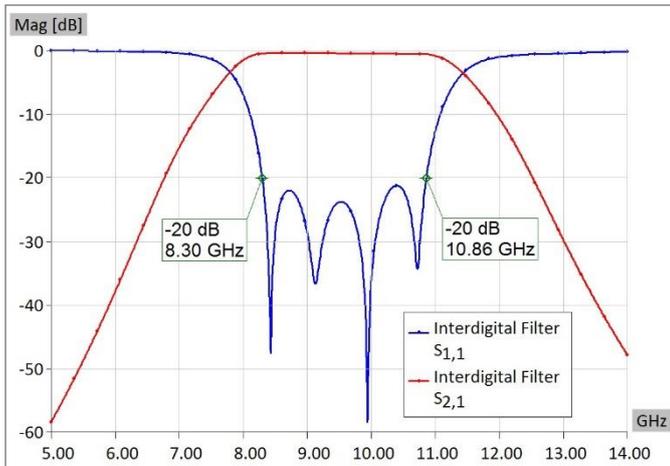


Figure 4.  $S_{11}$  and  $S_{21}$  parameters- simulated filter

## Conclusion

This application note presented a 3D EM model and simulation of an interdigital filter. The interdigital filter was modeled and simulated using WIPL-D Pro CAD software. All of the simulations (convergence check, final simulation) have been performed relatively fast on an inexpensive computer platform and have all required a small amount of computer memory. In addition, this note outlined utilization of coaxial ports and automatic de-embedding of final results. The similar approach can be applied to other classes of filters.