Waveguide Ports: Three Examples Using XFdtd®

Example 1: Slotted Waveguide Antenna

Summary: *A composite right/left-handed waveguide with irregularly spaced and rotated slots is used as an antenna.*

This example demonstrates a complex antenna comprised of a composite right/left-handed (CRLH) waveguide and unequally spaced slots [1]. The antenna is fed by a WR-90 waveguide that enters at the bottom of the device. After the input port, a matching transition region modifies the fields for propagation down the CRLH waveguide. The CRLH waveguide has numerous equally-spaced unit cells which each contain small apertures for field propagation. The radiation is through six tilted slots in the top plate of the waveguide. The spacing between the slots and the tilt angle of each slot varies.

The CAD-based geometry in XFdtd is shown in Figure 1 where the input port is to the left and bottom and the CRLH waveguide extends to the right. The slots are visible in the top of the structure of Figure 1. A more detailed view of the slots is shown in Figure 2, where the XFdtd mesh is also visible. Due to the complex nature of the slots which are not aligned with the FDTD grid, the XACT Accurate Cell Technology® meshing feature is used to precisely mesh the slot dimensions and orientation. In Figure 3, the input port at the bottom of the waveguide is shown with the applied TE_{10} mode. A cut-away mesh view of the interior of the waveguide is shown in Figure 4.

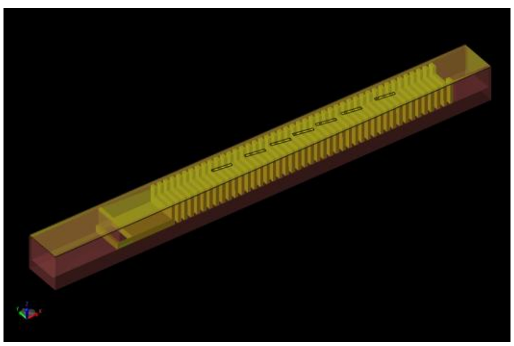


Figure 1: CAD view of the geometry constructed in XFdtd showing the CRLH waveguide and the radiating slots.

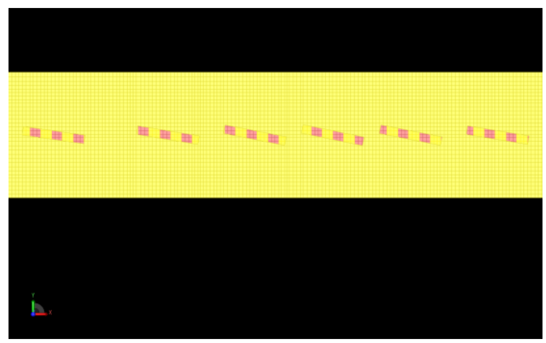


Figure 2: Detailed view of the XACT-meshed rotated slots of the device.

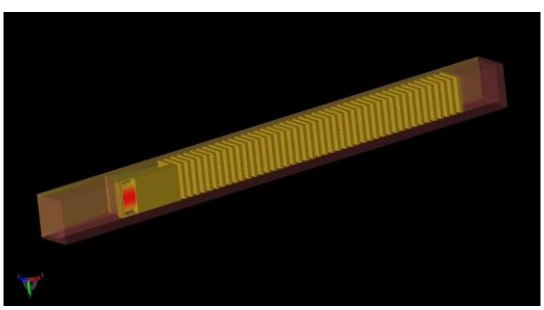


Figure 3: Bottom view of the device showing the input port with the waveguide excitation.

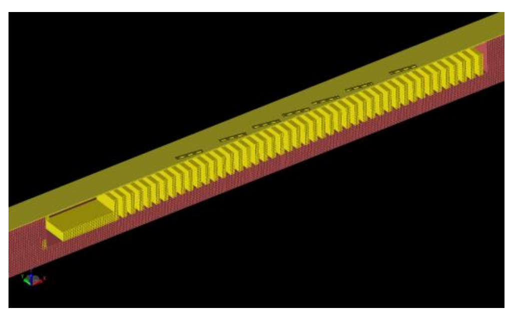


Figure 4: Cross-sectional mesh view of the device showing the interior CRLH cells.

The geometry is meshed with large boundaries surrounding the structure for better display of color field images. As meshed, the geometry requires about 268 MB of memory to simulate and runs in slightly more than six minutes on an NVIDIA C1060 Tesla GPU card.

Of primary interest in this example is the resulting radiation pattern from the device. The three-dimensional gain pattern from the antenna at the center frequency of 10 GHz is shown in Figure 5 with the device at the center of the pattern. The gain in H- and E-planes is shown in Figures 6 and 7. The conduction currents along the top plate of the antenna are shown in Figure 8. In Figure 9 the transient electric field radiating out of the waveguide is shown at an instance in time.

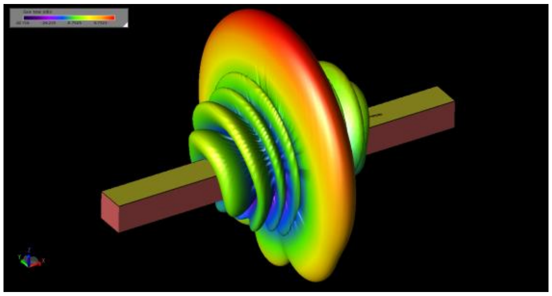


Figure 5: The three-dimensional radiation pattern of the antenna at 10 GHz.

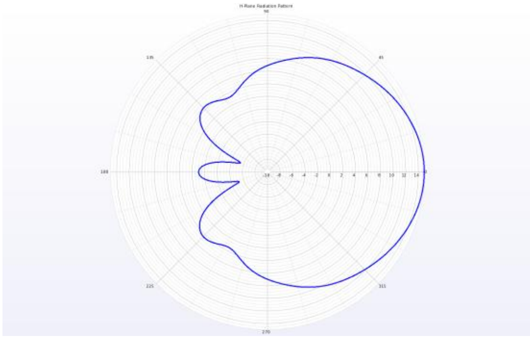


Figure 6: The H-plane radiation pattern at 10 GHz.

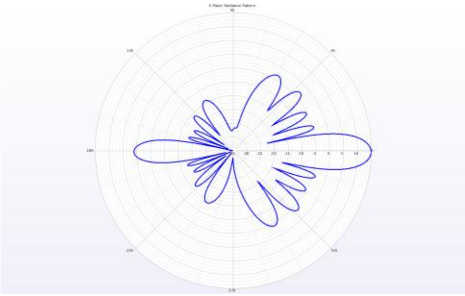


Figure 7: The E-plane radiation pattern at 10 GHz.

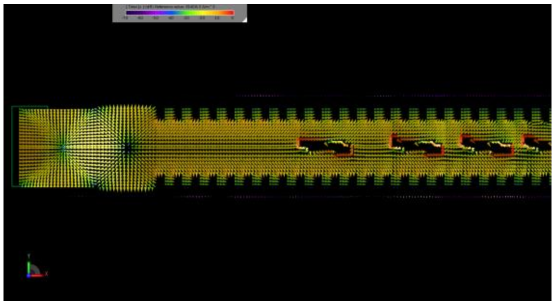


Figure 8: Vector display of the conduction currents on the top of the waveguide at 10 GHz.

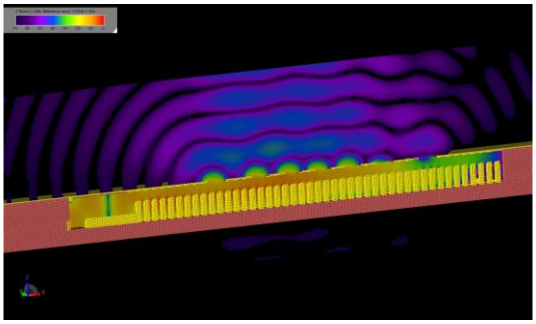


Figure 9: Image of the transient electric field in a cross-section of the device.

Request project files for this example by visiting: http://www.remcom.com/examples/slotted-waveguide-antenna.html

References

1. S. Liao, J. Wang, Y. Chen, W. Tang, J. Wei, J. Xu, and Z. Zhao, "Synthesis, Simulation and Experiment of Unequally Spaced Resonant Slotted-Waveguide Antenna Arrays Based on the Infinite Wavelength Propagation Property of Composite Right/Left-Handed Waveguide," *IEEE Trans. Antennas Propag.*, vol. 60, pp. 3182-3194, July 2012.

Example 2: Waveguide Cross-Coupled Filter Simulation

Summary: *Waveguide ports are used to excite a complex microwave filter with a folded waveguide structure linked by a cross-coupled filter.*

This example demonstrates the waveguide port source added with XFdtd Release 7.3 in a complex structure of a cross-coupled filter [1]. The filter structure is comprised of a WR-90 waveguide that is folded in a tight curve with an aperture coupled-cavity at the bend of the curve. Several irises are inserted within the waveguide as well. Details of the design procedure are described in the paper.

In the XFdtd simulation, the structure is first created as a CAD model as shown in Figure 1. The yellow portion of the structure is the waveguide filter while the two green rectangles at the edges represent the locations of the waveguide ports. The structure is created based on a parameter list for each dimension defined in the paper and shown in Figure 2. A global mesh size of 0.5 mm is used for this simulation with XACT Accurate Cell Technology meshing applied to the curved waveguide portion and Fixed Points meshing used for the waveguide ports. This configuration results in a varying mesh size which places grid lines precisely at the edges of each geometry feature. A cross-section of the resulting mesh is shown in Figure 3.

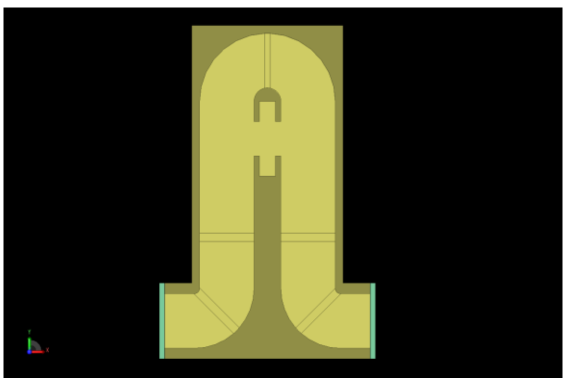


Figure 1: CAD representation of the waveguide cross-coupled filter geometry.

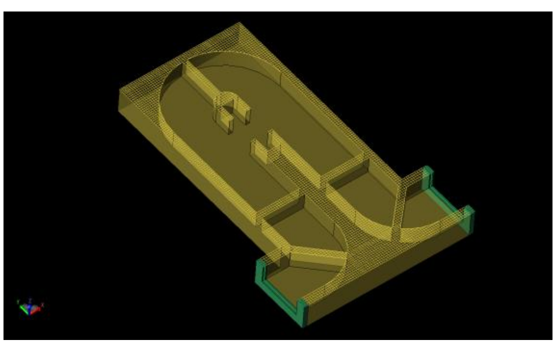
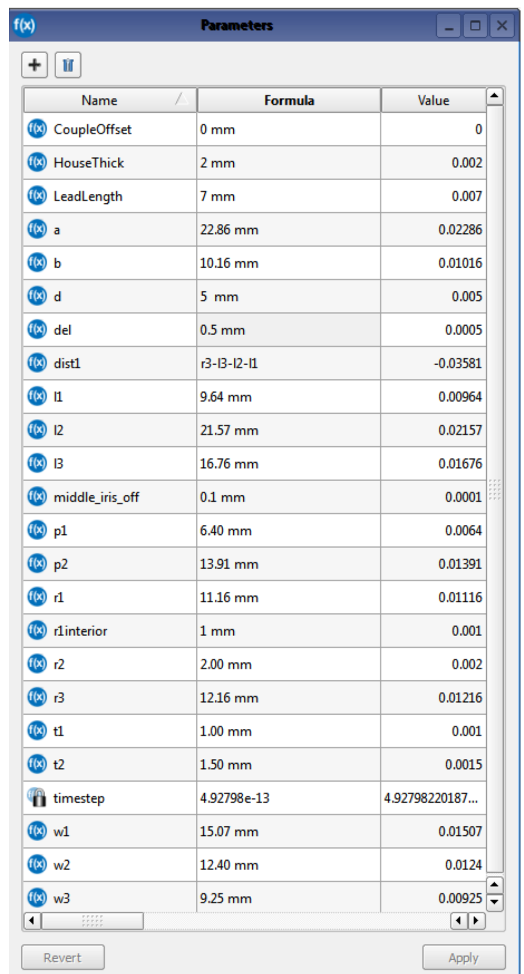


Figure 3: Cross-sectional view of the XFdtd mesh of the cross-coupled filter geometry.



Parameters

Name	Formula	Value
CoupleOffset	0 mm	0
HouseThick	2 mm	0.002
LeadLength	7 mm	0.007
a	22.86 mm	0.02286
b	10.16 mm	0.01016
d	5 mm	0.005
del	0.5 mm	0.0005
dist1	r3-l3-l2-l1	-0.03581
l1	9.64 mm	0.00964
l2	21.57 mm	0.02157
l3	16.76 mm	0.01676
middle_iris_off	0.1 mm	0.0001
p1	6.40 mm	0.0064
p2	13.91 mm	0.01391
r1	11.16 mm	0.01116
r1interior	1 mm	0.001
r2	2.00 mm	0.002
r3	12.16 mm	0.01216
t1	1.00 mm	0.001
t2	1.50 mm	0.0015
timestep	4.92798e-13	4.92798220187...
w1	15.07 mm	0.01507
w2	12.40 mm	0.0124
w3	9.25 mm	0.00925

Revert Apply

Figure 2: XFdtd parameter list of all dimensions used in the cross-coupled filter geometry.

The ports are added across the openings of the waveguide and the distribution is set up as a TE_{10} mode, as shown in Figure 4 for the input port. The simulation is executed with an input waveform with frequency content over the 8-12 GHz range of the device. The time to complete the example to -45dB convergence is about 15 minutes on an NVIDIA C1060 Tesla GPU card. Following the simulation, the S-Parameters at the input and output ports are available and are displayed in Figure 5.

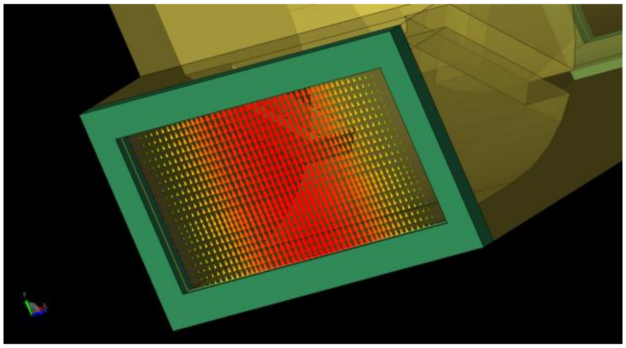


Figure 4: The TE_{10} waveguide port excitation applied to the input port of the device.

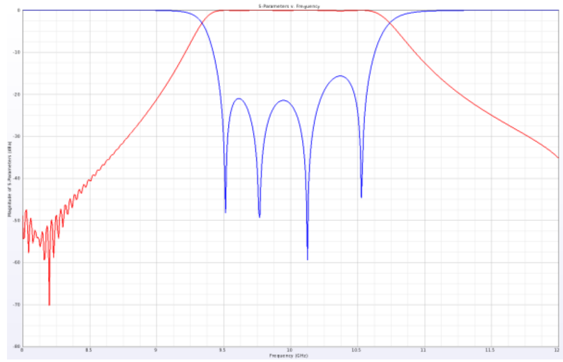


Figure 5: The computed S11 and S21 of the cross-coupled filter geometry.

References

1. Q. F. Zhang and Y. L. Lu, "Dimensional Synthesis of Symmetric Wideband Waveguide Cross-Coupled Filters Without Global Full-Wave Optimization," *IEEE Trans. Microw. Theory Tech.*, vol. 58, pp. 3742-3748, Dec. 2010.

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http://www.remcom.com/examples/waveguide-cross-coupled-filter-simulation.html

Example 3: Waveguide Pseudo-Elliptic Waveguide Filter

Summary: *Waveguide ports are used to excite a microwave filter constructed from WR-90 waveguide with cavity-backed inverters and multiple irises.*

This example describes the simulation of a waveguide filter that includes both E- and H-plane cavity-backed inverters in addition to several irises [1]. The basic geometry is shown in CAD format in Figure 1 where the E-plane cavity-backed inverter is above the waveguide and the H-plane cavity-backed inverter is on the back side. The waveguide is WR-90 and the dimensions of the design including the spacing and dimensions of the cavities and irises are easily entered as parameters into the XFdtd model. The structure is meshed with a 0.4 mm base cell size and fixed points are used on all parts to ensure the FDTD grid lines overlap the CAD dimensions.

The input port has a fundamental mode applied as shown in the cut-away mesh view of Figure 2. The frequency for the input excitation is 12 GHz which ensures frequency content in the simulation over the 8 to 12 GHz range of the device. The output for the simulation will be the S-parameters at the input and output ports, some images of the transient electric field propagation though the device, and point sensors of the electric field versus time.

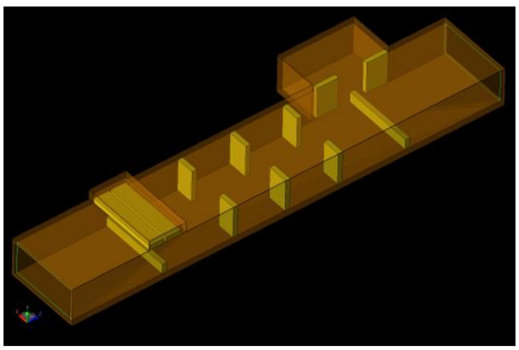

Figure 1: CAD representation of the device as constructed in XFdtd.

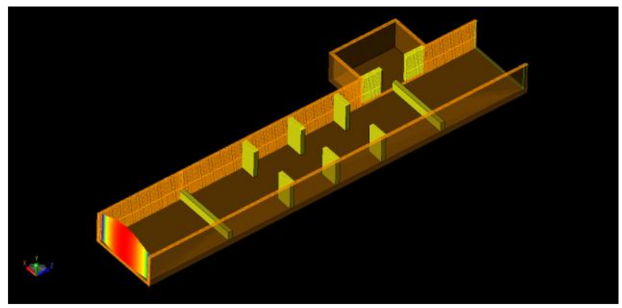

Figure 2: Cross-sectional XFdtd mesh view of the device with the input port excitation displayed.

The simulation requires approximately 122 MB of computer memory and runs to -45dB convergence in just over 14 minutes on an NVIDIA C1060 Tesla GPU card.

Following the simulation, the resulting S-parameters at each port, shown in Figure 3, are found to be a good match to the measured values reported in the paper. The transient electric field at an instance in time through the cross-section of the filter is shown in Figure 4. The transient electric field at point locations centered just beside each of the ports is shown in Figure 5.

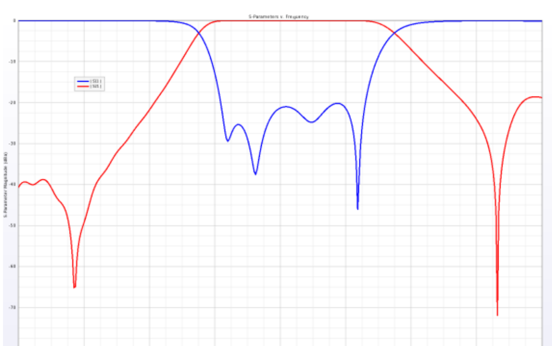

Figure 3: Resulting S11 and S21 of the device as simulated in XFdtd.

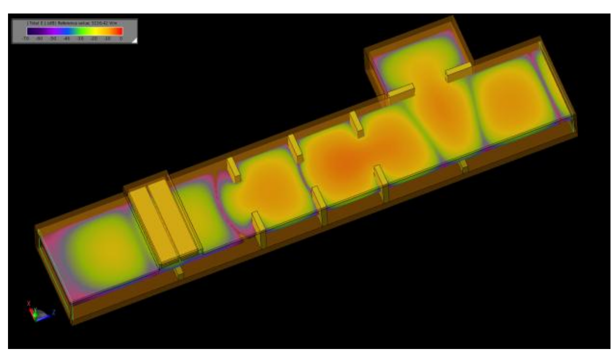

Figure 4: Transient electric fields propagating in the filter.

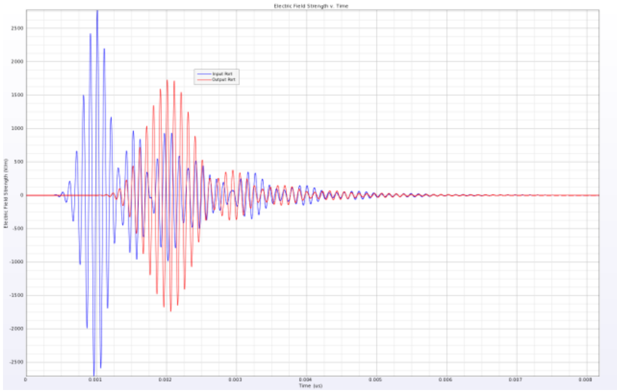

Figure 5: Electric field point sensor at the input and output ports of the filter.

References
1. Q. F. Zhang and Y. L. Lu, "Design of Wide-Band Pseudo-Elliptic Waveguide Filters With Cavity-Backed Inverters," *IEEE Microw. and Wirel. Comps. Letters*, vol. 20, pp. 604-606, Nov. 2010.

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