Filter Design Using Ansoft HFSS

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Outline

- Introduction
- Finite Element Method (FEM) Employed by HFSS
- Features of HFSS
- General Design Procedure
- Design Examples:
  - Eigen Mode: Dielectric Resonator
  - Driven Mode: Dielectric Resonator Filter
    Microstrip Line Structure

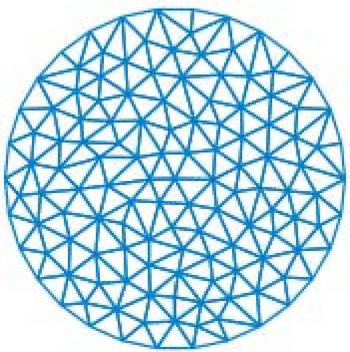
Introduction

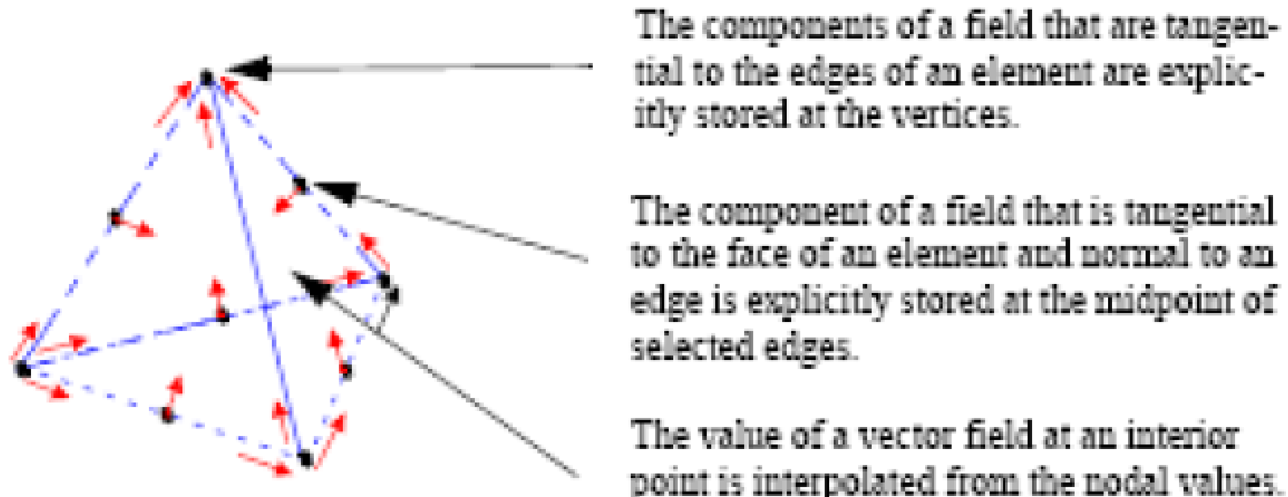
- The Ansoft High Frequency Structure Simulator (HFSS) is a full-wave electromagnetic (EM) software package for calculating the electromagnetic behavior of a 3-D structure.

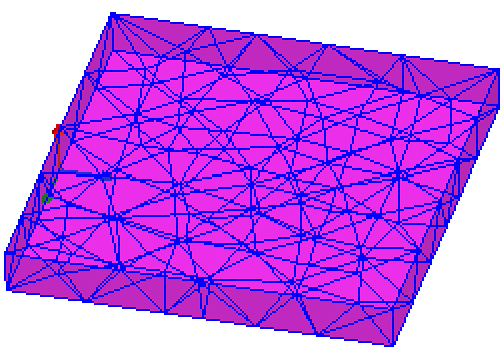
- Using HFSS, you can compute:
  - Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields;
  - The eigenmodes, or resonances, of a structure;
  - Port characteristic impedances and propagation constants;
  - Generalized S-parameters and S-parameters renormalized to specific port impedance;

FEM

- FEM is a numerical method for solving Maxwell Equations.
- Meshing Scheme:
  - 2D-triangles
  - 3D-tetrahedra







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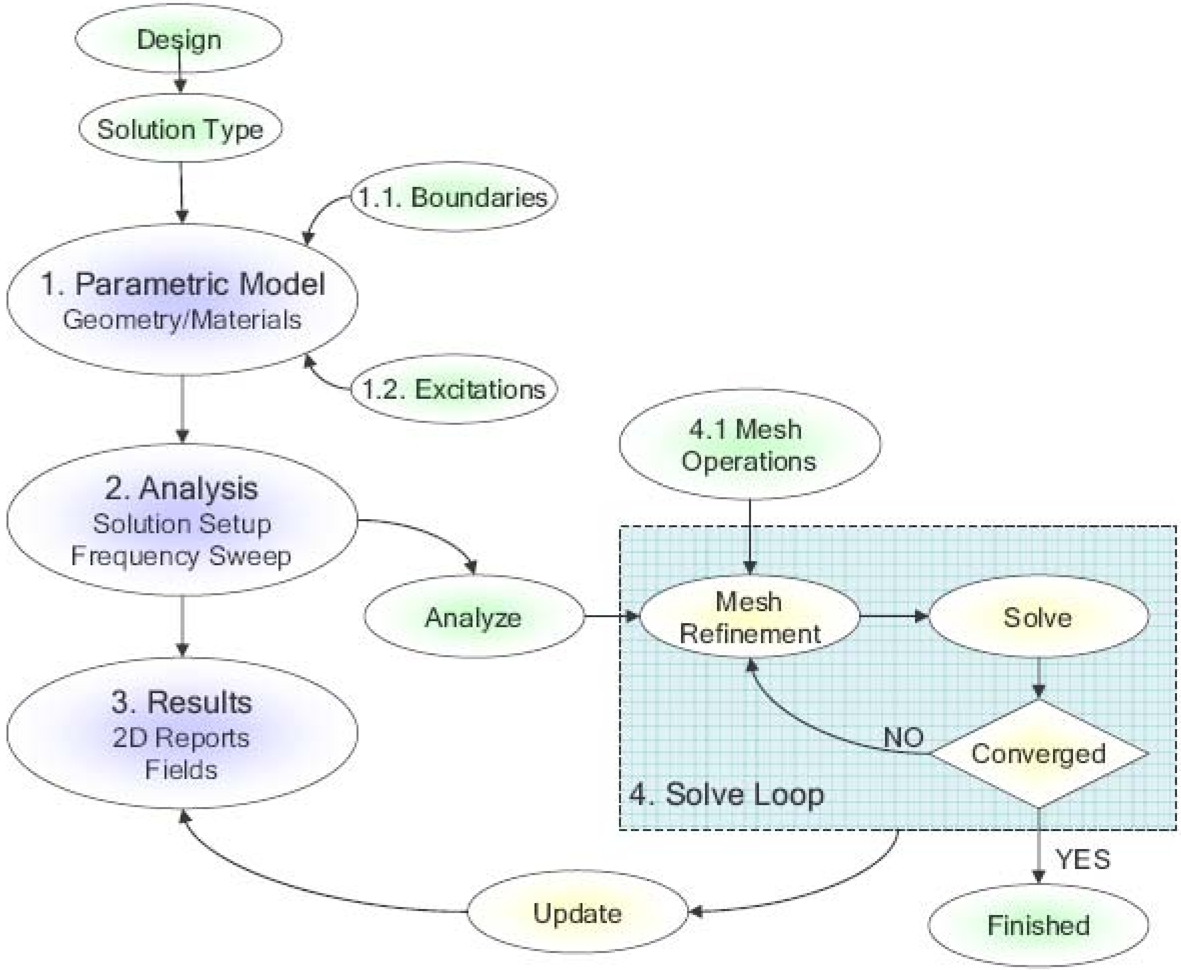
Features of HFSS

- Capabilities:
  - Accurate full-wave EM simulation
  - Import/export of 3D structures
  - Automatic adaptive mesh generation and refinement
  - Adaptive Lanczos-Padé Sweep for fast frequency sweeps
  - Inclusion of skin effect, losses
  - Direct and iterative matrix solvers
  - Eigen mode matrix solver

Features of HFSS (cont.)

- Solution Data (Visualization):
  - S-, Y-, Z-parameter matrix (2D plot, Smith Chart)
  - Port characteristic impedance
  - Current, E-field, H-field (3D static and animated field plot in vector display or magnitude display)
  - Far-field calculation (2D, 3D, gain, radiation pattern)
  - Material losses, radiation losses

General Design Procedure



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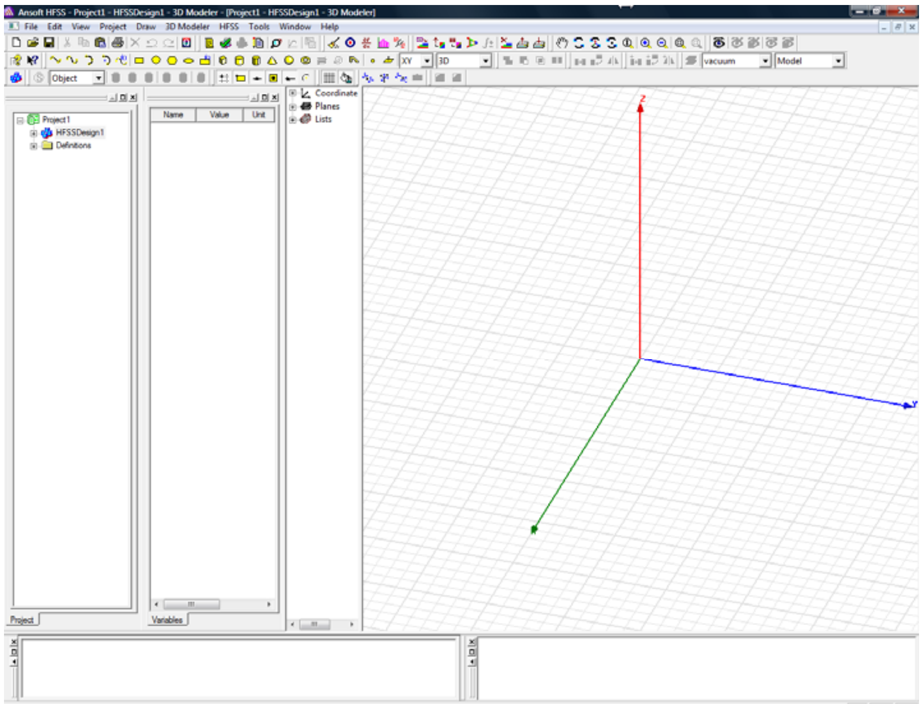
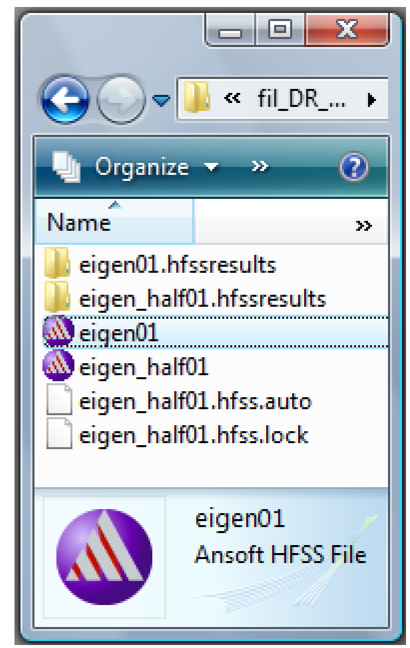
Design Examples (Eigen mode: DR)

- Opening a HFSS Project
  - To open a new project in a HFSS window:
    Select File > New, select Project > Insert HFSS Design





  - To open an existing project:

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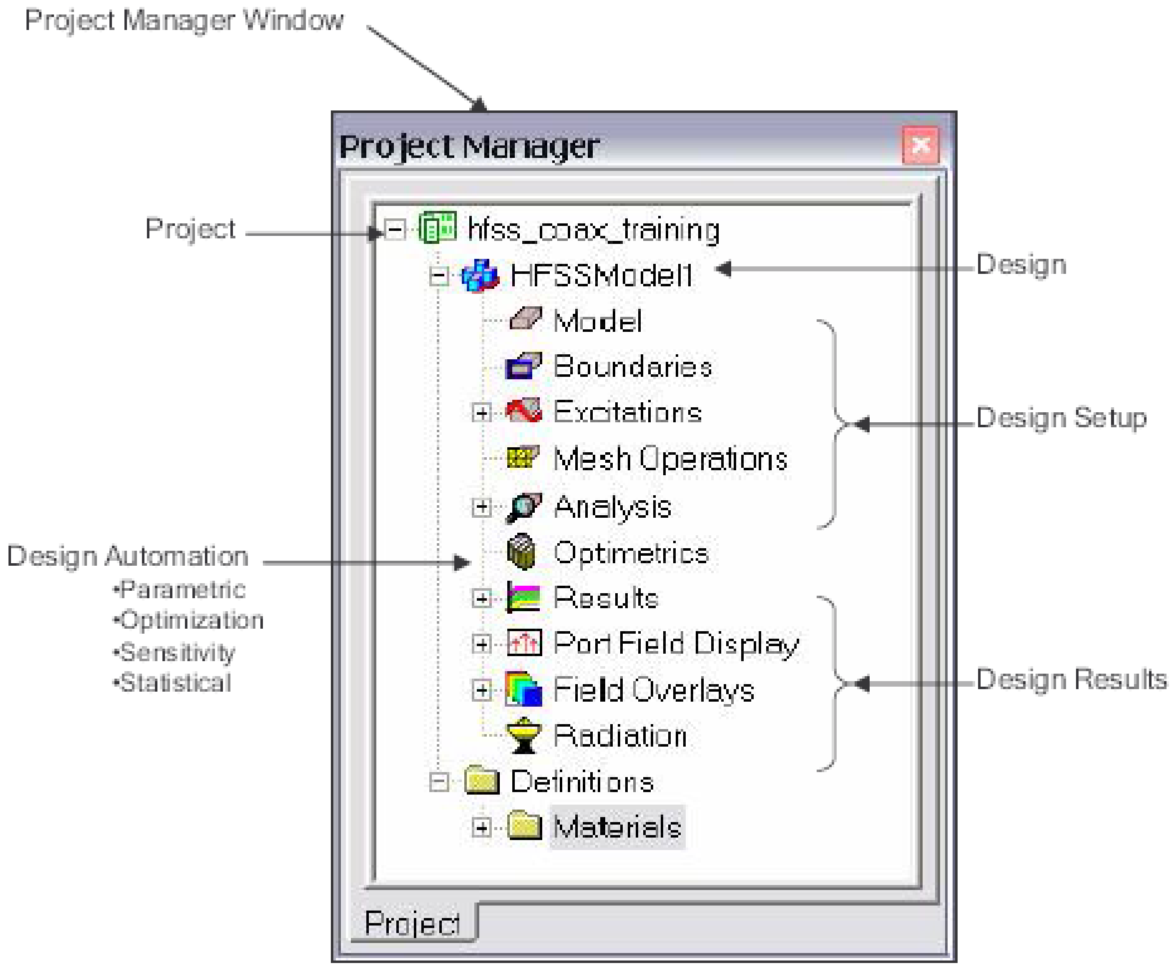
Design Examples (Eigen mode: DR) cont.

- Project Manager



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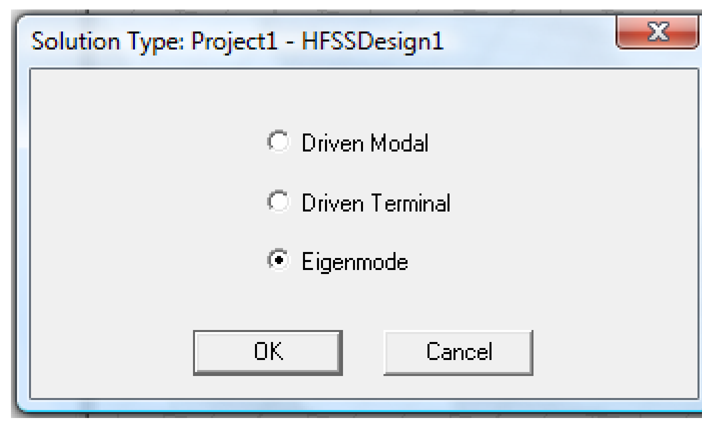
Design Examples (Eigen mode: DR) cont.

- Solution Type
  - **Driven Modal**: S-matrix solutions will be expressed in terms of the incident and reflected powers of waveguide modes.
  - **Driven Terminal**: S-matrix solutions of multi-conductor transmission line ports will be expressed in terms of terminal voltages and currents.
  - **Eigen Mode**: finding the resonant frequencies of the structure and the fields at those resonant frequencies.

- To Set the Solution Type
  Select *HFSS > Solution Type*



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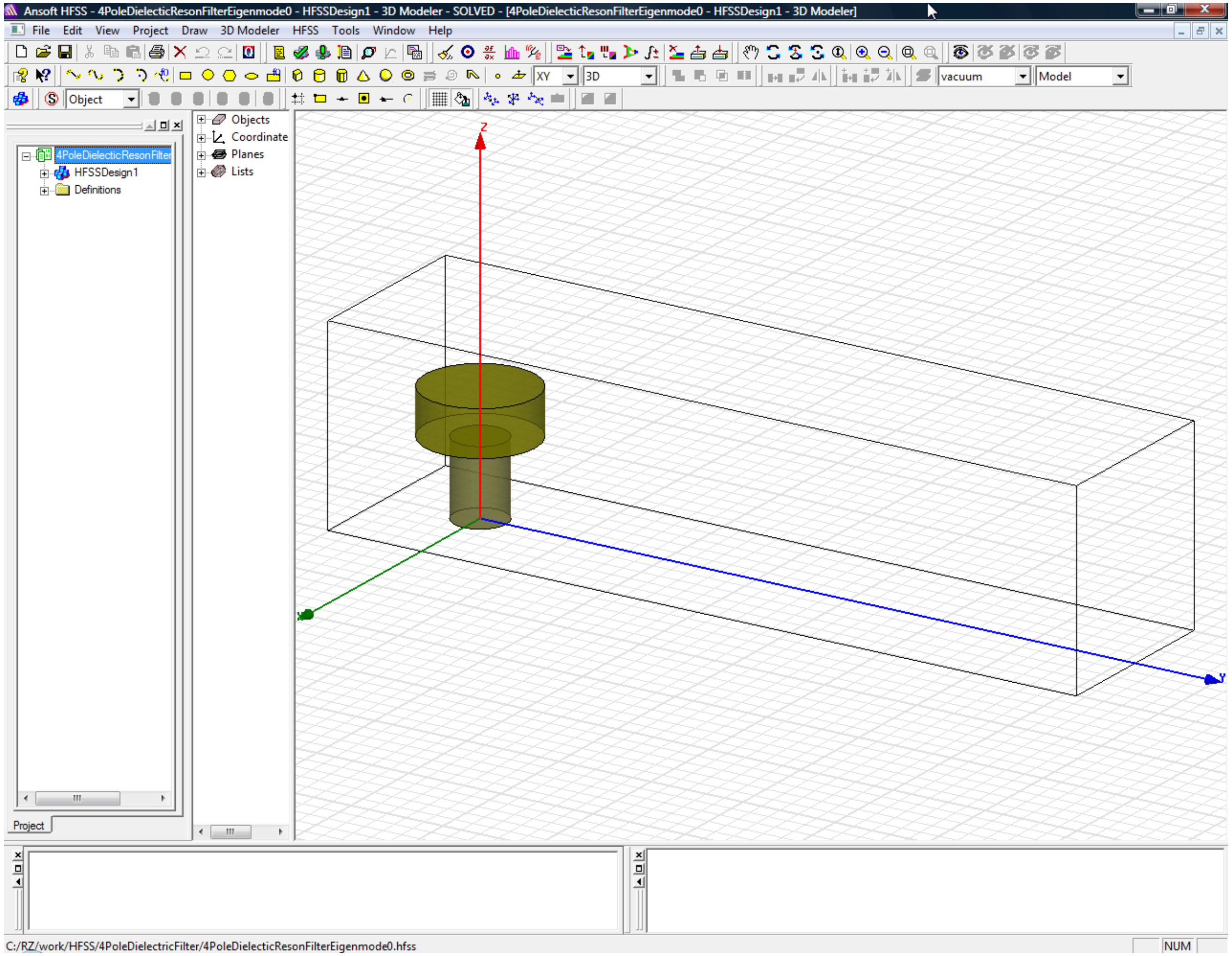
Design Examples (Eigen mode: DR) cont.

- 3D Modeler



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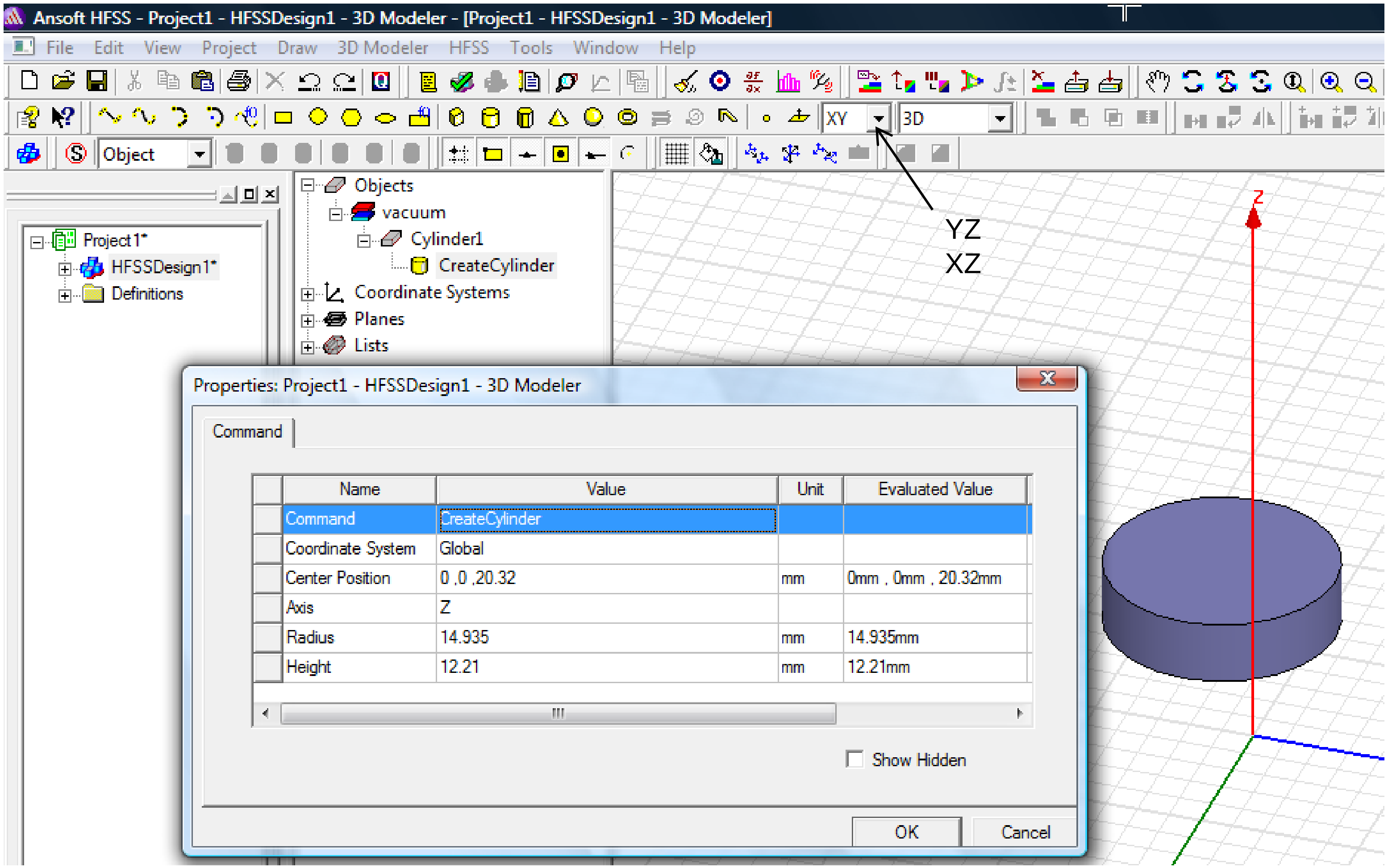
Design Examples (Eigen mode: DR) cont.

- Parametric Model Creation



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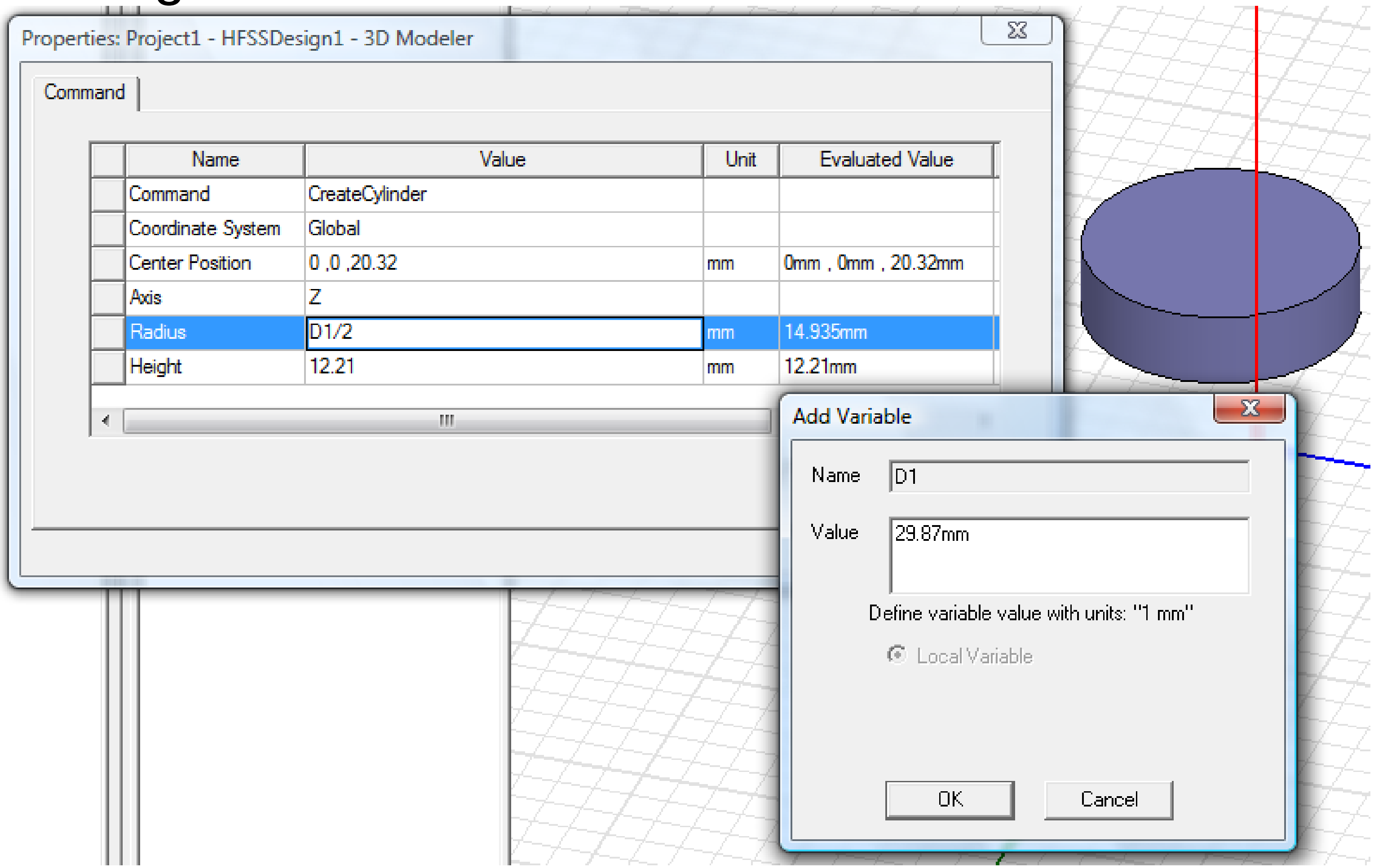
Design Examples (Eigen mode: DR) cont.

- Defining Variables



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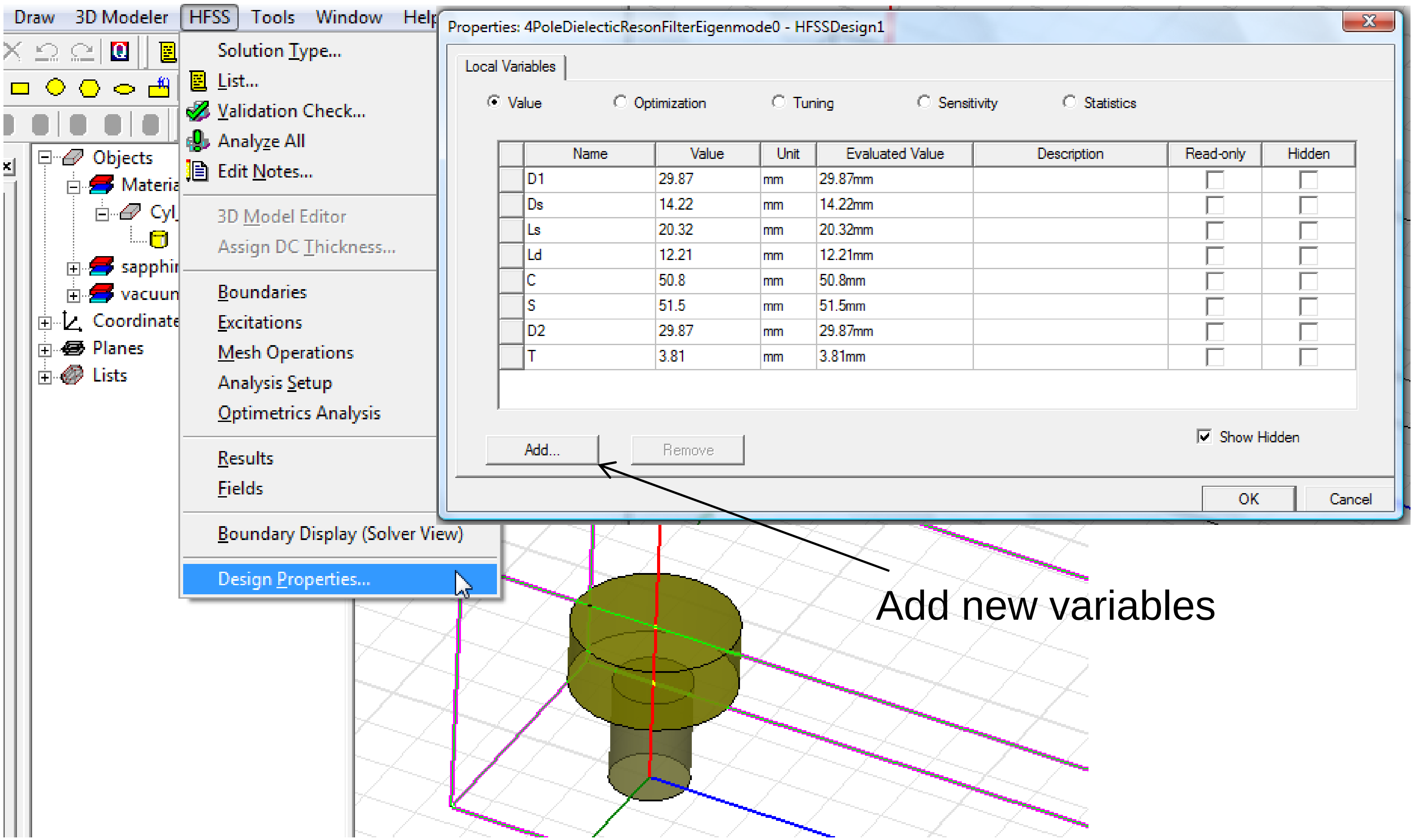
Design Examples (Eigen mode: DR) cont.

- Variable Settings



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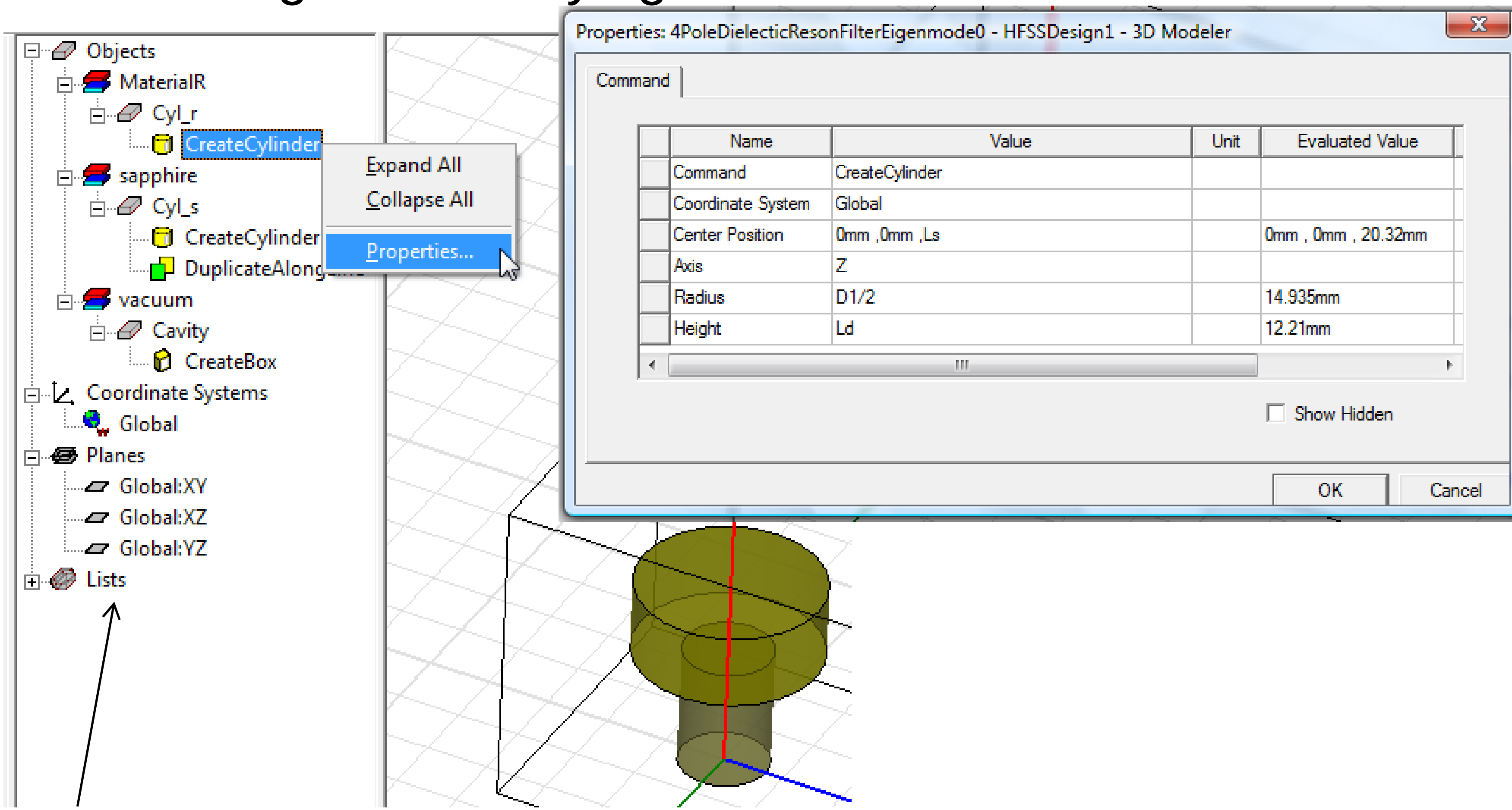
Design Examples (Eigen mode: DR) cont.

- Checking and Modifying Dimensions in 3D Modeler Tree



3D Modeler Tree

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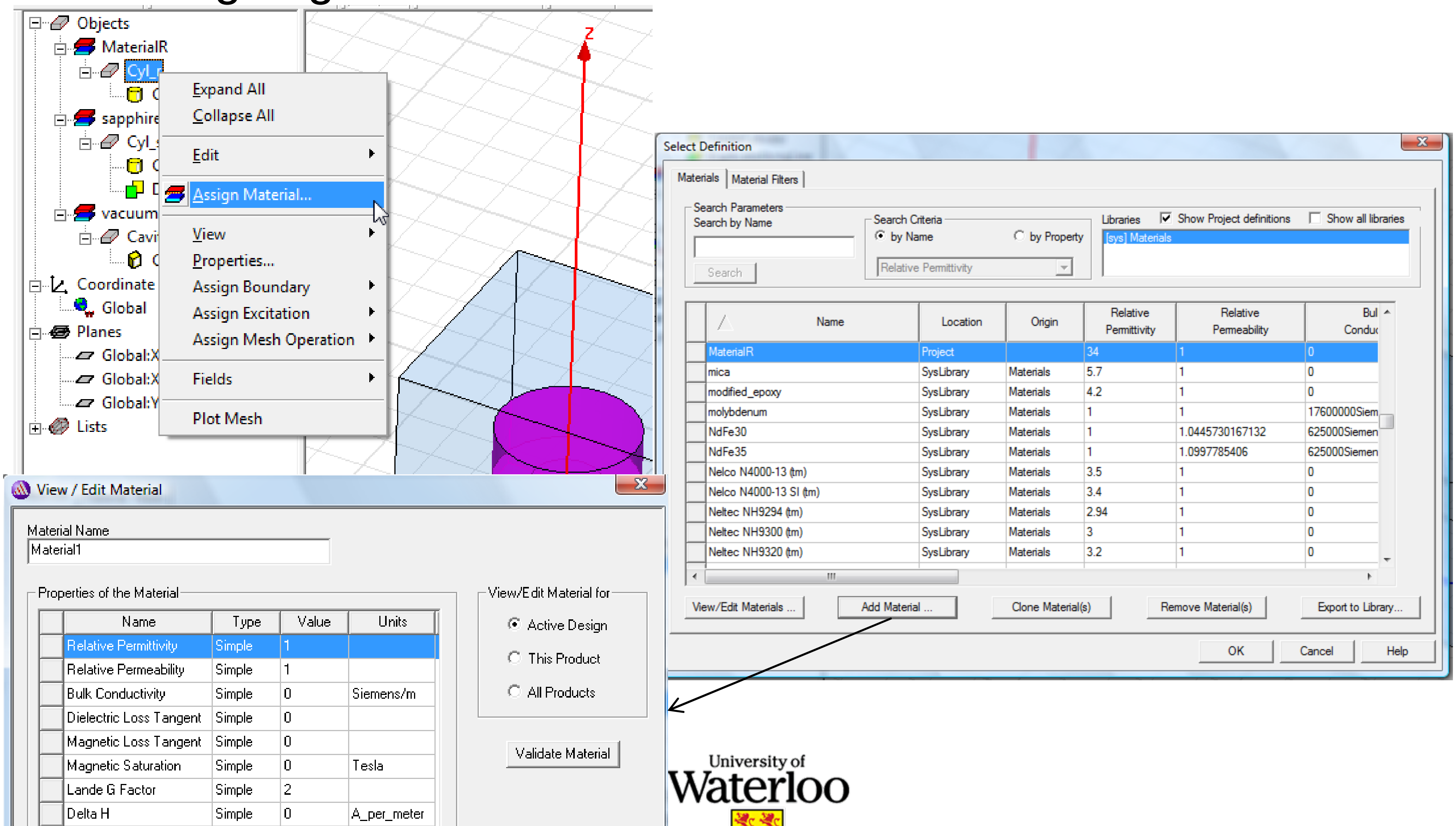
Design Examples (Eigen mode: DR) cont.

- Assigning Materials



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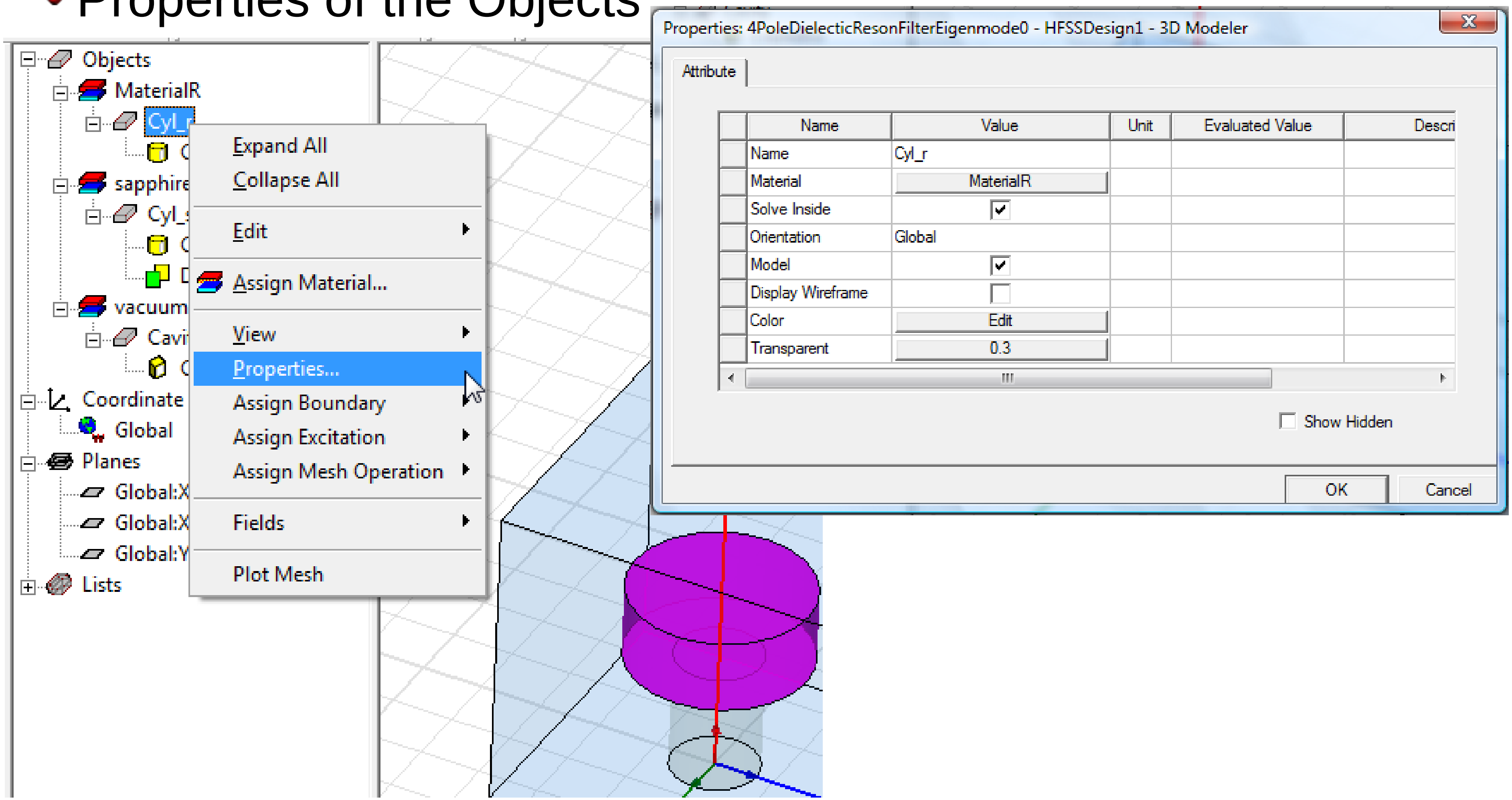
Design Examples (Eigen mode: DR) cont.

- Properties of the Objects



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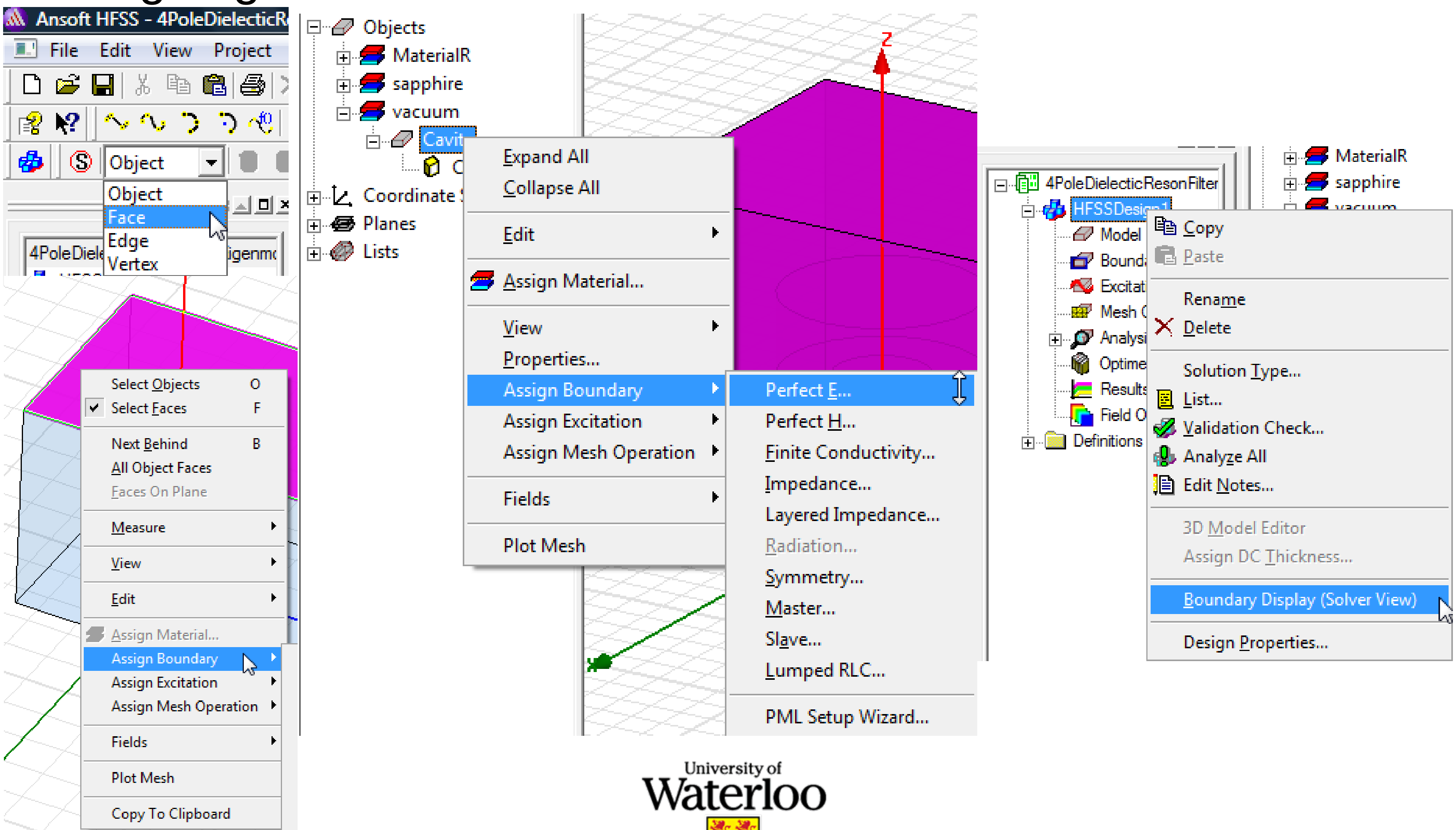
Design Examples (Eigen mode: DR) cont.

- Common Boundary Conditions
  - Material properties
    - Boundary between two dielectrics
    - Finite conductivity of a conductor
  - Surface approximations
    - Perfect electric or magnetic surfaces
    - Radiation surfaces
    - Symmetry planes
    - Background or outer surfaces
  - Excitations (Driven mode)
    - Wave ports (External)
    - Lumped ports (Internal)

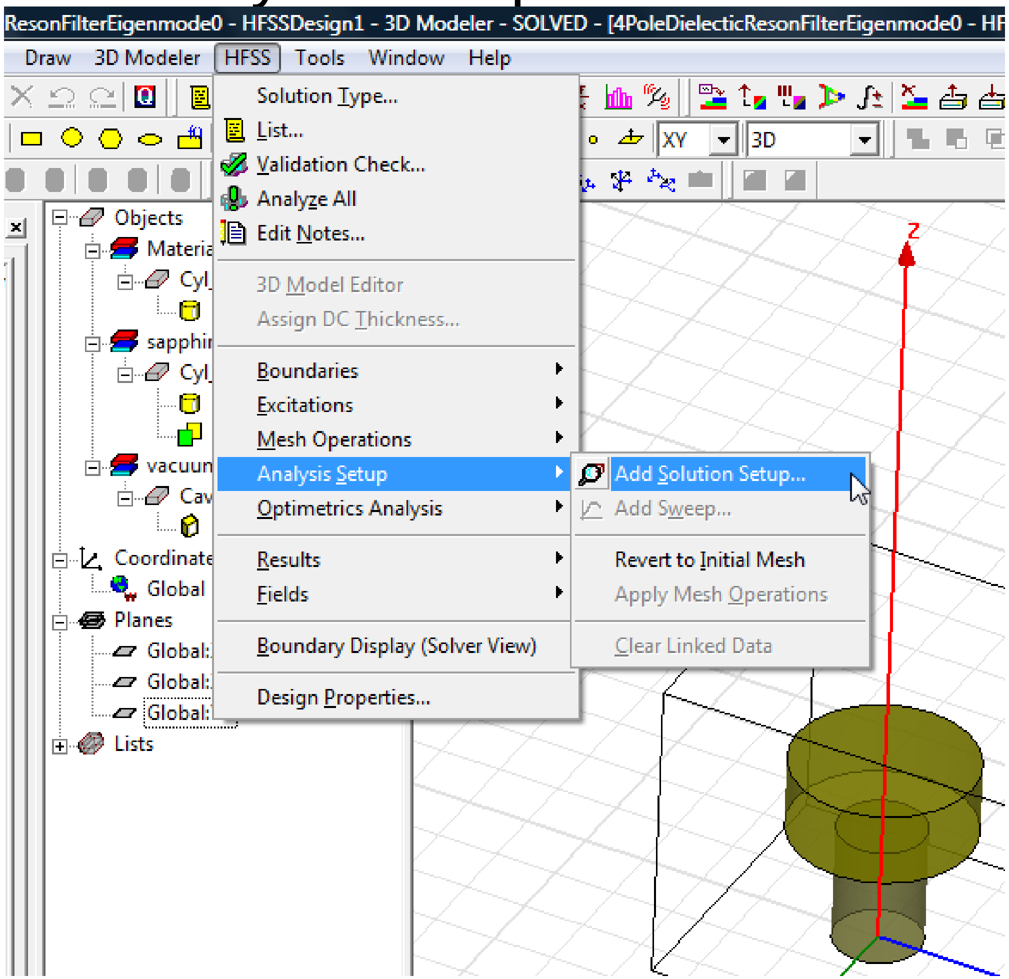
Design Examples (Eigen mode: DR) cont.

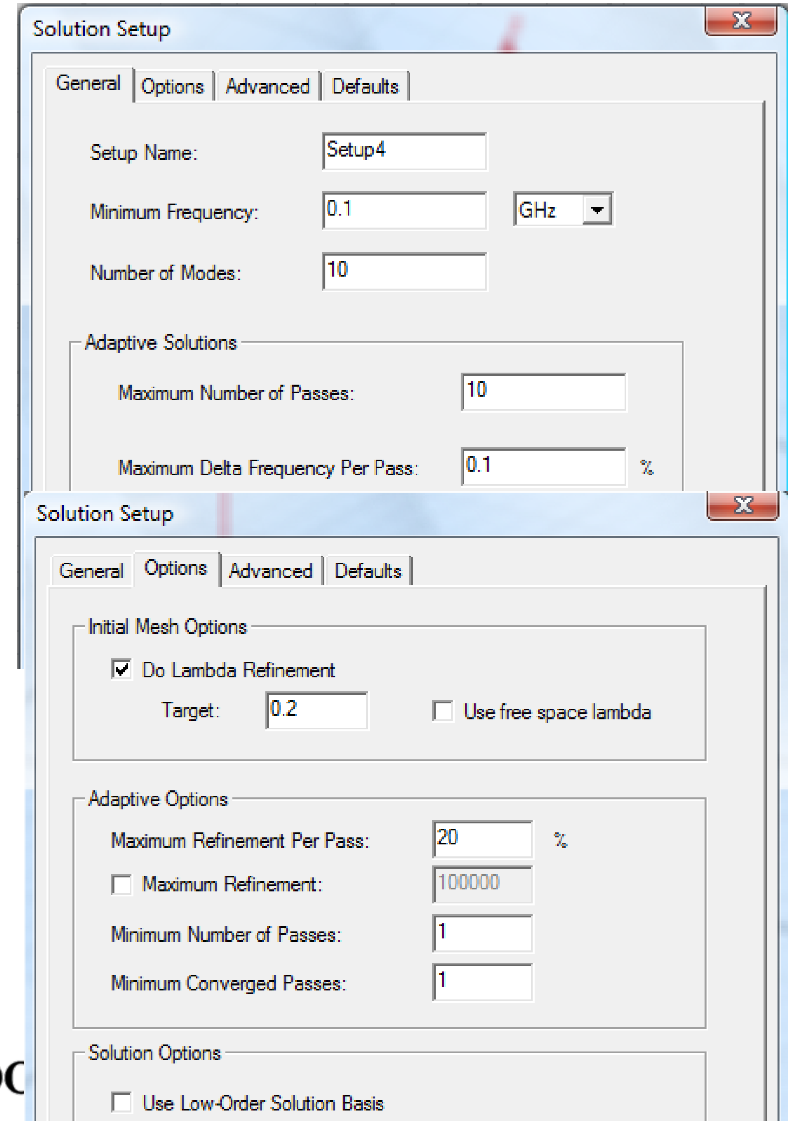
- Assigning Boundaries



Design Examples (Eigen mode: DR) cont.

- Analysis Setup





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Design Examples (Eigen mode: DR) cont.

- Adaptive Meshing
  - The mesh in HFSS is automatically constructed and tuned to give the most accurate and efficient mesh possible.
  - The adaptive meshing algorithm searches for the largest gradients in the E-field or error and sub-divides the mesh in those regions. It also targets singularities, such as the edge of a conductor, as locations to add extra elements.
  - The mesh growth for each adaptive pass is controlled by the Tetrahedron Refinement in percentage, which ensures that between each pass the mesh is sufficiently perturbed and guarantees the correct convergences.
  - After the mesh has been refined, a full solution is performed and the process is repeated until convergence.

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Design Examples (Eigen mode: DR) cont.

- Convergence
  - After each adaptive pass, HFSS compares the results (Frequencies for eigen mode, S-Parameters for driven mode) from the current mesh to the results of the previous mesh. If the answers have not changed by the user defined value or Delta Freq (for eigen mode)/Delta S (for driven mode), then the solution has converged and the current or previous mesh can be used to perform a frequency sweep (for driven mode).
  - If the solution has converged, then technically, the previous mesh is as good as the current mesh. In this case, HFSS will use the previous mesh (less than current mesh) to perform frequency sweeps (for driven mode) if they have been requested.

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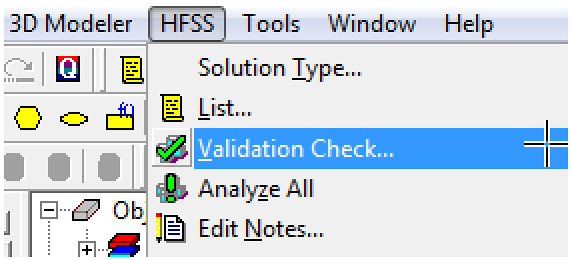
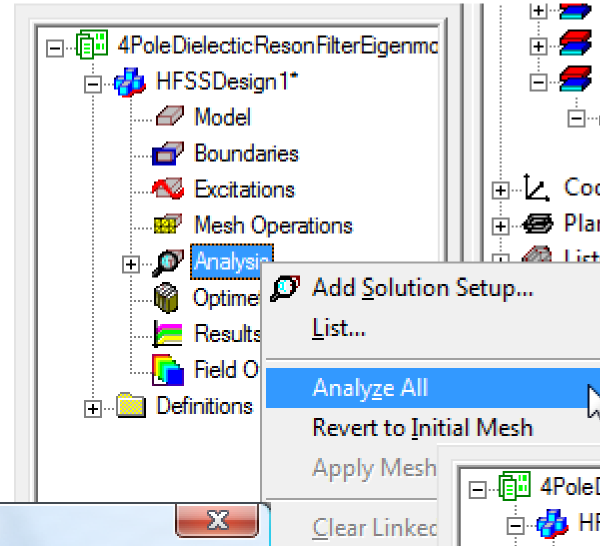
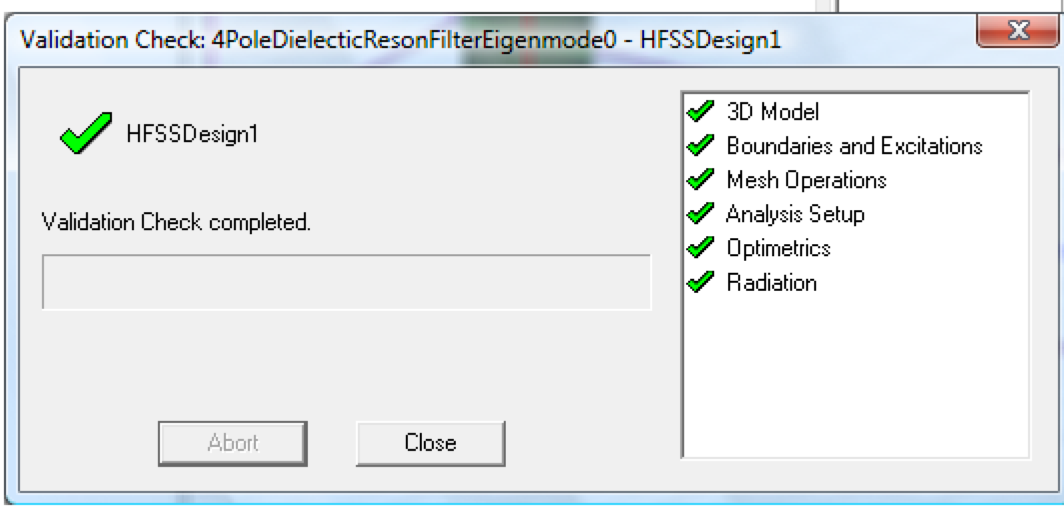
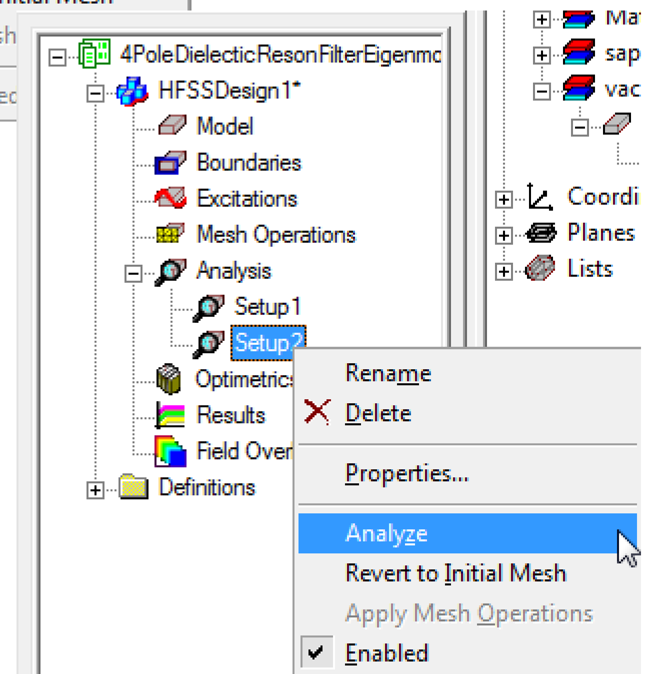
Design Examples (Eigen mode: DR) cont.

- Validation Check and Starting Analysis









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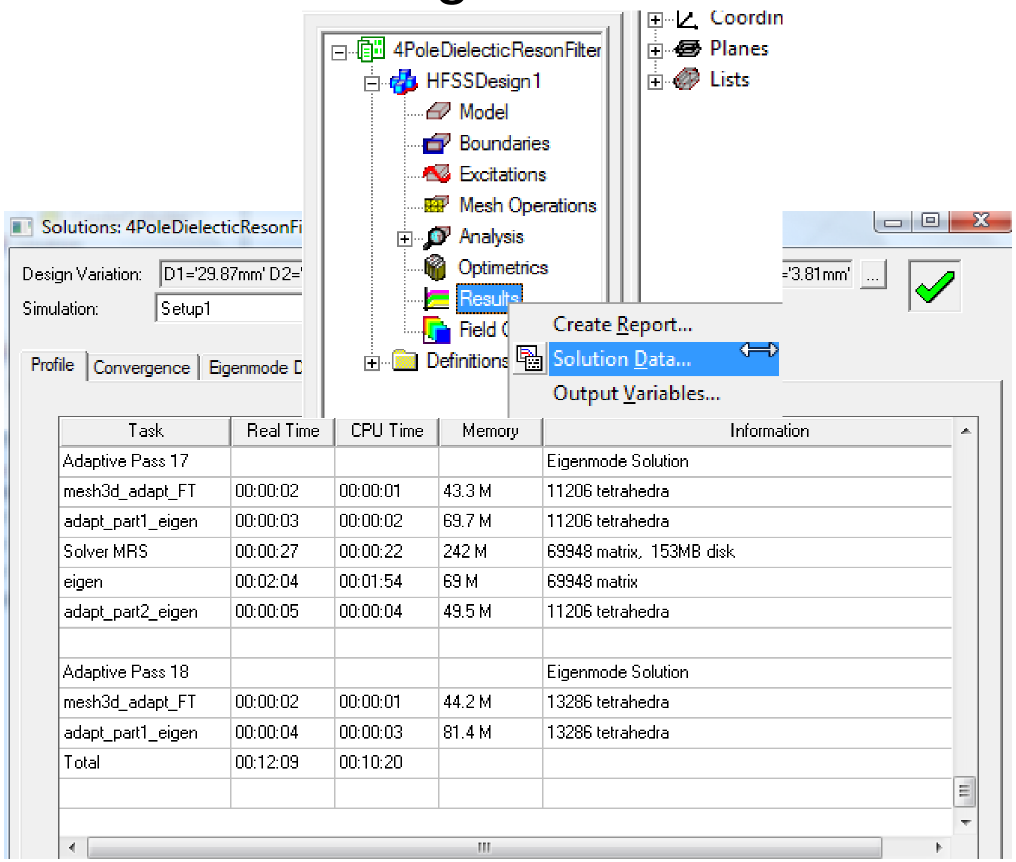
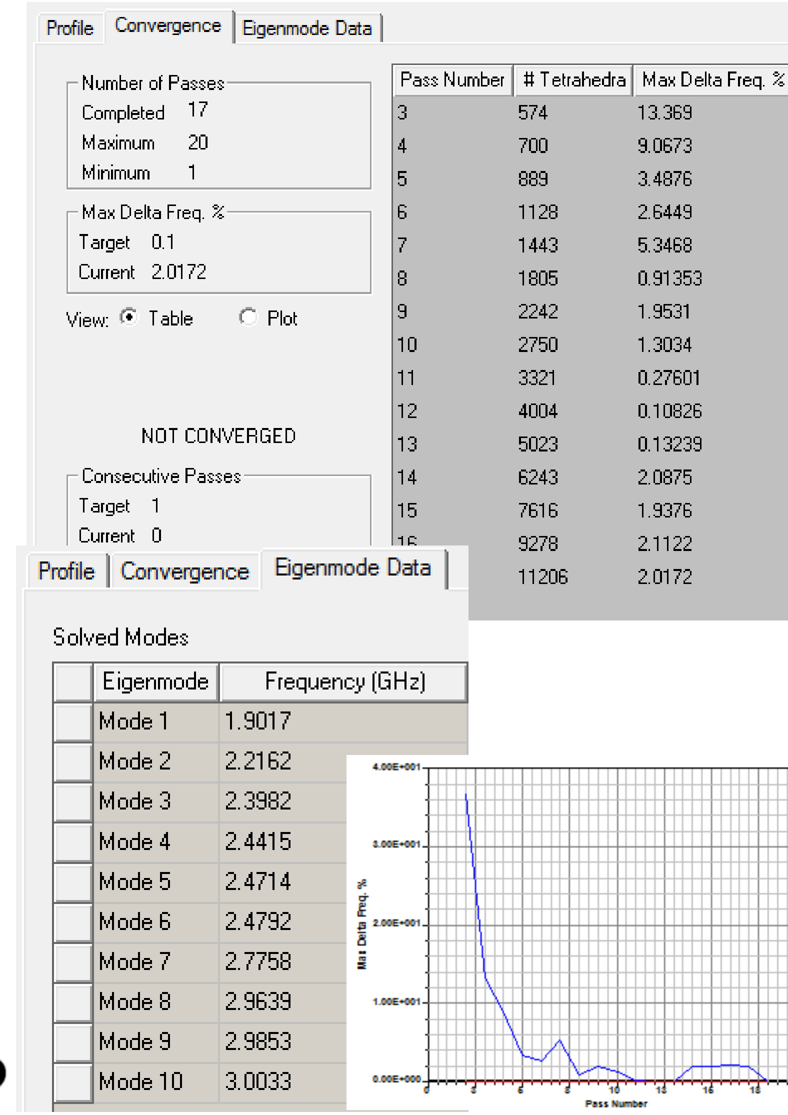
Design Examples (Eigen mode: DR) cont.

- Monitoring the Solution Process and Checking Solution Data





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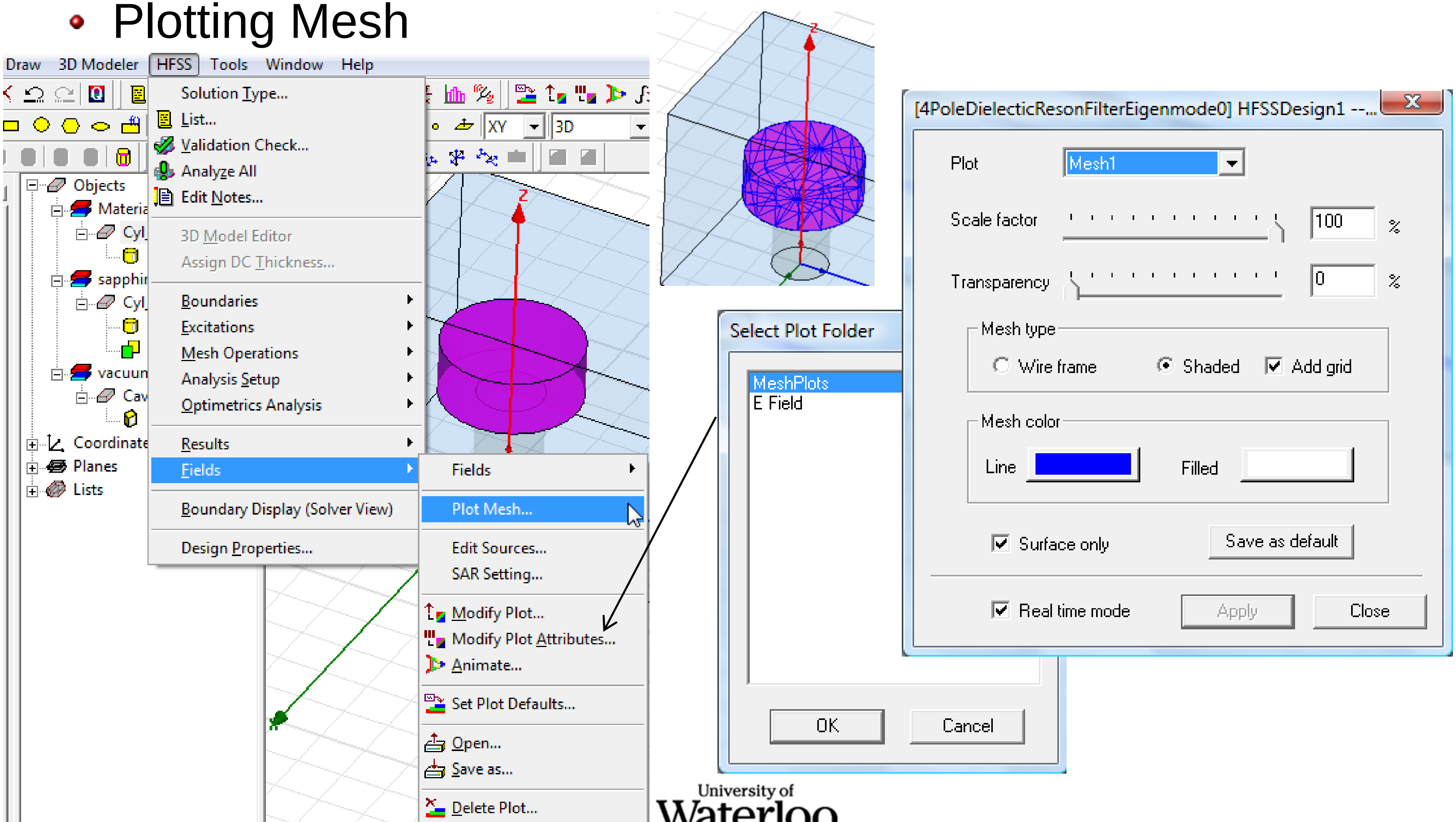
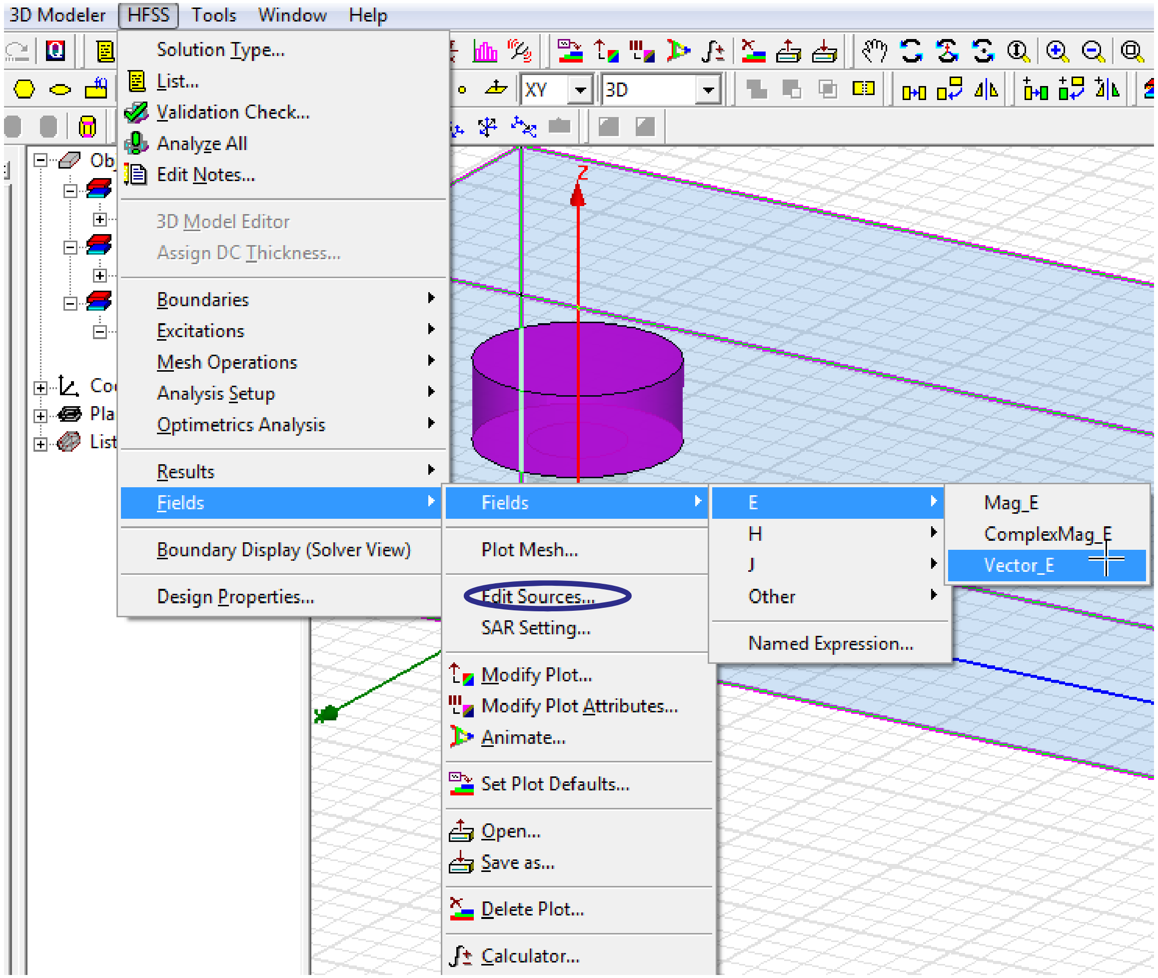
Design Examples (Eigen mode: DR) cont.

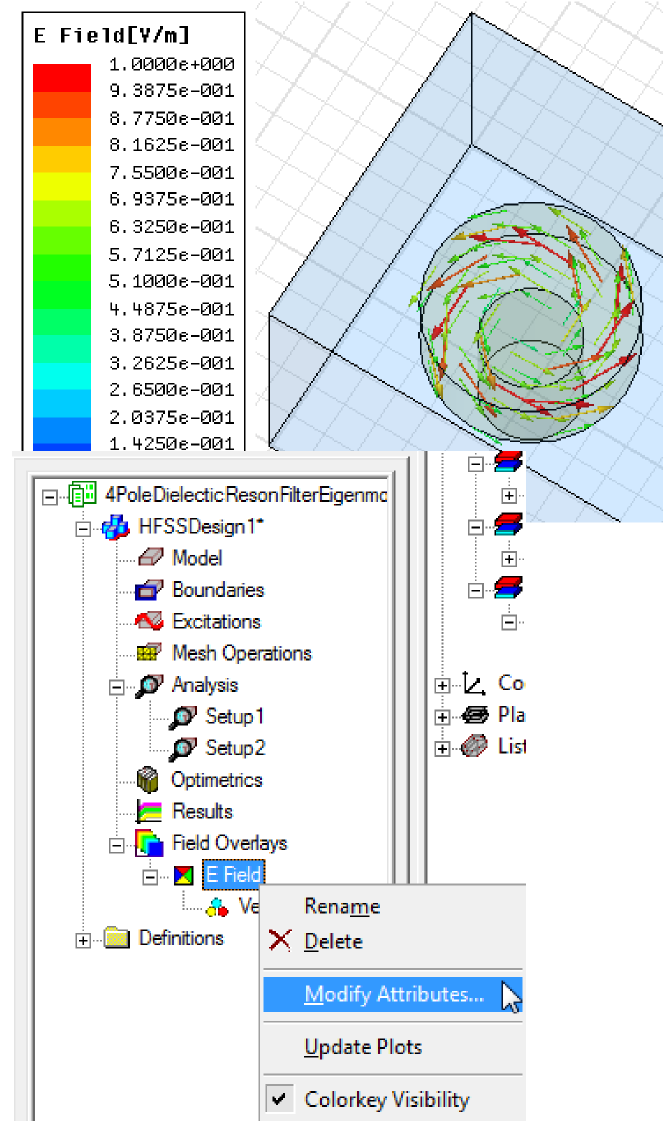
- Plotting Mesh



Design Examples (Eigen mode: DR) cont.

- Field Distributions





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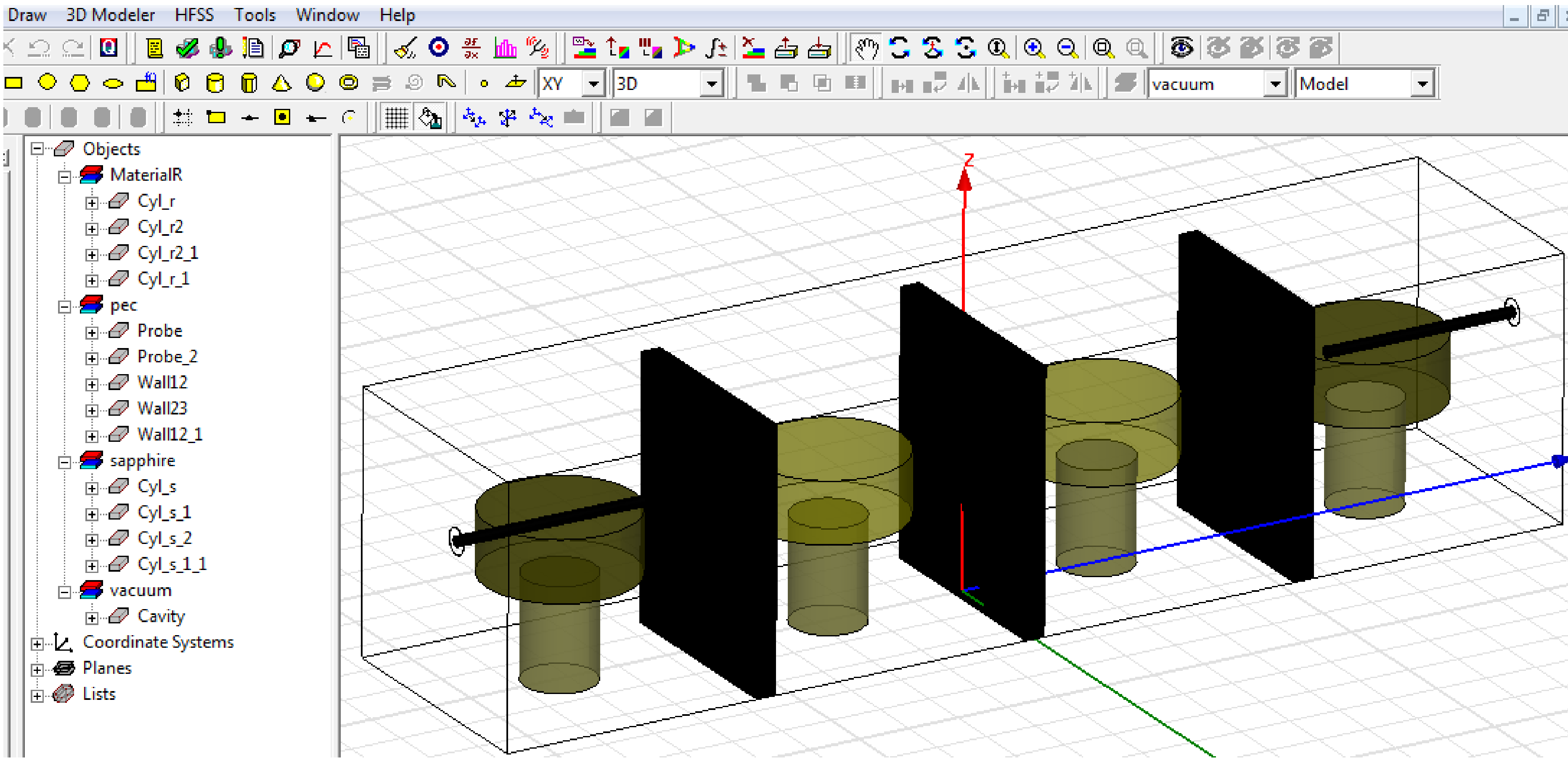
Design Examples (Driven mode: DR Filter)

- 3D Model of the DR Filter



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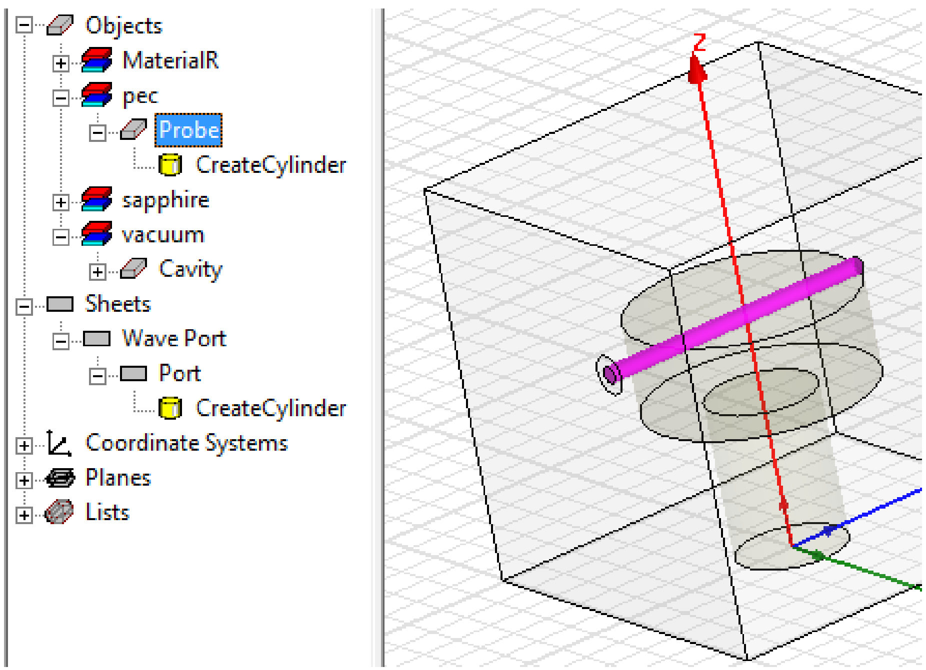
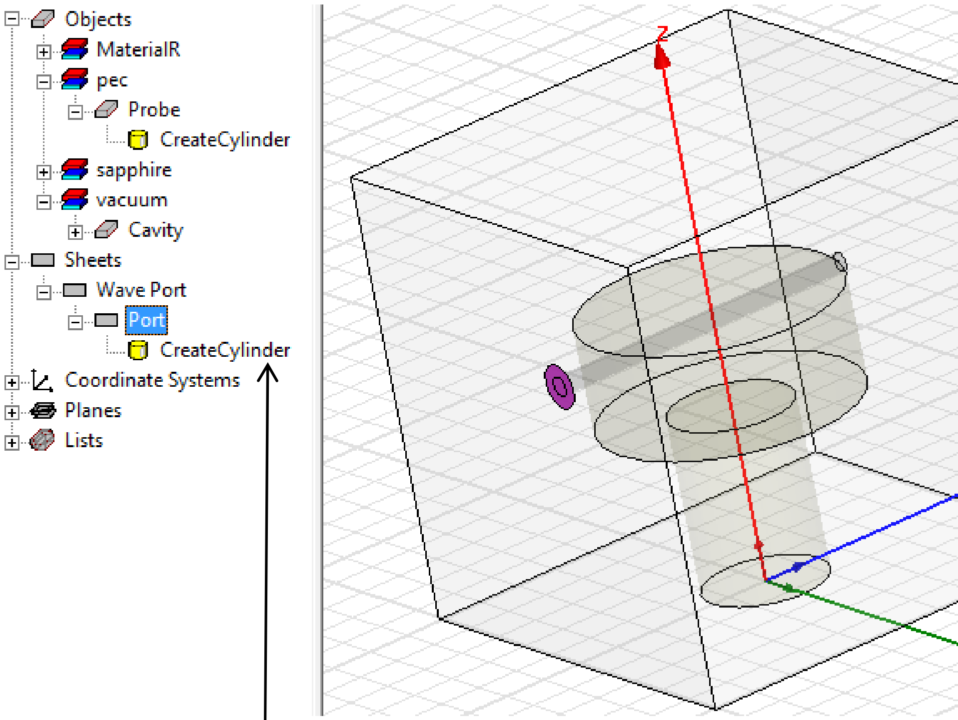
Design Examples (Driven mode: DR Filter) cont.

- Excitation
  - Probe
  - Port





The height of the cylinder is 0 = a sheet in a circular shape

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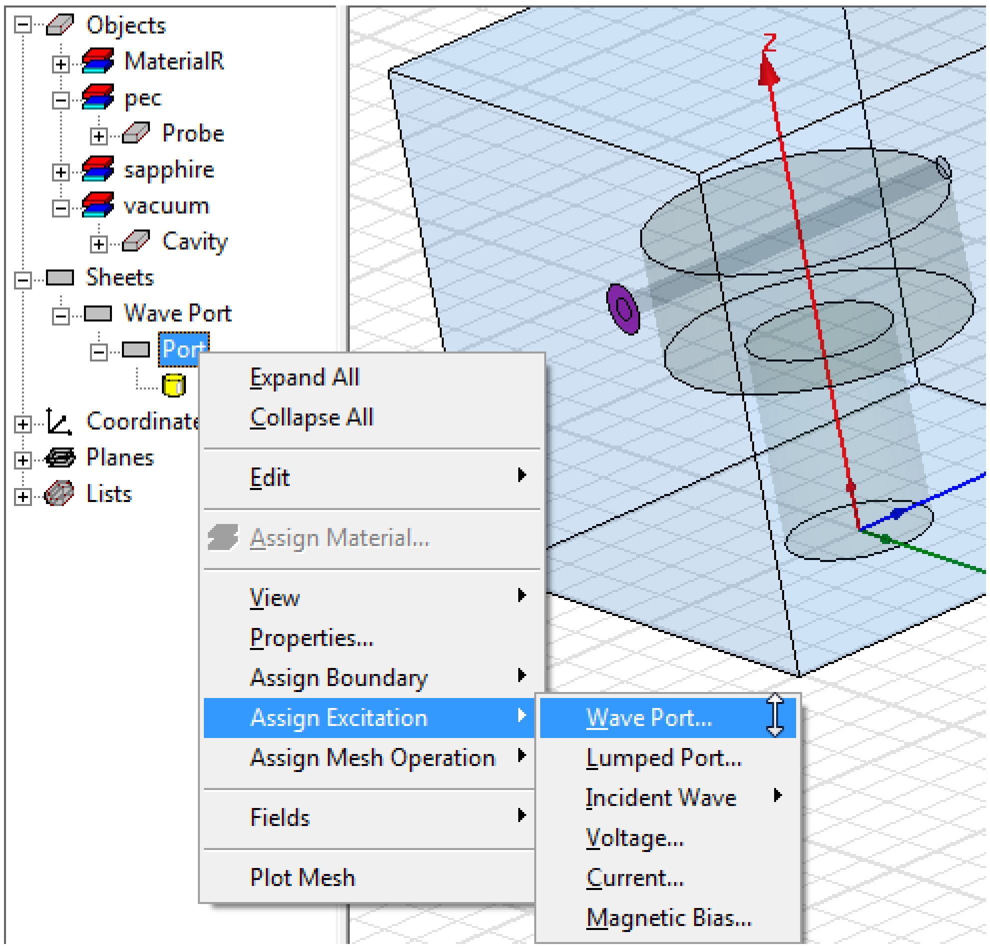
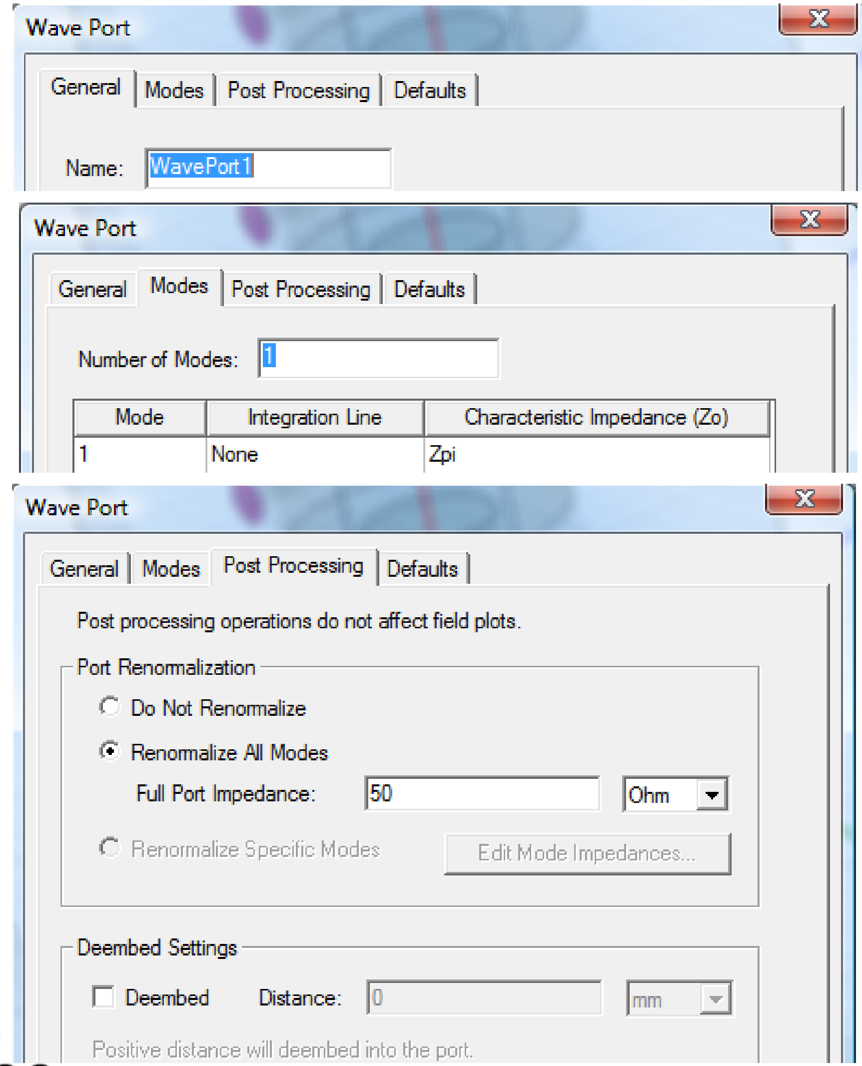
Design Examples (Driven mode: DR Filter) cont.

- Defining Port





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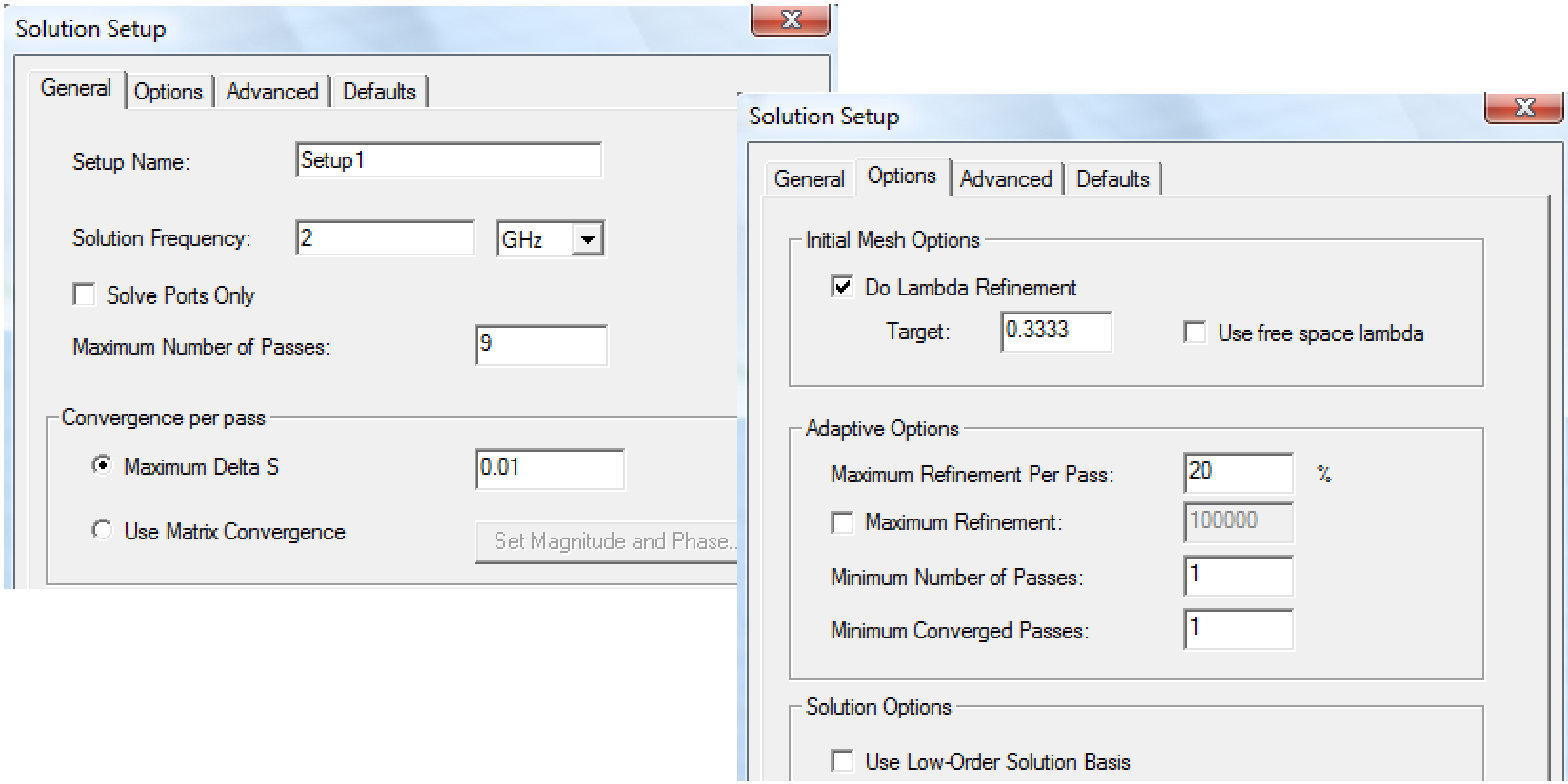
Design Examples (Driven mode: DR Filter) cont.

- Wave Port
  - HFSS assumes that the Wave Port is connected to a semi-infinite long waveguide that has the same cross-section and material properties as the port.
  - Wave ports calculate characteristic impedance, complex propagation constant, and generalized S-Parameters.
- Lumped Port
  - Lumped ports are similar to traditional wave ports, but can be located internally and have a complex user-defined impedance.

Design Examples (Driven mode: DR Filter) cont.

- Analysis Setup
  - Single Frequency



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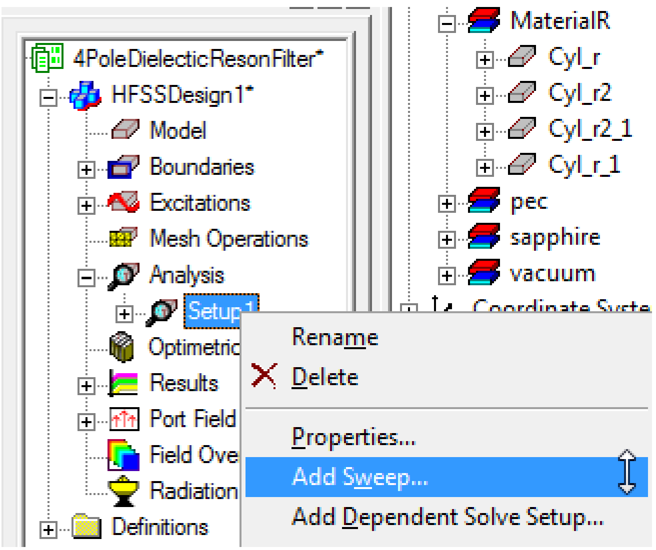
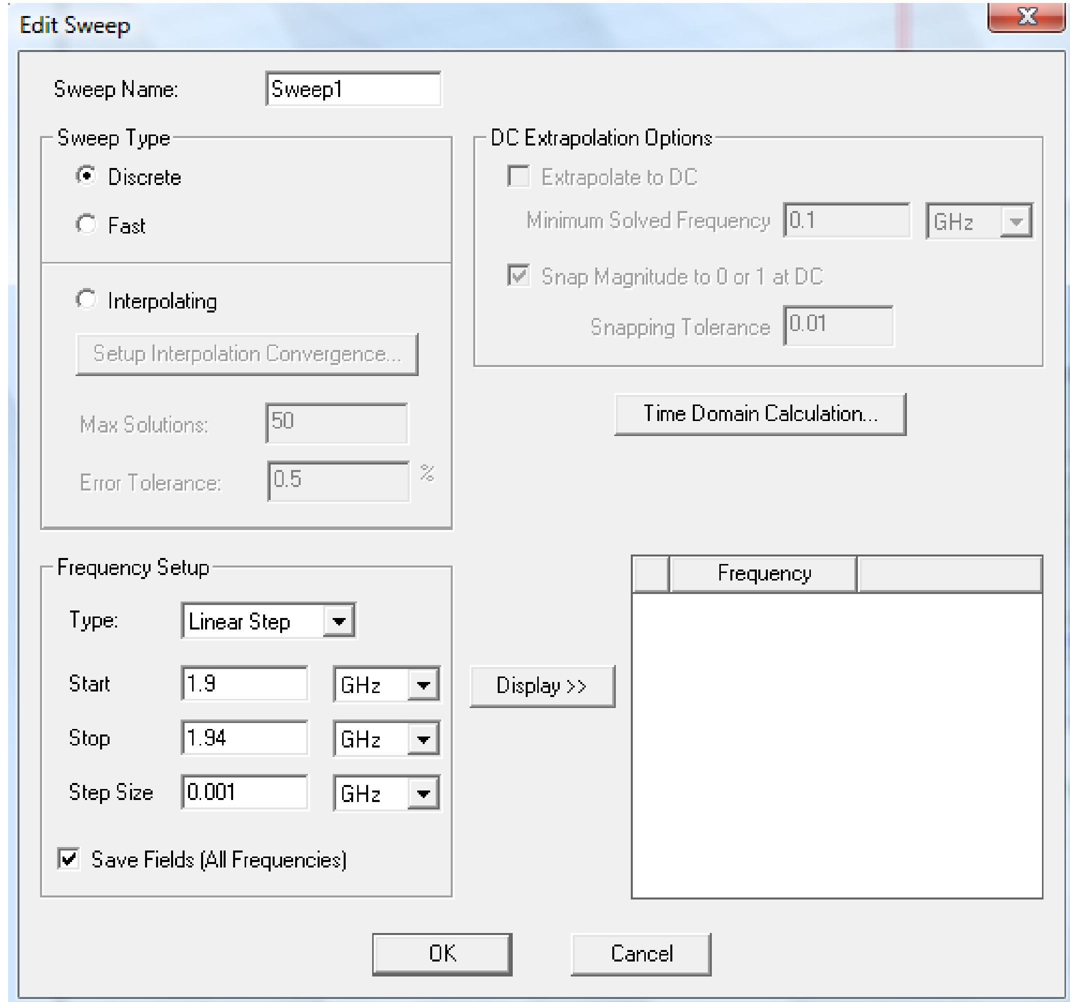
Design Examples (Driven mode: DR Filter) cont.

- Analysis Setup (cont.)
  - Frequency Sweep





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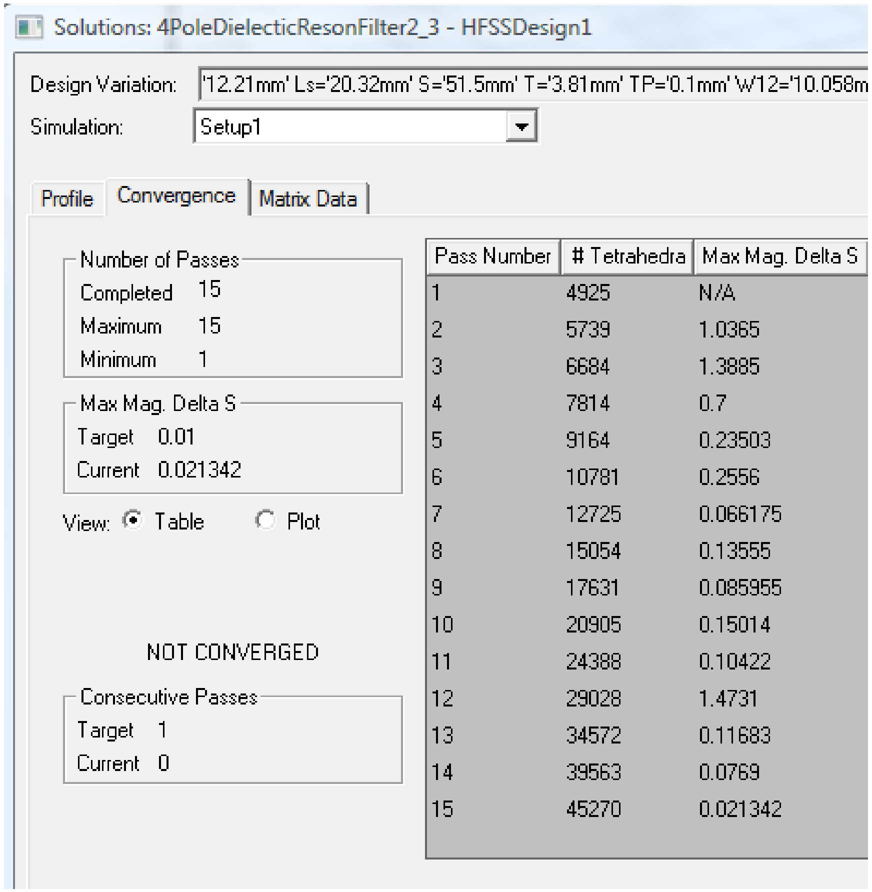
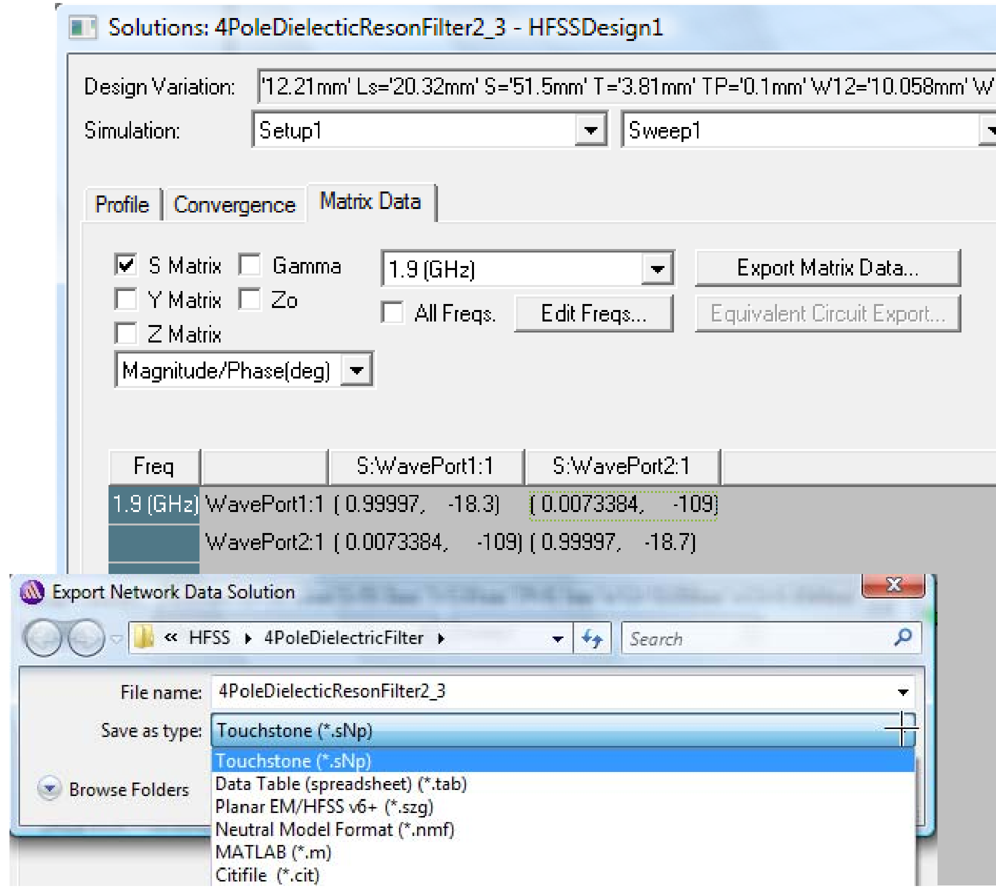
Design Examples (Driven mode: DR Filter) cont.

- Solution Data





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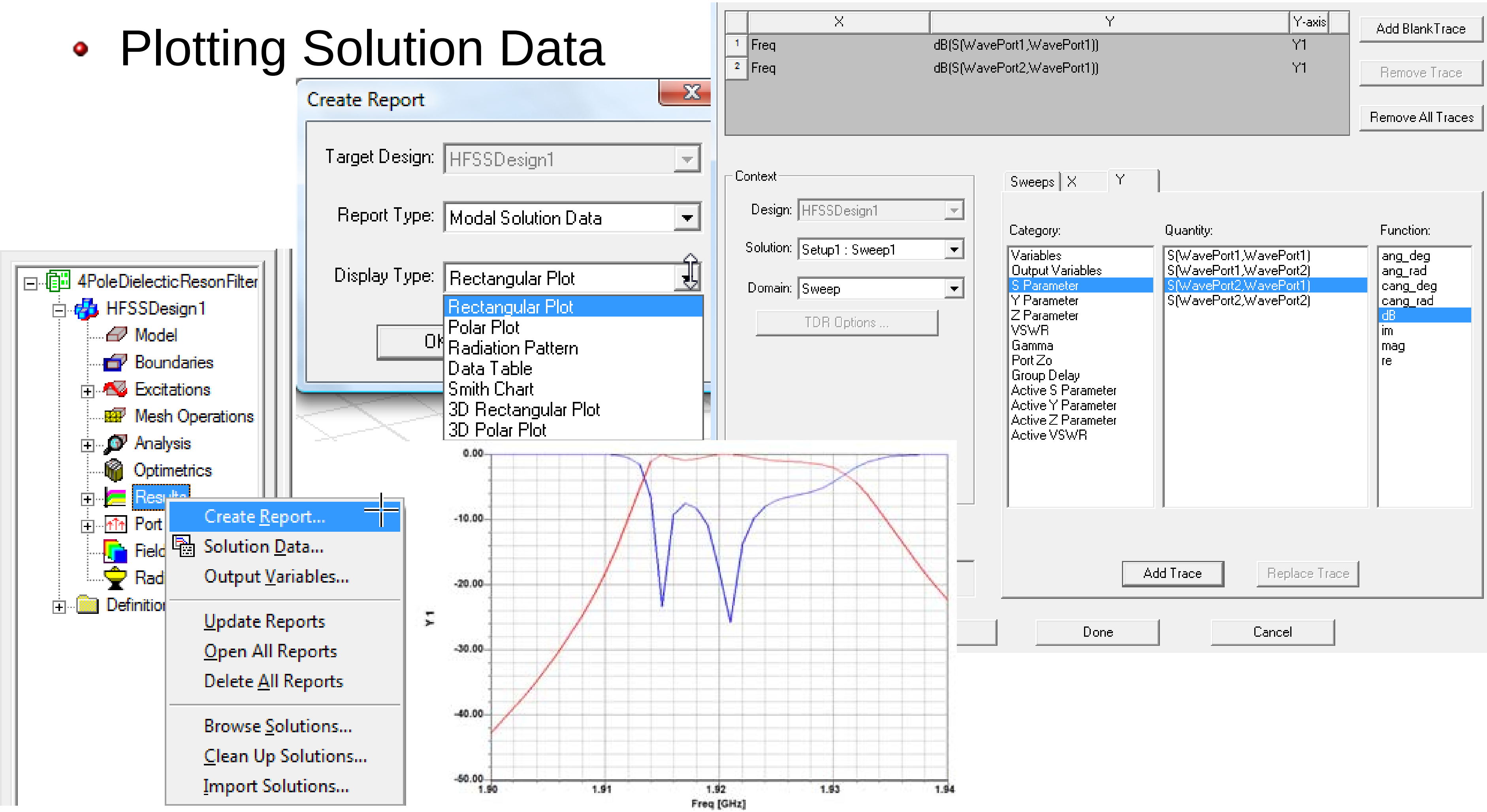
Design Examples (Driven mode: DR Filter) cont.

- Plotting Solution Data



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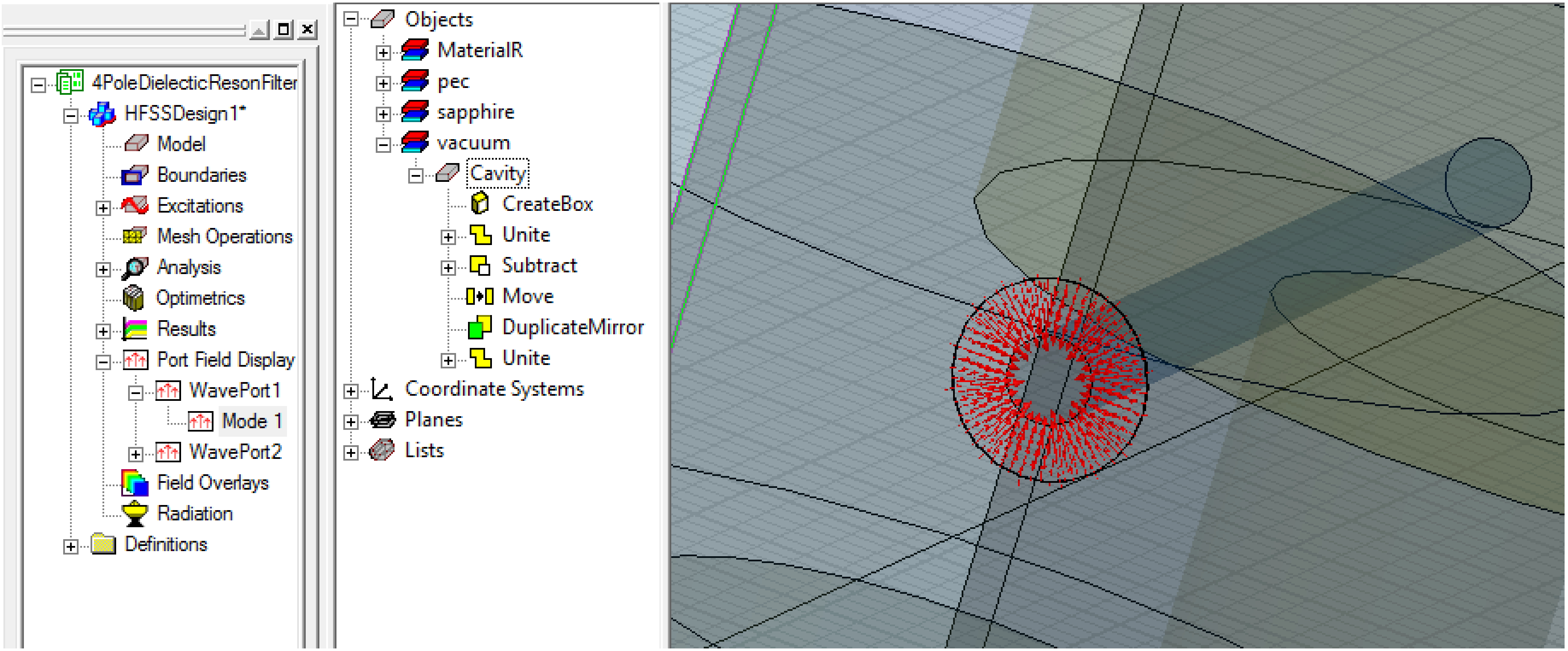
Design Examples (Driven mode: DR Filter) cont.

- Port Field Display



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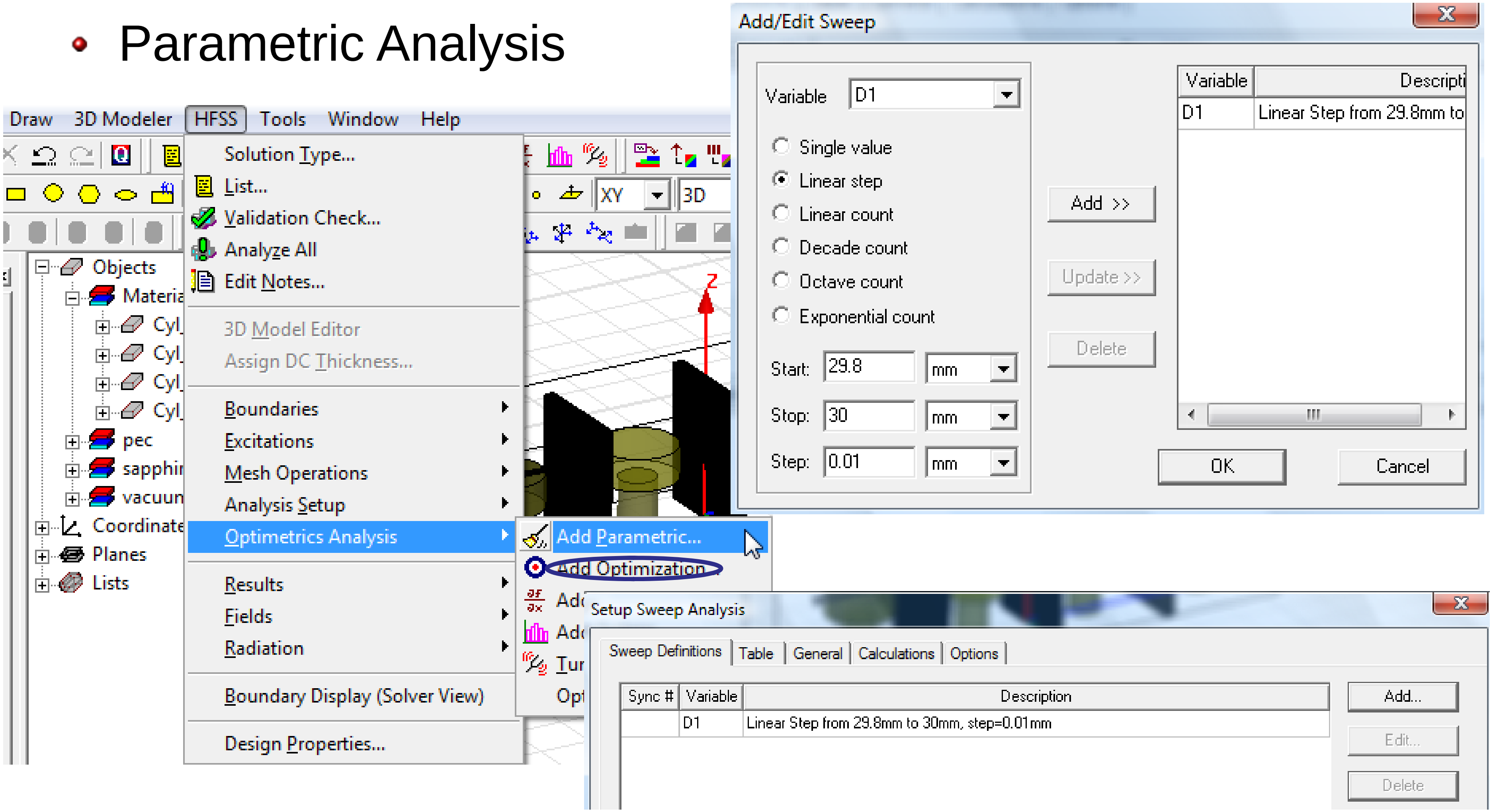
Design Examples (Driven mode: DR Filter) cont.

- Parametric Analysis



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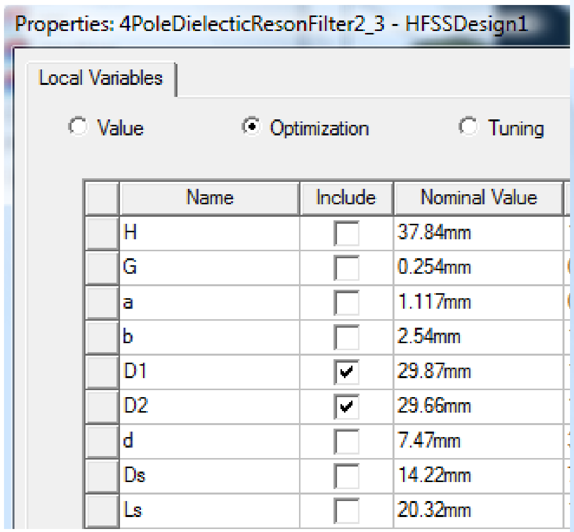
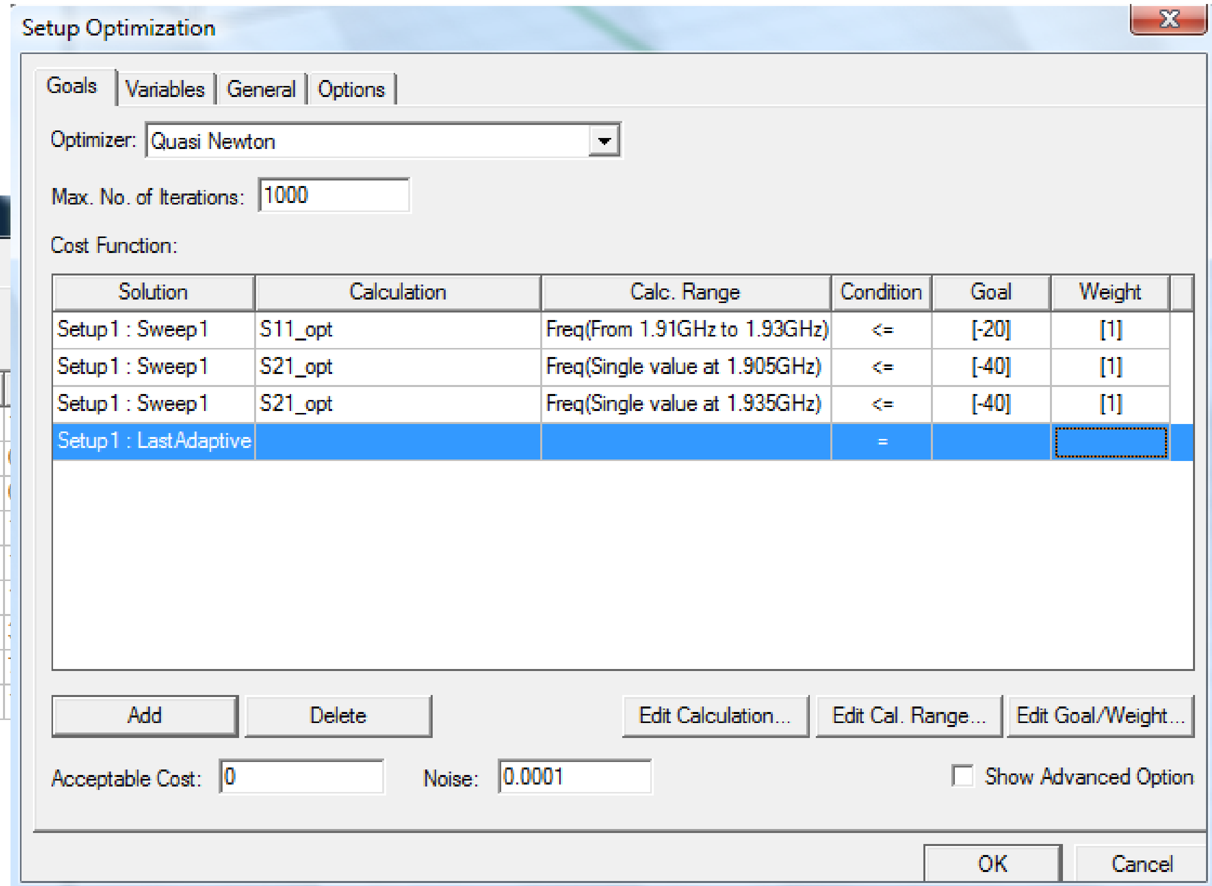
Design Examples (Driven mode: DR Filter) cont.

- Optimization





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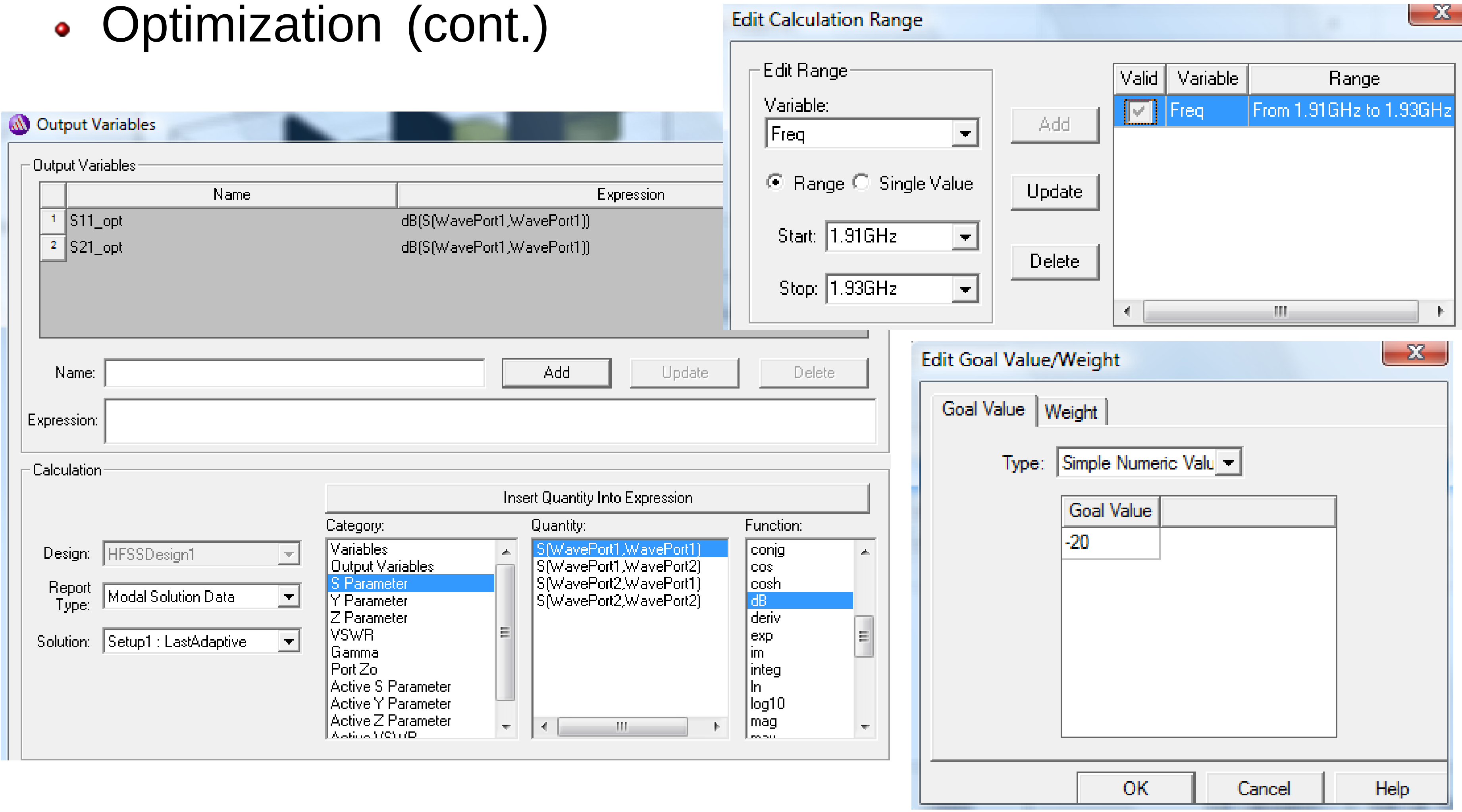
Design Examples (Driven mode: DR Filter) cont.

- Optimization (cont.)



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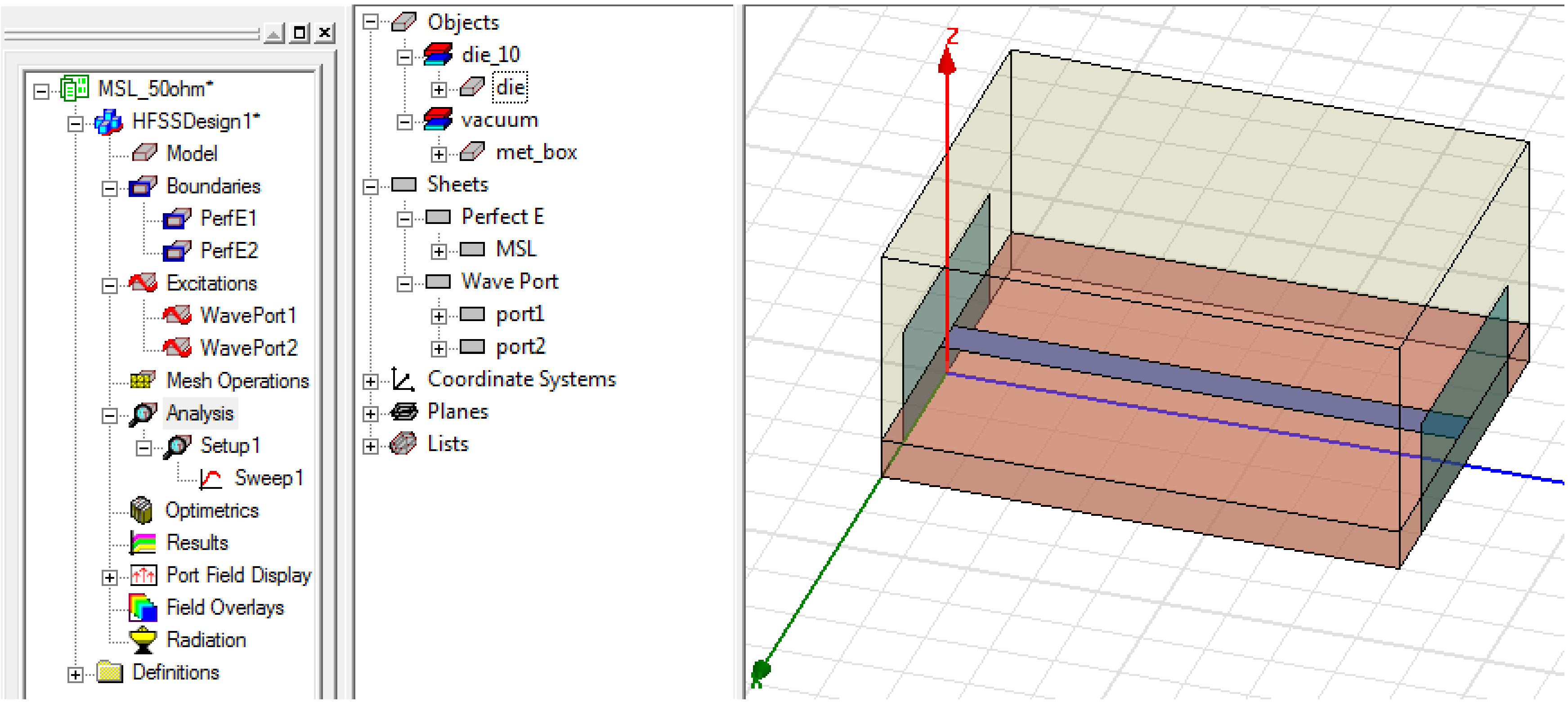
Design Examples (Driven mode: MSL)

- 3D Model of the MSL



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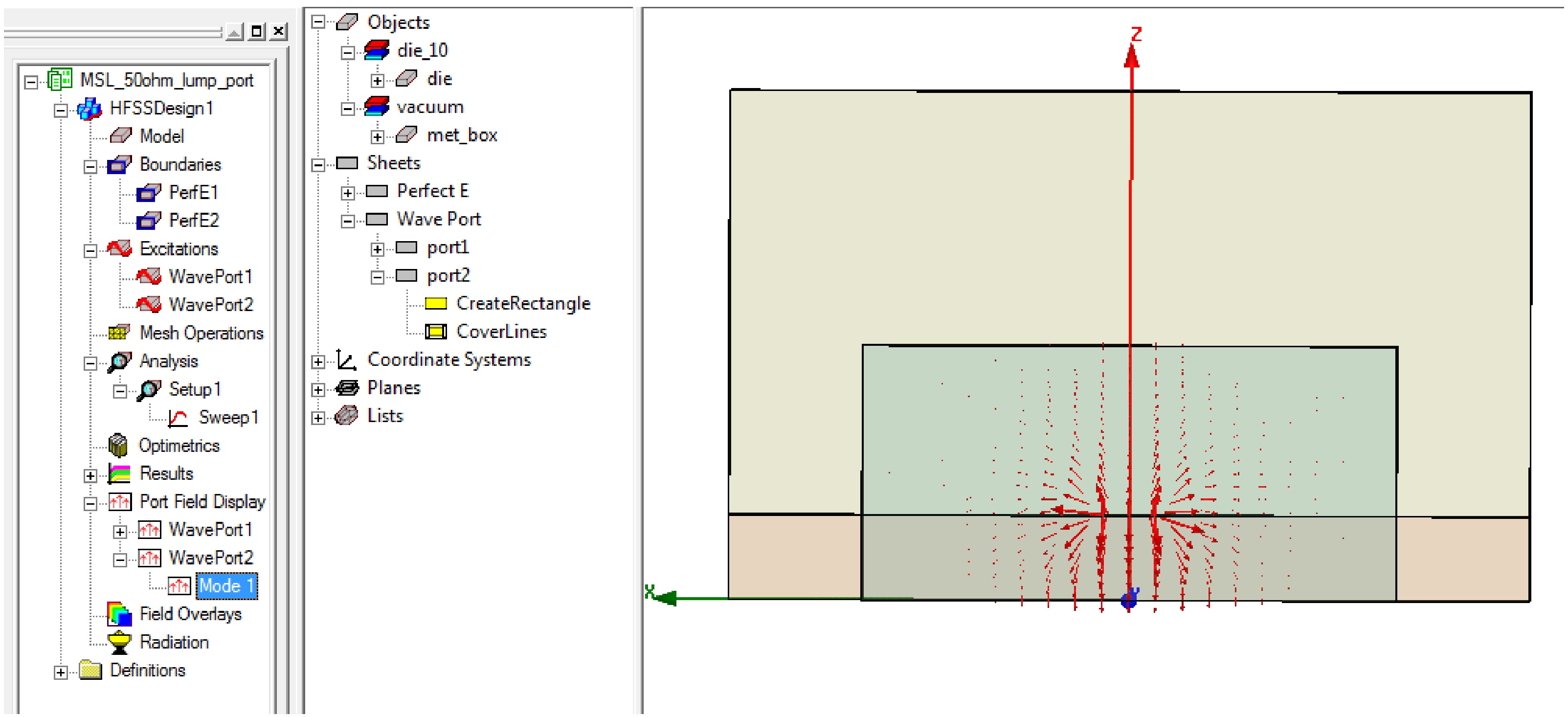
Design Examples (Driven mode: MSL)

- Port Field Display



Design Examples (Driven mode: MSL)

- Solution Data