

HFSS

Open Regions

As electromagnetic simulation technology advances, so does the need for faster simulation setup and execution. A necessary ingredient to the simulation process is the accurate setup and representation of the absorbing boundary conditions. In this application note, two new methods to create absorbing boundary conditions are showcased. These methods aim to simplify the process of creating absorbing boundary conditions that envelop the overall design. Therefore, the process of setting up simulations becomes less burdensome on the user

Introduction

As electromagnetic simulation technology advances, so does the need for faster simulation setup and execution. One aspect of the simulation is the need to accurately represent boundary conditions.

Absorbing Boundary Conditions (ABCs) are boundary conditions used to truncate the modeling domain in which the electric fields are computed. The ABCs are assigned to the outer surfaces of the modeling domain to absorb all outgoing waves, which enables the simulation of a radiating structure in an open environment. In this application note, we focus on two new methods introduced in ANSYS HFSS that simplify and expedite the process of creating these boundary conditions that envelope the overall design.

For a brief overview of the available variety of ABCs, please see the appendix at the end of this application note. The two new methods to implement the ABCs in ANSYS HFSS are showcased below. In both methods, the ABCs are automatically created by defining an Open Region. The first method defines the Open Region on the model, the second method defines the Open Region as part of the Solution Type.

Create Open Region with radiation boundary, FE-BI, or PML

In HFSS, there are two options to create open regions that are assigned directly to the model. The user can either right click on **Model** in the **Project Manager** window then select **“Create Open Region”** as shown in Figure 1 (a), or the user can use the menu bar **HFSS > Model > Create Open Region**, as shown in Figure 1 (b).

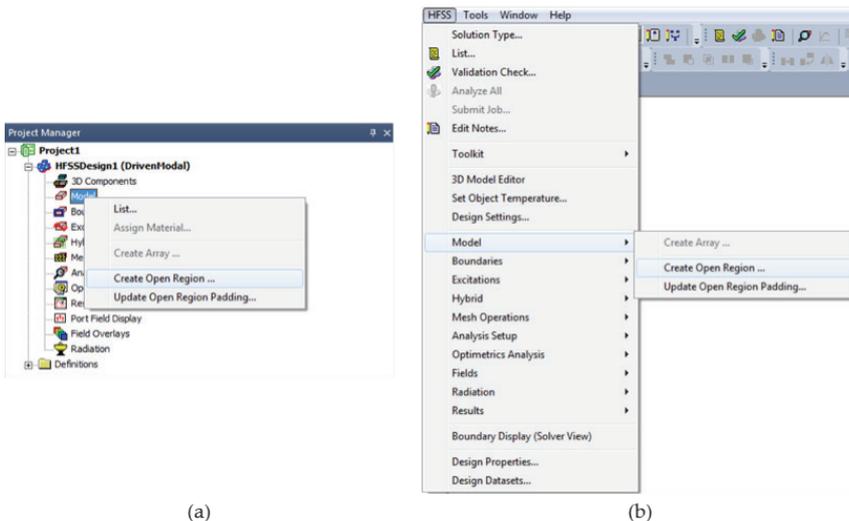


Figure 1. Two different ways to Create Open Region; (a) from the Project Manager window and (b) from the menu bar.

Upon selecting Create Open Region, the window in Figure 2 (a) pops up. The user is then prompted to define the operating frequency, as the region's distance from the radiator is defined based on the wavelength at that frequency. In most cases, the operating frequency should be the same as the solution frequency.

The user also has the option to define an infinite ground plane by checking the Apply infinite ground plane option, then specifying the plane in which this condition should be applied.

Finally, the user can specify the Boundary type used by the Open Region that best fits their design to be Radiation, FE-BI, or PML.

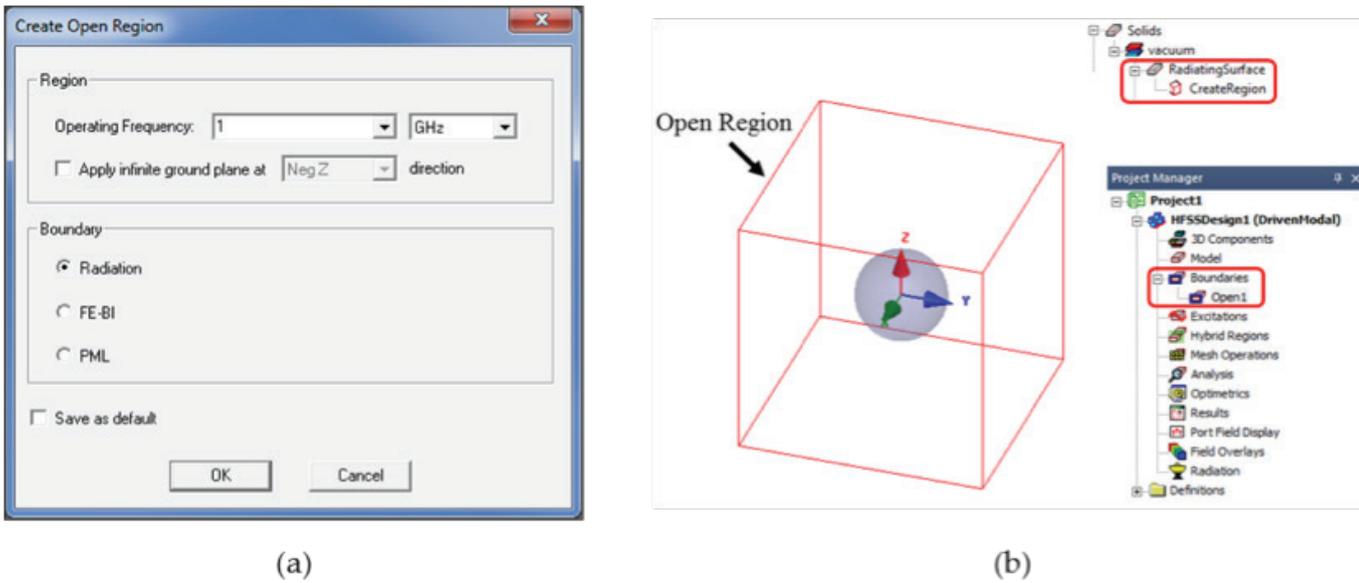


Figure 2. (a) Create Open Region pop-up window and (b) region included in Solids and Boundaries.

The **Create Open Region** takes the hassle out of calculating the region dimensions by prompting the user for the operating frequency and then automatically calculating the dimensions. This option is dynamic. If new objects are added to the design, the region dimensions will be updated automatically to maintain the desired separation between the design objects and the boundary (see Figure 3).

Solution Type: Auto-Open Region (with or without FE-BI).

This type of open region can be setup by using the menu bar **HFSS > Solution Type...** as shown in Figure 4 (a).

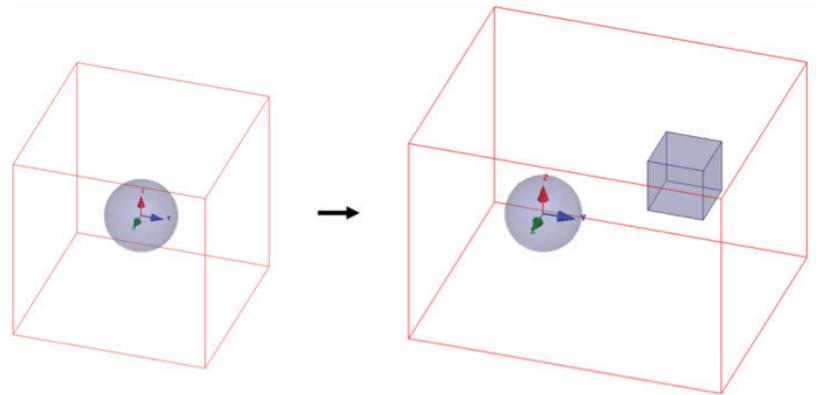


Figure 3. Open region automatically updates upon adding new objects to the design.

A pop-up window appears (see Figure 4. (b)). Within this window, the user can enable **Auto-Open Region** or **Auto-Open region with FE-BI**.

This type of open region essentially works by replacing HFSS's default PEC background by the background of the boundary (Auto-Open Region or Auto-Open Region with FE-BI). Consequently, the resulting region is hidden; neither visible in the object tree nor under Boundaries in the Project Manager. This is the simplest and quickest option to setup absorbing boundary conditions.

Summary

ANSYS HFSS provides the user with two new methods to setup absorbing boundary conditions. In this application note, we outline how of each one of these methods are used to setup Open Regions that are terminated with different boundary conditions: radiation boundary, PMLs, or FE-BI.

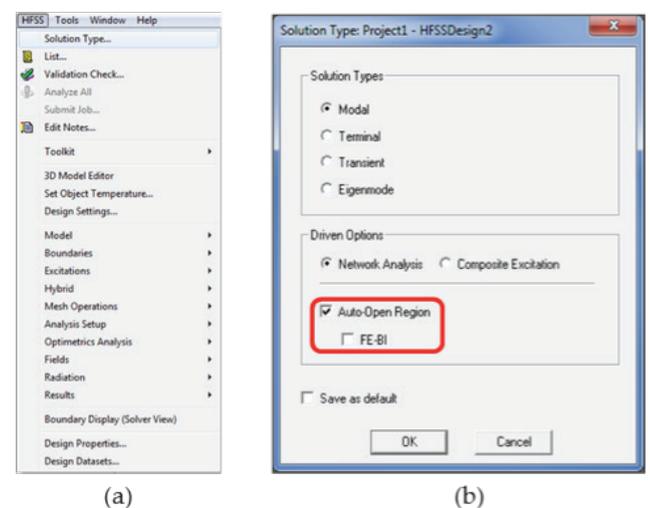


Figure 4. (a) Region setup from menu bar and (b) resultant pop-up window.

Appendix: Absorbing Boundary Conditions

ABCs are artificial boundaries used to truncate the modeling domain where the solution for Maxwell's equations is obtained. This appendix outlines the boundary conditions used to terminate the modeling domain by absorbing incident waves and therefore allowing simulations of structures radiating into open space.

- 1. Radiation Boundary** enables the user to model a surface as electrically open: waves impinging onto it are absorbed. Since no energy is reflected back to the radiating structure, this simulation setup is equivalent to analyzing a radiating structure in open space.

Radiation boundaries may be defined on arbitrarily shaped objects, as long as the object is convex (all surface normal point outwards and do not overlap).

When to use Radiation Boundaries? These boundaries are the default choice for quick and robust simulations. It is recommended that these boundaries are separated from the radiating structure by a distance of $\lambda/4$, where the wavelength λ is calculated at the antenna's resonant frequency or the lowest radiated frequency.

- 2. Perfectly Matched Layer (PML)** are objects with specifically calculated material properties so that they do not reflect any waves impinging on them and strongly attenuate the waves propagating through them. In free space termination, all PML objects must be included in a surface that radiates into free space equally in every direction. PMLs can be superior to radiation boundaries in this case because PMLs enable radiation surfaces to be located closer to radiating objects, reducing the problem domain. Any homogenous isotropic material, including lossy materials such as ocean water, can surround the model.

When to use PMLs? PMLs are typically used for designs that contain strong radiators. They are placed at a distance of at least $\lambda/8$ from the radiating aperture and should be at least $\lambda/3$ in thickness. Note that the wavelength (λ) is calculated at the antenna's resonant frequency or the lowest radiated frequency.

- 3. Finite Element-Boundary Integral (FE-BI)** is an alternative to Radiation and PML boundaries for radiating designs. The FE-BI boundary is a hybrid FEM (Volume) and IE solver (Radiating Surface). FE-BI is a reflection-less boundary that can be applied to arbitrarily shaped volumes. This boundary has no theoretical minimum distance from the radiator to the boundary. FE-BI boundaries require an HFSS-IE license.

When to use FE-BI boundaries? FE-BI are typically used with electrically large problems where mesh truncation can speed up the simulation significantly.

For more information, please see lecture notes in the Introduction to HFSS training material.



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