Ansys 2025 R2

POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT

Getting Started with HFSS™: Monostatic RCS of Trihedral using SBR+

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Conventions Used in this Guide

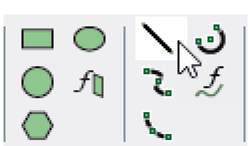
Please take a moment to review how instructions and other useful information are presented in this documentation.

- Procedures are presented as numbered lists. A single bullet indicates that the procedure has only one step.
- Bold type is used for the following:
  - Keyboard entries that should be typed in their entirety exactly as shown. For example, "**copy file1**" means you must type the word **copy**, then type a space, and then type **file1**.
  - On-screen prompts and messages, names of options and text boxes, and menu commands. Menu commands are often separated by greater than signs (>). For example, "click **HFSS** > **Excitations** > **Assign** > **Wave Port**."
  - Labeled keys on the computer keyboard. For example, "Press **Enter**" means to press the key labeled **Enter**.
- Italic type is used for the following:
  - Emphasis.
  - The titles of publications.
  - Keyboard entries when a name or a variable must be typed in place of the words in italics. For example, "**copy** *filename*" means you must type the word **copy**, then type a space, and then type the name of the file.
- The plus sign (+) is used between keyboard keys to indicate that you should press the keys at the same time. For example, "Press Shift+F1" means to press the **Shift** key and, while holding it down, press the **F1** key also. You should always depress the modifier key or keys first (for example, Shift, Ctrl, Alt, or Ctrl+Shift), continue to hold it/them down, and then press the last key in the instruction.

Accessing Commands: *Ribbons, menu bars,* and *shortcut menus* are three methods that can be used to see what commands are available in the application.

- The *Ribbon* occupies the rectangular area at the top of the application window and contains multiple tabs. Each tab has relevant commands that are organized, grouped, and labeled. An example of a typical user interaction is as follows:

  "Click **Draw** > **Line**"



This instruction means that you should click the **Line** command on the **Draw** ribbon tab. An image of the command icon, or a partial view of the ribbon, is often included with the instruction.

- The *menu bar* (located above the ribbon) is a group of the main commands of an application arranged by category such File, Edit, View, Project, etc. An example of a typical user interaction is as follows:

  "On the **File** menu, click the **Open Examples** command" means you can click the **File** menu and then click **Open Examples** to launch the dialog box.

- Another alternative is to use the *shortcut menu* that appears when you click the right-mouse button. An example of a typical user interaction is as follows:

  “Right-click and select **Assign Excitation** > **Wave Port**” means when you click the right-mouse button with an object face selected, you can execute the excitation commands from the shortcut menu (and the corresponding sub-menus).

Getting Help: Ansys Technical Support

For information about Ansys Technical Support, go to the Ansys corporate Support website, http://www.ansys.com/Support. You can also contact your Ansys account manager in order to obtain this information.

All Ansys software files are ASCII text and can be sent conveniently by e-mail. When reporting difficulties, it is extremely helpful to include very specific information about what steps were taken or what stages the simulation reached, including software files as applicable. This allows more rapid and effective debugging.

Help Menu

To access help from the Help menu, click **Help** and select from the menu:

- **[product name] Help** - opens the contents of the help. This help includes the help for the product and its *Getting Started Guides*.
- **[product name] Scripting Help** - opens the contents of the *Scripting Guide*.
- **[product name] Getting Started Guides** - opens a topic that contains links to Getting Started Guides in the help system.

Context-Sensitive Help

To access help from the user interface, press **F1**. The help specific to the active product (design type) opens.

You can press **F1** while the cursor is pointing at a menu command or while a particular dialog box or dialog box tab is open. In this case, the help page associated with the command or open dialog box is displayed automatically.

Table of Contents

1 - Introduction

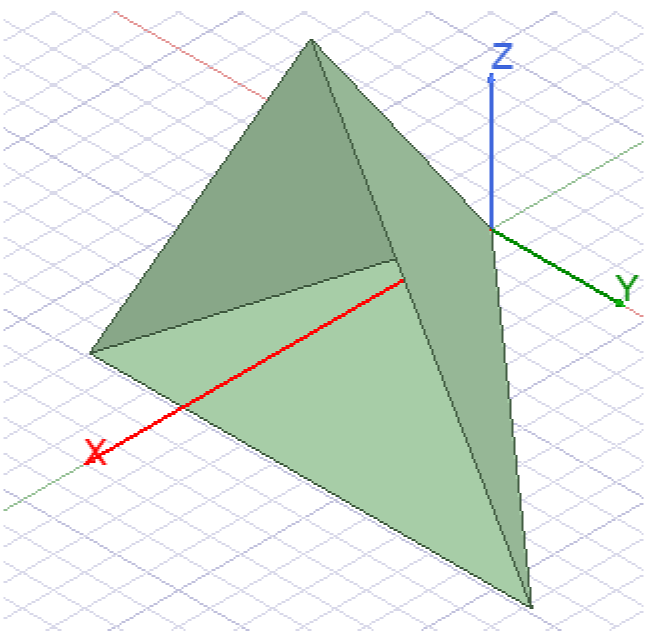
This *Getting Started* guide describes how to use HFSS to model a Monostatic Radar Cross Section (RCS) of a metal trihedral reflector using an SBR+ Hybrid Region. You will use an RCS example model that is already set up and ready to solve. This guide shows you how to verify the excitation and solution setup, analyze the model, and produce reports.

In this tutorial the following tasks are performed using HFSS:

- Verify the incident wave excitation
- Verify solution setups
- Run HFSS simulations
- Create 2D (XY) plots
- Create a 3D polar plot and overlay it on the model

Monostatic RCS of a Tridehral Reflector using an SBR+ Hybrid Region

Metal trihedrals are commonly employed as radar calibration targets because they provide strong, aspect-stable, and predictable Radar Cross Section (RCS) results over a wide range of angles. They are also easy to construct. In this example project, the monostatic RCS of a trihedral reflector is computed over a full azimuth (Theta) cut in the XY-plane (at Theta = 90°) using the HFSS SBR+ solver.

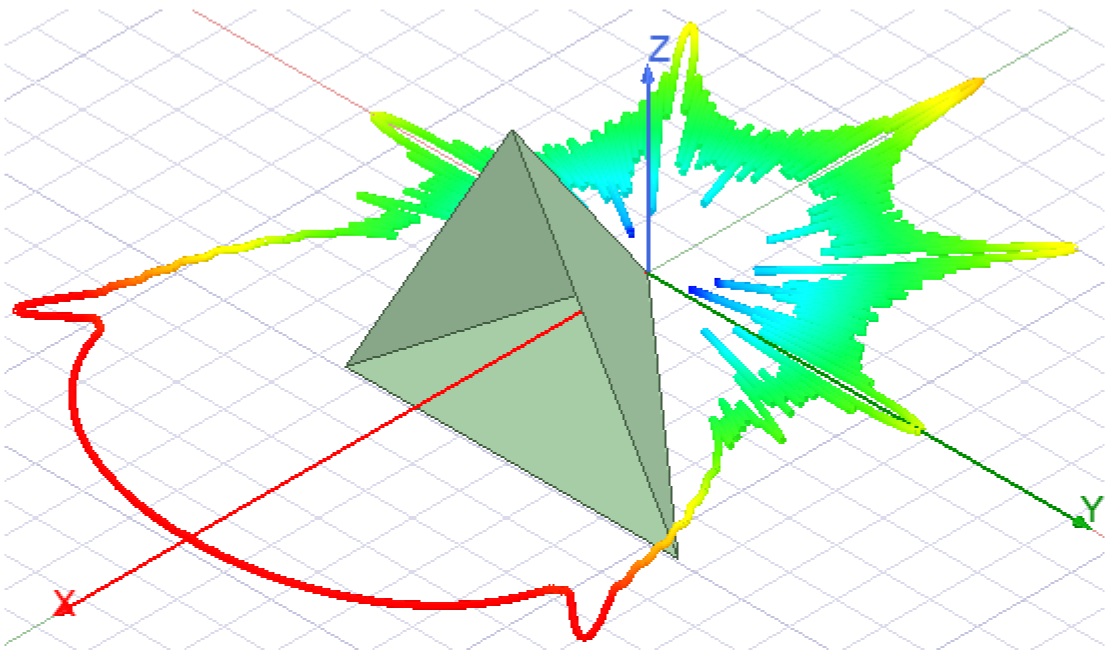


Model Description: The trihedral reflector is composed of three right-isosceles triangles, each of whose leg lengths is *s* = 0.5 m, as set by the HFSS project design variable, *sideLength*, in TriHedral_RCS.aedt. These triangular sides are arranged as a tetrahedron with one open face perpendicular to the +x axis and bounded by the hypotenuse of each triangle. The open face is an equilateral triangle whose sides are √2 *s* = 0.7071 m. The trihedron's apex, where the 90º corners of the right-isosceles triangles meet, is at the global coordinate origin.

The trihedral reflector is assigned a Perfect-E (PEC metal) boundary. With this construction, plane waves incident near the +x-axis will backscatter strongly, yielding a large RCS. In a geometric optic (GO) ray interpretation, each ray arriving from near the +x-axis direction will bounce successively off each of the three faces and then escape in the precise backscatter direction, all with the same path length, providing a strong, coherent backscatter return. In the asymptotic GO limit, the head-on RCS looking along the x-axis is given by:

$$\sigma = \frac{4\pi s^4}{3\lambda^2}$$

where λ is the wavelength. At a frequency of 10 GHz, with *s* = 0.5 m, we obtain σ = 291.3 m^2 = 24.6 dBsm (dB square-meters).



Launch EDT and Open the Example Model

You can open the example project from the Ansys Electronics Desktop (EDT) application, as follows:

1. Double-click the **Ansys Electronics Desktop** shortcut on your desktop (or click the equivalent Start Menu shortcut) to launch the application.
2. On the **Desktop** ribbon tab, click **Open Examples**.

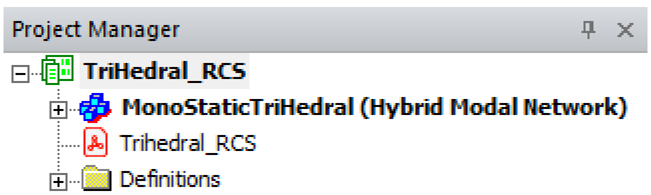
   The *Open* dialog box appears displaying the contents of the *Examples* folder.

3. Double-click the **HFSS** subfolder and then double-click the **RCS** subfolder under *HFSS*.
4. Select the **TridHedral_RCS** project and click **Open**.

   The example model loads.

5. Expand the **TriHedral_RCS** branch of the Project Manager.

   The project already contains a *MonoStaticTriHedral (Hybrid Modal Network)* design:



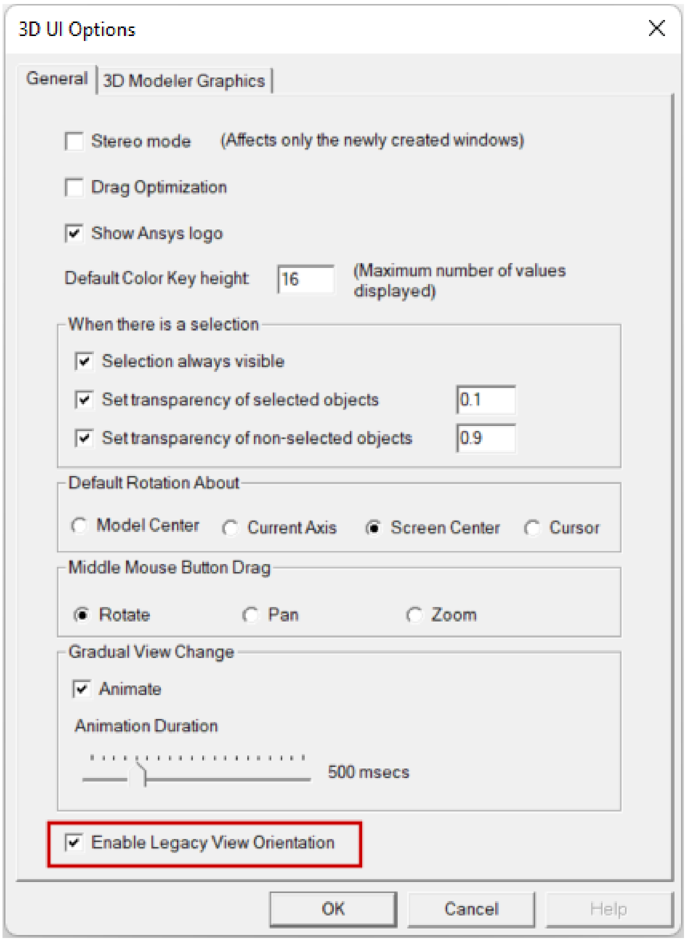
Enable Legacy View Orientations

This getting started guide was created based on standard view orientations that were in effect for version 2023 R2 and earlier of the Ansys Electronics Desktop application. For consistency between your experience and the views and instructions contained in this guide, select the *Enable Legacy View Orientation* option in the 3D UI Options dialog box, as follows:

1. From the menu bar, click **View** > **Options**.

   The *3D UI Options* dialog box appears.

2. Select **Enable Legacy View Orientation**:



3. Click **OK**.

   Changing the view orientation option does not change the model viewpoint that was in effect at the time.

4. On the **Draw** ribbon tab, click **Orient** to change to the *Trimetric* view, which is the default legacy view orientation.

   You do not have to select *Trimetric* from the *Orient* drop-down menu. The default view appears when you click *Orient*.

Although this option can only be accessed once a design is added to a project, it is a global option. Your choice is retained for all future program sessions, projects, and design types that use the 3D Modeler or that produce 3D plots of results.

At the end of this guide, you will be prompted to clear the *Enable Legacy View Orientation* option, if you prefer to use the view orientation scheme implemented for 2024 R1 and newer versions going forward.

For a comparison of the legacy and current view orientations, search for *"View Options: 3D UI Options"* in the HFSS help. Additionally, views associated with **Alt + double-click** zones have been redefined. The current orientations are shown in the help topic, *"Changing the Model View with Alt+Double-Click Areas."*

2 - Incident Wave Excitation

The excitation is already defined for you in the example model. However, you will review it now.

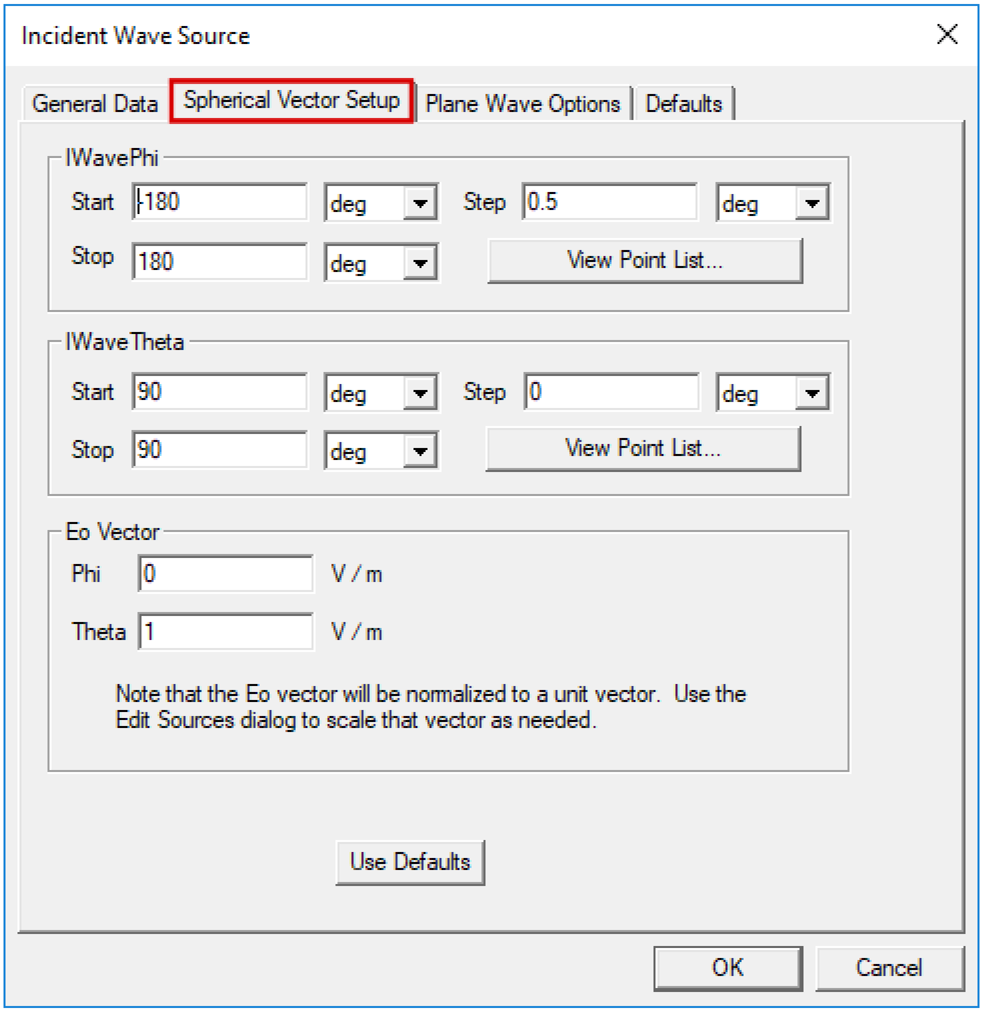
An incident plane-wave excitation is set for a complete incident phi-cut from -180° to 180° in 0.5° steps and fixed theta = 90°. Verify this swept plane-wave excitation in the example project by following these steps:

1. For a better view of all three sides of the tetrahedral reflector, change from the default trimetric view to an isometric view. (On the **Draw** ribbon tab, click **Orient** > **Isometric**.)
2. Expand the **MonoStaticTriHedral (DrivenModal)** branch of the Project Manager and then the expand **Excitations** subbranch.
3. Double-click **IncPWave1**.

   The *Incident Wave Source* dialog box appears.

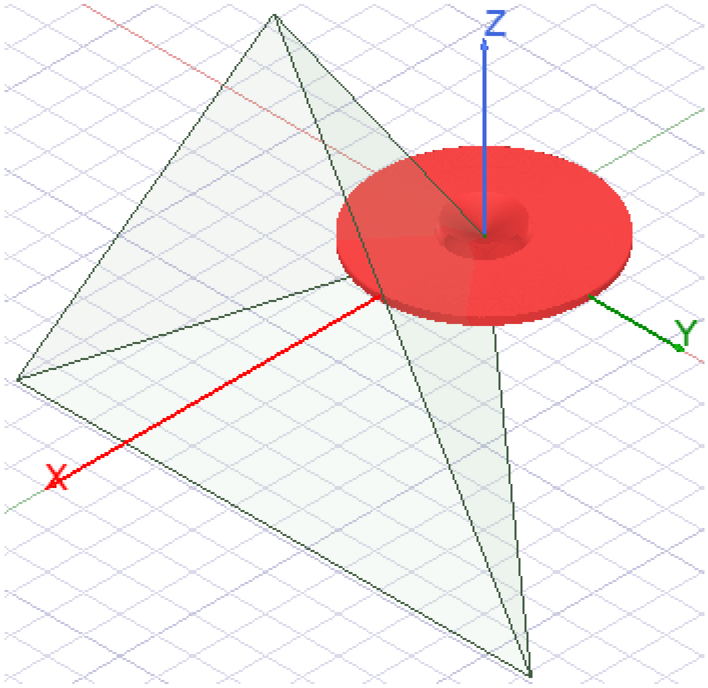
   > **Note:**
   >
   > If the excitation had not been defined already, you would have had to select the three *faces* of the trihedral reflector, right-click *Excitations* in the Project Manager, and select *Assign* > *Incident Wave* > *Plane Wave* from the shortcut menu to assign the excitation. A wizard would then step you through the excitation setup steps, which correspond to the tabs of the *Incident Wave Source* dialog box.

4. In the **General Data** tab of the *Incident Wave Source* dialog box, the **Spherical** option has been selected for the **Vector Input Format**.
5. The settings within the *Spherical Wave Setup* tab are as shown in the following figure:



6. Click **OK** to close the dialog box and keep the incident wave excitation selected.

> **Note:**
>
> With *IncPWave1* still selected, notice the visualization of the excitation at the apex of the model. A group of plane-wave incident angles is shown as red arrows pointing toward the coordinate system origin:



> **Note:**
>
> The arrows look like a disk because of the small *Step* size (0.5 deg) defined for *IWave Phi*. So, the arrows overlap each other. At a step size of around 10 deg or more, you would see separate arrows.

3 - Set Up and Solve the Analysis

The analysis setups are already defined for you in the example model. However, you will review these items now.

Setup Description: The trihedral monostatic RCS is simulated at 10 GHz. The example project contains two solution setups:

- PTD (Physical Theory of Diffraction)
- SBR (Shooting and Bouncing Ray technology)

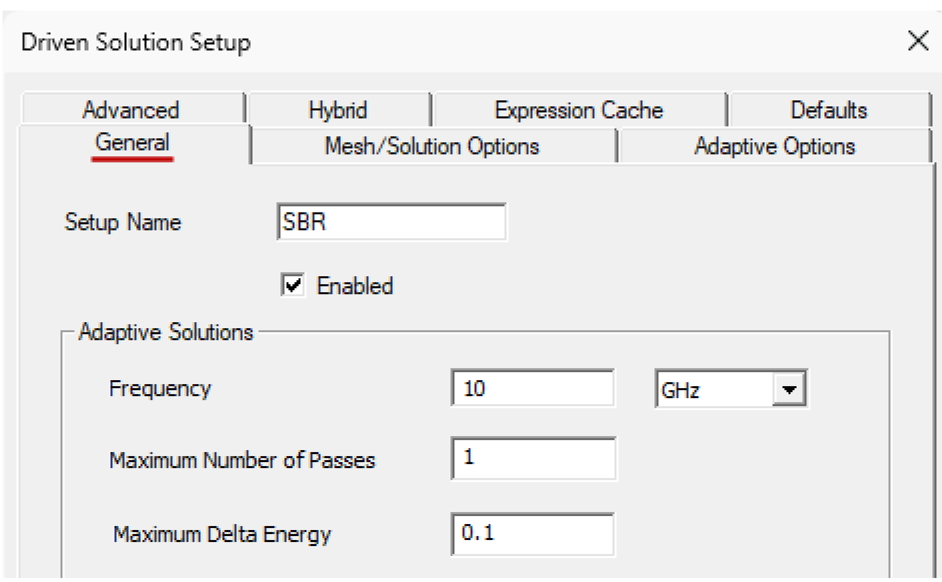
Verify the solution setups and perform the analysis as follows:

1. Expand the **Hybrid Regions** branch of the Project Manager and select **Hybrid1** to see the region visualized on the model.

   The trihedral reflector is assigned as an SBR+ hybrid region. This assignment was done by selecting the three faces of the model, right-clicking, and selecting **Assign Hybrid** > **SBR+ Region**, which created the *Hybrid1* entry under *Hybrid Regions* in the Project Manager.

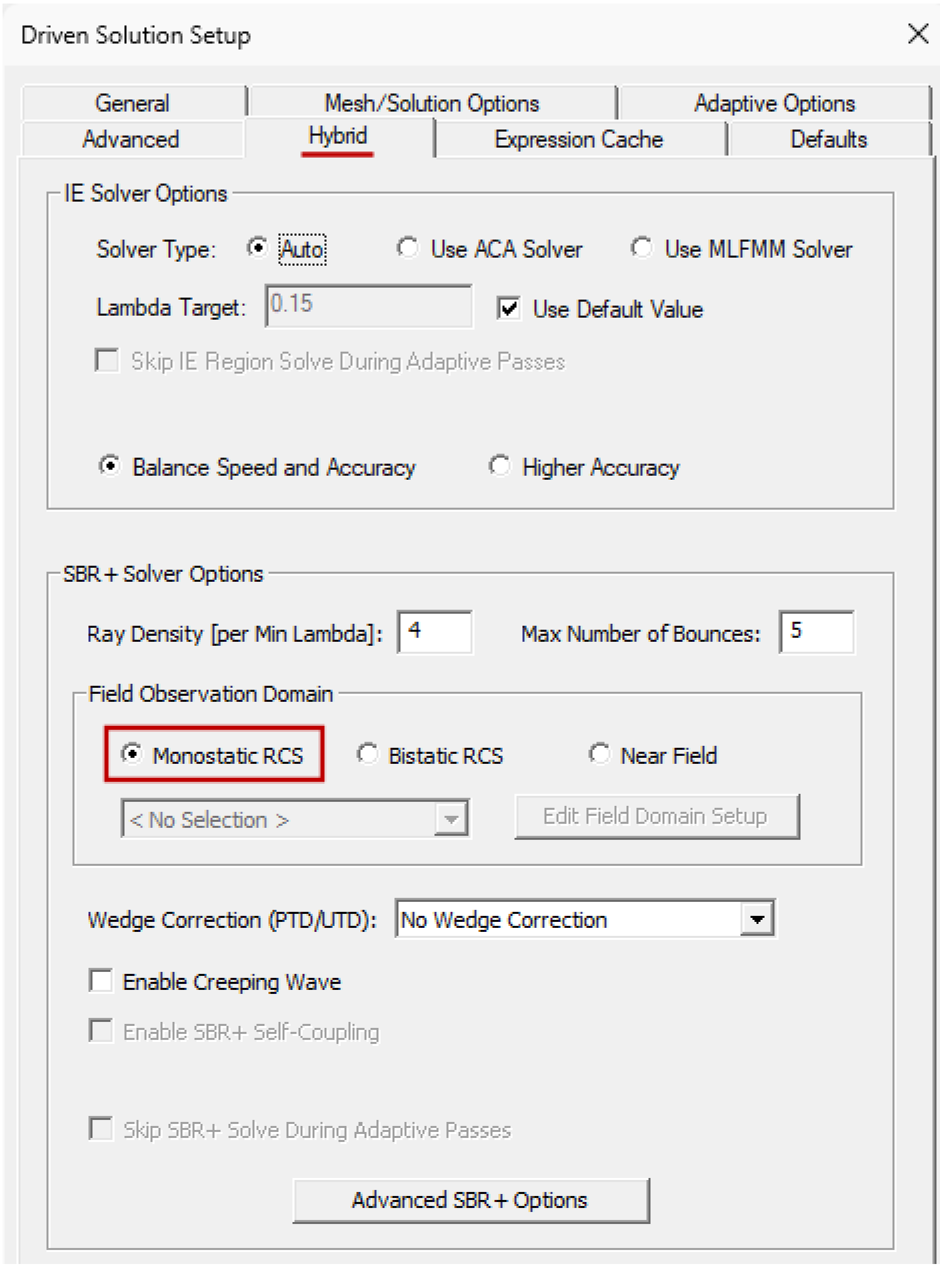
2. Optionally, double-click **Hybrid1** to see the *Name* and *Type* settings in the *Hybrid Region* dialog box. Then, click **OK** or **Cancel** to close the dialog box.
3. In the Project Manager, expand the **Analysis** branch and double-click **SBR**.

   The *Driven Solution Setup* dialog box appears. Review the settings in the **General** tab:

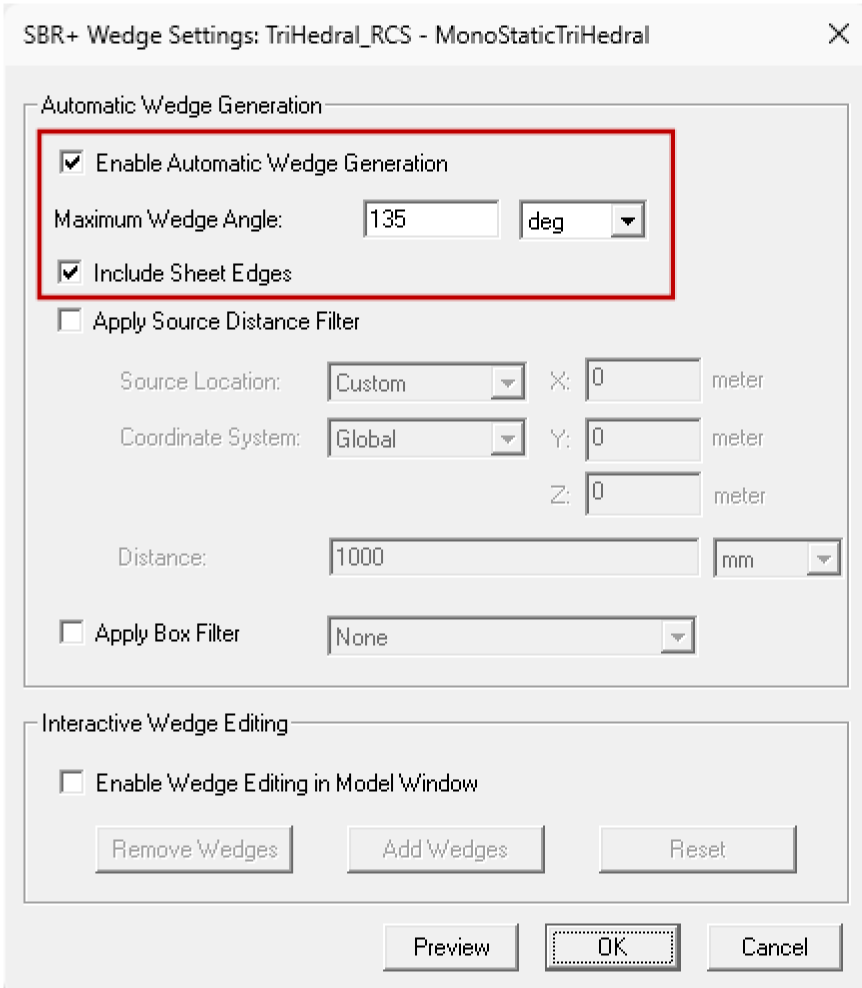
4. Select the **Hybrid** tab.

   This setup uses the default SBR settings in the *Hybrid* tab (see below):

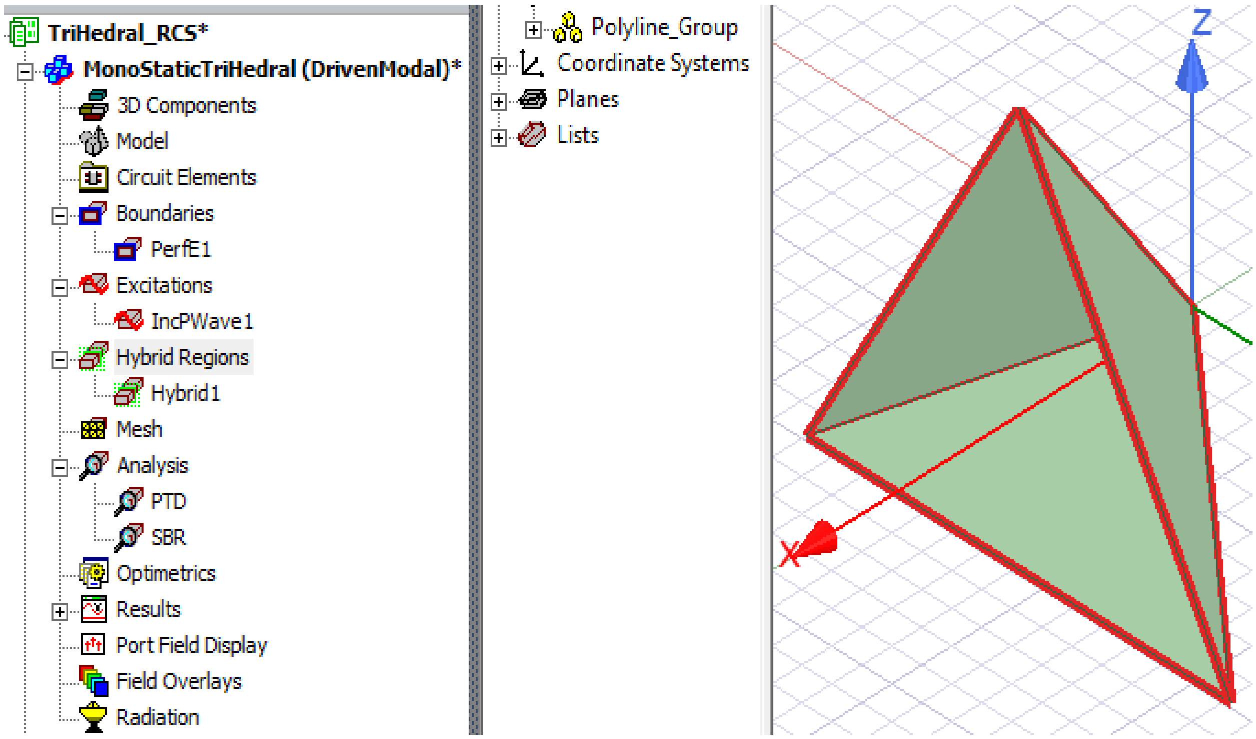


5. Click **OK** or **Cancel** to close the dialog box.
6. Right-click **Hybrid Regions** in the Project Manager and select **SBR+ Wedges** > **Settings** from the shortcut menu.

   To support the PTD correction available in SBR+ (for improving the accuracy of edge-diffraction modeling), the trihedron edges have been included for special processing. In the SBR+ Wedge Settings dialog box, the *Maximum Wedge Angle* is set to *135*^{o} and the *Include Sheet Edges* option is selected, as shown below:



This option causes HFSS to identify joined-face wedges with an interior angle less than 135^{o} (which includes the wedges where the isosceles sides meet) and the “knife edges” (sheet edges on the equilateral perimeter of the trihedral reflector's open side). The extracted edges are displayed as red lines in the model viewer by selecting the **Hybrid Regions** > **SBR+ Wedges** > **Wedge Visibility** option. However, the edge visibility will not be displayed until after the analysis has been solved.

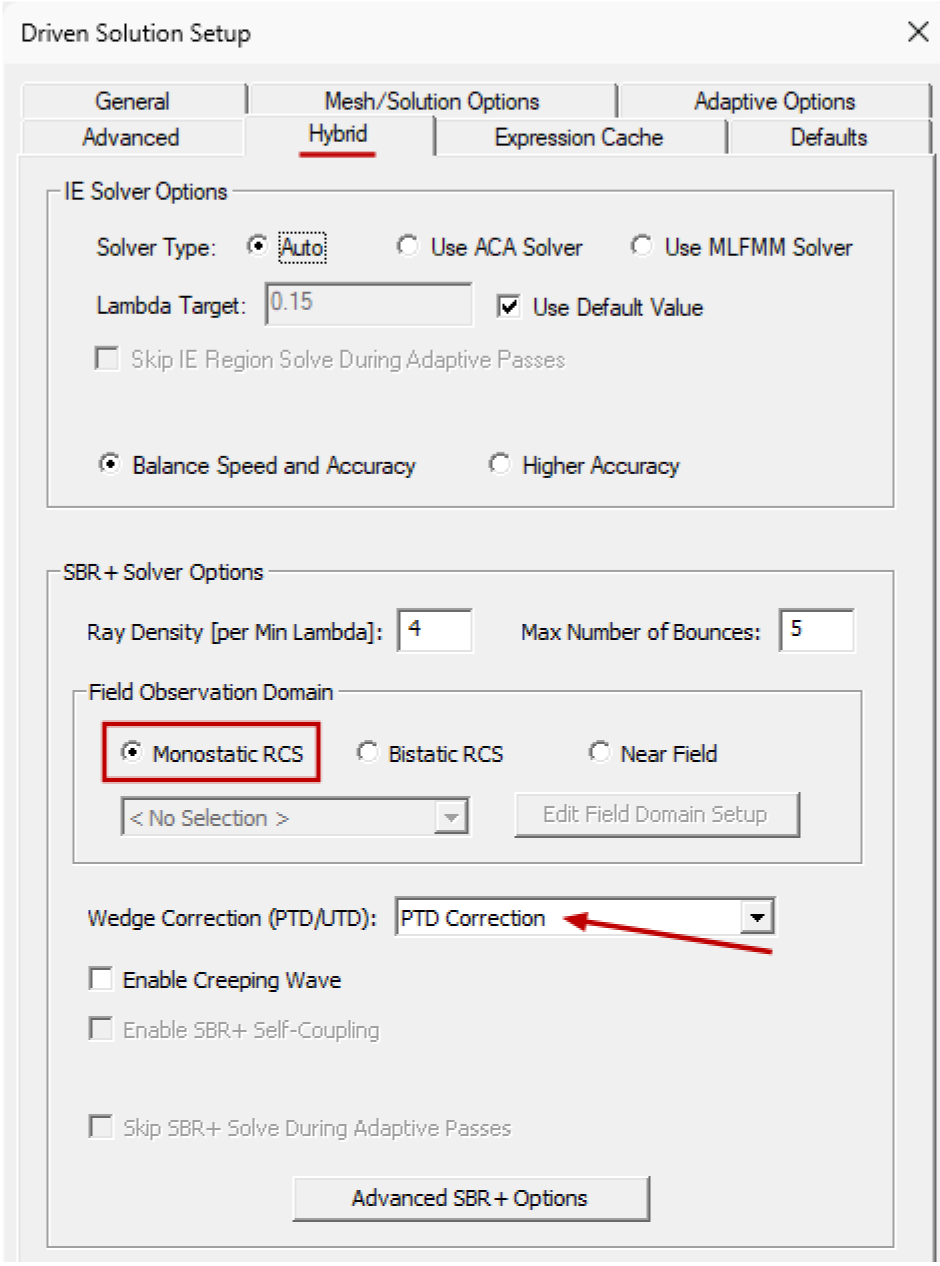


7. Click **OK** or **Cancel** to close the dialog box.
8. Double-click **PTD** under *Analysis* in the Project Manager.

   The settings in the **General** tab of the *Driven Solution Setup* dialog box are the same as those for the SBR setup, except for the *Setup Name*.

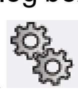
9. Select the **Hybrid** tab.

   For the PTD setup, the **PTD Correction** option is selected, which requires the edges that were extracted in the preceding **SBR+ Wedges** > **Settings** (step 6).



Both solutions setups have the *Field Observation Domain* set to *Monostatic RCS*. This option means that the observation angles are the same as those of the incident plane wave excitation, and it is therefore unnecessary to configure or select an Infinite Sphere Setup.

10. Click **OK** or **Cancel** to close the dialog box.

11. On the **Simulation** ribbon tab, click  **Analyze All**.

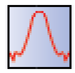
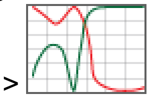
You cannot write to the *Examples* folder, so the program prompts you with a *Save As* dialog box.

12. Navigate to a folder of your choice for saving a copy of the project files and the results to be produced. Then, click **Save**.
13. In the *Handle Project Directory Files* dialog box that appears next, click **OK** to accept the default action.

Each solution setup (SBR and PTD) requires several seconds to analyze, depending on your computer hardware.

> **Note:**
>
> Alternatively, you could have run the setups individually by right-clicking each setup (under *Analysis* in the Project Manager) and choosing **Analyze** from the shortcut menu.

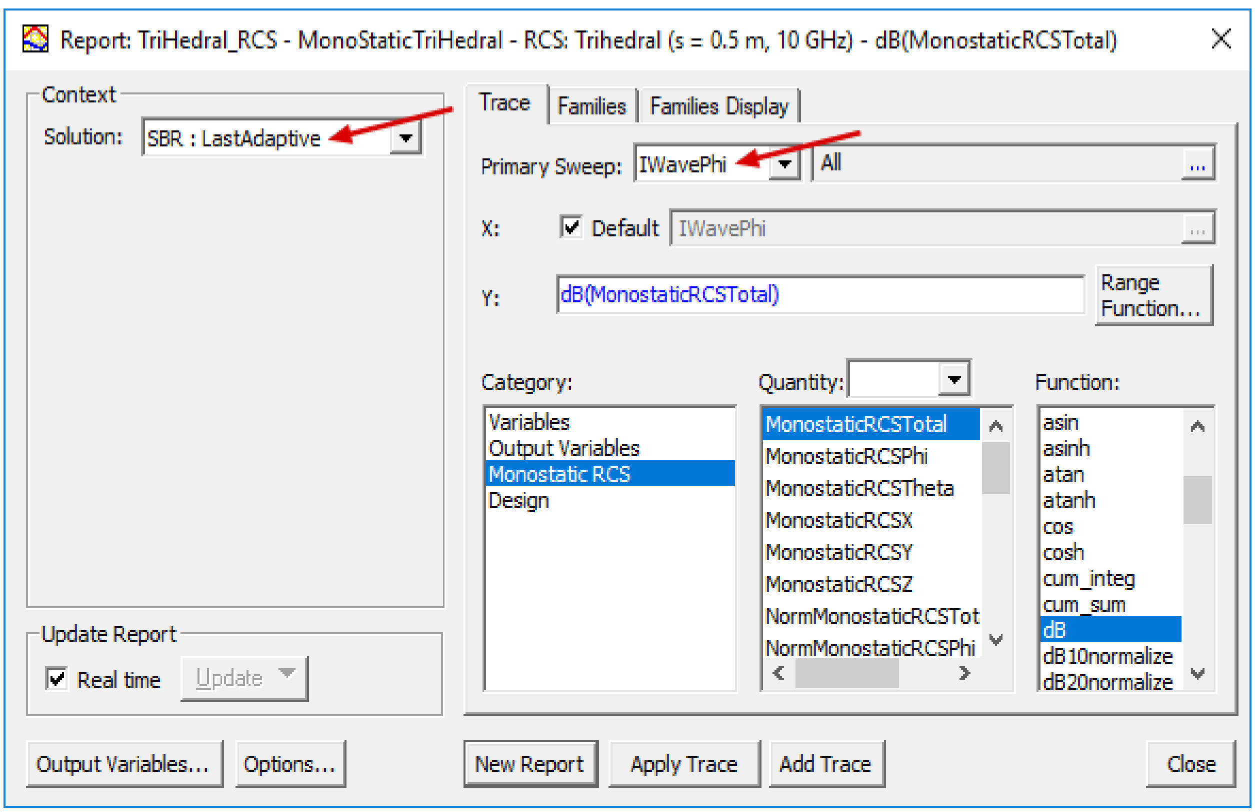
4 - Plot RCS Results (Rectangular Plot and 3D Overlay)

After you run the simulations, you can view the plots that have already been defined within the example project. A plot of RCS vs. aspect angle (phi) was made by right-clicking **Results** in the Project Manager and selecting **Create Monostatic RCS Report** > **Rectangular Plot** or by selecting the **Results** ribbon tab and clicking  **Monstatic RCS Report** >  **2D**. Either approach opens a *Report* dialog box where you set the plot properties.

To see the predefined plot properties, complete the following steps:

1. Under *Results* > *RCS: Trihedral (s = 0.5 m, 10 GHz)* in the Project Manager, right-click **dB (MonostaticRCSTotal)** and select **Modify Report** from the shortcut menu.

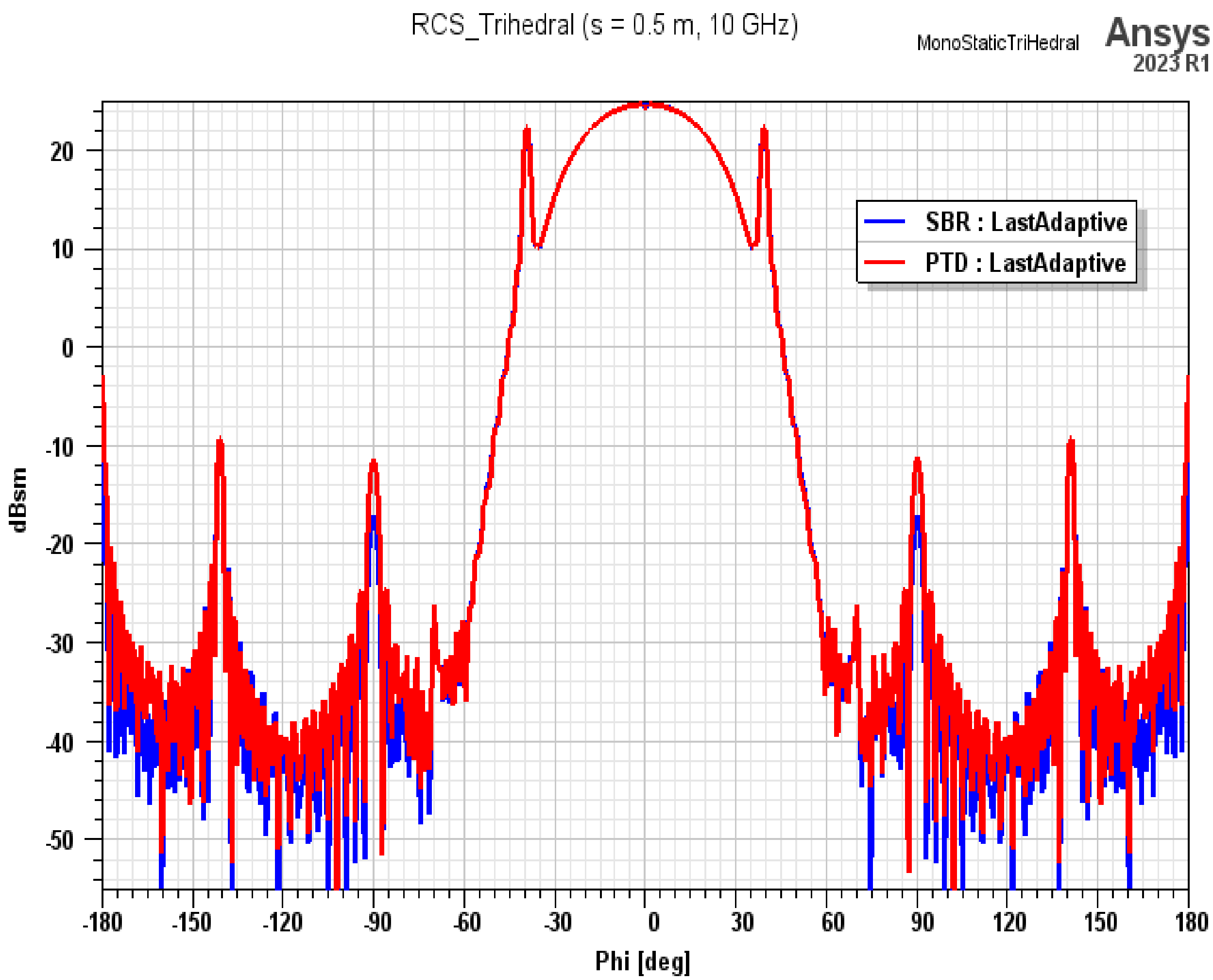
   The *Report* dialog box appears, and it is set up as shown in the following figure:



2. Click **Close**.
3. Repeat steps 1 and 2 except, this time, right-click **dB(MonostaticRCSTotal)_1**.

The setup is identical to the first trace's setup except that the selected *Solution* is *PTD : Last Adaptive* instead of *SBR : Last Adaptive*.

4. Under *Results* in the Project Manager, double-click **RCS: Trihedral (s = 0.5 m, 10 GHz)** to generate the RCS plot for both solution setups:



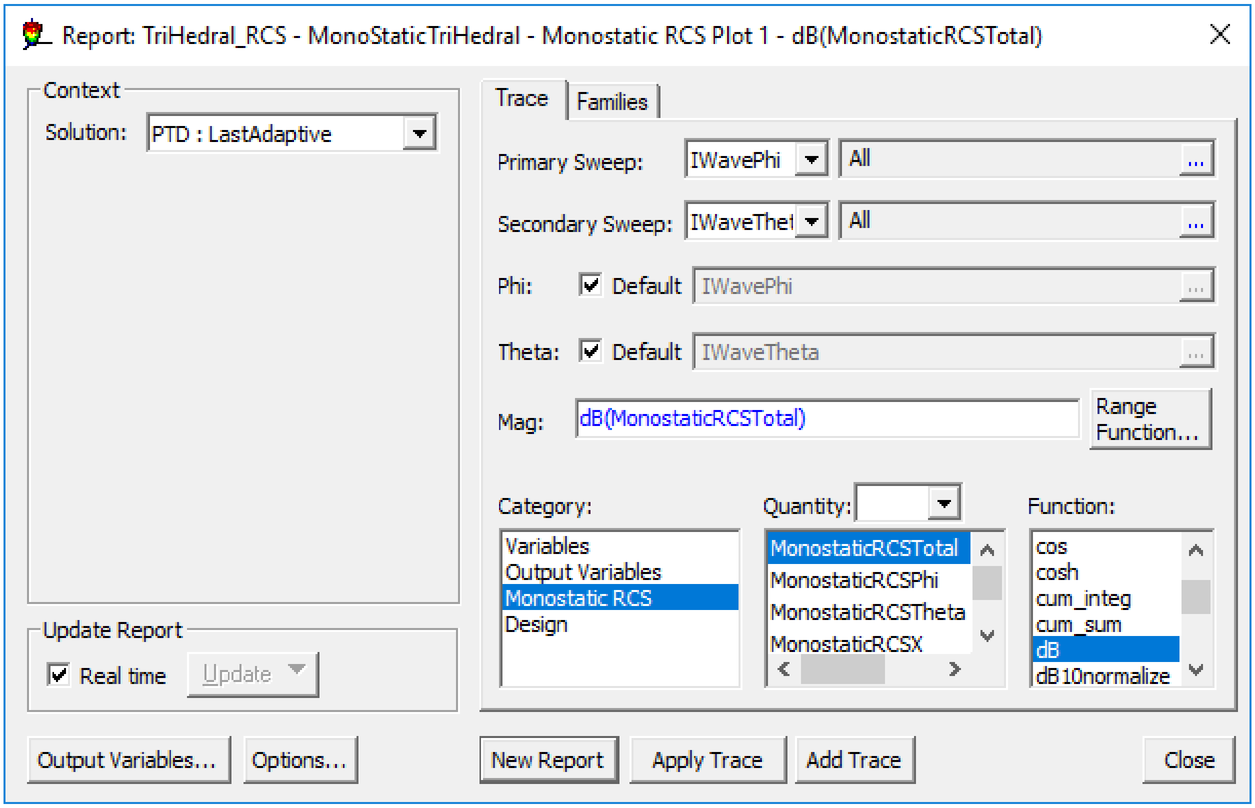
5. Under *Results* in the Project Manager, double-click **Monostatic RCS Table 1** to display a table of the data that was represented graphically in the plot you just reviewed.

   Scroll down to find the predicted peak RCS results at $\phi = 0$. The values are $\sigma = 24.45$ and 24.29 dBsm, respectively, for SBR and SBR+ PTD. The latter result is a few tenths of a dB below the theoretical value established earlier ($\sigma = 24.6$ dBsm) in the asymptotic (GO) limit. The derivation of the theoretical value is shown on the Introduction page. This small discrepancy is explained by the fact that the GO analytic value does not account for edge diffraction, which both the SBR and PTD solutions include. Between these two methods, the PTD solution addresses the dege diffraction effect more accurately.

From both the plot and the table, observe the following characteristics:

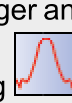
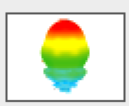
- For deviations up to about +/- 35^{o} from the central (ϕ = 0) angle, RCS slowly decreases from its peak. While the 3-bounce monostatic GO mechanism persists in this 70^{o} angular span, the effective projected area of the trihedral mouth supporting that mechanism shrinks with increasing deviation from ϕ = 0.
- Observe sharp peaks near |ϕ| = 39^{o}, where the bottom face of the trihedral briefly forms a dihedral (2-bounce) monostatic scattering mechanism with one of the side faces.
- Observe other lesser local peaks at |ϕ| = 90^{o}, 140^{o}, and 180^{o}. These correspond to edge diffractions, a weaker mechanism relative to GO, where the monostatic incident and observation angles measured relative to the relevant edge line(s) match. (That is, the observer is on the Keller cone of one or more edges, as defined by the incident plane-wave angle relative to the edge orientation.) Both SBR and SBR+PTD predict strong edge diffraction along the Keller cone; it is just that the effect is more accurately captured with PTD edge correction for metallic edges and wedges.

6. Under *Results* > *Monostatic RCS Plot 1* in the Project Manager, right-click **dB(MonostaticRCSTotal)** and choose **Modify Report** to display the setting for a polar plot of the RCS results:

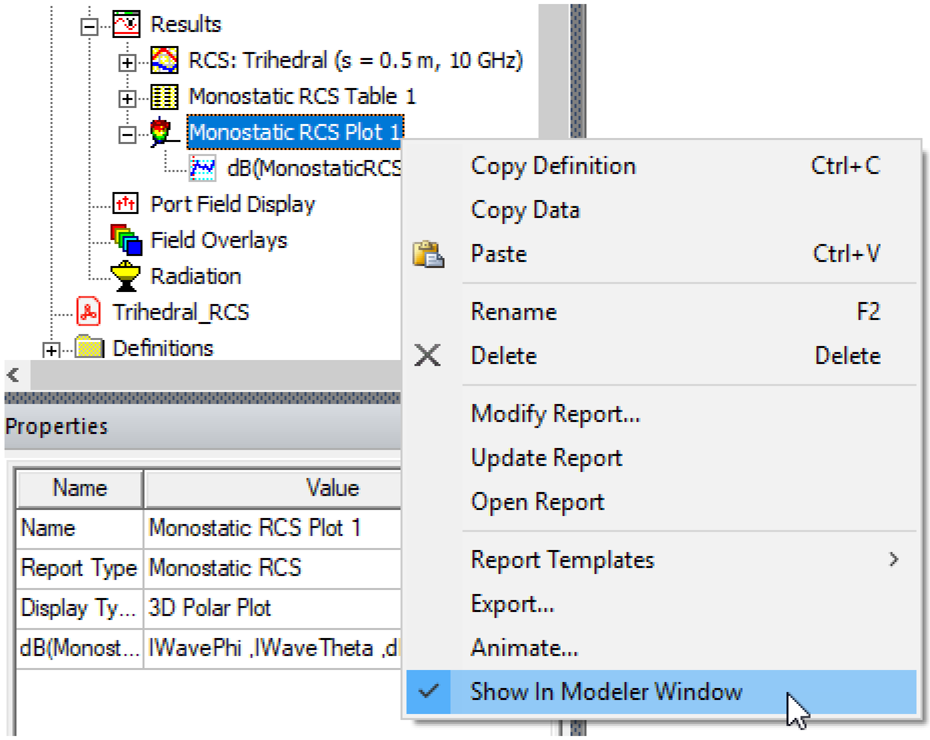


Notice that only a single trace is defined for the polar plot, the one that includes PTD correction.

Note:

This plot was created by right-clicking **Results** in the Project Manager and selecting **Create Monostatic RCS Report** > **3D Polar Plot** or by clicking  **Monstatic RCS Report** >  **3D Polar** from the **Results** ribbon tab.

7. Click **Close** after reviewing the settings.
8. Double-click **Monostatic RCS Plot 1** to display the polar monostatic RCS plot.
9. Use the **Window** menu to return to the *Modeler* window.
10. You can overlay polar plot of the RCS levels on the model of the trihedral radar target. To do so, right-click **Monostatic RCS Plot 1** (under *Results* in the Project Manager) and select the **Show In Modeler Window** option.

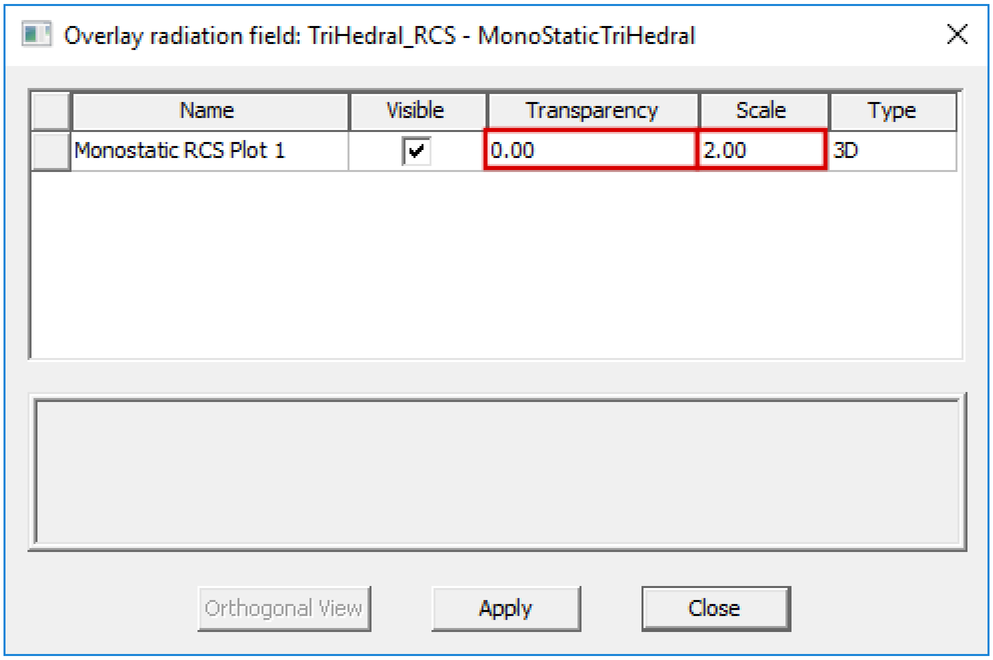


The default scale is too small to clearly see the polar plot overlay. In the next two steps, you will adjust the scale.

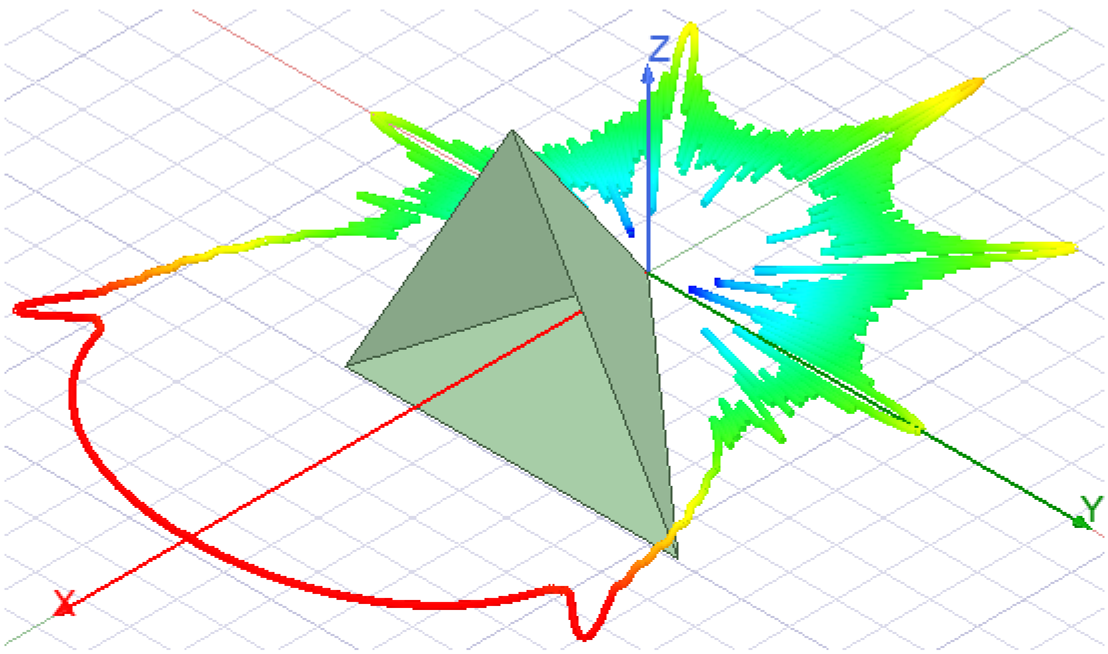
11. Right-click **Field Overlays** in the Project Manager and select **Plot Fields** > **Radiation Field**.

    The *Overlay radiation field* dialog box appears.

12. Set the **Transparency** and **Scale** properties to the values shown in the following image, and then click **Close**.



The Modeler window shows the adjusted plot overlay:



5 - Optionally, Restore Current View Orientations

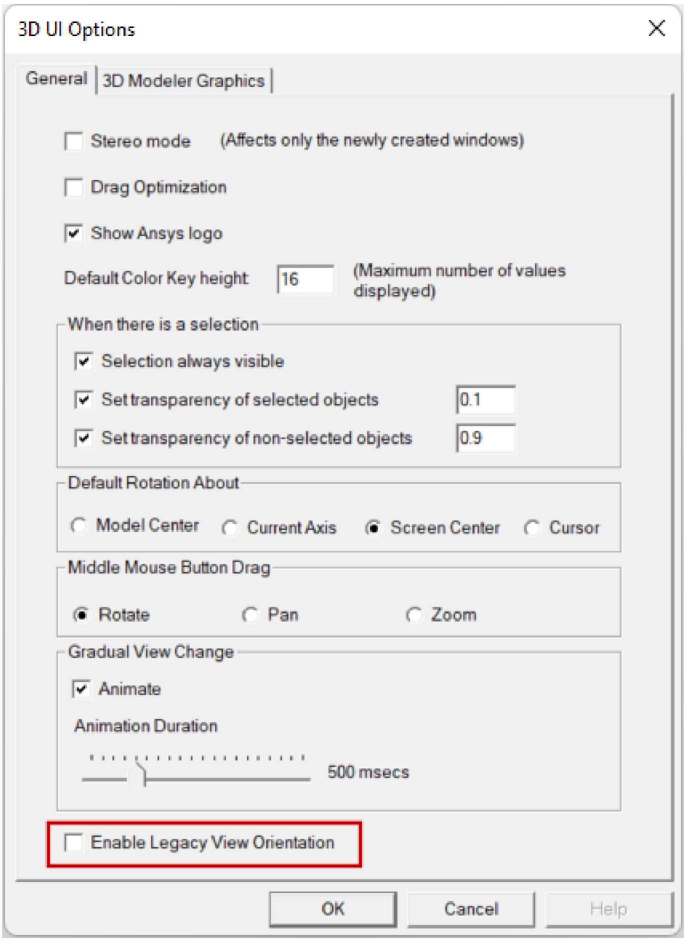
You have completed this getting started guide.

If you prefer to use the new view orientations implemented in version 2024 R1 of the Ansys Electronics Desktop application, clear the *Use Legacy View Orientation* option as follows:

1. From the menu bar, click **View** > **Options**.

   The *3D UI Options* dialog box appears.

2. Ensure that **Enable Legacy View Orientation** is cleared:



3. Click **OK**.

The settings in the 3D UI Options dialog box are global. Your choice is retained for all future program sessions, projects, and design types that use the 3D Modeler or that produce 3D plots of results.

You can now save and close this project.