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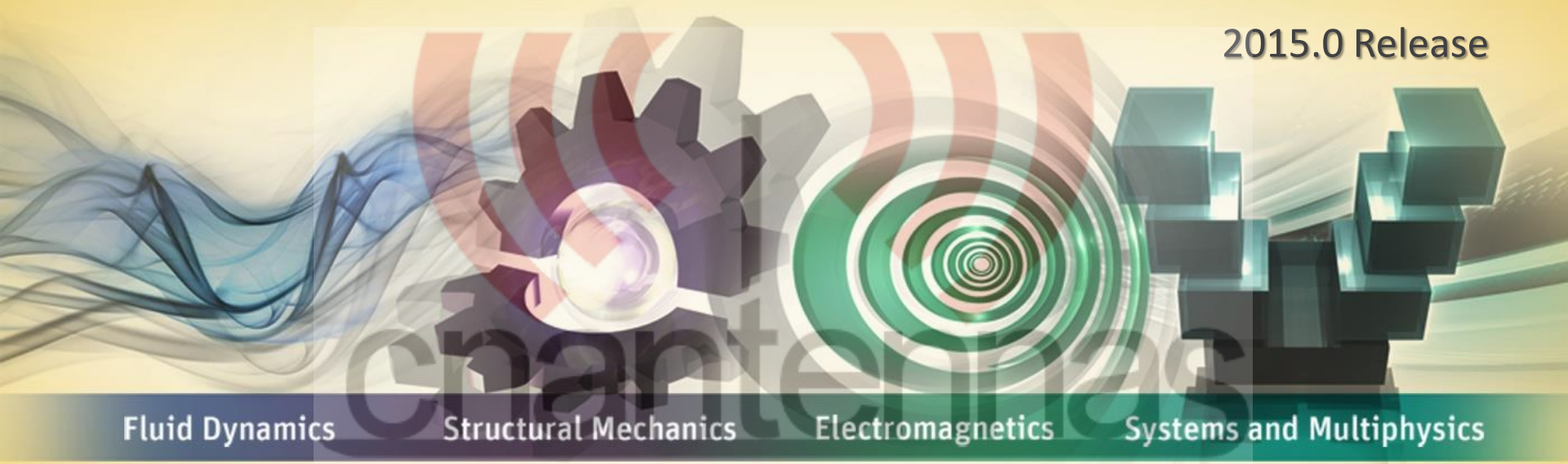
Workshop 6-1: Introduction to Optimetrics



ANSYS HFSS for Antenna Design

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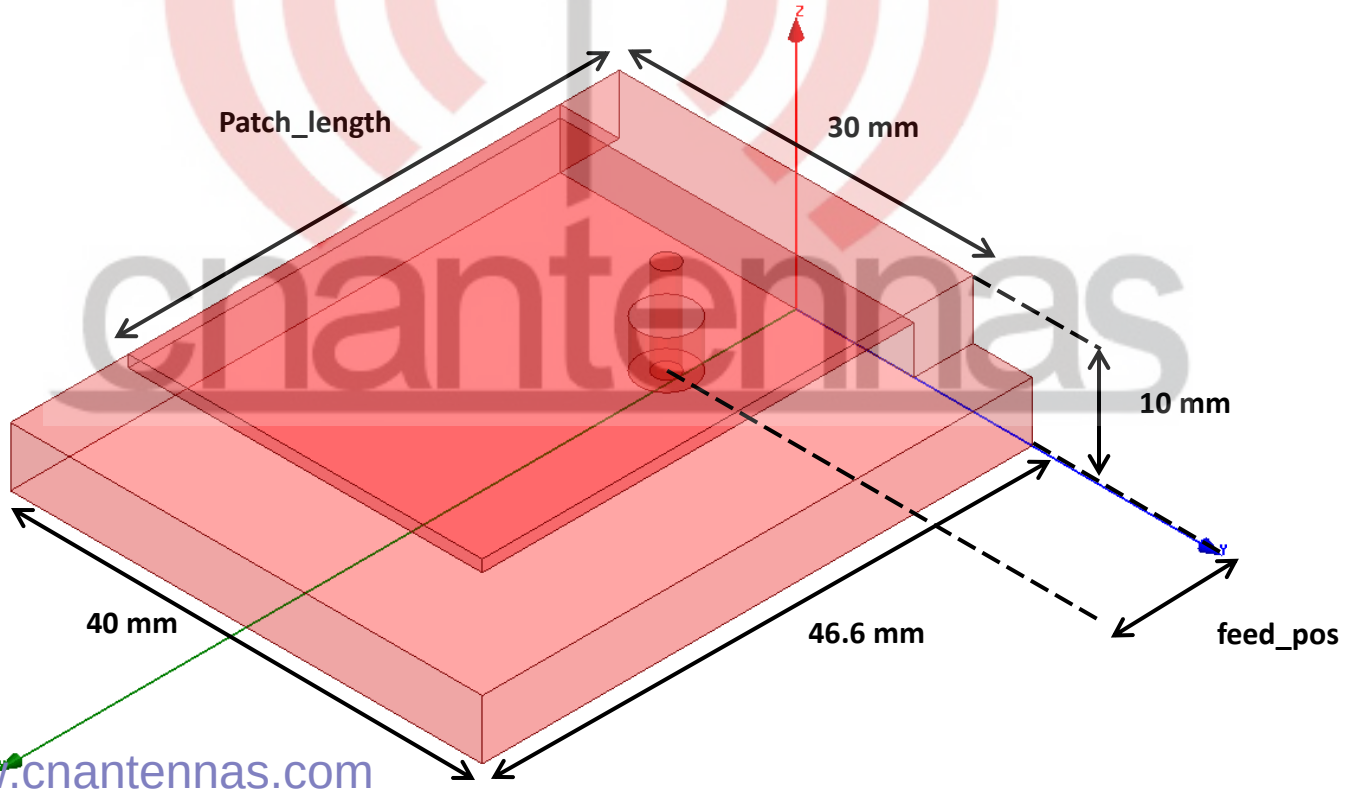
Optimetrics: Example

- **The Shorted Probe-Fed Patch Antenna with Optimetrics**
  - This example is intended to show users how to set up a parametric study, optimize, and simulate the Analytic derivatives of a probe feed patch antenna using the ANSYS HFSS Environment
  - A parametric sweep will be used to determine the effect on the input impedance match as a function of the feed pin position
  - This parametric sweep will be used to seed an optimization analysis that will be used to find the optimal position for the feed pin
  - Analytic derivatives will also be used to perform real time tuning of several dimensions of the patch antenna

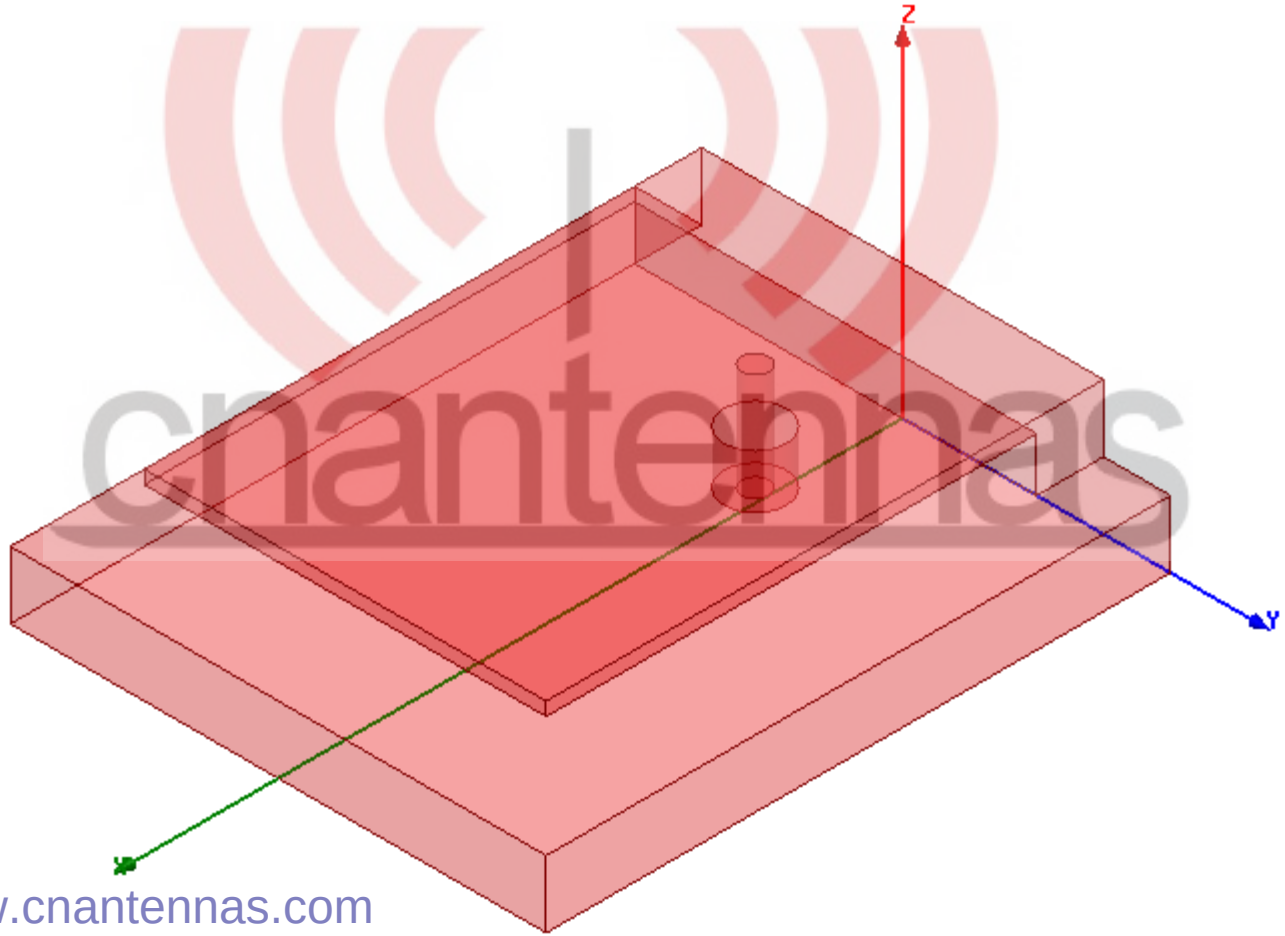


ANSYS HFSS: Getting Started

- **Launching ANSYS Electronics Desktop 2015**
  - To access ANSYS Electronics Desktop, click the Microsoft Start button,
    - Select ***Programs > ANSYS Electromagnetics > ANSYS Electromagnetics Suite 16.0***. Select ***ANSYS Electronics Desktop 2015***
- **Setting Tool Options**
  - **Note**: In order to follow the steps outlined in this example, verify that the following tool options are set:
  - Select the menu item ***Tools > Options > HFSS Options...***
    - Click the **General** tab
      - Use Wizards for data input when creating new boundaries: ☑ **Checked**
      - Duplicate boundaries/mesh operations with geometry: ☑ **Checked**
    - Click the **OK** button
  - Select the menu item ***Tools > Options > 3D Modeler Options…***.
    - Click the **Operation** tab
      - Select last command on object select: ☑ **Checked**
    - Click the **Display** tab
      - Set default transparency to **0.7**
    - Click the **Drawing** tab
      - Edit properties of new primitives: ☑ **Checked**
    - Click the **OK** button

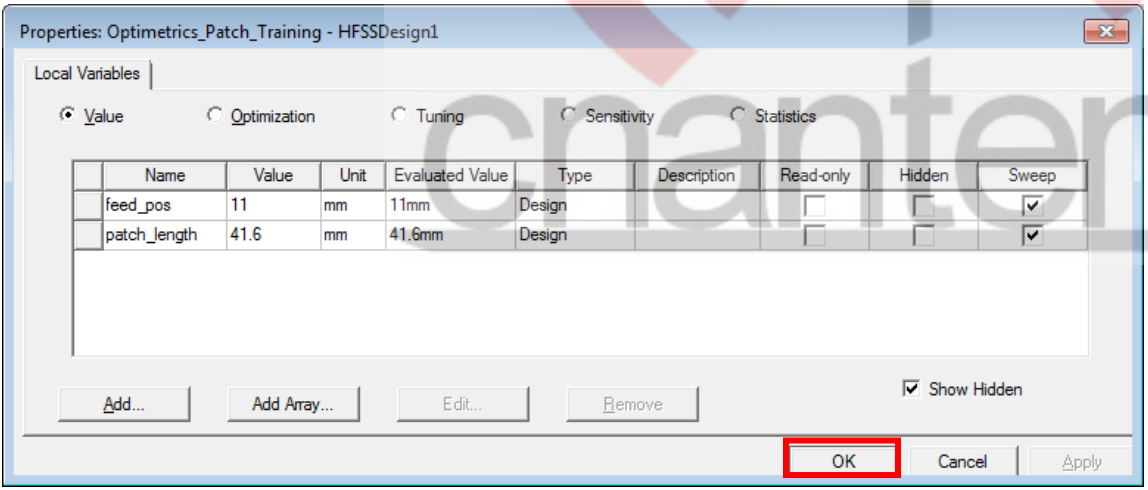
Open Project

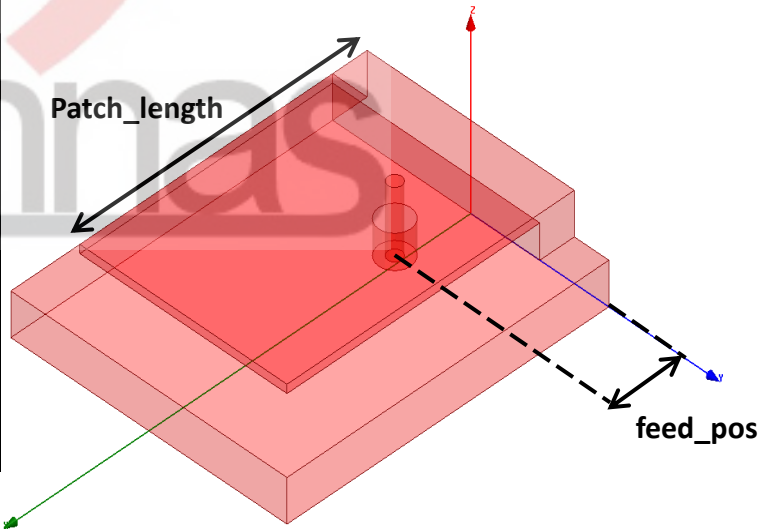
- **Opening a Project**
  - In the ANSYS Electronics Desktop, select the menu item ***File > Open***
    - Browse to the folder containing the file ***Optimetrics_Patch_Training.aedt*** and select **Open**



Design Variables

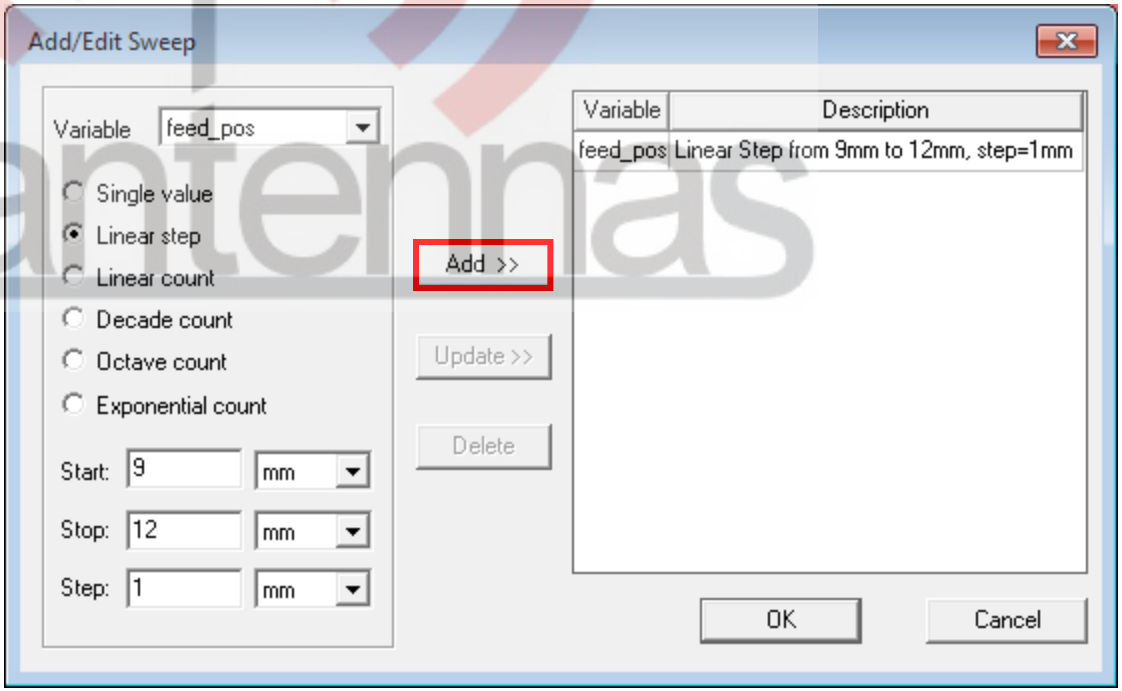
- **Checking Design Variables**
  - Two design variables have been created that control the location of the feed of the patch antenna, **feed_pos**, and the length of the patch, **patch_length**
  - To view a list of any design variables that have been created for this design:
    - Go to the menu item ***HFSS > Design Properties***
      - Alternatively, click on **HFSSModel1** in the **Project Manger Window**, the design variables will be displayed in the **Properties Window**
    - Verify that the variable **feed_pos** is assigned the value **11 mm**
    - Verify that the variable **patch_length** is assigned the value **41.6mm**
    - Press the **OK** button





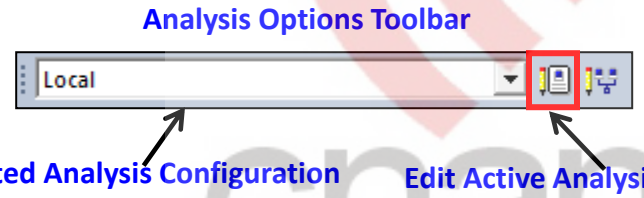
Parametric Analysis Setup

- **Parametric Sweep of Feed Position**
  - We will now complete the creation of the parametric project using the defined variable to vary the coaxial feed position in order to achieve optimal match between the patch antenna and its coaxial feed line. The ratio of the coaxial feed inner and outer diameters was chosen to achieve a 50 Ohm characteristic impedance. So we will effectively change the value of the feed offset until we find a position which presents a 50 Ohm load impedance on the coaxial feed line. The S11 vs. frequency plot has a dip at the patch resonant frequency, the dip is maximized when the optimal offset is found.
- **Create Parametric Sweep**
  - Select the menu item ***HFSS > Optimetrics Analysis > Add Parametric...***
    - Click the **Add...** button in the **Setup Sweep Analysis** window
      - In the **Add/Edit Sweep** window:
        - Select the variable **feed_pos**
        - Select **Linear Step**
        - Start: **9mm**
        - Stop: **12mm**
        - Step: **1mm**
        - Click the **Add>>** button
        - Click the **OK** button
    - Click the **OK** button

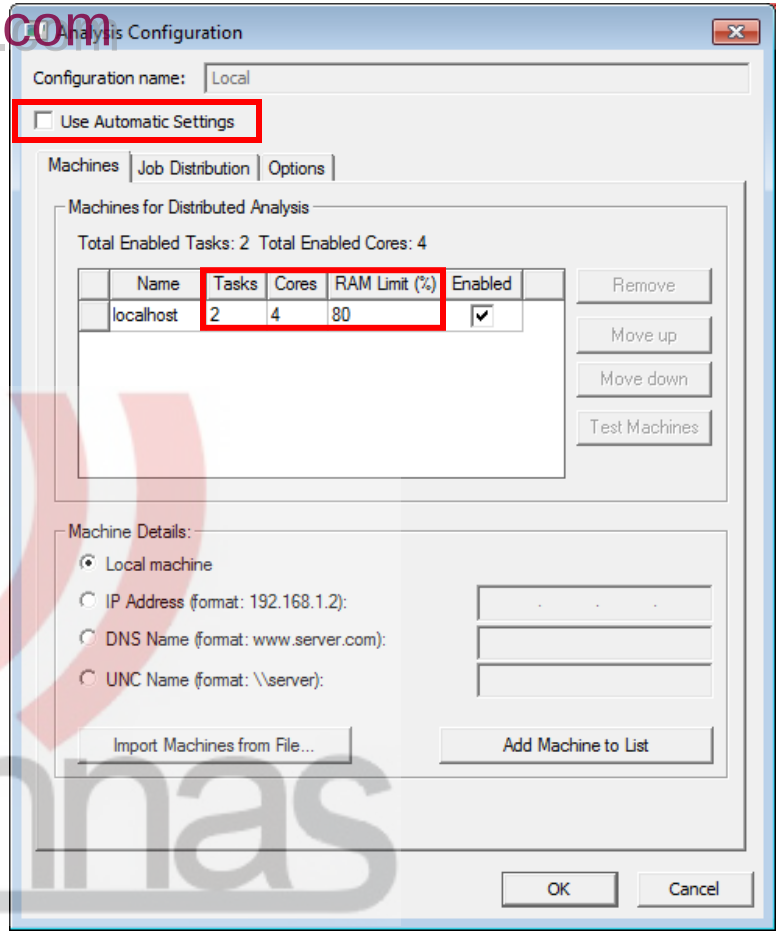


Analysis Configuration

- **High Performance Computing Configuration**
  - Parametric sweeps can be accelerated by solving multiple variations in parallel. The HPC Analysis Configuration will allow us to specify the number of cores and the number of tasks we would like to run. The number of tasks will correspond to the number of parametric variations or frequency points to run in parallel.
- **Configuring HPC Settings**
  - From the **Analysis Options Toolbar**, select **Local** configuration
  - Click the **Edit Active Analysis Configuration** button



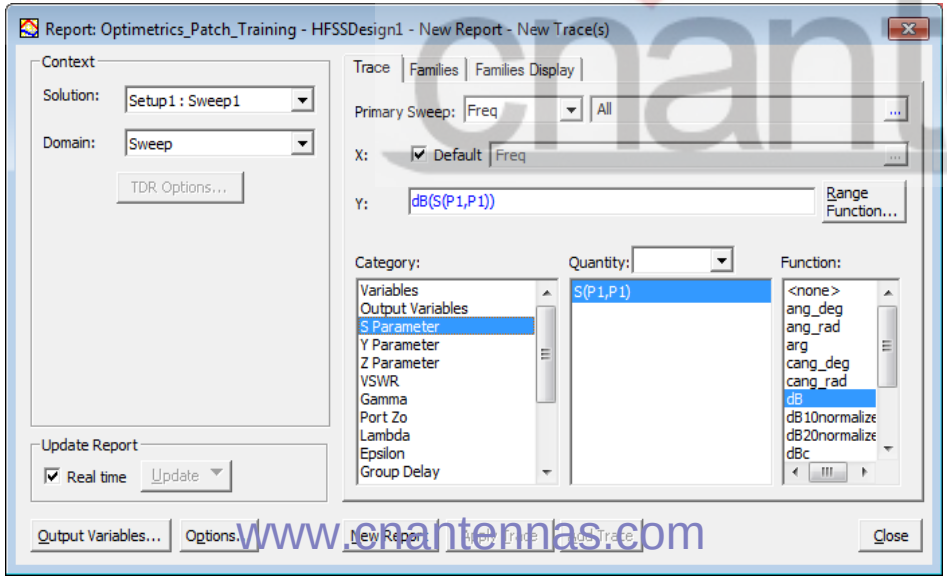
  - In the **Analysis Configuration** window, change the following:
    - Uncheck **Use Automatic Settings**
    - Tasks: **2**
    - Cores: **4**
    - RAM Limit(%): **80**
  - Click the **OK button** to finish and close configuration window
- **Analyze Parametric Sweep**
  - In the **Project Manager** window, select **Optimetrics > ParametricSetup1** right click and select **Analyze**

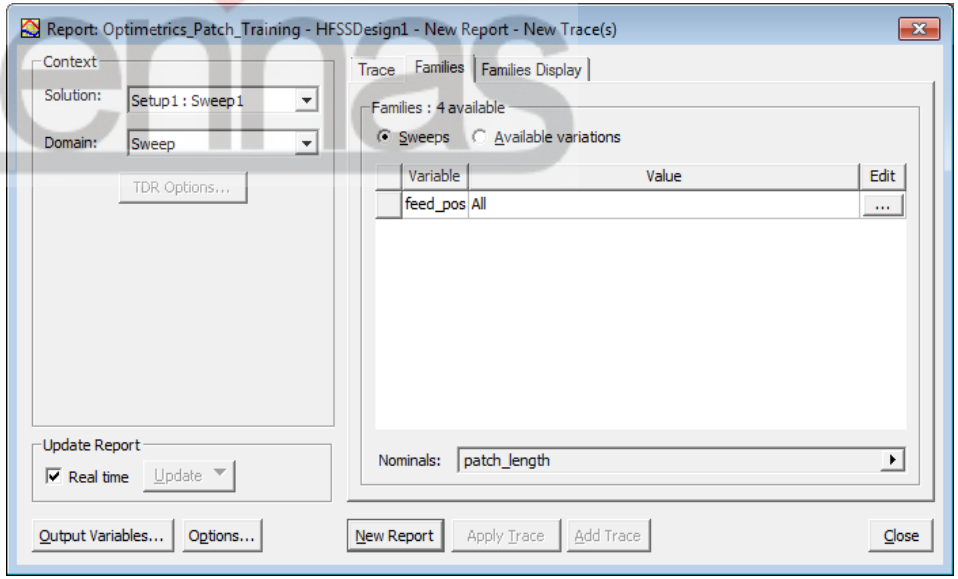


Note: Additional machines can be added to the configuration to further accelerate solutions. Each machine can be used to solve 1 or more task. If an analysis does not contain a parametric sweep, the solution will distribute frequency points if a frequency sweep has been specified.

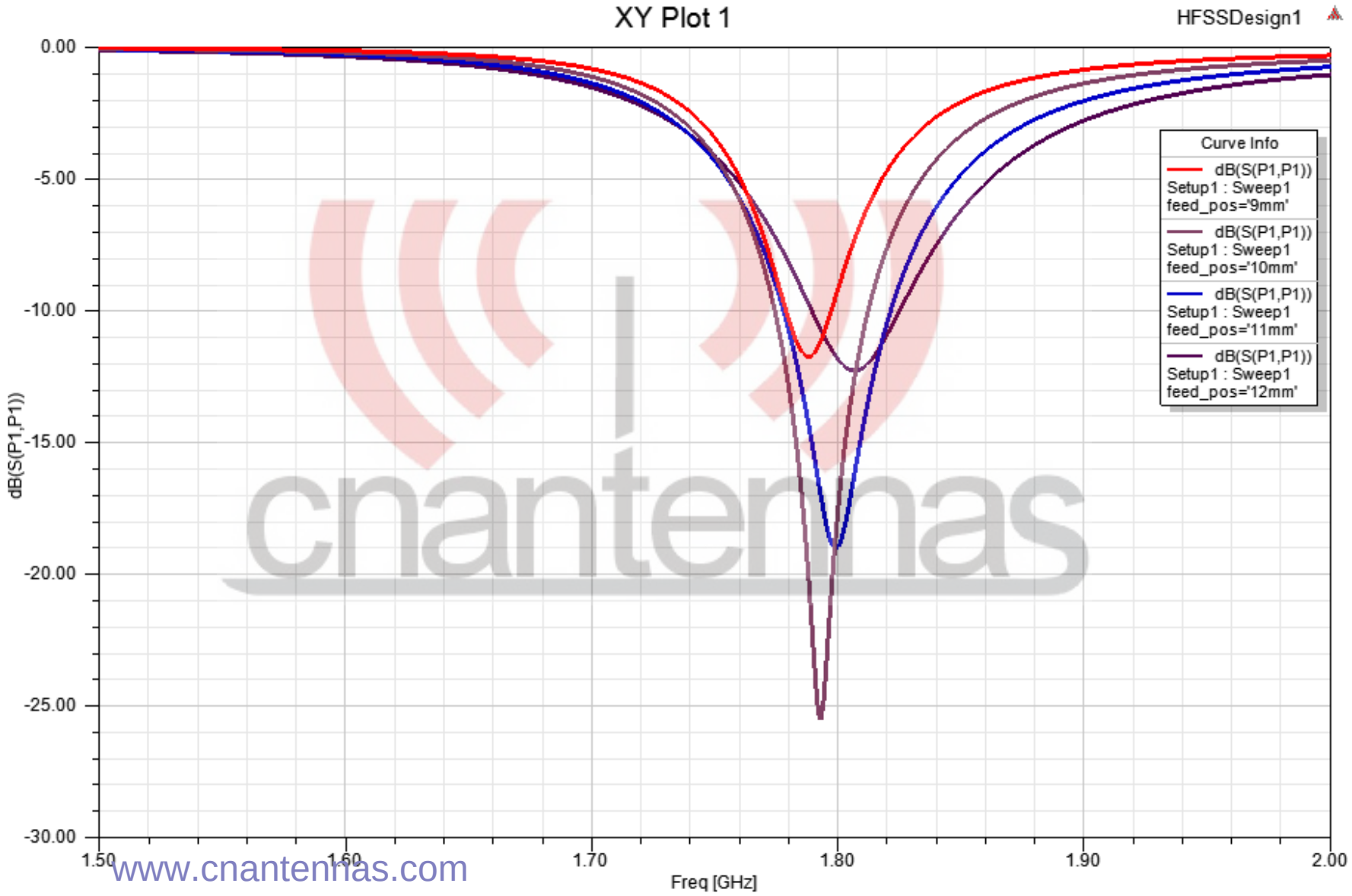
Create Reports

- **Create S-Parameter plot**
  - Select the menu item ***HFSS > Results > Create Modal Solution Data Report > Rectangular Plot***
    - Solution: **Setup1:Sweep1**
    - Domain: **Sweep**
    - In the **Trace** tab
      - Category: **S Parameter**
      - Quantity: **S(P1,P1)**
      - Function: **dB**
    - Click the **Families** tab
      - Make sure the Value for variable **feed_pos** is selected to **All**
    - Click **New Report** button
  - Click **Close** button



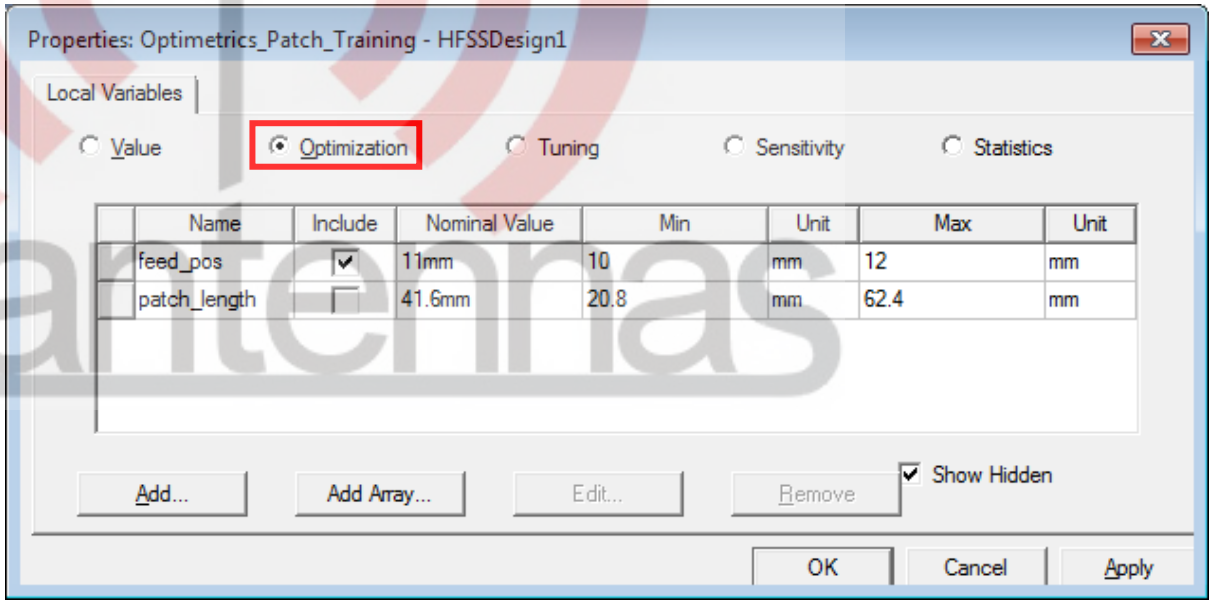


Results



Optimization Analysis Setup

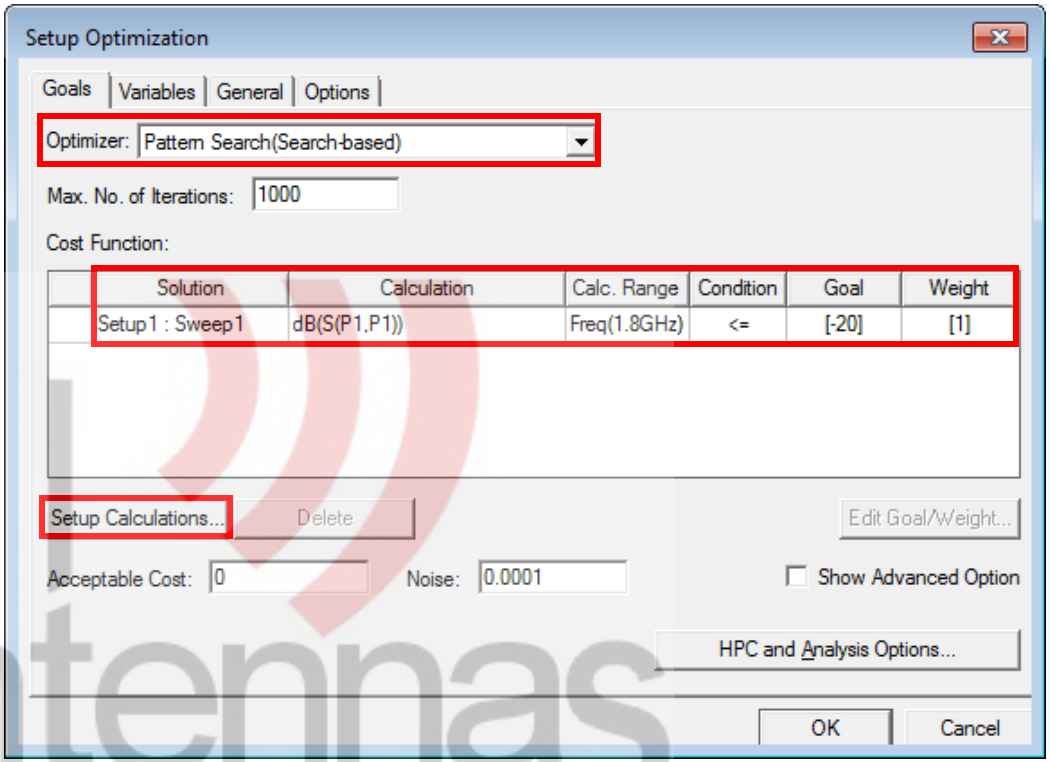
- **Optimization**
  - The Parametric Sweep was useful for generating design curves. For this simple design with only a single variable we could use the design curves to make educated guesses at performance targets that are not contained in the Parametric Sweep. To demonstrate this we will target a minimum of less than -20dB for S_{11} at 1.8GHz for this shorted patch antenna. From the Parametric Sweep results, we can see that the minimum return loss at 1.8 GHz will be achieved when the variable **feed_pos** is around 11mm.
- **Create an Optimization Setup**
  - Select the menu item ***HFSS > Design Properties***
    - Click the **Optimization** radio button:
      - Name: **feed_pos**
      - Include: ☑ **Checked**
      - Min: **10 mm**
      - Max: **12 mm**
    - Click the **OK** button

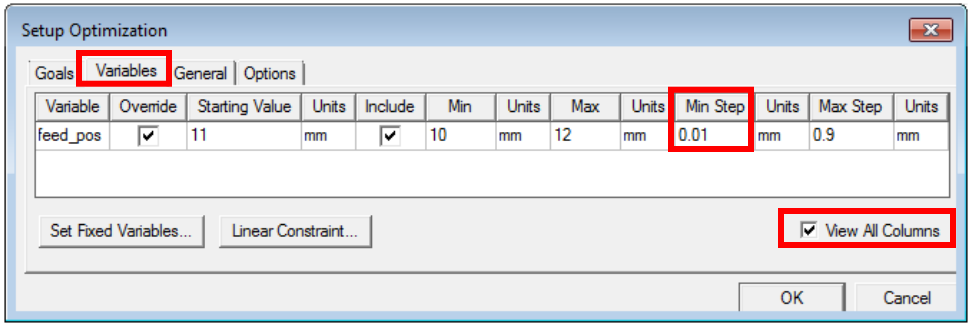


- **Add Optimization Setup**
  - Select the menu item ***HFSS > Optimetrics Analysis > Add Optimization...***

Optimization Analysis Setup

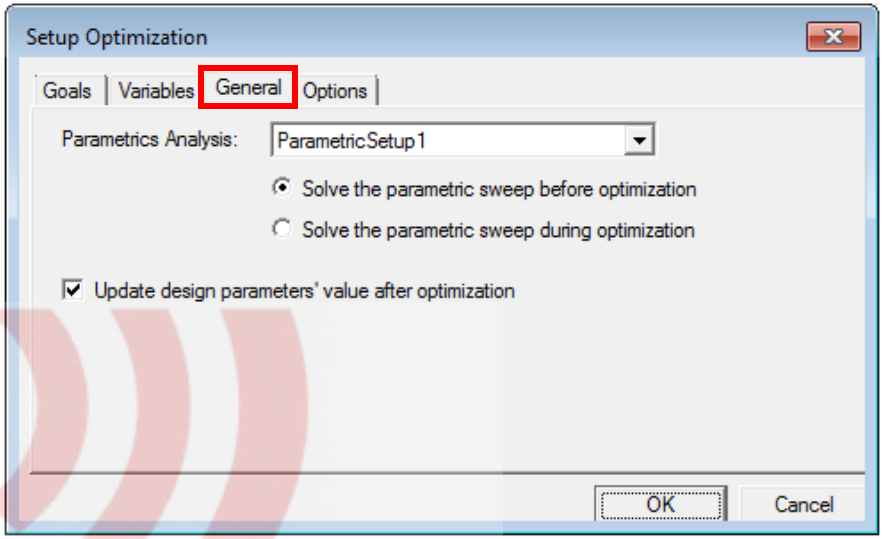
- **Setup Optimization**
  - In the **Goals** tab:
    - Optimizer: **Pattern Search(Search-based)**
    - Click the **Setup Calculations...** button
      - In the **Add/Edit Calculation** dialog:
        - Report Type: **Modal Solution Data**
        - Solution: **Setup1: Sweep1**
        - Domain: **Sweep**
        - Category: **S Parameter**
        - Quantity: **S(P1,P1)**
        - Function: **dB**
        - Click the **Add Calculation** button
        - Click the **Done** button
    - Click the value under **Calc. Range** and select **Edit...**
      - Click the **Edit** button
      - Click the **Select values** radio button and select **1.8GHz**
      - Click **OK** button
    - Condition: **<=**
    - Goal = **-20**
    - Weight = **1**
  - Click the **Variables** tab:
    - Select **View All Columns** in lower right corner: ☑ **Checked**
    - Set **Min Step** value: **0.01**





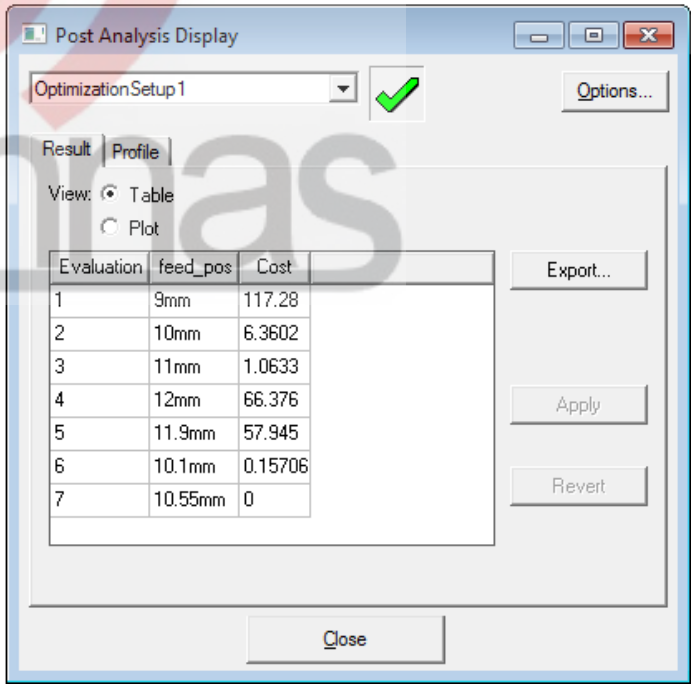
Optimization Analysis Setup

- **Setup Optimization (continued)**
  - Click the **General** tab:
    - Parametric Analysis: **ParametricSetup1**
      - This parametric analysis that we solved earlier will be used to seed the optimization
  - Click the **OK** button to complete the optimization setup



- **Analyze Optimization**
  - In the **Project Manager** window, select **Optimetrics > OptimizationSetup1,** right click and select **Analyze**

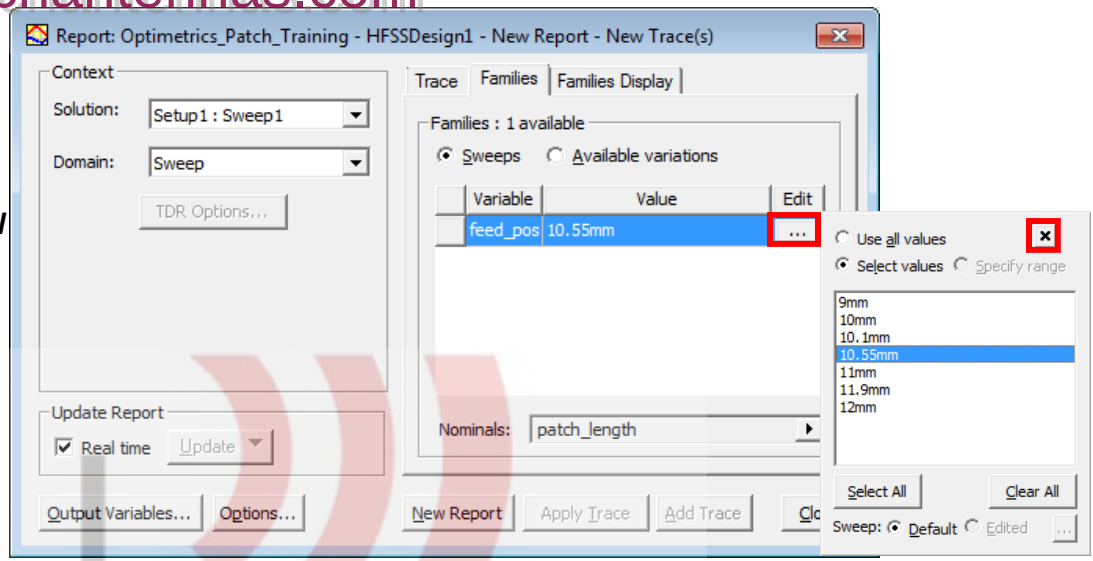
- **Optimetrics Results**
  - Right-click on **OptimizationSetup1** and select **View Analysis Result**
    - In the **Result** tab, select the radio button for **Table**
    - Click the **Close** button when you are finished viewing the results

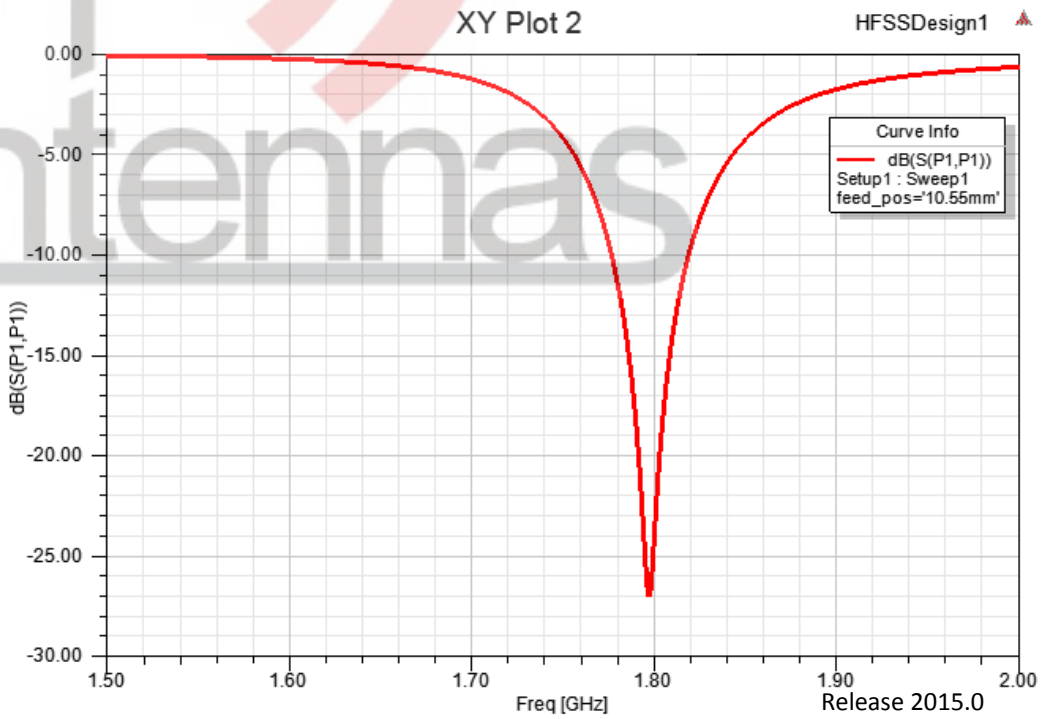


Optimal solution occurs at ~10.55mm, depending on the points chosen by the optimizer, other values of feed_pos may satisfy the optimization criteria

Results

- **Create Reports**
  - Select the menu item ***HFSS > Results > Create Modal Solution Data Report > Rectangular Plot***
    - Solution: **Setup1:Sweep1**
    - Domain: **Sweep**
    - In the **Trace** tab
      - Category: **S Parameter**
      - Quantity: **S(P1,P1)**
      - Function: **dB**
    - Click the **Families** tab
      - Click the **Edit** button
        - Click **10.55mm** in the pop-up window
        - Close the pop-up window by clicking the **X** button
    - Click **New Report** button
    - Click **Close** button

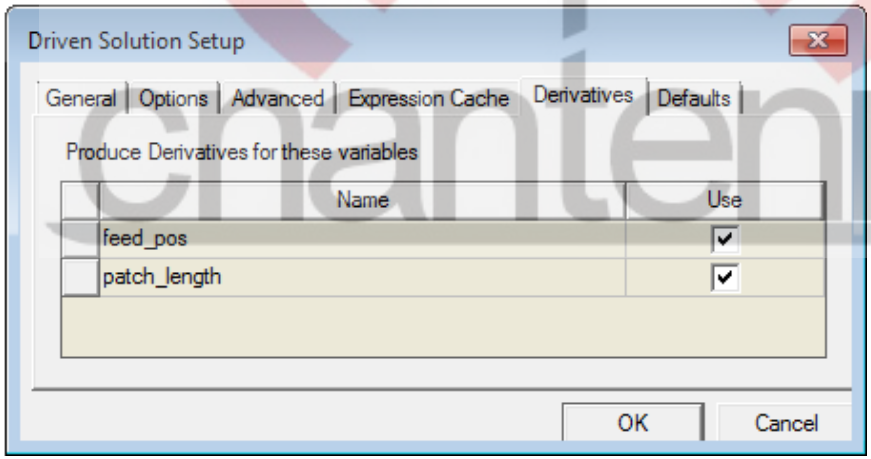


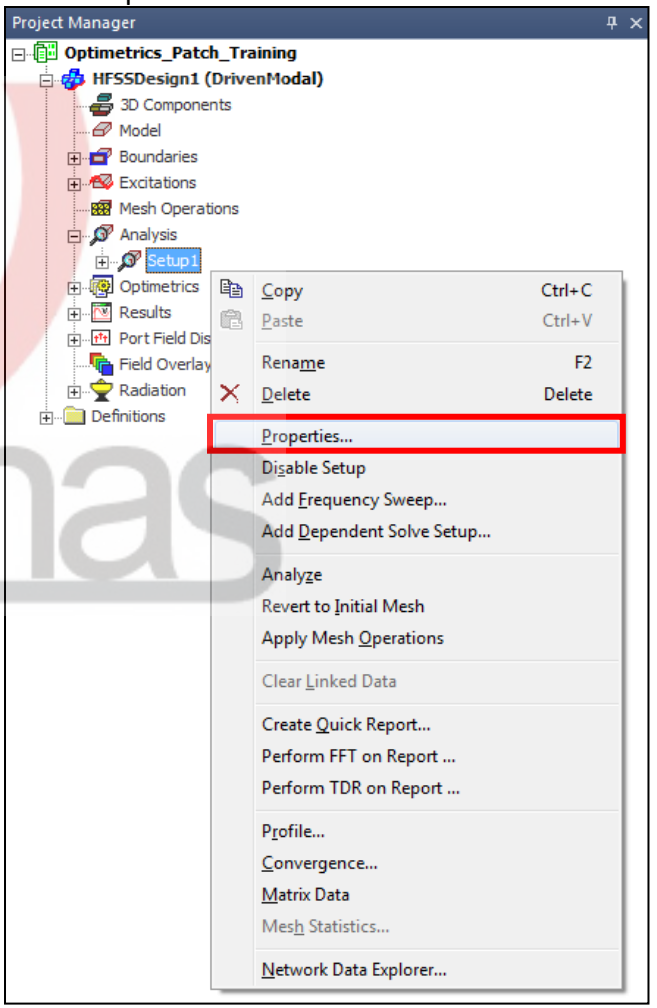


Analytic Derivatives

- **Analytical Derivatives**
  - From the parametric sweep and optimization of the feed position we can see that the optimal position is at about 10.55mm. To further investigate or an alternative to the optimization, we could use analytical derivatives to predict the behavior of our model with respect to small changes in design variables.

- **Enable Analytic Derivatives**
  - Right click on **Setup1** in **Project Manager** Window and select **Properties...**
    - Select Derivatives Tab
      - **feed_pos: Use ☑ Checked**
      - **patch_length: Use ☑ Checked**
    - Click the **OK** button

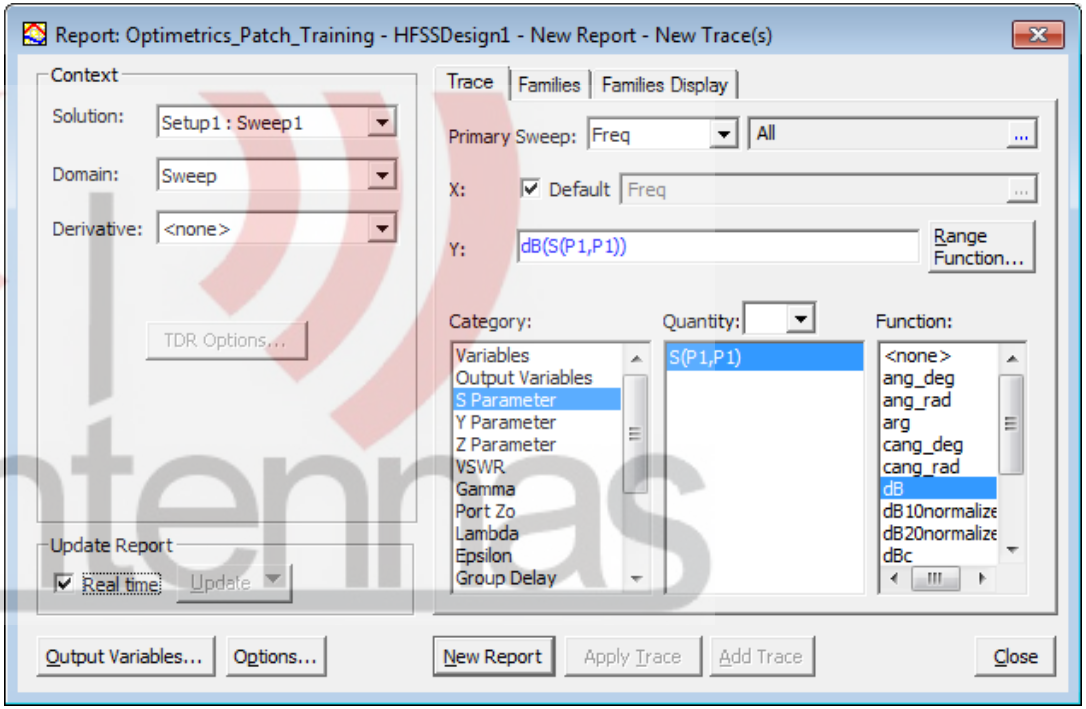




- **Analyze**
  - Select the menu item ***HFSS > Analyze All***

Creating a Tuning Plot

- **Create Nominal Plot for Comparison**
  - Select the menu item ***HFSS > Results > Create Modal Solution Data Report> Rectangular Plot***
    - Solution: **Setup1: Sweep1**
    - Domain: **Sweep**
    - Derivative: **<none>**
    - In the **Trace** tab
      - Category: **S Parameter**
      - Quantity: **S(P1,P1)**
      - Function: **dB**
    - Click the **Families** tab
      - Click the **Edit** button
        - Click **10.55mm** in the pop-up window
        - Close the pop-up window by clicking the **X** button
    - Click the **New Report** button



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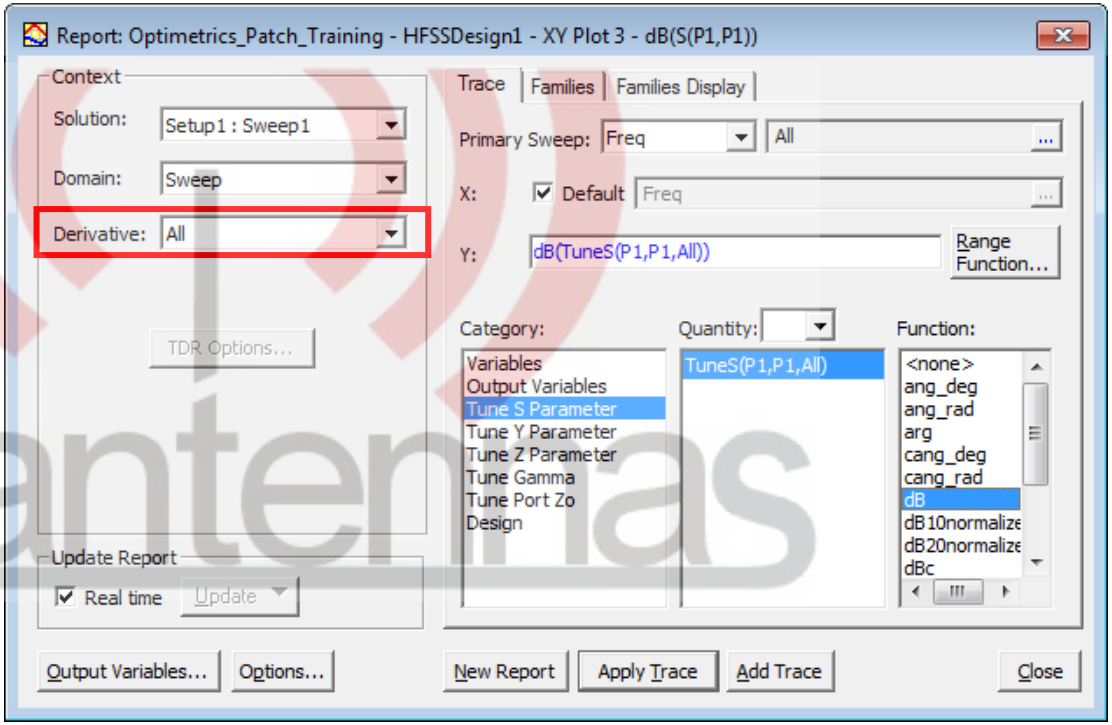
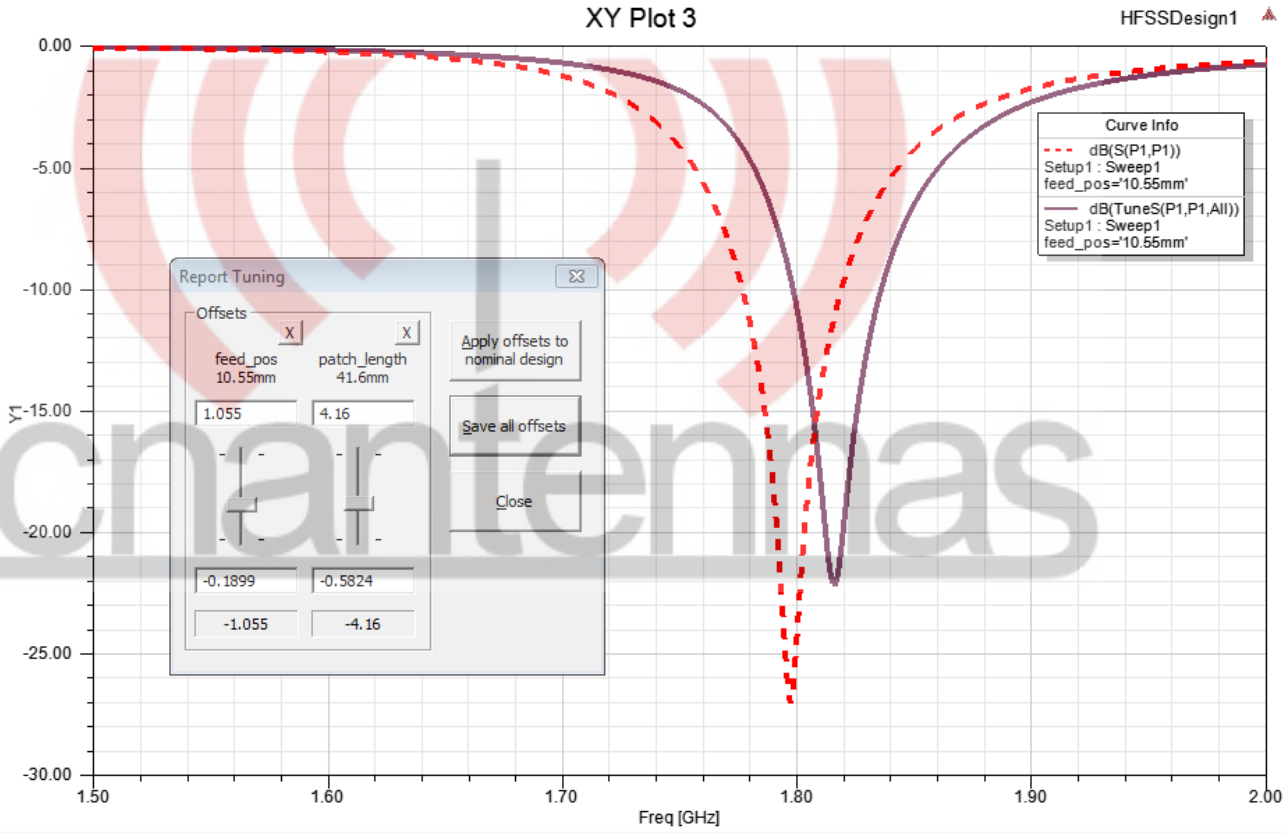
Creating a Tuning Plot

- **Create Tuning Plot**
  - In the Create Rectangular Plot Report, change the **Derivative** option
    - Solution: Setup1: Sweep1
    - Domain: Sweep
    - Derivative: **All**
    - In the **Trace** tab
      - Category: **Tune S Parameter**
      - Quantity: **Tune S(P1,P1,All)**
      - Function: **dB**
    - Click the **Add Trace** button
    - Click the **Close** button



Tuning Plot

- **Tuning Plot**
  - Select the menu item ***HFSS > Results > Tune Reports …***
  - Move the scroll bars in the **Report Tuning** window to predict the performance for various patch width and feed position values
  - Click the **Close** button



Note: The predicted response is based off the nominal solution and partial derivative that was computed during the solution process. Analytic Derivatives could have been used before any optimization to more quickly narrow the solution space by testing how individual parameters will affect the antenna performance.

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