Module 4 – Workshop 2: Maxwell and Icepak Multiphysics in AEDT

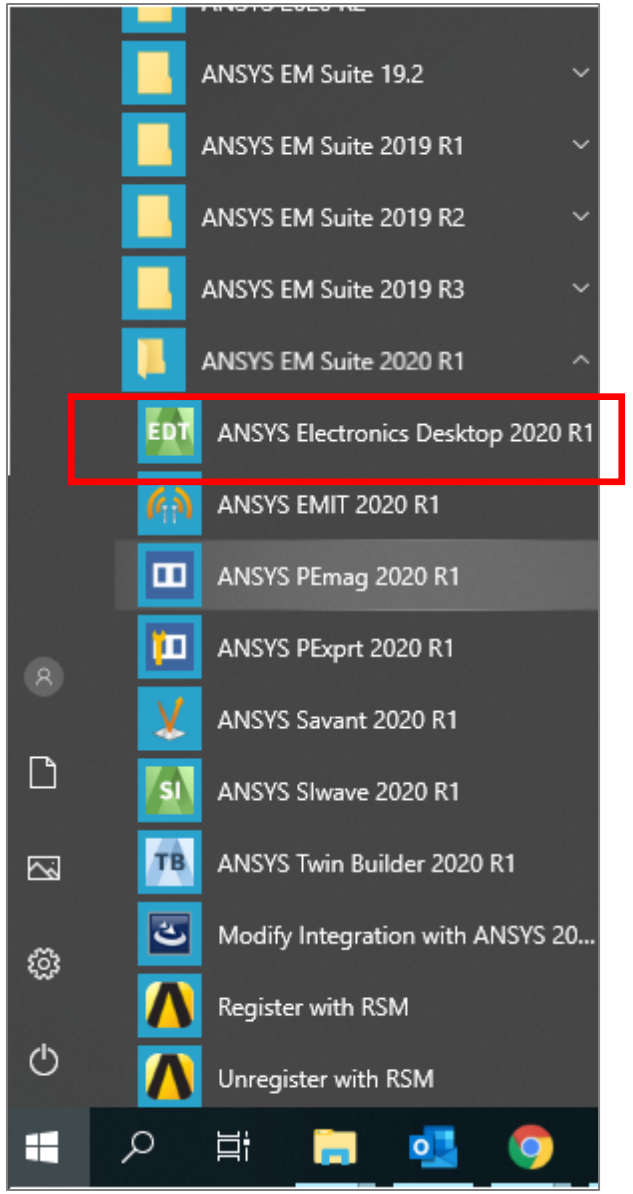
Release 2020 R1

Introduction

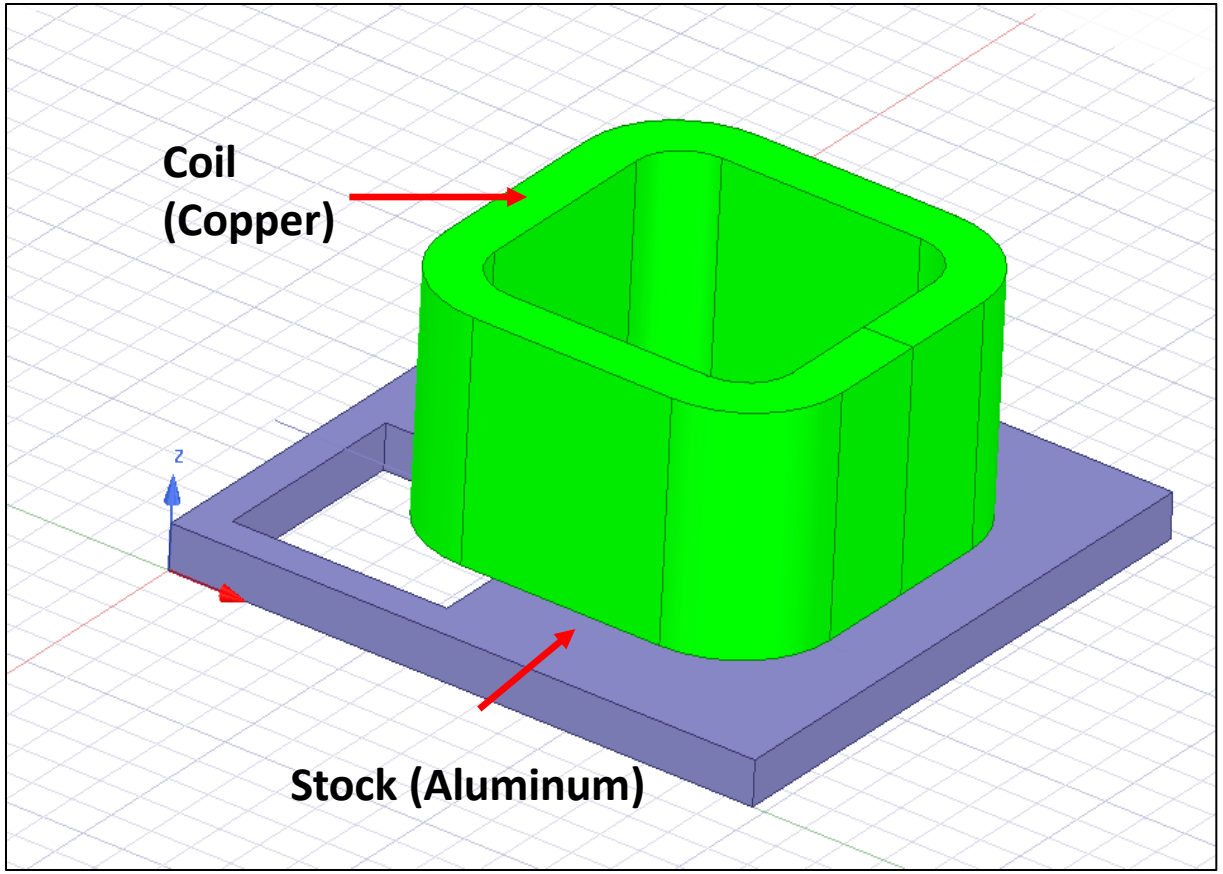
- This workshop demonstrates how Ohmic losses can be transferred from Maxwell to Icepak in ANSYS Electronics Desktop using 2-Way Coupling
- This workshop involves an eddy current solver of Maxwell to calculate heat losses which are then applied to Icepak to simulate natural convection.

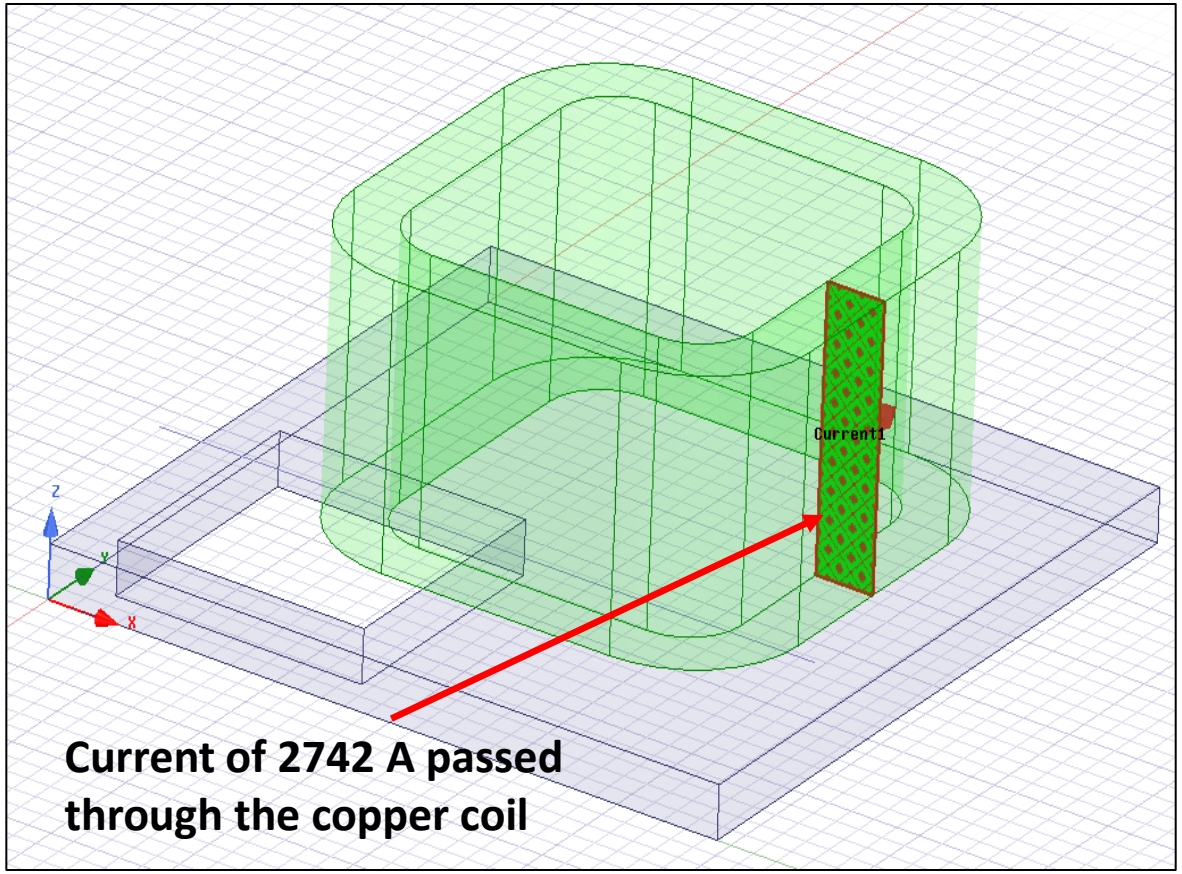
Getting Started

- ANSYS Electronics Desktop is the electronics equivalent to ANSYS Workbench
- The tool is located under the ANSYS EM Suite 2020 R1



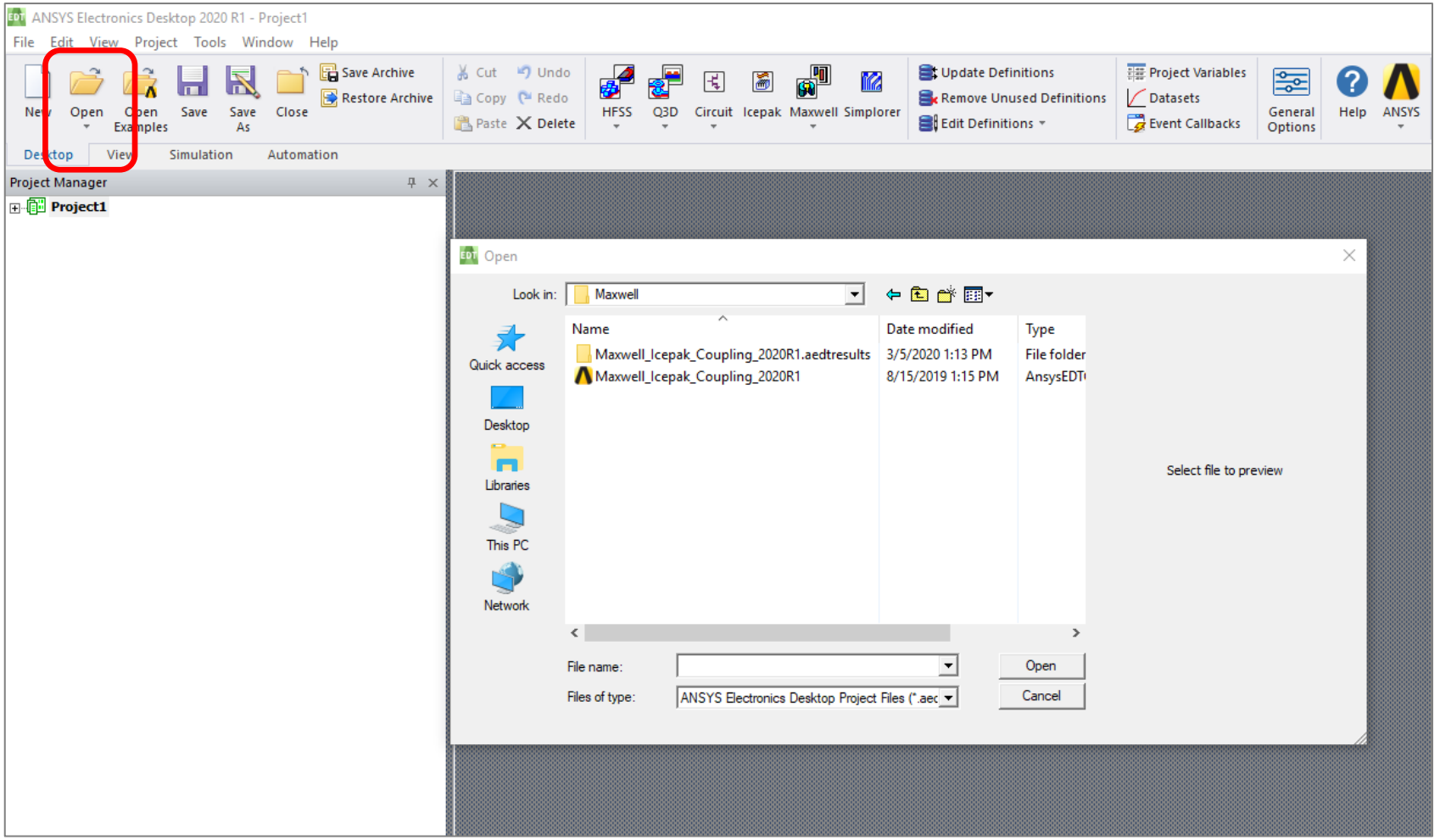
Problem Description





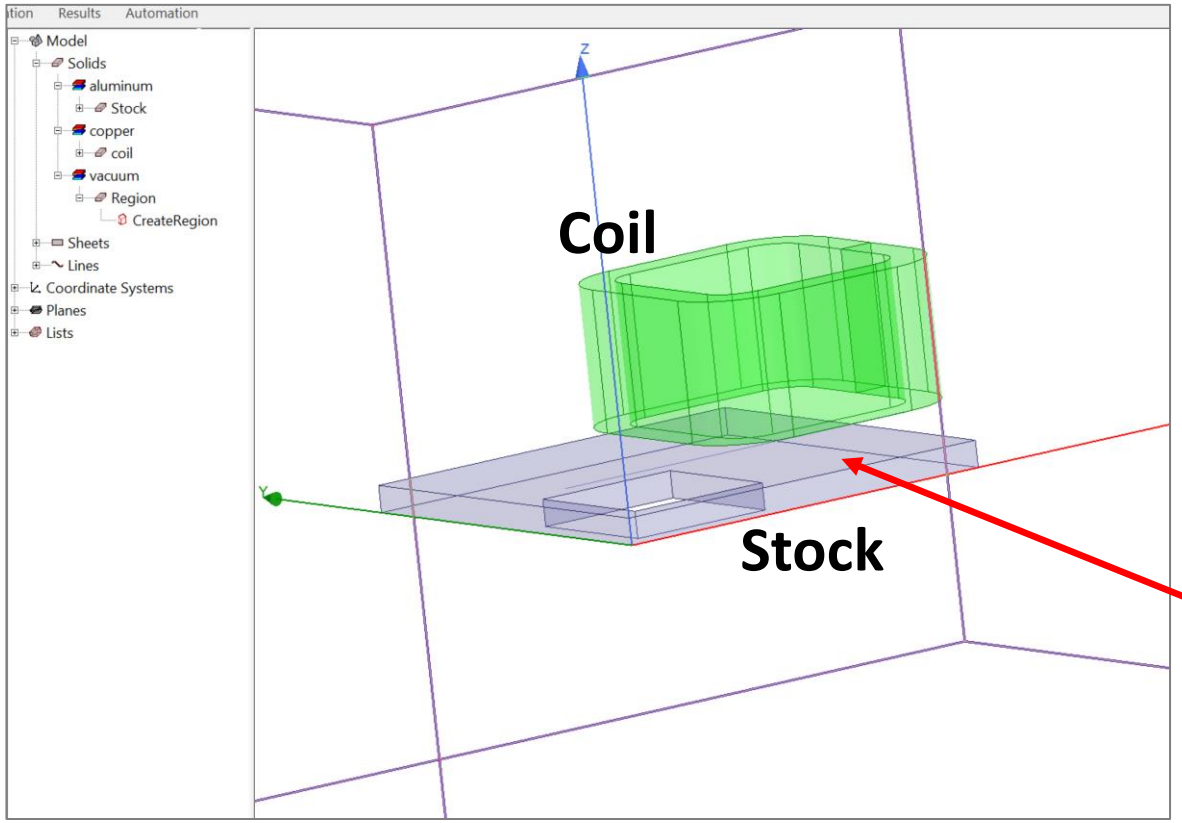
Open Maxwell Project

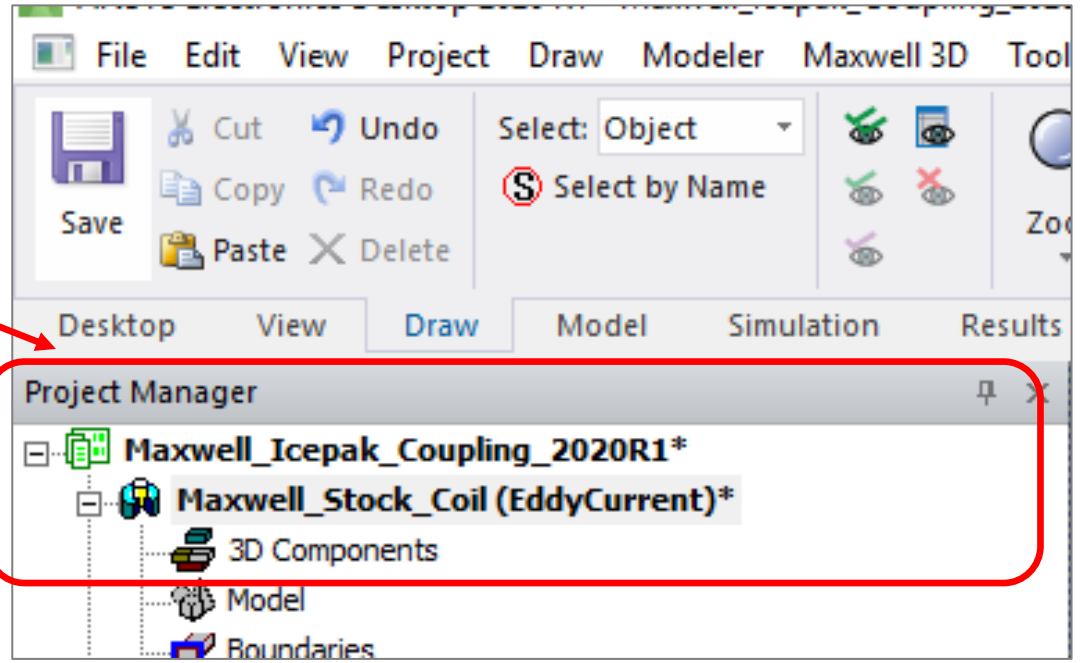
- Open the Maxwell project file ‘Maxwell_Icepak_Coupling_20202R1” from the workshop folder



Geometry in Maxwell GUI

Rename the design as '**Maxwell_Stock_Coil**'

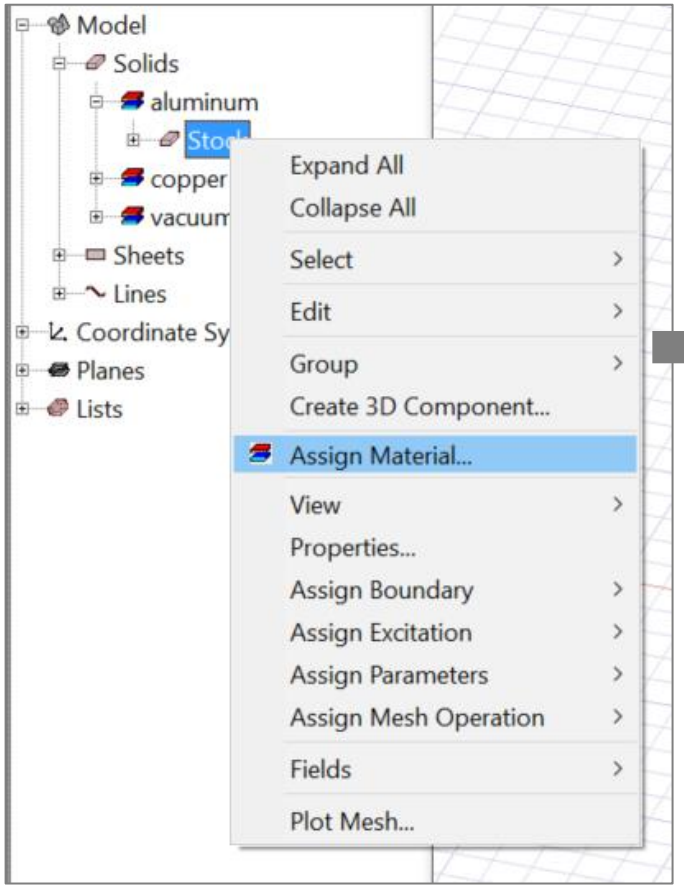


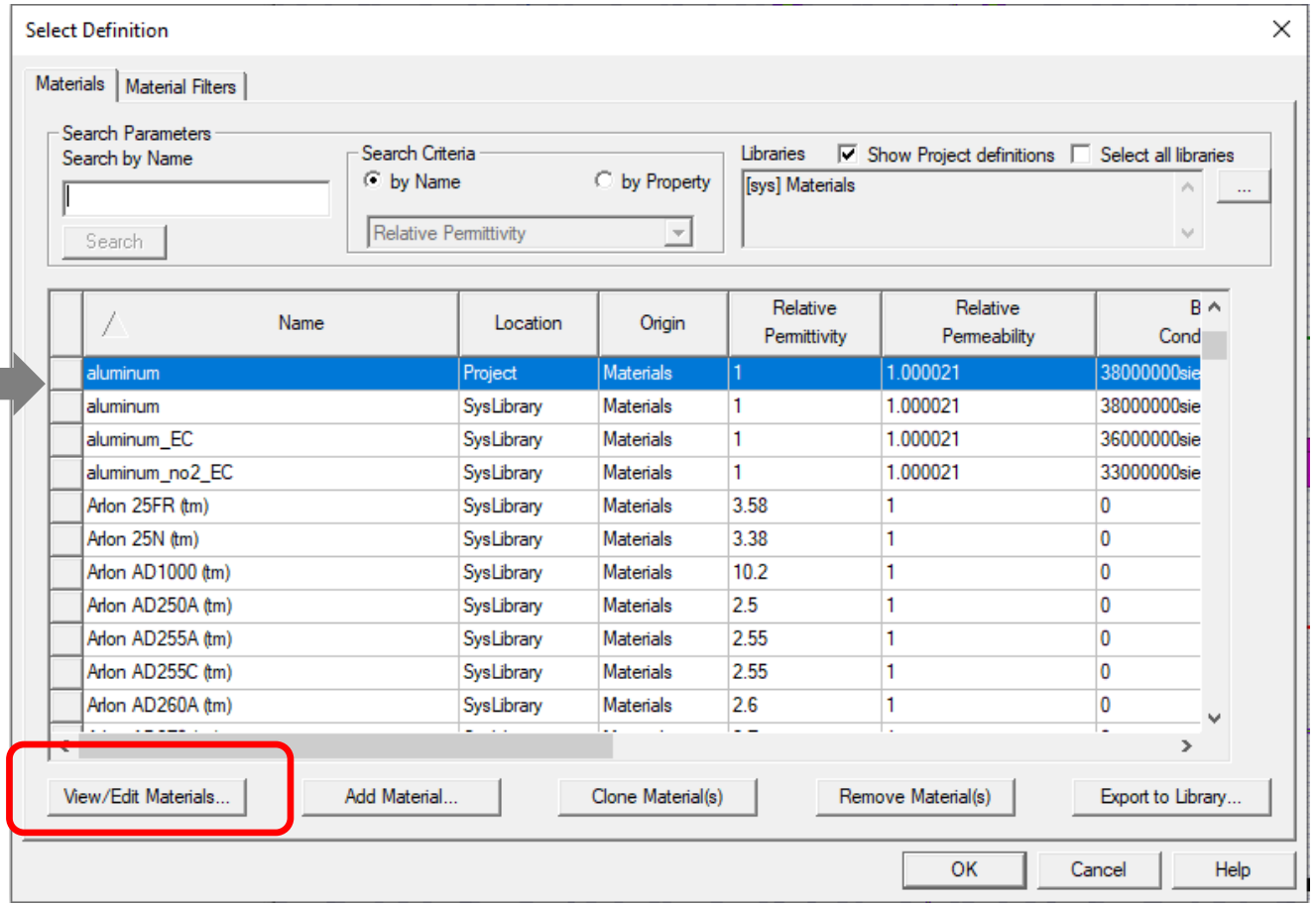


Coil and stock are electrically isolated (i.e. they are not touching each other)

Maxwell: Assignment of Material Properties

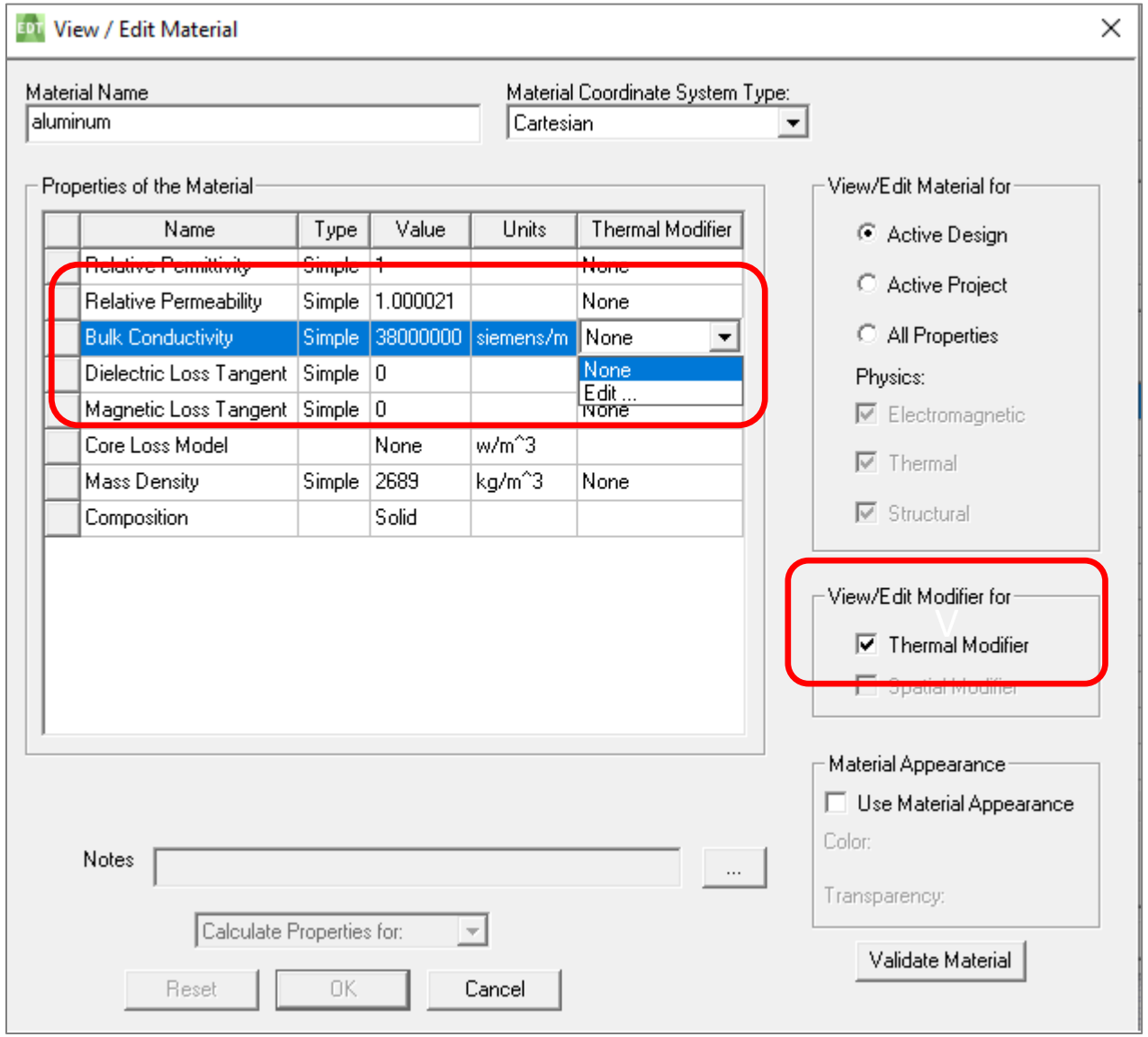
- Select the Stock object from the history tree, right-click and select Assign Material.
- In the **Select Definition** panel, select **View/Edit Materials** to open **View/Edit Material Panel (shown in the next slide)**





Maxwell: Thermal Modifier

- Enable **Thermal Modifier**.
- Go to the **Thermal Modifier** column for bulk conductivity and select **Edit** from the drop-down menu.
- This will open ‘Edit Thermal Modifier’ panel (shown in the next slide)



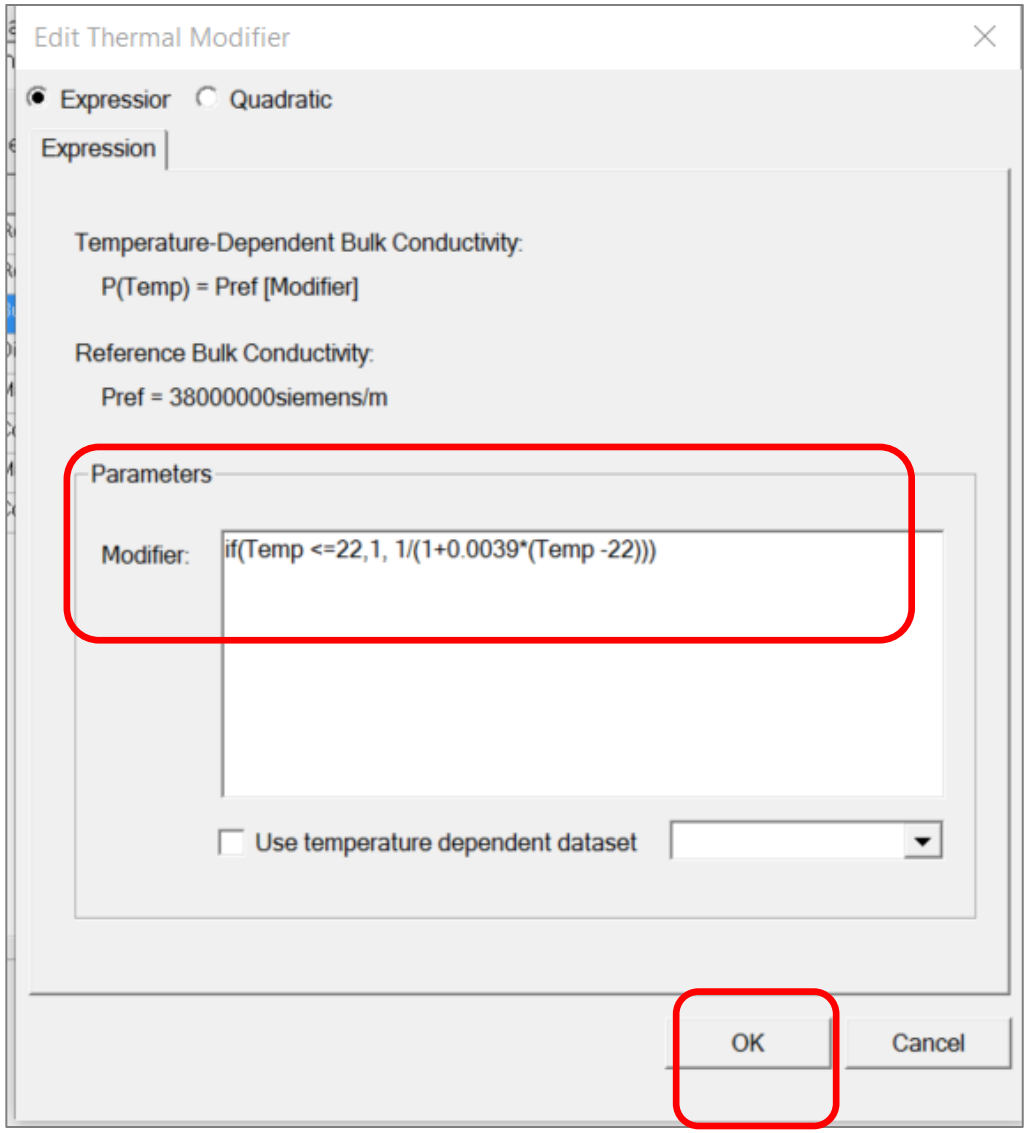
Maxwell: Temperature Dependent Bulk Conductivity

- In the **Edit Thermal Modifier** panel,

  Set modifier as:

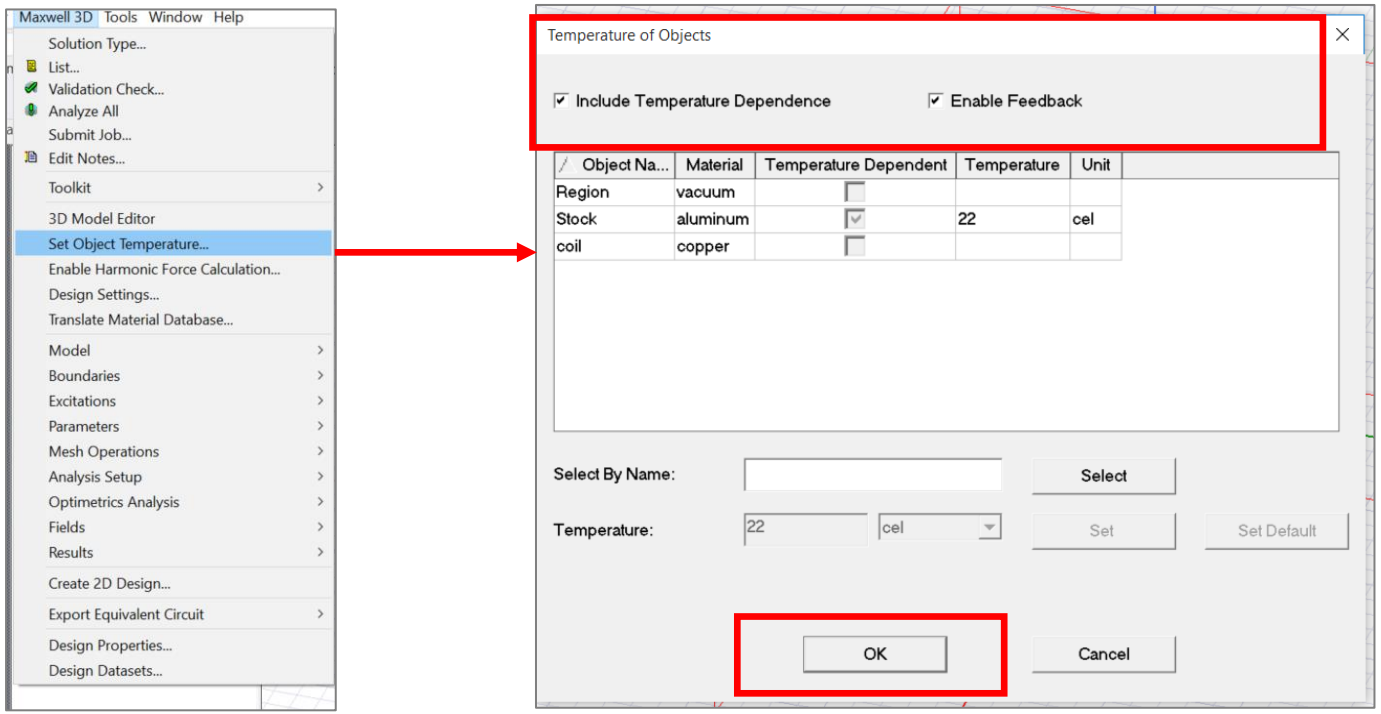
  if (Temp <=22, 1, 1/(1+0.0039*(Temp-22)))
- Click **OK**.

Note: In order to use 2-ways coupling Temperature dependent properties are required for at least one component



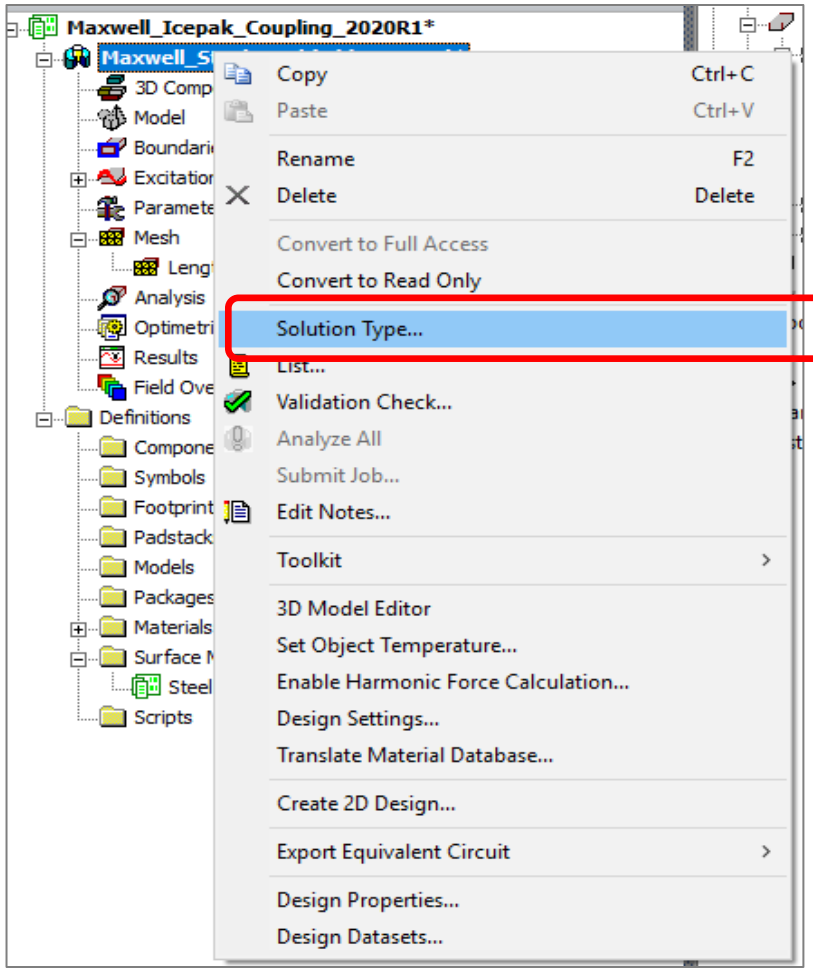
Maxwell: Enable Temperature Feedback

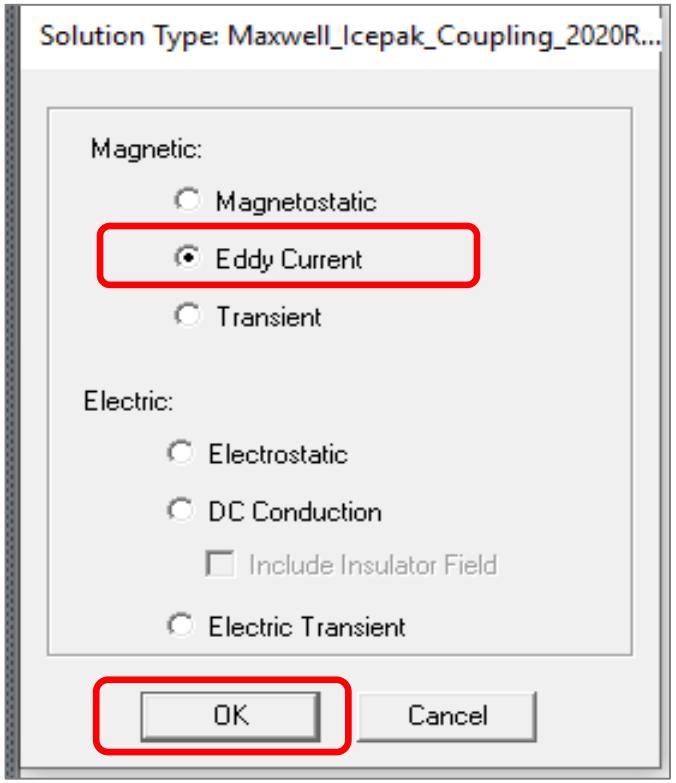
1. From the Main Menu use **Maxwell 3D → Set Object Temperature**.
   - This feature can also be accessed from the Project manager →Maxwell_Stock_Coil→ RMB→Set Object Temperature
2. In the **Temperature of Objects** panel, enable **Include Temperature Dependence** and **Enable Feedback**.
3. Click **OK**.



Maxwell : Solution Type

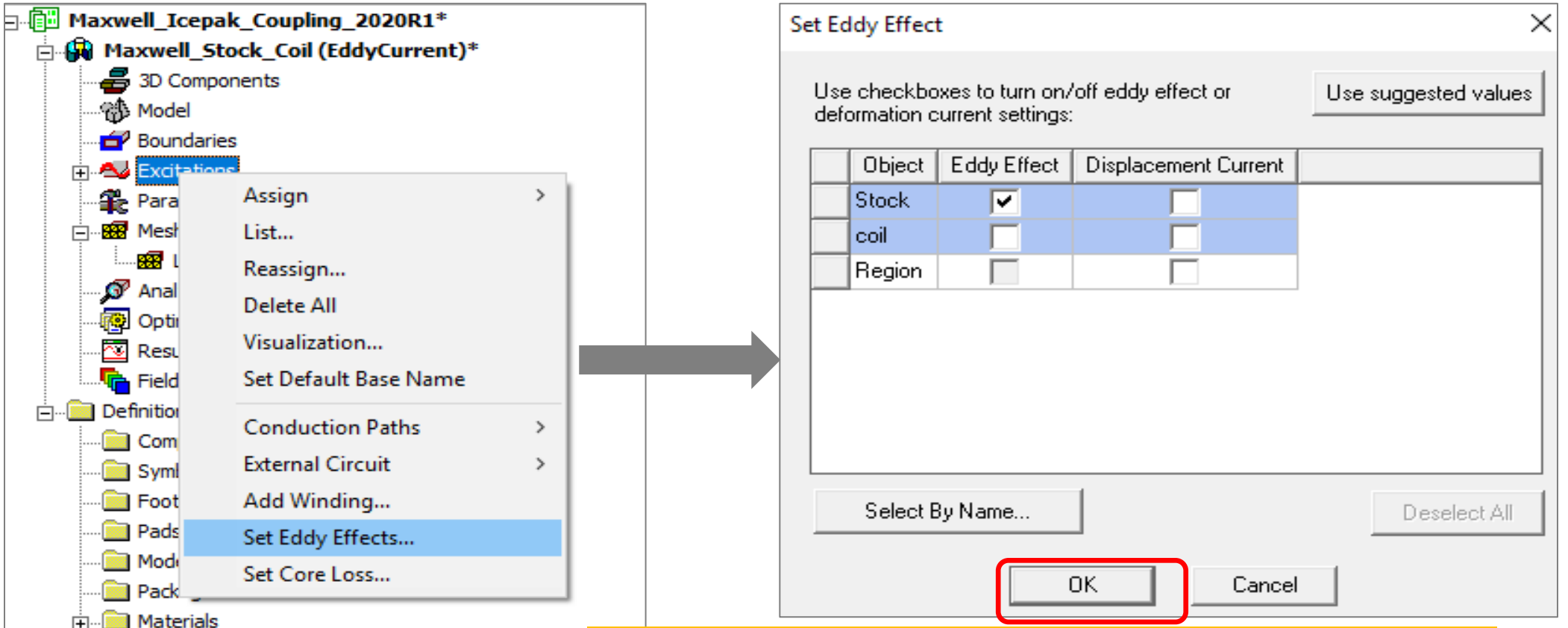
- Right click on the Project Maxwell_Stock_Coil → Solution Type and define ‘Eddy Current’ under Magnetic solution type.





Maxwell : Eddy Effects…

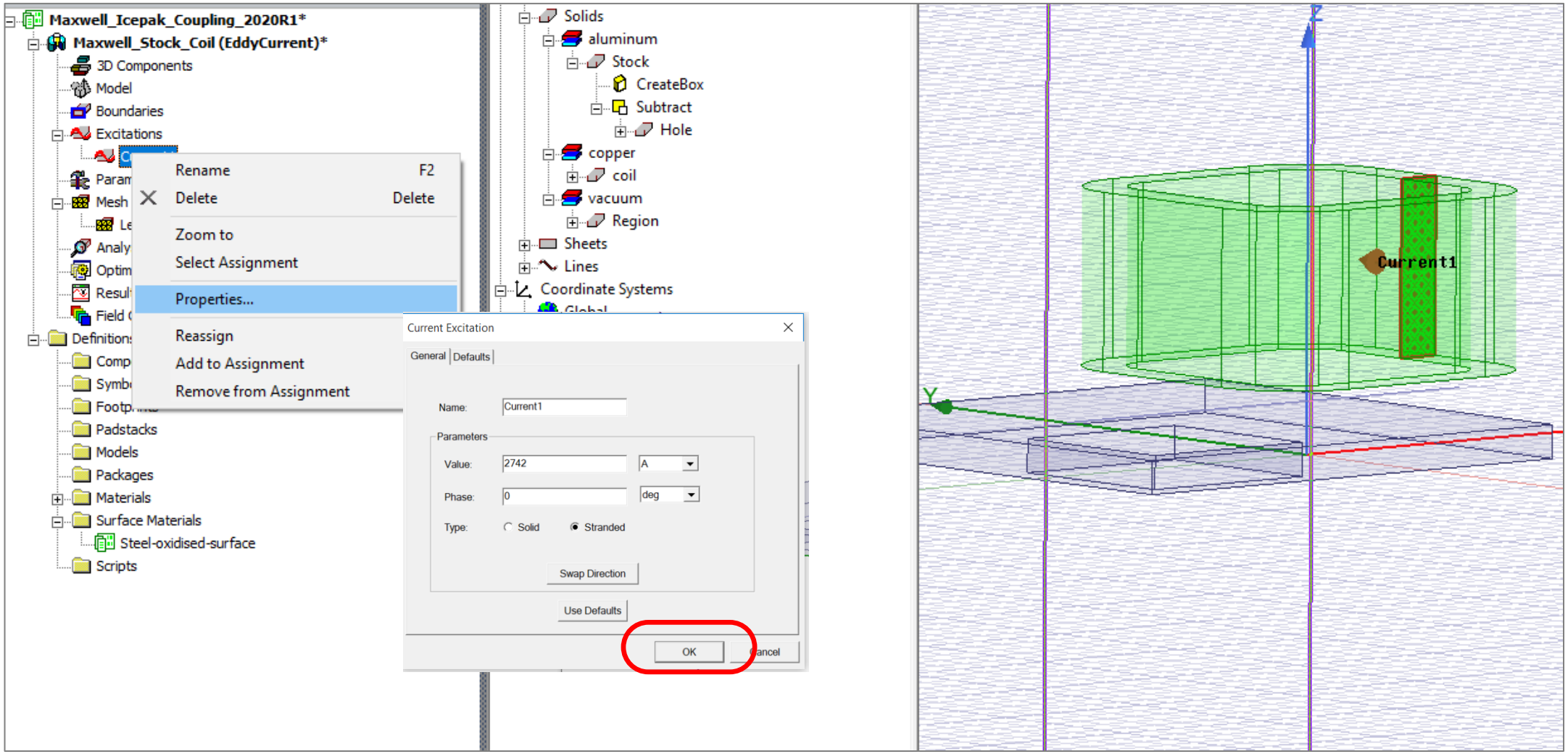
- Right click on ‘Excitations’ → Set Eddy Effects and select Eddy Effect for the object Stock.



This example uses a stranded "bulk" coil. For such cases, the eddy effect is turned OFF for coil and only the DC winding losses are calculated.

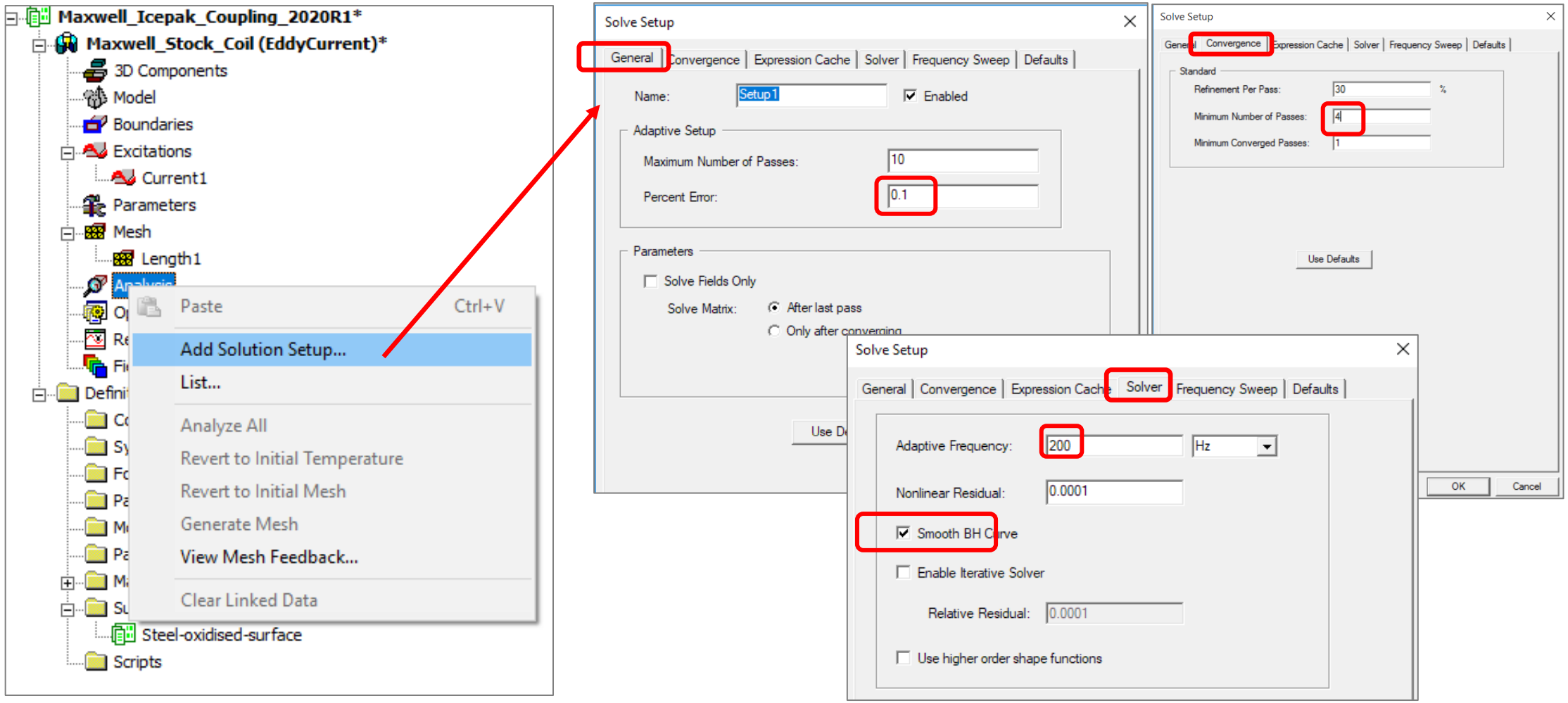
Maxwell : Current Excitation

- Define the Current properties as shown in the Current Excitation panel.

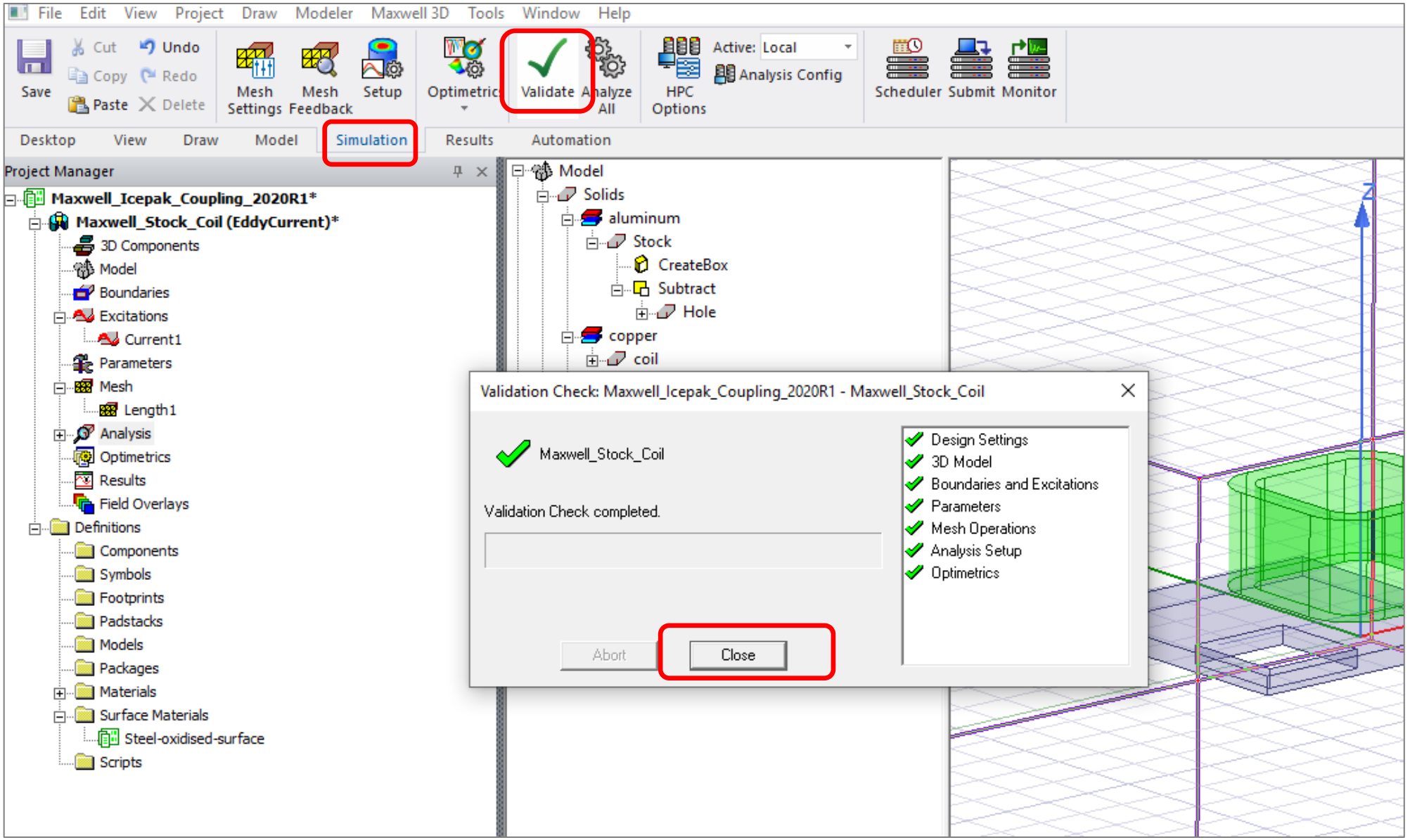


Maxwell : Add Solution Setup

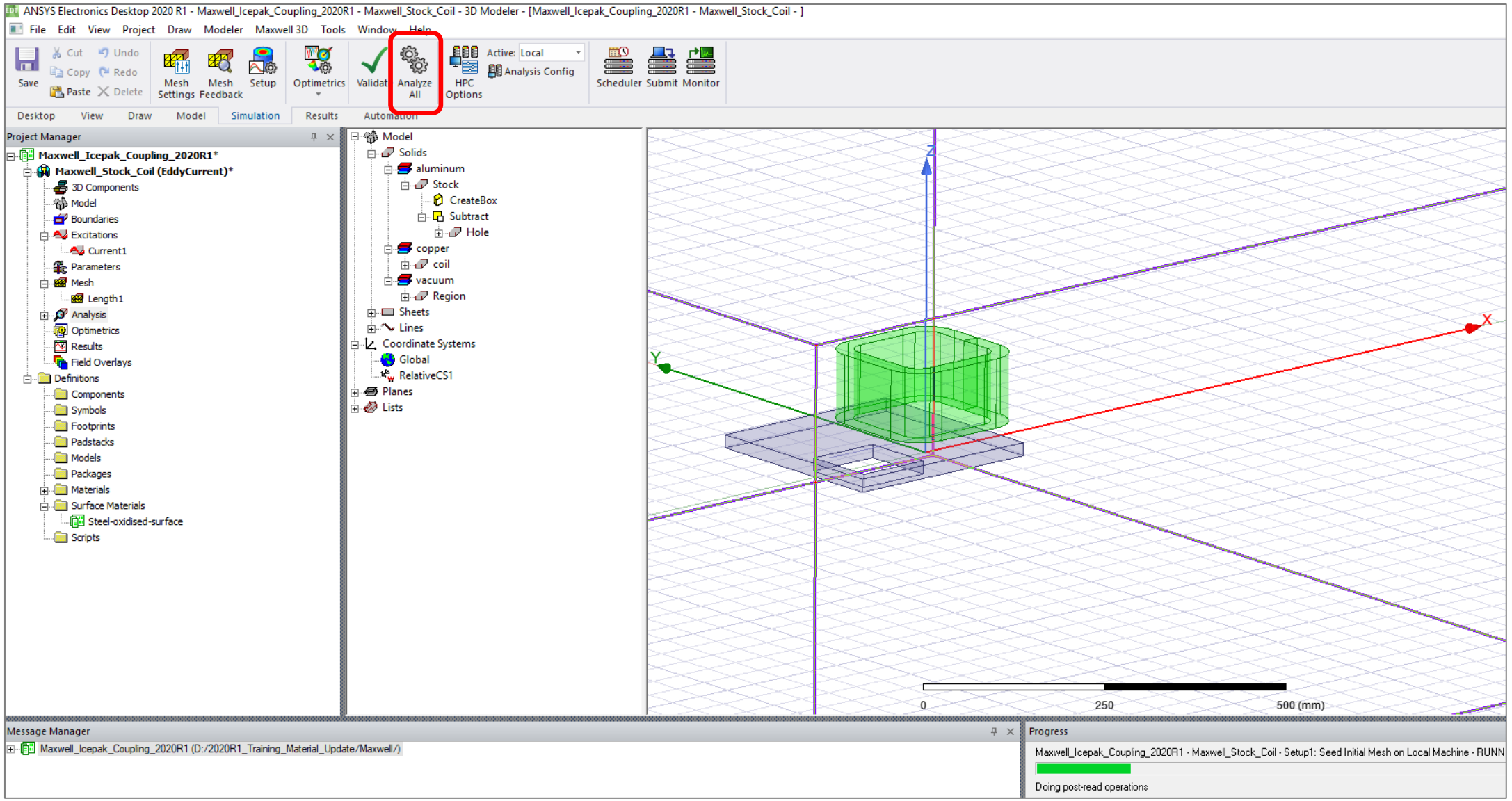
- In the Solve Setup Panel go through the General, Convergence and Solver panel as shown below:



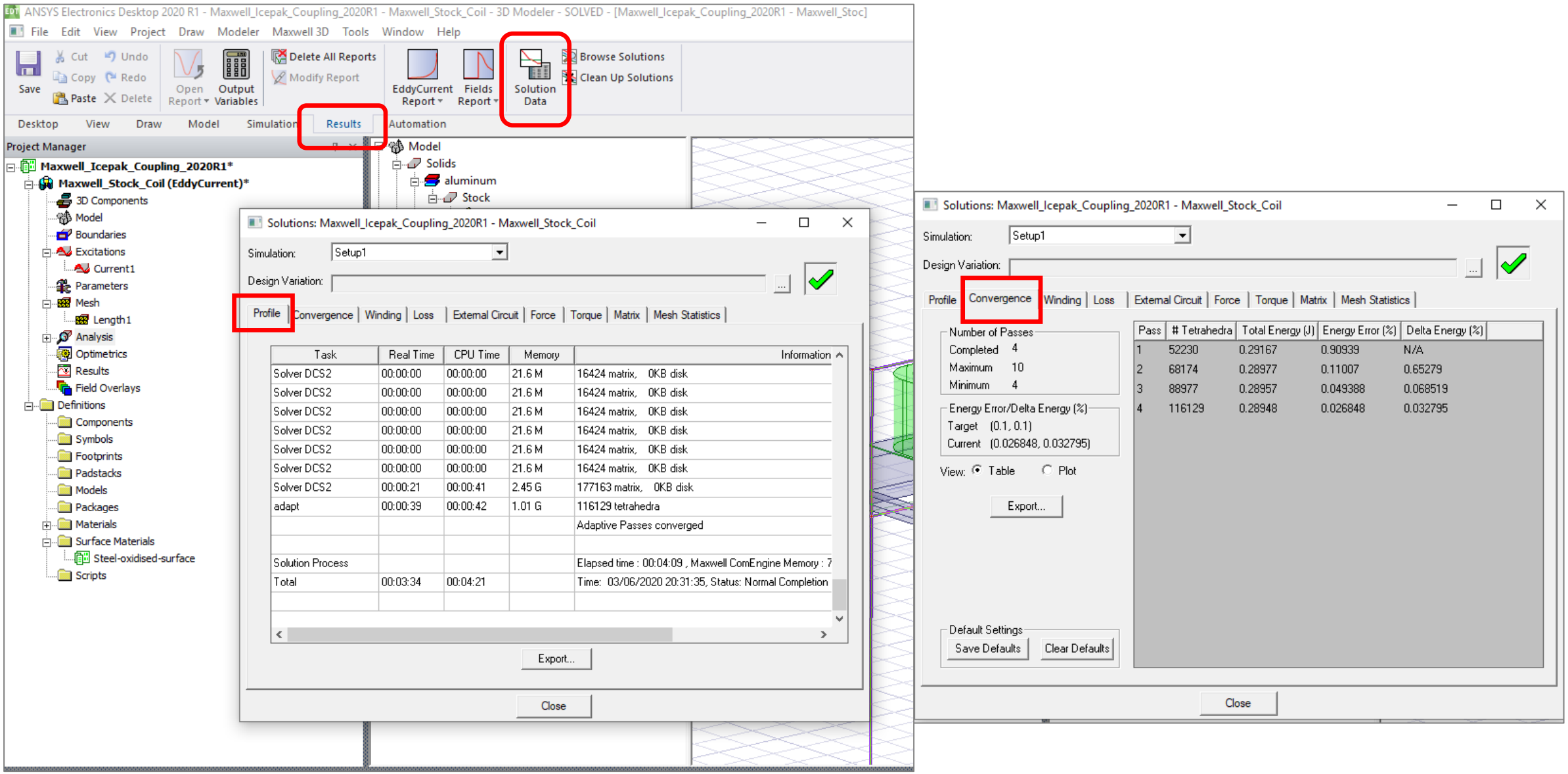
Maxwell : Validate



Maxwell : Solve



Maxwell : Convergence



Maxwell : Calculate Ohmic Loss for Stock using Field Calculator

- **From Fields Calculator panel select:**

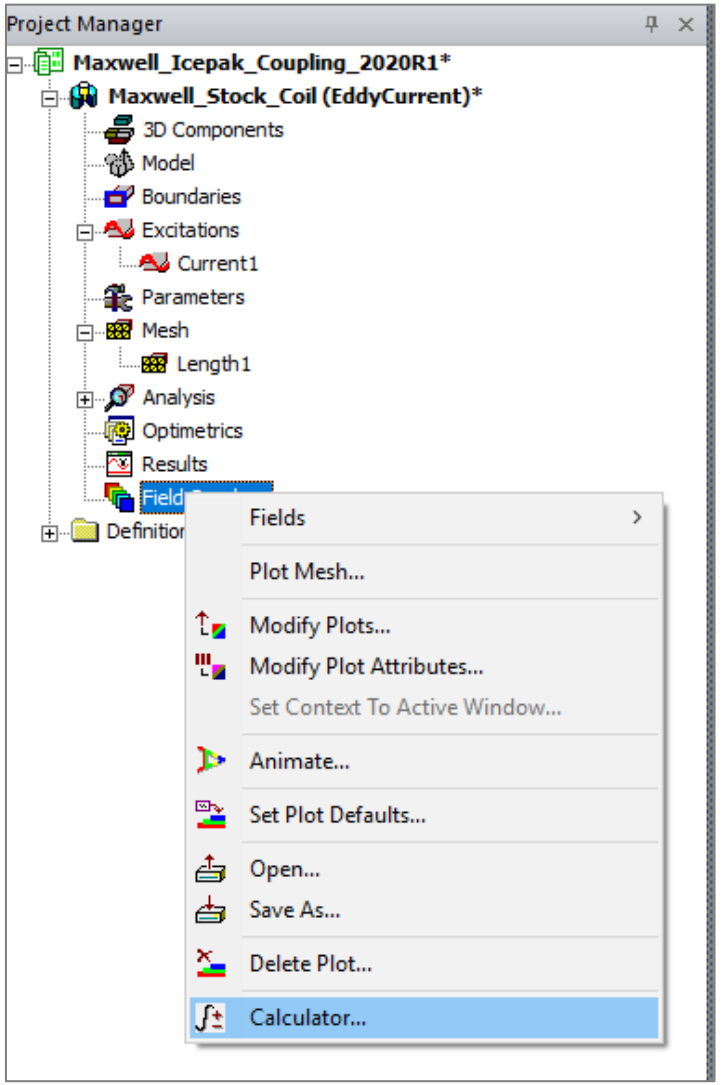
1. **Input → Quantity → OhmicLoss**
2. **Input→ Geometry → Volume → Stock**
3. **Scalar → ∫ (Integrate)**

Click Add… and enter Name as - *loss_stock*

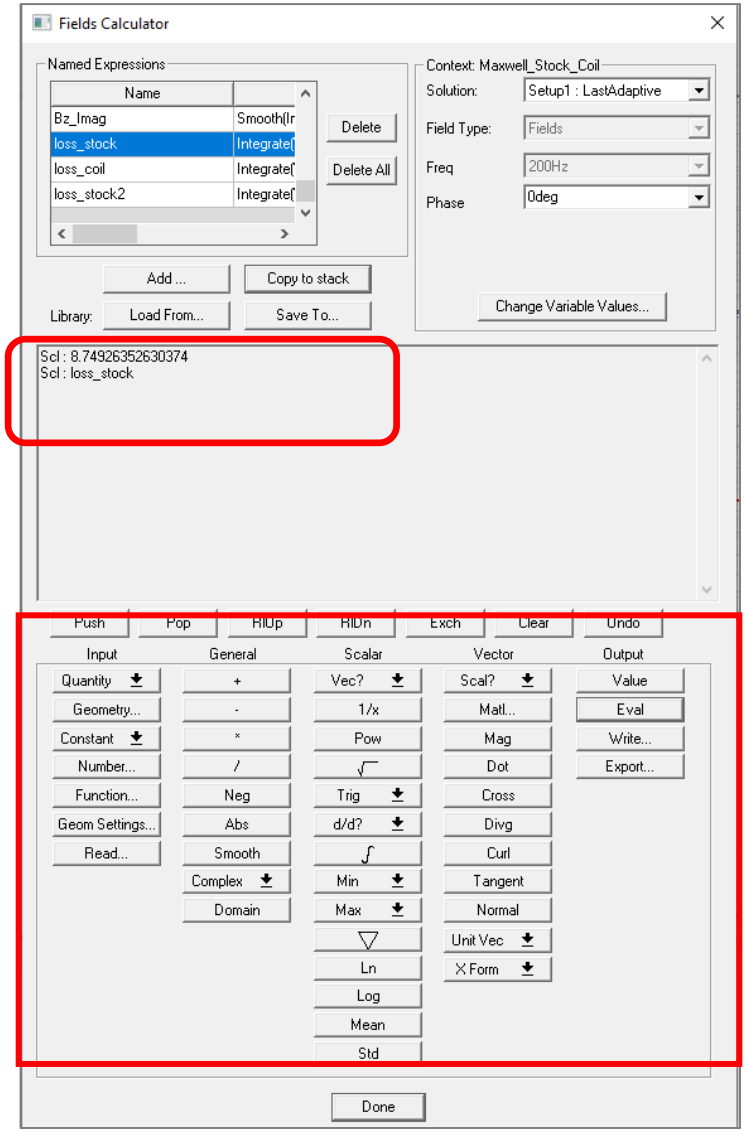
Select “loss_stock” from Named expressions list and Select “Copy to stack”

- **Select “Eval” under output option**

The Ohmic losses in Stock volume are around *8.749* W. These losses are the induced AC losses in the plate.

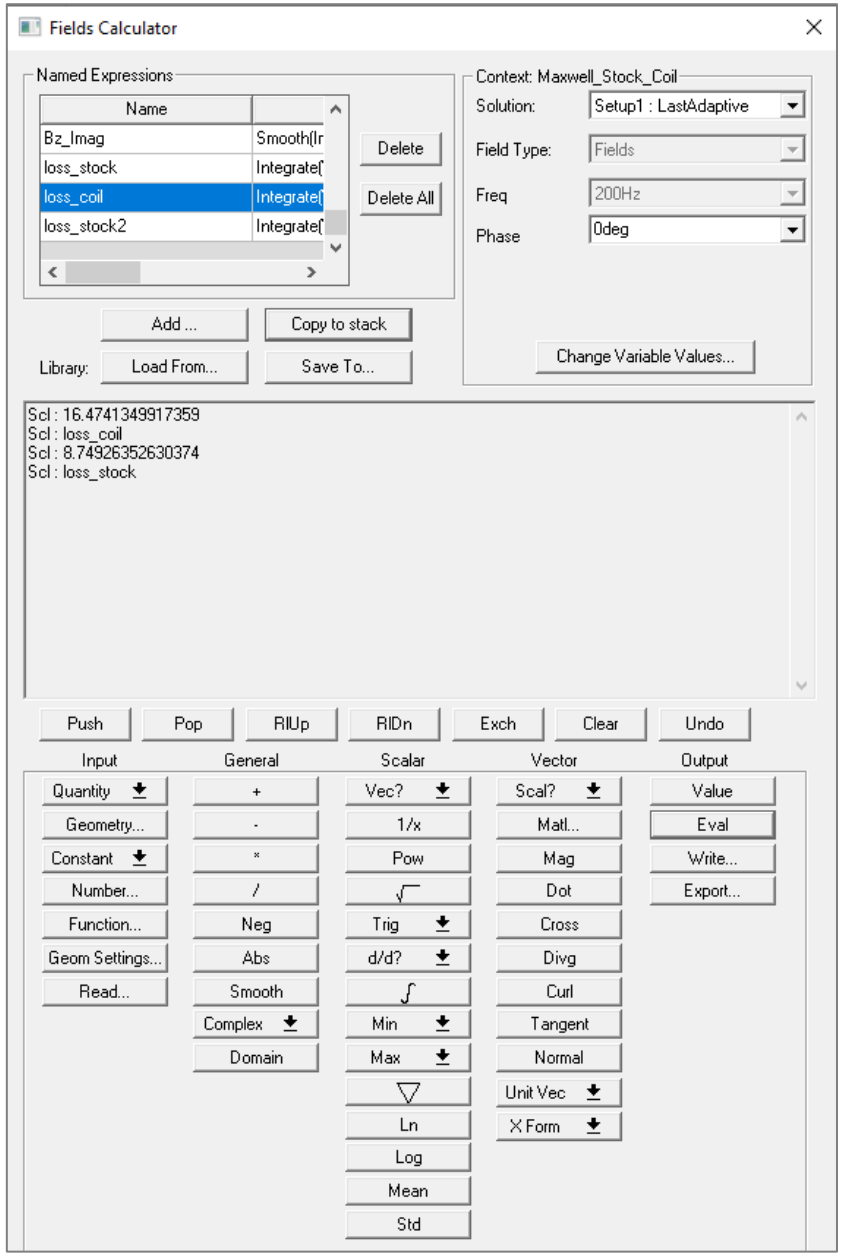


Has been created

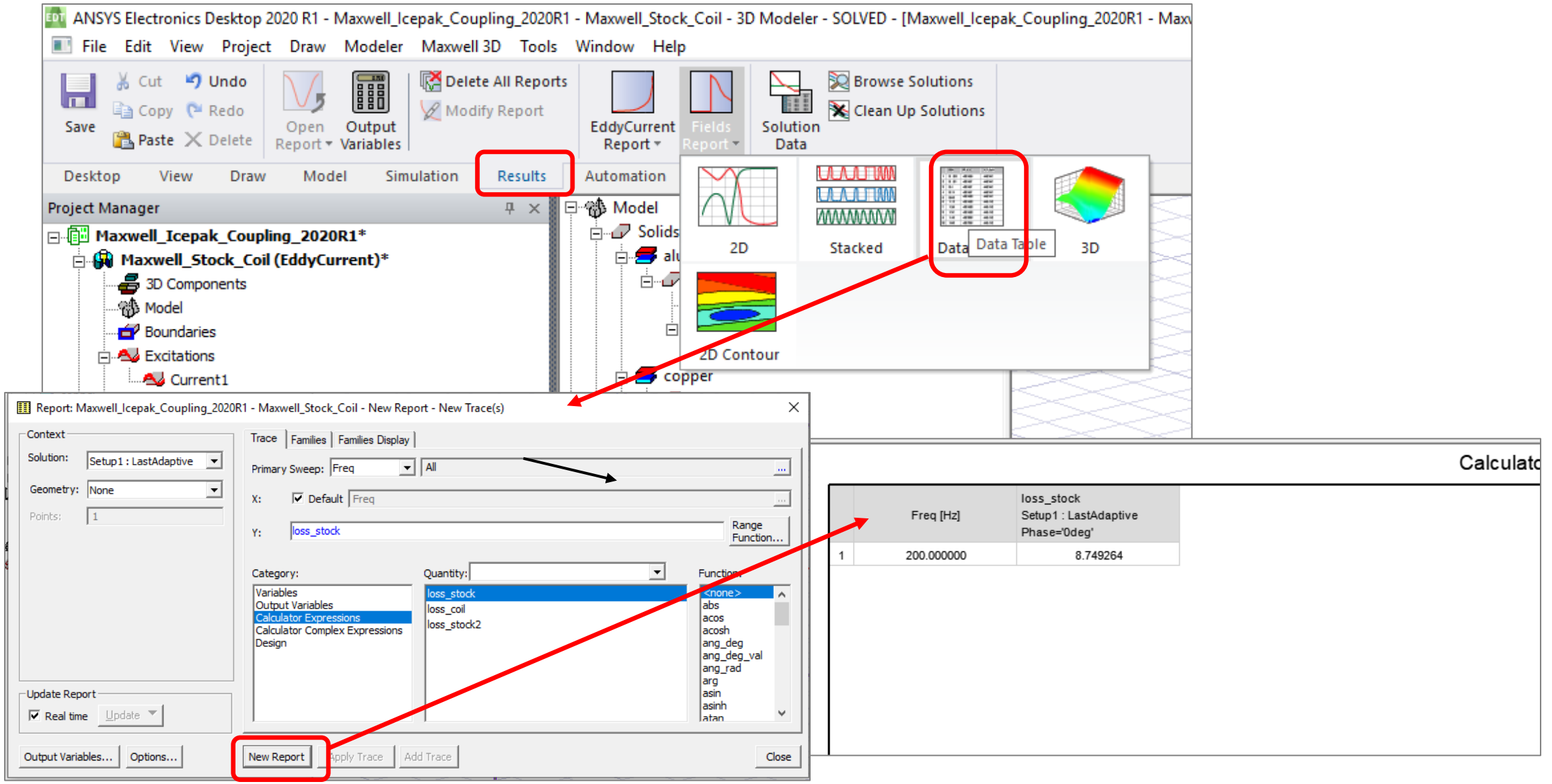


Maxwell : Ohmic Loss for Coil

- Create similar Named Expression for coil
- The Ohmic losses in Coil volume are ~16.47 Watts.
  Note: Since the coil consists of many small conductors, it was modelled as a bulk "stranded" source which neglects all AC skin and proximity effects.
- The reported loss is due to the DC resistance of the coil.

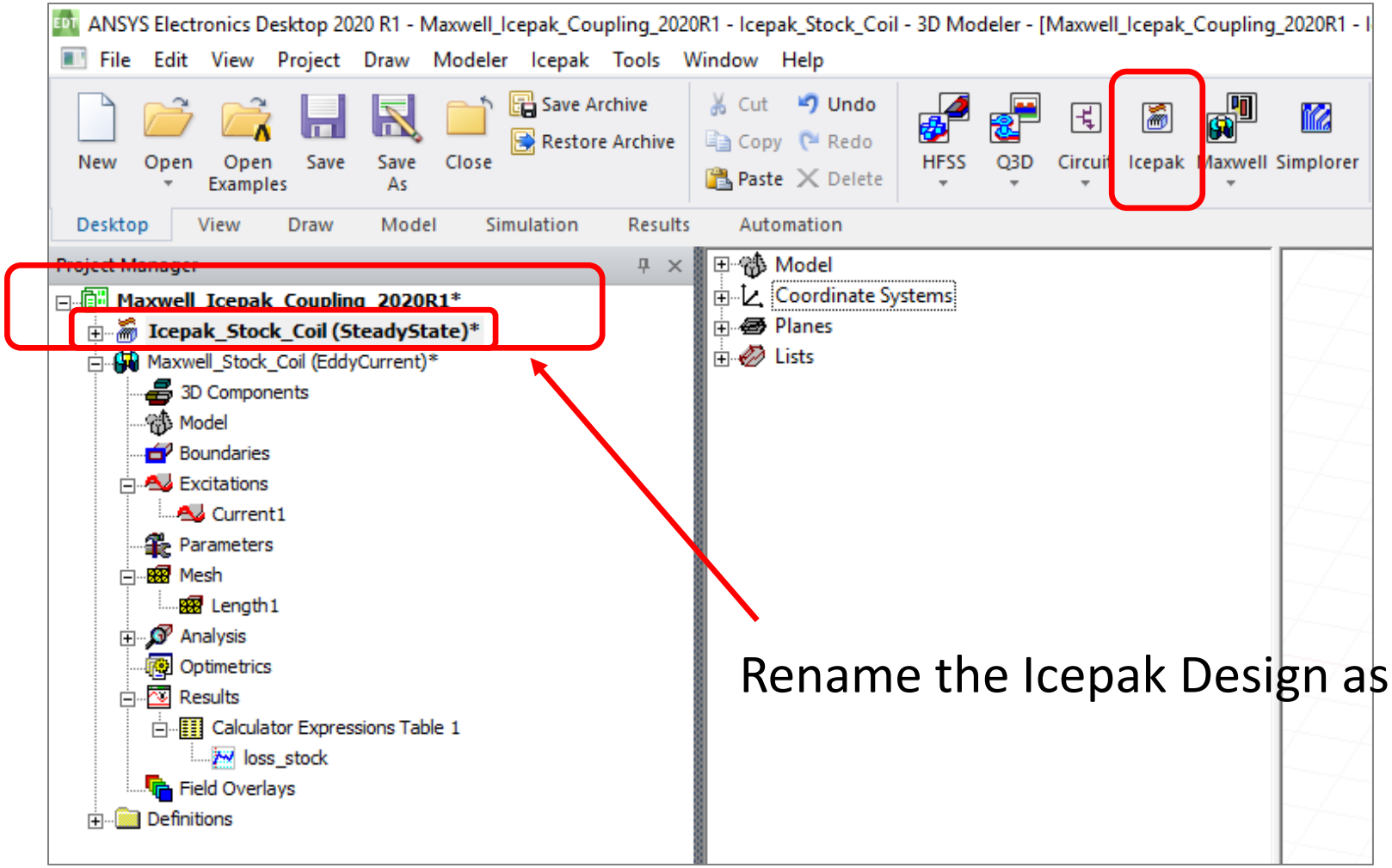


Maxwell : Field Report - Data Table



Insert Icepak Design

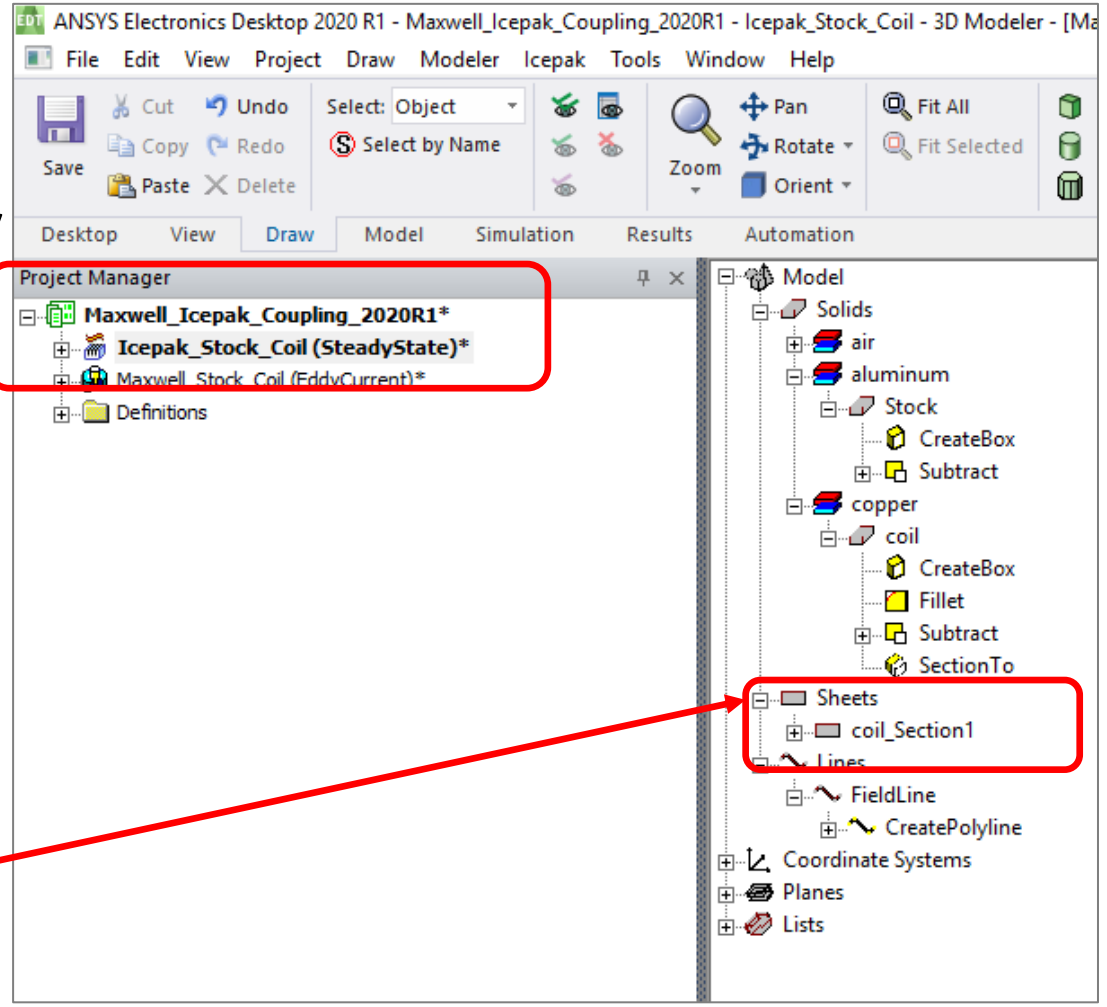
- Insert an Icepak Design from Desktop menu



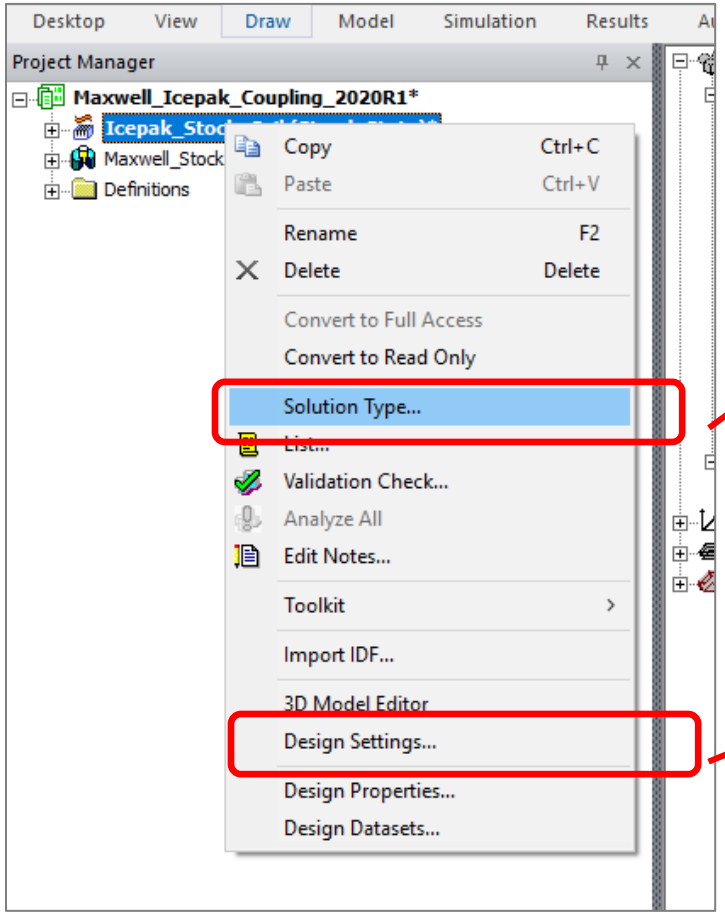
Rename the Icepak Design as “Icepak_Stock_Coil”

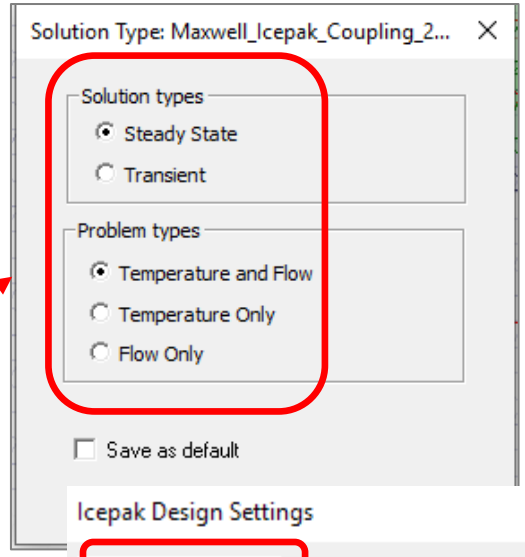
Copy Maxwell model to Icepak

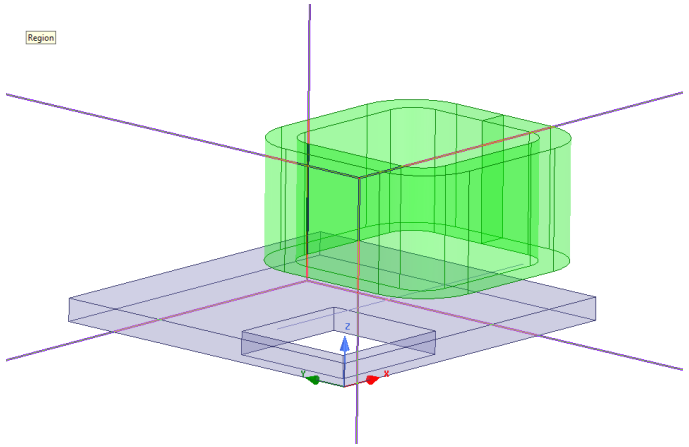
- Double click on ‘Maxwell_Stock_Coil’ design from Project Manager window.
- Use Ctrl A to select the entire Maxwell Geometry and Material information
- Use Ctrl C to copy the above information
- Double click on “ Icepak_Stock_Coil”
- Use Ctrl V to paste the information in Icepak design and use Fit All option to see the model.
  - Note the automatic creation of the “air” region around the copied geometry
- Select unwanted bodies like Sheets, Lines which are not required for Thermal Analysis and right click to delete it.

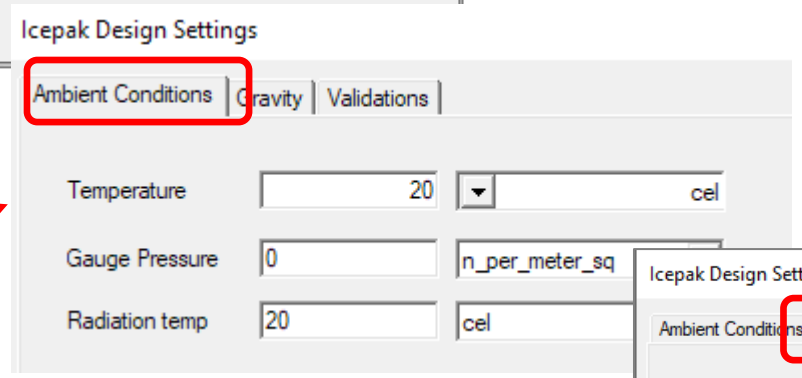


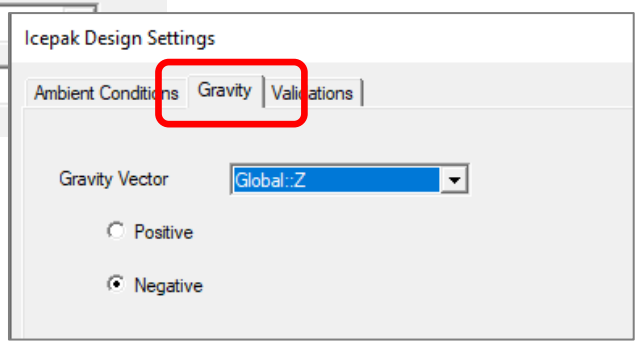
Icepak : Solution Type & Design Settings..







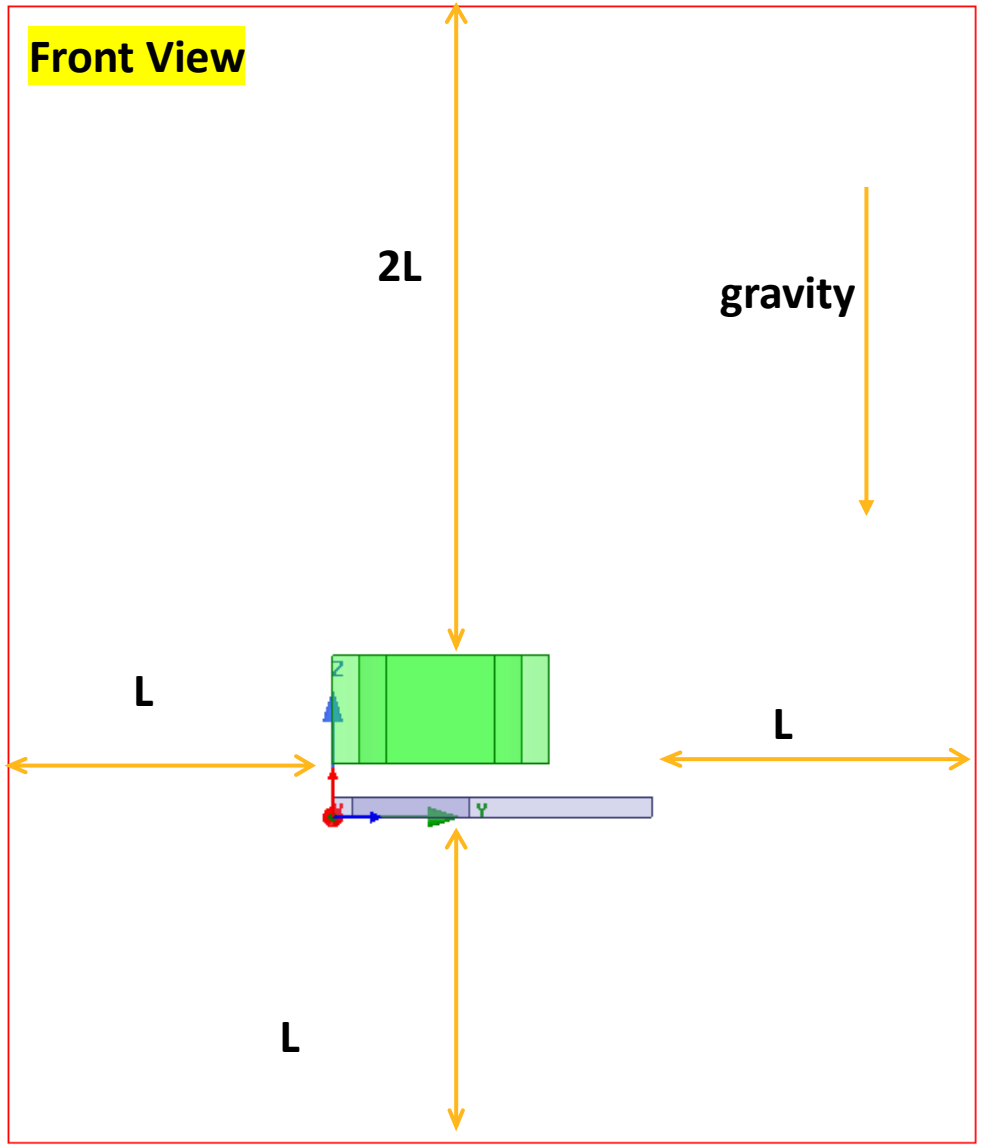




Note: Setting Gravity direction alone will not include the effect of gravity.
The gravity needs to be included in Setup panel which is shown later.

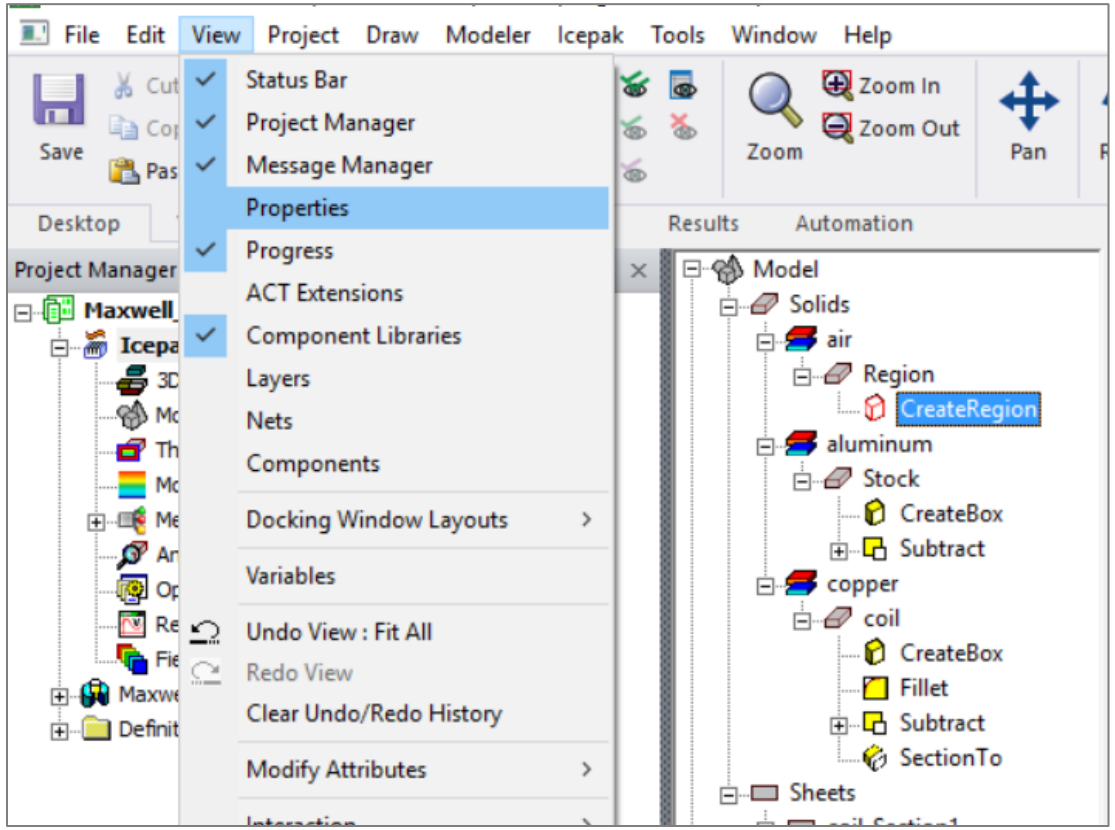
Icepak : Region Resizing

- The region needs to be sufficiently large so the boundary conditions do not affect the results – gradients of variables normal to the boundaries should be small.
- Rules of thumb :
  - Top (against gravity): at least 2L to capture the plume accurately
  - Sides: at least ½ L
  - Below: at least L
  - Where L is the largest dimension of the unit in 3 directions.



Icepak : Region sizing

1. **Select Create Region and use Properties option from View menu to open Properties panel**
2. **Change the Padding Type to Absolute Offset and use 600 mm for positive Z and 300 mm for other directions.**

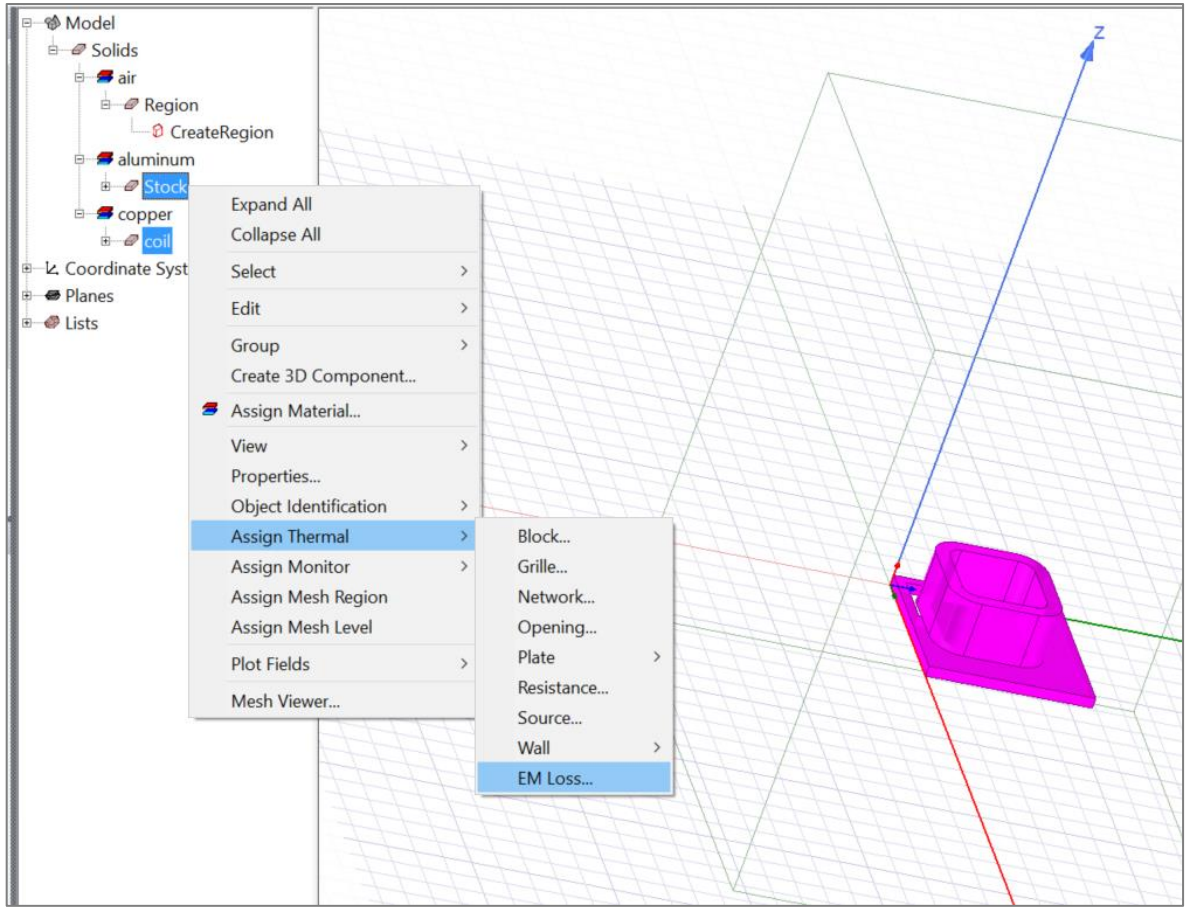


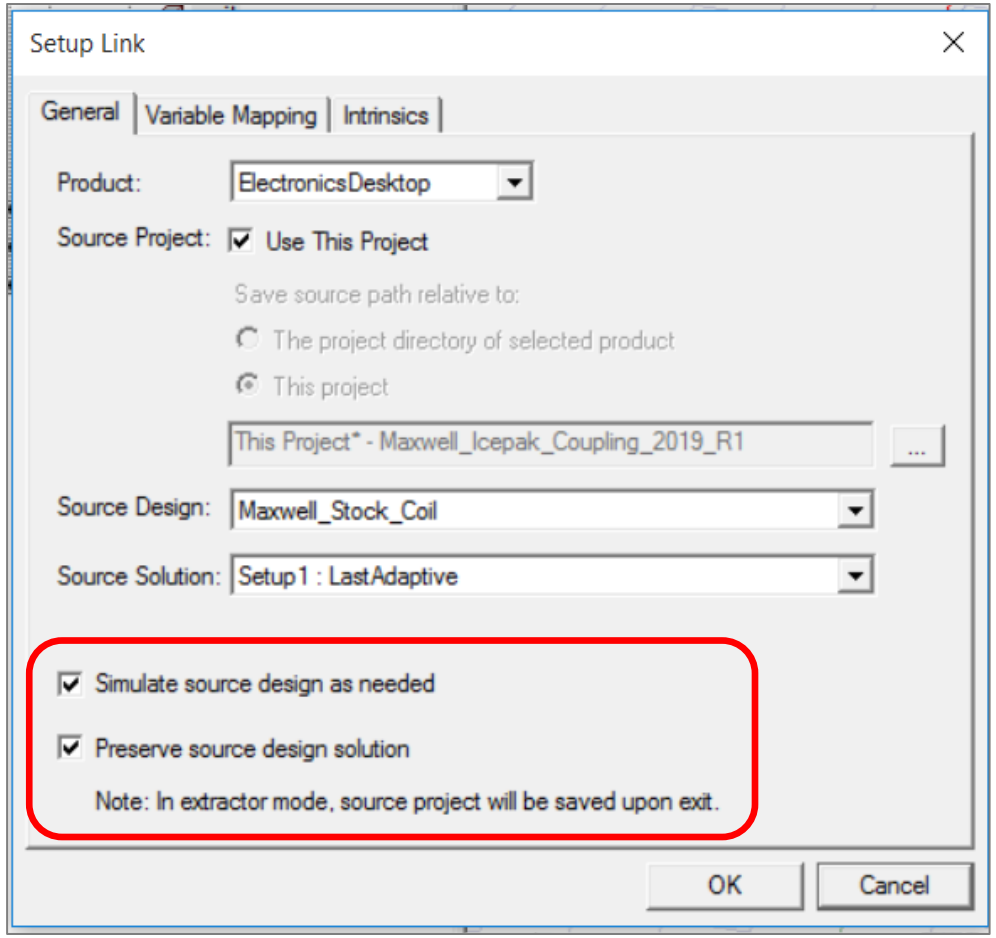
Properties

Name	Value	Unit	Evaluated Value
Command	CreateRegion		
Coordinate...	Global		
+X Paddin...	Absolute Offset		
+X Paddin...	300	mm	300mm
-X Paddin...	Absolute Offset		
-X Paddin...	300	mm	300mm
+Y Paddin...	Absolute Offset		
+Y Paddin...	300	mm	300mm
-Y Paddin...	Absolute Offset		
-Y Paddin...	300	mm	300mm
+Z Paddin...	Absolute Offset		
+Z Paddin...	600	mm	600mm
-Z Paddin...	Absolute Offset		
-Z Paddin...	300	mm	300mm

Icepak : EM Mapping

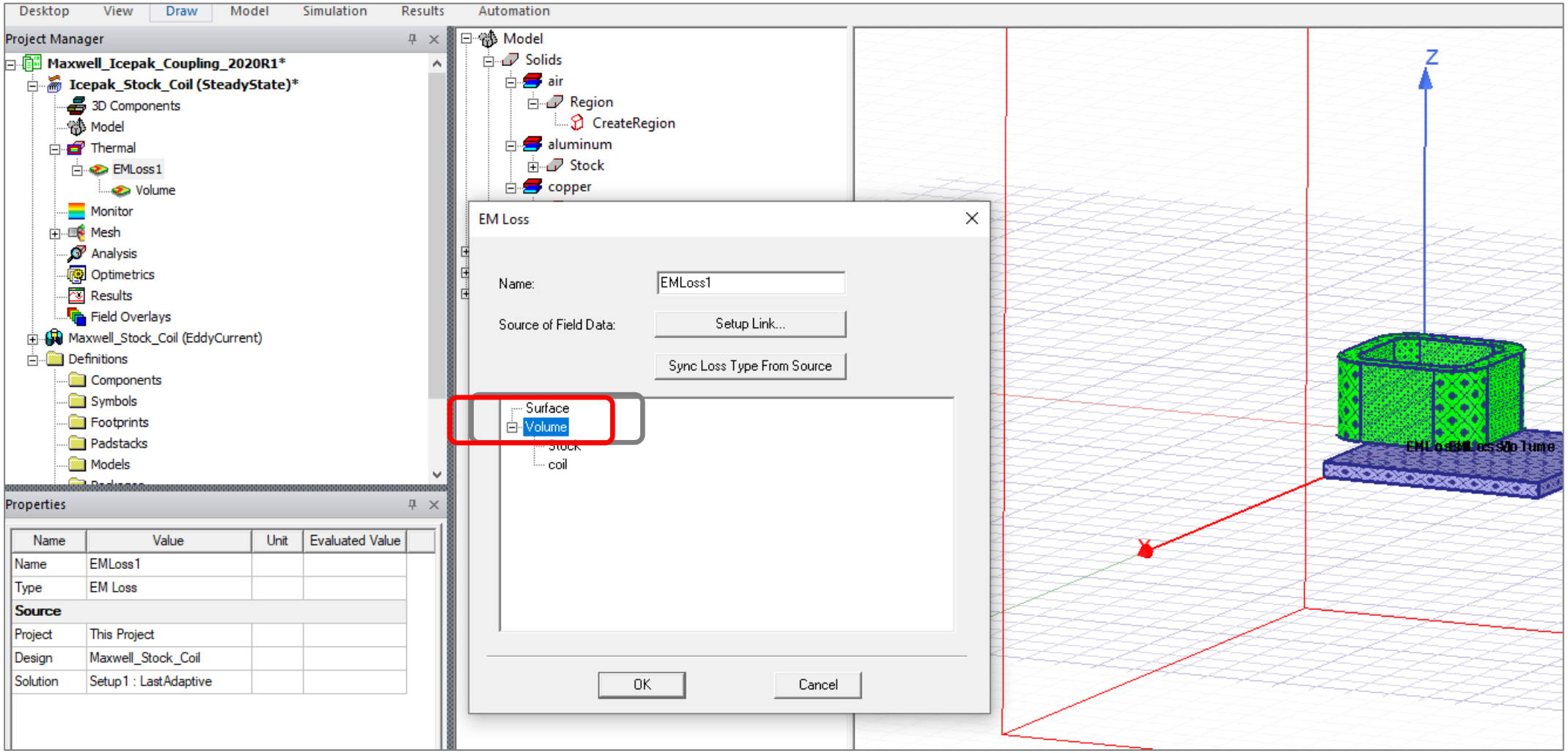
- Select Coil and Stock from GUI and right click to Assign Thermal → EM Loss
- Select ‘Use This Project’ and ‘Simulate source design as needed’ in setup link panel





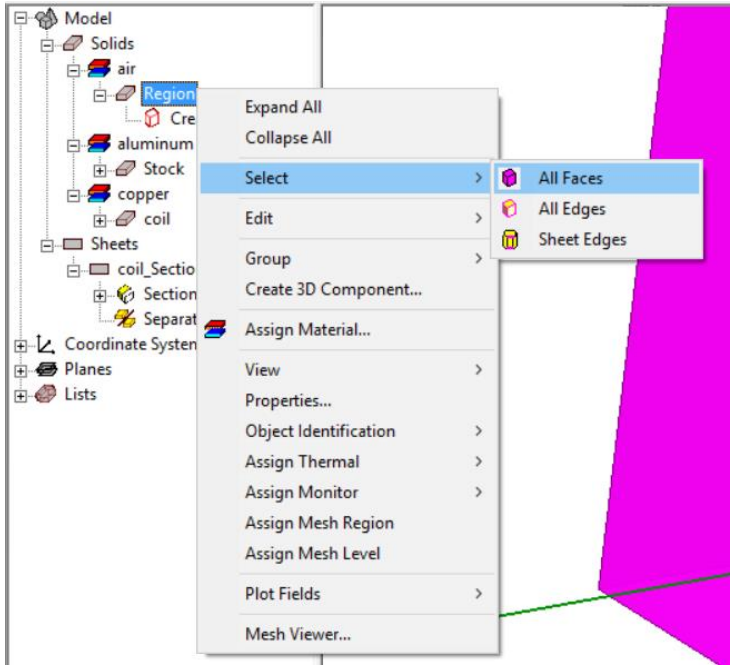
Icepak : EM Mapping

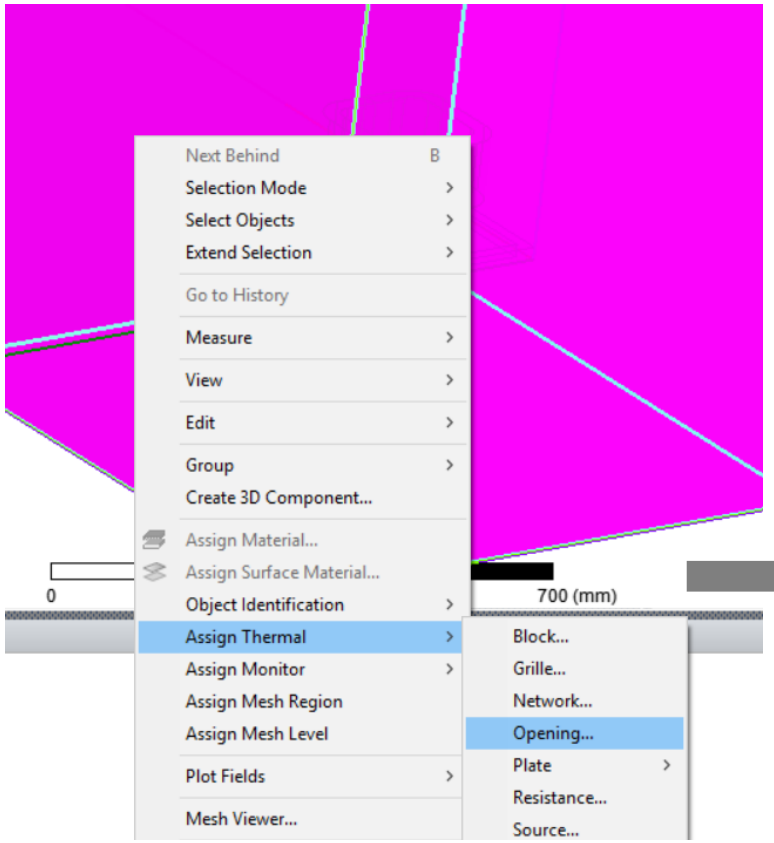
Set up the Electro-Thermal link to map Volume EM losses on the Stock and Coil

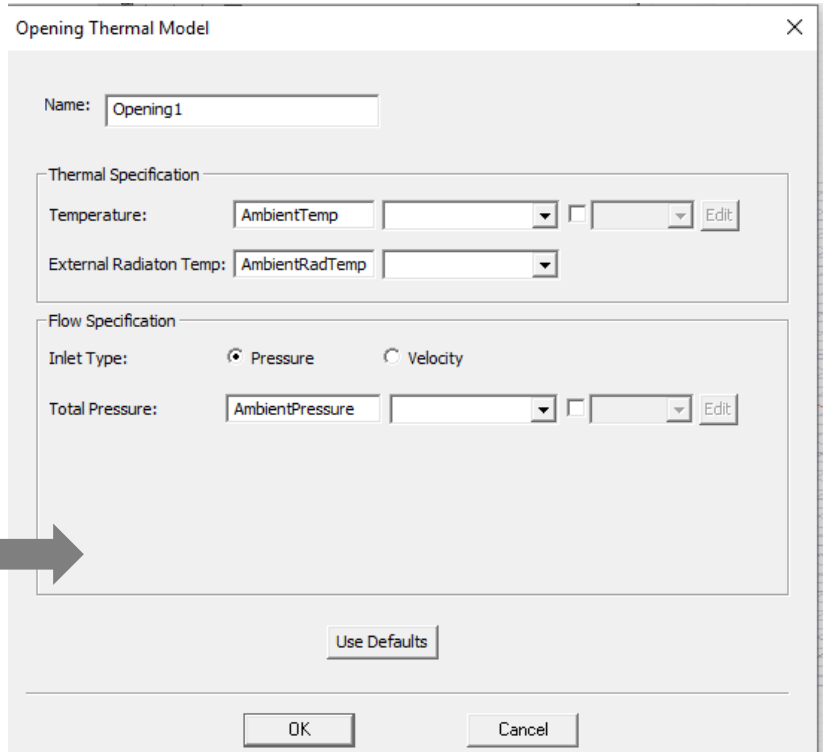


Icepak : Create Openings for the Region object

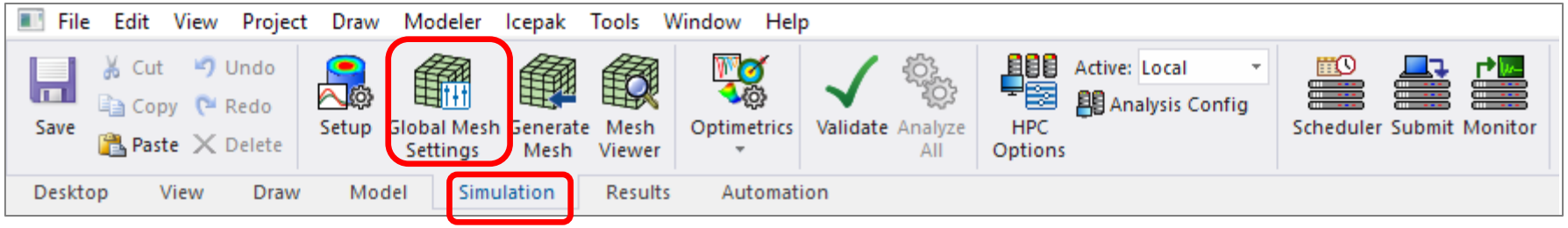
- Select object “Region” and right click and select → All Faces
- Right click on region face in GUI →Assign Thermal → Opening
- Keep default boundary conditions

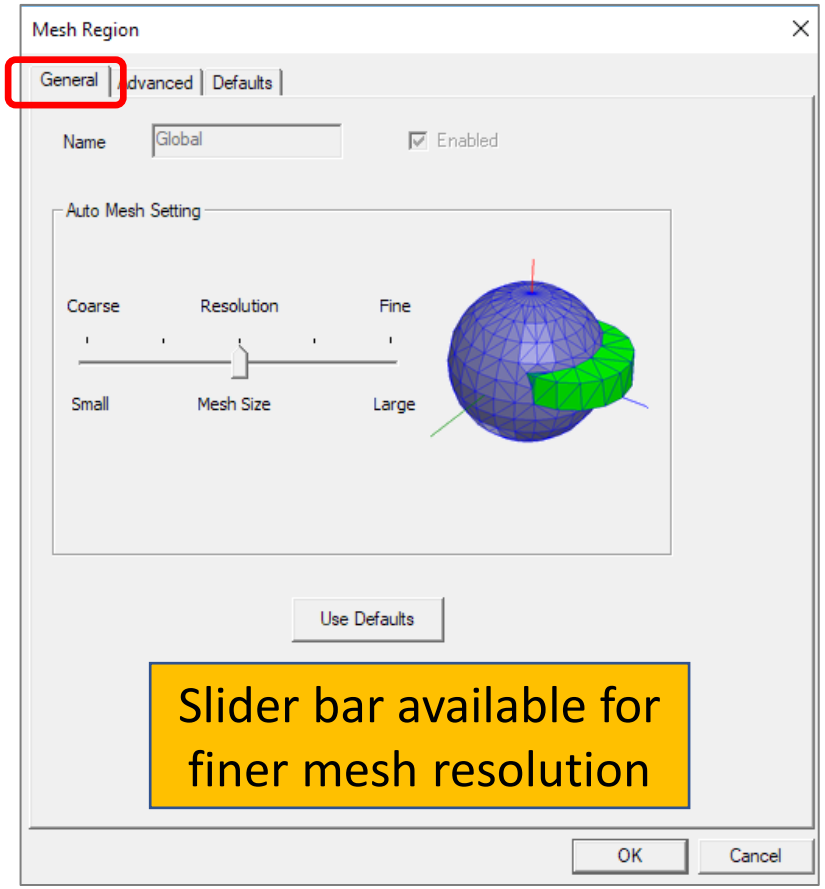




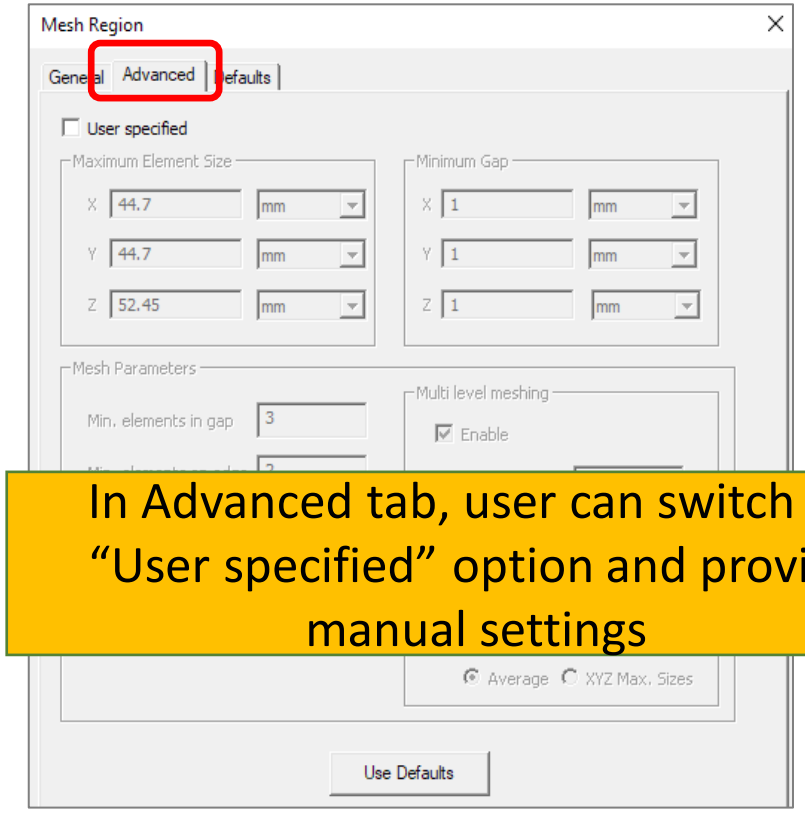


Icepak : Mesh





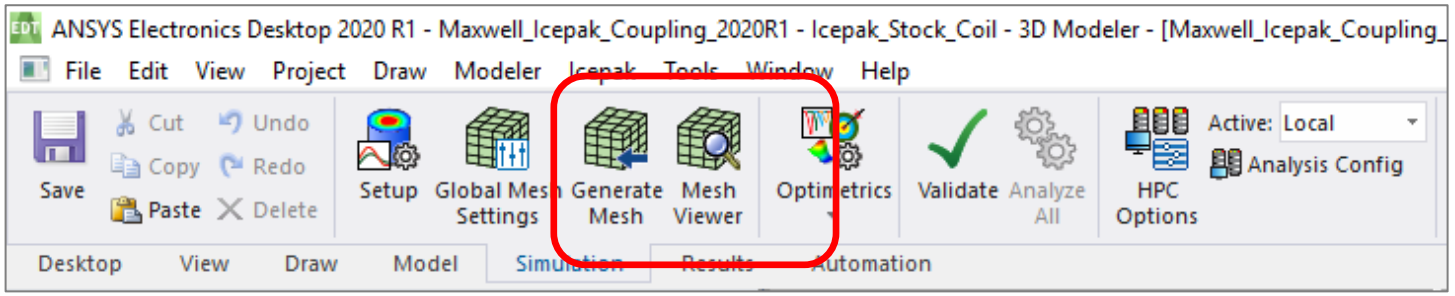
Slider bar available for finer mesh resolution

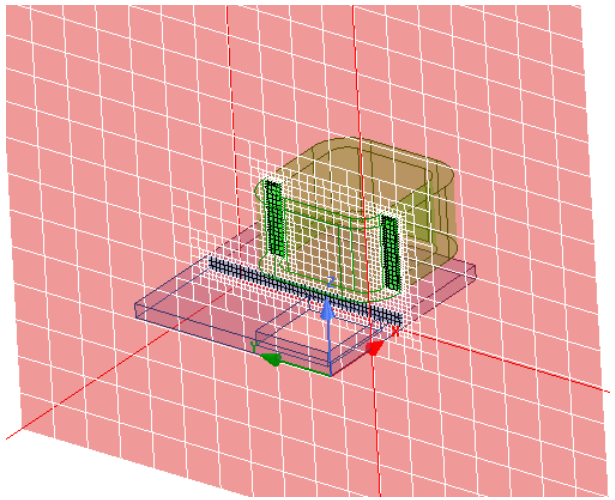


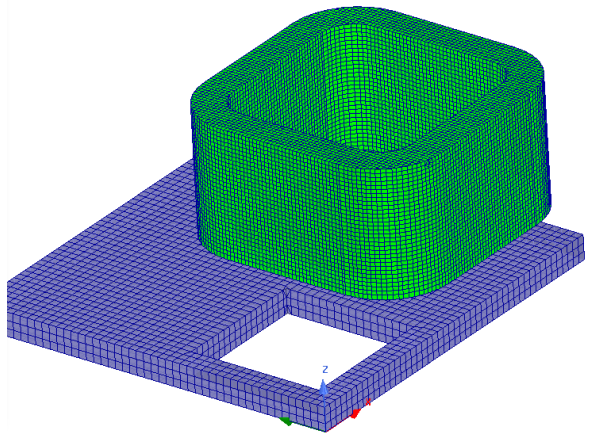
In Advanced tab, user can switch on “User specified” option and provide manual settings

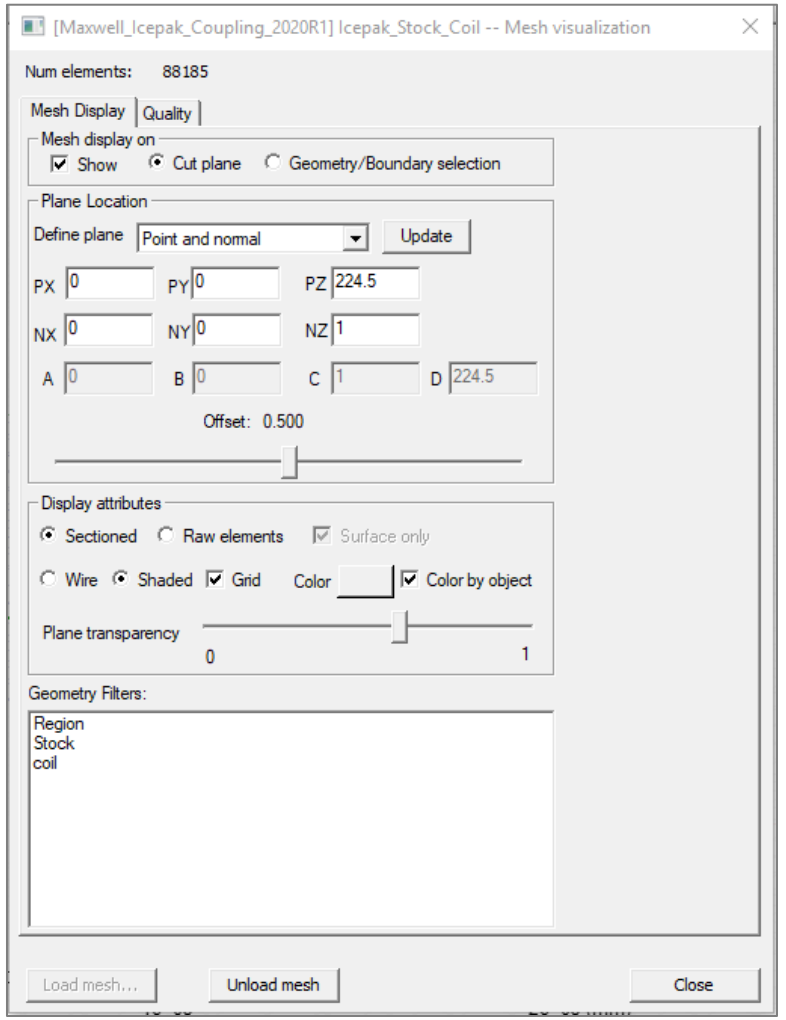
Icepak : Generate and View Mesh

Generate Mesh and Click Mesh Viewer to review the mesh on planes and individual bodies



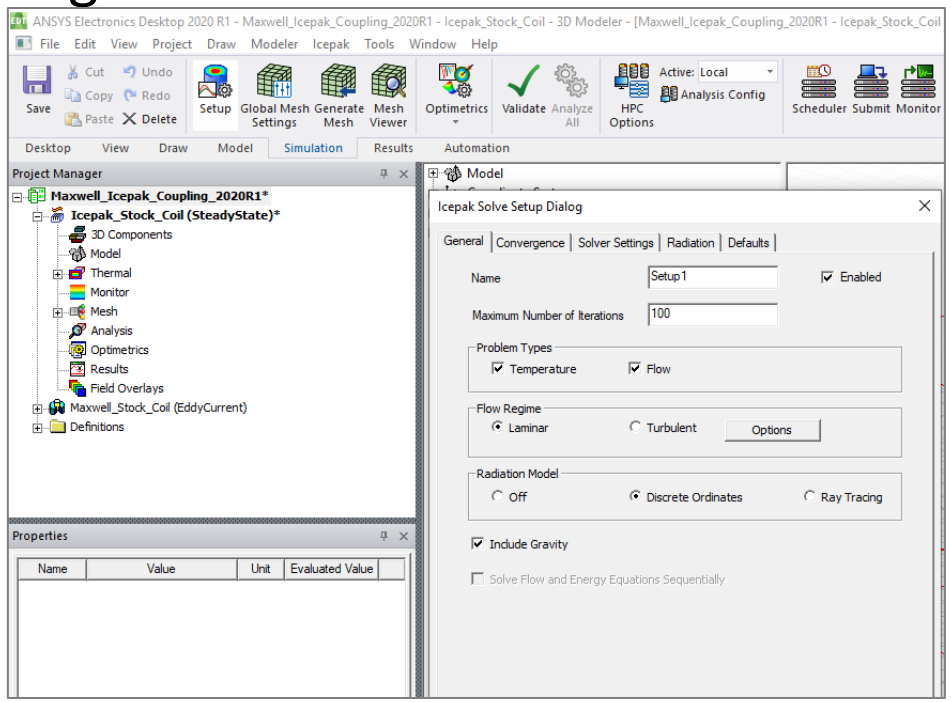


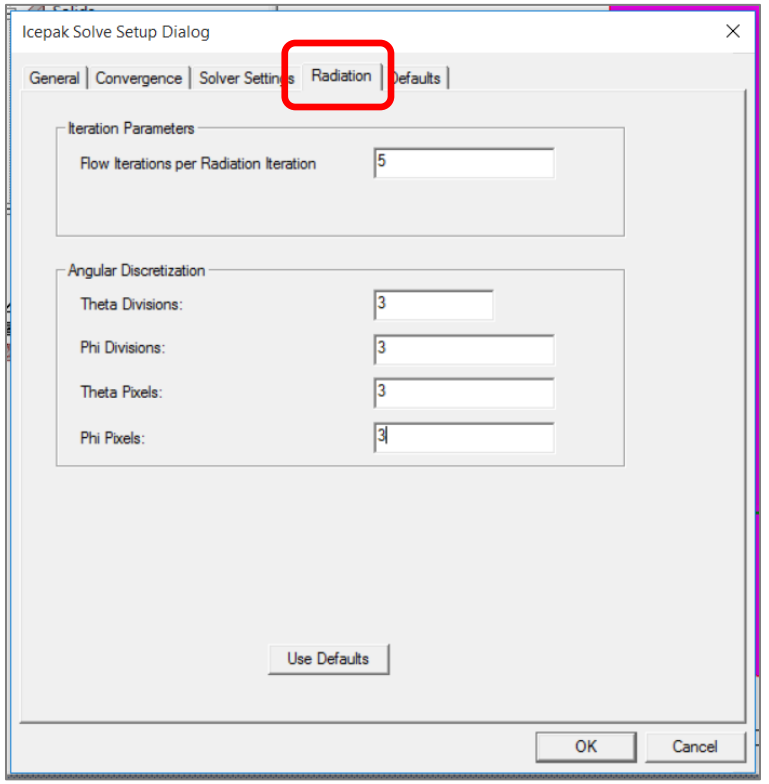




Icepak : Setup the Model for Thermal simulation

1. Click on ‘Setup’ to open Solve setup Panel.
2. In ‘General’ Tab:
   - Select Problem Types, Flow Regime and
   - Turn on DO Radiation Model and ‘Include Gravity’ option
3. Use finer settings for DO radiation model

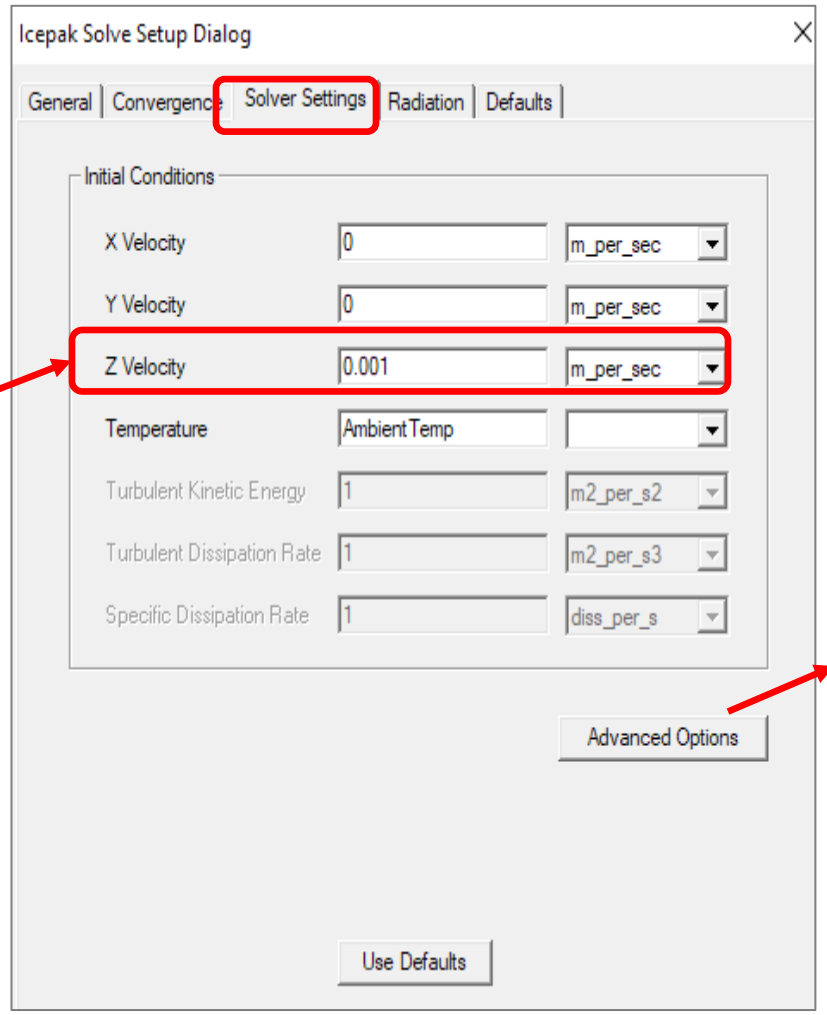


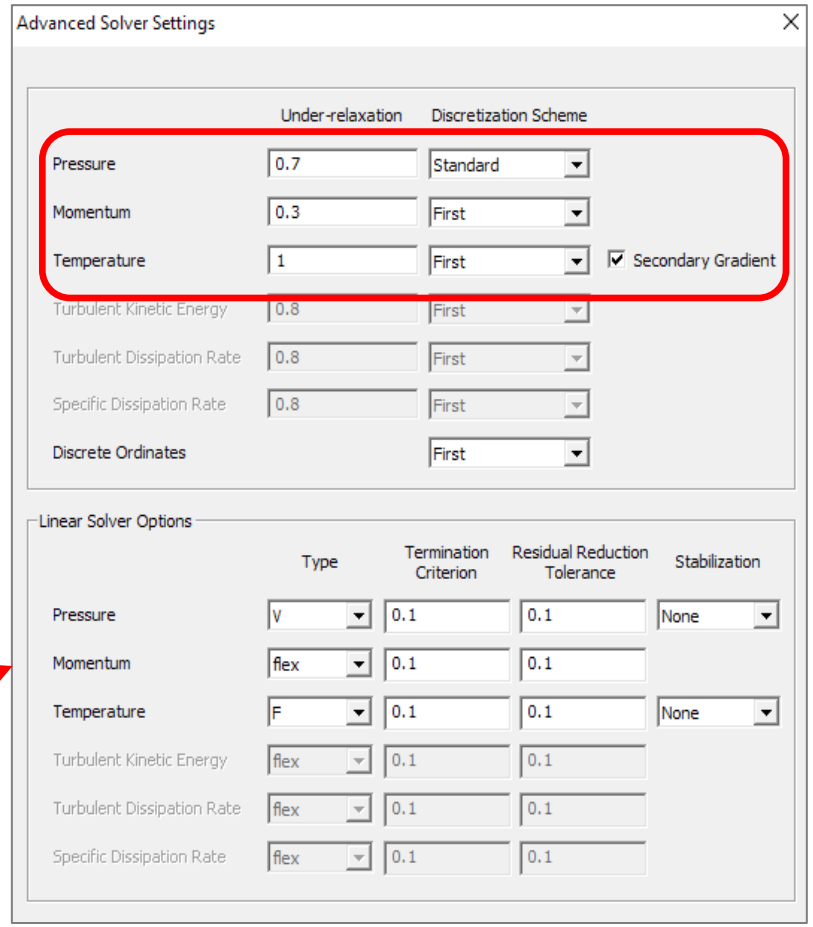


Icepak : Additional Setup

- Some additional settings for helping solver converge natural convection problems

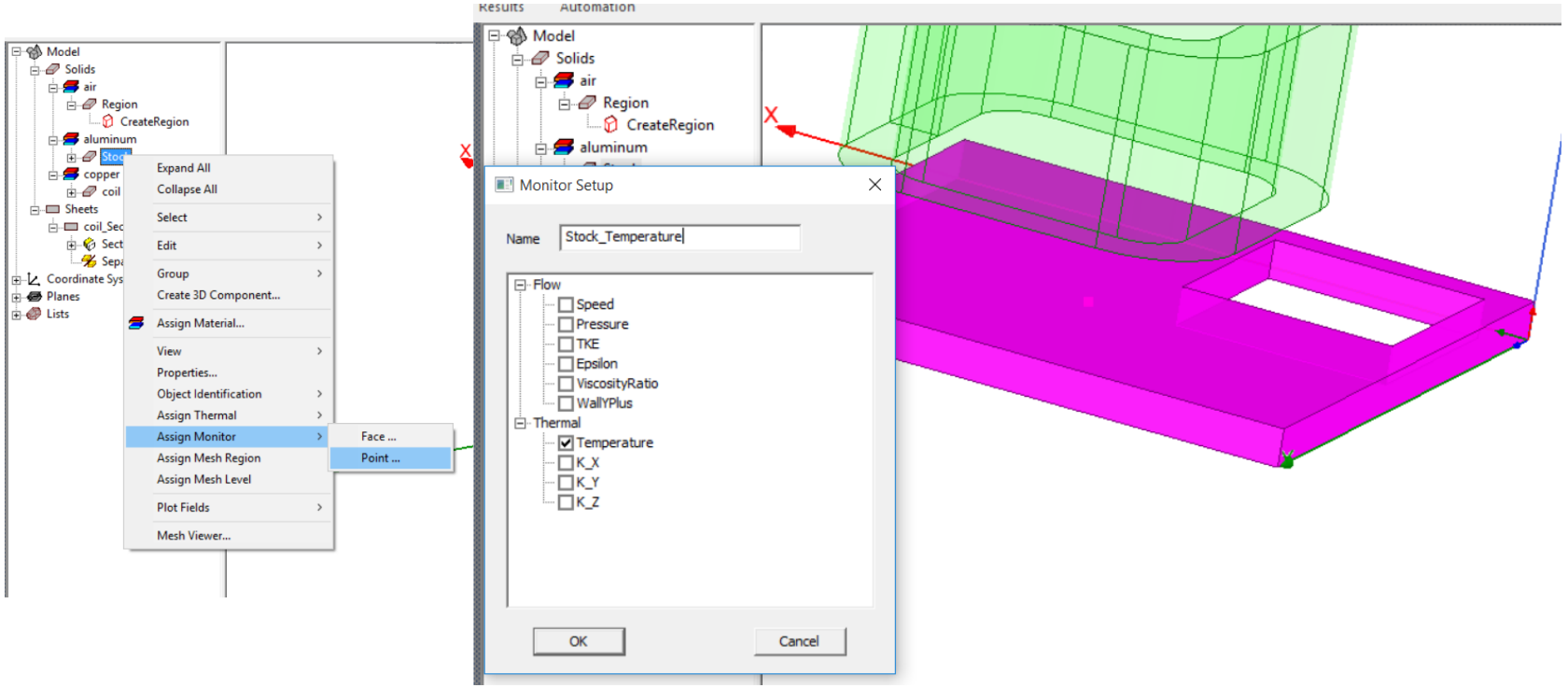
Recommended to provide small velocity in flow direction (due to natural convection plumes will rise opposite to gravity)





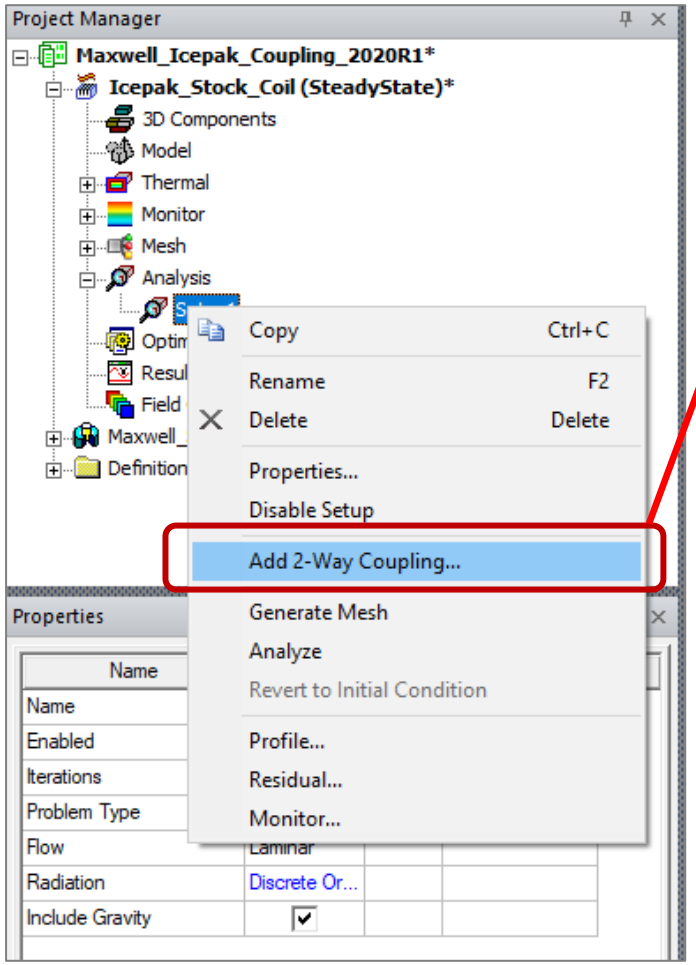
Icepak : Assign Monitor Point

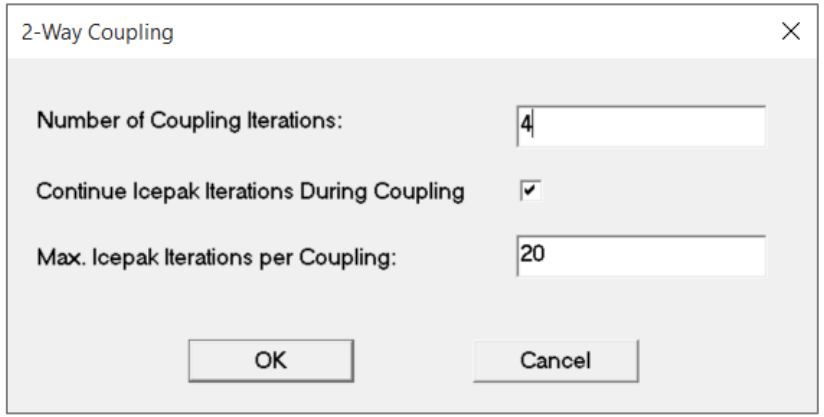
- Select Stock and right click Assign Monitor → Point…
- Rename monitor name as Stock_Temperature
- Select variables of interest Thermal > Temperature
- Note the monitor point location at the centre of stock

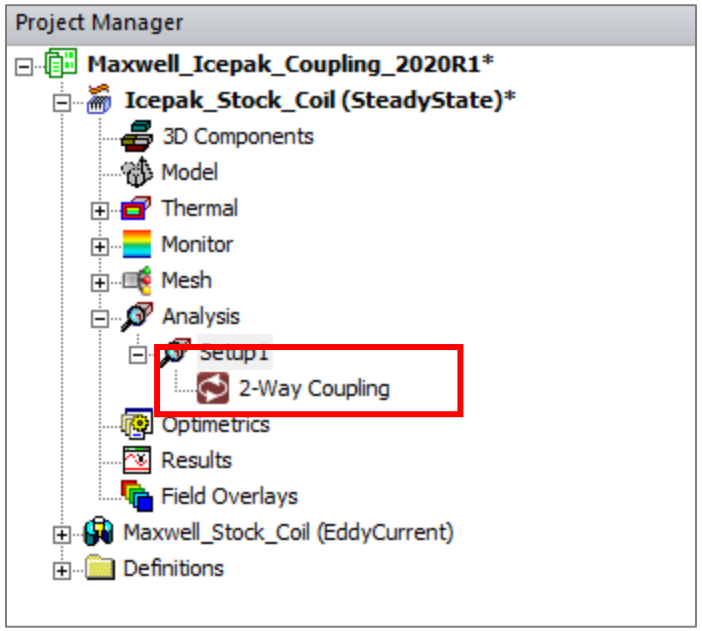


2-Way Coupling

Right click on Setup1 and select ‘ Add 2-Way Coupling

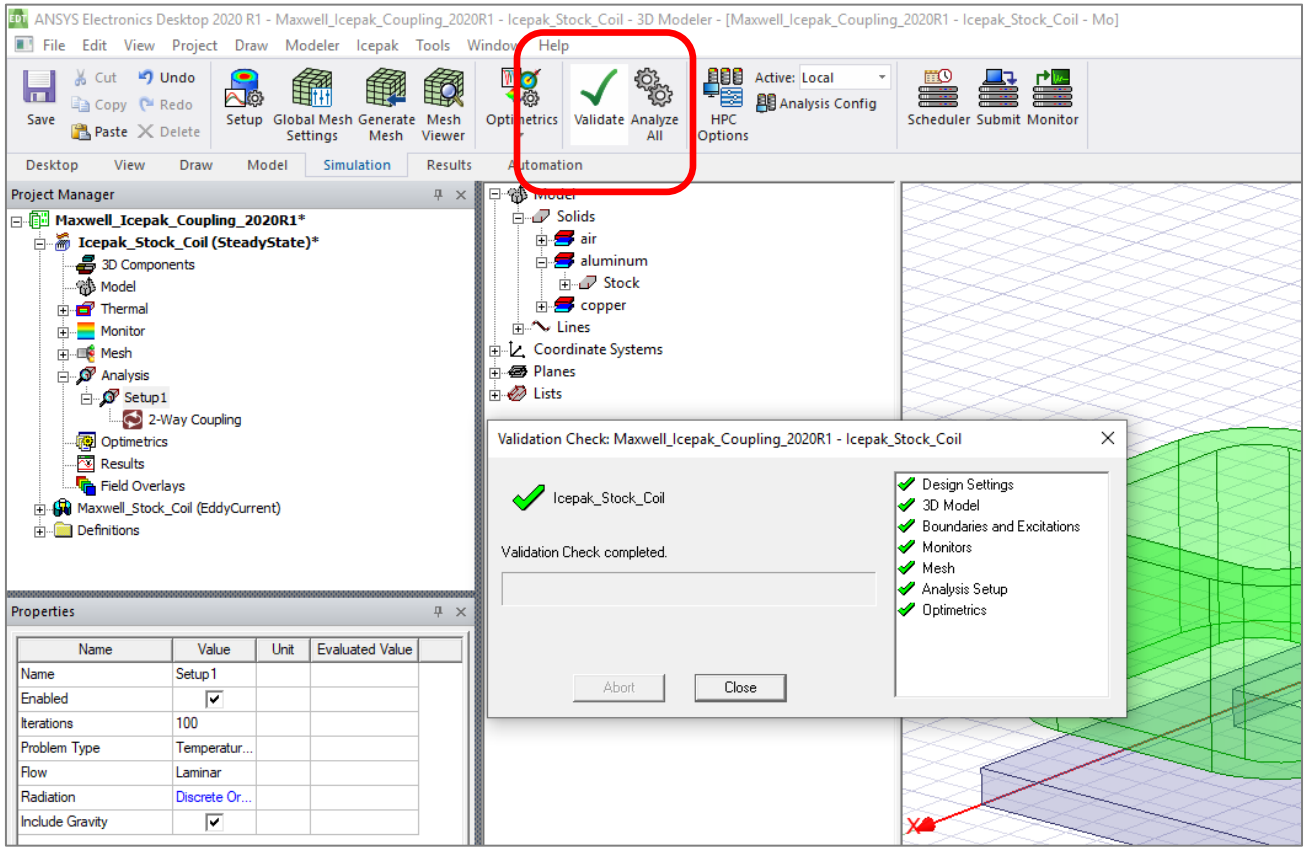


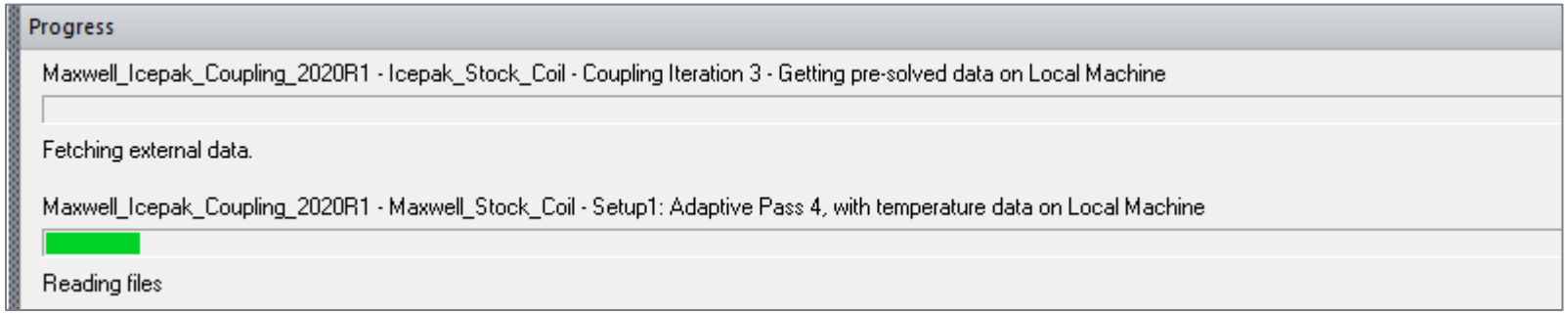




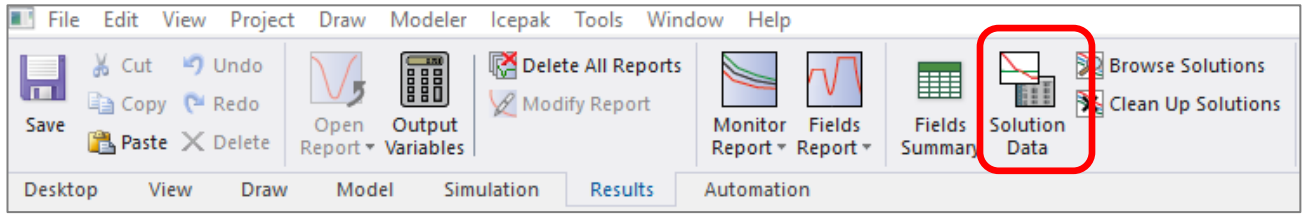
Icepak : Validation and Analyze

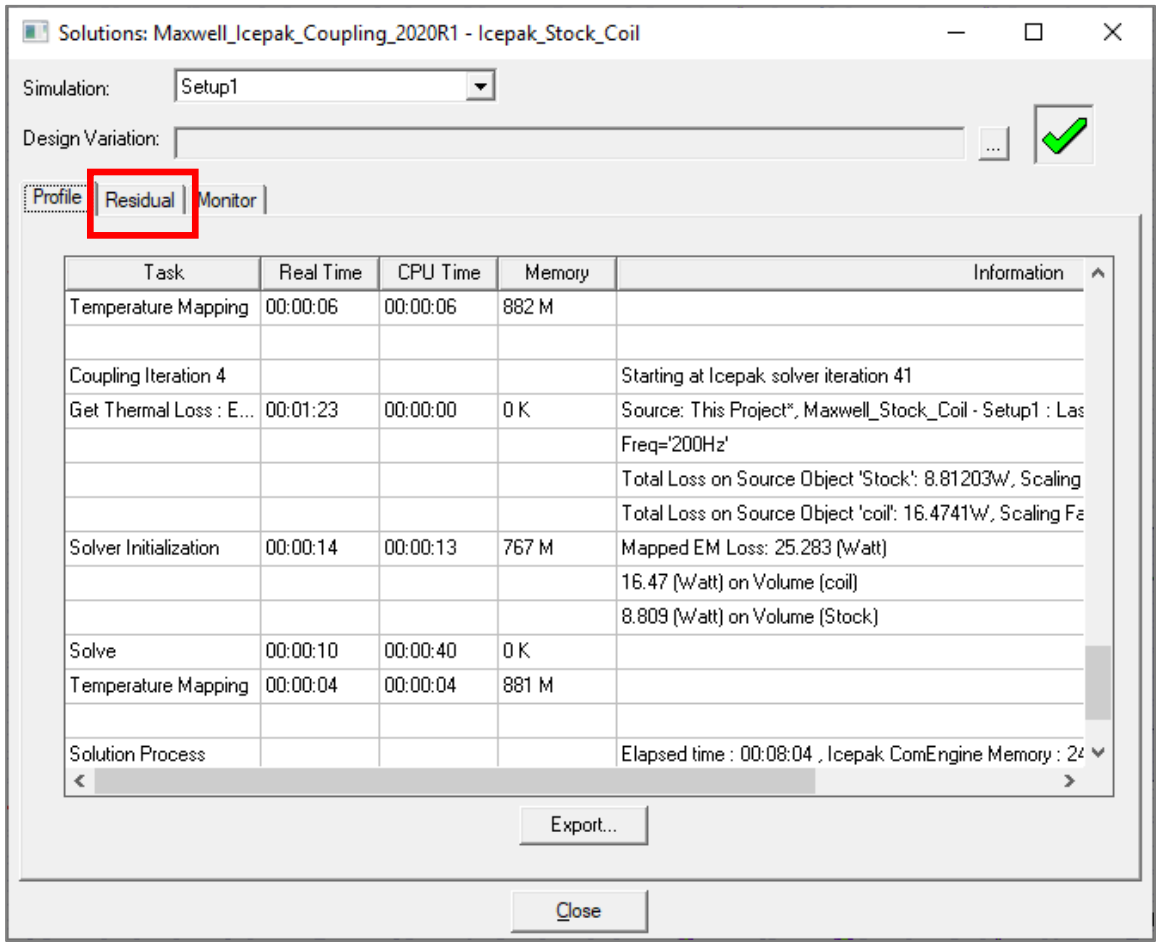
- Validation ensures all the elements of the setup are ready and good to solve!
- Click *Analyze All* to start the solver for 2-way coupling

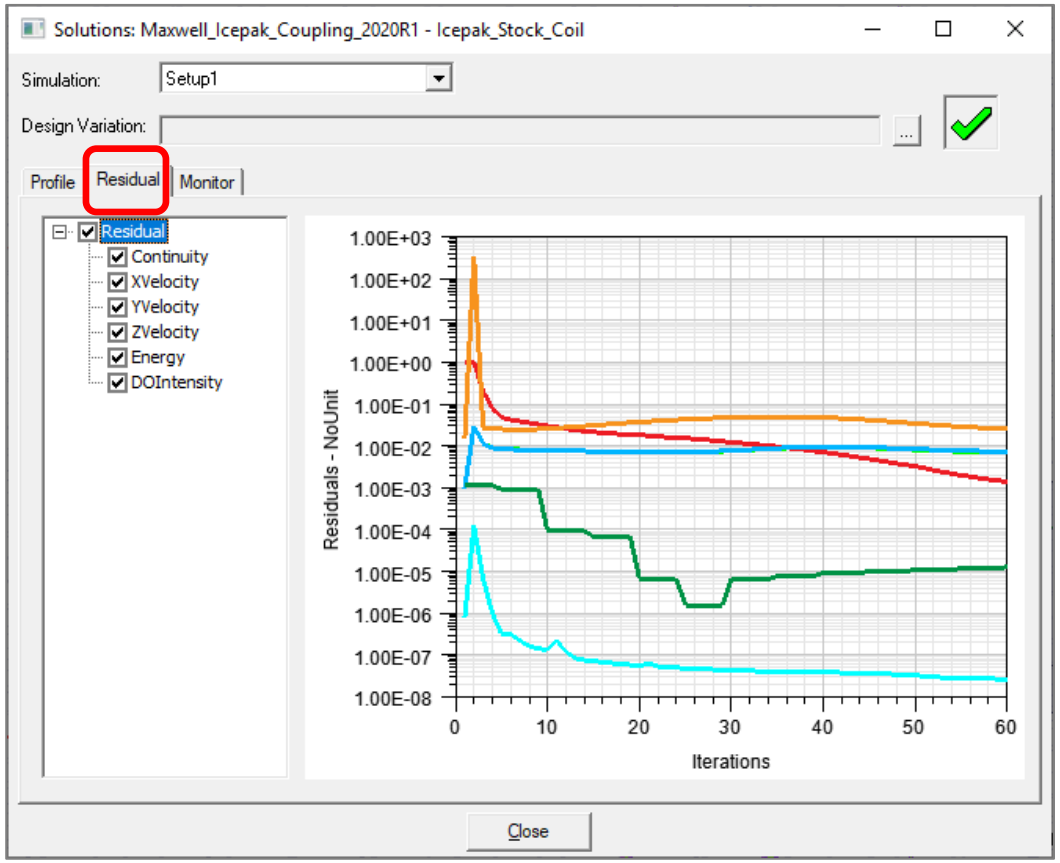




Icepak : Results

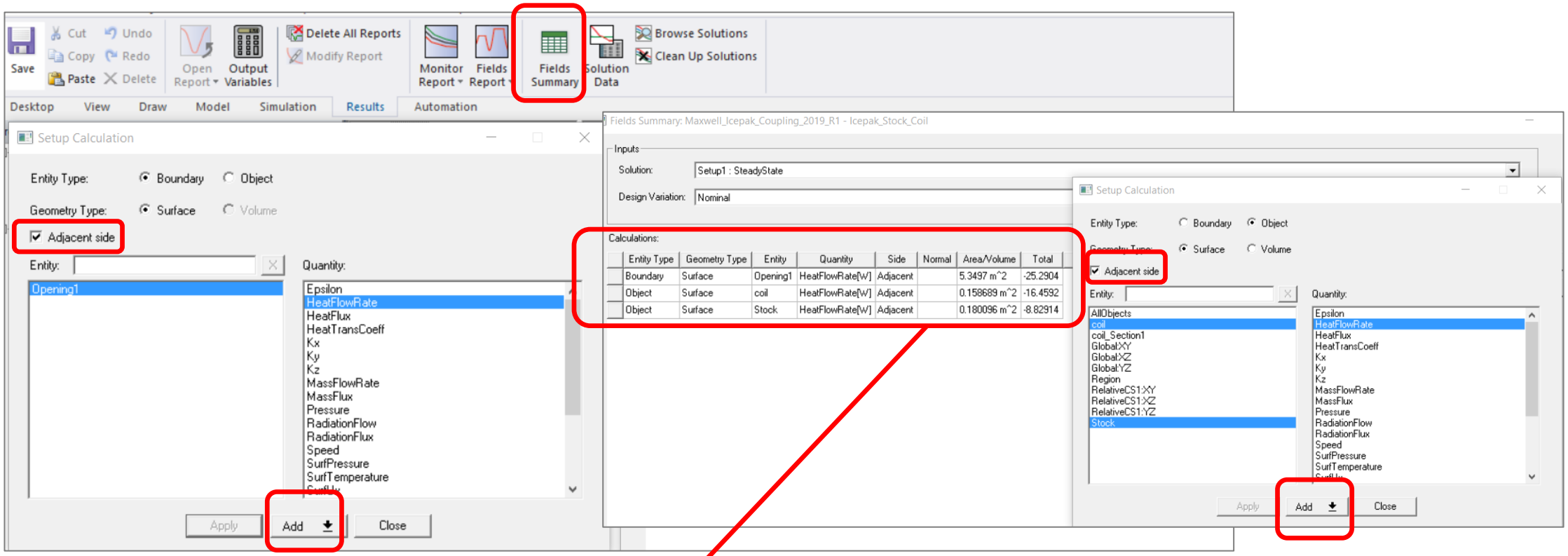






Icepak : Results – Heat Balance Check

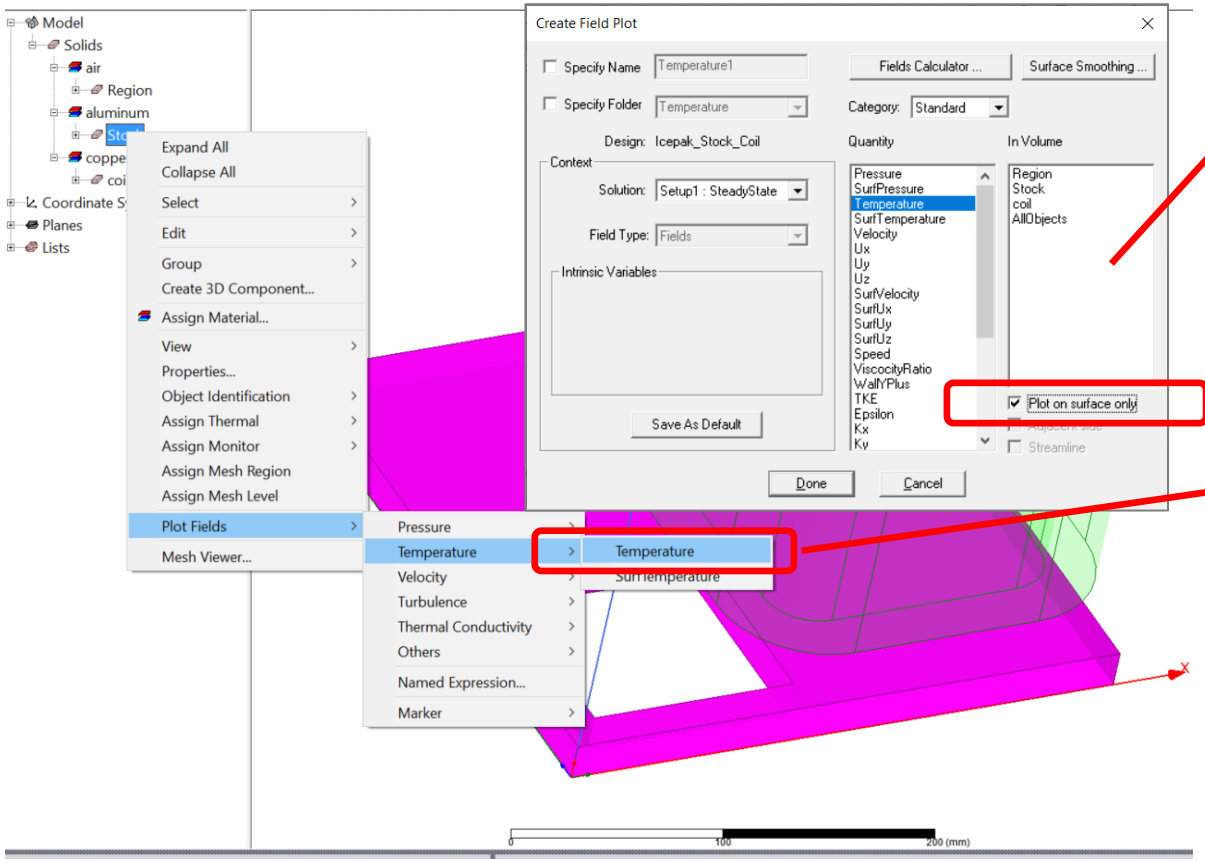
Heat Flow Rate through Opening1 Boundary and Coil and Stock

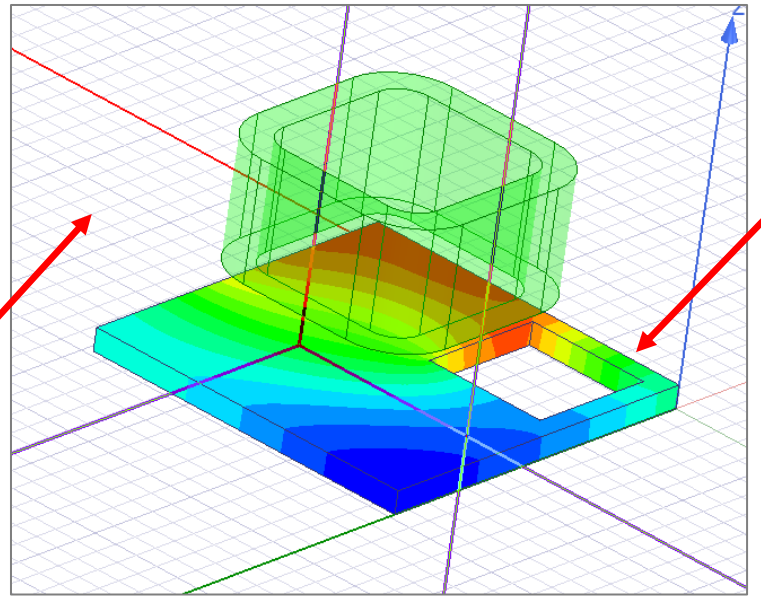


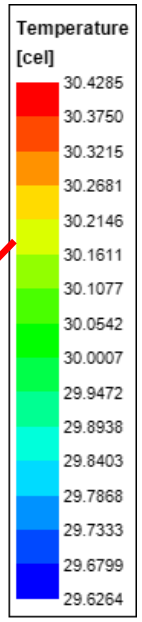
Total heat dissipated out from the openings should match the Ohmic loss generated by Coil & Stock

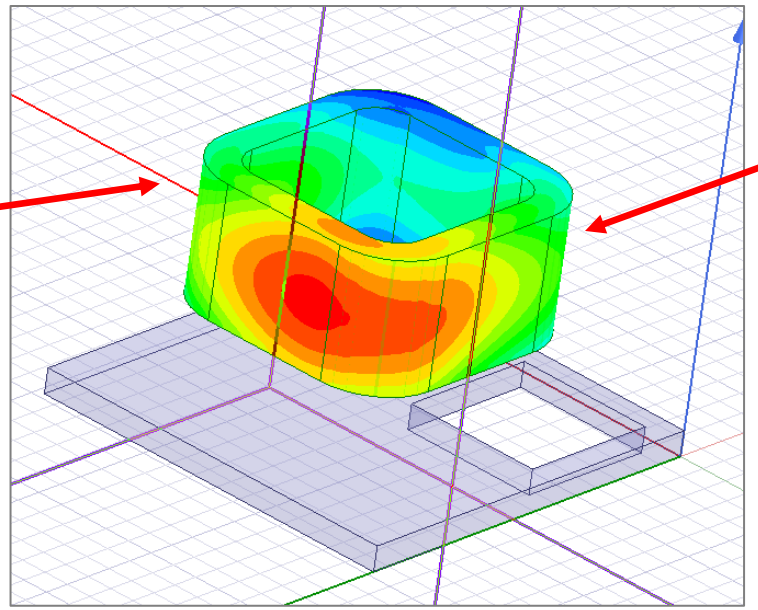
Icepak : Results - Contour Field

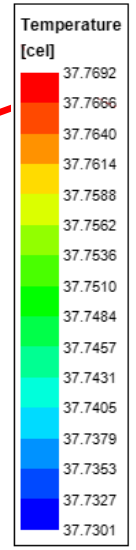
1. Select Coil from Model tree and plot temperature, make sure that check **Plot on surface only**
2. Similarly plot temperature for Stock





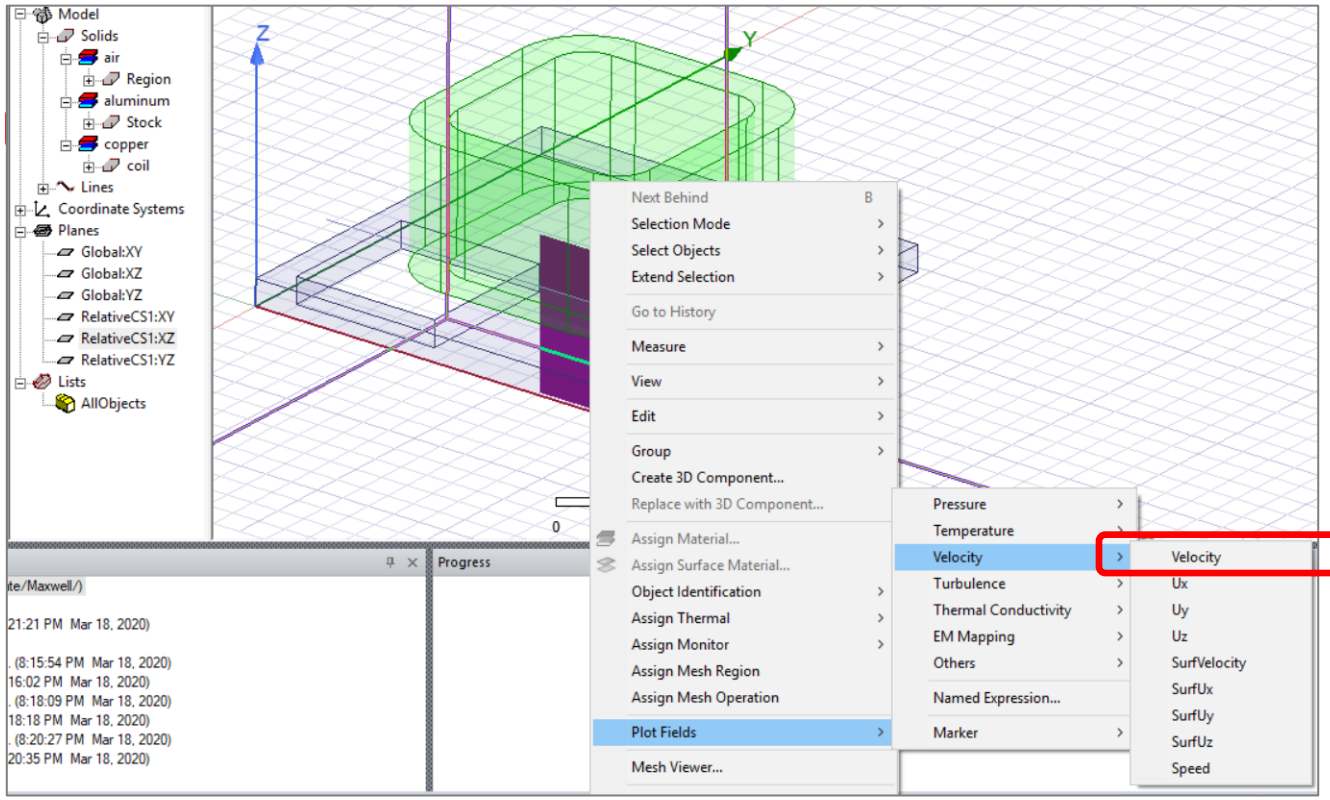


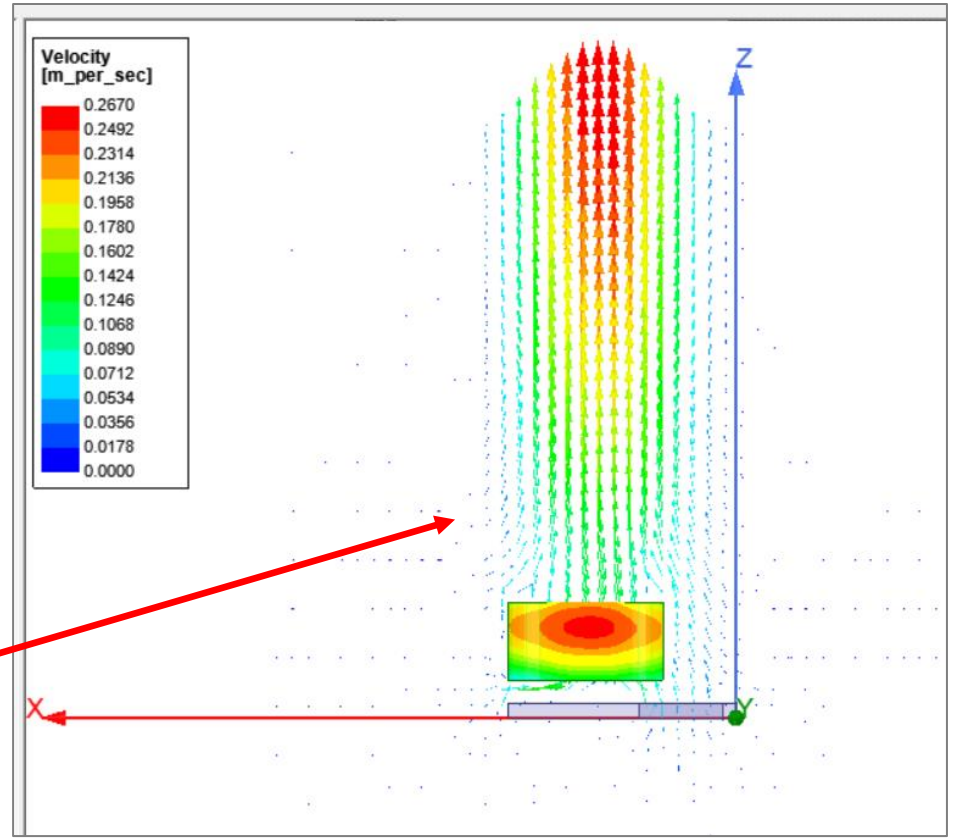




Icepak : Results Vector Field

- **Select Plane RelativeCS1:XZ and right click to Plot Velocity Field**





End of presentation