ANSYS

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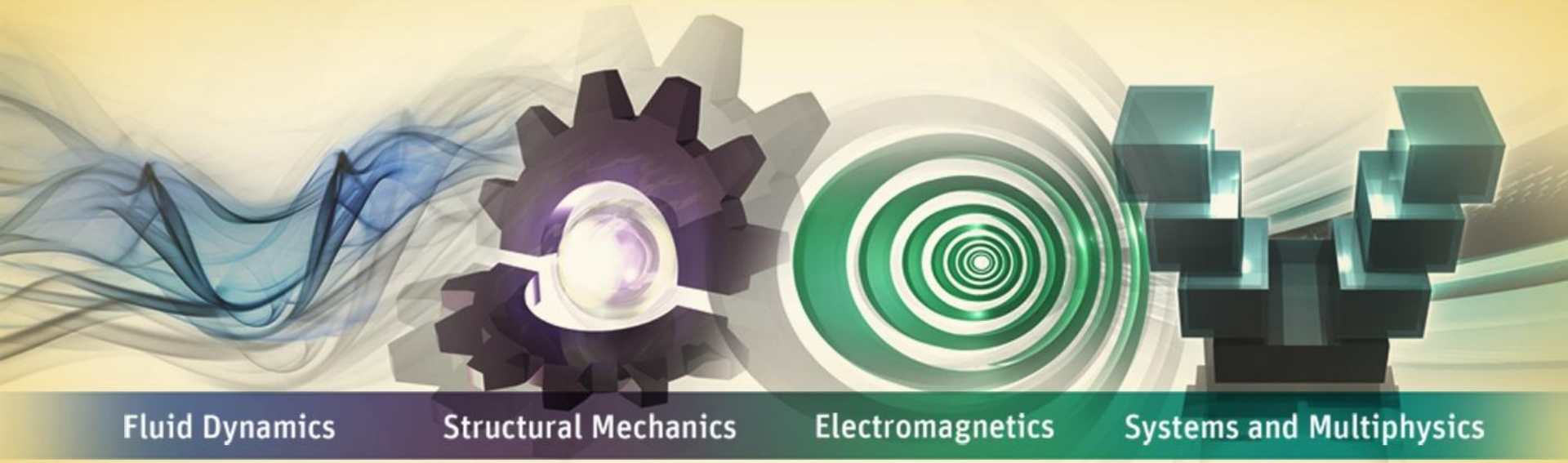
# Workshop 9:
# Basic Postprocessing



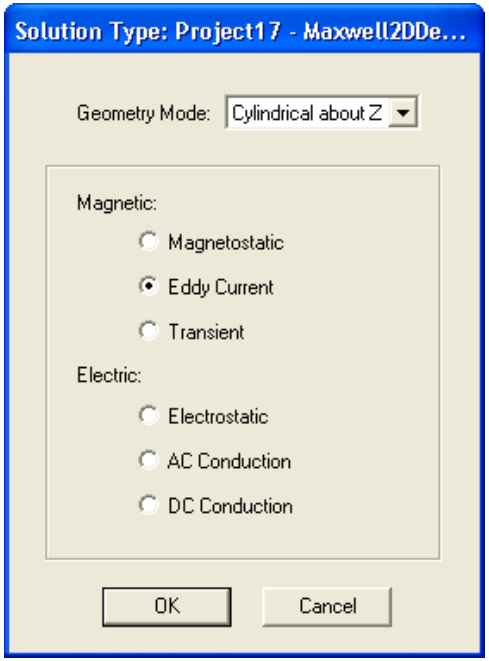

## ANSYS Maxwell 2D V16

# About Workshop

- **Post Processing in Maxwell 2D**
  - This workshop will discuss how to use the Maxwell 2D Post Processor. Field plots and calculator operations will demonstrated on an Eddy Current project. The following tasks will be performed:
    - Plot the mesh
    - Plot of MagB
    - Plot of B_vector
    - Plot of MagH along a line
    - Create a table of MagH along a line
    - Calculate average MagB in an object
    - Verify DivB = 0
    - Calculate loss in the conductor
    - Calculate net and total current flowing in the conductor
    - Export field results to a file.

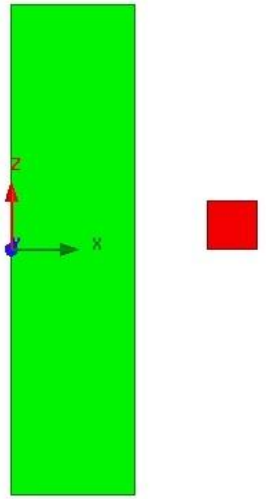
# Problem Setup

- **Create Design**
  - Select the menu item ***Project → Insert Maxwell 2D Design***, or click on the icon
  - Change the name of the Design to **Post_exercise**
- **Set Solution Type**
  - Select the menu item ***Maxwell 2D → Solution Type***
  - Solution Type Window:
    1. Geometry Mode: **Cylindrical about Z**
    2. Choose **Magnetic > Eddy Current**
    3. Click the **OK** button



# Create Model

- **Create Core**
  - Select the menu item ***Draw → Rectangle***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z:-10**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 5, dY: 0, dZ: 20**, Press the **Enter** key
  - Change the name of the sheet to **Core** and material to **iron**
- **Create Coil**
  - Select the menu item ***Draw → Rectangle***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 8, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 2, dY: 0, dZ: 2**, Press the **Enter** key
  - Change the name of the sheet to **Coil** and material to **copper**

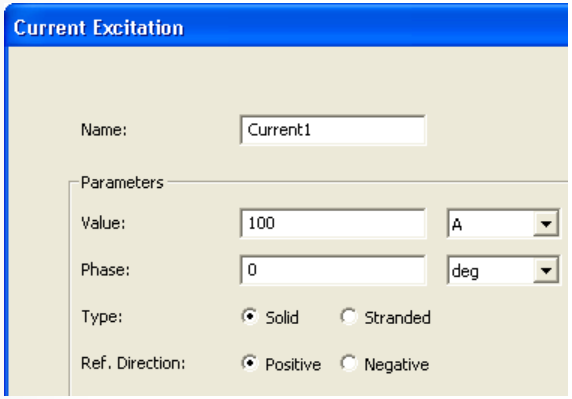


# Create Model (*Contd…*)

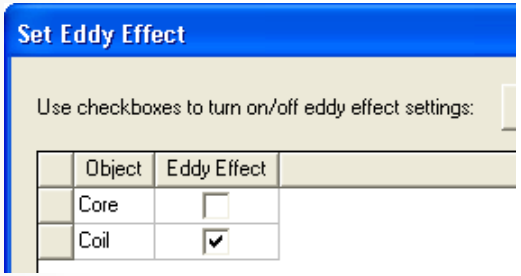
- **Create a line for plotting of the fields**
  - Select the menu item ***Draw → Line***
    1. Using the coordinate entry fields, enter the first vertex
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the second vertex
       - **X: 0, Y: 0, Z: 20**, Press the **Enter** key
    3. Press **Enter** to exit line creation
- **Create Simulation Region**
  - Select the menu item ***Draw → Region***
  - In Region window,
    1. Padding all directions similarly: ☑ **Checked**
    2. Padding Type: Percentage Offset
       - Value: **100**
    3. Press **OK**

# Assign Excitation

- **Assign Excitation**
  - Select the sheet **Coil** from the history tree
  - Select the menu item ***Maxwell 2D → Excitations → Assign → Current***
  - In Current Excitation window,
    1. Value: **100 A**
    2. Phase: **0**
    3. Type: **Solid**
    4. Press **OK**



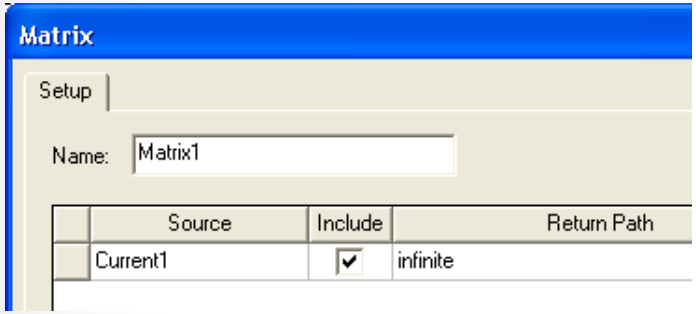

- **Set Eddy Calculations**
  - Select the menu item ***Maxwell 2D → Excitations → Set Eddy Effect***
  - In Set Eddy Effect window,
    1. **Core**
       - Eddy Effects: ☐ **Unchecked**
    2. Press **OK**




***Note: Eddy Effects can be calculated only with solid excitations. For Stranded coils eddy effects are not considered.***

# Assign Parameters and Boundary

- **Setup Impedance Calculations**
  - Select the menu item ***Maxwell 2D → Parameters → Assign → Matrix***
  - In Matrix window,
    1. **Current1**:
       - Include: ☑ **Checked**
    2. Press **OK**




- **Assign Boundary**
  - Select the sheet **Region** from history tree
  - Select the menu item ***Edit → Select → All Object Edges***
  - Select the menu item ***Maxwell 2D → Boundaries → Assign → Balloon***
  - In Balloon Boundary window,
    - Press **OK**

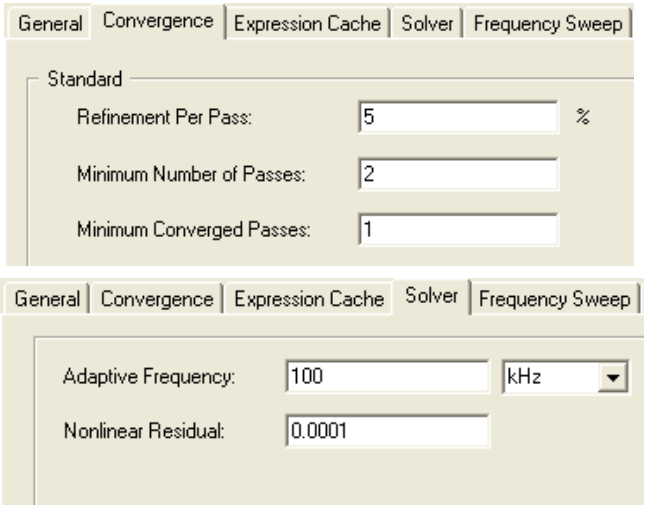
***Note: On symmetry axis, "Balloon Boundary" assignment is automatically skipped, This can also be achieved by selecting the edges of region which are not on symmetry axis.***

# Apply Mesh Operations

- **Apply Mesh Operations for Core**
  - Select the sheet **Core** from the history tree
  - Select the menu item ***Maxwell 2D → Mesh Operations → Assign → Inside Selection → Length Based***
  - In Element Length Based Refinement window,
    1. Name: **Length1**
    2. Restrict Length Of Elements: ☐ **Unchecked**
    3. Restrict the Number of Elements: ☑ **Checked**
    4. Maximum Number of Elements: **500**
    5. Press **OK**
- **Apply Mesh Operations for Coil**
  - Similarly assign mesh operation to **Coil** with following parameters
    1. Name: **Length2**
    2. Restrict Length Of Elements: ☐ **Unchecked**
    3. Restrict the Number of Elements: ☑ **Checked**
    4. Maximum Number of Elements: **500**
    5. Press **OK**

# Analyze

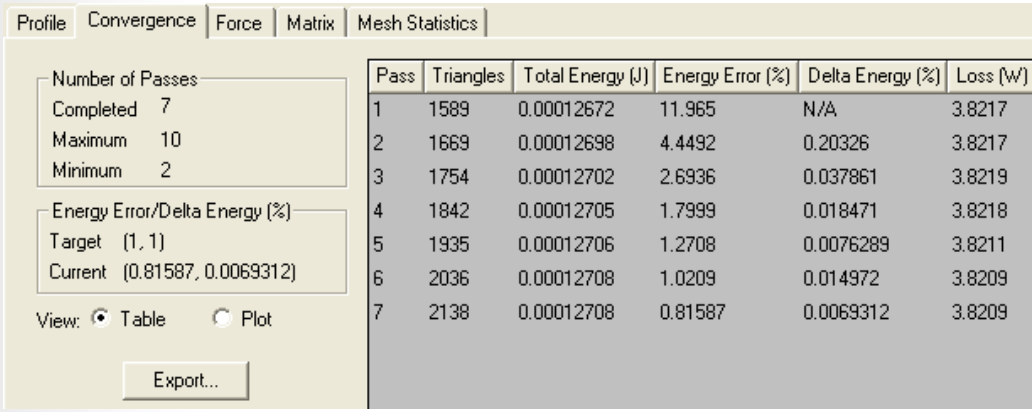
- **Create an analysis setup:**
  - Select the menu item ***Maxwell 2D → Analysis Setup → Add Solution Setup***
  - Solution Setup Window:
    1. **Convergence** tab
       - Refinement Per Pass: **5 %**
    2. **Solver** tab
       - Adaptive Frequency: **100 kHz**
    3. Click the **OK** button




- **Run Solution**
  - Select the menu item ***Maxwell 2D → Analyze All***

# Solution Data

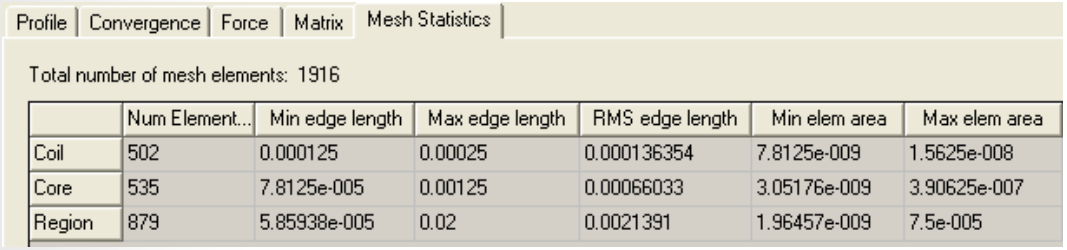
- **View the Solution Data:**
  - Select the menu item ***Maxwell 2D → Results → Solution Data***
  - To view the Profile:
    1. Click the **Profile** Tab.
  - To view the Convergence:
    1. Click the **Convergence** Tab




| Pass | Triangles | Total Energy (J) | Energy Error (%) | Delta Energy (%) | Loss (W) |
|---|---|---|---|---|---|
| 1 | 1589 | 0.00012672 | 11.965 | N/A | 3.8217 |
| 2 | 1669 | 0.00012698 | 4.4492 | 0.20326 | 3.8217 |
| 3 | 1754 | 0.00012702 | 2.6936 | 0.037861 | 3.8219 |
| 4 | 1842 | 0.00012705 | 1.7999 | 0.018471 | 3.8218 |
| 5 | 1935 | 0.00012706 | 1.2708 | 0.0076289 | 3.8211 |
| 6 | 2036 | 0.00012708 | 1.0209 | 0.014972 | 3.8209 |
| 7 | 2138 | 0.00012708 | 0.81587 | 0.0069312 | 3.8209 |

***Note: The default view is for convergence is Table. Select the Plot radio button to view a graphical representations of the convergence data.***

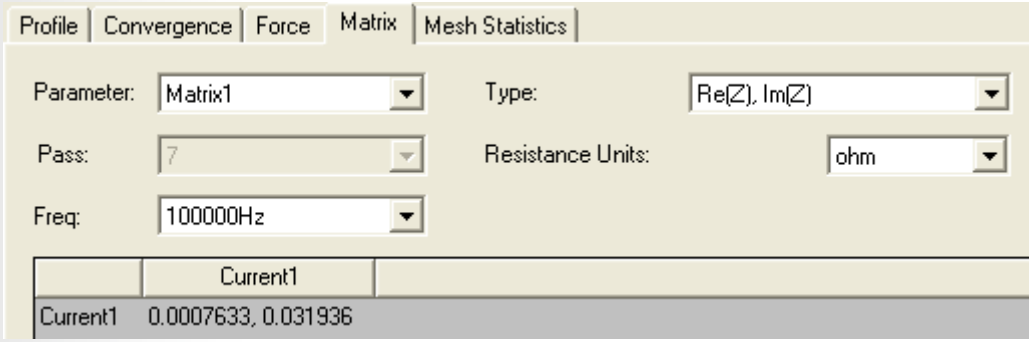
  - To View Mesh information
    1. Click **Mesh Statistics** Tab




| | Num Element... | Min edge length | Max edge length | RMS edge length | Min elem area | Max elem area |
|---|---|---|---|---|---|---|
| Coil | 502 | 0.000125 | 0.00025 | 0.000136354 | 7.8125e-009 | 1.5625e-008 |
| Core | 535 | 7.8125e-005 | 0.00125 | 0.00066033 | 3.05176e-009 | 3.90625e-007 |
| Region | 879 | 5.85938e-005 | 0.02 | 0.0021391 | 1.96457e-009 | 7.5e-005 |

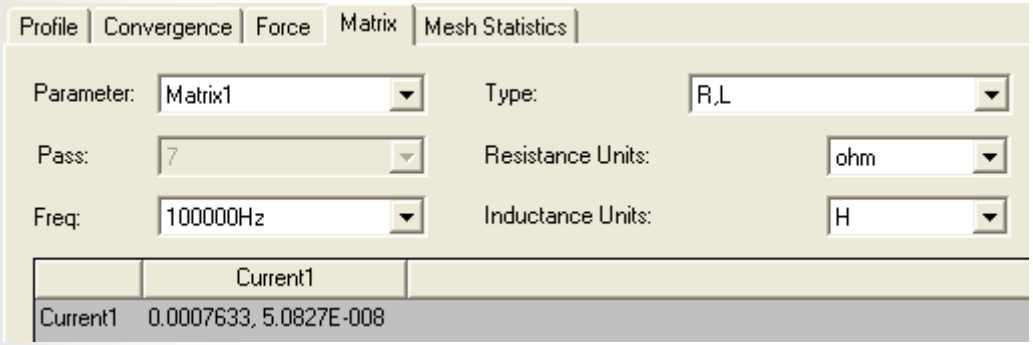
# Solution Data (*Contd…*)

- **View Matrix Results**
  - To View Impedance values
    1. Click **Matrix** tab
    2. Set Type to **Re(Z), Im(Z)**




***Note: the imaginary term of the matrix includes both the inductive and capacitive reactance are reported in Ohms.***

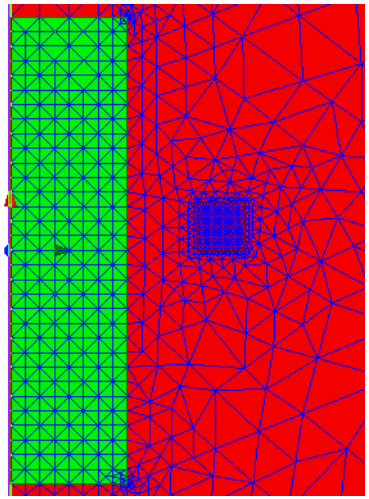
3. Change Type to **R,L**



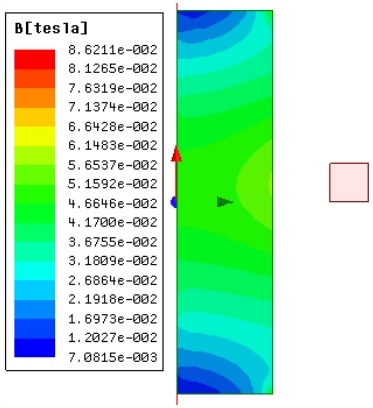

***Note: the imaginary term of the matrix includes only the inductance and is reported in Ohms and Henries***

# Create Field Plots

- **Plot Mesh**
  - Select the menu item ***Edit → Select All***
  - Select the menu item ***Maxwell 2D → Fields → Plot Mesh***
  - In Create Mesh Plot window,
    1. Press **Done**



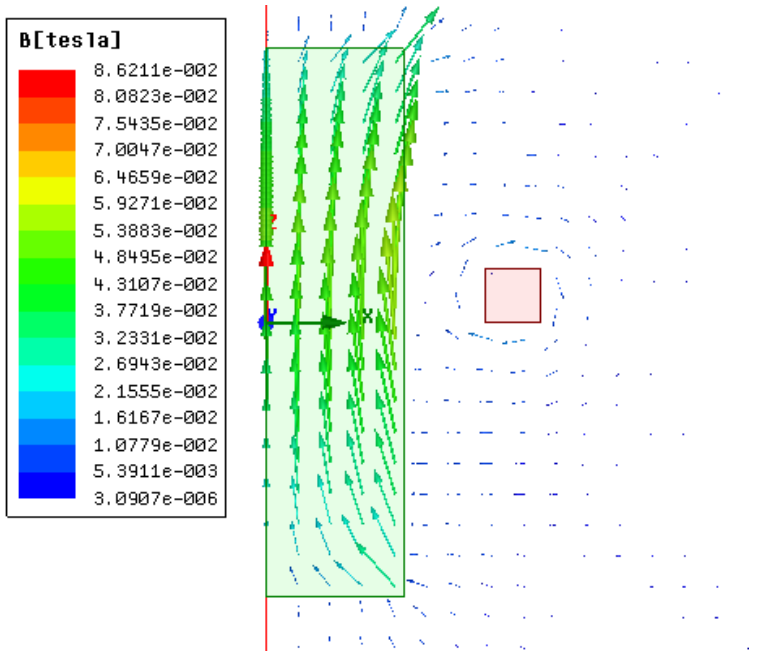
- **Plot Mag_B**
  - Select the sheet **Core** from the history tree
  - Select the menu item ***Maxwell 3D → Fields → Fields → B → Mag_B***
  - In Create Field Plot window,
    1. Press **Done**




***Note: To hide the previously created filed plots, right click on plot from Project manager window and uncheck Plot Visibility***

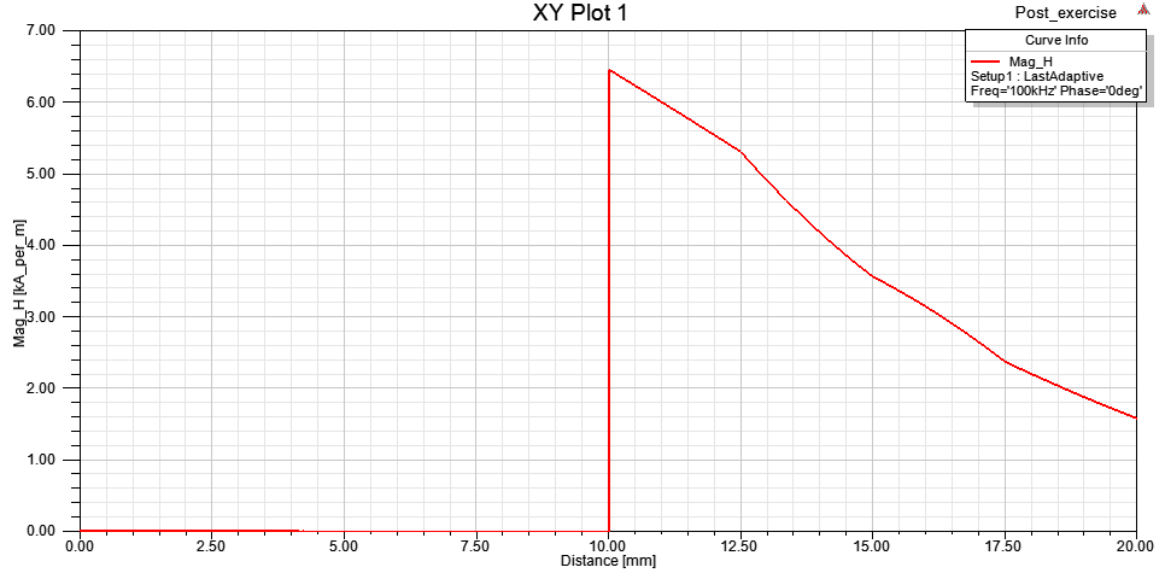
# Create Vector Plot

- **Plot Vector_B**
  - Select the menu item ***Edit → Select All***
  - Select the menu item ***Maxwell 2D → Fields → Fields → B → B_Vector***
  - In Create Field Plot window
    1. Press **Done**
  - Double click on the legend to change plot properties
  - In the window
    1. **Plots** tab
       - Plot: **B_Vector1**
       - Select the tab **OnSurface**
       - Vector Plot
         1. Spacing: **Five Spaces**
         2. Min: **0.5**
         3. Max: **2**
    2. Press **Apply** and **Close**



# Create XY Plot

- **Plot Mag_H along a Line**
  - Select the menu item ***Maxwell 2D → Results → Create Field Reports → Rectangular Plot***
  - In Report window.
    1. Geometry: **Polyline1**
    2. X : **Default**
    3. Category: **Calculator Expressions**
    4. Quantity: **Mag_H**
    5. Select **New Report**



# Create Data Table

- **Table of Mag_H along a Line**
  - Select the menu item ***Maxwell 2D → Results → Create Field Reports → Data Table***
  - In Report window.
    1. Geometry: **Polyline1**
    2. X : **Default**
    3. Category: **Calculator Expressions**
    4. Quantity: **Mag_H**
    5. Select **New Report**

| | Distance [mm] | Mag_H [kA_per_m] Setup1 : LastAdaptive Freq='100kHz' Phase='0deg' |
|---|---|---|
| 1 | 0.000000 | 0.009644 |
| 2 | 0.020000 | 0.009645 |
| 3 | 0.040000 | 0.009647 |
| 4 | 0.060000 | 0.009649 |
| 5 | 0.080000 | 0.009651 |
| 6 | 0.100000 | 0.009653 |
| 7 | 0.120000 | 0.009654 |
| 8 | 0.140000 | 0.009656 |
| 9 | 0.160000 | 0.009658 |
| 10 | 0.180000 | 0.009659 |
| 11 | 0.200000 | 0.009661 |
| 12 | 0.220000 | 0.009663 |
| 13 | 0.240000 | 0.009664 |
| 14 | 0.260000 | 0.009666 |
| 15 | 0.280000 | 0.009667 |
| 16 | 0.300000 | 0.009669 |
| 17 | 0.320000 | 0.009670 |
| 18 | 0.340000 | 0.009671 |
| 19 | 0.360000 | 0.009673 |
| 20 | 0.380000 | 0.009674 |
| 21 | 0.400000 | 0.009675 |

# Calculate Average Mag_B

- **Calculate Average Mag_B in an Object**
  - Select the menu item ***Maxwell 2D → Fields → Calculator***
    1. Select **Input > Quantity > B**
    2. Select **General > Complex > Real**
    3. Select **Vector > Mag**
    4. Select **Input > Geometry**
       - Select **Volume > Core >** Press **OK**
    5. Select **Scalar > Integral > RZ**
    6. Select **Input > Number**
       - Select **Scalar > Value: 1 >** Press **OK**
    7. Select **Input > Geometry**
       - Select **Volume > Core >** Press **OK**
    8. Select **Scalar > Integral > RZ**
    9. Select **General > / (Divide)**
    10. Select **Output > Eval**

```
Scl : 0.0382242802204938
Scl : /(RZIntegrate(Volume(Core), Mag(Real(<Br,0,Bz>))), RZIntegrate(Volume(Core), 1))
```

  - The average value of flux density calculated is around **0.038 Tesla**

# Calculate DivB

- **Calculate DivB**
  - In Field Calculator window,
    1. Select the button **Clear** to remove previous expression
    2. Select **Input > Quantity > B**
    3. Select **General > Complex > Real**
    4. Select **Vector > Divg**
    5. Select **Input > Geometry**
       - Select **Volume > Core >** Press **OK**
    6. Select **Scalar > Integral > RZ**
    7. Select **Output > Eval**

```
Scl : 1.84067713921683E-009
Scl : RZIntegrate(Volume(Core), Divg(Real(<Br,0,Bz>)))
```

  - The divergence of B is approximately zero

# Calculate loss in a conductor

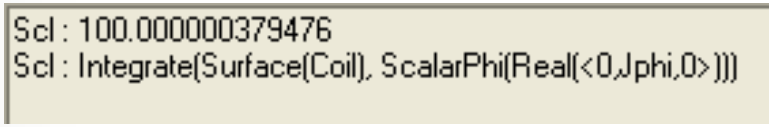
- **Calculate losses in Coil**
  1. Select the button **Clear** to remove previous expression
  2. Select **Input > Quantity > OhmicLoss**
  3. Select **Input > Geometry**
     - Select **Volume > Coil >** Press **OK**
  4. Select **Scalar > Integral > RZ**
  5. Select **Output > Eval**

```
Scl: 3.82081517243659
Scl: RZIntegrate(Volume(Coil), Ohmic-Loss)
```

  - The ohmic loss in the coil at 100kHz is approximately **3.82 Watts.**

# Calculate Current in Conductor

- **Calculate Net Current in Coil**
  1. Select the button **Clear** to remove previous expression
  2. Select **Input > Quantity > J**
  3. Select **General > Complex > Real**
  4. Select **Vector > Scal? > ScalarPhi**
  5. Select **Input > Geometry**
     - Select **Surface > Coil >** Press **OK**
  6. Select **Scalar > Integral >XY**
  7. Select **Output > Eval**




  - The net current in the coil is equal to the source amp-turns = **+/- 100**

***Note: Since total current needs to be calculated over the 2D section of Coil, Integration is done with XY integral and not RZ***

# Calculate Current in Conductor (*Contd…*)

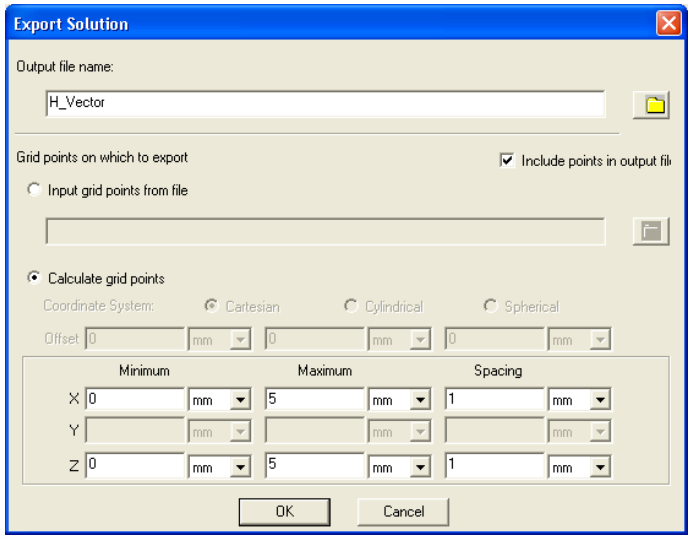
- **Calculate Total Current including Eddy Component**
  1. Select the button **Clear** to remove previous expression
  2. Select **Input > Quantity > J**
  3. Select **General > Complex > CmplxMag**
  4. Select **Vector > Scal? > ScalarPhi**
  5. Select **Input > Geometry**
     - Select **Surface > Coil >** Press **OK**
  6. Select **Scalar > Integral >XY**
  7. Select **Output > Eval**

```
Scl : 129.921385972135
Scl : Integrate(Surface(Coil), ScalarPhi(CmplxMag(<0,Jphi,0>)))
```

  - Calculated value of current comes out to be around **130 A**

# Export Field Results

- **Export Results to a file**
  1. Select the button **Clear** to remove previous expression
  2. Select **Input > Quantity > H**
  3. Select **Output > Export**
  4. In Export Solution window,
     - Output file name: **H_Vector**
     - Calculate grid points: ☑ **Checked**
     - Minimum: **(0, 0)**
     - Maximum: **(5, 5)**
     - Spacing: **(1, 1)**




***Note: In order to use the field results in another software program, you can export the fields on a uniform 2-dimensional grid.***

***In the dialogue box***

- ***Minimum: The minimum coordinates of the grid, and unit of measure***
- ***Maximum: The maximum coordinates of the grid, and unit of measure***
- ***Spacing: The distance between grid points, and unit of measure***