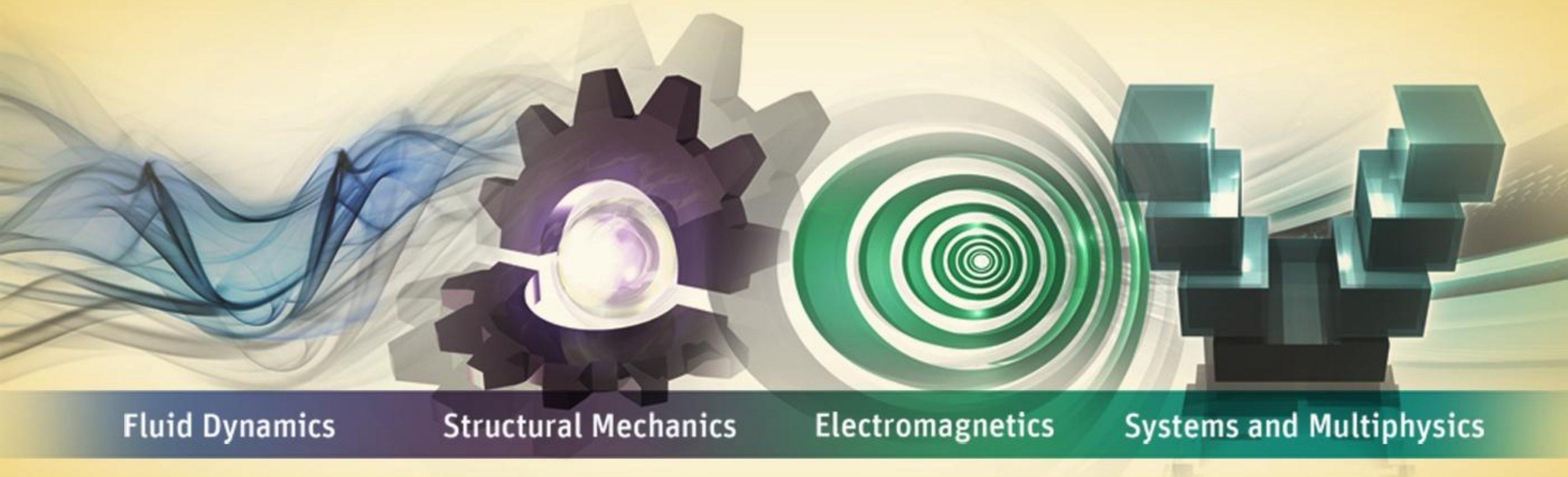
Realize Your Product Promise™

Workshop 9: Basic Postprocessing



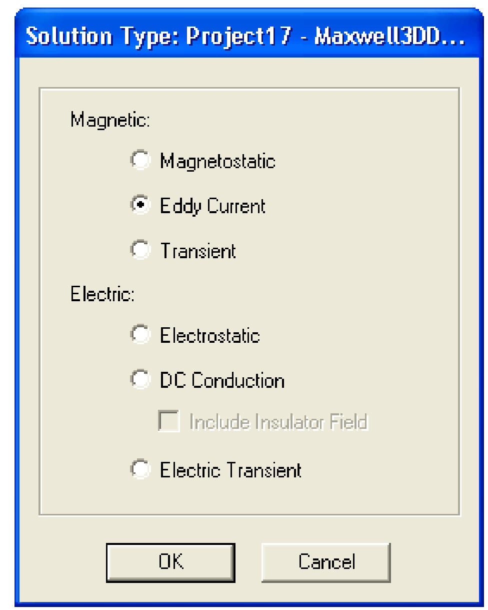
ANSYS Maxwell 3D V16

About Workshop

- **Post Processing in Maxwell 3D**
  - This workshop will discuss how to use the Maxwell 3D Post Processor. Field plots and calculator operations will demonstrated on an Eddy Current project. The following tasks will be performed:
    - Plot the mesh on the core and coil
    - Plot of MagB on a plane
    - Plot of B_vector on a plane
    - Plot of MagH along a line
    - Create a table of MagH along a line
    - Calculate average MagB in an object
    - Verify DivB = 0
    - Calculate flux flowing through the top surface of the core
    - Calculate loss in the conductor
    - Calculate net and total current flowing in the conductor
    - Export field results to a file.

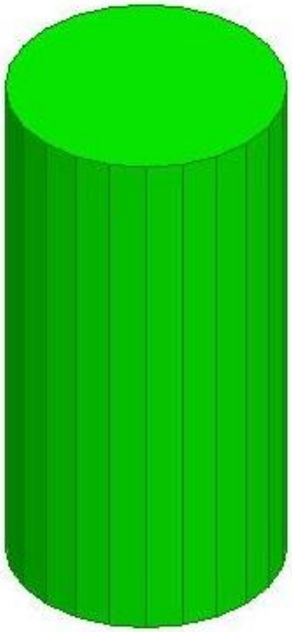
Problem Setup

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



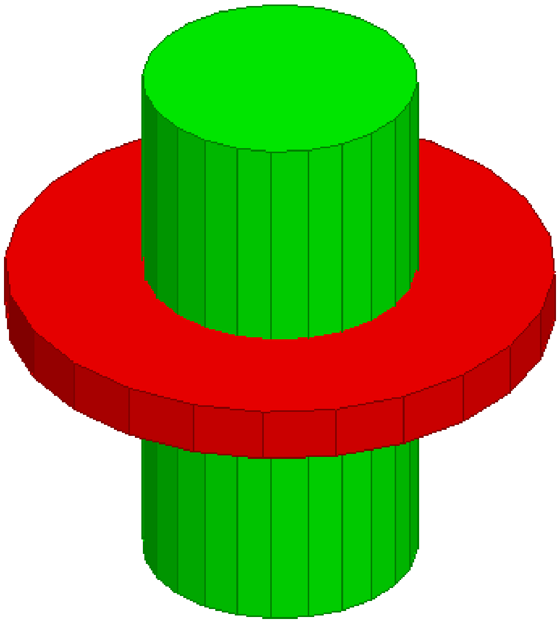
Create Core

- **Create Regular Polyhedron**
  – Select the menu item ***Draw → Regular Polyhedron***
    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 and height
       – **dX: 0, dY: 5, dZ: 20**, Press the **Enter** key
    3. Number of Segments: **24**
  – Change the name of the Object to **Core**
  – Change material to **iron**



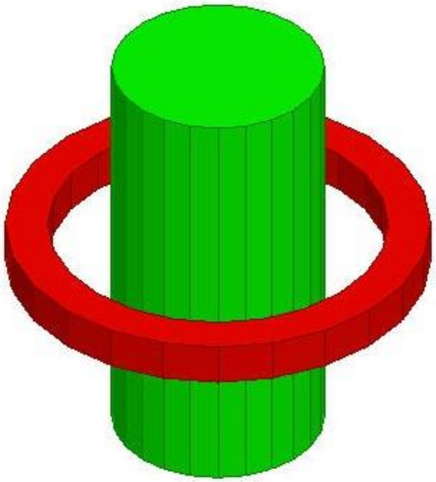
Create Coil

- **Create Regular Polyhedron**
  - Select the menu item ***Draw → Regular Polyhedron***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius and height
       - **dX: 10, dY: 0, dZ: 2**, Press the **Enter** key
    3. Number of Segments: **24**
  - Change the name of the Object to **Coil**
  - Change the material to **copper**



Create Coil (*Contd…*)

- **Create Hole**
  - Select the menu item ***Draw →Regular Polyhedron***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 8, dY: 0, dZ:2**, Press the **Enter** key
    3. Number of Segments: **24**
  - Change the name of the Object to **Hole**
- **Subtract Objects**
  - Press **Ctrl** and select the objects **Coil** and **Hole**
  - Select the menu item, ***Modeler →Boolean →Subtract***
    1. Blank Parts: **Coil**
    2. Tool Parts: **Hole**
    3. Click the **OK** button

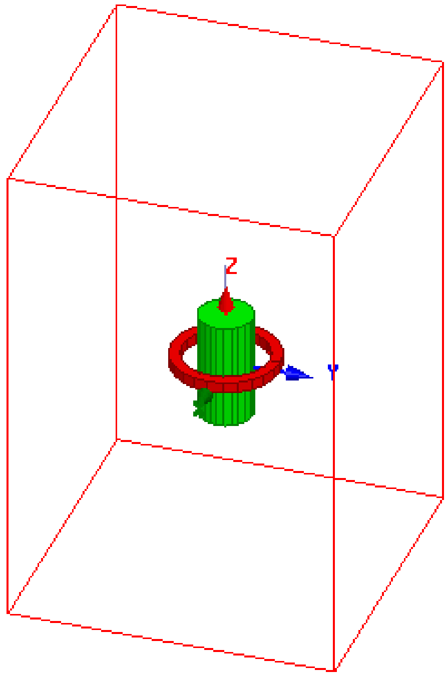


Create Coil Terminal

- **Create Coil terminal**
  - Select the object **Coil** from the history tree
  - Select the menu item *Modeler →Surface →Section*
    1. Section Plane: **YZ**
    2. Press **OK**
  - Change the name of the resulting sheet to **Terminal**
- **Separate Sheets**
  - Select the sheet Terminal from the history tree
  - Select the menu item ***Modeler →Boolean →Separate Bodies***
- **Delete Extra Sheet**
  - Select the sheet **Terminal_Separate1** from the history tree
  - Select the menu item ***Edit →Delete***

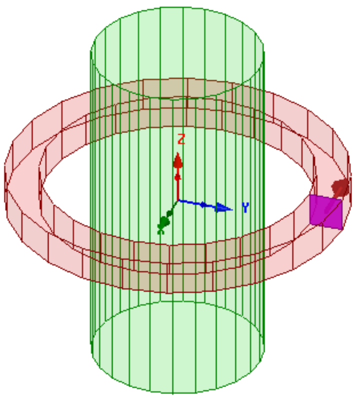
Finalize Geometry

- **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**

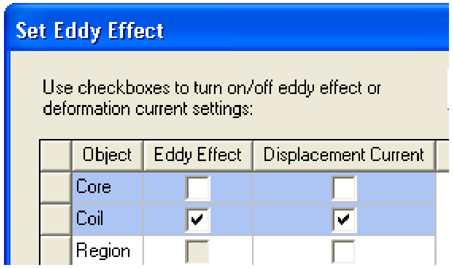


Assign Excitation

- **Assign Current Excitation**
  - Select the sheet **Terminal** from the history tree
  - Select the menu item ***Maxwell 3D → 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 3D → 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.

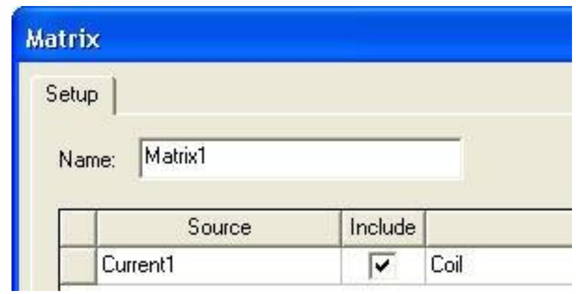
Apply Mesh Operations

- **Apply Mesh Operations for Core**
  - Select the object **Core** from the history tree
  - Select the menu item ***Maxwell 3D → Mesh Operations → Assign → On 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: **5000**
    5. Press **OK**

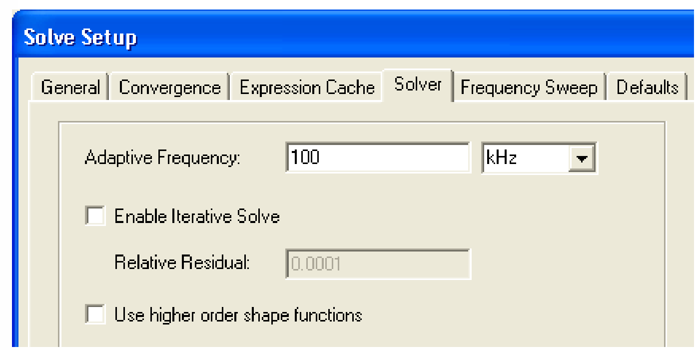
- **Apply Mesh Operations for Coil**
  - Similarly assign mesh operation to **Coil** with following parameters
    1. Name: **Length2**
    2. Restrict Length Of Elements: ☐ **Unchecked**
    3. Restrict the Number of Elements: ☑ **Checked**
    4. Maximum Number of Elements: **5000**
    5. Press **OK**

Analyze

- **Setup Matrix Calculations**
  - Select the menu item ***Maxwell 3D → Parameters → Assign → Matrix***
  - In Matrix window,
    1. Current1:
       - Include: ☑ **Checked**
    2. Press **OK**



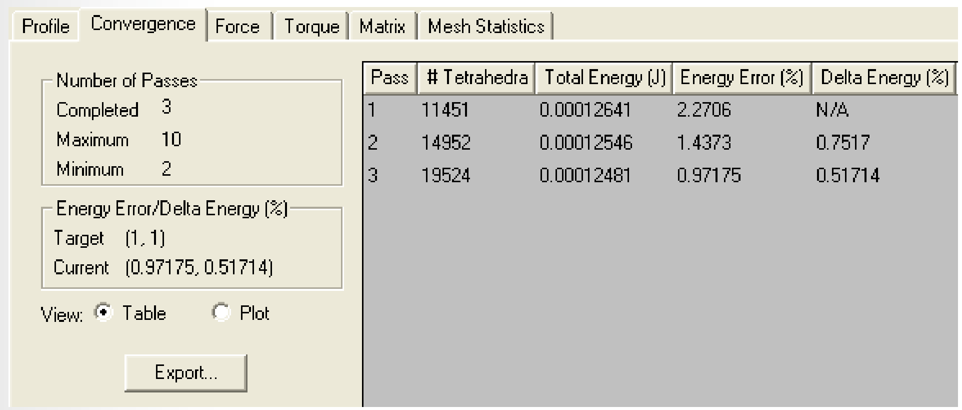
- **Create an analysis setup:**
  - Select the menu item ***Maxwell 3D → Analysis Setup → Add Solution Setup***
  - Solution Setup Window:
    1. **Solver** tab
       - Adaptive Frequency: **100 kHz**
    2. Click the **OK** button



- **Run Solution**
  - Select the menu item ***Maxwell 3D → Analyze All***

Solution Data

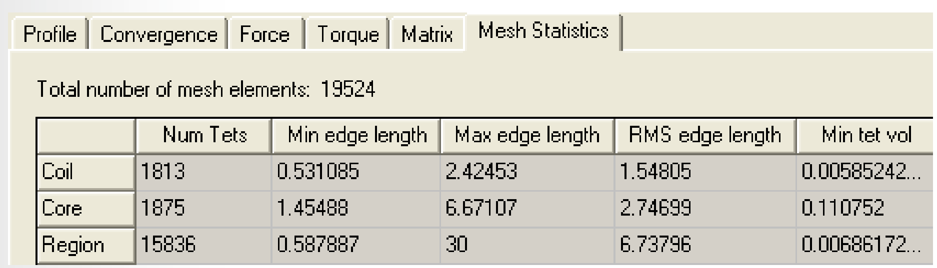
- **View the Solution Data:**
  - Select the menu item ***Maxwell 3D → Results → Solution Data***
  - To view the Profile:
    1. Click the **Profile** Tab.
  - To view the Convergence:
    1. Click the **Convergence** Tab



Pass	# Tetrahedra	Total Energy (J)	Energy Error (%)	Delta Energy (%)
1	11451	0.00012641	2.2706	N/A
2	14952	0.00012546	1.4373	0.7517
3	19524	0.00012481	0.97175	0.51714

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

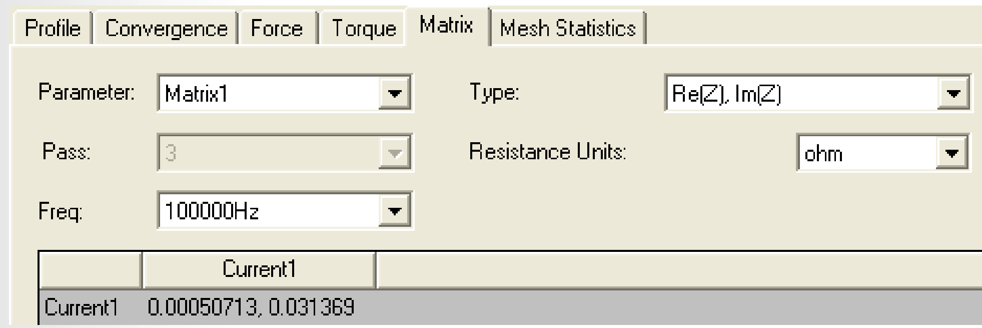
- To View Mesh information
  1. Click **Mesh Statistics** Tab



	Num Tets	Min edge length	Max edge length	RMS edge length	Min tet vol
Coil	1813	0.531085	2.42453	1.54805	0.00585242...
Core	1875	1.45488	6.67107	2.74699	0.110752
Region	15836	0.587887	30	6.73796	0.00686172...

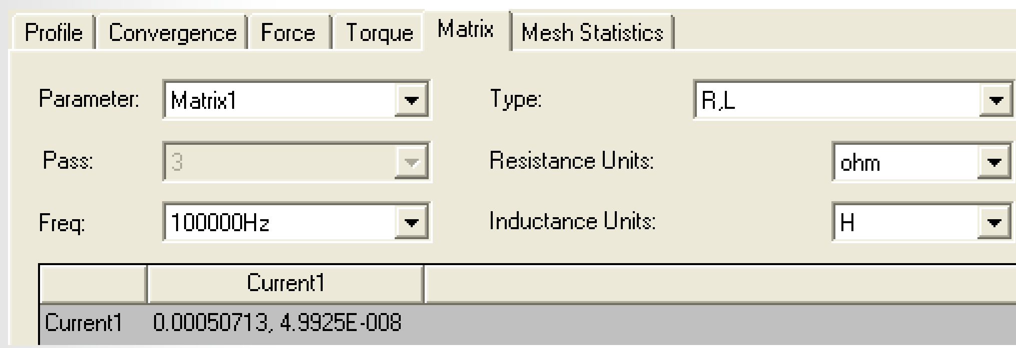
Solution Data (*Contd…*)

- **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.

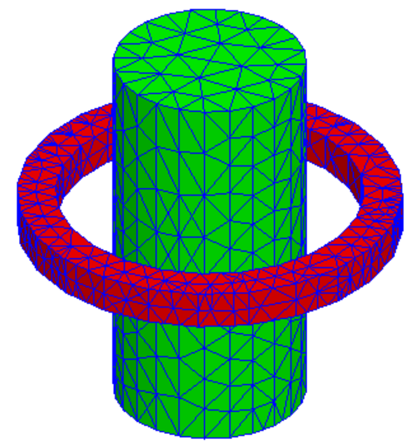
3. Change Type to **R,L**



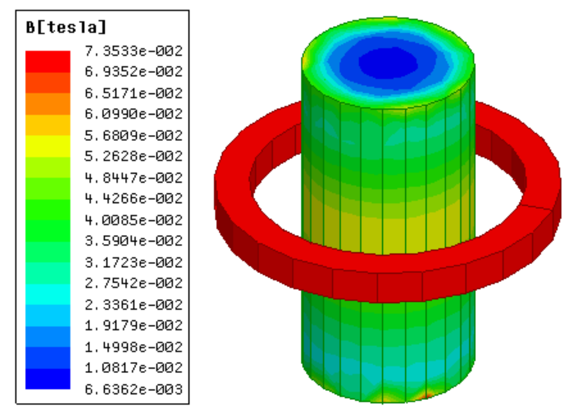
Note: the imaginary term of the matrix includes only the inductance and is reported in Ohms and Henries

Create Field Plots

- **Plot Mesh on Core and Coil**
  - Press **Ctrl** and select the objects **Core** and **Coil**
  - Select the menu item ***Maxwell 3D → Fields → Plot Mesh***
  - In Create Mesh Plot window,
    1. Press **Done**



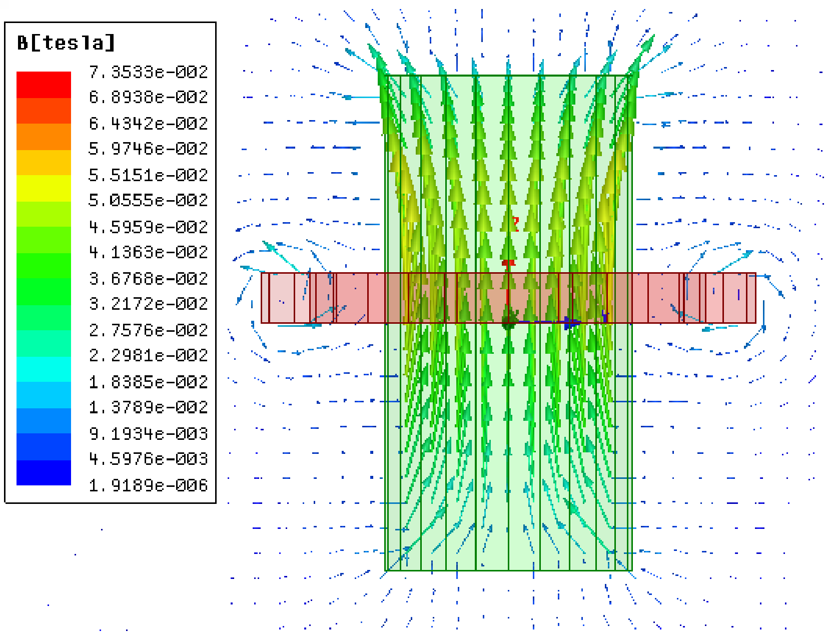
- **Plot Mag_B on Core**
  - Select the object **Core** from the history tree
  - Select the menu item ***Maxwell 3D → Fields → Fields → B → Mag_B***
  - In Create Field Plot window,
    1. Plot on surface only: ☑ **Checked**
    2. Press **Done**



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

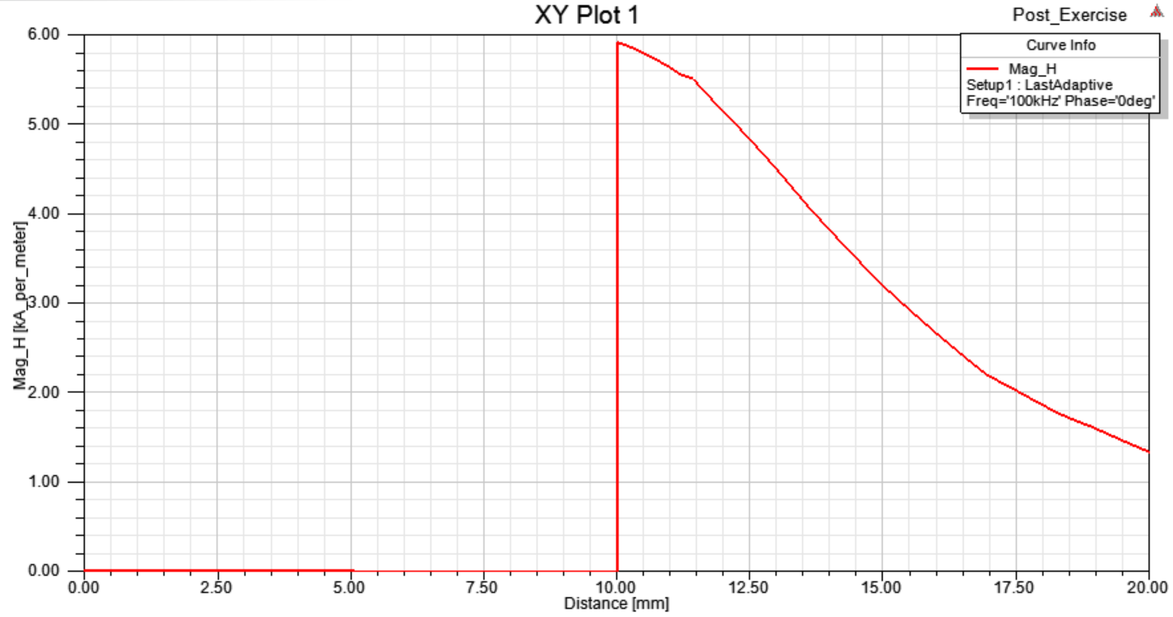
Create Vector Plot

- **Plot Vector_B on YZ Plane**
  - Expand the tree for Planes in History tree and select the plane **Global:YZ**
  - Select the menu item ***Maxwell 3D → Fields → Fields → B → Vector_B***
  - In Create Field Plot window
    1. Press **Done**
  - Double click on the legend to change plot properties
  - In the window
    1. **Marker/Arrow** tab
       - **Arrow** Options
         1. Size: **Set to appropriate value**
    2. **Plots** tab
       - Plot: **Vector_B1**
       - **Vector** Plot
         1. Spacing: **Minimum**
         2. Min: **1**
         3. Max: **3**
    3. Press **Apply** and **Close**



Create XY Plot

- **Plot Mag_H along a Line**
  - Select the menu item ***Maxwell 3D → 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 3D → 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_meter] Setup1 : LastAdaptive Freq='100kHz' Phase='0deg'
1	0.000000	0.009283
2	0.020000	0.009285
3	0.040000	0.009287
4	0.060000	0.009289
5	0.080000	0.009291
6	0.100000	0.009293
7	0.120000	0.009295
8	0.140000	0.009297
9	0.160000	0.009298
10	0.180000	0.009300
11	0.200000	0.009302
12	0.220000	0.009304
13	0.240000	0.009305
14	0.260000	0.009307
15	0.280000	0.009308
16	0.300000	0.009309
17	0.320000	0.009311
18	0.340000	0.009312
19	0.360000	0.009313
20	0.380000	0.009314
21	0.400000	0.009316

Calculate Average Mag_B

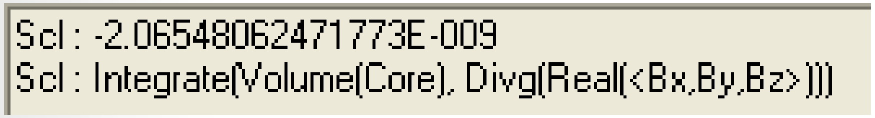
- **Calculate Mag_B Over a Volume**
  - Select the menu item ***Maxwell 3D → Fields → Calculator***
    1. Select **Input > Quantity > B**
    2. Select **General > Complex > Real**
    3. Select **Vector > Mag**
    4. Select **Input > Geometry**
       - Select **Volume > Core >** Press **OK**
   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

```
Scl : 0.0368526330349115
Scl : /(Integrate(Volume(Core), Mag(Real(<Bx,By,Bz>))), Integrate(Volume(Core), 1))
```

  - The average value of flux density calculated is around **0.036 Tesla**

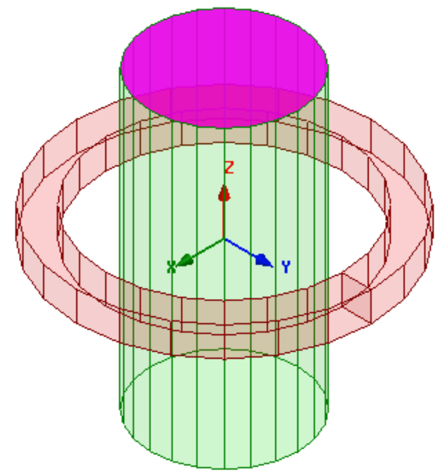
Calculate DivB

- **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 >**  **Integrate**
    7. Select **Output > Eval**
  - The divergence of B is approximately zero
  - Press **Done** to close Field Calculator window



Calculate Magnetic Flux

- **Calculate flux flowing out of the top surface of the core**
  - Select the menu ***Edit* → *Select* → *Faces*** or press **F** from keyboard
  - Select the top face of the Core as shown in below image
  - Select the menu item ***Modeler* → *List* → *Create* → *Face List***
  - Select the menu item ***Maxwell 3D* → *Fields* → *Calculator***
    1. Select the button **Clear** to remove previous expression
    2. Select **Input > Quantity > B**
    3. Select **General > Complex > Real**
    4. Select **Input > Geometry**
       - Select **Surface > Facelist1 >** Press **OK**
    5. Select **Vector > Normal**
    6. Select **Scalar >** **Integrate**
    7. Select **Output > Eval**
  - The net flux flowing out of the core is approximately **(1 e-6 Webers)**




```
Scl : 9.97236315760708E-007
Scl : Integrate(Surface(Facelist1), Dot(Real(<Bx,By,Bz>), SurfaceNormal))
```

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 >** **Integrate**
  5. Select **Output > Eval**

```
Scl : 2.53565907560684
Scl : Integrate(Volume(Coil), Ohmic-Loss)
```

– The ohmic loss in the coil at 100 kHz is approximately 2.53 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 **Input > Geometry**
     – Select **Surface > Terminal >** Press **OK**
  5. Select **Vector > Normal**
  6. Select **Scalar >** $\int$ **Integrate**
  7. Select **Output > Eval**

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

```
Scl : -100
Scl : Integrate(Surface(Terminal), Dot(Real(<Jx,Jy,Jz>), SurfaceNormal))
```

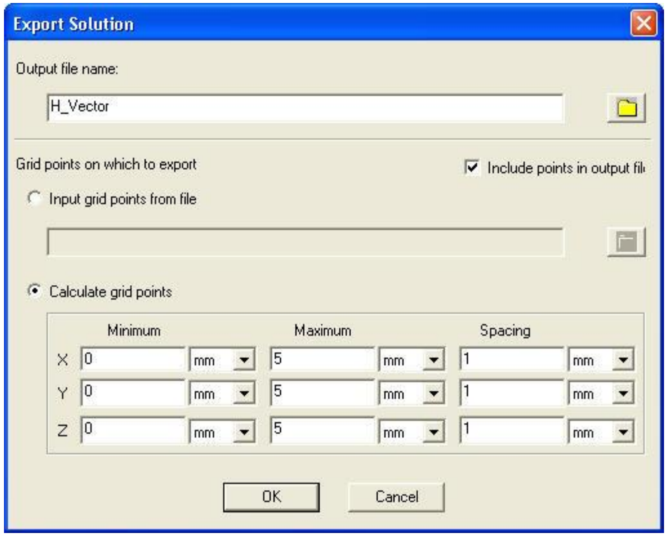
Calculate Current in Conductor (*Contd…*)

- **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 Input > Geometry
     - Select **Surface > Terminal >** Press **OK**
  5. Select **Vector > Normal**
  6. Select **Scalar >** **Integrate**
  7. Select **Output > Eval**
  - Calculated value of current comes out to be around **120 A**

Scl : 119.609606360425
Scl : Integrate(Surface(Terminal), Dot(CmplxMag(<Jx,Jy,Jz>), SurfaceNormal))

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, 0,0)**
     - Maximum: **(5, 5, 5)**
     - Spacing: **(1, 1, 1)**



Note: In order to use the field results in another software program, you can export the fields on a uniform 3-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***