Ansys Maxwell Getting Started

Workshop 3.2: 3D Magnetic Transient Analysis

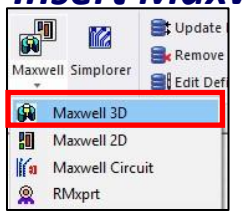
Release 2020R2

Overview

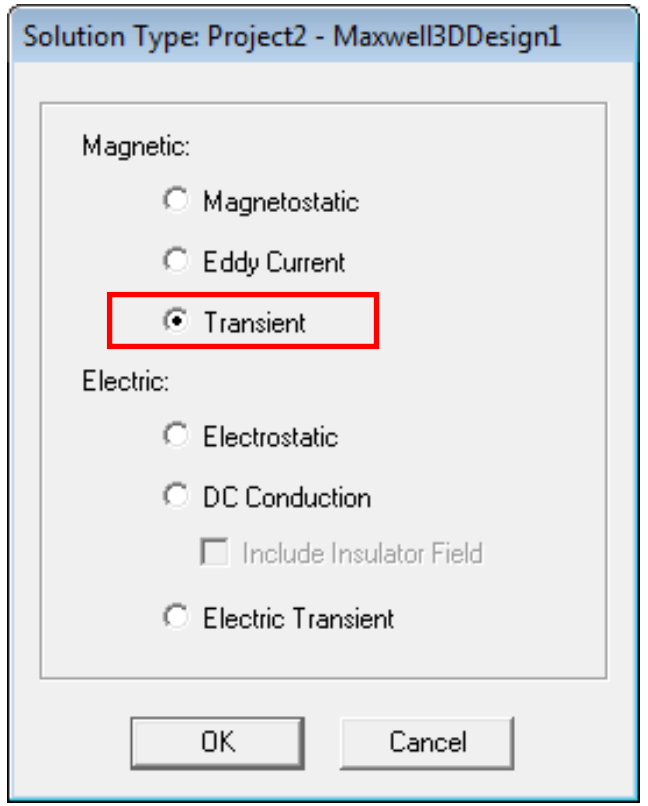
- **Transient Setup**
  - This workshop discusses basic setup details of Magnetic Transient solver
  - The transient setup is described with two different excitation methods
- **Example 1: Transient With Sources**
  - This example shows setup of Transient solver with time varying excitation applied through datasets and equation.
  - Final assigned excitation is evaluated based on combined output of both methods
- **Example 2: Transient With Circuits**
  - This example explains the setup of transient excitations through External Circuit method.
  - The excitation circuit is set using Maxwell Circuit Editor
  - Maxwell excitation values are calculated based on the circuit model assigned through Circuit Editor

Model Setup

- Insert Design
  - Select the menu item *Project → Insert Maxwell 3D Design*, or click on the icon in drop down list Maxwell on panel Desktop
  - Change the name to WS_3_2



- Set Solution Type
  - Select the menu item *Maxwell 3D → Solution Type*
  - Choose *Magnetic → Transient*
  - Click the OK button
- Set Model Units
  - Select the menu item Modeler → Units
  - In Set Modeler Units window,
    - Select units: mm (millimeters)
    - Press the OK button
- Rename the Design
  - Double Click on the new Design
  - Change the name to BE_Trans_sources

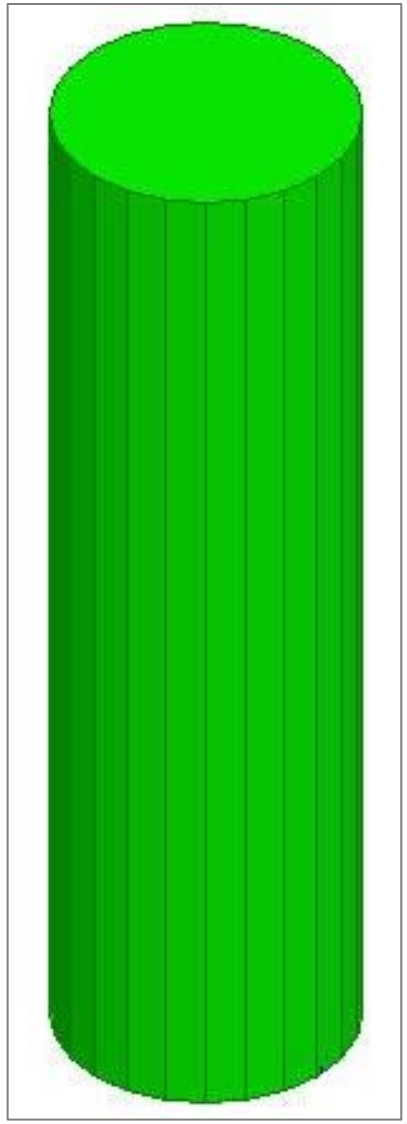


Create Core

- Create Regular Polyhedron
  - Select the menu item *Draw → Regular Polyhedron*
    - Using the coordinate entry fields, enter the center of the base

      X: 0, Y: 0, Z: 0, Press the *Enter* key
    - Using the coordinate entry fields, enter the radius

      dX: 2, dY: 2, dZ: 20, Press the *Enter* key
    - Number of Segments: 24
  - Change the name of the Object to Core
  - Change the material of the object to ferrite

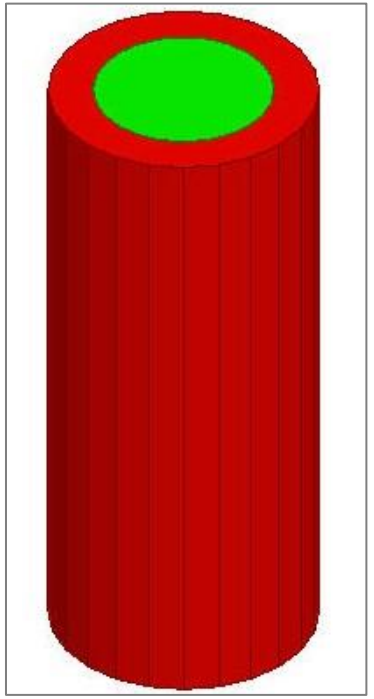


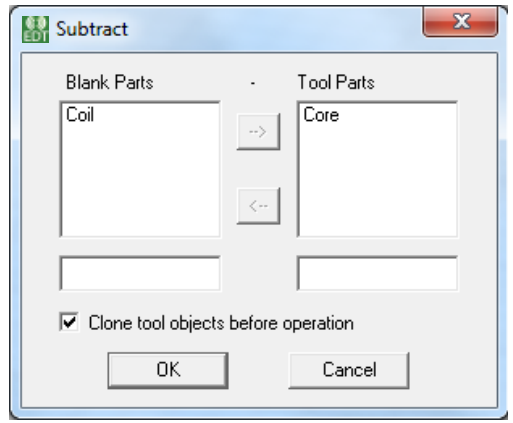
Create Coil

- Create Regular Polyhedron
  - Select the menu item *Draw → Regular Polyhedron*
    - Using the coordinate entry fields, enter the center of the base

      X: 0, Y: 0, Z: 0, Press the Enter key
    - Using the coordinate entry fields, enter the radius

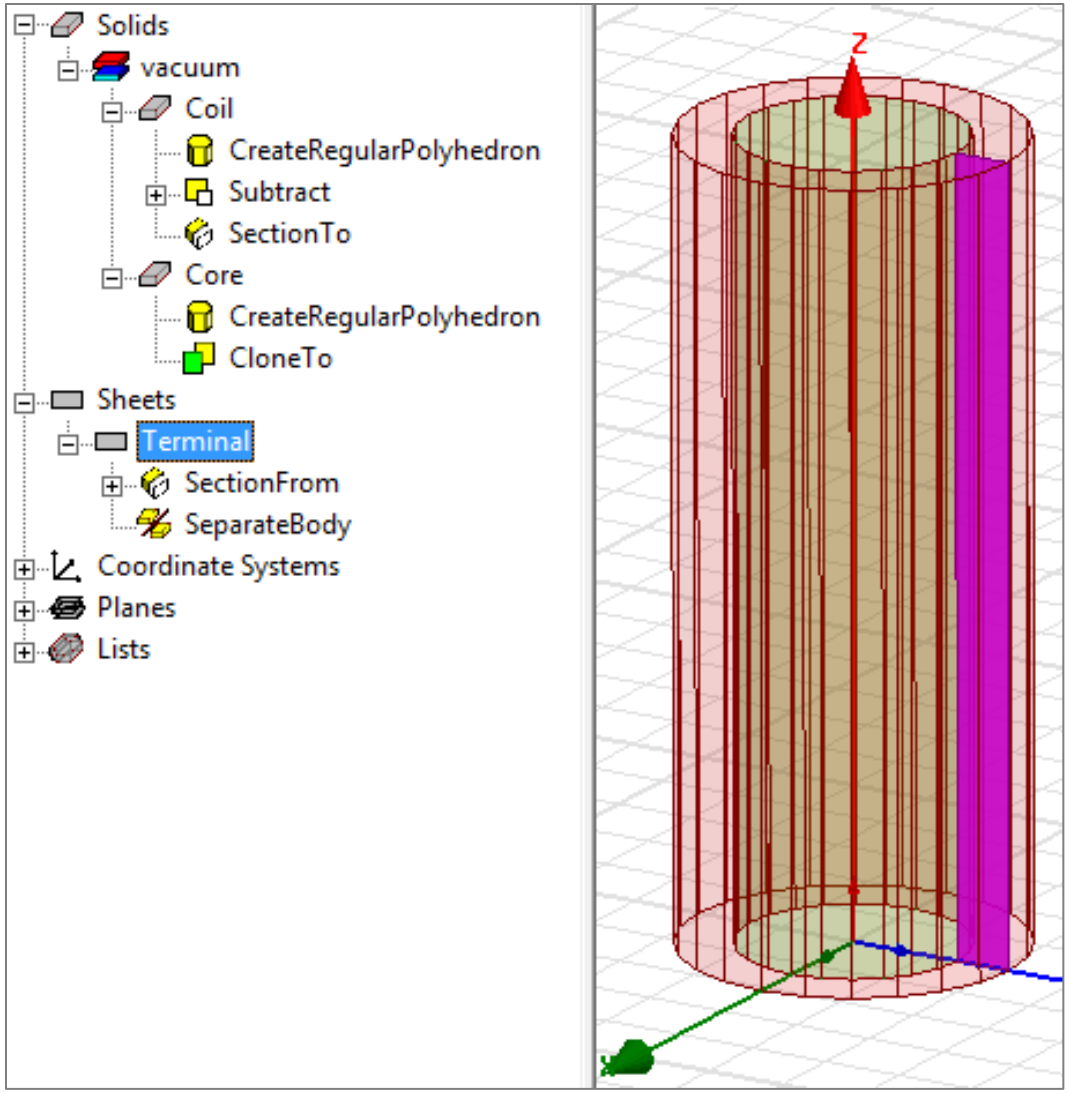
      dX: 3, dY: 3, dZ: 20, Press the Enter key
    - Number of Segments: 24
  - Change the name of the Object to Coil and material to Copper
- Subtract Objects
  - Press Ctrl and select the objects Coil and Core from the history tree
  - Select the menu item, *Modeler → Boolean → Subtract*
  - Blank Parts: Coil
  - Tool Parts: Core
  - Clone tool objects before operation: ☑ Checked
  - Click the OK button





Create Coil Terminal

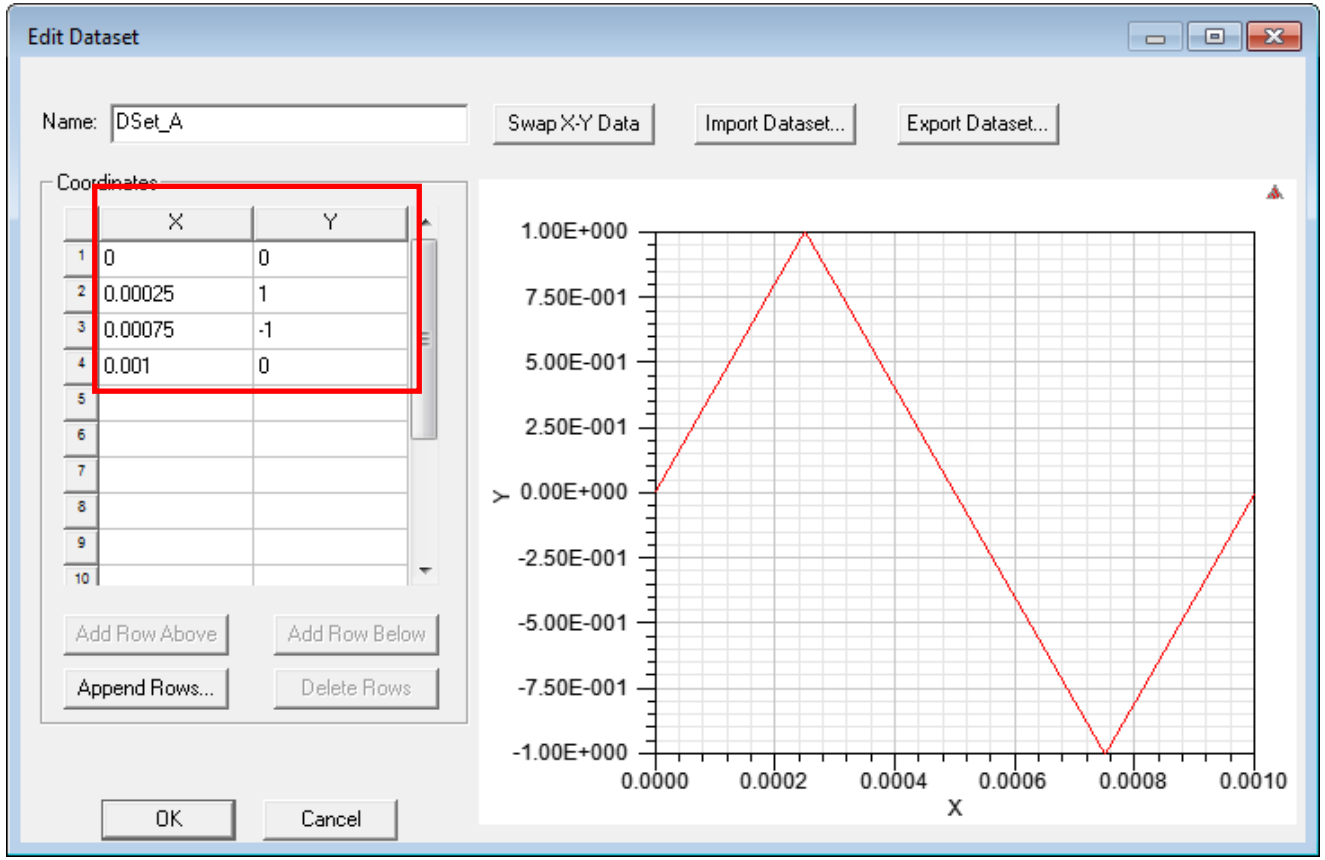
- Create Coil terminal
  - Select the object Coil from the history tree
  - Select the menu item *Modeler → Surface → Section*
    - Section Plane: YZ
    - Press OK
  - Change the name of the resulting sheet to Terminal
- Separate Sheets
  - Select the sheet Terminal from the history tree
  - Select 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*



Assign Excitation

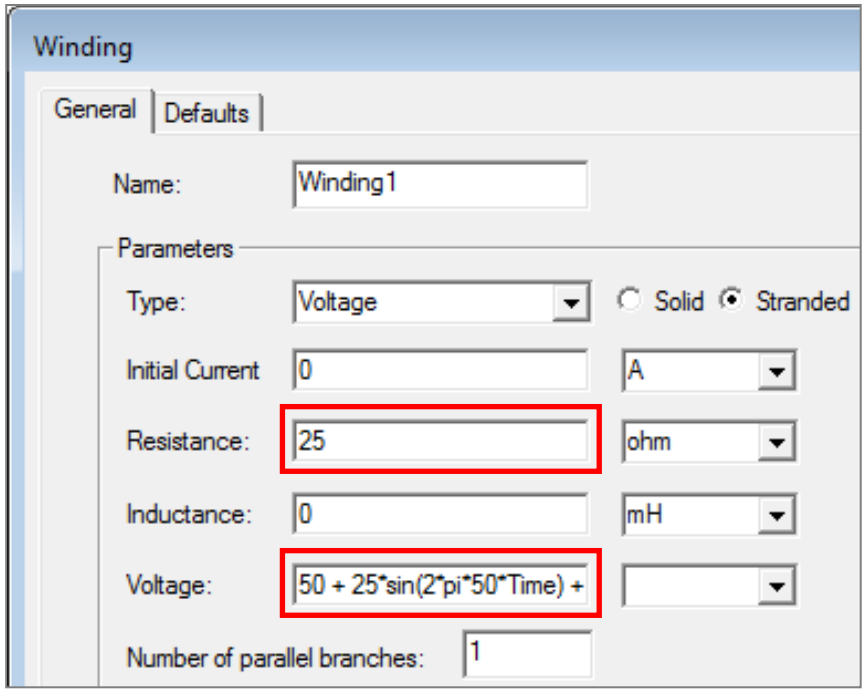
Note: The excitation for this problem is a voltage source with a 1KHz triangular wave superimposed on a 50 Hz sine wave with a 50 V DC offset. Triangular wave is specified through a design dataset.

- **Specify Dataset**
  - **Select the menu item *Maxwell 3D → Design Datasets***
  - **In Datasets window, select Add**
  - **In Add Dataset window,**
    - **Name: DSet_A**
    - **Coordinates:**
    - **X1 = 0 Y1 = 0**
    - **X2 = 25e-5 Y2 = 1**
    - **X3 = 75e-5 Y3 = -1**
    - **X4 = 1e-3 Y4 = 0**
    - **Select OK and Done**



Assign Excitation

- **Add Winding**
  - Select RMB on *Excitations → Add Winding*
  - In Winding window,
    - **Name: Winding_A**
    - **Type: Voltage**
    - **Stranded: ☑ Checked**
    - **Initial Current: 0 A**
    - **Resistance: 25 ohm**
    - **Inductance: 0 H**
    - **Voltage: *50 + 25*sin(2*PI*50*Time) + 5*pwl_periodic(DSet_A, Time)***
    - **Press OK**



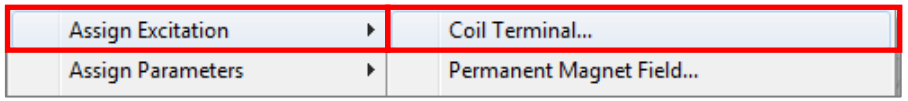
Note: The expression specified for Voltage has three different components

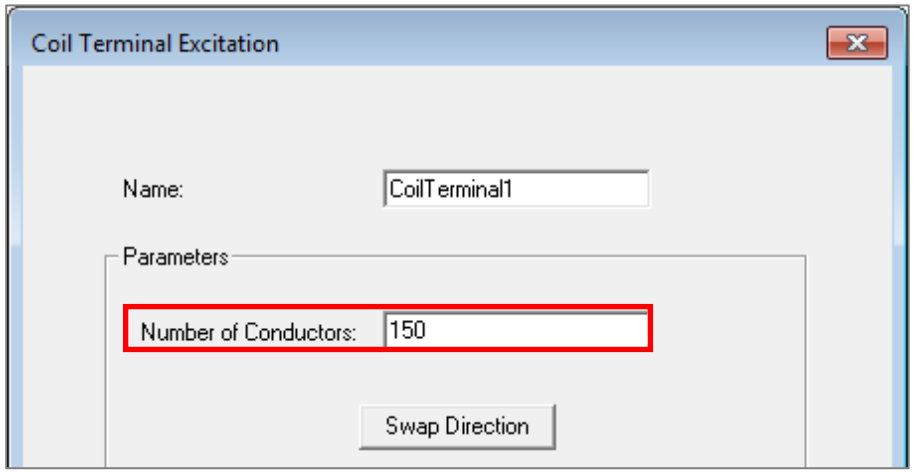
- ***The first term is a 50 V DC offset***
- ***The second term is a 25 Vp-p, 50 Hz sine wave***
- ***The third term is a 5 Vp-p, 1 KHz triangular wave***

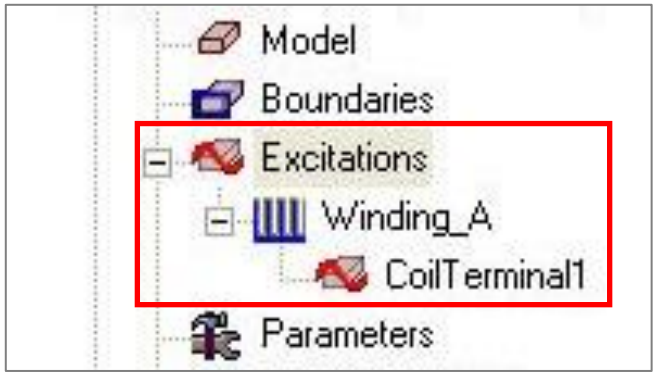
Assign Excitation

- Assign Coil Terminal
  - Select the sheet Terminal from the history tree
  - Select *RMB on selected Object → Assign Excitation → Coil Terminal*
  - In Current Excitation window,
    - Name: CoilTerminal1
    - Number of Conductors: 150
    - Press OK

- Add Terminal to Winding
  - In Project manager window, expand the tree for Excitations
  - Right click on the tab CoilTerminal1 and select Add to Winding
  - In Add to Winding window,
    - Select Winding_A
    - Press OK

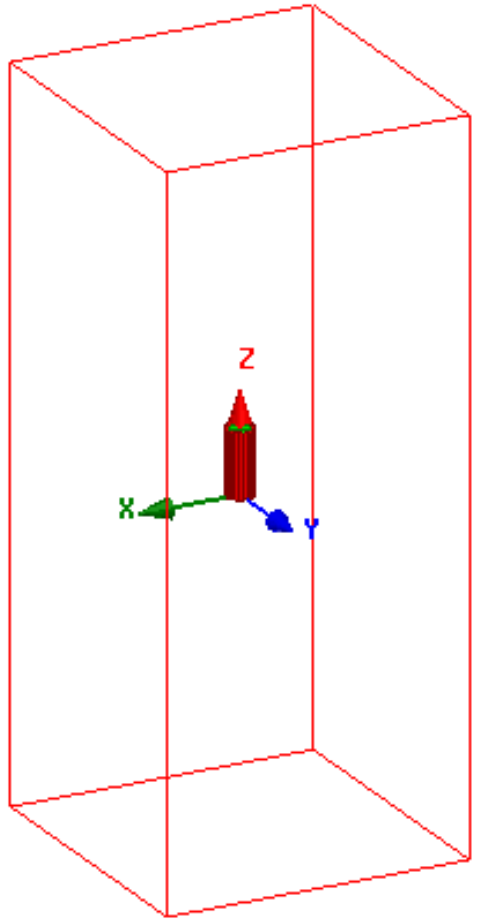






Create Region

- Create Simulation Region
  - Select the menu item *Draw → Region*
  - In Region window,
    - Padding all directions similarly: ☑ Checked
    - Padding Type: Percentage Offset
    - Value: 500
    - Press OK

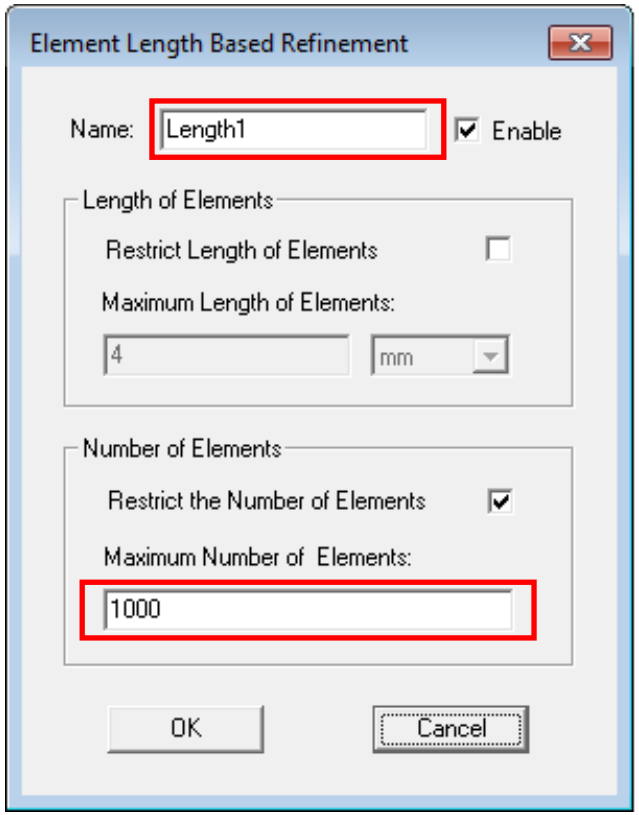


Note: As Core and Coil are in direct contact with each other, an insulation boundary has to be defined between them to avoid current leakage from Coil to Core. In present case however that is not necessary as the ferrite has a conductivity = 0.01S/m, far below the default conductor/insulation threshold 1S/m

Apply Mesh Operations

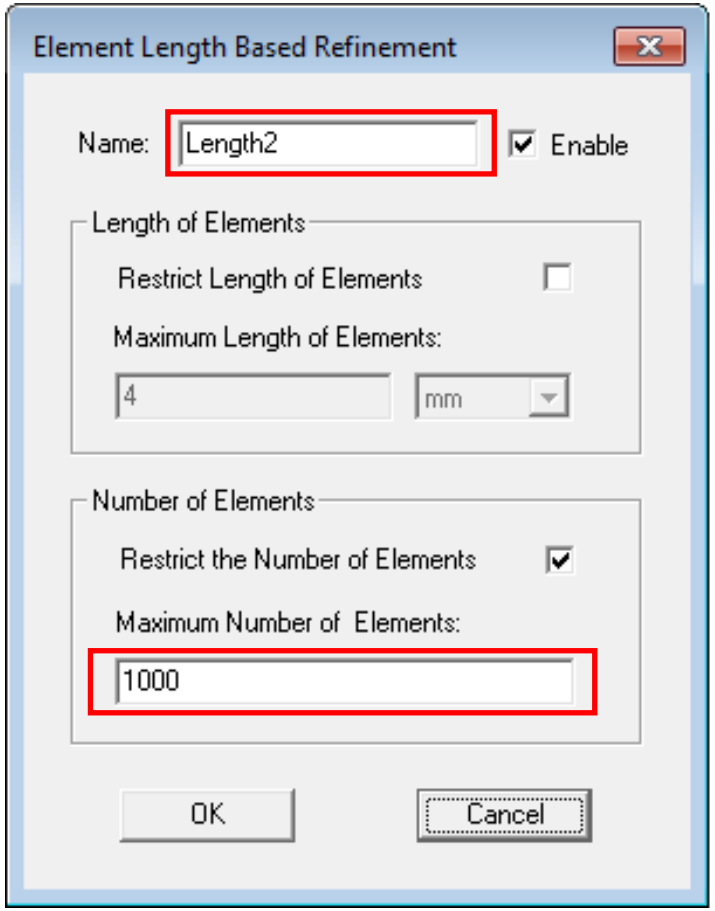
Note: A transient solver does not use the adaptive meshing technique. Thus manual mesh specifications are required to refine the mesh in important regions to achieve accuracy of results

- **Apply Mesh Operations for Core**
  - **Select the object Core from the history tree**
  - **Select *RMB everywhere → Assign Mesh Operations → On Selection → Length Based***
  - **In Element Length Based Refinement window,**
    - **Name: Length1**
    - **Restrict Length Of Elements: ☐ Unchecked**
    - **Restrict the Number of Elements: ☑ Checked**
    - **Maximum Number of Elements: 1000**
    - **Press OK**



Apply Mesh Operations

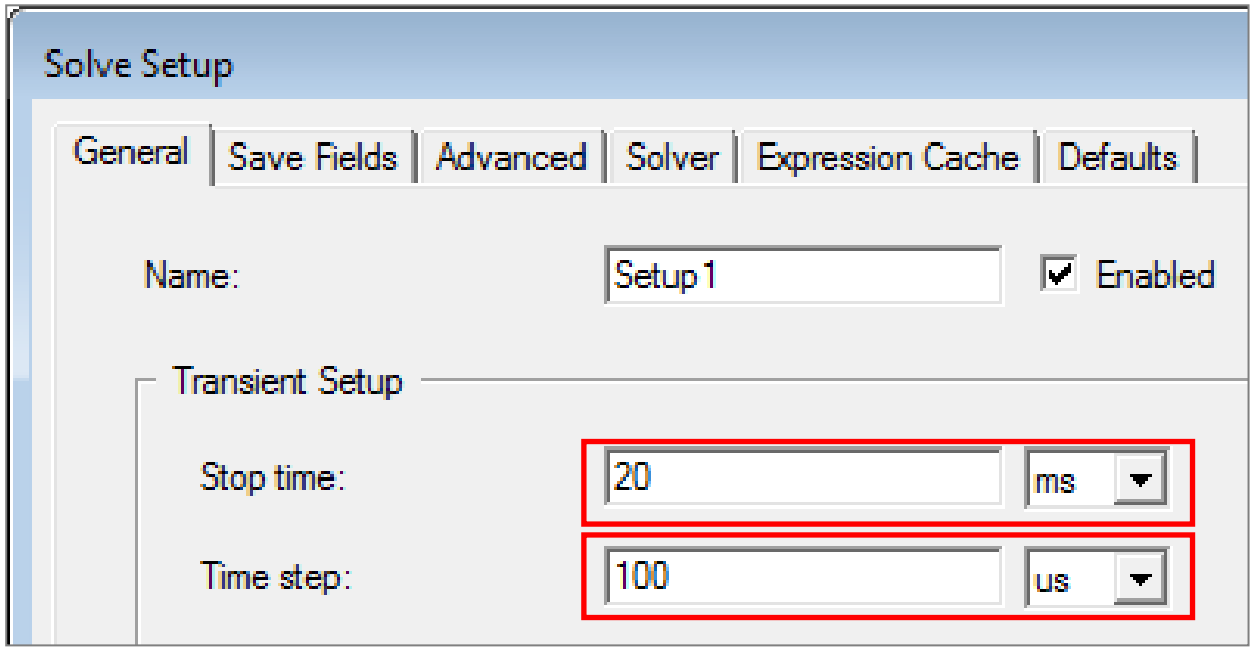
- **Apply Mesh Operations for Coil**
  - Select the object **Coil** from the history tree
  - Select ***RMB everywhere → Assign Mesh Operations → Inside Selection → Length Based***
  - In Element Length Based Refinement window,
    - **Name: Length2**
    - **Restrict Length Of Elements: ☐ Unchecked**
    - **Restrict the Number of Elements: ☑ Checked**
    - **Maximum Number of Elements: 1000**
    - **Press OK**



Analyze

- **Create an analysis setup:**
  - **Select *RMB on Analysis → Add Solution Setup***
  - **Solution Setup Window:**
    - **General tab**
    - **Stop Time: 20 ms**
    - **Time Step: 100 us**
    - **Press OK**

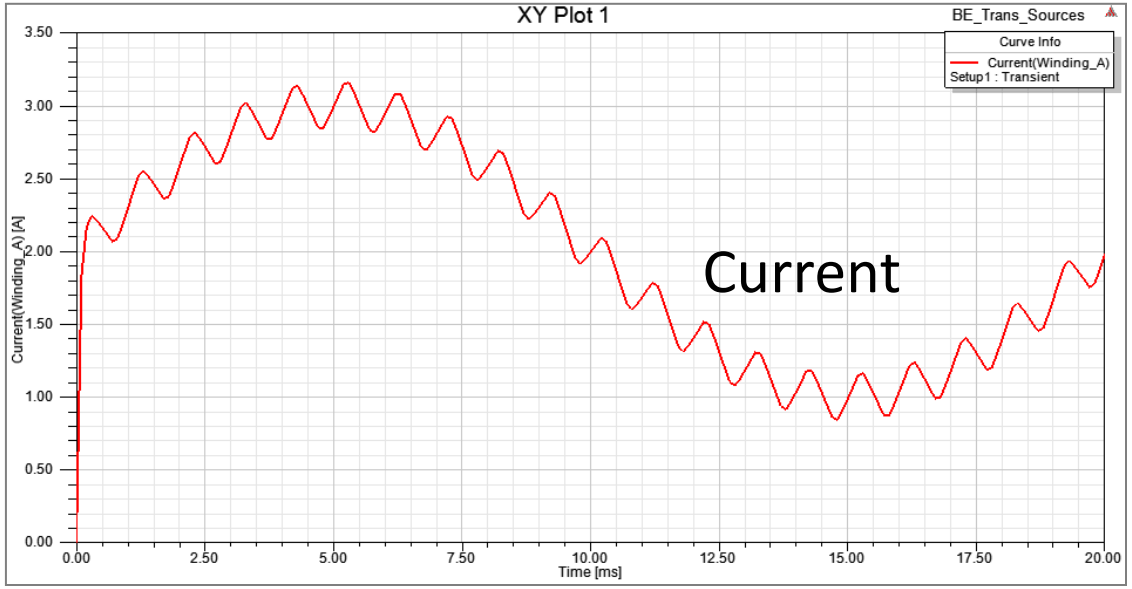
- **Run Solution**
  - **Select *RMB on Setup1 → Analyze***

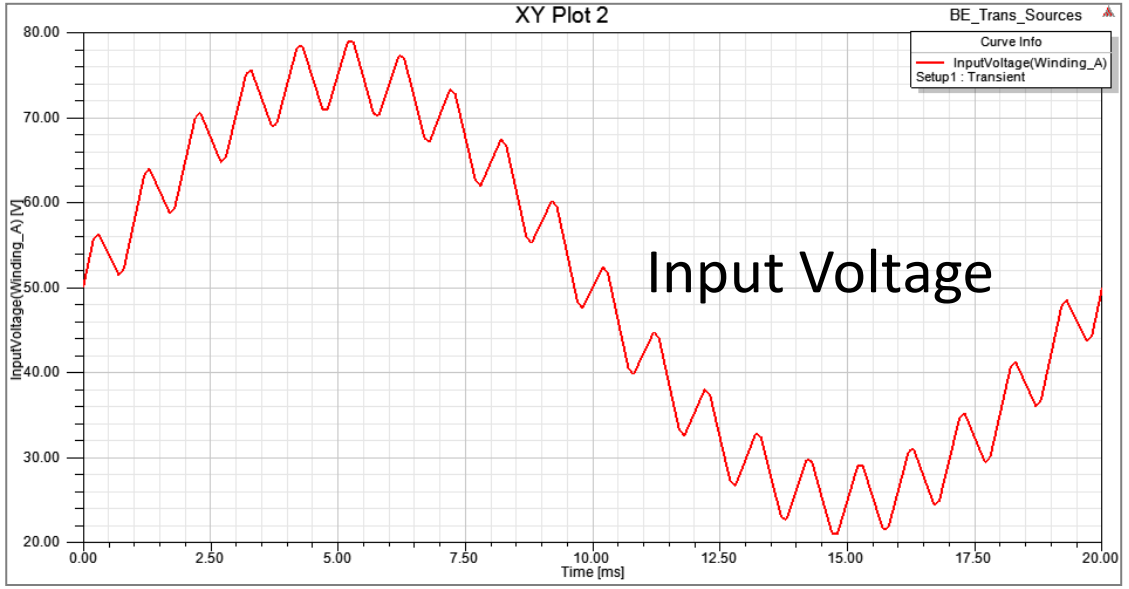


Note: By default few output quantities are calculated for all time steps. Fields are saved only for Stop time. If user need to post process fields for any in-between time steps, they need to save the fields at required time steps using save fields tab

Plot Voltage and Current

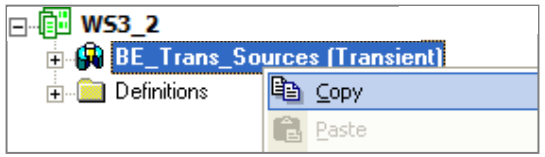
- Create Plots
  - Select *RMB on Results → Create Transient Report → Rectangular Plot*
  - In Reports window,
    - Category: Winding
    - Quantity: Current(Winding_A)
    - Select New Report
    - Change Quantity to InputVoltage(Winding_A)
    - Select New Report

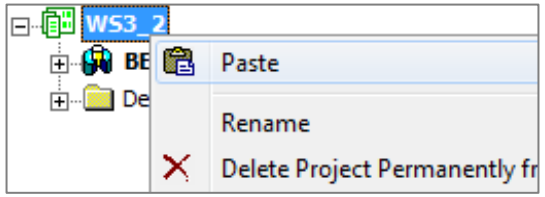




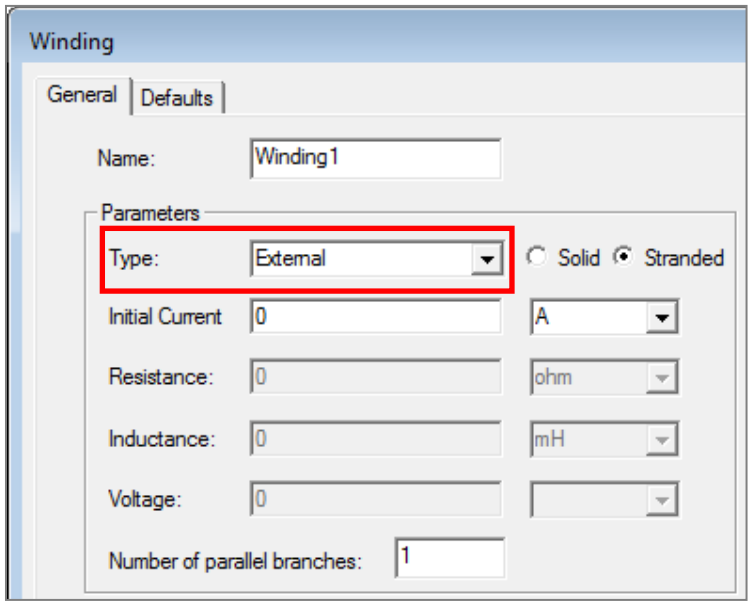
Model Setup

- Copy Design
  - Select the design BE_Trans_Sources from Project manager tree
  - Right click and select Copy
  - Select the name of the project from Project Manager tree
  - Right click on it and select Paste
  - Rename the new design as “BE_Trans_Circuit”





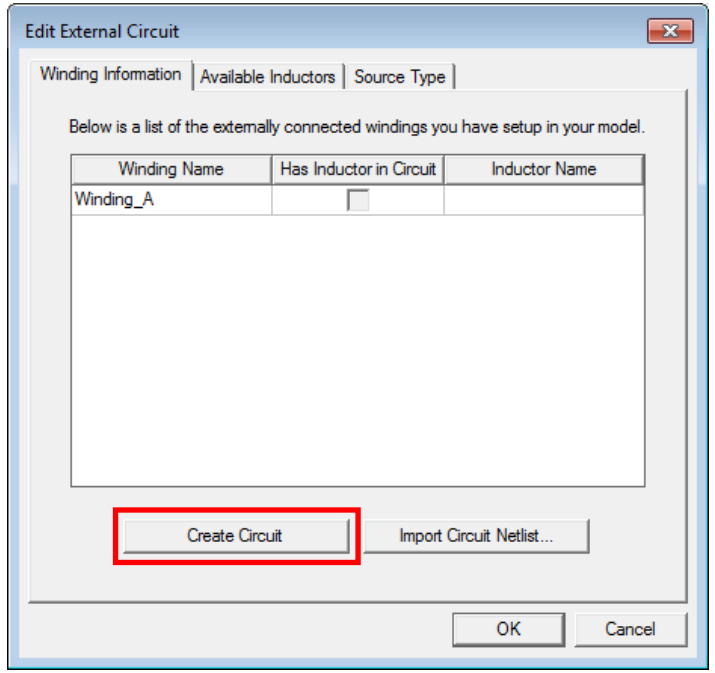
- Modify Winding Setup
  - Expand the Project Manager tree to view Excitations
  - Double click on Winding_A under Excitations
  - Change the Type to External
  - Press OK



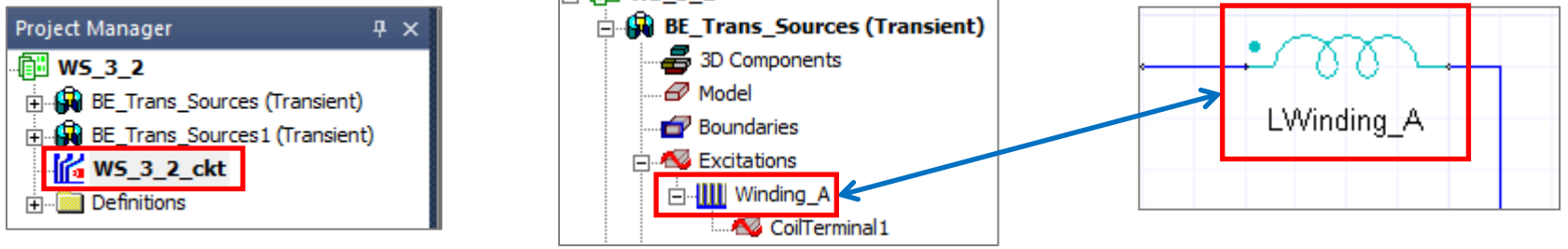
Note: When Excitation Type is set to External, External circuit will be used to calculate inputs for winding

Create External Circuit

- Maxwell Circuit Editor
  - Select *RMB on Excitations → External Circuit → Edit External Circuit*
  - In Edit External Circuit window,
    - Click on Create Circuit
  - Maxwell Circuit Editor is added to existing project with windings as defined

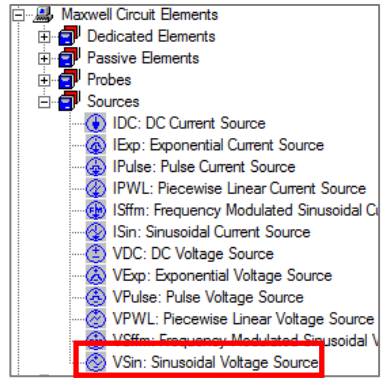


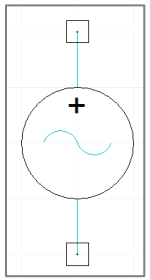
In Maxwell Circuit Editor special components are created by default corresponding to windings in Maxwell. The name of the windings are the same used in Maxwell. The two names must match each other to assure the correct link



Create External Circuit

- Add Source Components
  - In Component Libraries window, expand the tree for *Maxwell Circuit Elements → Sources*. Select the element Vsin from the tree, drag and drop it on the worksheet
  - Note: if the Component Libraries does not show up, go to menu item *View → Component Libraries* to make it visible
  - Press Esc to exit component insertion
  - Double click on the component to modify its properties
    - Set Va to 100 V
    - Set VFreq to 50 Hz
  - Similarly add another source VSin
    - Set Va to 10 V
    - Set VFreq to 1000 Hz





Parameter Values | Property Displays

Value Statistics

Name	Value	Unit	Evaluated Value
Name			
V0	0	V	0V
Va	100	V	100V
VFreq	50		50
Td	0		0
Df	0		0
Phase	0	deg	0deg
AF	0		0
Type	TIME		

Parameter Values | Property Displays

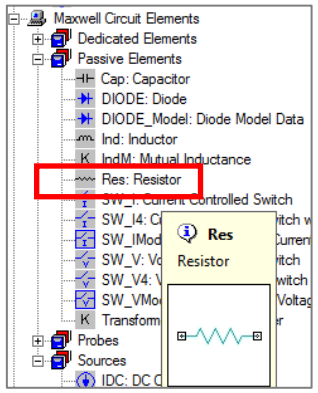
Value Statistics

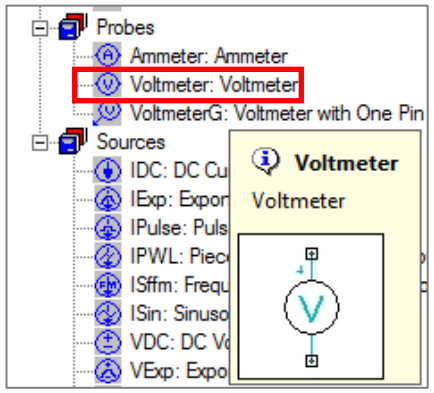
Name	Value	Unit	Evaluated Value
Name			
V0	0	V	0V
Va	10	V	10V
VFreq	1000		1000
Td	0		0
Df	0		0
Phase	0	deg	0deg
AF	0		0
Type	TIME		

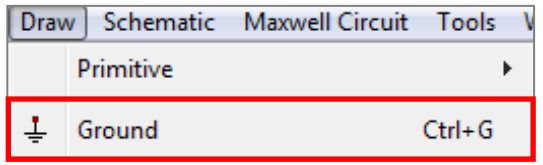
Create External Circuit

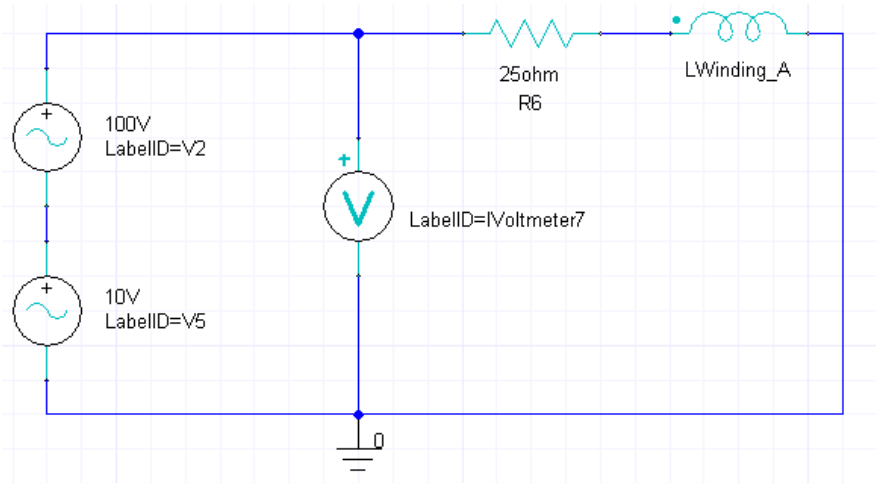
- Add Other Components
  - Similarly add *Passive Elements > Res: Resistor*
    - Change the value of R to 25 ohm
  - Add Probes > Voltmeter
- Build Circuit
  - Select the menu item *Draw → Ground* to add ground
  - Connect the component as shown in image

***Note:** Circuit will provide a 10V 1KHz sinusoidal source superimposed on 100V - 50Hz Sine wave*



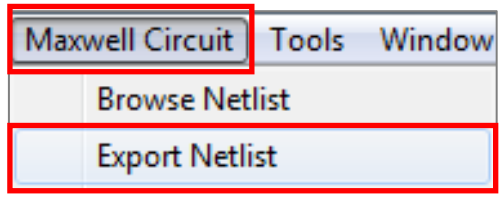


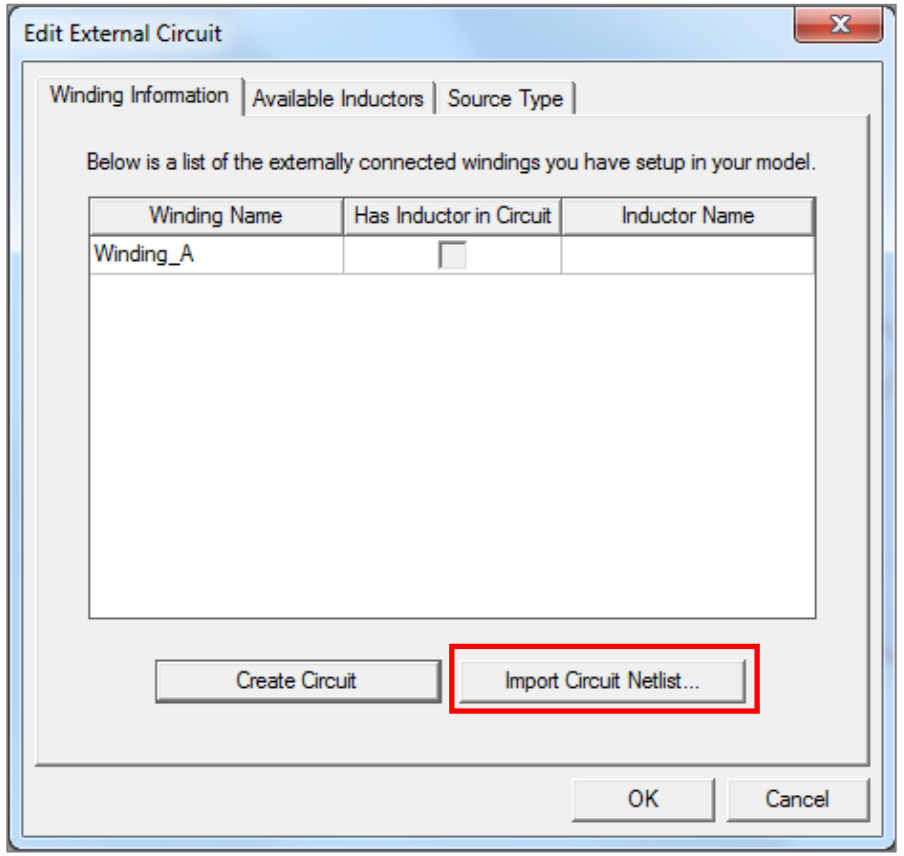




Transfer Circuit to Maxwell

- Save File
  - Select the menu item *File → Save*
- Export Circuit
  - Select the menu item *Maxwell Circuit → Export Netlist*
    - Save the file with the name WS_3_2_Circuit.sph
- Import circuit in Maxwell
  - Return to Maxwell window
  - In Edit External Circuit window,
    - Select Cancel
    - Select the tab Import Circuit
    - Browse to file WS_3_2_Circuit.sph
    - Select the file and press OK





Analyze

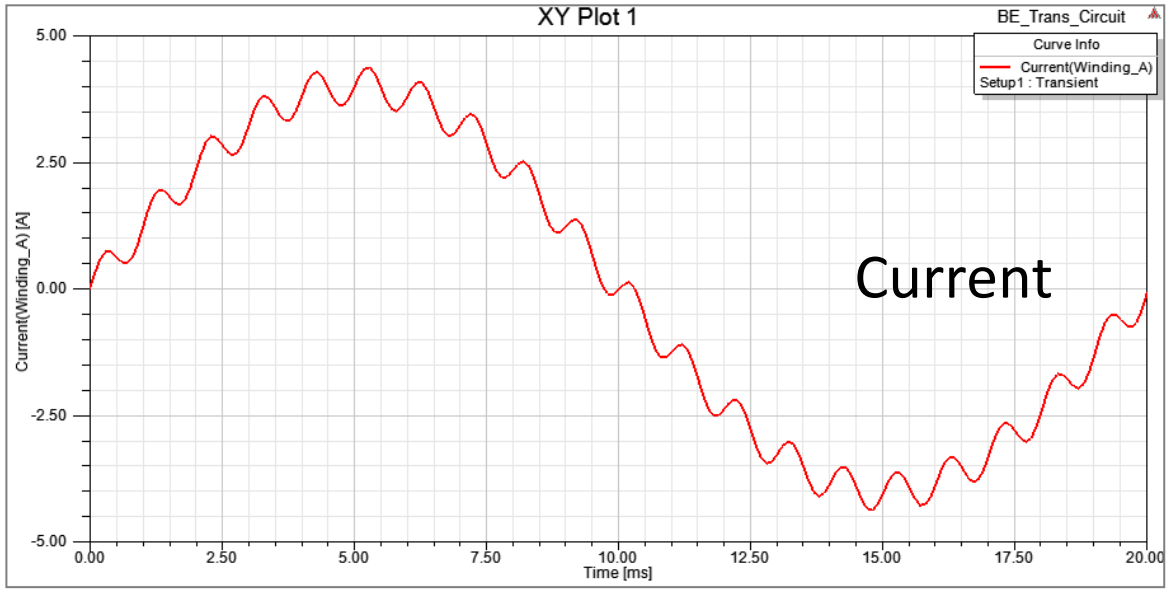
- **Run Solution**
  - **Solution setup is already copied from original design**
  - **Select *RMB on Setup1 → Analyze***

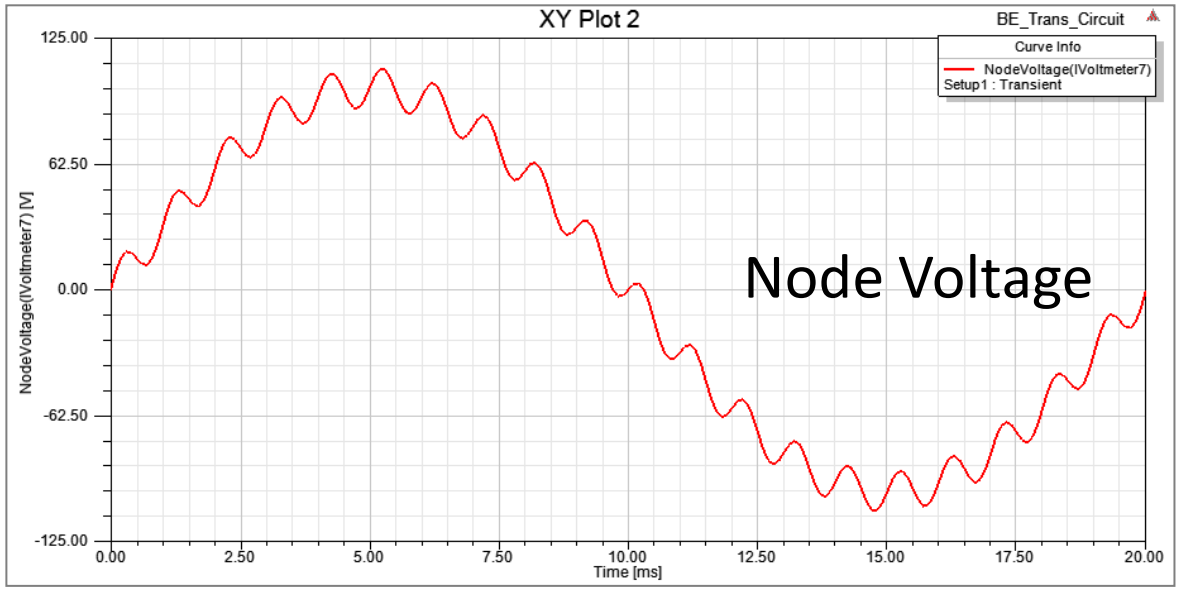
***Note:** When an external circuit is defined, the time step is controlled from the circuit simulator. The time step values are calculated based on circuit transients and occurrences such as switching instances. Due to variable time steps resulting from circuit, Maxwell can miss the Save Fields points if defined in Solution Setup. Thus fields on the next time step occurring after the missed point will be saved*

Users can set the minimum time step size used for circuit simulator from Maxwell 3D → Excitations → External Circuit → Set Minimum Time Step.

Plot Voltage and Current

- Plot the Voltage and Current
  - Plots from previous design will still be there. But Voltage plot has no reference since Input voltage is not applied but received from circuit
  - Double click on the plot from Project manager tree
    - Change Category to NodeVoltage
    - Quantity: NodeVoltage
    - Select Apply Trace





Saving the Project

- This completes the workshop
- Save the file with the name Workshop_3_2 in the working folder

End of Presentation