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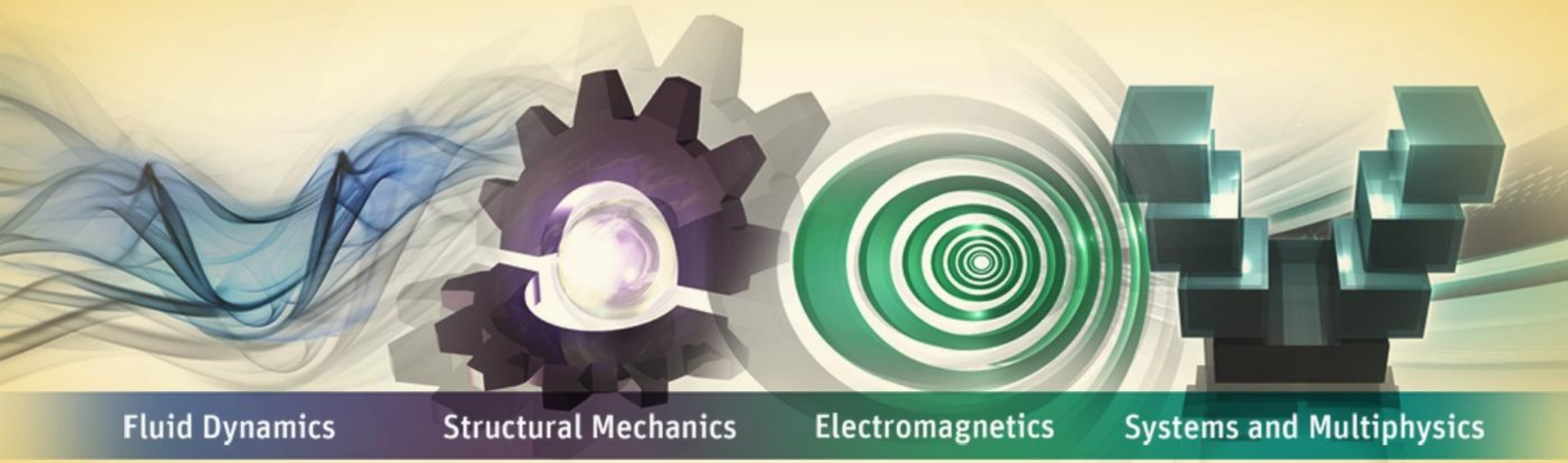
# Workshop 5:
# Basic Transient Sources and Circuit




## ANSYS Maxwell 2D V16

# About Workshop

- **Transient Setup**
  - This workshop discusses basic setup details of 2D Magnetic Transient solver
  - The transient setup is described with two different excitation methods

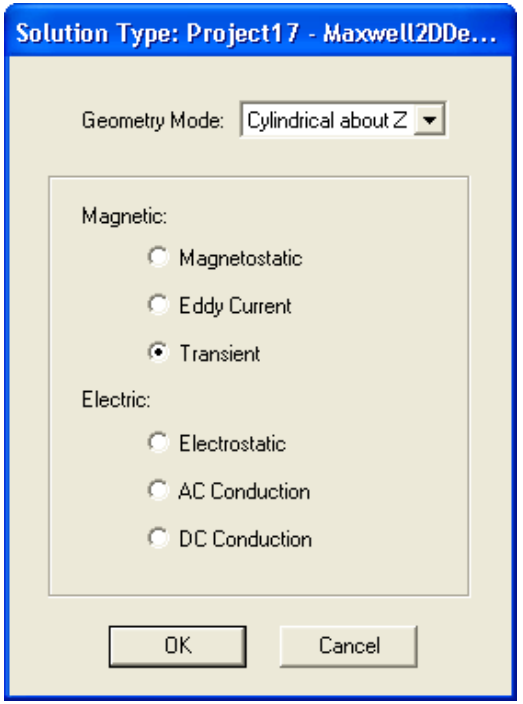
  **Example 1: Transient With Sources**
  - This example shows setup of 2D Transient solver with time varying excitation applied through datasets and equation.
  - Final assigned excitation is evaluated based on combined output of both methods

  **Exampled 2: Transient With Circuits**
  - This example explains the setup of transient excitations through External Circuit method.
  - The excitation circuit is setup using Maxwell Circuit Editor
  - Maxwell excitation values are calculated based on the circuit model assigned through circuit editor

# Example 1: Transient With Sources

# 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 **BE_Trans_Sources**
- **Set the Solution Type:**
  - Select the menu item ***Maxwell 2D → Solution Type***
  - Solution Type Window:
    1. Geometry Mode: **Cylindrical about Z**
    2. Choose **Magnetic > Transient**
    3. Click the **OK** button

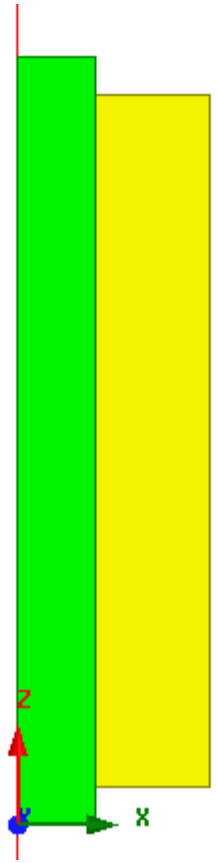


# Create Model

- **Create Core**
  - Select the menu item ***Draw → Rectangle***
    1. Using the coordinate entry fields, enter the position of rectangle
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 2, dY: 0, dZ: 20**, Press the **Enter** key
  - Change the name of resulting sheet to **Core** and color to **green**
  - Change the material of the sheet to **Ferrite**
- **Create Coil**
  - Select the menu item ***Draw → Rectangle***
    1. Using the coordinate entry fields, enter the position of rectangle
       - **X: 0, Y: 0, Z: 1**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 5, dY: 0, dZ: 18**, Press the **Enter** key
  - Change the name of resulting sheet to **Coil** and color to **Yellow**
  - Change the material of the sheet to **Copper**

# Create Model (*Contd…*)

- **Subtract Sheets**
  - Press **Ctrl** and select the sheets **Core** and **Coil**
  - Select the menu item ***Modeler → Boolean → Subtract***
    - Blank Part: **Coil**
    - Tool Part: **Core**
    - Clone tool objects before subtracting: ☑ **checked**
- **Create Simulation Region**
  - Select the menu item ***Draw → Region***
  - In Region window,
    1. Pad all directions similarly: ☑ **Checked**
    2. Padding Type: **Percentage Offset**
    3. Value: **500**
    4. Press **OK**

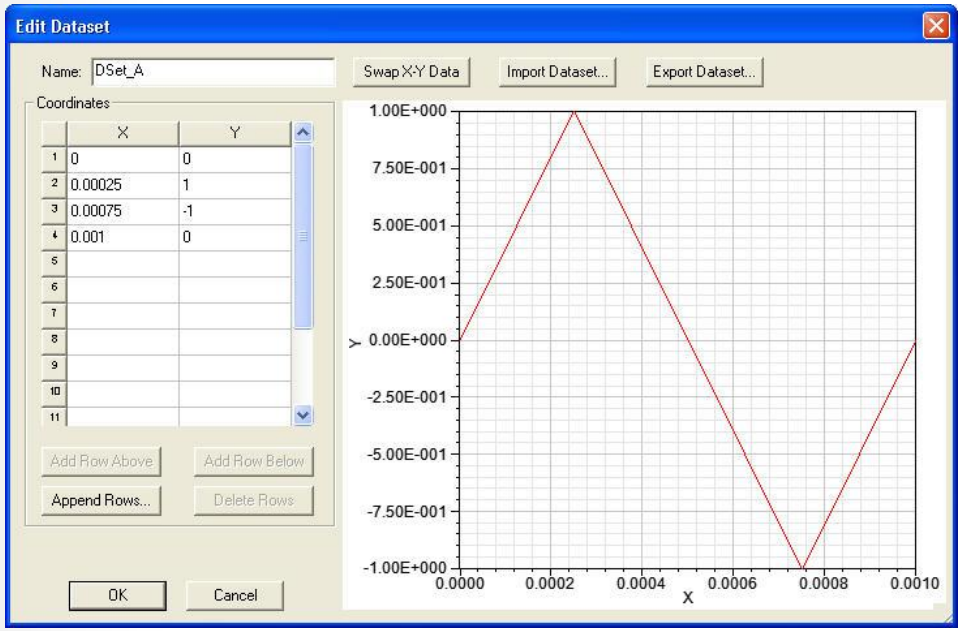



***Note: Region will not be created in Negative X direction due to RZ-symmetry about the Z-axis.***

# Assign Excitation

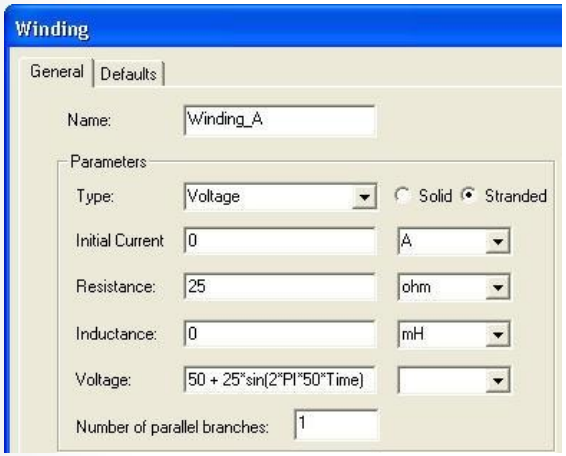
***Note: The excitation for this problem will be a voltage source with a 1KHz triangular wave superimposed on a 50 Hz sine wave that has a 50 volt DC offset. Triangular wave will be specified through a design dataset.***

- **Specify Dataset**
  - Select the menu item ***Maxwell 2D → Design Datasets***
  - In Datasets window, select **Add**
  - In Add Dataset window,
    - Name: **DSet_A**
    - Coordinates:
      1. X1 = **0** Y1 = **0**
      2. X2 = **250e-6** Y2 = **1**
      3. X3 = **750e-6** Y3 = **-1**
      4. X4 = **1e-3** Y4 = **0**
    - Select **OK** and **Done**



# Assign Excitation (*Contd…*)

- **Add Winding**
  - Select the menu item ***Maxwell 2D → Excitations → Add Winding***
  - In Winding window,
    1. Name: **Winding_A**
    2. Type: **Voltage**
    3. Stranded: ☑ **Checked**
    4. Initial Current: **0 A**
    5. Resistance: **25 ohm**
    6. Inductance: **0 H**
    7. Voltage: **50 + 25*sin(2*PI*50*Time) + 5*pwl_periodic(DSet_A, Time)**
    8. Press **OK**




***Note: The expression specified for Voltage has three different components***

***1. The first term is a 50 V DC offset***

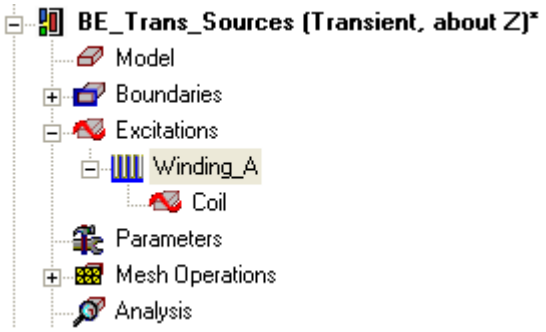
***2. The second term is a 25 Vp-p, 50 Hz sine wave***

***3. The third term is a 5 Vp-p, 1 KHz triangular wave***

***Final applied voltage will be combined output of all three components***

# Assign Excitation (*Contd…*)

- **Create Coil**
  - Select the object **Coil** from history tree
  - Select the menu item ***Maxwell 2D → Excitations → Assign → Coil***
    - Name: **Coil**
    - Number of Conductors: **150**
    - Polarity: **Positive (into the screen)**
- **Add Coil to Winding**
  - Expand the Project Manager tree to view **Excitations**
  - Right click on the tab **Winding_A** and select **Add Coils**
  - In Add Terminals window,
    - Select **Coil**
    - Press **OK**



# Assign Boundary

- **Assign Balloon Boundary**
  - Select the object **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.***

# Assign 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.***

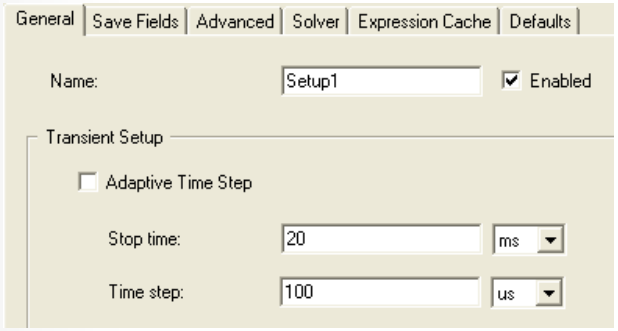
- **Assign Mesh Operation for Core**
  - Select the object **Core** from history tree
  - Select the menu item ***Maxwell 2D → Mesh Operations → Assign → Inside Selection → Length Based***
  - In Element Length Based Refinement window,
    - Name: **Core_Inside**
    - Restrict Length Of Elements: ☐**Unchecked**
    - Restrict Number of Elements: ☑**Checked**
    - Maximum Number of Elements: **250**
    - Press **OK**

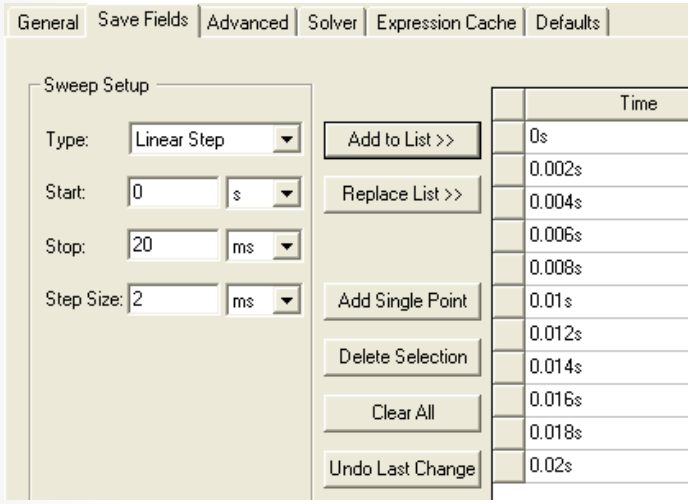
# Assign Mesh Operations (*Contd…*)

- **Assign Mesh Operation for Coil**
  - Select the object **Coil** from history tree
  - Select the menu item ***Maxwell 2D → Mesh Operations → Assign → Inside Selection → Length Based***
  - In Element Length Based Refinement window,
    - Name: **Coil_Inside**
    - Restrict Length Of Elements: ☐**Unchecked**
    - Restrict Number of Elements: ☑**Checked**
    - Maximum Number of Elements: **100**
    - Press **OK**

# Analyze

- **Create Analysis Setup**
  - Select the menu item ***Maxwell 2D → Analysis Setup → Add Solution Setup***
  - In Solve Setup window,
    - **General** tab
      - Stop Time: **20 ms**
      - Time Step: **100 us**
    - **Save Fields** Tab
      - Type: **Linear Count**
      - Start: **0 sec**
      - Stop: **20 ms**
      - Step Size: **2 ms**
      - Click on: **Add to List**
    - Press **OK**

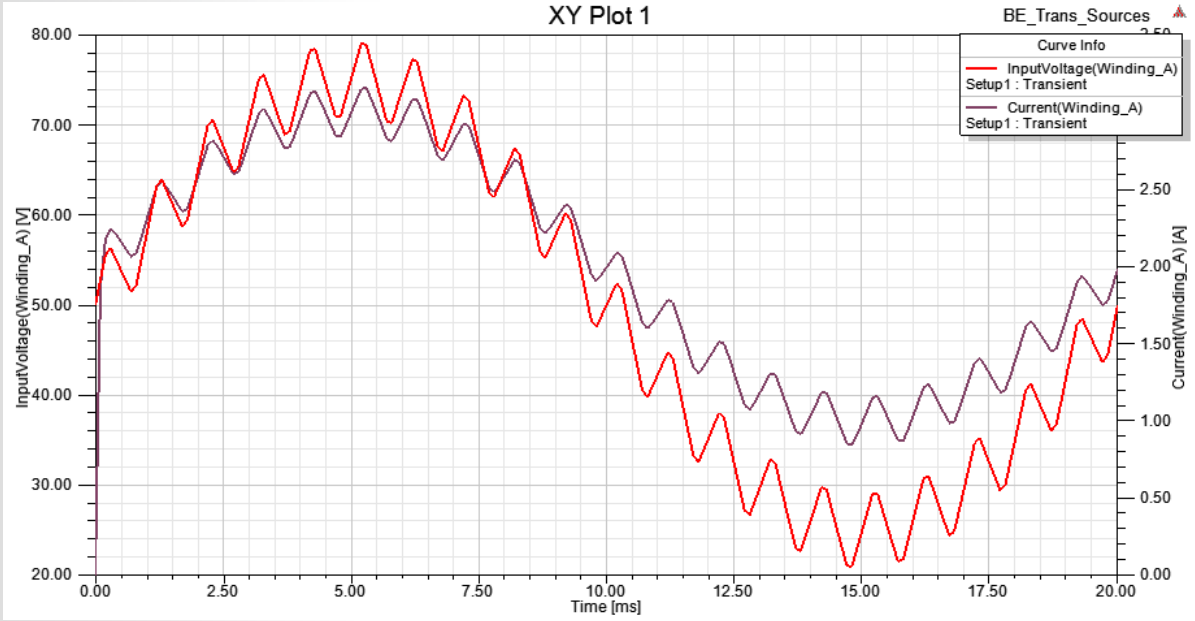



- **Run Solution**
  - Select the menu item ***Maxwell 2D → Analyze All***

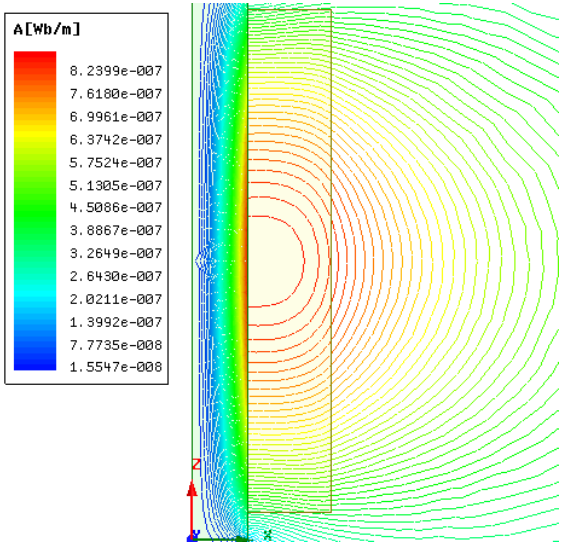
# Plot the Voltage and Current

- **Create a Plot**
  - Select the menu item ***Maxwell 2D → Results → Create Transient Report → Rectangular plot***
    1. In Reports window, Category: **Winding**
    2. Quantity: **InputVoltage(Winding_A)**
    3. Select **New Report**
    4. Change Quantity to **Current(Winding_A)**
    5. Select **Add Trace**
    6. Press **Close**



# Plot Flux Lines

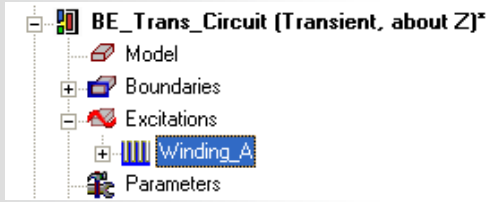
- **Plot Flux Lines**
  - Be sure that the 2D Modeler window is in the active view window.
  - Select the menu item ***View → Set Solution Context***
  - In Set view Context window,
    - Time: Set to **0.01 sec**
    - Press **OK**
  - Select the menu ***Edit → Select All***
  - Select the menu item ***Maxwell 2D → Fields → Fields → A → Flux_Lines***
  - In Create Field Plots window, Press **Done**
- **Modify Plot**
  - Double click on the legend to modify its attributes
  - In the window,
    - **Scale** tab
      - Num. Divisions: **56**
    - Press **Apply** and **Close**

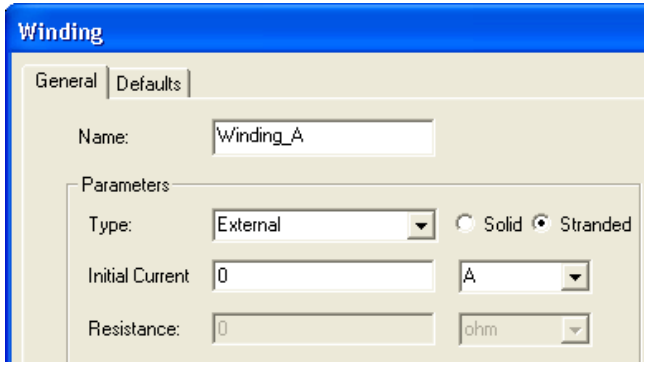


# Example 2: Transient With Circuit

# Problem 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**

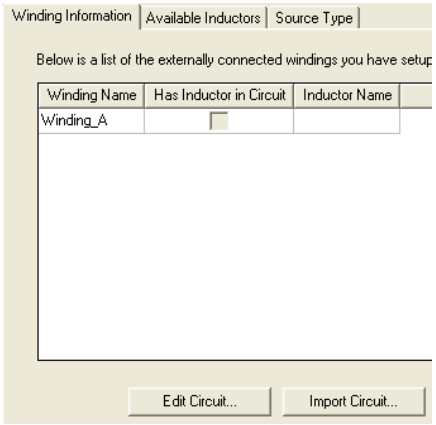


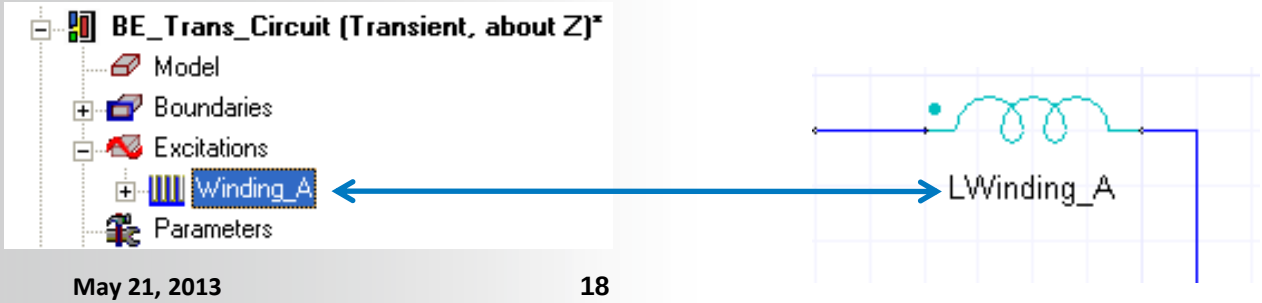

***Note: When Excitation Type is set to External, External circuit will be used to calculate inputs for winding***

# Create External Circuit

- **Launch Maxwell Circuit Editor**
  - Select the menu item ***Maxwell 2D → Excitations → External Circuit → Edit External Circuit***
  - In Edit External Circuit window,
    - Select **Edit Circuit**
  - Maxwell Circuit Editor will launch in separate window

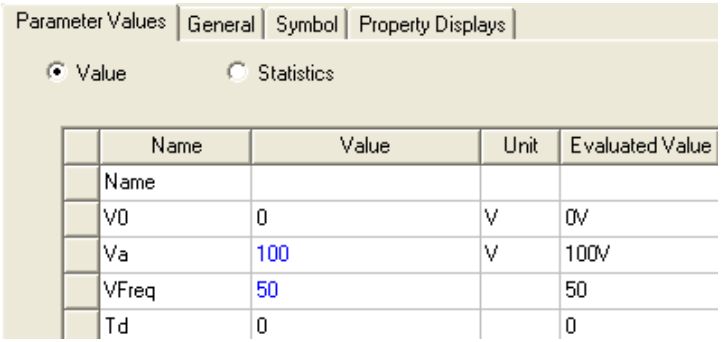



***In Maxwell Circuit Editor a Component is created by default corresponding to winding in Maxwell. The name of the winding is same as as used in Maxwell in Maxwell 3D > Excitations > Add Winding. If users add winding by themselves they should ensure these names match***



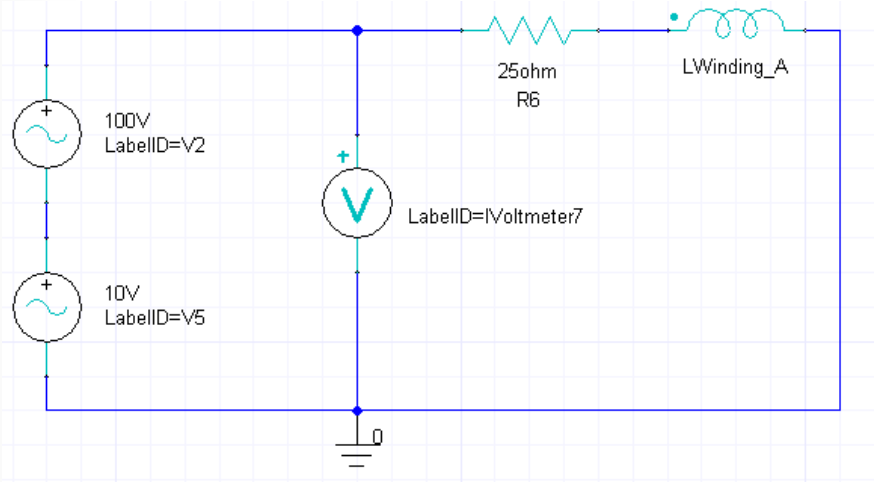
# Create External Circuit (*Contd…*)

- **Add Source Components**
  - Change the tab in Project Manager window to **Components**
  - In Project Manager window, expand the tree for ***Maxwell Circuit Elements > Sources***. Select the element **Vsin** from the tree, drag and drop it on the worksheet.
  - Press **Esc** to exit component insertion
  - Double click on the component to modify its properties
    1. Change the value of **Va** to **100 V**
    2. Change the value of **VFreq** to **50 Hz**
  - Similarly add another source **VSin**
    1. Change the value of **Va** to **10 V**
    2. Change the value of **VFreq** to **1000 Hz**



# Create External Circuit (*Contd…*)

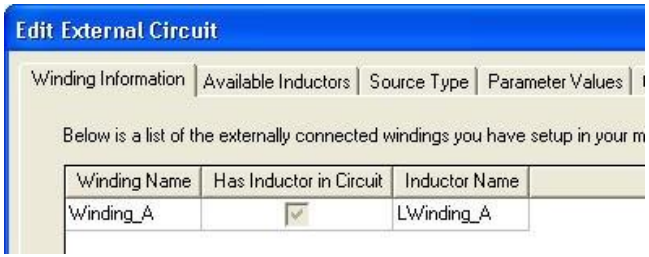
- **Add Other Components**
  - Similarly add ***Passive Elements > Res***
    1. Change the value of **R** to **25 ohm**
  - Add ***Probes > Voltmeter***
- **Build Circuit**
  - Select the menu item ***Draw → Wire*** to draw wires
  - Select the menu item ***Draw → Ground*** to add ground
  - Build the circuit as shown in image




***Note: Circuit will provide a 10V 1KHz sinusoid superimposed on 100V 50Hz Sine wave.***

# Transfer Circuit to the Maxwell

- **Save File**
  - Select the menu item ***File → Save***
    1. Save the file with the name **WS5_BasicTransient_Circuit.amcp**
- **Export Circuit**
  - Select the menu item ***Maxwell Circuit → Export Netlist***
    1. Save the file with the name **WS5_BasicTransient_Circuit.sph**
- **Import circuit in Maxwell**
  - Return to Maxwell window
  - In Edit External Circuit window,
    1. Select **Cancel**
    2. Select the tab **Import Circuit**
    3. Browse to file **WS5_BasicTransient_Circuit.sph**
    4. Select the file and press **OK**



# Analyze

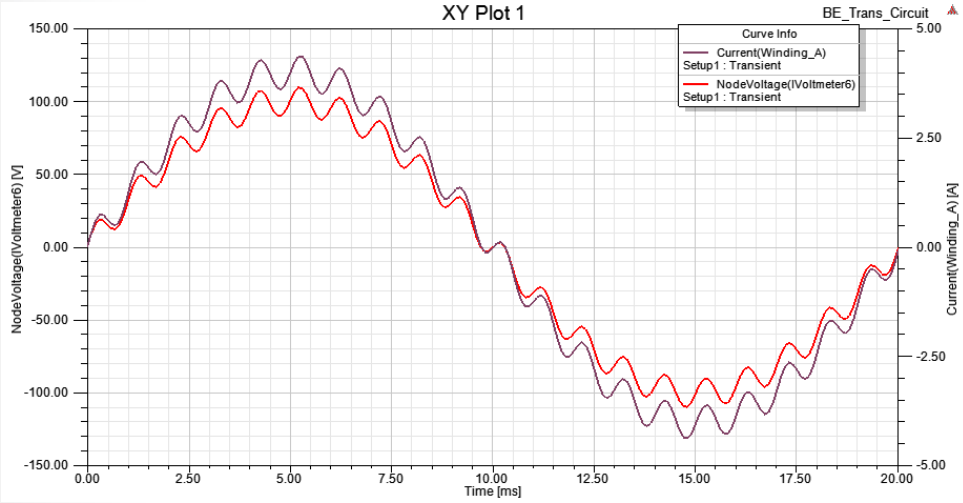
- **Run Solution**
  - Solution setup is already copied from original design
  - Select the menu item ***Maxwell 3D → Analyze All***

***Note: When an external circuit is defined, the time step is controlled from the circuit simulator. The time step values are calculated based 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 of 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 the 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
    1. Change Category to **NodeVoltage**
    2. Quantity: **NodeVoltage**
    3. Select **Apply Trace**
  - To View Results better, double click on Y Axis corresponding to NodeVoltage and change its range to -150 to 150 V



# Plot Flux Lines

- **Plot Flux Lines**
  - Select the menu item ***View → Set Solution Context***
  - In Set view Context window,
    - Time: Set to **0.01 sec**
    - Press **OK**
  - Flux Lines plot is copied with the design.
  - Double click on the plot to view the results