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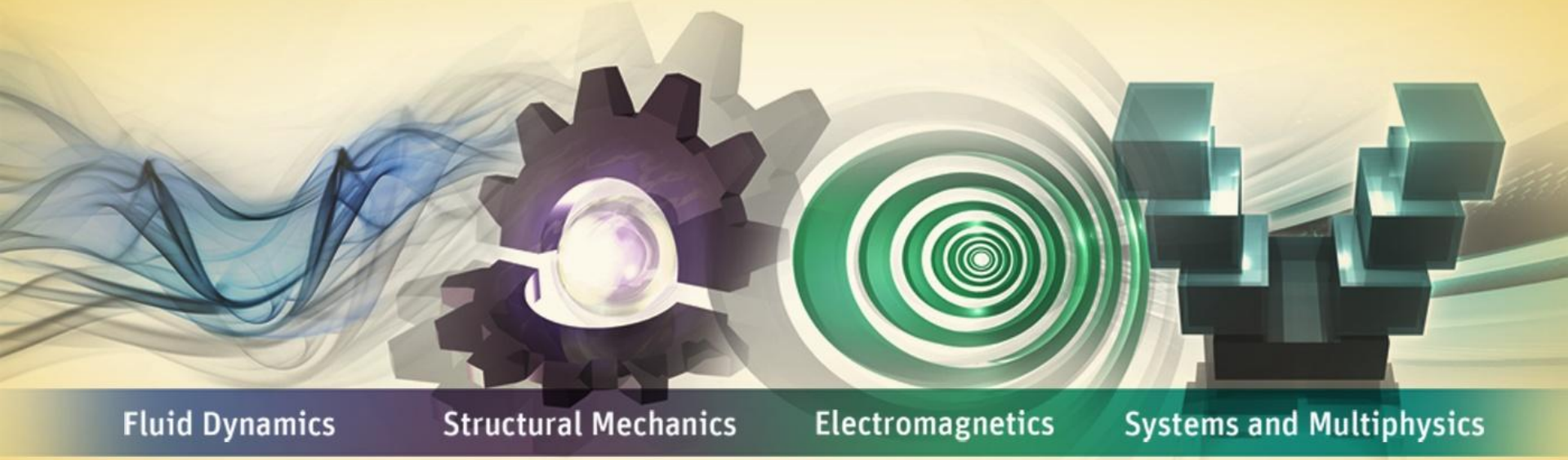
Workshop 5:
Basic Transient Sources and Circuit



ANSYS Maxwell 3D V16

About Workshop

- **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

  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

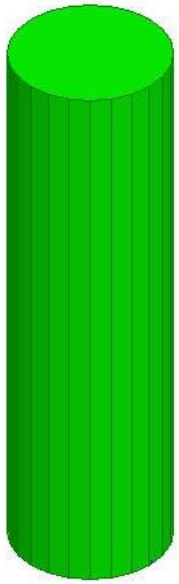
Example 1: Transient With Sources

Problem Setup

- **Create Design**
  - Select the menu item ***Project → Insert Maxwell 3D 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 3D → Solution Type***
  - Solution Type Window:
    1. Choose **Magnetic > Transient**
    2. Click the **OK** button

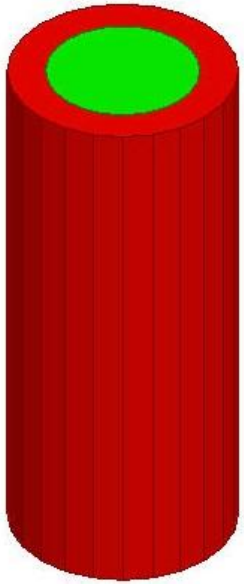
Create Core

- **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: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 2, dY: 2, dZ: 20**, Press the **Enter** key
    3. 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***
    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: 3, dY: 3, dZ: 20**, Press the **Enter** key
    3. Number of Segments: **24**
  - Change the name of the Object to Coil
  - Change the material of the object to copper
- **Subtract Objects**
  - Press Ctrl and select the objects **Coil** and **Core** from the history tree
  - Select the menu item, ***Modeler → Boolean → Subtract***
    1. Blank Parts: **Coil**
    2. Tool Parts: **Core**
    3. Clone tool objects before operation: ☑ **Checked**
    4. Click the **OK** button



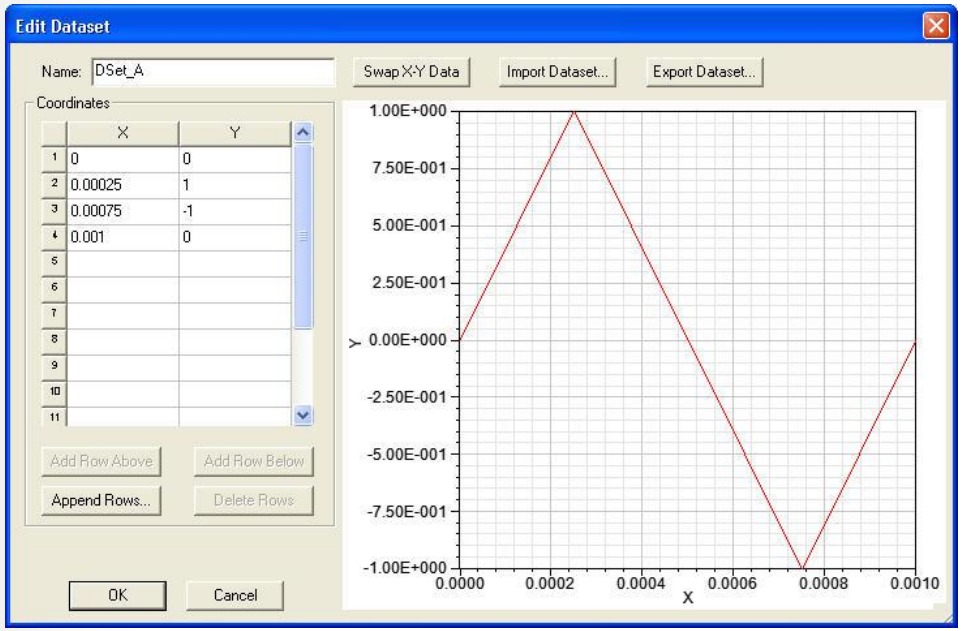
Create Coil Terminal

- **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***

Assign Excitation

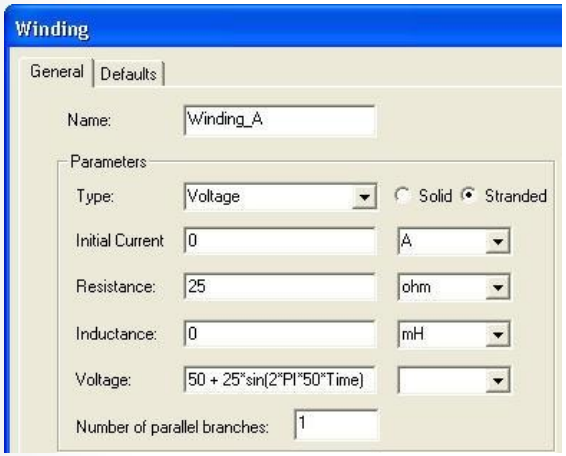
Note: The excitation for this problem will be a voltage source with a 1KHz triangular wave superimposed on a 50 Hz sine wave that has a 50 volt DC offset. Triangular wave will be specified through a design dataset.

- **Specify Dataset**
  - Select the menu item ***Maxwell 3D → 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 3D → 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

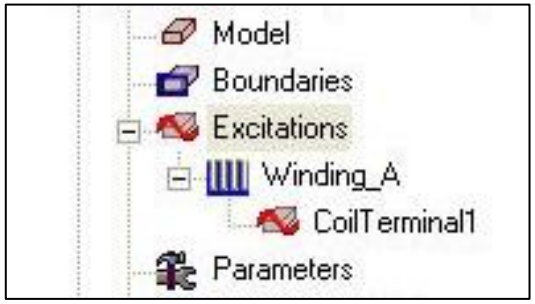
2. The second term is a 25 Vp-p, 50 Hz sine wave

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

Final applied voltage will be combined output of all three components

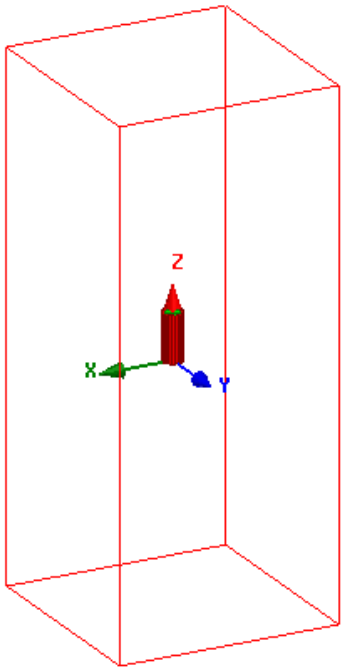
Assign Excitation (*Contd…*)

- **Assign Coil Terminal**
  - Select the sheet **Terminal** from the history tree
  - Select the menu item ***Maxwell 3D → Excitations → Assign → Coil Terminal***
  - In Current Excitation window,
    1. Name: **CoilTerminal1**
    2. Number of Conductors: **150**
    3. 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,
    1. Select **Winding_A**
    2. Press **OK**



Create Region

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



Note: As core and coil are in direct contact with each other, an insulation boundary is needed to be defined between them to avoid current leakage from coil to core. But in or case its is not necessary as the ferrite core has a conductivity = 0.01S/m which below the default conductor/insulation threshold of 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.

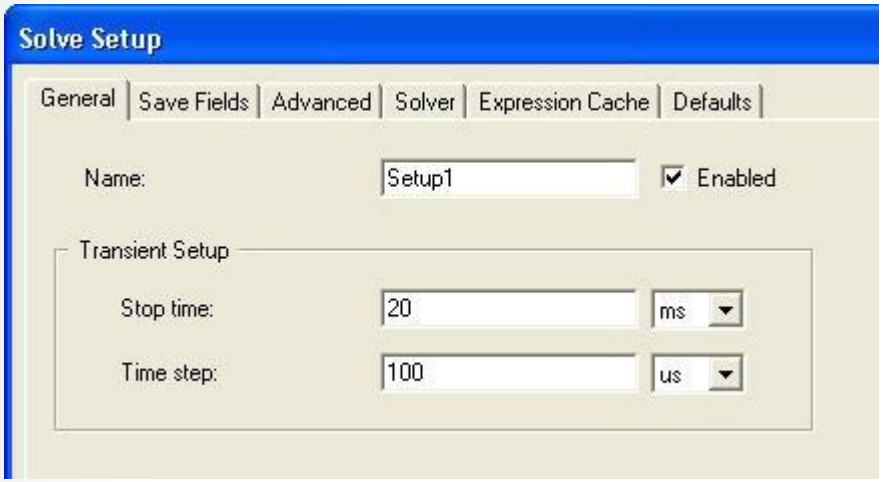
- **Apply Mesh Operations for Core**
  - Select the object **Core** from the history tree
  - Select the menu item ***Maxwell 3D → Mesh Operations → Assign → On Selection → Length Based***
  - In Element Length Based Refinement window,
    1. Name: **Length1**
    2. Restrict Length Of Elements: ☐ **Unchecked**
    3. Restrict the Number of Elements: ☑ **Checked**
    4. Maximum Number of Elements: **1000**
    5. Press **OK**

Apply Mesh Operations (*Contd…*)

- **Apply Mesh Operations for Coil**
  - Select the object **Coil** 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: **Length2**
    2. Restrict Length Of Elements: ☐ **Unchecked**
    3. Restrict the Number of Elements: ☑ **Checked**
    4. Maximum Number of Elements: **1000**
    5. Press **OK**

Analyze

- **Create an analysis setup:**
  - Select the menu item ***Maxwell 3D → Analysis Setup → Add Solution Setup***
  - Solution Setup Window:
    1. **General** tab
       - Stop Time: **20 ms**
       - Time Step: **100 us**
    2. Click the **OK** button

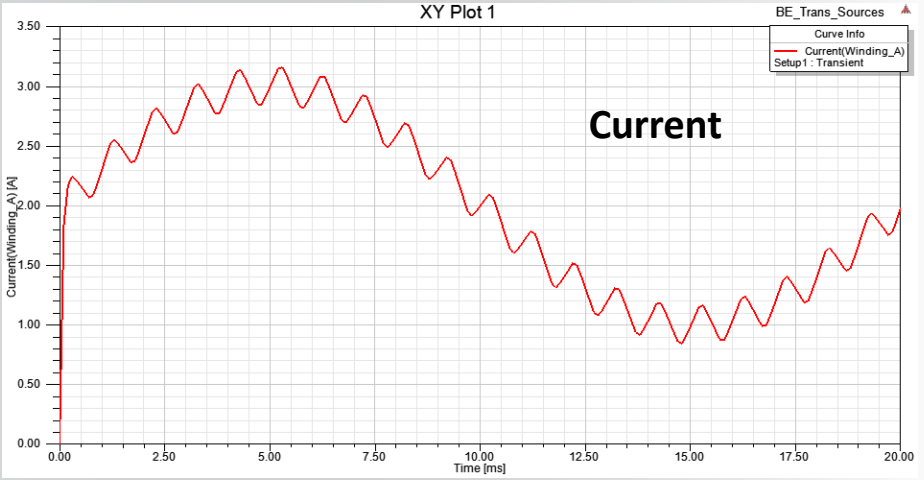


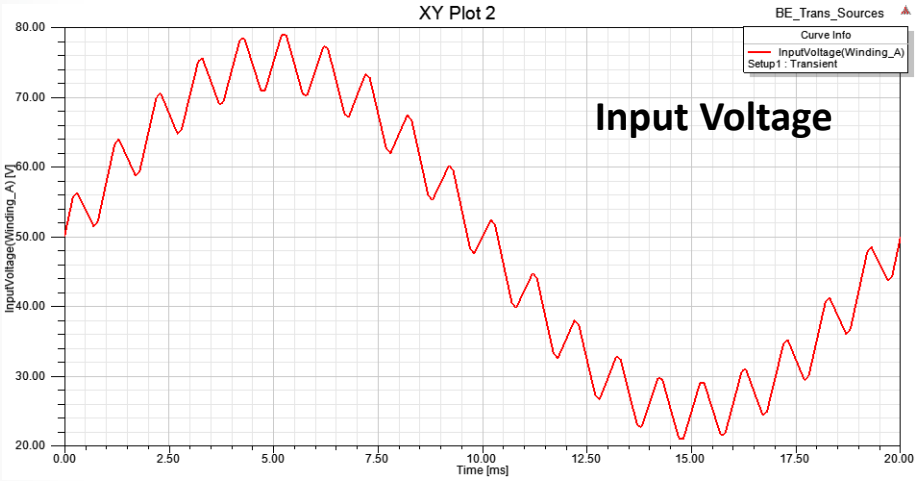
- **Run Solution**
  - Select the menu item ***Maxwell 3D → Analyze All***

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 the Voltage and Current

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

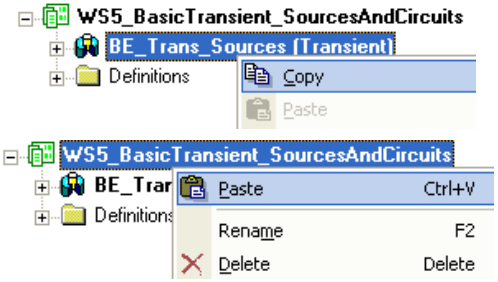




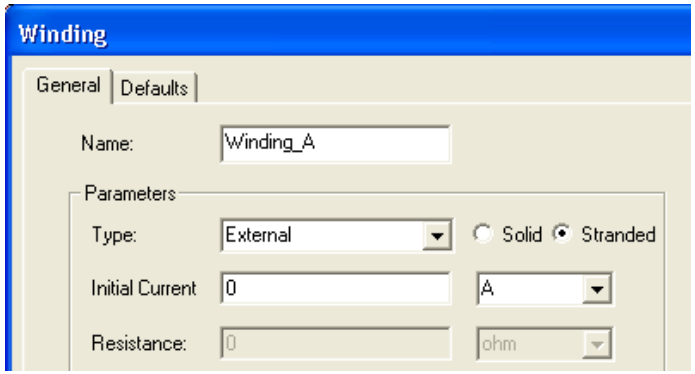
Example 2: Transient With Circuit

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"**



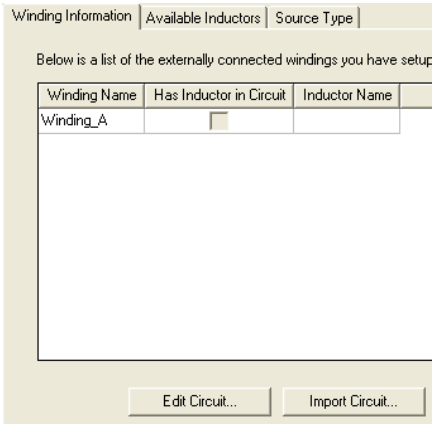
- **Modify Winding Setup**
  - Expand the Project Manager tree to view **Excitations**
  - Double click on **Winding_A** under Excitations
  - Change the Type to **External**
  - Press **OK**



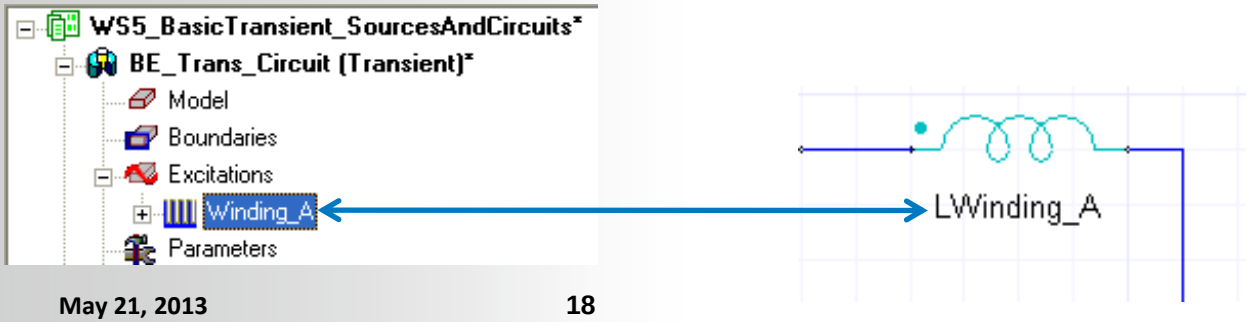
Note: When Excitation Type is set to External, External circuit will be used to calculate inputs for winding

Create External Circuit

- **Launch Maxwell Circuit Editor**
  - Select the menu item ***Maxwell 3D → Excitations → External Circuit → Edit External Circuit***
  - In Edit External Circuit window,
    - Select **Edit Circuit**
  - Maxwell Circuit Editor will launch in separate window

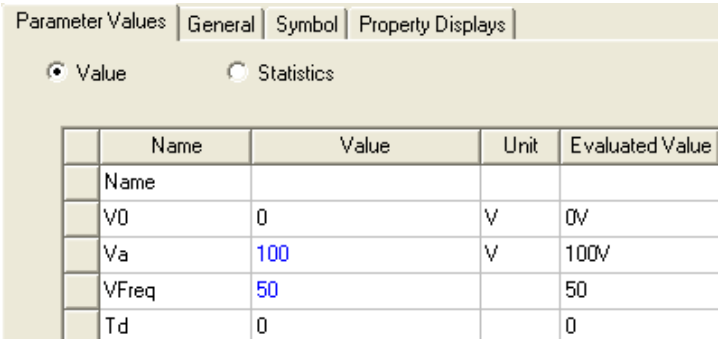


In Maxwell Circuit Editor a Component is created by default corresponding to winding in Maxwell. The name of the winding is same as as used in Maxwell in Maxwell 3D > Excitations > Add Winding. If users add winding by themselves they should ensure these names match



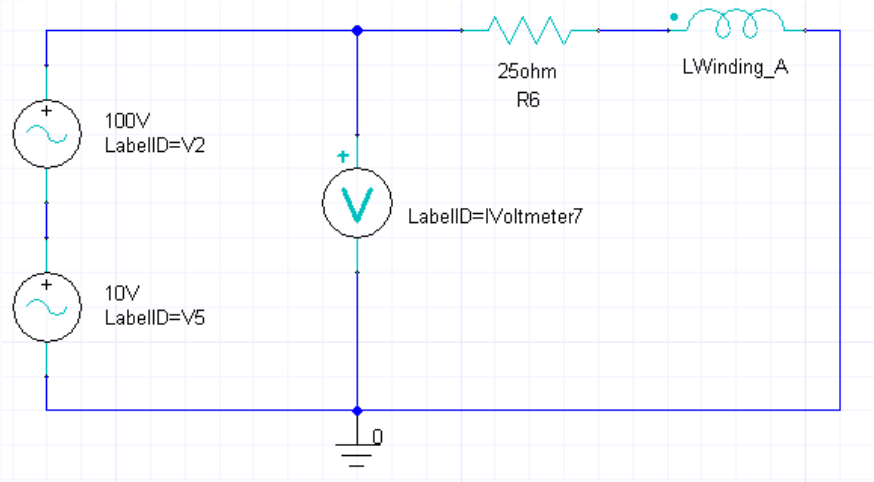
Create External Circuit (*Contd…*)

- **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…*)

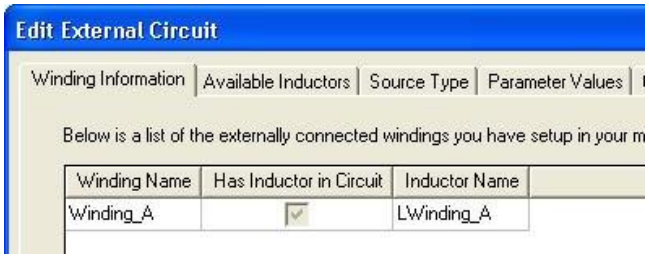
- **Add Other Components**
  - Similarly add ***Passive Elements > Res***
    1. Change the value of **R** to **25 ohm**
  - Add ***Probes > Voltmeter***
- **Build Circuit**
  - Select the menu item ***Draw → Wire*** to draw wires
  - Select the menu item ***Draw → Ground*** to add ground
  - Build the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