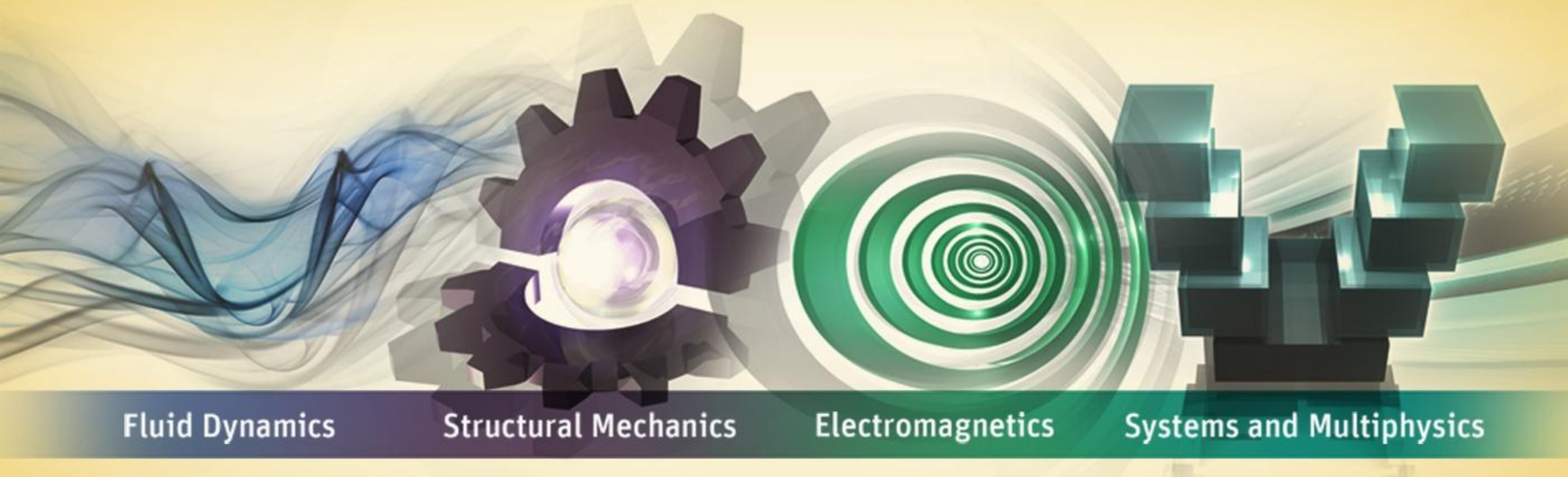
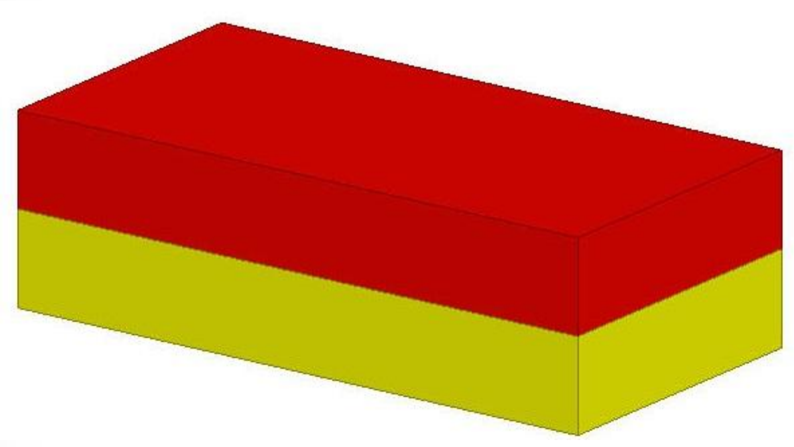
Workshop 7:
Basic Electric Transient Analysis



ANSYS Maxwell 3D V16

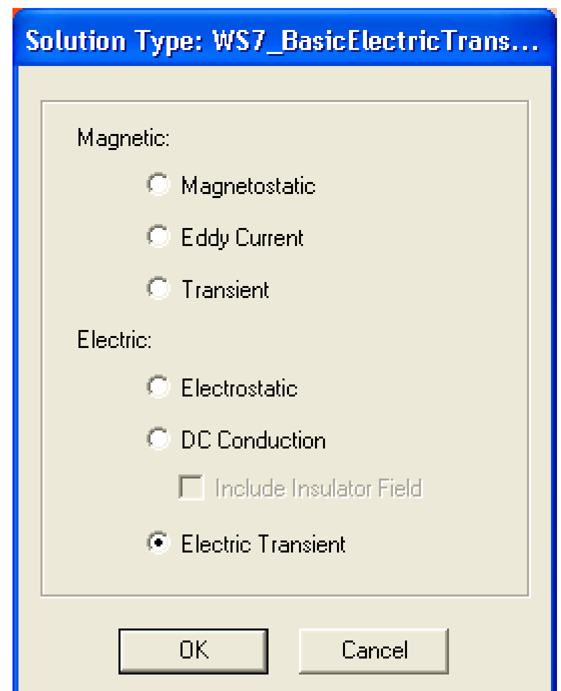
About Workshop

- **Basic Electric Transient**
  - This workshop introduces the Electro Transient solver based on a simple example.
  - In this example, we want to determine the transient electric field in the two layers of “real” dielectric material between two plates connected to a voltage source. Material properties in the two layers of dielectric are uniform within each layer but different between the two layers. We do not need to draw the plates; we just need to draw the two media regions.



Problem Setup

- **Create Design**
  - Select the menu item ***Project* → *Insert Maxwell 3D Design***, or click on the icon
- **Set the Solution Type:**
  - Select the menu item ***Maxwell 3D* → *Solution Type***
  - Solution Type Window:
    1. Choose **Electric > Electric Transient**
    2. Click the **OK** button



Create Geometry

- **Create Box_Bottom**
  - Select the menu item ***Draw → Box***
    1. Using the coordinate entry fields, enter the box position
       - **X: -1, Y: -2, Z: -0.6**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 2, dY: 4, dZ: 0.6**, Press the **Enter** key
  - Change the name of the Object to **Box_Bottom**
- **Create Box_Top**
  - Select the object **Box_Bottom** from the history tree
  - Select the menu item ***Edit → Duplicate → Along Line***
    1. Using the coordinate entry fields, enter the first point of duplicate vector
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 0, dY: 0, dZ: 0.6**, Press the **Enter** key
    3. Total Number: **2**
    4. Press **OK**
  - Change the name of the Object to **Box_Top**

Define Material

- **Create Material for Box_Bottom**
  - Select the object **Box_Bottom**, right click and select **Assign Material**
  - In Select Definition window, select **Add Material**
    1. In View/Edit Material window,
       - Material Name: **Mat_Bottom**
       - Relative Permittivity: **5**
       - Bulk Conductivity: **1e-7 siemens/m**
       - Select **OK**
- **Create Material for Box_Top**
  - Select the object **Box_Top**, right click and select **Assign Material**
  - In Select Definition window, select **Add Material**
    1. In View/Edit Material window,
       - Material Name: **Mat_Top**
       - Relative Permittivity: **4**
       - Bulk Conductivity: **2e-8 siemens/m**
       - Select **OK**

Assign Excitations

- **Assign Excitations**
  - Select the menu item ***Edit → Select → Faces***
  - Select the top face of the object **Box_Top**
  - Select the menu item ***Maxwell 3D → Excitations → Assign → Voltage***
  - In Voltage Excitation window,
    1. Set Value to **if(Time<2.5e-3,1,0)**
    2. Press **OK**
  - Select the bottom face of the object **Box_Bottom**
  - Select the menu item ***Maxwell 3D → Excitations → Assign → Sink***
  - In Sink Excitation window,
    1. Press **OK**

Note: We apply the voltage to the plates. We did not draw the plates, because we can apply a voltage to the top and bottom part of the regions.

Assigned equation for voltage will apply 1V till 2.5ms on Top plate and will set 0V after 2.5ms

Assign Mesh operations

- **Assign Mesh operations**
  - Select the menu item ***Edit → Select → Objects***
  - Press Ctrl and select the objects **Box_Bottom** and **Box_Top**
  - Select the menu item ***Maxwell 3D → Mesh Operations → Assign → Inside Selection → Length Based***
  - In Element Length Based Refinement window,
    1. Restrict length of Elements: ☑ **Checked**
    2. Maximum Length of Elements: **0.55 mm**
    3. Press **OK**
- **Create Points for**
  - Select the menu item ***Draw → Point***
    1. Using the coordinate entry fields, enter the point position
       - **X: 0, Y: 0, Z: 0.3**, Press the **Enter** key
  - Select the menu item ***Draw → Point***
    1. Using the coordinate entry fields, enter the point position
       - **X: 0, Y: 0, Z: -0.3**, Press the **Enter** key

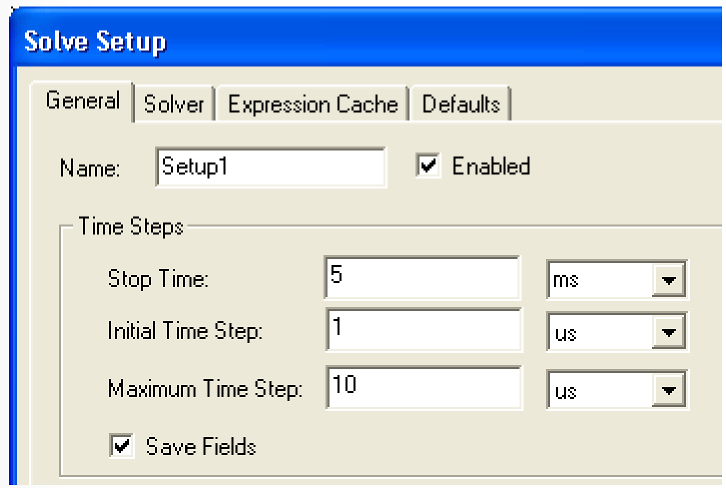
Analyze

- **Create an analysis setup:**
  - Select the menu item ***Maxwell 3D* → *Analysis Setup* → *Add Solution Setup***
  - Solution Setup Window:

    1. General Tab

    - Stop Time: **5 ms**
    - Initial Time Step: **1us**
    - Maximum Time Step: **10 us**
    - Save Fields: ☑ **Checked**

    2. Click the **OK** button



Note: Electric transient solver uses adaptive time stepping approach.

- **Start the solution process:**

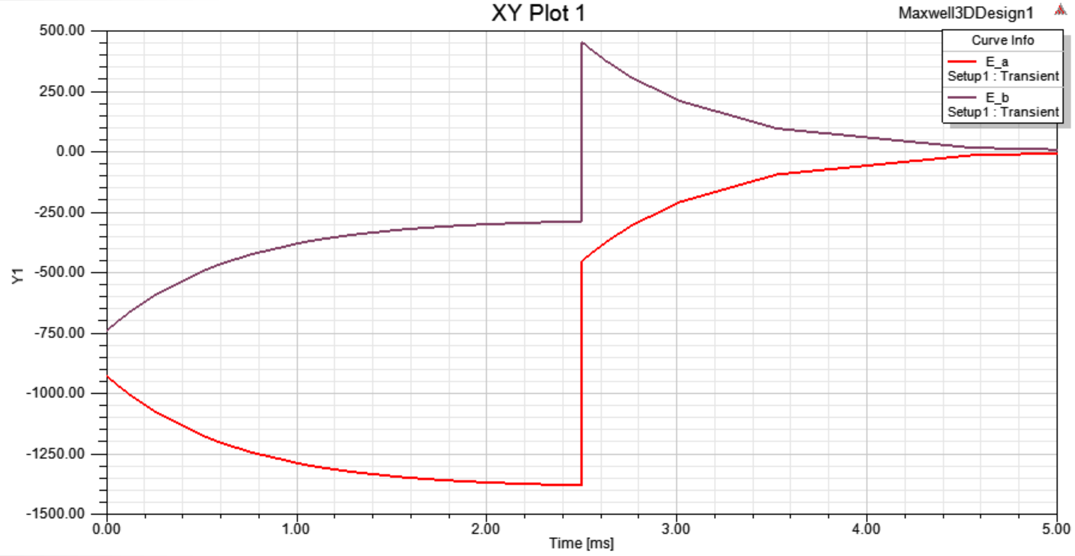
  1. Select the menu item ***Maxwell 3D* → *Analyze All***

Create Parameters for Plot

- **To Create Parameters**
  - Select the menu item ***Maxwell 3D → Fields → Calculator***
    1. Select **Input > Quantity > E**
    2. Select **Vector > Scal? > ScalarZ**
    3. Select **Input > geometry**
       - Select **Point > Point1 >** Press **OK**
    4. Select **Output > Value**
    5. Press **Add**
       - Specify name of the parameter as **E_a** and press **OK**
    6. Select **Input > Quantity > E**
    7. Select **Vector > Scal? > ScalarZ**
    8. Select **Input > geometry**
       - Select **Point > Point2 >** Press **OK**
    9. Select **Output > Value**
    10. Press **Add**
        - Specify name of the parameter as **E_b** and press **OK**
    11. Press **Done**

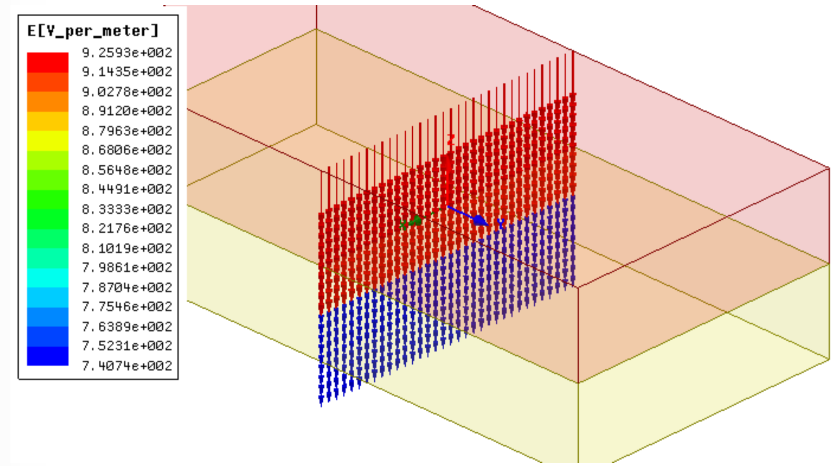
Create Plot

- **Create Plot**
  - Select the menu item ***Maxwell 3D → Results → Create Field Report → Rectangular Plot***
  - In Report window,
    - X: **Default**
    - Category: **Calculator Expressions**
    - Quantity: **E_a**
    - Select **New Report**
    - Change Quantity to **E_b**
    - Select **Add Trace**



Plot E_Vector on a Plane

- **Plot E_Vector**
  - Expand the tree for Planes from history tree and select the plane **Global:XZ**
  - Select the menu item ***Maxwell 3D → Fields → Fields → E → E_vector***
  - In Create Field Plot window,
    1. Instrinsic Variables >Time:**1e-6 sec**
    2. Press **Done**



Note: Default plot may not look as shown in image. Users can modify attributes of plot to make it look better. Double click on the legend to modify plot attributes.

- **Animate Plot**
  - Expand the tree for **Field Overlays** from Project Manager window
  - Select the plot **E_Vector1** from the list, right click and select **Animate**
  - In Setup Animation window, set start time and Stop Time and press **OK**

System Level Simulation

- **Equivalent Circuit Model**
  - Due to uniform thickness of the dielectric layer, the surface of separation between the two dielectrics can be assumed to be equipotential. Thus it becomes possible to replace the two dielectric layers with equivalent series/parallel RC circuits shown below.
  - Since the material and geometry information of the two dielectric layers are known, the resistances and capacitances can be calculated with the equations:

$$R = \frac{l}{\sigma A}, \quad C = \frac{\varepsilon A}{l}$$

  - Comparison of the voltages across the dielectric layers simulated in a circuit/system level simulator and calculated in Maxwell