

Electromagnetic Simulation Software -- tutorial --

December 1, 2016

PHYS 402: E&M 2

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Login to Computer Terminal
Do NOT open FEKO

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Principle Numerical 3D EM Methods

Method of Moments (MoM)

Solves Maxwell's equations in **integral** form in the frequency domain.
(boundary conditions included in integral)

- For discretized volume/surface of sources, integral eq. reduces to a **matrix** eq.
- Solves matrix eq. **exactly** to get $J(r_i)$ and $\rho(r_i)$.
- Once $J(r_i)$ and $\rho(r_i)$ are known, then compute $E(r_i)$ and $B(r_i)$.

Finite Element Method (FEM)

Solves Maxwell's equations in **differential** form in the frequency domain.

- Entire solution volume is discretized, boundary cond. imposed explicitly.
- Diff. eq. become large **sparse matrix eq.**
- Solves matrix eq. **approximately** to get $E(r_i)$, and thus $B(r_i)$, $J(r_i)$, and $\rho(r_i)$.

Finite Difference Time Domain (FDTD)

Solves Maxwell's equations in differential form in the time domain.

- Staggered E and B cubic discretization lattices (MoM/FEM → triangle discr.)
- Calculate E → calculate B → time-step forward → calculate E, etc ...

Commercial 3D EM Solvers

FEKO (part of Altair Inc.)

- primary solver: MoM
- also uses FEM, FDTD, and hybrid MoM-FEM.

HFSS (part of ANSYS)

- primary solver: FEM
- also uses hybrid MoM-FEM

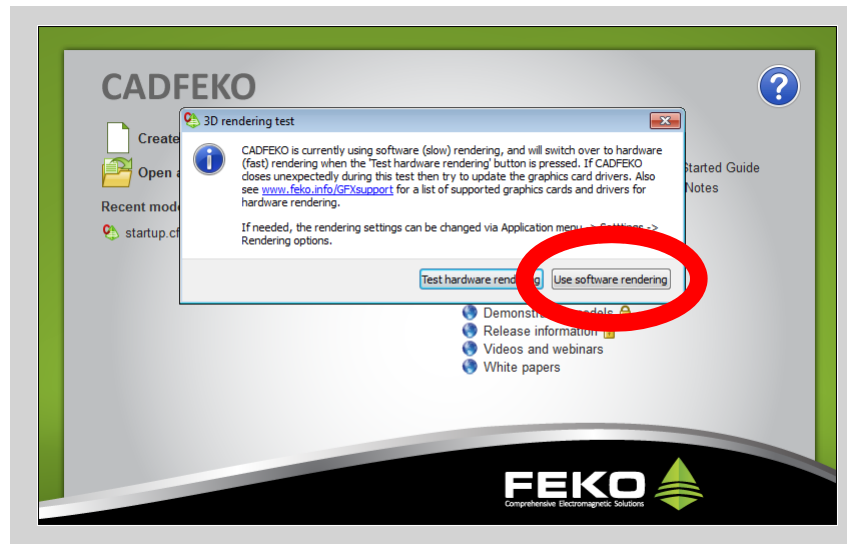
COMSOL Multiphysics (AC/DC and RF modules)

- primary solver: FEM

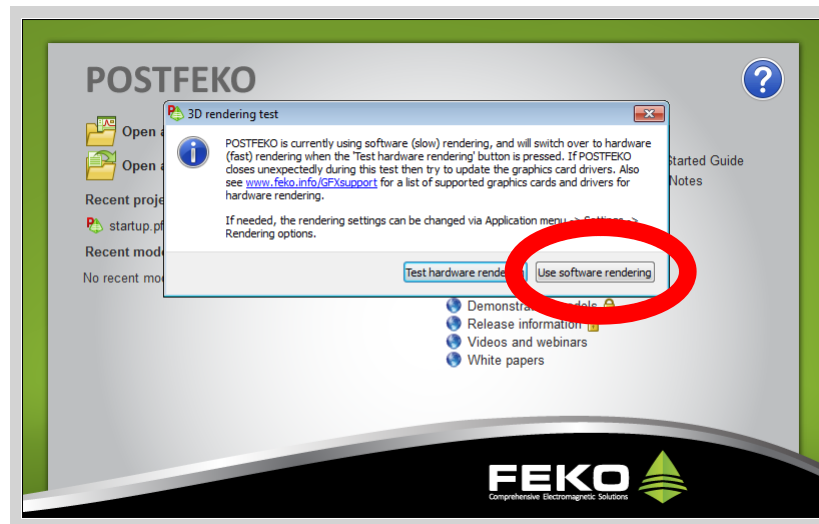
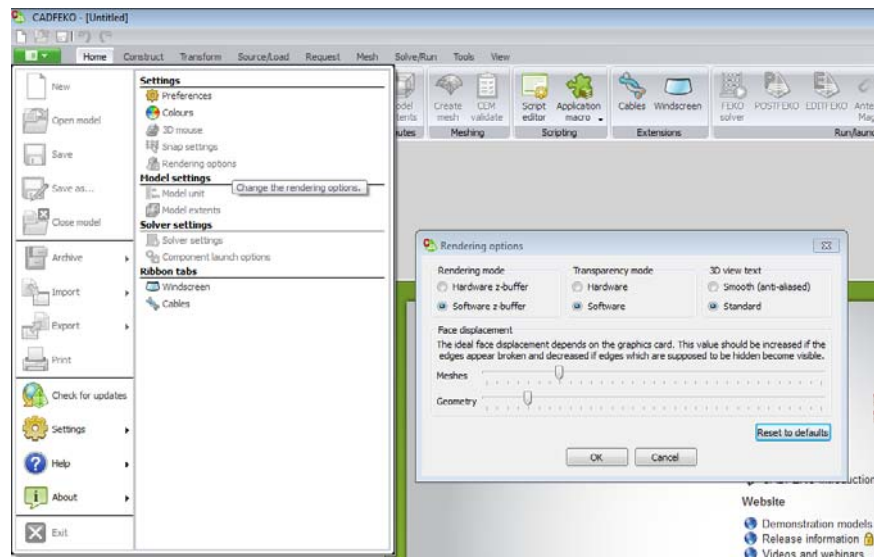
CST Microwave Studio (by CST)

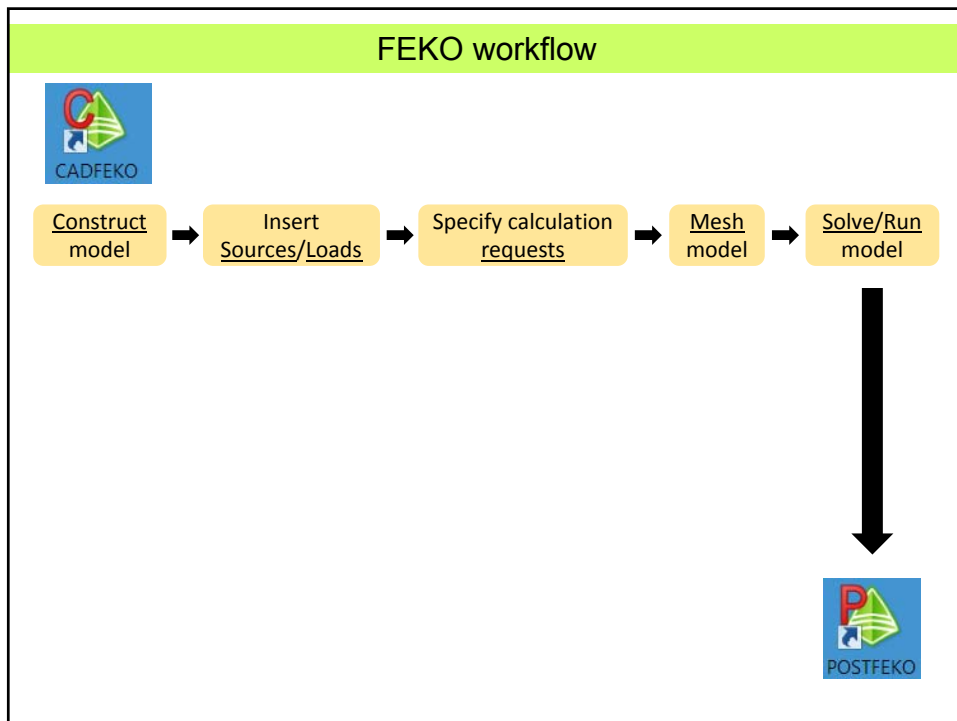
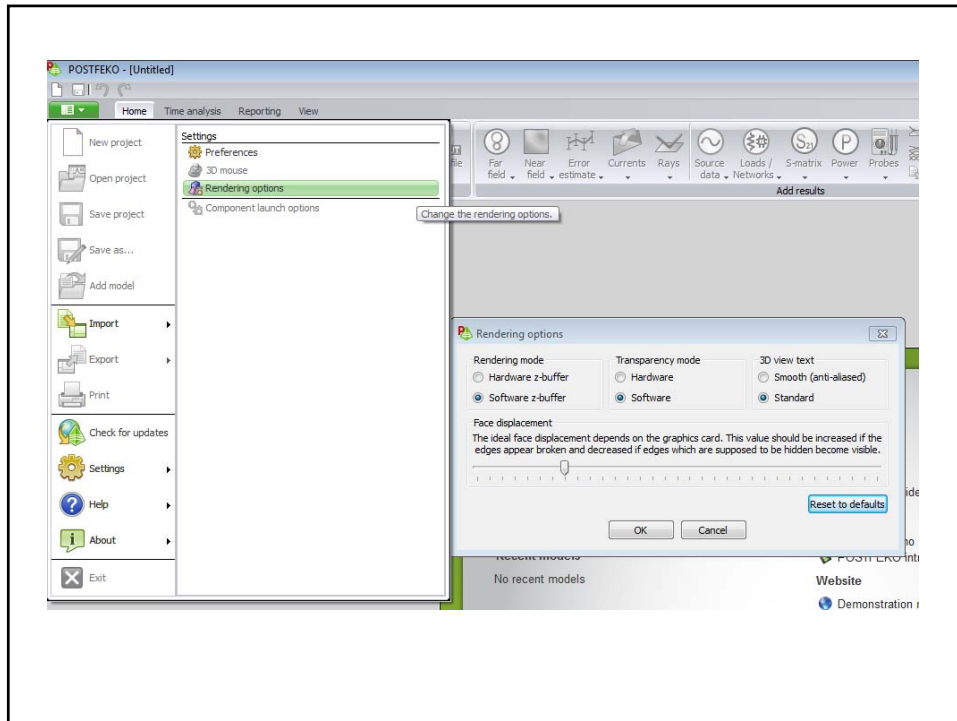
- primary solver: FDTD (with some integral eq. solving also).

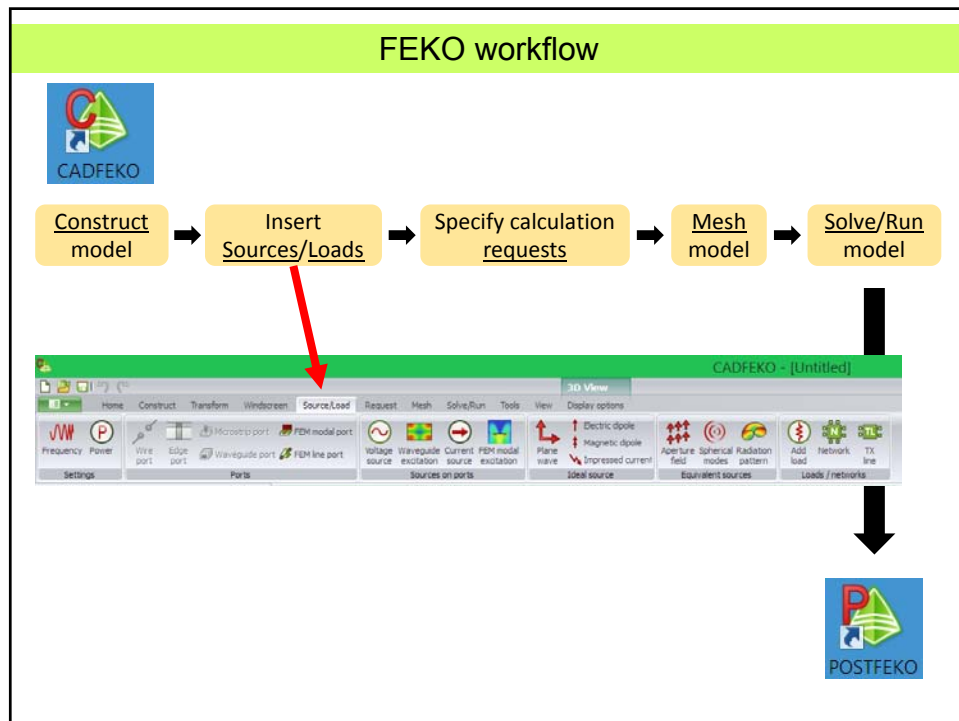
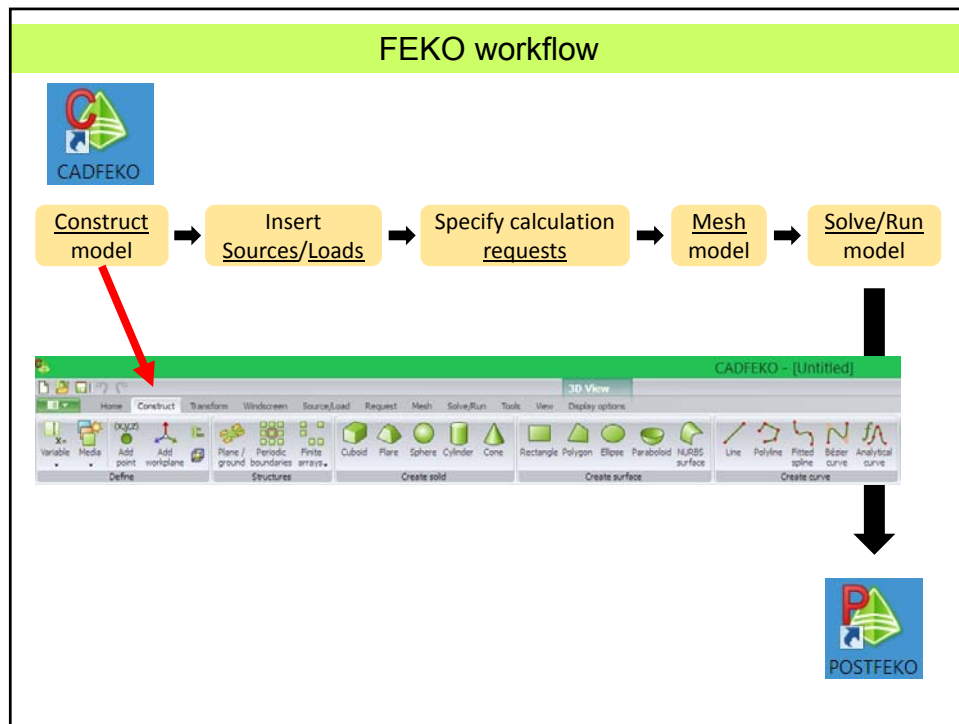
Open CADFEKO

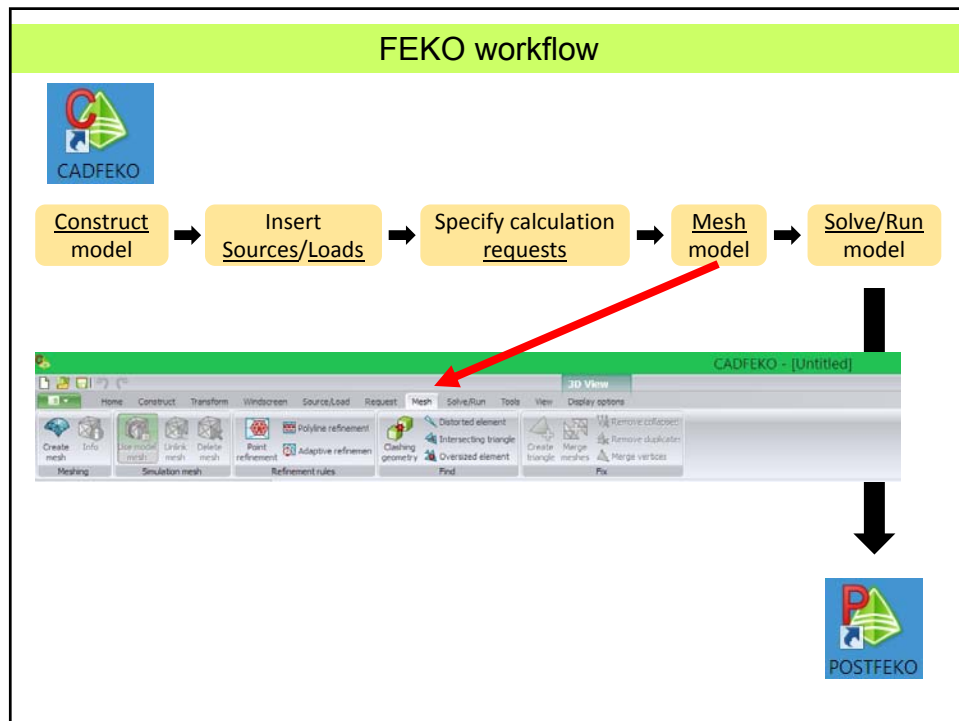
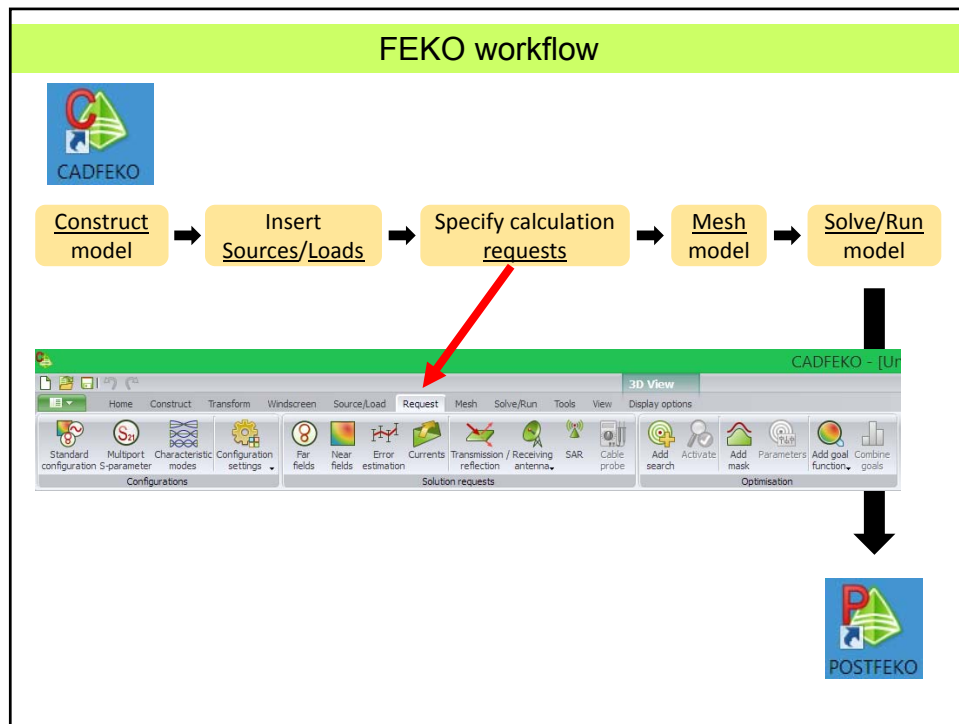


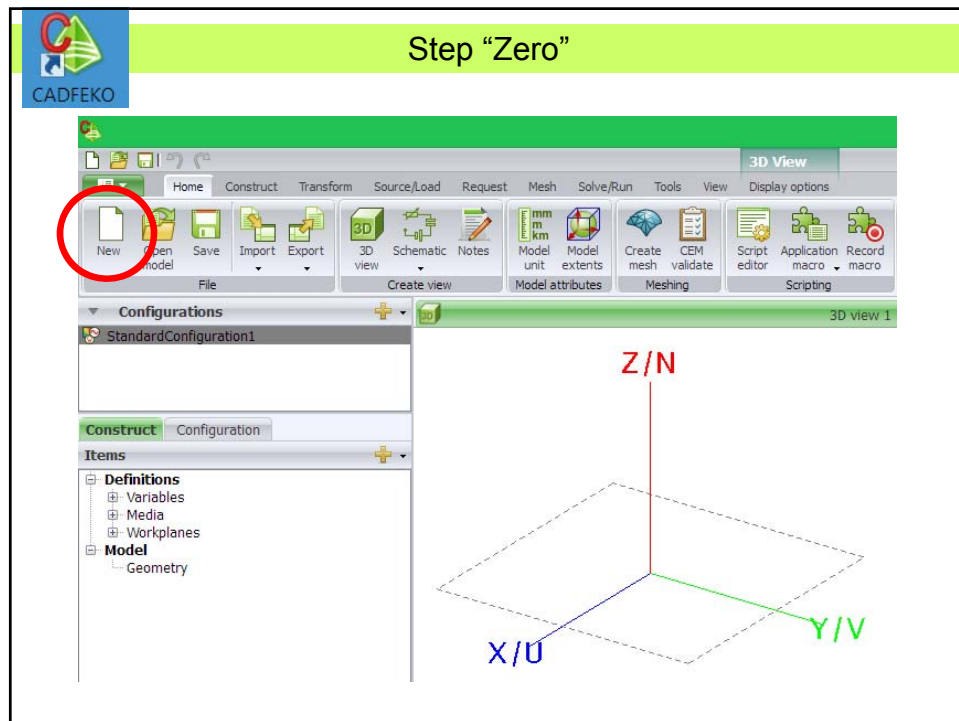
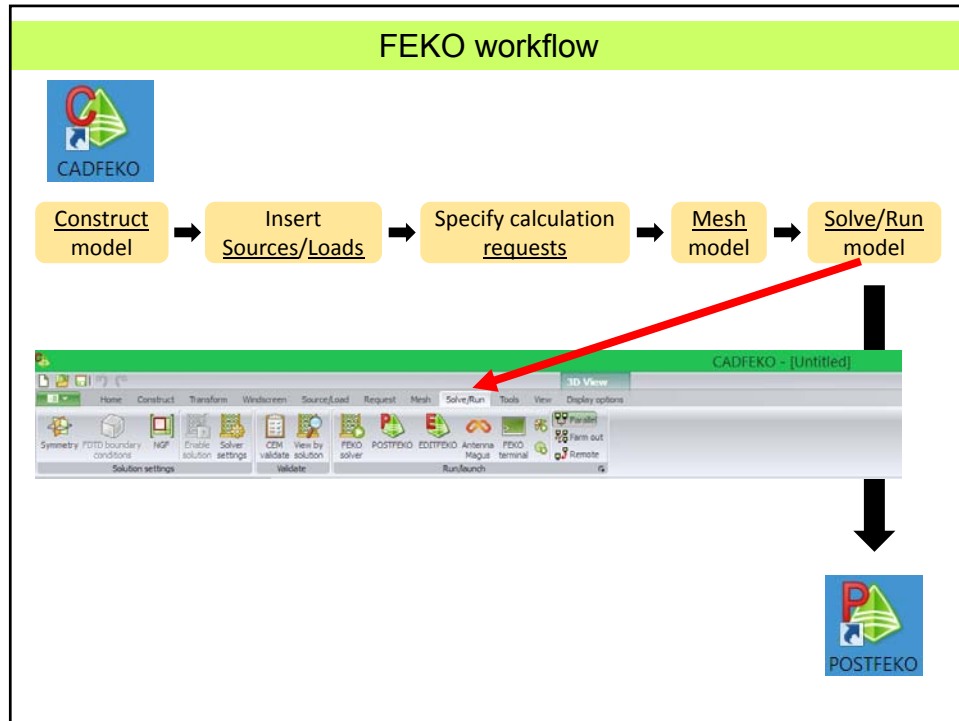
Just in case: Adjusting the Rendering









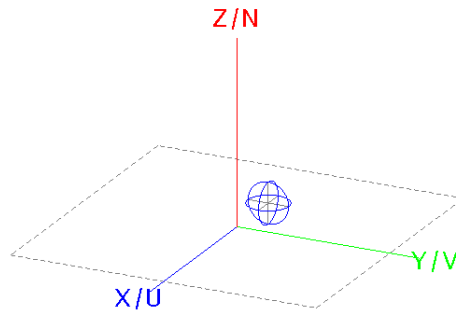


FEKO: 3D perspective navigation

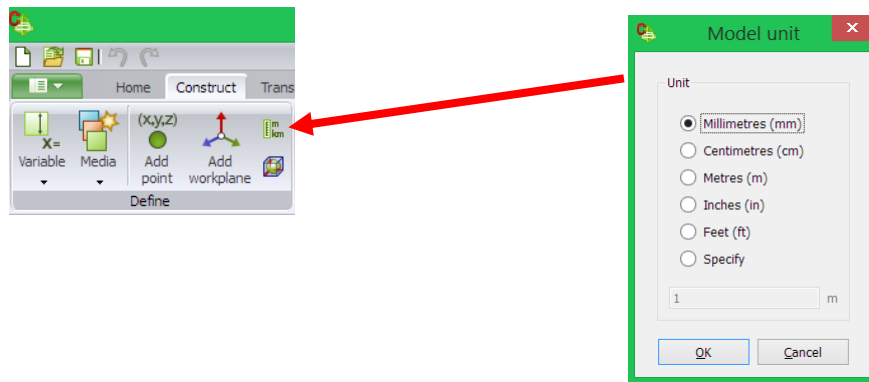
Rotation: Mouse-left-click + drag

Zoom: Shift + Mouse-left-click + drag vertical

Translate: Ctrl + Mouse-left-click + drag



Dipole Antenna: Construction definitions



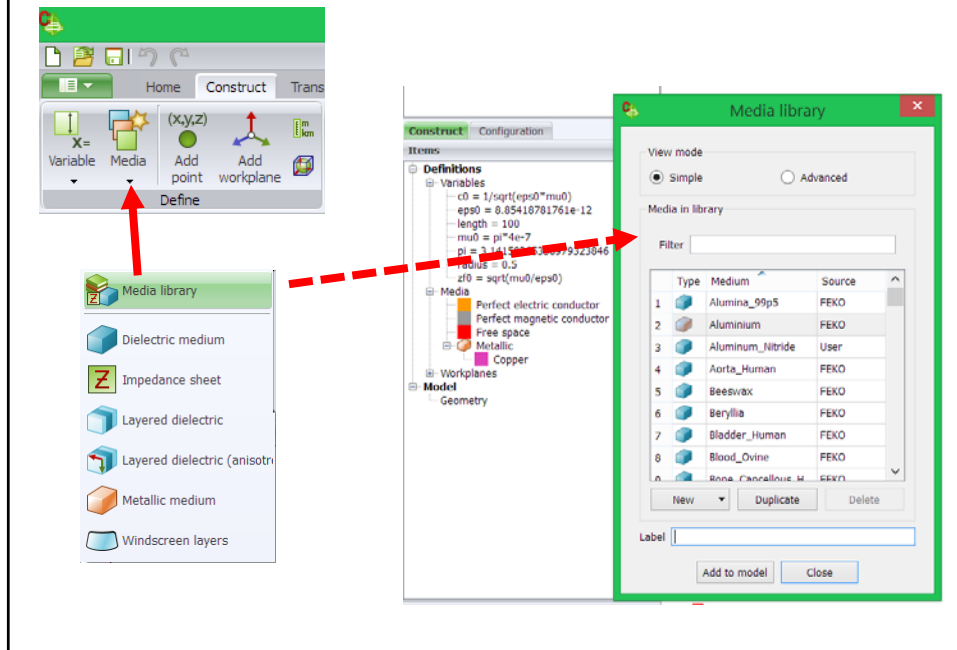
Dipole Antenna: Construction definitions

The screenshot shows the software interface for defining construction parameters for a Dipole Antenna. The 'Construct' tab is active, and the 'Define' section is visible. A red arrow points from the 'Model unit' dialog box to the 'Add variable' button. Another red arrow points from the 'Add variable' button to the 'Modify variable' dialog box. The 'Model unit' dialog box shows 'Unit' set to 'Millimetres (mm)'. The 'Modify variable' dialog box shows 'Name' as 'length', 'Expression' as '100', and 'Value' as '100'. The 'Items' tree on the left shows 'Definitions' with 'length = 100' highlighted.

Dipole Antenna: Construction definitions

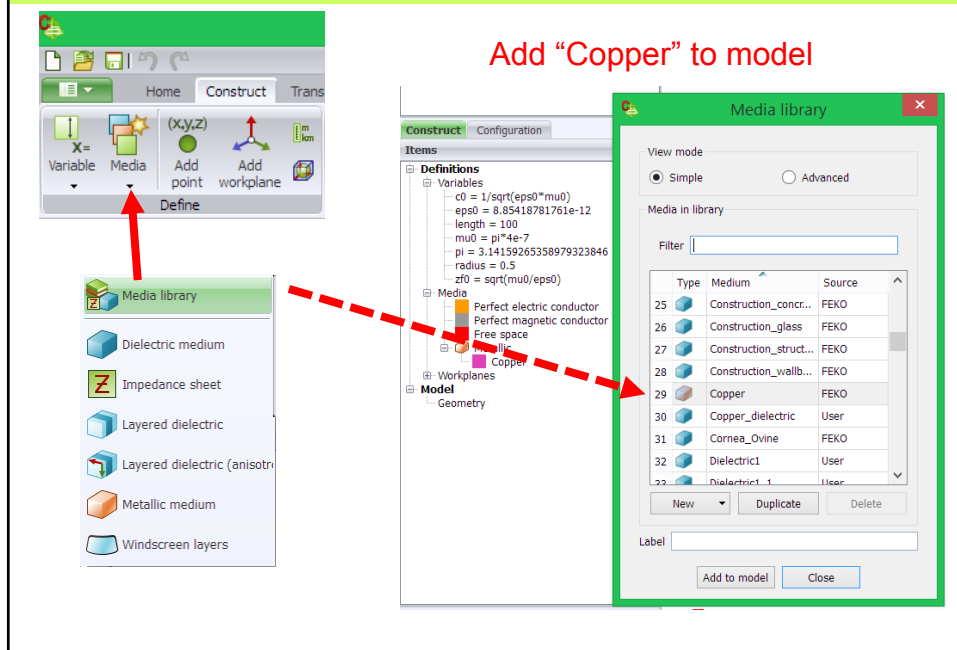
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Dipole Antenna: Construction definitions

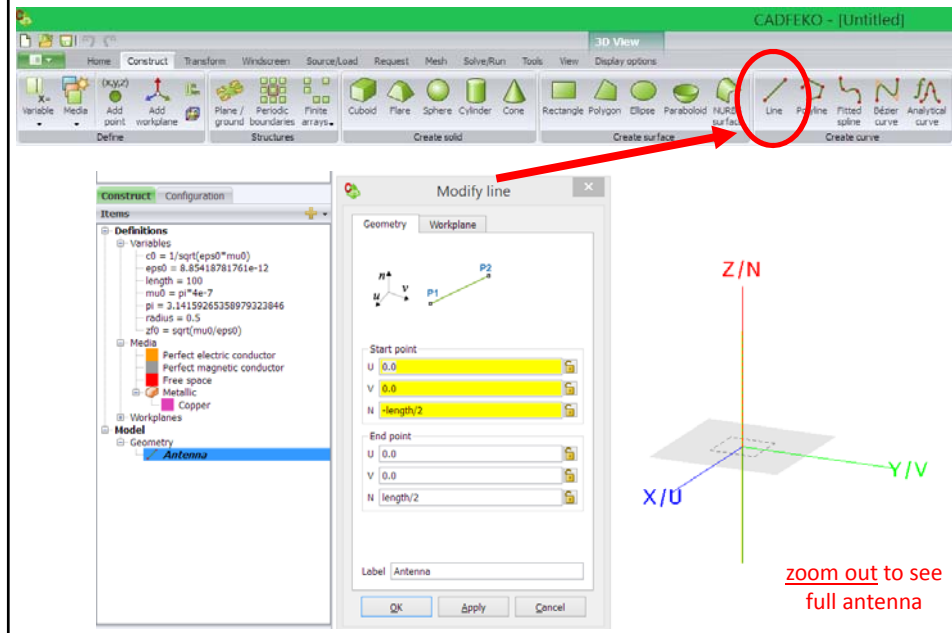


Dipole Antenna: Construction definitions

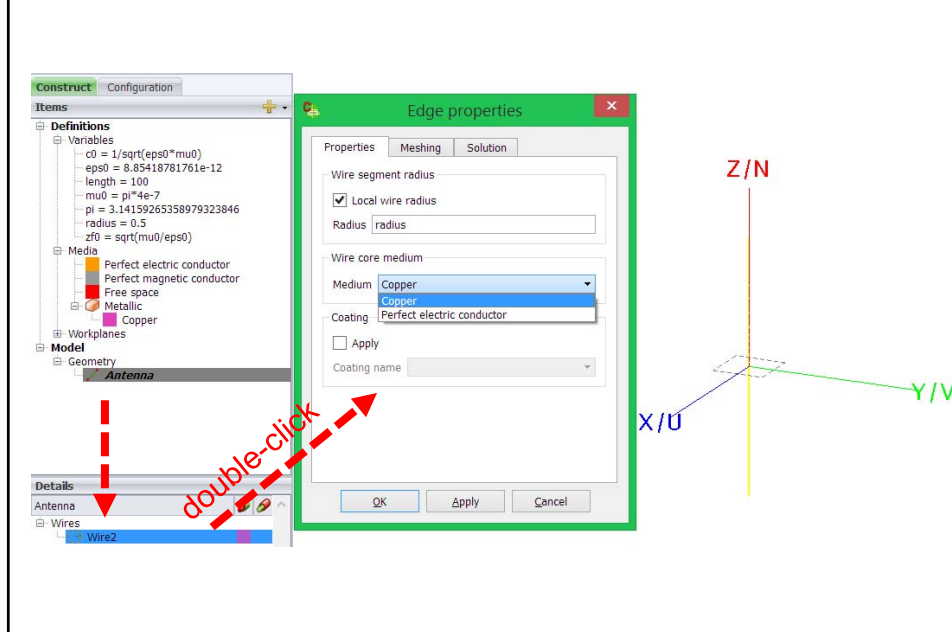
Add "Copper" to model



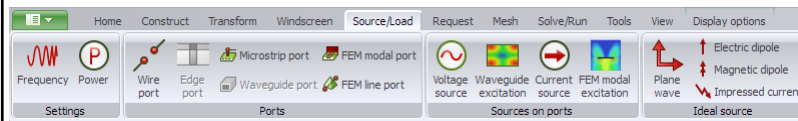
Dipole Antenna: Construct Antenna



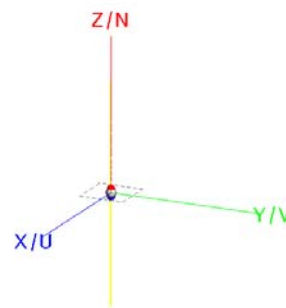
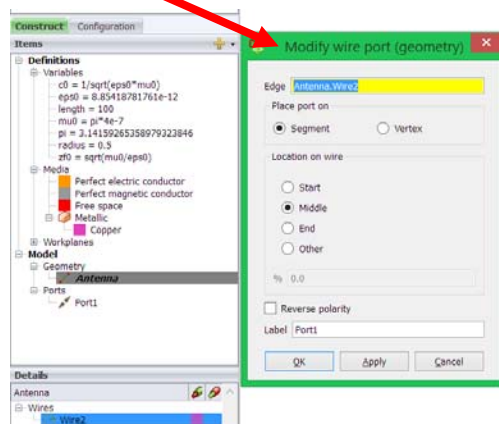
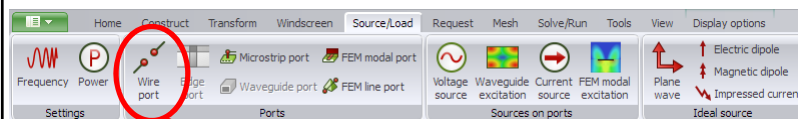
Dipole Antenna: Construct Antenna → assign material



Dipole Antenna: Excitation Source



Dipole Antenna: Excitation Source



Dipole Antenna: Excitation Source

The screenshot shows the software interface with the **Source/Load** tab selected. The **Ports** group contains icons for **Wire port**, **Edge port**, **Microstrip port**, **Waveguide port**, **FEM modal port**, and **FEM line port**. The **Sources on ports** group contains icons for **Voltage source**, **Waveguide excitation**, **Current source**, and **FEM modal excitation**. The **Ideal source** group contains icons for **Electric dipole**, **Magnetic dipole**, **Plane wave**, **Impressed current**, and **Ideal source**. A red circle highlights the **Voltage source** icon, with a red arrow pointing to the **Modify voltage source** dialog box.

The **Modify voltage source** dialog box has the following settings:

- Port: Port1
- Voltage:
 - Magnitude (V): 1
 - Phase (degrees): 0
 - Port impedance (Ohm): 50
- Label: VoltageSource1

The **Construct** panel on the left shows the **Items** tree with **Port1** selected under the **Antennas** group. A red circle highlights **Port1** with the word "select" written below it. The **Details** panel shows the **Antenna** group with **Wire2** selected.

A 3D coordinate system is shown with axes labeled **X/U** (blue), **Y/V** (green), and **Z/N** (red).

Dipole Antenna: model configuration

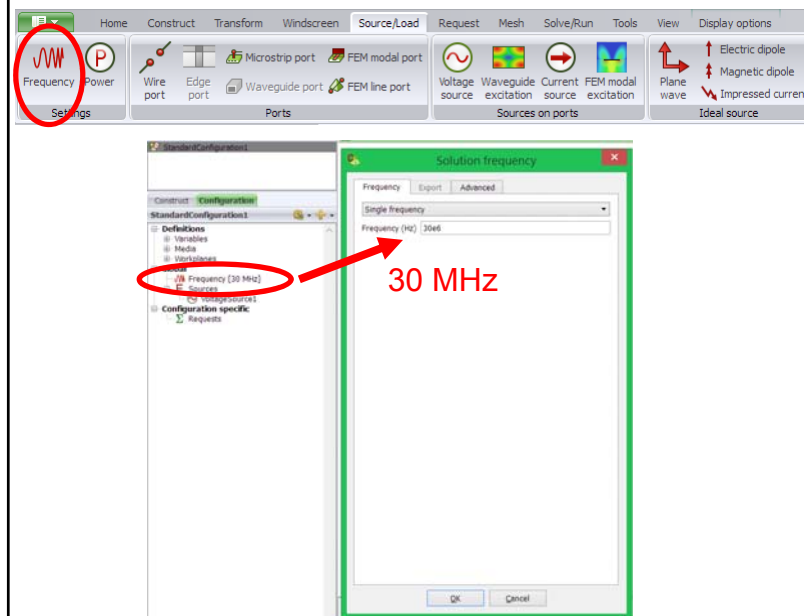
The screenshot shows the software interface with the **Source/Load** tab selected. The **Ports** group contains icons for **Wire port**, **Edge port**, **Microstrip port**, **Waveguide port**, **FEM modal port**, and **FEM line port**. The **Sources on ports** group contains icons for **Voltage source**, **Waveguide excitation**, **Current source**, and **FEM modal excitation**. The **Ideal source** group contains icons for **Electric dipole**, **Magnetic dipole**, **Plane wave**, **Impressed current**, and **Ideal source**. A red circle highlights the **Configuration** tab in the **Construct** panel.

The **Configuration** panel on the left shows the **StandardConfiguration1** group with the following settings:

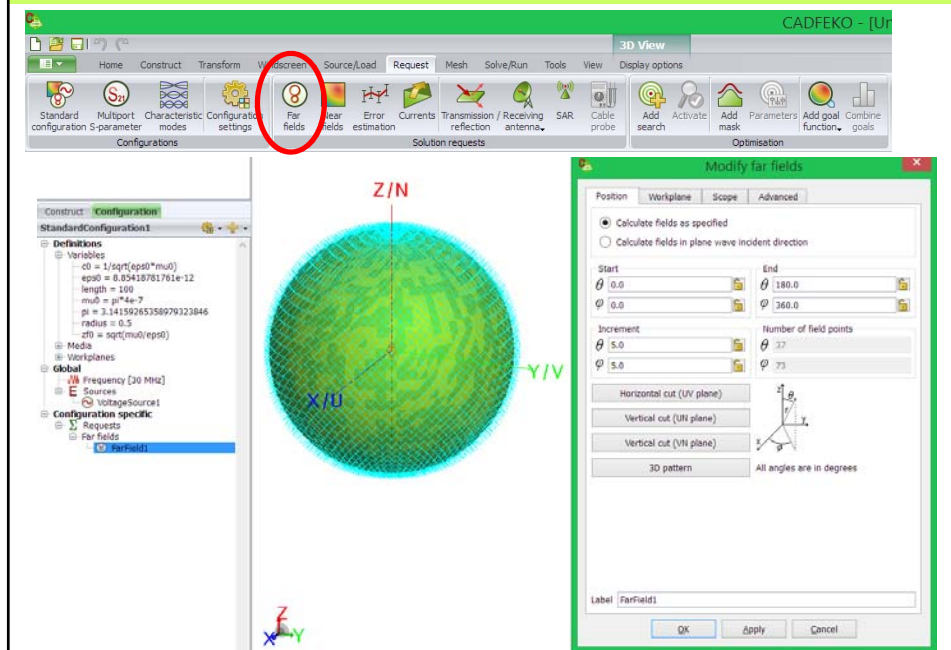
- Definitions**
 - Variables
 - Media
 - Workplanes
- Global**
 - Frequency [0 Hz]
 - Sources
 - VoltageSource1
- Configuration specific**
 - Requests

A 3D coordinate system is shown with axes labeled **X/U** (blue), **Y/V** (green), and **Z/N** (red).

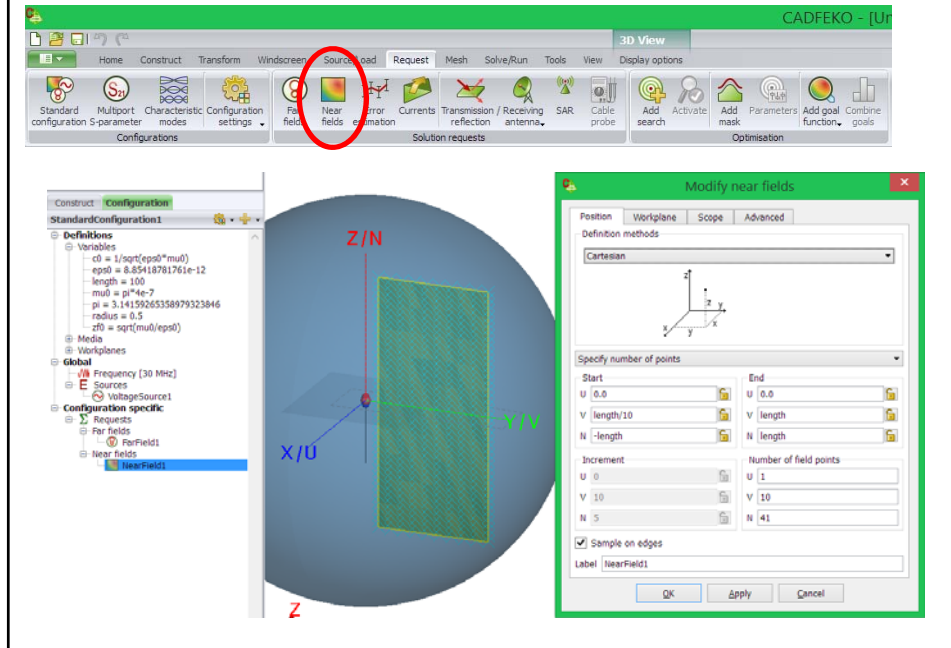
Dipole Antenna: set solution Frequency



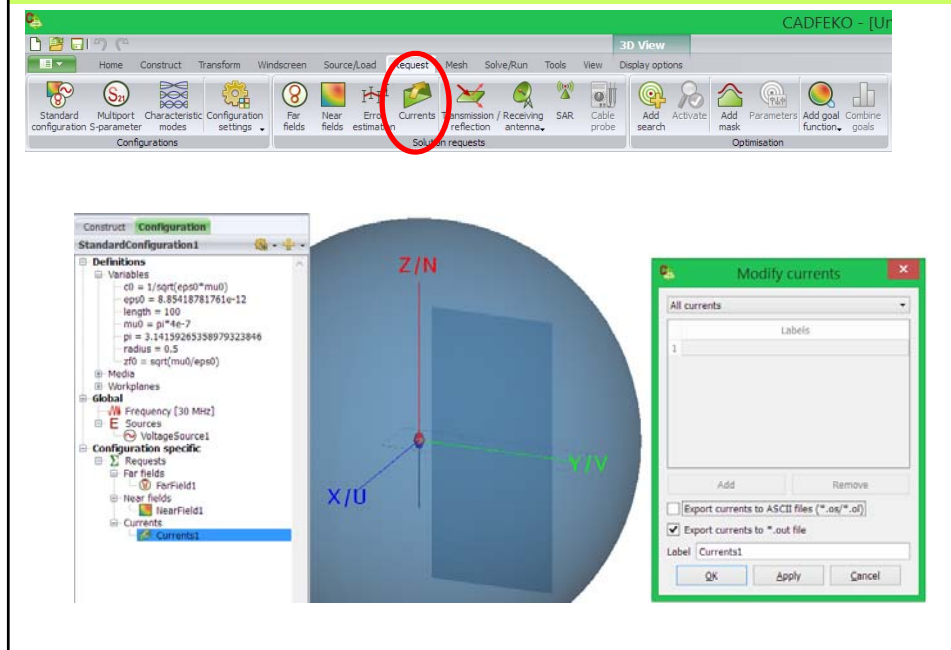
Dipole Antenna: Calculation Requests



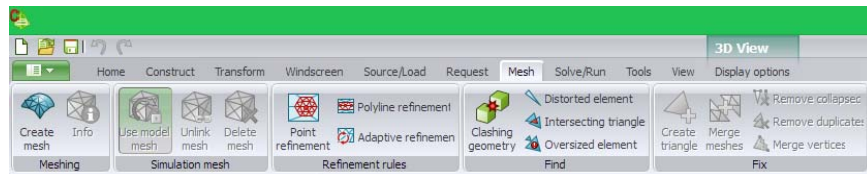
Dipole Antenna: Calculation Requests



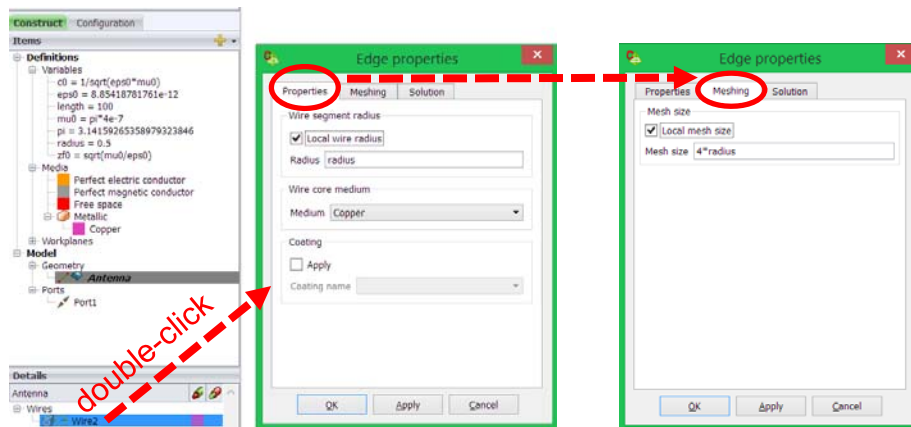
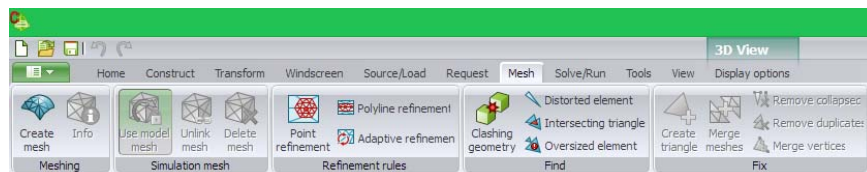
Dipole Antenna: Calculation Requests



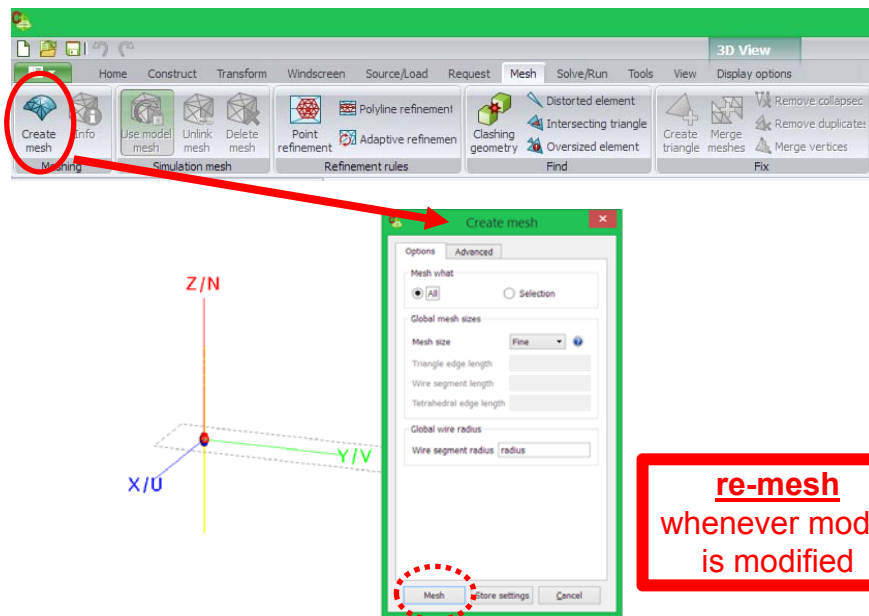
Dipole Antenna: Mesh the model



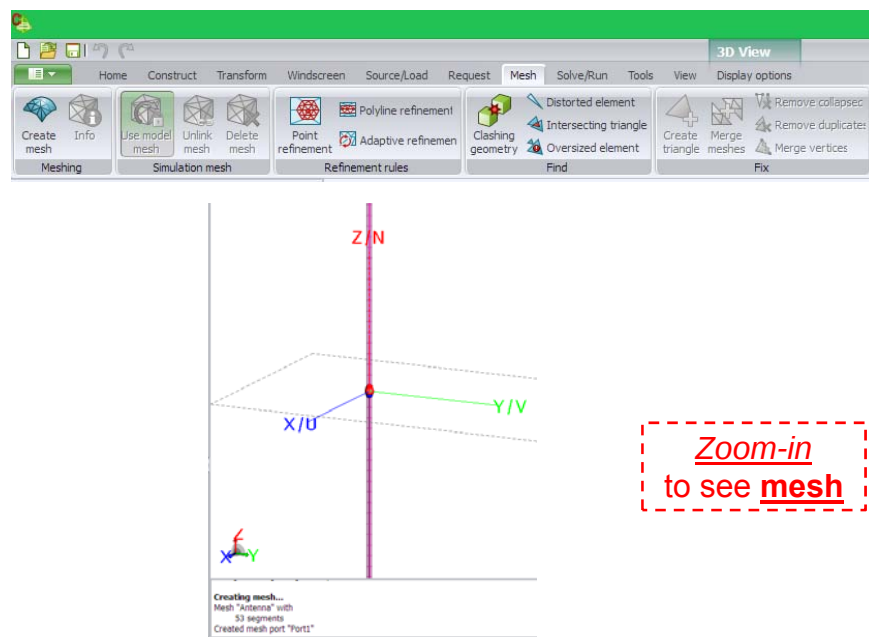
Dipole Antenna: Mesh the model



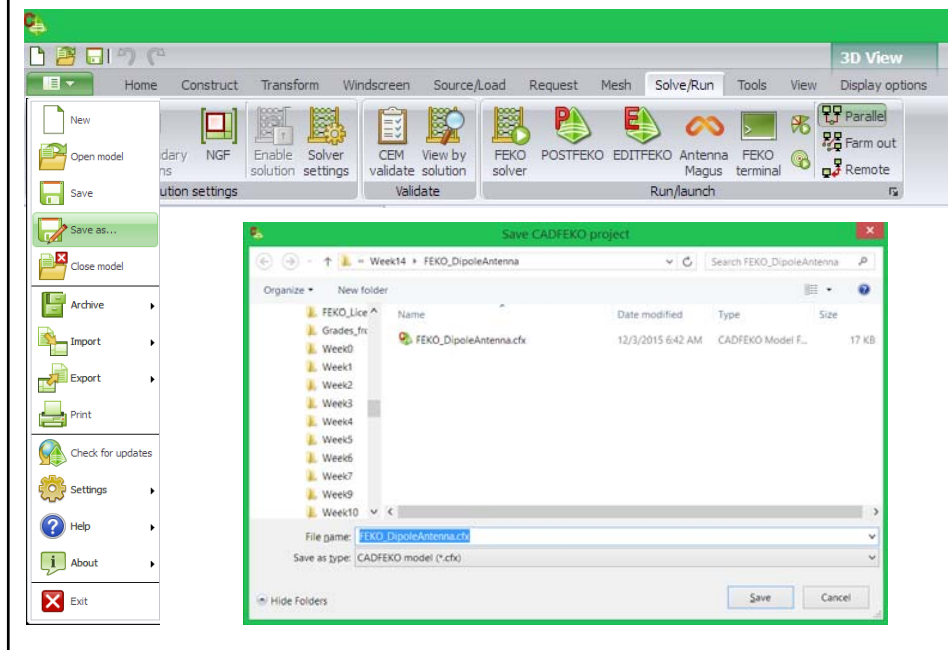
Dipole Antenna: Mesh the model



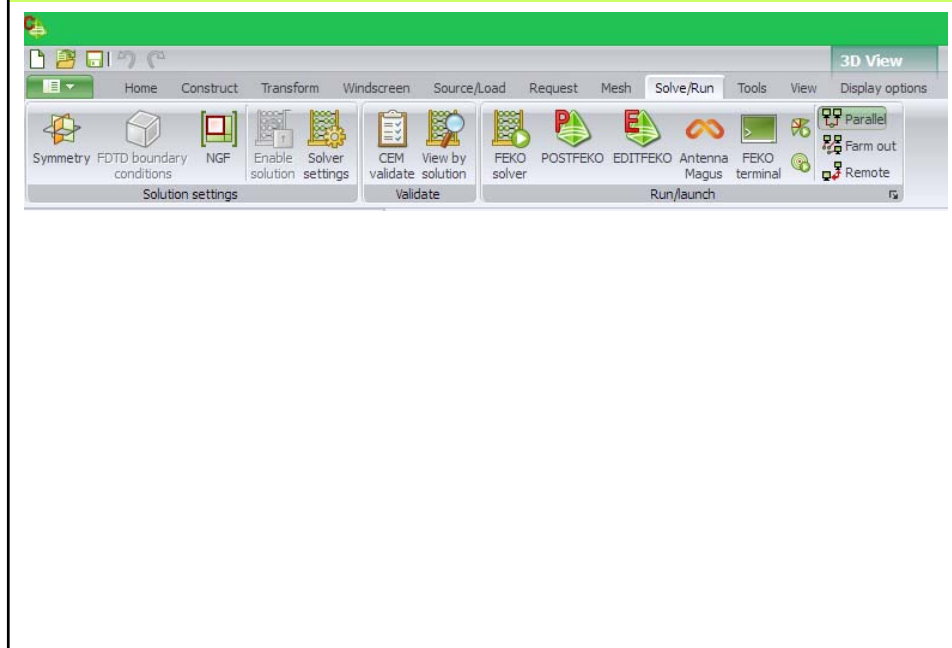
Dipole Antenna: Mesh the model



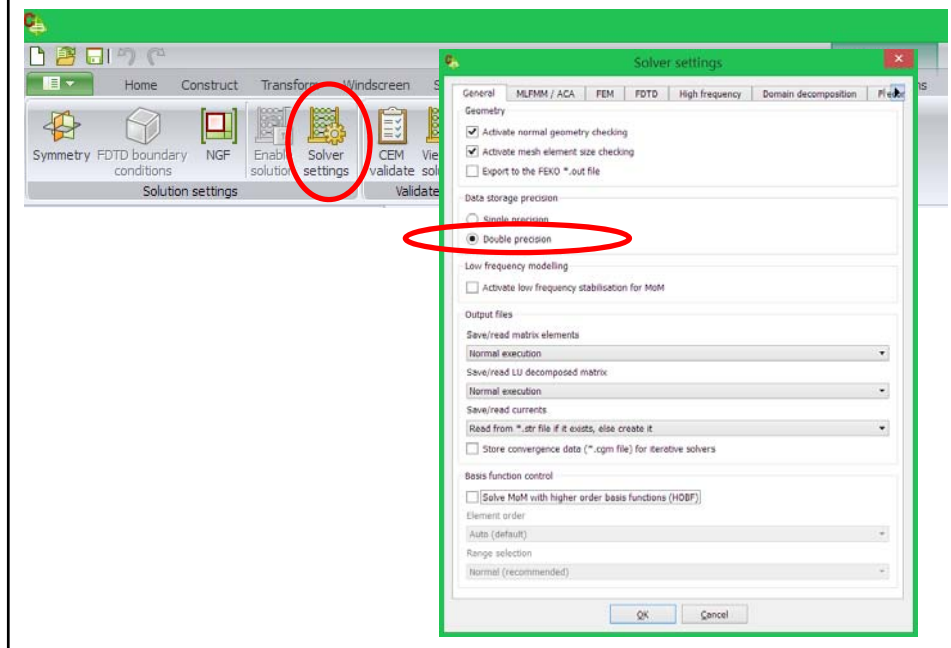
Dipole Antenna: Save the model



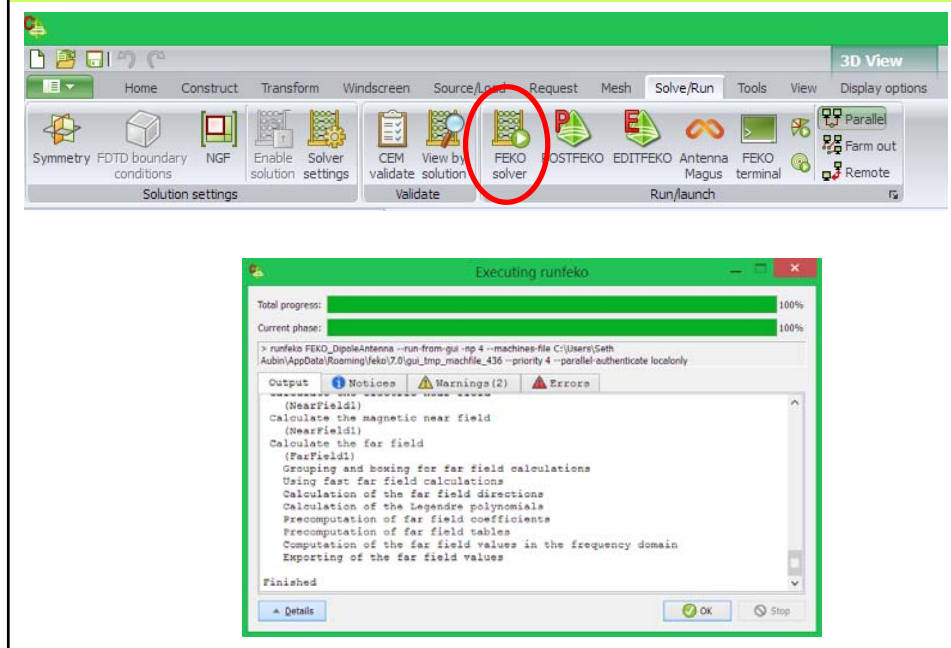
Dipole Antenna: Solve the model



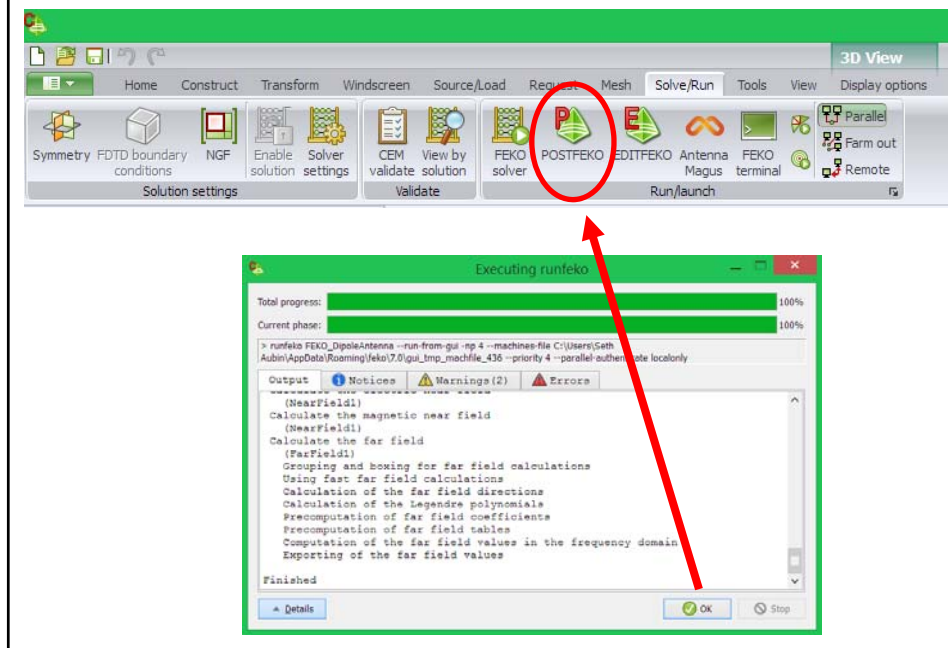
Dipole Antenna: Solve the model



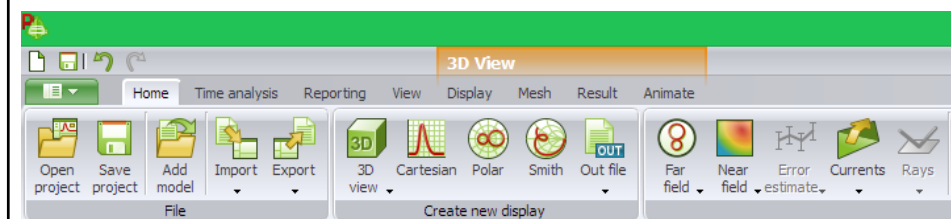
Dipole Antenna: Solve the model



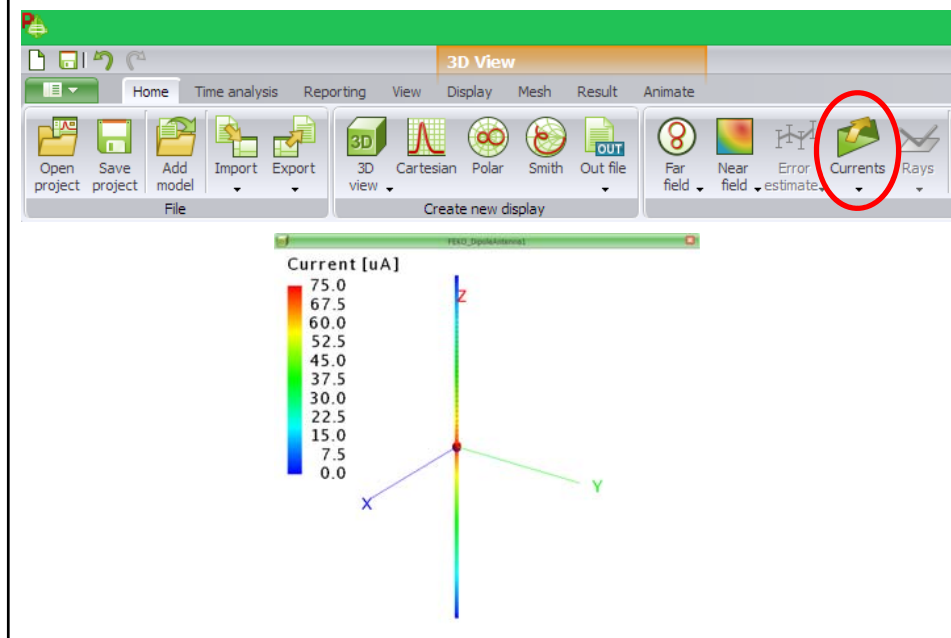
Dipole Antenna: Solve the model



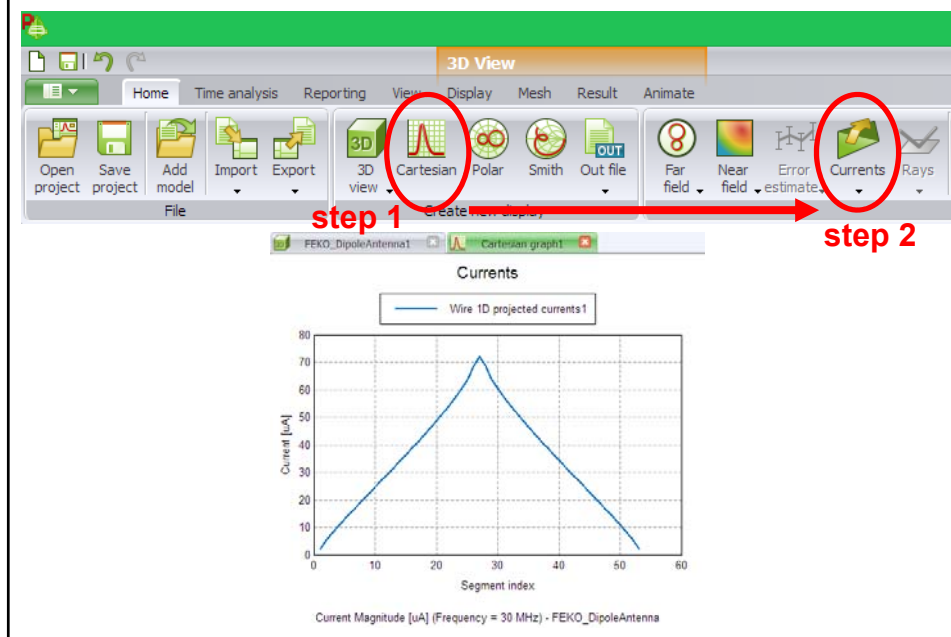
POSTFEKO: Analysis of Solutions



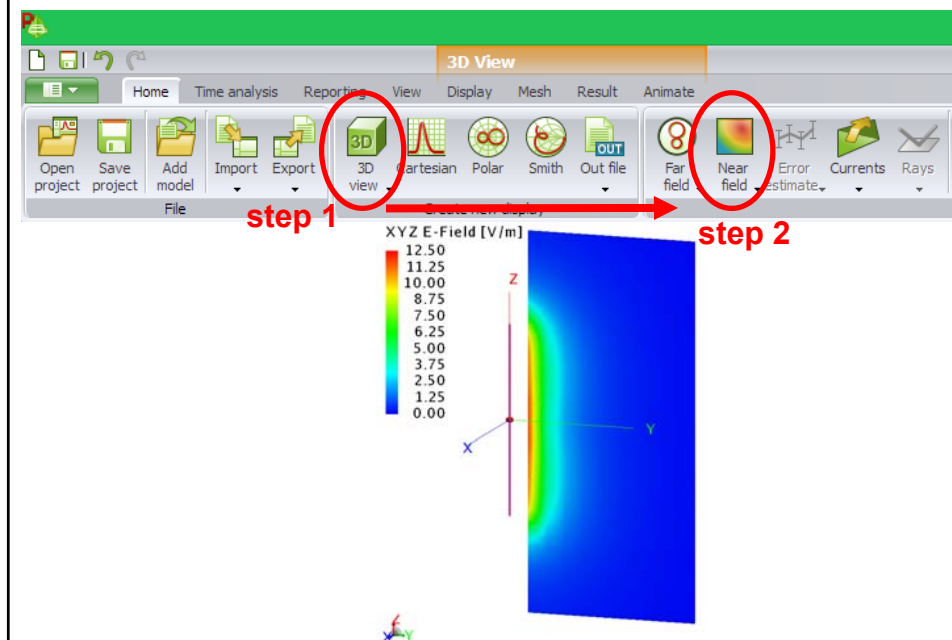
POSTFEKO: Analysis of Solutions



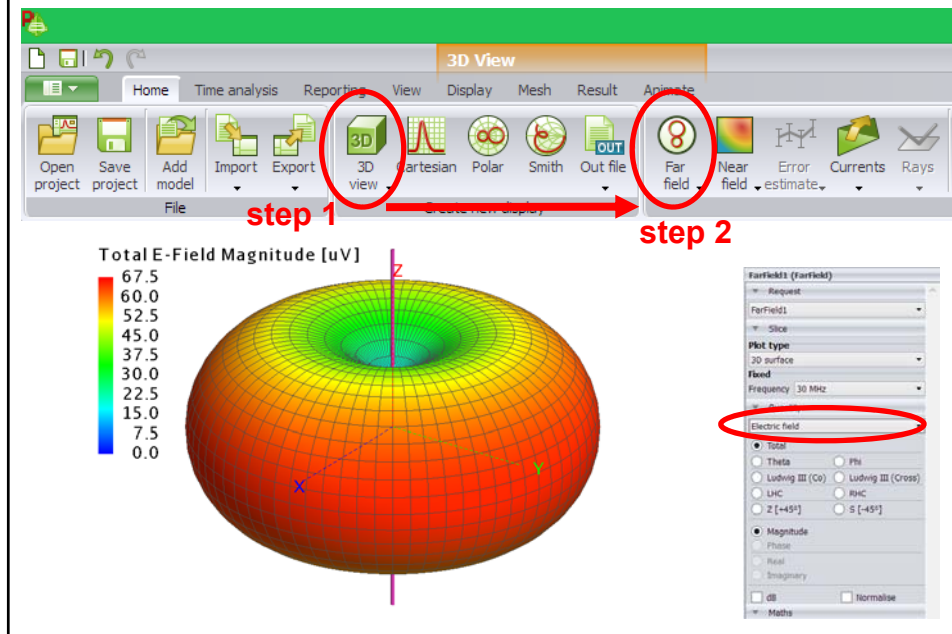
POSTFEKO: Analysis of Solutions



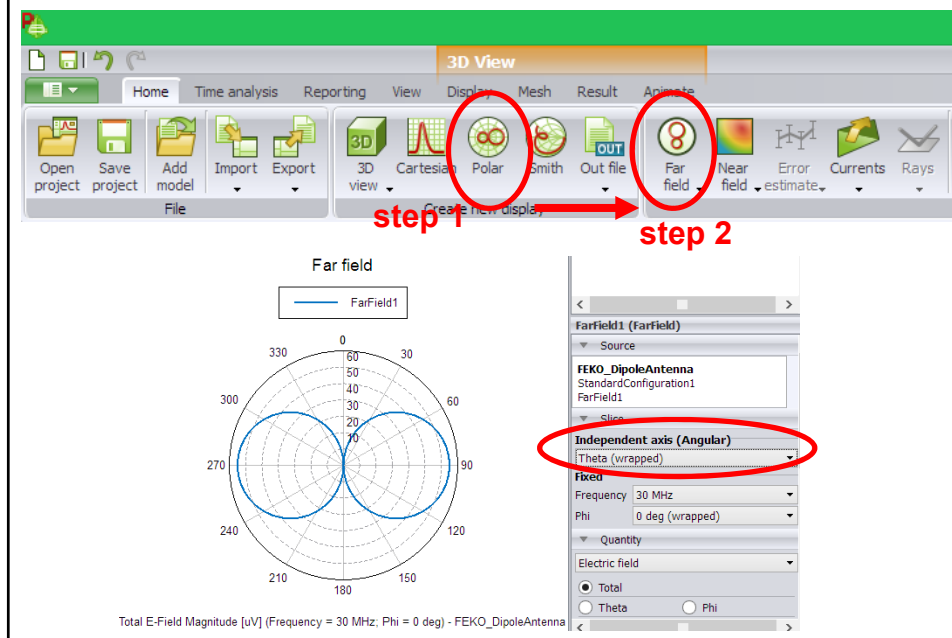
POSTFEKO: Analysis of Solutions



POSTFEKO: Analysis of Solutions



POSTFEKO: Analysis of Solutions



Exercises

Calculate the Current and Far-Field (Gain or E-field) for the following:

1. Length = $\lambda/2$ or λ
2. Length = $3\lambda/2$, 2λ , or 5λ