### 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 $J(r)$ and $\rho(r)$.
- Once $J(r)$ and $\rho(r)$ are known, then compute $E(r)$ and $B(r)$.

#### 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 $E(r)$, and thus $B(r)$, $J(r)$, and $\rho(r)$.

#### 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 $\rightarrow$ triangle discr.)
- Calculate $E$ $\rightarrow$ calculate $B$ $\rightarrow$ time-step forward $\rightarrow$ 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

CADFEKO

![CADFEKO Image]

CADFEKO is currently using software (low) rendering, and will switch over to hardware (fast) rendering when the 'Use hardware rendering' button is pressed. If rendering does unexpectedly during this test then try to update the graphics card drivers. Also see www.bleu.info/support for a list of supported graphic cards and drivers for hardware rendering.

If needed, the rendering settings can be changed via application menu > View > 3D rendering options.
Just in case: Adjusting the Rendering
FEKO workflow

1. Construct model
2. Insert Sources/Loads
3. Specify calculation requests
4. Mesh model
5. Solve/Run model
FEKO workflow

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Step “Zero”
**FEKO: 3D perspective navigation**

**Rotation:** Mouse-left-click + drag

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

**Translate:** Ctrl + Mouse-left-click + drag

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**Dipole Antenna: Construction definitions**

[Image of construction definitions interface]
Dipole Antenna: Construction definitions

Add 2nd variable
Dipole Antenna: Construction definitions

Add "Copper" to model
Dipole Antenna: Construct \textbf{Antenna}

zoom out to see full antenna

Dipole Antenna: Construct \textbf{Antenna} \rightarrow assign material

double-click
Dipole Antenna: Excitation Source

[Image of software interface showing dipole antenna settings and options for excitation sources.

Dipole Antenna: Excitation Source

[Image showing how to modify wire port geometry within the software interface.]
Dipole Antenna: Excitation Source

Dipole Antenna: model configuration
Dipole Antenna: set solution Frequency

30 MHz

Dipole Antenna: Calculation Requests
Dipole Antenna: Calculation Requests
Dipole Antenna: **Mesh** the model
Dipole Antenna: **Mesh** the model

Mesh the model whenever model is modified.

Zoom-in to see mesh.
Dipole Antenna: **Save** the model

Dipole Antenna: **Solve** the model
Dipole Antenna: Solve the model

POSTFEKO: Analysis of Solutions
POSTFEKO: Analysis of Solutions

Step 1: 
- Select the field type
- Open the 3D view

Step 2: 
- Choose the appropriate field option
- Navigate to the visualization settings
Calculate the Current and Far-Field (Gain or E-field) for the following:

1. Length = $\lambda/2$ or $\lambda$.

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

Exercises