

CONCEPT-II

CONCEPT-II is a frequency domain method of moment (MoM) code, under development at the Institute of Electromagnetic Theory at the Technische Universität Hamburg-Harburg (www.tet.tuhh.de).

Overview of demo examples

The following demonstration examples for CONCEPT-II will be discussed in detail (\$CONCEPT: home directory of the package):

1. Wire loop, directory \$CONCEPT/demo/example1-wire-loop
2. Cylindrical monopole antenna radiating over a finite ground plate, directory \$CONCEPT/demo/example2-monopole-on-plate
3. Box with aperture and internal radiator, directory \$CONCEPT/demo/example3-box-with-aperture
4. Dielectric sphere in a plane wave field, directory \$CONCEPT/demo/example4-dielectric-sphere

In order to find out how CONCEPT-II works it is recommended to start with the example 1 (wire loop)

Important: file names should never contain blanks.

Shortcuts: **Help** → **Navigation**

Example 2: Cylindrical monopole antenna radiating over a finite ground plate

It is assumed that the user is already familiar with example 1.

It is recommended to start from an empty directory and set up the simulation according to Fig 2.

\$CONCEPT/demo/example2-monopole-on-plate

A thick monopole antenna on a square ground plate in free space shall be investigated. All dimensions can be taken from Fig 1.

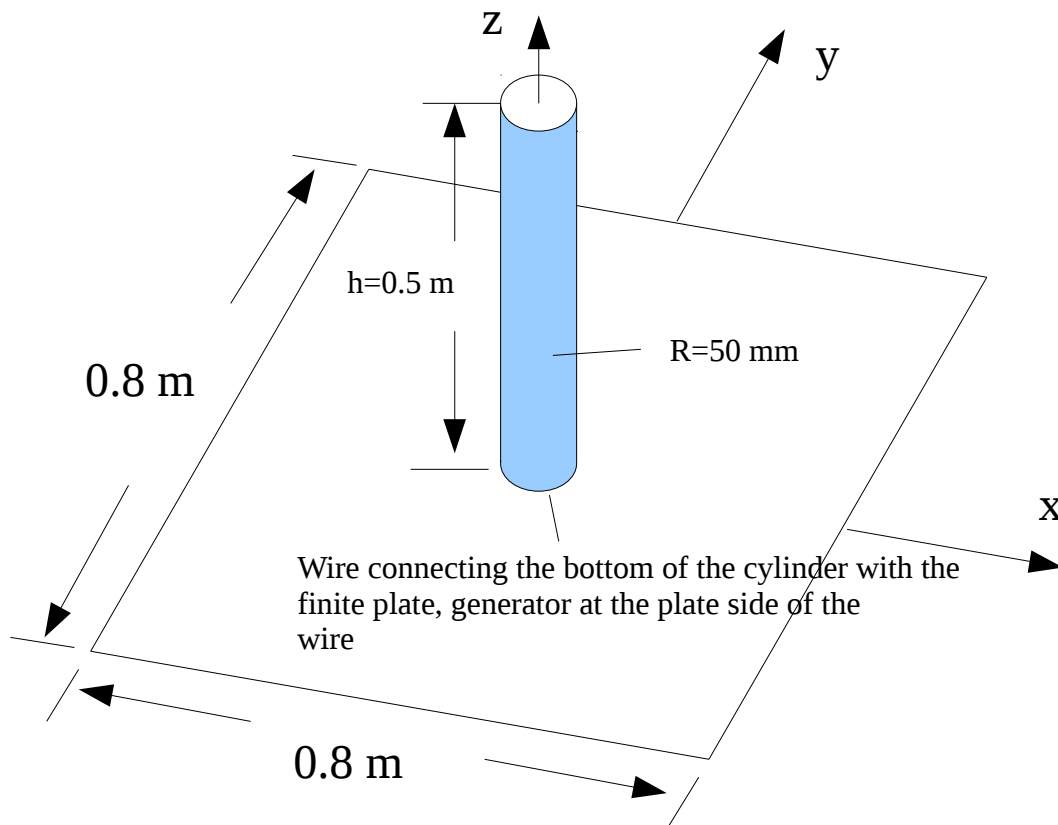


Fig 1: Geometry of the structure under investigation

The antenna is formed by a cylinder of 0.5 m height. A wire (length 2 cm, radius $R = 0.5$ mm) serves as connection between cylinder and plate. A power generator at the lower end of the wire is feeding the structure with 1 W. A frequency loop shall be considered from 10,...,300 MHz.

As there is **geometrical symmetry and electrical symmetry**, only one quarter of the structure needs to be discretized (1. quadrant). The x-z plane and the y-z plane are planes of magnetic symmetry.

Two surface patch files need to be generated which are called *plate.surf* and *antenna.surf* in the example. The wire connecting the bottom of the cylinder with the plate is contained in the file *generator.wire*. Notice the corresponding file names in the simulation project tree, see left side of GUI, Fig 2 (section 'Project View').

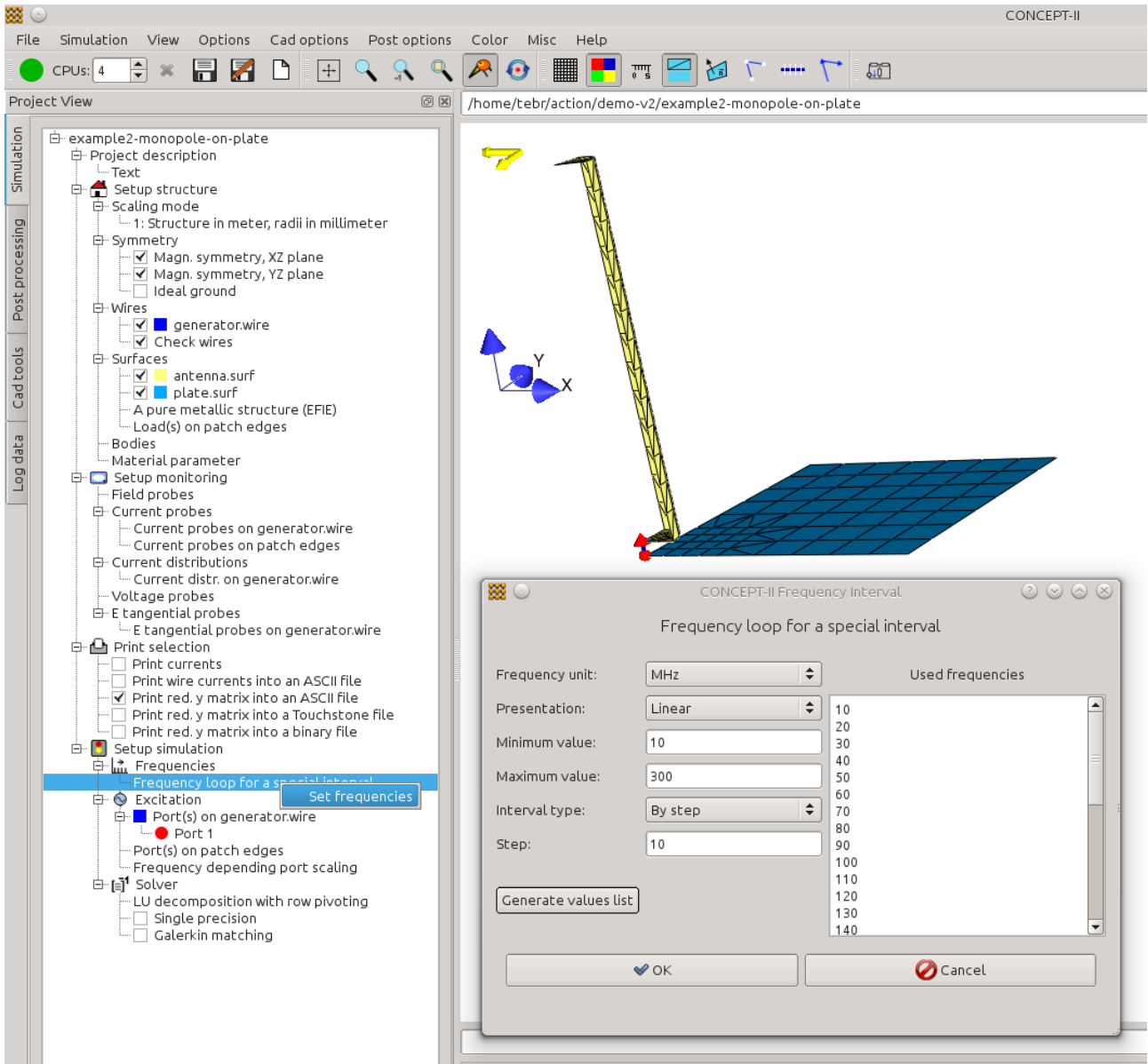



Fig 2: In the display area we see the discretized structure according to Fig 1. Note that only the symmetric parts need to be considered setting up the numerical model.

A structure as depicted in the display area of the GUI according to Fig 2 has to be discretized first.

Discretizing the finite ground plate

Activate: **CAD tools** → **Cad tools 2**. Click on . The window of the plate tool opens (Fig 3):

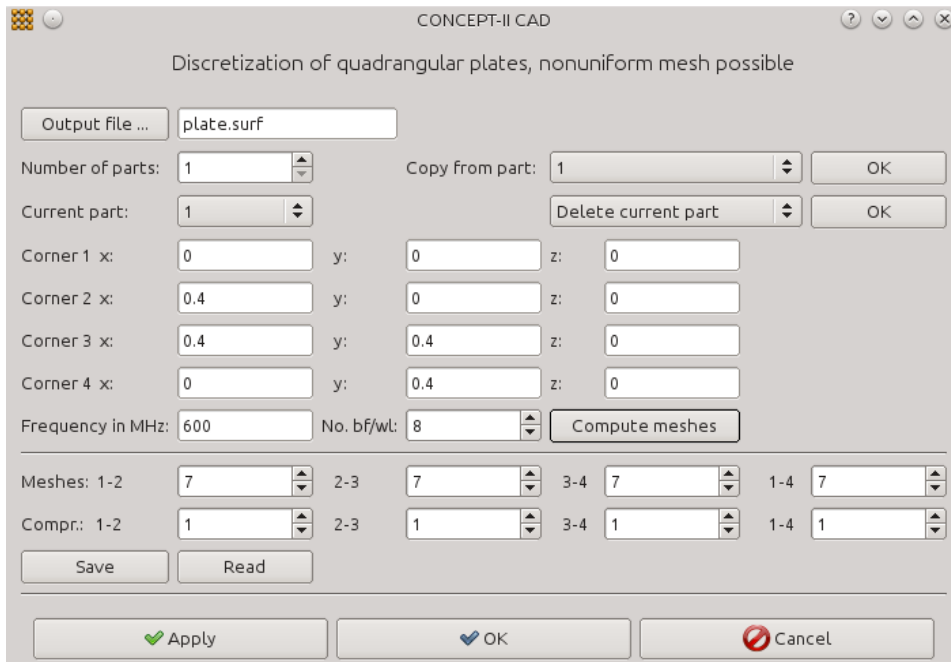


Fig 3: Creating the mesh of a 0.4 m x 0.4 m plate at 600 MHz with 8 basis functions per wavelength. Using 8 to 10 basis functions per wavelength is a well-known rule of thumb for electrically large structure parts.

Here a frequency of 600 MHz ('Frequency in MHz:') in combination with 8 basis functions per wavelength ('No. bf/wl') is applied to generate the surface patch grid. This frequency is far higher than the max. frequency according to the problem definition (300 MHz, see above).

By setting an appropriate combination of frequency and number of patches per wavelength a suitable grid can be adjusted. Here, clicking on **Compute meshes** gives a 7 by 7 element mesh. Clicking on **OK** provides the surface patch file *plate.surf* ('Output file...'). In the general case the plate tool plate can discretize arbitrary plates with four (or three) vertices.

Near the feed region which is at (0m, 0m, 0m) a rapid variation of the antenna near field and of the surface current distribution have to be expected. Hence the grid should be refined in this region. Select a preview pattern in the 'Mesh refinement' section of the **Cad tools 1** card.

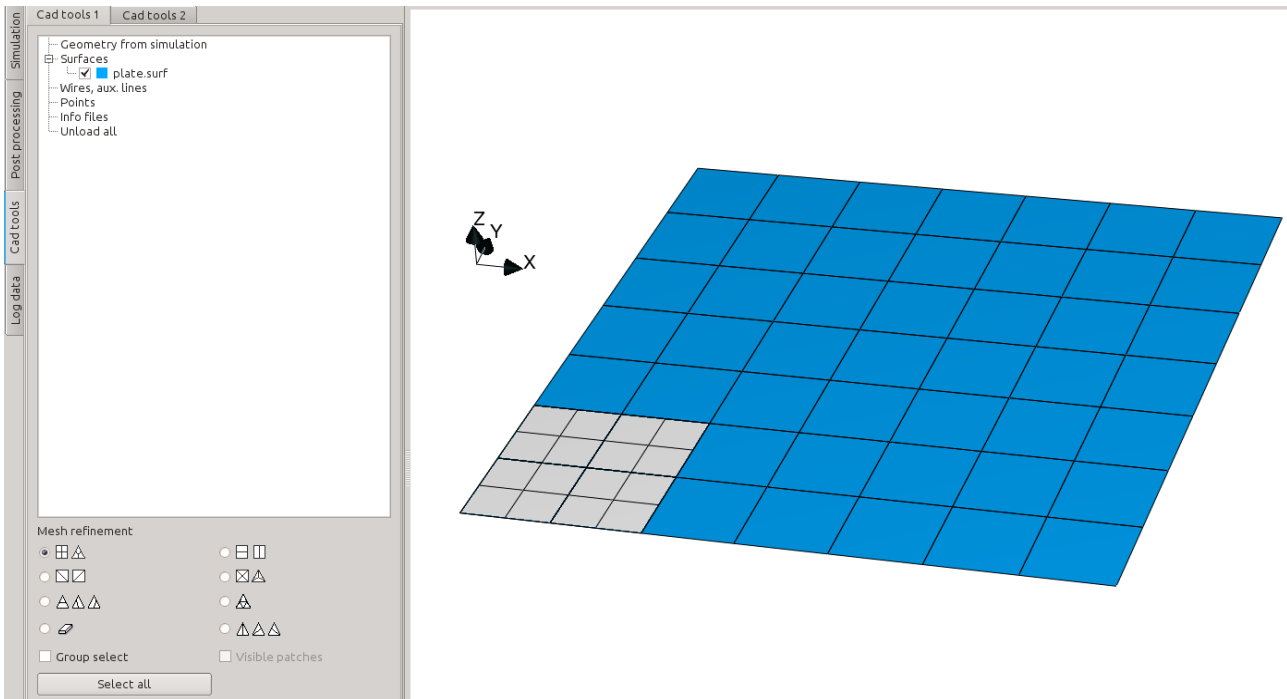






Fig 4: Local mesh refinement close to the antenna feed point, see Fig 2

Choosing   means that in our case quadrangles can be selected by right clicks. Each quadrangle will be subdivided into 4 smaller quadrangles.

Selected patches are marked by preview patterns. It is suggested that four patches near the bottom left corner, i.e. near the antenna feed point, should be marked as illustrated in Fig 4.

Clicking on  or typing 'e' results in the mesh according to Fig 5 . Note that triangles are generated in the transition region. Each node of a patch is connected to the nodes of all adjacent patches. An overall triangular mesh can easily be generated now, click on  (tool bar)

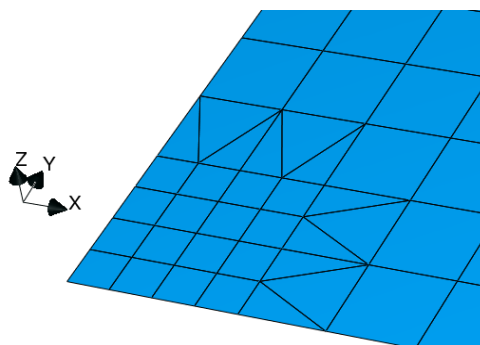


Fig 5: Mesh refinement near the bottom left corner near $(0, 0, 0)m$

Creating the cylinder


Activate **CAD tools**, then click on  (tool bar). The following window opens:



Fig 6: Only a quarter of a full cylinder will be discretized when clicking on **OK** or **Apply**

In order to get an appropriate mesh the 'Number of patches per wavelength' has been set to 12 and the frequency to 600 MHz, although the maximum applied frequency is only 300 MHz. Magnetic symmetry with respect to the y-z plane and the x-z plane has been specified. Hence only a quarter of a cylinder is generated when pressing **OK**.

Creating the wire

The wire could be easily introduced as has been described in example 1, simply by entering the coordinates (0,0,0), (0,0,0.02) under **Simulation** → **Wires** → **New wire file**. Another way of generating wires is as follows: Click on the 'Wires' radio button in the **Cad tools 1** section. The 'Add' button will be activated automatically:



Now select two nodes as illustrated in Fig 7 by right clicking on the respective nodes. A node is ready to be selected once the mouse pointer is turned into a cross.

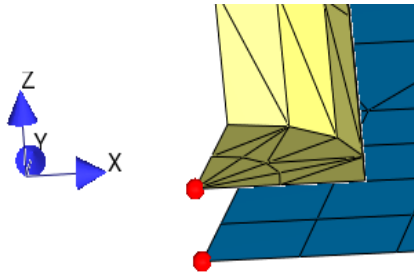


Fig 7: Two patch nodes have been selected by right mouse clicks for introducing a wire

Clicking on  or typing 'e' gives the following sub-window, enter the respective data.

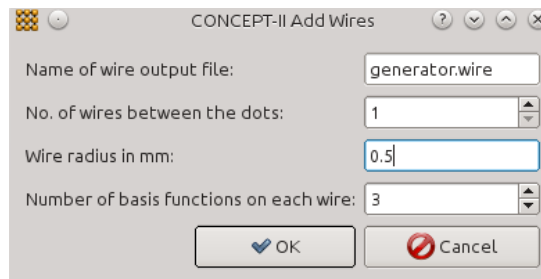


Fig 8: Change the default entries to the ones shown here

OK creates the wire file *generator.wire* .

Load the structure into the simulation: Activate the **Simulation** tab → right click on the top entry → select **Load all files from 'CAD'**.

Set the check marks for 'Magn. symmetry, XZ plane' and 'Magn. symmetry, YZ plane'

Frequency sampling

How to do this is indicated in Fig 2. Right click on **Frequencies** > **Frequency loop for a special interval**. The shown sub-window opens. Enter the sampling data and click on **Generate values list**. Only frequency steps appearing in the list on the right side will be considered in the simulation.

Excitation

Right click on **Excitation** → **Ports (power input/voltage input)** → **Port(s) on generator.wire** → **Set ports** → enter wire number 1 and 1 W (see Fig 9)

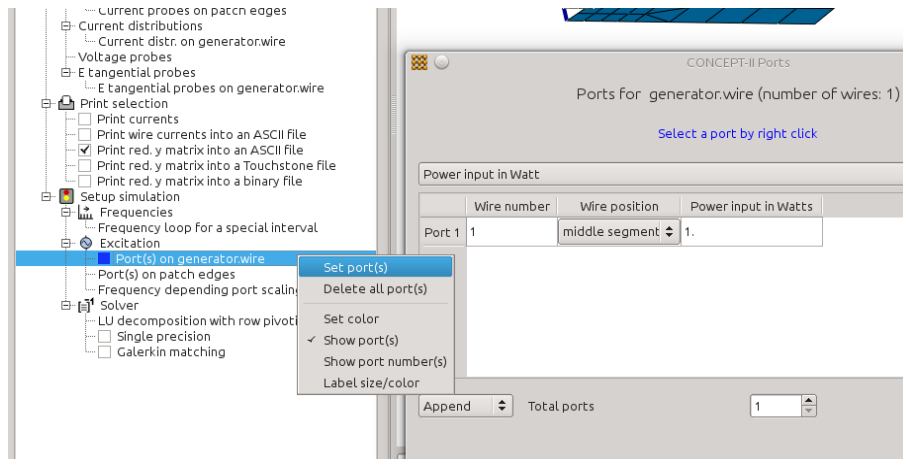


Fig 9: Right-clicking on the **Excitation** item provides the possibility to switch to a different type of excitation

The wire where to place the port can also be selected by a right click.

In general ports (loads, voltage probes, current probes, voltage generators) can be placed at the end, center, or at the beginning of a wire.

Checking geometry, starting of the simulation

Once it is ensured that all data is correct the simulation can be started: .

As a frequency loop has been specified it may take a while for the back end to finish. Note that a linear system of equations has to be set up and solved for each frequency step. If not sure how the MoM works refer to Section 4 of the User's manual.

Sometimes it is advantageous to proceed as follows before starting the simulation:

Simulation (see menu bar) → **Run simulation front-end**.


Notice the output in the message section under the display area (number of unknowns, size of system matrix etc.)

Post processing → 'Show complete structure' 

Generally all wires are combined into *wire.0* and all surfaces into *surf.0*. Note that by hovering the mouse pointer over a node or a patch all available information is printed in a special line under the display area.

Displaying the surface current distribution

For displaying the current distribution (back end has finished):

- Go to **Post processing** (see Fig 10)
- Click on 
- Enter the values according to Fig 10, the current distribution at 300 MHz has been selected for representation

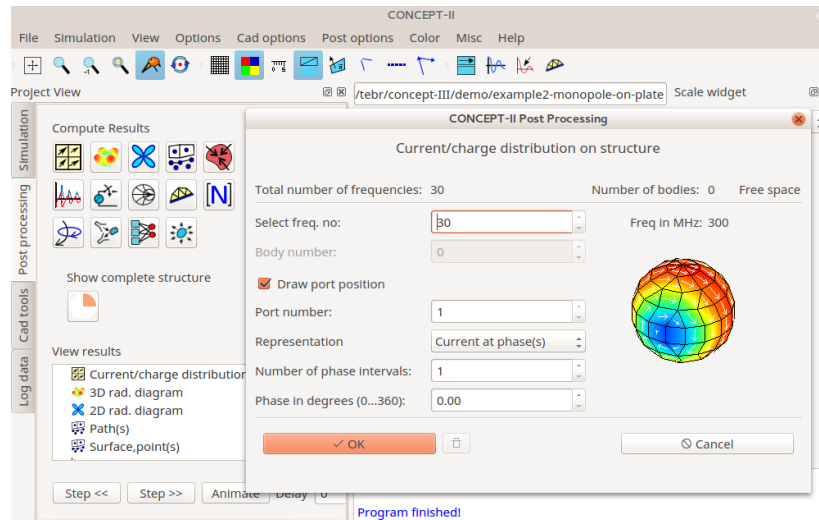


Fig 10: Window for controlling the current distribution to be displayed. It is recommended to enter 16 phase intervals for a movie.

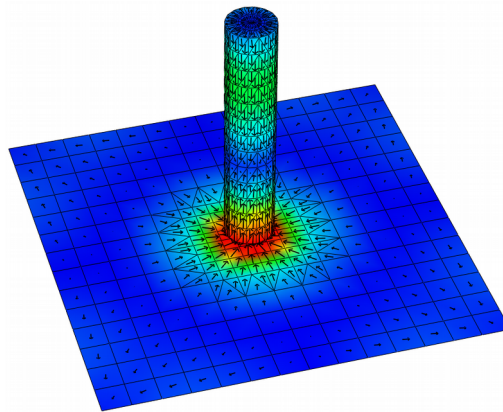


Fig 11: Computed current distribution at 300 MHz (phase: 0°)

Pressing **OK** provides the structure with current distribution at 0° in the display area. A certain scaling is necessary in order to obtain a view according to Fig 11. Vector and arrow scaling has already been explained in example 1 for the case of a 2D field distribution.

In order to validate the result, the power budget shall be investigated. Since lumped loads (resistors) have not been introduced and the whole structure under investigation includes only perfect conductors the input power should be completely radiated. In other words: the

computed surface current distribution should be able to radiate the input power of 1 W. Of course, this can be achieved only up to a certain degree in a numerical simulation. For the determination of the radiated power it is necessary to compute a 3D radiation diagram.

Creating a 3D radiation diagram

- Go to **Post processing**

- Click on . A sub-window as depicted in Fig 12 shall be computed

In our case we have chosen **All frequencies**. Hence a 3D pattern will be computed for

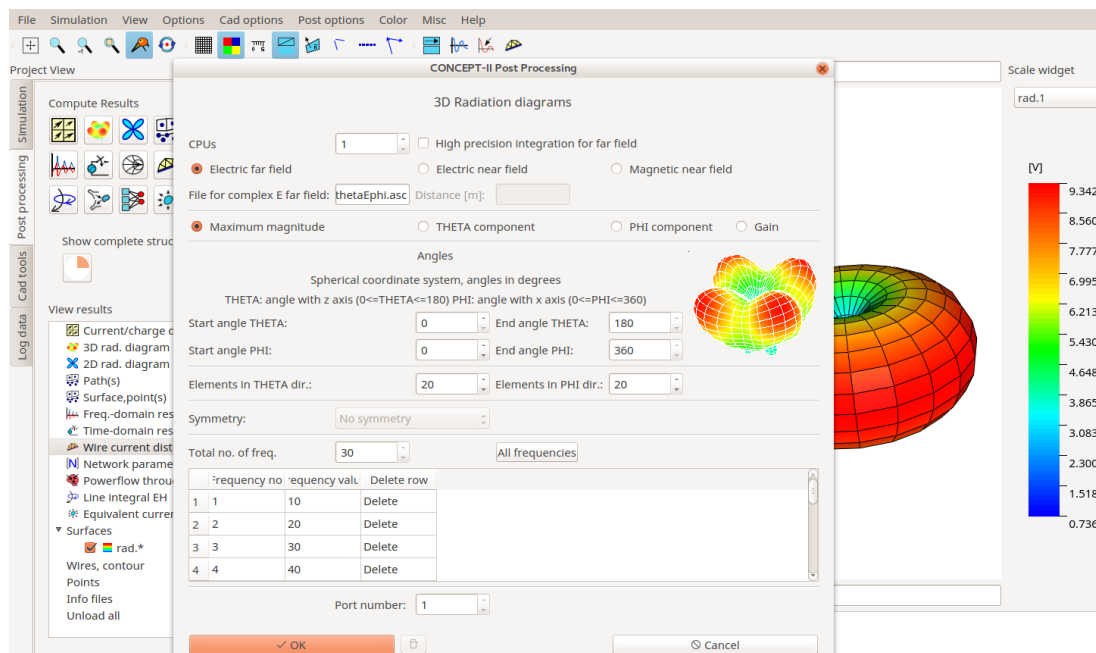


Fig 12: The electric far field shall be computed

each frequency step.

Choosing a sufficient number of elements in theta and phi direction is important to resolve all lobes that in general might appear (imagine a grid on a unit sphere, the far field is computed at each intersecting point). Multiply clicking on **Step** shows the development of the 3D radiation diagram as a function of frequency.

Click the **Log data** tab → **3D rad. Diagram**. This gives numerical data with respect to the diagram computation in the display area.

Example values, computation by the power flow in the far field (Poynting vector):

10 MHz, radiated power: 0.976 W

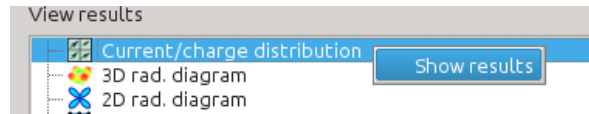
300 MHz, radiated power: 0.999 W

A deviation of 5% between input power and radiated power can be tolerated for a loss-less structure in practical situations.

Note that computed values are always given in [V]. Divide a diagram value by the distance in the far field region and get the E field strength in the chosen direction!

Hint: to quickly get back to the already computed surface current distribution at this stage of post processing, click as follows:

Current/Charge distribution → Show results



The input impedance as a function of frequency

- Go to **Post processing**

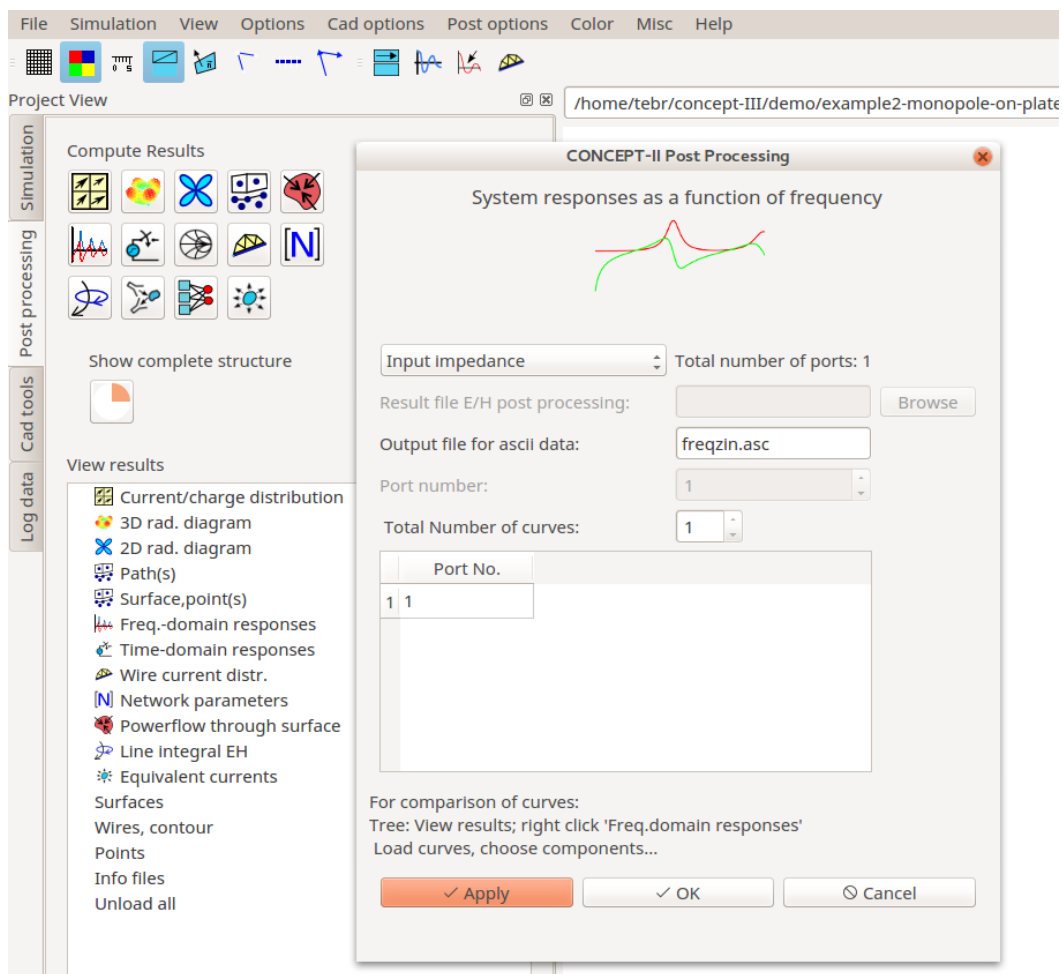


Fig 13: Window for the selection of system responses to be displayed as a function of frequency

- Click on . A sub-window as shown in Fig 13 opens.

The input impedance of the port generator has automatically been stored. **OK** provides the magnitude in the display area as a function of frequency.

For an enhanced representation click ('View results' section) **Freq.-domain responses** → **show results** in the post processing tree. This opens the CONCEPT-II gnuplot front end. Change the default entries to the entries as shown in Fig 14 and click **Run gnuplot**.

CONCEPT-II Gnuplot front-end

File Options Ratapprox...

GNU PLOT FRONT-END FOR CONCEPT-II

Title: Input impedance

X label: Frequency in MHz

Y label: Z [Ohm]

Z label:

Legend position: right top

Number of files: 2 ☐ Use rel. path

	File name	Take	Style	Width	Color	Legend title	Using
1	port-zin1.asc	<input checked="" type="checkbox"/>	Lines	3	red	Real part	1:2
2	port-zin1.asc	<input checked="" type="checkbox"/>	Lines	3	green	Imag. part	1:3

Output to: Concept View File name:

Fig 14: The real and the imaginary part of the antenna input impedance shall be plotted (columns 2 and 3 of the ASCII data file port-zin1.asc; column 1 is the frequency)

The following curves are displayed:

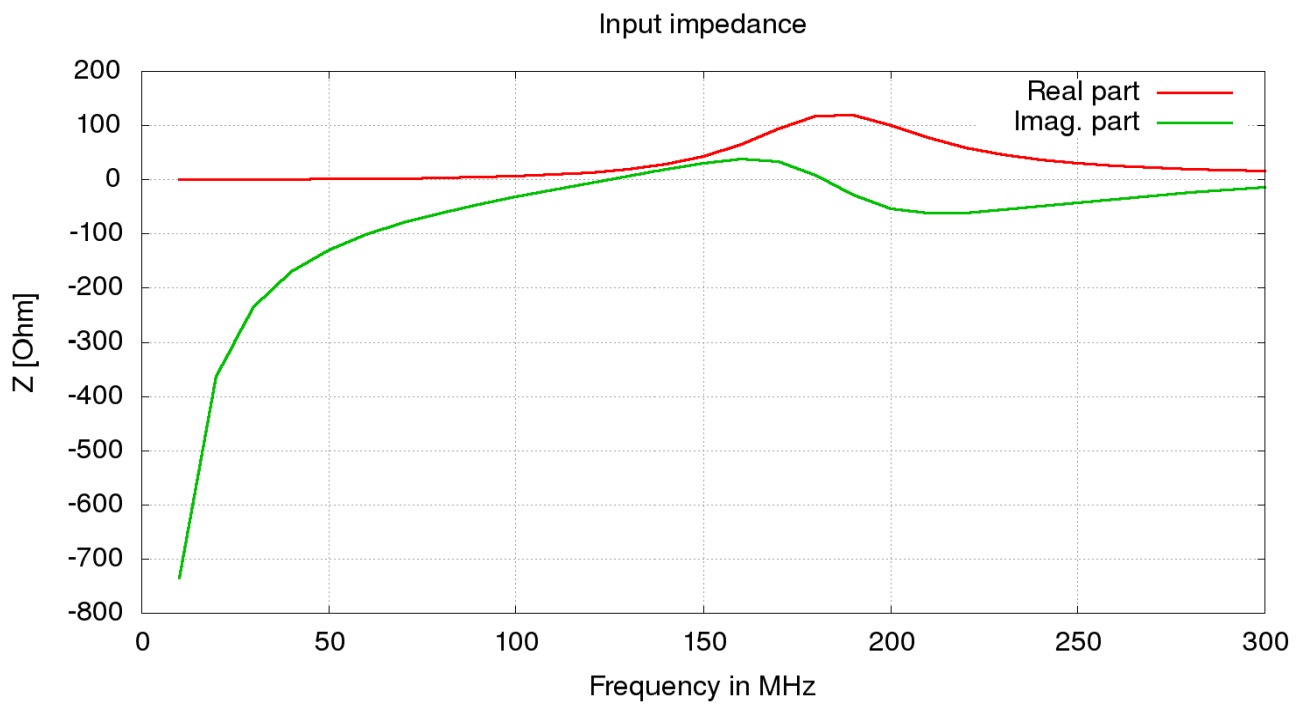


Fig 15: The complex input impedance as a function of frequency

As could be expected we have a large negative imaginary part and a very small positive real part at the low frequency end.