FEKO
Getting Started Manual

Suite 5.1

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Contents

1 Introduction

The first section in this *Getting Started* manual discusses the installation of FEKO under MS Windows on PC's and on UNIX workstations. Note that the graphical user interface (CADFEKO, EDITFEKO and POSTFEKO) is currently only available under MS Windows and Linux.

The next sections discuss a number of simple step-by-step examples designed to guide the user through the process of:

- Creating geometry in the CADFEKO user interface.
- Setting the appropriate electromagnetic parameters in the EDITFEKO user interface.
- Solving the electromagnetic problem at hand.
- Using the POSTFEKO user interface to view the model and plot solution data.

This guide contains three examples:

- The first example introduces all the components of FEKO and the basic solution process. A model of a horn antenna is distributed with the FEKO suite. This model is discussed and instructions are given for the extraction of results from this model.
- In the second example we introduce symmetry and labels and look at some mesh requirements. The second example shows the development of a FEKO model of a patch antenna on a finite sized substrate. Dielectric regions and local mesh parameters are set for this example.
- The third example considers a simple EMC type problem and demonstrates how to set up a model in the presence of a ground plane.

These examples present a very basic introduction to FEKO. The *FEKO User's Manual* should be consulted for a broader presentation of all the features available in FEKO. (It can be found in the `doc` directory under the FEKO installation directory, or in the `doc` directory on the FEKO CD and can be viewed and printed with the Adobe Reader — see section 2.6.) New users should read at least the *General comments* section of the *User's Manual*.

Other simple examples which illustrate certain features of FEKO are discussed in the *FEKO Examples Guide* which may be found in the same location as the *User's Manual*. The input files for these examples are available in the `examples\CAD_input` and `examples\text_input` directories, respectively, under the FEKO installation directory.

1.1 FEKO components

This section gives a quick overview of the various FEKO components and their availability on the various platforms. Presently both pre- and post processing have to be done under MS Windows or Linux.

- The CADFEKO interface is used for geometry specification and mesh generation.
- The electromagnetic parameters are set in the EDITFEKO interface, which provides a user friendly interface to the input cards required by FEKO.
- Both the solution kernel, FEKO, and the preprocessor/mesher, PREFEKO, as well as the adaptive frequency component, ADAPTFEKO, are available on all supported PC and workstation platforms.
- The POSTFEKO interface is used to display the model and all the results of the simulation.
- The support components, OPTFEKO and TIMEFEKO — used for optimisation and time domain analysis respectively — are available on all supported PC and workstation platforms.

1.2 Using FEKO LITE instead of the full version

FEKO can be run in a mode called *FEKO LITE*. This is a limited version of the FEKO suite. All the components of the suite, from the graphical user interfaces to the solver, are limited in capability when running in this mode. Note that the LITE version of FEKO is not an evaluation version! An evaluation licence will allow the unlimited use of FEKO for 30 days. If you are considering the purchase of FEKO, please contact your distributor for an evaluation licence.

A licence is required to run FEKO in LITE mode. If no licence is present, FEKO will run for a period of 30 days. The FEKO licence is stored in the file `secfeko.dat` in the `license` subdirectory of the FEKO installation.

A licence for the FEKO LITE mode can be requested from the FEKO website. The licence that will be provided will expire after 6 months, at which time a re-registration is required. Once the registration from is filled in, it will be submitted to the distributor for your region for processing. Once the request is processed, a licence file will be sent to you via email.

You can register your copy of FEKO LITE at
www.feko.info/register_lite

FEKO LITE is limited with respect to problem size and can therefore run only about half the examples in the *FEKO Examples Guide*. The examples in this guide were chosen with this in mind and only the last two examples need some modification to run them with FEKO LITE. Only the final example in this guide can be run in FEKO LITE mode, with some minor modification.

1.3 Installing the full version after using FEKO LITE

If you have an installation of FEKO LITE, switching to the full version is simple. (Note that the evaluation version is a full version which is limited only in the period for which it can be used.) In order to create a FEKO licence for a computer, some information about that computer is required. Execute the script `request.bat` in the `bin` subdirectory of the FEKO installation. This creates a file `request` in the `license` subdirectory. Edit this file to enter the information requested at the top of the file and email or fax the file to your distributor. You will then receive a file `secfeko.dat` which you must copy to the `license` subdirectory of the FEKO installation (overwrite any existing files).

1.4 Contacting your distributor or EMSS

You can find the distributor for your region at

www.feko.info/contact.htm

Alternatively, for technical questions, please send email to

feko_support@emssusa.com	for North America
feko_support@emss.de	for Europe
feko_support@emss.co.za	for all other regions

or, for activation codes and licence queries, to

feko_license@emssusa.com	for North America
feko_license@emss.de	for Europe
feko_license@emss.co.za	for all other regions

1.5 Updates to the documentation

Changes in this manual with respect to the previous one of July 2005 (Suite 5.0) are indicated as follows:
Sections that have changed from those in the previous version of the manual.
Sections that were newly added to this version of the manual.

2 Installation of FEKO

2.1 Introduction

This section describes the installation procedures for FEKO on PCs and workstations. You should be able to install the software successfully by following the on-screen installation instructions. *However, it is recommended that you work through the installation procedures described here.* If you have technical questions, please contact your distributor (see section 1.4).

The PC installation is for Windows NT/2000/XP (Windows 98 and ME are no longer supported). The workstation installation is for any of the major UNIX workstation platforms, including HP, SGI, SUN and Linux. An efficient parallel version of FEKO is also available on all these platforms (Windows, Linux and UNIX).

The installation copies the FEKO manuals to the `doc` subdirectory. These manuals are in PDF format and a PDF viewer, for example the Adobe Reader, is required to view them. The installation of the Adobe Reader is discussed in section 2.6. On MS Windows systems the FEKO installation configures the GUI components to use the default PDF viewer, hence the PDF viewer should be installed before FEKO. (It is, of course, possible to configure the PDF viewer in the GUI components if it is installed / updated after installing FEKO.)

2.2 MS Windows installation

Unless you install the 30-day unregistered version of FEKO LITE, FEKO requires a licence file (see section 2.2.5). FEKO can only be installed on Windows NT/2000/XP machines by a user with administrative rights. The parallel version must be installed separately — in the same directory — on each PC in the cluster. In addition you must have an account with the same password on all the PCs you want to use.

There are three different ways to install FEKO:

- Graphical interactive mode
- Silent mode using the installation executable
- Silent mode using the embedded Microsoft Installer database

Note that using the silent installation to install the parallel solver is not recommended, because the silent installation does not perform all the necessary setup steps (some steps always require user input). FEKO will be installed, but the configuration must be completed on all machines in the cluster. This can be done by editing the file `machines.feko` (located in `%FEKO_HOME%\mpi\shares`) and running `mpiregister.bat` (in `%FEKO_HOME%\mpi\bin`) on all the target machines.

After completing the installation, the examples in the remaining sections of this manual should be consulted for a step-by-step introduction to the basic operation of FEKO.

2.2.1 System requirements

The following are the minimum requirements for the Windows installation:

- An IBM compatible PC with a Pentium or higher processor.
- Operating system MS Windows NT 4.0/2000/XP.
- 100 MByte free hard disk space (120 MByte for the parallel version).
- 256 MByte of free base memory, more memory is required to solve large problems.
- The GUI components were designed for a screen resolution of 1024×768 (using small fonts) or larger. Lower resolutions may result in truncated dialogs.
- A colour depth of 256 colours is required, but more colours are preferred.

2.2.2 Installing FEKO

There are two FEKO installations for MS Windows

Platform	Filename
32-bit Intel or compatible	`feko_distrib_xx.yy_win32.tar.gz`
64-bit on Intel Itanium, Intel EM64T or AMD Opteron	`feko_distrib_xx.yy_win64.tar.gz`

where the `xx.yy` in the filename indicates the FEKO Suite number. The 64-bit installation automatically detects the platform and installs the correct version of the executables. Note that it installs 32-bit versions of the GUI components. The GUI will therefore run in emulation mode on Intel Itanium systems — its performance will be somewhat degraded. It is also, of course, possible to install the 32-bit version on a 64-bit system, but then the 32-bit limits (such as allocating a maximum of 2 GByte RAM) still apply. Hence one would not normally do this, especially on Intel Itanium systems.

If you have downloaded the installation executable, copy it to a temporary directory on your hard drive and execute it.

If you have a FEKO CD, insert it into your CDROM drive. The FEKO installation program should start automatically. (If not, execute `startup.exe` in the root directory of the FEKO CD.) Click *Install 32-bit FEKO ("Silver" licence)* to install the 32-bit version or *Install 64-bit FEKO ("Gold" licence)* for the 64-bit version. (The different licences relate to the pricing structure. If you are uncertain of your licence type, please contact your distributor.) Note that the *Install 64-bit FEKO* button will be disabled when running on a 32-bit system. If this button is disabled in error, the installation executable can be found in the `installs\windows` directory.

- You must uninstall any existing versions of FEKO (prior to version 5.0) before continuing. If you have FEKO 5.0 or later installed, the installation will automatically upgrade your existing installation. (All user and licence files will be retained.)
- The *Select features* page controls what is installed. *FEKO (Solver and GUI)* must be selected if this PC will be used to setup and solve FEKO models.

  If this PC is part of a windows cluster that is intended to run the parallel verion of FEKO, the *Include parallel solver* option must be checked. FEKO must be installed separately — in the same location — on all the PCs in the cluster.

  Select *Install as FEKO LITE* to install a limited version which can be used for 30 days without a licence. After 30-days you need to register FEKO LITE or switch to a full version. (See section 2.2.5 below.)

  If you purchased floating licences, you must install a *Floating licence server* on one sever in your network (see section 2.4).
- The *Choose a scratch directory* page allows the user to determine where FEKO writes temporary files during the out-of-core solution. This should be a directory which can accommodate very large files. This path is stored in the environment variable `FEKO_TMPDIR` which may be modified if the temporary files should be written to a different location (such as when a second hard disk is used to provide larger scratch space).
- FEKO can be configured by setting certain environment variables. (See the *General comments* chapter of the main FEKO manual.) The installation already sets the most common of these.
- During setup a number of examples are copied to the subdirectory `examples` under the FEKO installation. These may be used to test your FEKO installation and to provide examples of the various FEKO features. (For more detail consult the *Examples Guide* which may be found in PDF format in the `doc` subdirectory of the FEKO installation directory.)

2.2.3 Installing FEKO in silent mode using the installation executable

The FEKO installer for Windows can also be installed in silent mode. This mode is used to install FEKO without manually going through the installation dialogues.

- To use the installer in silent mode, a response file must first be created. The response file only needs to be created once, and can then be used on all the target machines. The FEKO CD contains a template response file called `setup.iss`. This file is located in the `installs\windows` directory on the CD. Copy this file to a temporary location on the target computer's hard drive. This file contains the header information required by the installer when running in silent mode.

- The next step is to run the installer in record mode. Launch the installer as follows: `feko_distrib_xx.yy_winNN.exe /r /f1"C:\Temp\setup.iss"` where `"C:\Temp\setup.iss"` specifies the absolute path to the `setup.iss` file. This will launch the installer in record mode and record all the steps followed (selecting installation directory, installed components etc.). Note that this will install FEKO on the computer that is used to create the response file.

- The completed `setup.iss` file can now be copied to all the target machines. To install FEKO in silent mode on a target machine, launch the installer as follows: `feko_distrib_xx.yy_winNN.exe /s /f1"C:\Temp\setup.iss"` where `"C:\Temp\setup.iss"` specifies the absolute path to the `setup.iss` file.

2.2.4 Installing FEKO in silent mode using the MSI database

The last mechanism provided to install FEKO silently uses the embedded MSI file directly.

- The FEKO installer (`feko_distrib_xx.yy_winNN.exe`) contains a MSI database. This must first be extracted before it can be used. To extract the MSI database, launch the FEKO installer normally (i.e. by double-clicking it or just typing `feko_distrib_xx.yy_winNN.exe` at a command prompt). When the welcome screen is displayed, click the "Cancel" button and abort the installation. The FEKO MSI database can then be found under `%WINDIR%\FEKO Installations\{GUID}\`. Copy this file to all the target machines. Note that FEKO is NOT installed on the machine that the file was extracted on.

- On the target machines, open a command prompt and change directory to the location of the MSI database. Then launch the Windows installer as follows: `msiexec /i "FEKO x.y.msi" /qb+ [variables]` where [variables] must contain

  - `INSTALLDIR="C:\FEKO"` : The path where FEKO must be installed.
  - `FEKO_USER_HOME="C:\FEKO"` : The location of the FEKO user files.
  - `FEKO_TMPDIR="C:\Temp"` : The path to the directory where FEKO will store temporary files.
  - `FEKOLANG="e"` : The language used by FEKO when creating output files; specify "e" for English or "d" for German.
  - `FEKO_SILENT="1"` : This must be specified in silent MSI mode.
  - `ADDLOCAL="Default,..."` : The features to install. Specify any of the following items (with "Default") in a comma-separated list: FEKOKernel, Parallel, FEKOLITE or FloatingLicence. Note that you must not specify FEKOLITE and FloatingLicence together.

  Note that you may also specify `/qn`, `/qn+` or `/qb` instead of `/qb+`.

2.2.5 Obtaining the FEKO licence file

The installation program should have created the file `request` in the `license` subdirectory of the FEKO installation. If it does not exist, this file can be created by executing `request.bat` in the `bin` subdirectory of the FEKO installation.

Edit the file — enter the information requested at the top thereof — and email or fax it to your distributor (see section 1.4). You will then receive a licence file `secfeko.dat` which must be placed in the `license` subdirectory of the FEKO installation to activate your licence. (You can run an unregistered version of FEKO LITE — the GUI components will switch automatically if no licence is found — for a period of 30 days until you obtain this file. After 30 days you also need a licence file to run FEKO LITE.) If you are using floating licences the procedure is the same, but you may need to edit this file, see section 2.4).

If you want to switch to an evaluation version after running FEKO LITE, you need to create and send the `request` file to your distributor as mentioned above. Then overwrite the existing file `secfeko.dat` with the new one obtained from your distributor.

2.3 UNIX / Linux workstation installations

To install FEKO on a UNIX or Linux workstation (both parallel and sequential versions) the FEKO installation script must be executed, see below for detailed instructions. Note again that the pre- and post processing support components are currently only available on Windows or Linux PCs.

2.3.1 Supported platforms

The workstation platforms currently supported are summarised below. *A parallel version of FEKO is available for all these platforms.* For FEKO on other workstation platforms please contact your distributor. The indicated filename is relevant only if you are not installing directly from the FEKO CD. The string `xx.yy` in the filename indicates the FEKO Suite version.

Platform	Filename
Linux (32-bit Intel or compatible)	`feko_distrib_xx.yy_LINUX.tar.gz`
Linux (64-bit on Intel Itanium)	`feko_distrib_xx.yy_LINUX_IA64.tar.gz`
Linux (64-bit on Intel EM64T)	`feko_distrib_xx.yy_LINUX_EM64T.tar.gz`
Linux (64-bit on AMD Opteron)	`feko_distrib_xx.yy_LINUX_AMD64.tar.gz`
HP-UX (64-bit on Intel Itanium)	`feko_distrib_xx.yy_HP_IA64.tar.gz`
HP-UX (64-bit on HP PA 2.0)	`feko_distrib_xx.yy_HP.tar.gz`
SGI IRIX (n32- and 64-bit)	`feko_distrib_xx.yy_SGI.tar.gz`
SUN Solaris (32- and 64-bit)	`feko_distrib_xx.yy_SUN.tar.gz`

If downloading the installation files or manually copying them from the FEKO CD, then in addition to the platform dependent file listed in the table above, you will also need the documentation and examples which are available in the file

```
feko_distrib_xx.yy_documents.tar.gz
```

If installing under Linux (32- or 64-bit) then the corresponding GUI executables and help files are required from the packed archive

```
feko_distrib_xx.yy_LINUX_GUI.tar.gz
```

See the following section for detailed installation instructions.

2.3.2 Installation

The following procedure can be used to install FEKO on a new workstation or to perform an update of an existing installation (in the case of an update, a backup of the old installation is created automatically). If you have technical questions, please contact your distributor (see section 1.4).

- The default FEKO installation path is `/opt/feko`. Of course any other directory can be specified during the interactive installation process. Make sure at this stage that you have write permissions on the directory where you want to install FEKO. In most situations, one might now have to change to the `root` user, in particular if FEKO shall be installed in a global directory accessible by more than one user.
- For the next step, we distinguish between three different situations:

  a.) You have received FEKO on a CD, and the workstation where you want to install FEKO has a CDROM drive. Then you can install directly from the CD. Load the CD on this workstation and mount it. The command for this is system dependent, for example

  ```
  mount /dev/hdc /mnt/cdrom
  ```

  (check for your system). It is assumed that the CD has been mounted to `/mnt/cdrom`, then simply execute now the FEKO installation script

  ```
  cd /mnt/cdrom/installs/unix
  sh ./INSTALL.SH
  ```

  which will guide you step by step through the installation process. *Note that the mount options may influence the case of file and directory names — please use* `ls` *to determine the case of the directory and file names if it is not the same as above.* (The installation script will account for both cases.)

b.) If you have received FEKO on a CD, but cannot read the CD from your workstation, then copy the appropriate `*.tar.gz` file for your platform (see table in section 2.3.1, e.g. `feko_distrib_xx.yy_LINUX.tar.gz` for the FEKO Suite `xx.yy` for Linux PCs) from the subdirectory `installs/unix/archives` on the CD to a temporary directory on the workstation (you may temporarily need up to 390 MByte of disk space there). This can be done for instance by reading the CD on a PC, and transferring the file by ftp (binary mode) to the workstation, or by using a shared network drive. Also copy the FEKO example and documentation files from the CD (file `feko_distrib_xx.yy_documents.tar.gz` with the Suite number `xx.yy` in the same directory `installs/unix/archives`) to this temporary directory. If installing on a Linux PC, then also copy the GUI archive `feko_distrib_xx.yy_LINUX_GUI.tar.gz` there. Now follow the instructions in the next paragraph c.

c.) If you have not received FEKO on a CD, but rather the installation file (e.g. `feko_distrib_xx.yy_LINUX.tar.gz` for Suite `xx.yy` for Linux PCs) directly by email or WWW download, then put this file to a temporary directory on your workstation (you may temporarily need up to 390 MByte of disk space there). In the following it is assumed that this directory is `/tmp`. Also put there the file `feko_distrib_xx.yy_documents.tar.gz` in order to install the FEKO examples and documentation. If installing under Linux, you also need to get the GUI archive `feko_distrib_xx.yy_LINUX_GUI.tar.gz`.

Then proceed as follows (this is an example for 32-bit Linux PCs, substitute the correct filenames for your platform and note again that the GUI is available only for Linux, i.e. skip the second file if installing say on an HP workstation):

```
cd /tmp
gunzip -c feko_distrib_xx.yy_LINUX.tar.gz | tar -xf -
gunzip -c feko_distrib_xx.yy_LINUX_GUI.tar.gz | tar -xf -
gunzip -c feko_distrib_xx.yy_documents.tar.gz | tar -xf -
cd feko_install
sh ./INSTALL.SH
```

This will start the installation script, follow the online instructions, which will guide you step by step through the installation process.

Once the installation is finished, the temporary files in `/tmp/feko_install` can be deleted again, see also instructions given to you online.

- Note that before FEKO can be used on the workstation, certain environment variables must be set. To this end a shell script `initfeko` will be created during the installation, which can be found in the subdirectory `bin` of the FEKO installation tree, e.g. `/opt/feko/bin`. See the instructions given on the screen of how this file must be executed (it can, for example, be inserted into your personal startup file `$HOME/.profile` or `$HOME/.bash_profile`). This initialisation script `initfeko` is intended for the ksh, bsh, sh, and bash shells.

A similar script `initfeko.csh` is created (also in the subdirectory `$FEKO_HOME/bin`) for the C-Shell (i.e. csh, tcsh). For an automatic execution, please execute this script from the personal startup files `$HOME/.login` or `$HOME/.cshrc`.

- The installation script will create a file `request` in the subdirectory `license` under the FEKO installation directory (e.g. `/opt/feko/license/request`). Some updates will require a new password file. (FEKO will then give a message if the password file is no longer valid if you run it after the installation.) If this is the case, or if this is a new installation, please email or fax the `request` file to your distributor (see section 1.4).

  You will then get a file `secfeko.dat` with the passwords for your workstation (or for a parallel machine for all nodes of the cluster). This file `secfeko.dat` must be put into the `license` subdirectory of the FEKO installation directory, see also detailed instructions with the full path for your specific setup in the file `request` and on the screen during the FEKO installation.

2.4 Floating licences

By default FEKO uses a node locked licence scheme. From FEKO Suite 4.2 a floating licence scheme is also available. This whole section 2.4 is only relevant if you purchased this separate licence option, otherwise it can be skipped.

2.4.1 Concept of floating licences and general comments

The concept of floating licences is quite simple. A floating licence server is chosen, which manages the FEKO licences. This server machine should be a reliable machine running more or less permanently, without being rebooted too often (it can be rebooted, but any FEKO jobs running at that time even on remote client machines will then be terminated).

At the time of installation (see separate details below for UNIX and Windows) only the `request` file of the floating licence server needs to be sent to EMSS in order to create a licence file `secfeko.dat`. The client machines can be chosen arbitrarily, but need to have a permanent network connection to the floating licence server (i.e. a notebook computer cannot act as a client if FEKO shall be used on this while for instance travelling. For such cases, EMSS also offers special licences locked to a dongle).

The obtained licence file `secfeko.dat` must be copied into the subdirectory `license` of your FEKO installation. This must also be done to all client machines, so that they know which floating licence server to contact (hostname or IP address) and which TCP port to use for the communication. This information is in the header section of the licence file and can be edited:

```
############### START USER EDITABLE SECTION ###############
# Specify here your licence server, either using the hostname
# or the IP address (from each client you must be able to reach
# the server in this way, if you have problems try "ping"
# with exactly the hostname or IP address you have specified
# below after the SERVER keyword).
SERVER  machine.domain.xx.yy
#
# Specify here the TCP port number that should be used for the
# communication between clients and server. Leave the default
# if you are unsure. If you get an error message that the port
# is in use you will have to change.
PORT    11601
###############  END USER EDITABLE SECTION  ###############
```

Note that while you can edit the `SERVER` hostname or IP address, you cannot move the floating licence server to another machine without first having sent the `request` file of this machine to your distributor and having obtained a new valid licence file `secfeko.dat` for the new licence server machine.

An arbitrary TCP port can be selected, by default FEKO uses 11601. Note that when editing the port information, this must be the same on the client and the server side. Also when changing the port on the server side, don't forget to restart the floating licence server so that this change comes into effect.

Such management tasks like restarting the floating licence server can be accomplished by a graphical utility `secfeko_gui` (see *FEKO User's Manual* for details) or by using the command line utility `secfeko`. Just type `secfeko` in a command or shell window to get a syntax overview. Restarting the floating licence server can be done for instance by using the command `secfeko -r`.

2.4.2 Floating licence server installation and maintenance (Windows)

Under MS Windows, the floating licence server must be installed on a machine running Windows NT or 2000 or XP. Note that administrative rights are required during the installation (the FEKO floating licence server `secfekod.exe` will be installed as a service under the SYSTEM account).

Follow the standard installation instructions under Windows. On the *Select features* page, *Floating licence server* must be selected. You may or may not install the solver and GUI on the licence server, but you cannot install FEKO LITE and the floating licence server on the same PC.

A `request` file will be created during each FEKO installation. Please send this request file of the server (and not the ones of the client machines) to EMSS. See section 2.2.5 for details.

Once you have obtained the FEKO licence file `secfeko.dat` and copied this into the `license` subdirectory of your FEKO installation, the floating licence server must be started. Do this either from a command window by typing

```
secfekod --start
```

or from the programme menu under Settings - Control Panel - Administrative Tools - Services and there in the list right click on the service `FEKO floating licence manager` and select `Start`. In a few cases this operation may not be successful. Then the licence server must be rebooted.

From this service menu under Windows the floating licence server can also be stopped in the same way. When using the command line interface, the corresponding call is

```
secfekod --stop
```

to stop the service. With

```
secfekod --remove
```

the floating licence server will be stopped if it is running, and the service removed (but it will not be removed from the hard disk). To install it again as a service, use

```
secfekod --install
```

These two last options should normally not be required, but are listed for completeness.

Once you have obtained the licence file and started the floating licence server, it is a good idea to check its proper operation by starting `secfeko_gui` (see *FEKO User's Manual* for more details on this). It should then connect to the floating licence server and obtain a list of the floating licences and show their status (available versus in-use etc.).

All error messages that the floating licence server encounters are written to the system event log facility, which can be viewed from the Control Panel - Administrative Tools - Event Viewer - Applications. In this event log the name `secfekod` is used as source, and not only errors are logged, but also startup and stop notices.

All errors of the floating licence server are also written to a file `licence.error` in the subdirectory `license` of the FEKO installation. The error descriptions should be relatively clear, in case of problems please contact FEKO Support (see section 1.4 for details) with a problem description and the error number (preferably send the complete `licence.error` file as an e-mail attachment).

One potential problem shall be mentioned here: Under Windows XP one can activate an internet connection firewall for network connections under the advanced TCP/IP networking settings. If this firewall is active on the floating licence server, then in the default configuration, incoming connections to the chosen TCP port (see comment above, by default 11601) will be blocked and clients attempting to connect to the floating licence server will terminate with a suitable error message. In this case please configure the firewall such that incoming connections on this TCP port are allowed from your domain (add a specific service `secfekod` to the firewall settings, see the Windows documentation on how to do this).

2.4.3 Floating licence server installation and maintenance (UNIX)

Under UNIX, perform a standard installation of FEKO on the machine that shall act as a floating licence server and on all the client machines where FEKO shall be used, see section 2.3.

A `request` file will be created during the FEKO installation, and please send this request file of the server (and not the ones of the client machines) to EMSS. See section 2.2.5 for details.

Once you have obtained the FEKO licence file `secfeko.dat` and copied this into the `license` subdirectory of your FEKO installation (on the server machine but also on all the client machines), the floating licence server must be started. To this end three different startup scripts have been created during the FEKO installation process in the directory `$FEKO_HOME/bin`:

`secfekod_init.SuSE`	for SuSE Linux
`secfekod_init.RedHat`	for RedHat Linux
`secfekod_init.generic`	a generic script e.g. for HP-UX

Please check the setting of the variable `FEKODIR` in the appropriate file for you to match the FEKO installation directly, and then copy this file to the general daemon startup directory such as `/etc/init.d/` by using the for instance for SuSE Linux the command

```
cp $FEKO_HOME/bin/secfekod.init_SuSE /etc/init.d/secfekod
```

Register this service by using the suitable system command, e.g.

```
insserv secfekod
```

for Linux, so that it will be started automatically at the next time you boot your machine. For the first time now manually start the daemon using the command

```
/etc/init.d/secfekod start
```

This will start the floating licence server as a background process. This is the recommended way of operation, but `root` privileges will be required. Should this not be desired, one can also just start the FEKO floating licence server in an interactive mode (use `$FEKO_HOME/bin/secfekod -i`) or as daemon (use `$FEKO_HOME/bin/secfekod -d`) under any user account.

Once you have started the floating licence server, it is a good idea to check its proper operation by starting `secfeko_gui` (see *FEKO User's Manual* for more details on this). It should then connect to the floating licence server and obtain a list of the floating licences and show their status (available versus in-use etc.).

This utility `secfeko_gui` is not available yet for all UNIX platforms. If not available, then use the command

```
secfeko -p
```

to retrieve and display such licence usage information.

In case of any errors: In the interactive mode (see startup option `-i` mentioned above) error messages that the floating licence server encounters are written to the console to `stderr`.

When running `secfekod` as a daemon (default and recommended), then all error messages are written to the system event log facility, typically this is the file `/var/log/messages`. All startup and stop notices are also logged there.

For the daemon mode, all errors of the floating licence server are also written to a file `licence.error` in the sub-directory `license` of the FEKO installation. The error descriptions should be relatively clear. In case of problems please contact FEKO Support (see section 1.4 for details) with a problem description and the error number (preferably send the complete `licence.error` file as an e-mail attachment).

2.5 Setup of remote launching

A remote launching facility is available in FEKO so that for instance sequential or parallel jobs on a workstation or parallel cluster can be launched from a local desktop PC.

It is suggested that new users first install FEKO locally and familiarise themselves with FEKO. Then this section can be skipped. One can later came back to setup the remote launching if this is desired.

For the remote launching in FEKO, there is no need for the file systems to be shared, all the file copy operations are performed automatically. Also the progress of the remote run (including warning or error messages) can be monitored locally, similar to launching the job locally. This remote launching is also cross platform, one can for instance launch a remote job from a Windows PC on a Linux cluster or on an HP workstation, but also from Linux to Linux, or even from a SUN workstation to a Windows PC etc.

The requirements and setup of this remote launching facility shall be described here:

- FEKO must be installed on both the local client and the remote host. Also valid FEKO licences must be available on both computers. When using floating licences, two separate licences will be required, one for the client and one for the remote host. It is, however, possible to use a local GUI–only licence to launch a full FEKO job elsewhere.
- The remote launching and file copy operations are based on the SSH protocol. Thus an SSH client must be installed on the local machine and an SSH server must be running on the remote host. For UNIX / Linux machines this is typically readily the case. If not, one implementation is OpenSSH which is available from http://www.openssh.com.

  For Windows clients different SSH implementations exist (e.g. CYGWIN or PUTTY). For Windows servers CYGWIN can be used (see http://cygwin.com)
- On the client the `ssh` and `scp` executables must be in the local PATH.
- Public key authentication must be used. If this has not yet been setup, do this:
  - If a private/public key pair has not yet been created on the client (check for files `$HOME/.ssh/id_dsa*`), then run

    ```
    ssh-keygen -t dsa -N ""
    ```

    in order to create such a public/private DSA key pair.
  - In the local directory `$HOME/.ssh` a file `id_dsa.pub` is then created. Copy this to the remote host and there append to the file `authorized_keys` in the `$HOME/.ssh` directory there (create this file if it does not exist).
- Verify that SSH is working with public key authentication. Type on the client

  ```
  ssh remote_host ls
  ```

  where `remote_host` is the hostname or IP address of the remote host to be used. This should give a listing of the files in the home directory on the remote host. If not then the error message should give an indication what is wrong. One can also create debug output using the verbose option `-v` as follows:

  ```
  ssh -v remote_host ls
  ```

- On the remote host the FEKO environment must be set properly. Verify this with

  ```
  ssh remote_host prefeko
  ```

  If the executable `prefeko` is not found, then the environment variables as defined in `$FEKO_HOME/bin/initfeko` are not available. When using for instance the BASH shell on the remote host, make sure to add a line

  ```
  . /opt/feko/bin/initfeko
  ```

  (note the dot followed by a space) to your `.bashrc` file (adding this to `.bash_profile` as for a normal FEKO installation will not work since SSH opens a non-interactive shell only). Also note that the path `/opt/feko/bin` might be different for your FEKO installation.

- On the remote host the utilities `mkdir` (to create directories) and `rm` (to delete files) must be available. For UNIX / Linux this is the case, when using a Windows server these can be installed as part of CYGWIN (see above).

After these initial setup steps, remote FEKO jobs on other computers can be launched. Please see the *FEKO User's Manual* for further usage instructions, both from within the FEKO GUI and also from the command line.

Advanced users or system administrators might deviate from the setup procedure as described above. For instance, if public key based SSH authentication cannot be used but something else is available (like the insecure `rsh` with `rcp` for the file copy operations), then the corresponding FEKO remote launching scripts can be customised. For Windows this is the batch file `feko_remote.bat` and for UNIX installations of FEKO this is the shell script `feko_parallel`, both residing in the `bin` subdirectory of the FEKO installation. Please see the comments in these files. Note, however, that when updating FEKO any changes made to these files will be overwritten, so make a backup copy and keep at a safe place.

2.6 Adobe Reader installation

A PDF viewer is required to view and/or print the *Getting Started Manual*, the *Examples Guide* and the *FEKO User's Manual* that are available on the FEKO CD in the `doc` directory (and are installed in the `doc` subdirectory under the FEKO installation).

The Adobe Reader 7.0 can be downloaded from

http://www.adobe.com/products/acrobat/readstep.html

3 Getting started example 1: Rectangular Horn example

The first example makes use of an already set up and solved model of a horn antenna to familiarise the user with the FEKO program flow. The discussion assumes that this is read after the demo has been watched. If this is not the case, it is strongly recommend that the demo be watched before working through this example. (The demo example is the short movie of the solution of a horn antenna that is shipped with the FEKO installation.) The demo can be found in the `doc` subdirectory of the FEKO installation. For Windows installations, this file is an `.exe` file, which can be executed directly. On Linux installations, the demo is opened inside an `.htm` file.

3.1 Example overview

This example uses the same antenna as the demo example. The geometry is that of a rectangular horn with a probe feed in a short waveguide section. (Please refer to the text example `example_08` for a discussion of ways to feed a horn with a waveguide excitation.) The demo example shows the construction of the horn, the specification of the excitation, and the request of the near and far field patterns and basic display of the results. This example concerns itself with the reinforcement of the program model and the use of the different FEKO components. This example should take 30 minutes to work through.

The example is already set up and solved, and can be found in the `examples\projects\horn` directory of the FEKO installation. It is expected that while working through this text, the steps are followed sequentially. As far as is possible, the example is designed such that steps are independent of order, but it is not always possible to achieve this. If an explanation seems out of context, it might depend on a previous step.

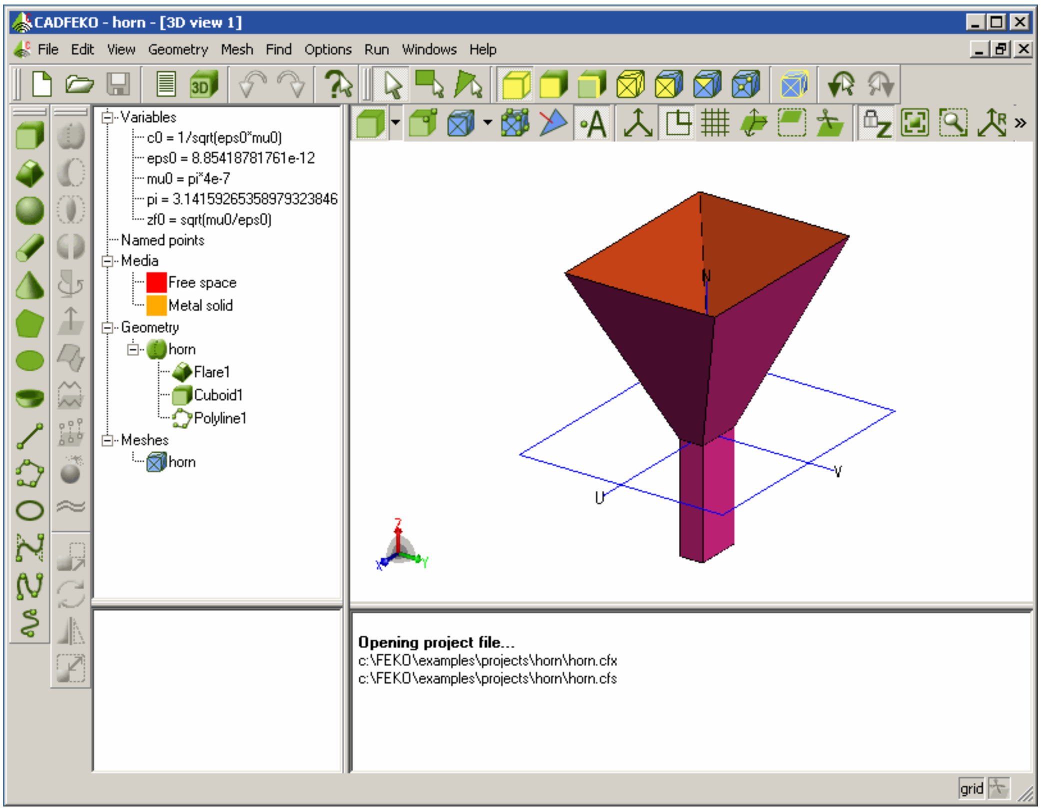
3.2 Creation of the geometry in CADFEKO

The first step in every FEKO solution is to construct the geometry. The geometry is created by the component CADFEKO and stored in the `*.cfx` file. To start CADFEKO from the Windows *Start* menu, choose

Programs → *FEKO* → *CADFEKO*

or open a console window and type `cadfeko`.

From the main menu in CADFEKO select *File* → *Open* and select the file `horn.cfx` in the `examples\projects\horn` directory of the FEKO installation. The geometry of the horn is now visible on the screen. The CADFEKO interface has a Windows look and feel, which should be familiar to most users.



There are a number of toolbars visible on the CADFEKO window at startup. For a detailed discussion of each one, please refer to the CADFEKO section of the FEKO user manual. Since the geometry is already created for this example, the two toolbars on the extreme left won't be used. The toolbar immediately above the 3D view controls properties that are associated with the 3D view, such as workplane settings, and settings controlling the visibility of different features of the geometry. Above this toolbar is the selection toolbar, which controls the way that items are selected from the 3D view. It is also used to control which features (faces, edges, etc.) are selected. Also visible is the contents tree on the left hand side, and the details tree below it. The message window is directly below the 3D view of the horn.

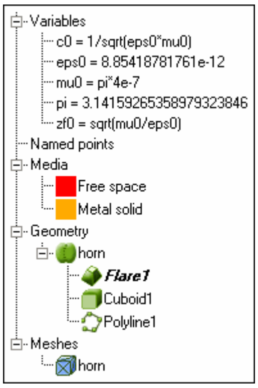
The seperators between the different areas of the screen can be dragged to resize areas as desired. The model can be rotated by using the mouse, left clicking and dragging. The zoom factor is changed by rotating the mouse wheel. Pressing the mouse wheel and dragging pans the model. This mouse behaviour is common to both POSTFEKO and CADFEKO.

Context sensitive help is available in CADFEKO by pressing <F1> at any time.

3.2.1 The contents tree

The contents tree is located to the left of the 3D view. It contains a history of the geometry creation process as well as the resultant mesh information and any variables/named points that were used during the creation process.

- The *Variables* branch contains all the variables used in this model. In this case the only variables are the default variables.
- The *Named points* branch contains named points used in the model - there are none for this example.
- The *Media* branch lists all available media that can be used in this model. In this case, the only available media are free space and solid metal.
- The *Geometry* branch contains the history of the geometry creation. In this case, the geometry tree contains one part named *horn* (a part is anything on the first level of the *Geometry* branch). This part was made of three child parts, namely *Flare1*, *Cuboid1* and *Polyline1*. All of these items are primitives, meaning that they have no child parts.



- The *Mesh* branch contains all the mesh items in the model. Any meshes created from geometry or imported meshes will be shown in this branch. The name of the mesh is referred to as its *label*. In this case, there is only one mesh, with the label *horn*.

It is possible to edit items by selecting them either in the 3D view or in the contents tree. In some cases, the contents tree must be used. For instance, to change the length of the flare, simply double-click on the *Flare1* primitive in the tree - it would not be possible to select the flare in the 3D view, since it doesn't exist there anymore. The dialog that was used to create the flare initially is opened for editing. If any values are changed, the contents tree is re-evaluated, applying the changes further up the tree.

3.2.2 The details tree

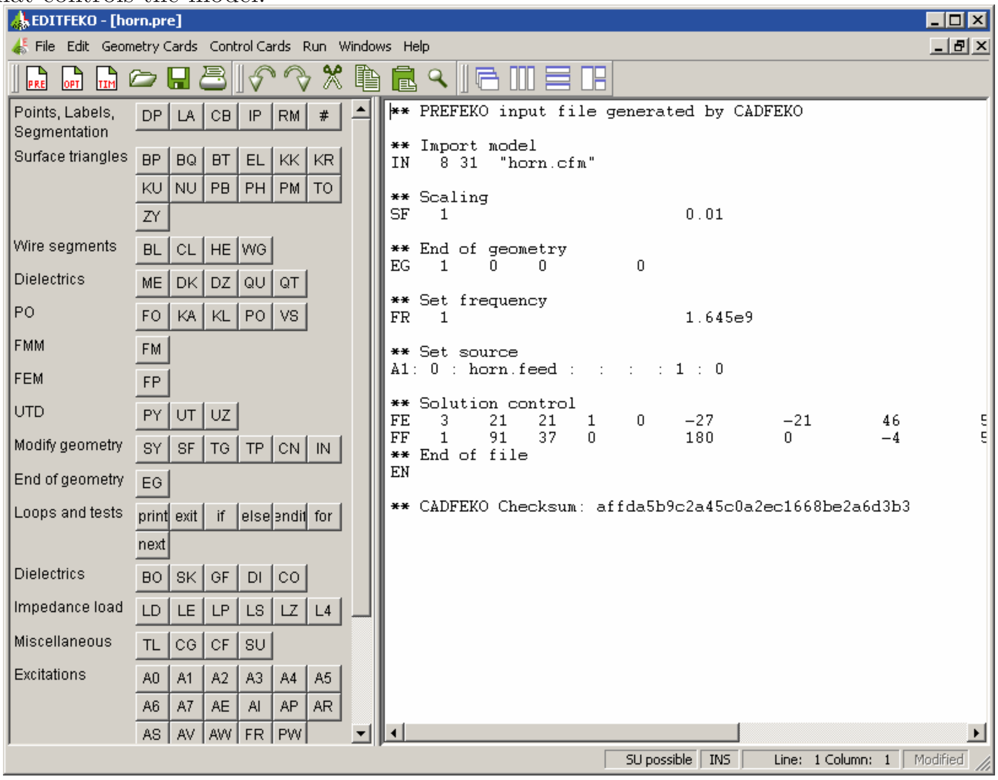
When a part or a mesh is selected in the contents tree, some additional information is shown in a tree positioned just below the contents tree. This is known as the *Details tree*.

If *horn* is selected in the *Geometry* branch of the contents tree, note that the details tree contains a tree with two branches, namely *Faces* and *Edges*. If the geometry had contained a volume, a *Regions* branch would also be visible. By selecting edges, faces or regions in this tree, local properties (like mesh size) can be set. Note that in this case one of the edges is named *feed*.

If *horn* is selected in the *Meshes* branch of the contents tree, note that the details tree contains a branch called *Labels*. This tree contains all the subsets of the horn that can be individually isolated during later processing. For instance, the tree contains the label *feed*. This means that there is a label *horn.feed* that can be used to uniquely identify the segment that is used for the excitation.

3.3 Setting the solution control

The solution parameters are defined by high level commands or cards — just lines of text — in the `*.pre` file. This text file may be created with any editor, but the customised editor EDITFEKO simplifies this process. To start EDITFEKO, select *Run* → *EDITFEKO* from the main menu in CADFEKO. EDITFEKO now shows the `horn.pre` file that controls the model.



Each line of the `*.pre` file represents a specific command to the FEKO solver. These commands are given in a column or colon delimited format. The format of the command does not need to be understood by the user to use the program. To modify a command, simply move the cursor to that line and press <F1>. A panel will open on the left side of the window. The panel is used to edit the command in a user friendly way. The command name is given by the first two letters of each line. The commands used in this example are:

- ** This is not a command - it is a comment that can be inserted anywhere in the file to describe the solution control.
- IN This command instructs the solver to retrieve the mesh information that was saved by CADFEKO.
- SF This command tells the FEKO solver that all dimension related values should be scaled to get them into meters. In this example, all dimensions are entered in centimeter, so the scale factor should be 0.01.
- EG This command seperates the the geometry related information (above the command) and the control information (below the command.
- FR A number of different types of frequency solutions can be selected. This command specifies the method that should be used, and any parameters associated with it. In this case, a single frequency calculation is requested.
- A1 Each excitation type in FEKO is designated with a command starting with an A. An A1 type excitation specifies the voltage over a specified segment. In this case the segment with the label *horn.feed* is used, and a voltage of 1 is set.
- FE This command instructs the solver to calculate near field results. The required coordinates for the calculation must be specified. A number of options, including coordinate system choice and field type choice, can be selected on the panel. In this case, a plane of near fields is requested in the opening of the horn. Both E and H fields are calculated.
- FF This command is used to instruct the solver to calculate the radiated or far field pattern of the antenna. This must always be in spherical coordinates. In this case a full 3D pattern is requested.
- EN The last command is to let the solver know that the model is now complete.

The commands are executed sequentially. Certain commands result in a set of commands being run in a loop. More information can be found in the user manual. Note that if no field, current, coupling or other result is requested, FEKO will not solve the model, as no output is requested. The geometry can also be specified in terms of commands.

3.4 Obtaining a Solution

In this example, the solution is provided to save time. Ordinarily, once the model preparation is complete (Geometry, mesh and control), the pre-processor PREFEKO is run. This program interprets the model and prepares it for solution by the FEKO solver. This interpreted model is stored in a `*.fek` file. It is this file that is displayed by POSTFEKO.

Once the `*.fek` file is created, the FEKO solver can be run. If the FEKO solver is run from one of the GUI components, and one of the model input files has been changed, PREFEKO will be automatically launched before solving the model.

More comments on obtaining a solution can be found in the *The program FEKO* chapter of the User Manual.

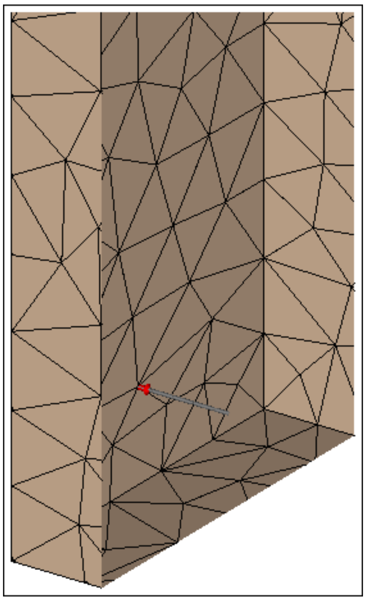
3.5 Viewing the model and results

The POSTFEKO component of the FEKO suite is used for model validation (the process of checking that the simulated model represents the intended model) and result visualisation. To launch POSTFEKO, select *Run* → *POSTFEKO* from the menu bar in either CADFEKO or EDITFEKO.

POSTFEKO also makes use of the standard Windows look and feel, making it intuitive to use. Similarly to EDITFEKO, POSTFEKO has a control panel to the left of the 3D view. This panel is used to configure the current view. Many different types of results can be visualised, meaning that many configuration options are needed. The options are grouped by basic functionality. The toolbar on the far left is used to select a group of options to set for the 3D visualisation window. The toolbar to the right of the view is used to control the view camera. The toolbar above the view is used to add 2D result visualisation windows to the current session or to launch one of the other FEKO components.

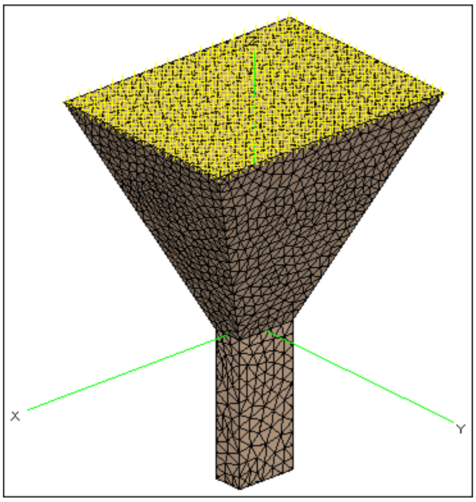
3.5.1 Model validation

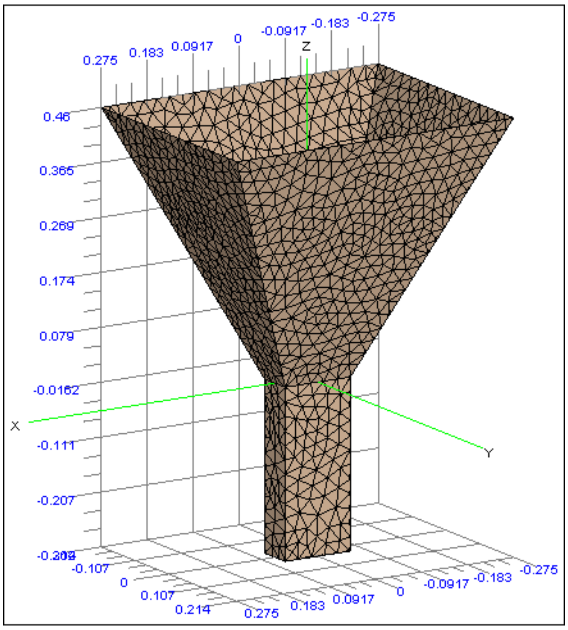
Many models require significant computational resources to solve. It is therefore a good idea to check that the model was correctly specified. POSTFEKO has features for this task, collectively referred to as model validation tools. The two tools that will be used to validate this model are the *Show excitation* and the *Display requested field points* tools.



Select the *Show excitation* button on the left side toolbar. Rotate and zoom in the 3D view so that feed probe is visible. (Alternatively, the *cutplanes* option on the left toolbar can be used to 'cut' through the mesh to see the feed probe.) The first segment (connecting the waveguide wall to the remainder of the probe) will have a red arrow on it indicating the location of the source.

Return to the default zoom and model orientation. Select the *Display requested field points* button on the left hand toolbar. The requested near field points are shown using yellow crosses, and the requested far field points are shown with green crosses. Note that although the far field points are shown in the vicinity of the antenna structure, they are computed in the far field. They are displayed close to the antenna for convenience purposes only. Uncheck the *Visible* checkboxes to hide the requested field points.





The last step in the validation process is to visually check the dimensions. It is a good idea to switch on a measurement grid to check that the geometry size is roughly correct, in case mistakes were made when scaling the model. To turn on a measurement grid, select the *Axis settings* button on the left toolbar. In the *Grid options* group, select a XY grid, and adjust the position slider until the grid is roughly coincident with the horn aperture. Once the size has been checked, the grid can be switched off by un-selecting the checkbox.

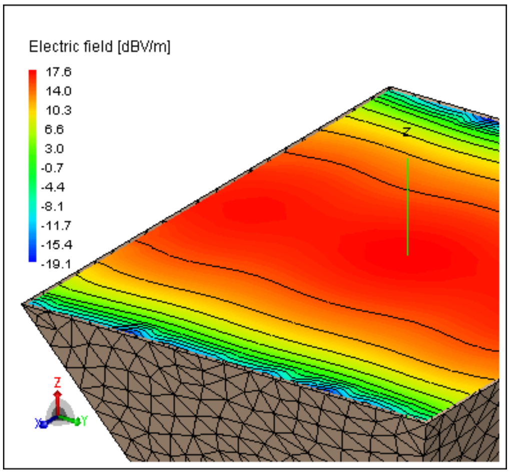
Model validation is now complete. Note that these steps are not compulsory, they are simply good modelling practice.

3.5.2 Near field results

The near field calculation that was requested earlier in this example has been performed and stored. To display this data in the 3D view, select the *View Near field ortho slices* button on the left toolbar. Note that the control panel contains many customisation options.

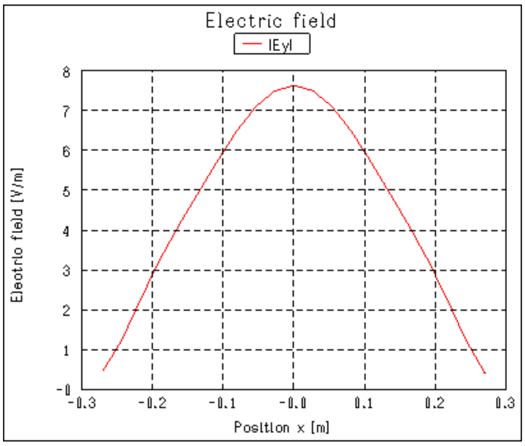
For the purposes of this example, the magnitude of the E_y component of the field should be displayed in dB, together with a legend and a few contour lines.

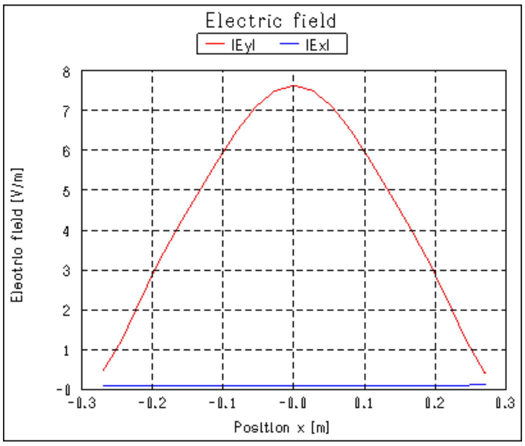
In the *Component* group, the *X* and *Z* components should be de-selected. The *dB* button should be selected in the *Scale* group. The *Legend* list is located at the very bottom of the configuration panel. Select *Top Left* from this list. To place the contour lines onto the display, select the *Options* tab. Fill in 11 for the number of contours. The contour lines now correspond to the values in the legend.



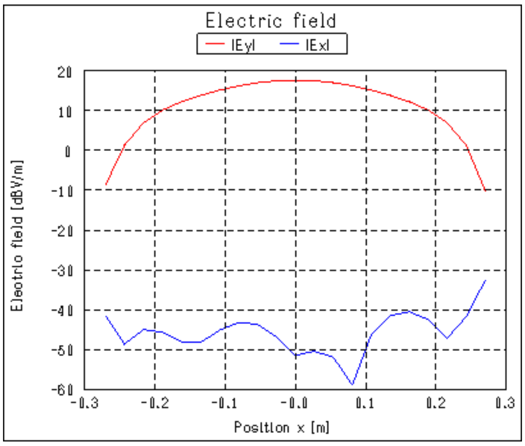
The near field results can be shown on a 2D graph for comparison purposes, or for quantitive results that are easy to read. The *Add a near field graph* button on the task bar located above the 3D view is used to request such a plot. For the purposes of this example the E_y and E_x component of the field through the centre of the horn in the y direction will be plotted on the same set of axes, for comparison purposes.

When the *Add a near field graph* button is pressed, a default plot line is made. From the default view, change the component to E_y, the independent direction to Y and the X position to 0.0. The E_y component will now be shown.





To add the second trace to the graph, the *New series* button at the top of the panel should be used. When this button is pressed, a second tab is added to the panel. Select the *series_2* tab to change the settings for the second trace. Change the settings in the *Component* group to X only to display the E_x component of the field. Change the independent direction to Y and set the X position to 0.0.

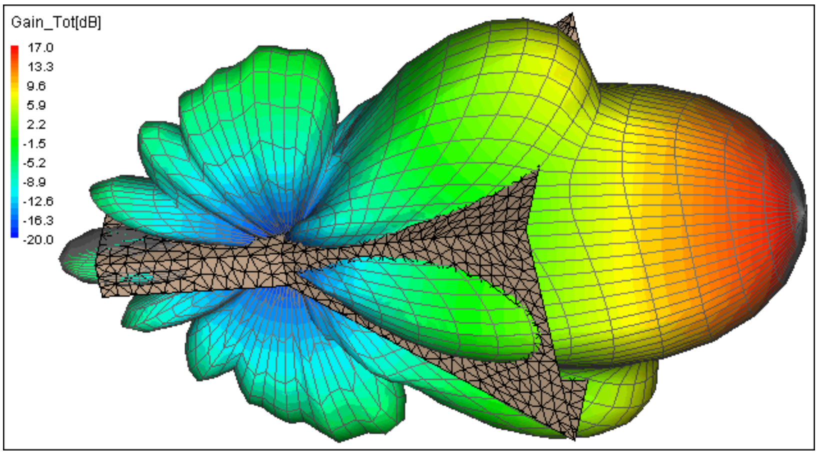


There is a vast difference in the magnitude of the two components. Plotting these results in dB would greatly aid visualisation. In order to plot the field values in dB, the settings for the left axis must be changed. Select the *Left axis* button to change these settings. Select the *dB* option on the configuration panel to change the setting. Other settings relating to the appearance of the graphs can be changed by selecting the appropriate configuration panel.

3.5.3 Far field results

The far fields on a full sphere are requested in the solution control phase of this example. This section explains the procedure to plot these results in the 3D view, and on a 2D graph.

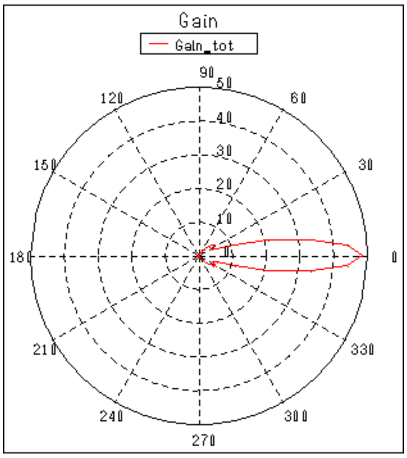
In order to display the results in the 3D view the 3D view must be the active window. Select this window from the *Windows* menu item in POSTFEKO. Select the *View 3D far fields* option on the left side toolbar to display the far fields. Note that the fields are immediately displayed, and that the configuration panel on the left lists options for this display. On the configuration panel, are two tabs - one to control the displayed data, and the other to change the way the data is displayed. On the *Data* tab, the displayed quantity can be chosen from the *Quantity* group. Select *Gain* from this group. The *dB* option from the *Scale* group is selected to display the gain in dB. To set the range of the displayed result, select the *Manual limits* checkbox and enter values for the minimum and maximum values of the display. In this case, a minimum of -20dB and a maximum of 17dB is set. At the bottom of the panel the legend display is chosen from the drop-down list. On the *Options* tab, the size of the plot can be changed. Move the *Scale factor* slider until the field results are reasonably sized, compared to the geometry size.

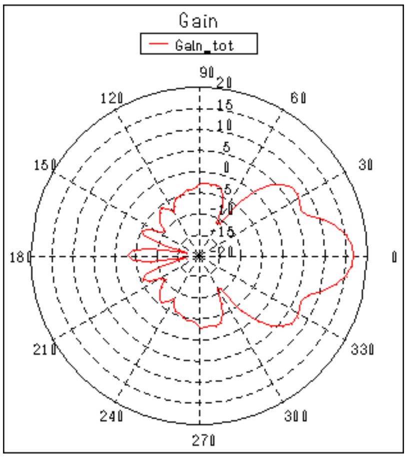


Far field radiation patterns are often displayed on 2D polar graphs. Since full 3D data is requested in this simulation, 2D cuts can be extracted. To open a new 2D graph, select the *Add a far field graph* button from the toolbar above the 3D view.

In this case, it is requested that the far field gain be plotted in the YZ plane on a polar graph. This corresponds to plotting the data with respect to *theta* at *phi* = 90°. The data should be plotted in dB, using a data range of -20dB to 20dB.

In the *Independent variable* group, *theta* should already be selected. The value of *phi* to be used (90°) is selected from the drop down list below the name. *Gain* is selected from the *Quantity* group. Select the *Graph settings* button on the left toolbar to set the *Plot type* to *Polar*. Take note of the other setting that are controlled from this panel.





The radial axis settings are now controlled by the left axis settings panel. Select the *left axis* button from the left toolbar. Select the *dB* scaling option. Note that the autoscale already selects the correct range for this example.

3.6 Closing remarks

This introductory example has shown aspects of the user interface of FEKO, from preprocessing through to post processing, using an already set up model of a horn antenna. The horn geometry is entered (with a detailed explanation in the FEKO demo file). The control specification for the frequency, excitation, request of near- and far- field data calculation is discussed together with EDITFEKO. The display of the simulated model, together with results is explained in detail.

4 Getting started example 2: Patch antenna example

The second example introduces dielectric material into the model and sets local mesh properties. To illustrate the use of dielectric regions, a patch antenna on a substrate is used. Dielectric material modelling in FEKO is not restricted to planar antenna modelling. Dielectric regions of arbitrary shape and dielectric parameters can be used.

The example covers all phases of the modelling process. This necessarily means that all phases must be executed sequentially. It is not possible to only work through one subsection of this example. This example will take approximately 60 minutes to work through.

4.1 Example overview

The input impedance over frequency of a resonant patch antenna is investigated close to resonance. The patch (31.1807mm by 46.7480mm) is printed onto a finite sized substrate (50mm by 80mm) with a thickness of 2.87mm. The relative dielectric constant of the substrate is 2.2. The patch is fed with an SMA connector (pin diameter 1.3mm) located 8.9mm from the centre of the long edge. The only observable of interest is the input impedance over the band 2.6 GHz to 3.1 GHz. Adaptive frequency sampling will be used to reduce the number of frequency samples in the band.

4.2 Creation of the geometry in CADFEKO

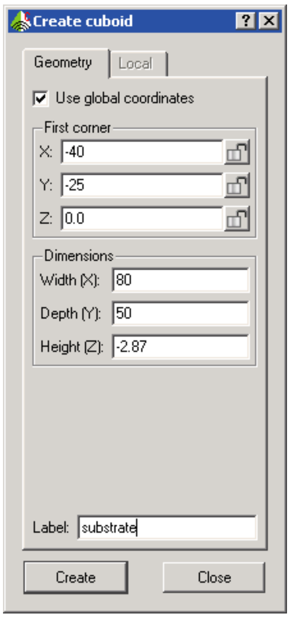
The first step in every FEKO solution is to construct the geometry. The geometry is created by the component CADFEKO and stored in the `*.cfx` file. To start CADFEKO from the Windows *Start* menu, choose

Programs → *FEKO* → *CADFEKO*

or open a console window and type `cadfeko`.

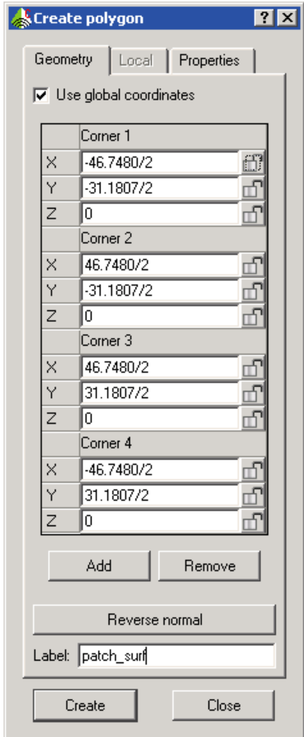
CADFEKO will start with a blank project. When enetring entities, all dimension related values will be entered in mm. For simplicity, the model will not use any variables or parameters.

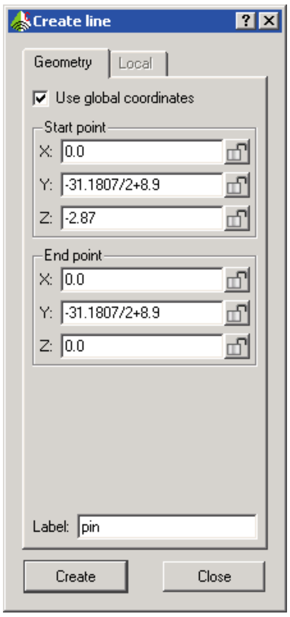
The substrate is modelled using a cuboid. A polygon is drawn to represent the patch surface. A wire element is drawn to model the feed pin. Properties for the substrate and local mesh settings are then set.



The first step is to draw the cuboid. Select the *Cuboid* button on the extreme left to open the *Create cuboid* panel. All items are drawn in global coordinates for this example. If the dialog is shown in terms of U-V-N coordinates, please change the *Default local coordinates* setting to *Global* in the *Options* → *Preferences* dialog.
Enter the coordinates as shown on the left. Notice that the cuboid is made with a negative height, since the top corner of the cuboid should be coincident with $z = 0$ plane. Close the dialog after creating the cuboid. Press the *Zoom to extents* button on the toolbar located immidiately above the 3D view to zoom out so that the substrate can be seen.

Next, the surface of the patch is drawn with a polygon. To draw a polygon, select the *Create polygon* button on the leftmost toolbar. This opens the *Create polygon* dialog. Enter the values as shown on the left. Note that the *Add* button should be pressed to add a fourth corner to the polygon. The coordinates for the polygon are entered using expressions to make it easier to understand how the enetered values are calculated. Close the dialog after creating the polygon.

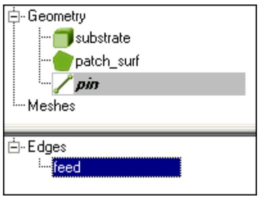




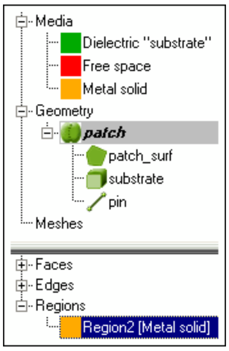
The only part of the geometry that still needs to be drawn is the wire. Select the *line* button on the leftmost toolbar. The wire is positioned 8.9mm from the edge of the long side.

The position of the feed needs to be uniquely identifiable. The name of the edge to be excited must be set so that this name can be used to identify the segment to the FEKO solver. In this case the wire will be shorter than the segment length, meaning that the meshed model will have only one segment. If this is not the case, a seperate wire should define the feed segement. See the first and third getting started example for demonstrations on how this is achieved using a polyline entity.

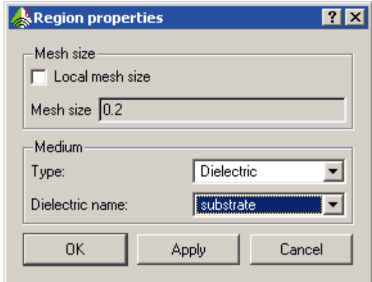
Select the part *pin* in the geometry tree. Note that the detail tree (directly below the geometry tree) contains an *Edges* entry, with one child, named *Wirexx* where *xx* is a number. Select this wire, and press F2 to rename this wire, and rename it to *feed*.



To ensure proper connectivity between these separate parts, they must be joined together. This process is called unioning. Select all three parts in the geometry tree and then select the *Union parts* button from the toolbar to the immediate left of the geometry tree. Note that a new level is now created in the geometry tree, with the three parts as child parts. Select this new part, and press <F2> to rename it. Change the name to *patch*. Note that the edge corresponding to the feed wire retains the name change previously specified.



If the structure was to be meshed at this stage, CADFEKO would assume all structures to be metallic. Since this is not the case, the properties of the region must be set. Before the substrate medium can be used in for the region, it must be defined in the *Media* branch of the content tree. Double click on the *Media* label in the contents tree to create a new medium. Name the new medium *substrate*. To set the properties of the interior region of the model, select the part in the geometry tree. The detail tree now shows a *Regions* branch. Expand this branch to see a list of available regions. In this example, only one region (the inside of the cuboid) exists. Right click on this region, and select *Properties*.



Select *Dielectric* from the first drop down list in the *Medium* group. In this case, the medium *substrate* is the only defined dielectric medium, and will be selected by default in the second drop down list. Note that the electromagnetic properties of this region are not set at this stage. The icon next to the part in the geometry tree will change, signifying that the part contains a dielectric region.

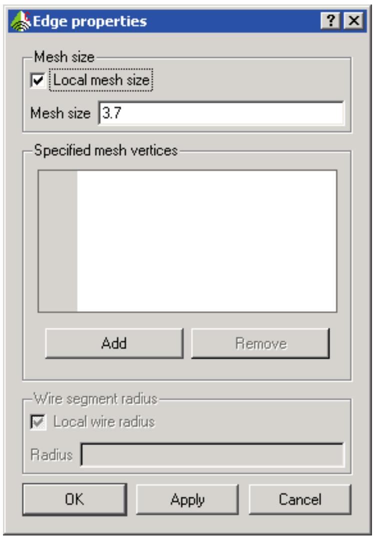
If the structure was to be meshed at this stage, none of the surfaces of the dielectric region would be have a metallic coating. Two of the surfaces, namely the patch and the groundplane, should be marked as metal. To select these surfaces, switch to face selection mode by pressing the *Select faces* button from the selection toolbar. Select the patch surface in the 3D view. Right click on it and select *Properties*. Check the *Metal surface* checkbox and press *OK*. Note the icon change in the details tree. Repeat this process for the groundplane. (The faces can be selected simultaneously, and their properties set simultaneously.)

The geometry creation is now complete. Save the model before proceeding.

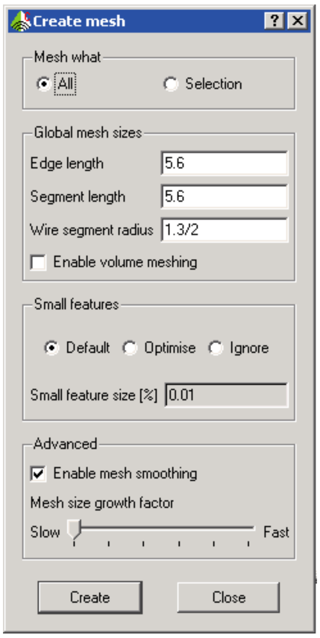
4.3 Mesh creation

The last step to be completed in CADFEKO is the mesh generation for the simulation. For most models, a constant mesh size of $\lambda/10$ is preferred (where λ is the free space wavelength). When a model contains dielectric materials, a mesh size for all triangles that have at least one side on the surface of the dielectric, a mesh size of $\lambda_d/10$ should be used (where λ_d is the wavelength inside the dielectric). These rules are generally applicable, but shouldn't be applied blindly. A denser mesh should be used where the current is known to vary more quickly, and a less dense mesh can be used when some modeling approximations are suitable. Refer to the *General comments* section of the

FEKO user manual for more information regarding mesh size guidelines. In this example, the current is known to vary more quickly near to the long edges of the patch - making these a good candidate for finer meshing. A mesh density of $\lambda_d/12$ will be used as the general mesh size, with a finer mesh along the two long edges of the patch, of $\lambda_d/18$. Both of these mesh sizes are denser than the recommended guideline because of the thickness of the substrate.



To set the mesh size along the two edges of interest, switch to edge selection mode by clicking on the *Select edges* button on the selection toolbar - the topmost toolbar on the CADFEKO window. Left clicking the mouse will now select edges - note the selection shown in the detail tree. Select one of the long edges of the patch. Right click on either the edge, or the corresponding entry in the detail tree, and select *Properties*. Select the *Local mesh size* checkbox and enter a mesh size of 3.7mm into the edit box. The same should be done for the other long edge. (Note that the properties for both edges can be set simultaneously by selecting both edges.)



Now that the local mesh properties have been set, the geometry can be meshed. Select *Mesh* → *Create mesh* from the CADFEKO menu bar. The global mesh size for triangular and wire elements should be set to 5.6mm. The radius of the feed pin is 0.65mm. All other options should be left as is for this example. Select *Create* to create the mesh. Note the finer mesh along the long edges.

The mesh of the model is now complete. The model should be saved in CADFEKO at this point.

4.4 Setting the solution control

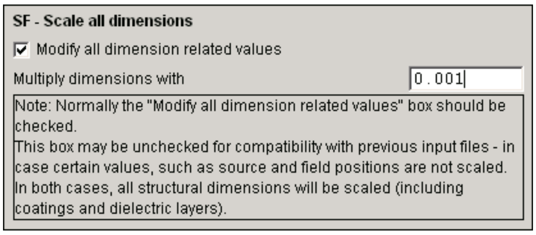
The next step in the simulation procedure is to set the model parameters, such as frequency range, excitation, dielectric parameters and required observables. Parameters are set using the EDITFEKO user interface. In this example, adaptive (continuous) frequency sampling will be used, and the input impedance will be extracted.

EDITFEKO can be launched directly from the CADFEKO user interface. Select *Run* → *EDITFEKO* from the menu bar to launch the user interface.

As described in the preceding example, the model control is specified using a series of sequential commands. The first two characters of each line specify the command, and the parameters for the command are set in the configuration panel on the left. To open the configuration panel for a specific command, place the cursor on the same line as the command, and press <F1>.

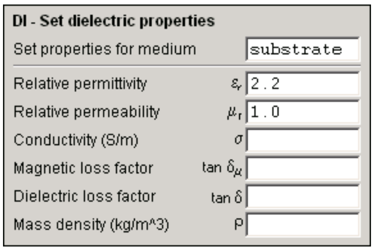
The first line of the standard control file starts with two asterisks. This means that this line is not a command, rather a comment. Anything after the two asterisks is ignored by FEKO.

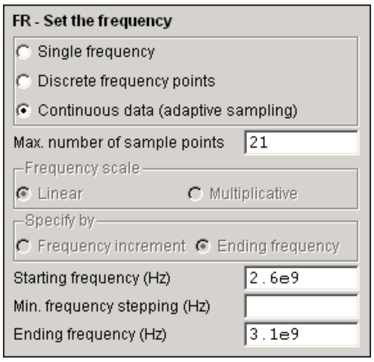
The first command in the standard file is the IN command. This command instructs the solver to extract the mesh information from the CADFEKO output. This command can be left in the default configuration for this example.



The first command that should be entered is the SF command. This command instructs FEKO to accept all dimension related values in millimeters. To enter this command, position the cursor on an empty line below the IN command, and above the EG command. Then press the SF button located on the left side of the text area. A scale factor of 0.001 should be entered into the *Multiply dimensions with* edit box. Press *OK*.

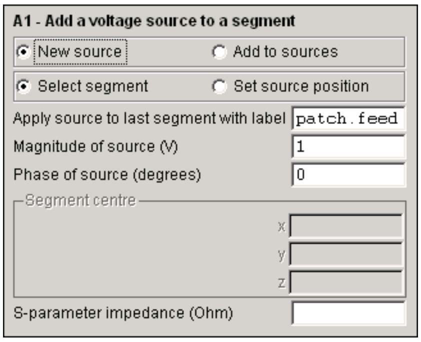
The dielectric properties of the substrate have not yet been set. The parameters are set using the DI command. Position the cursor below the EG card, and press the DI button to the left of the text area. This opens the configuration panel for this command on the left of the text area. Enter the relative permittivity and permeability of the substrate. Note that the name given to the dielectric region in CADFEKO must be used in the *Set properties for medium* edit box. Press *OK*.

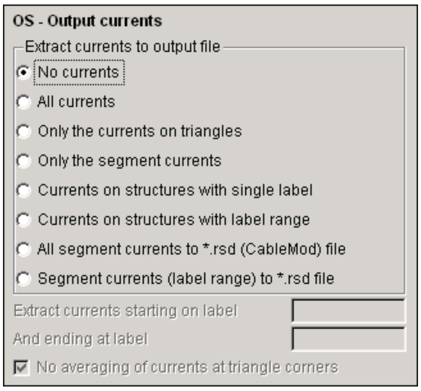




Frequency control for the model is set using the FR command. This command is already inserted into the default control parameter file. To edit the command, position the cursor on the same line as the current FR command, and press <F1>. This opens the configuration for the existing command, rather than inserting a new command. Choose *Continuous data (adaptive sampling)* from the three different frequency sampling modes. Set the maximum number of samples that the adaptive method can use to 21. Set the frequency range to start at 2.6GHz and to end at 3.1GHz. This command now instructs the FEKO solver to sample the frequency at optimal locations in the band. More information about this method can be found in the ADAPTFEKO section of the user manual.

The model, now complete with dielectric parameters and frequency specification, still requires an excitation to be set. Position the cursor below the *** Set source* comment. Press the A1 button on the left of the text area. The configuration panel for an A1 source type will open on the left. This source type is used to specify a voltage excitation over a wire segment. More information about this and other excitations can be found in the user manual. The label of the segment to feed is *patch.feed* — this should be entered into the *Apply source to last segment with label* edit box. Since input impedance is the only observable of interest, the voltage specification will not influence the result. Therefore a value of 1V with 0° phase is specified.





The model is completely specified at this point, but no output is requested. FEKO will therefore not solve the model. The input impedance for sources is calculated regardless of which computation instruction is given. In order to instruct the solver to calculate the input impedance, we use the command to calculate the currents in the model. This command is the OS command. Position the cursor below the *** Solution control* comment and press the OS button on the left of the text area to open the configuration panel for the command. Select the *No currents* option on the panel. In this configuration, the FEKO solver will calculate the currents, and therefore the input impedance, without writing all the currents to the output file — which could result in a very large output file.

The solution control parameters are now completely defined. The control specification script should now look like this:

```
** PREFEKO input file generated by CADFEKO

** Import model
IN   8 31  "patch.cfm"
SF   1                        0.001
** End of geometry
EG   1    0    0         0
DI: substrate :  :  :  :  : 2.2 : 1.0
** Set frequency
FR   21   2                   2.6e9               3.1e9
** Set source
A1: 0 : patch.feed :  :  :  : 1 : 0
** Solution control
OS   0
** End of file
EN

** CADFEKO Checksum: 3a5792486fd158826e2ee87f4196cb70
```

The solver does not interpret these commands directly - a pre process step is still required. To pre-process the model, simply select *Run* → *PREFEKO* from the EDITFEKO menu bar. PREFEKO interprets the model and commands into a low level format that is used by the solver. After running PREFEKO, the model is ready to be solved.

4.5 Obtaining a solution

After completing the model preparation, the solver should be invoked to calculate the requested results. The solver can be invoked in a number of ways, from a command window or from any one of the GUI components. In this example, the solver will be invoked from EDITFEKO.

At this stage of the solution process, it is advisable to perform model validation, as described in the first getting started example. In this case it is advisable to check that the metalisation of the patch and groundplane surfaces was correctly performed and that the scaling was correctly applied. To create the model from the script, select *Run → PREFEKO* from the EDITFEKO menu bar.

To invoke the solver from EDITFEKO select *Run → FEKO* from the menu bar. A window will open, giving step by step feedback as the simulation progresses. The solver will use 6 frequency samples in the band. The simulation time should be between 70 and 100 seconds per frequency, depending on the processor speed of the computer. Peak memory utilisation should be of the order of 140MByte. The simulation time and peak memory usage could be reduced significantly by exploiting the magnetic symmetry of this example. See the discussion on the use of symmetry in the FEKO user manual.

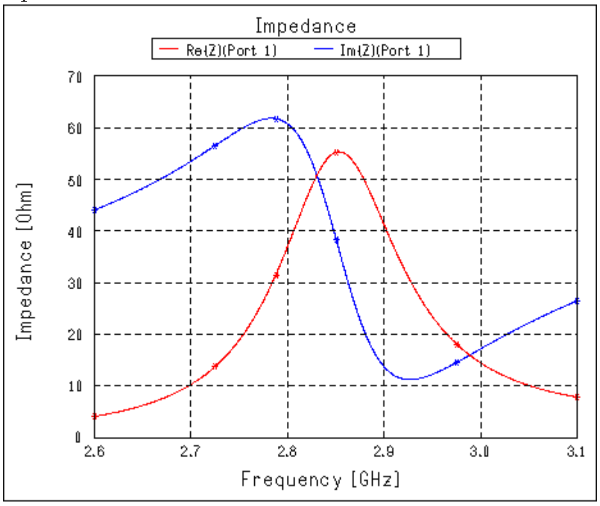
4.6 Visualisation of results

To launch POSTFEKO, select *Run → POSTFEKO* from the EDITFEKO menu bar. POSTFEKO will open, with the patch antenna in the 3D view. POSTFEKO is used for all post processing operations, including the plotting of input impedance versus frequency as needed in this example.

A new graph that plots information relating to the source is started by pressing the *Add a source data graph* button on the 2D graphing toolbar. (This toolbar is located above the 3D view.)

A default graph of input impedance versus frequency is opened with the input impedance at the first frequency sample point displayed. Continuous frequency sampling is used for this example, meaning that the solver automatically chooses the frequency sample points. The sample points that were chosen can be seen in the list on the configuration panel. Below this list is a check box labelled *Use continuous frequency*. Select this checkbox to plot the results as calculated by the adaptive process. The magnitude of the input impedance over the entire frequency range will be shown. The sample points (the exact frequencies at which a solution was obtained) are shown with markers. Select *Real* in the *Part* group to plot the real part of the input impedance rather than the magnitude. To add another trace (for the imaginary part of the impedance) select the *New series* button located on the toolbar at the top of the configuration panel. A second tab named *series_2* will be created on the configuration panel - select this tab.

Turn on the continuous frequency sampling by checking the *Use continuous frequency* check box. The second trace will now be visible, showing the magnitude of the input impedance. Select *Imag* from the *Part* group to change this trace to display the imaginary part of the input impedance.



The input impedance characteristics of the patch antenna are easily accessed from this graph. The graph can be customised using the settings panels available using the buttons on the toolbar to the very left of the window.

4.7 Closing remarks

A rectangular, pin fed, patch antenna on a finite sized dielectric substrate is simulated. The real and imaginary parts of the input impedance are plotted versus frequency in the band of interest.

The geometry is drawn entirely in CADFEKO. Three key steps are the setting of the region properties for the substrate, setting the label of the feed segment and setting the local mesh properties along two of the edges.

The model control script is specified using the EDITFEKO user interface. The mesh is imported, a scale factor specified, substrate properties set, excitation specified and output requested.

The results are visualised using the POSTFEKO user interface.

5 Getting started example 3: EMC coupling Example

5.1 Example overview

This example considers the coupling between a typical HF monopole antenna and a loaded transmission line as shown in figure 5-1. Both the antenna and the transmission line consist of wire conductors, which are long compared to their diameters.

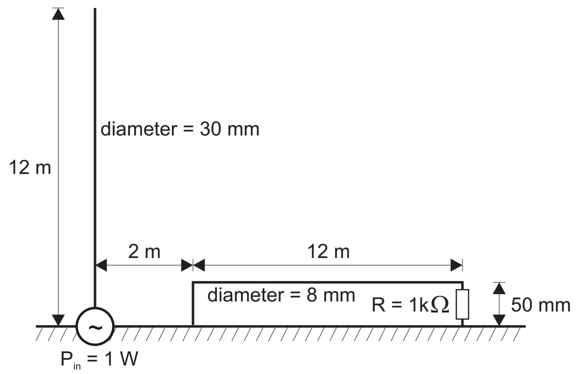


Figure 5-1: Sketch of the model

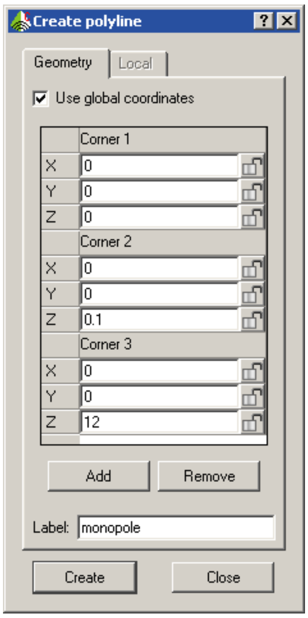
The example illustrates how to use the BO card to simulate a perfectly conducting infinite ground plane. Loading of a segment with a complex impedance will be shown. Working through this example should require about 70 minutes.

5.2 Creation of the geometry in CADFEKO

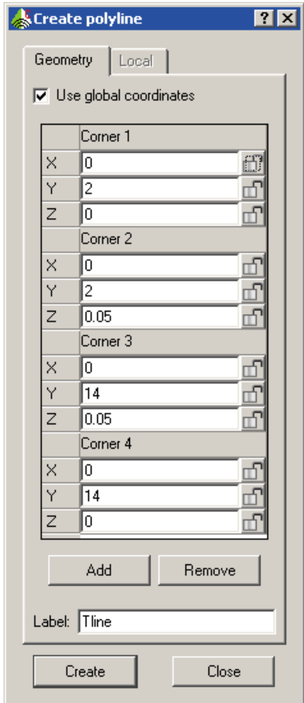
The first step in every FEKO solution is to construct the geometry. The geometry is created by the component CADFEKO and stored in the `*.cfx` file. To start CADFEKO from the Windows *Start* menu, choose
    Programs → *FEKO* → *CADFEKO*
or open a console window and type `cadfeko`.

In contrast to the preceding examples, all dimension related values will be enetered directly in meters.

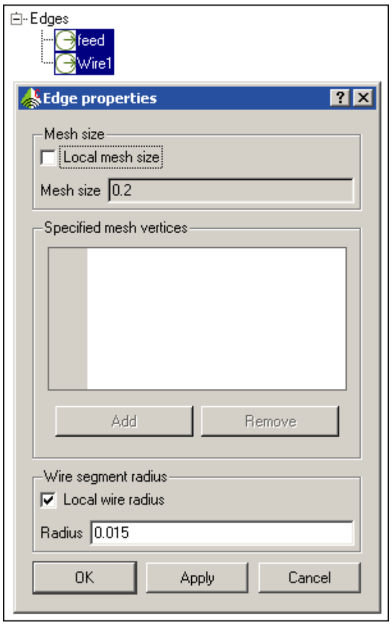
Both the monopole and the transmission line are created using polyline entities. The groundplane is defined as part of the control section in EDITFEKO - this is because the presence of a infinite groundplane changes the formulation used in the solver. The same is true of infinite planar or spherical Green's functions. (See the GF card entry in the user manual for more information regarding the use of this feature.)



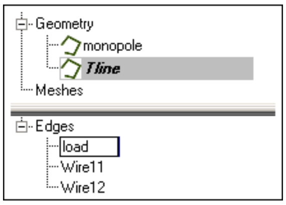
The first step is to draw the monopole along the positive z-axis. Press the *Polyline* button on the geometry creation toolbar. A third point should be added to the polyline, so that a separate feed segment can be created. The feed segment is created as 100mm long - this is more than 3 times the diameter of the wire. If the feed segment is specified too short compared to the diameter of the wire, FEKO will give a warning. More information about this can be found in the *General Comments* section of the user manual. Note the specification of *monopole* as the name for this part. After creating this part, press the *Zoom to extents* button on the toolbar immediately above the 3D view.



The transmission line is created using the same dialog as the monopole creation. The transmission line is created along the y-axis. Note the naming of the polyline to *Tline*. Press the *Zoom to extents* button on the toolbar above the 3D view to get the structure to fit inside the 3D view.



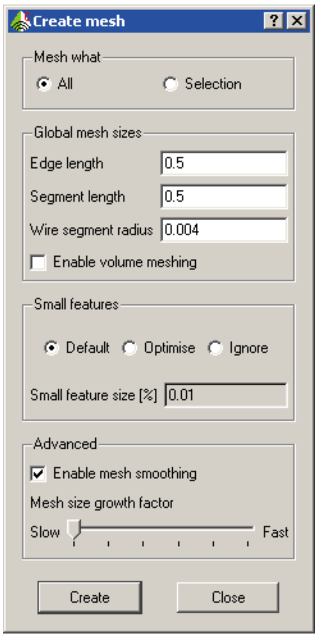
The feed segment of the monopole should be renamed, so that the label of the element can be easily identified to the FEKO solver. Open the *Edges* tree in the detail tree of the monopole. Select the edge corresponding to the feed segment, and press <F2> to change the name to *feed*.
The radius of the two structures (monopole and transmission line are not the same. A global wire radius cannot be used. Select both edges in the detail tree of the monopole. Right click and select *Properties*. On this dialog, the wire radius can be set. Set the radius to 0.015m.



The load segment of the transmission line should be renamed, so that the label of the element can be easily identified to the FEKO solver. Open the *Edges* tree in the detail tree of the transmission line. Select the edge corresponding to the load segment (changing the zoom may be required for this), and press <F2> to change the name to *load*.
The global wire radius will be set at a later stage equal to that of the transmission line (4mm). It is therefore not necessary to set the wire radius for these edges at this stage.

The geometry of the problem is now completely defined. The next step is to create a mesh for the structure. It is advisable to save the example at this point.

5.3 Mesh creation



The global edge length is set to 0.5m. This mesh size is quite fine, considering that the highest frequency of the solution will be 30 MHz - or a wavelength of 10m. In this case, resources will not be a problem, so over discretisation is not a problem. The global wire radius is set to that of the transmission line - 4mm. The wire diameter for the monopole is set locally and will override this value.

At this stage, the geometry is completely defined and meshed. The only further requirement is the model solution control script. Save the model before continuing.

5.4 Setting the solution control

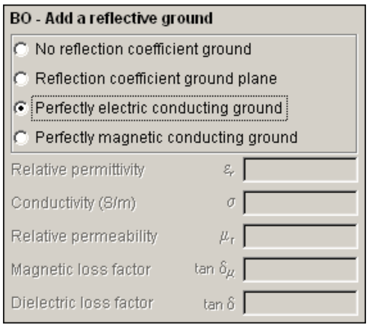
The next step in the simulation procedure is to set the model parameters, such as frequency range, excitation and required observables. Parameters are set using the EDITFEKO user interface. In this example, adaptive (continuous) frequency sampling will be used, and the currents on the structure will be extracted.

EDITFEKO can be launched directly from the CADFEKO user interface. Select *Run* → *EDITFEKO* from the menu bar to launch the user interface.

As described in the first example, the model control is specified using a series of sequential commands. The first two characters of each line specify the command, and the parameters are set in the configuration panel on the left. To open the configuration panel for a specific command, place the cursor on the same line as the command, and press <F1>.

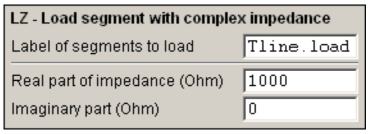
The first line of the standard control file starts with two asterisks. This means that this line is not a command, rather a comment. Anything after the two asterisks is ignored by FEKO.

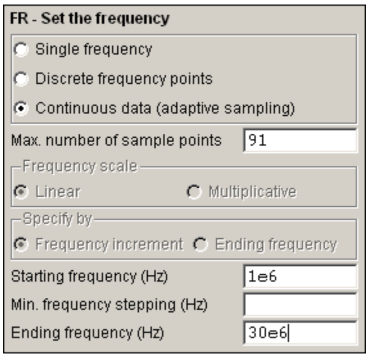
The first command in the standard file is the IN command. This command instructs the solver to extract the mesh information from the CADFEKO output. This command can be left in the default configuration for this example.



The first command that should be added is the BO command. This command instructs the solver to place a reflective ground at the $z = 0$ plane. Place the cursor on the line below the EG command and press the BO button on the panel on the left. Select the *Perfectly electric conducting ground*option.

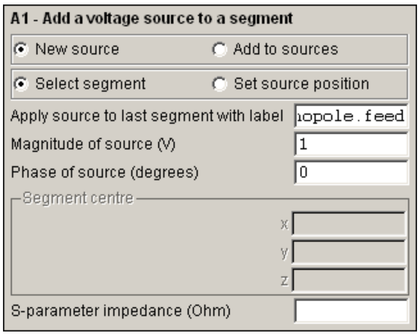
The next command is the LZ command, which is used to specify the load on the terminating segment of the transmission line. Place the cursor on the line below the BO command and press the LZ button on the panel on the left. Specify the *Tline.load* label, and a real impedance of 1000 Ohms.

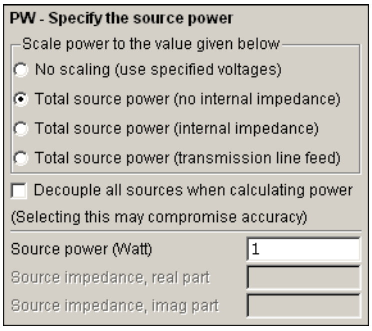




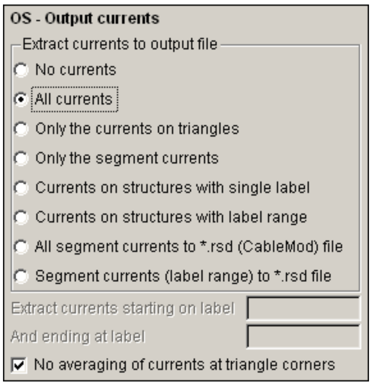
The existing FR command should be edited to set the frequency range for the simulation. Position the cursor on the line containing the FR command and press <F1> to edit this command. Continuous frequency sampling should be used, with a maximum of 91 frequency samples between 1 MHz and 30 MHz.

The excitation is set using the A1 command. Position the cursor below the *** Set source* comment, and press the A1 button on the left side of the screen. This opens the dialog to edit the A1 command. The label for the feed segment should be set to *monopole.feed*. The radiated power will be controlled with another command, so any value of voltage can be used in this command. A setting of 1 is typically used.





The second last command used in this example is the PW command. It instructs the FEKO solver to scale the amount of radiated power. Position the cursor below the *** Solution control* comment, and press the PW button on the left. Select the *Total source power (no internal impedance)* option. (More information on the difference between these power specification options can be found in the user manual.) Set the total value for the power to 1W.



The last command required in this example is the OS command. This command instructs the FEKO solver to calculate the currents along the wires, and save this solution in the FEKO output. Select the *All currents* option on this dialog.

The solution control script is now complete. The file should look as follows:

```
** PREFEKO input file generated by CADFEKO
** Import model
IN   8 31  "coupling.cfm"
** End of geometry
EG   1    0    0         0
BO   2
LZ: Tline.load :  :  :  :  : 1000 : 0
** Set frequency
FR   91   2                   1e6                 30e6
** Set source
A1: 0 : monopole.feed :  :  :  : 1 : 0
** Solution control
PW   1    0                   1
OS   1         1
** End of file
EN
** CADFEKO Checksum: eb9165c1df57b096f2cd094bfd25f236
```

5.5 Obtaining a solution

The model input has been prepared, and the FEKO solver should be executed to produce the requested output (current along the wire).

To launch the solver from EDITFEKO, select *Run* → *FEKO* from the menu bar. The preprocessor, PREFEKO, will be launched automatically.

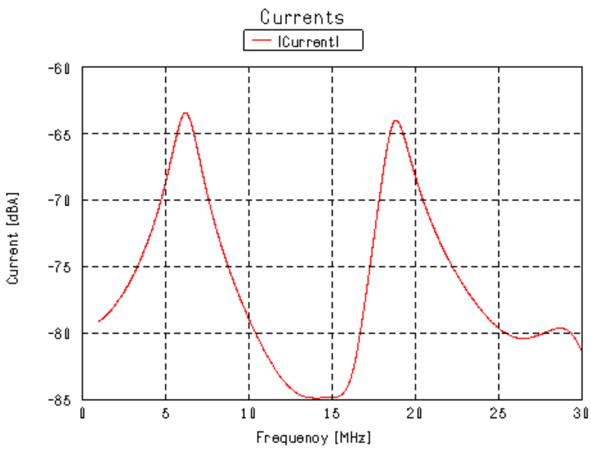
The solver requires 40 frequency samples and a maximum memory usage of around 70 kByte.

5.6 Visualisation of results

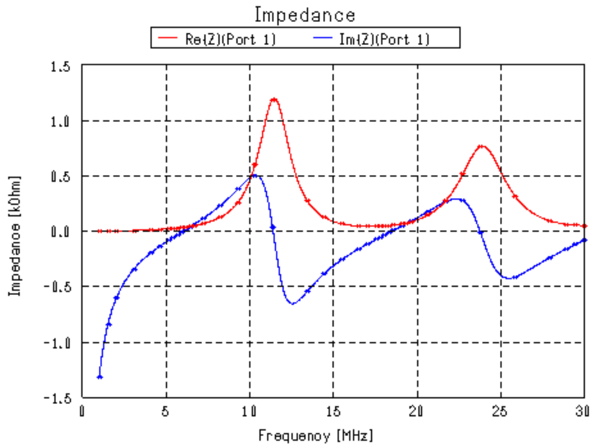
At this stage, the entire model has been set up and solved. The only remaining step is to visualise the result.

Result visualisation is done in POSTFEKO. POSTFEKO can be launched from EDITFEKO by selecting *Run* → *POSTFEKO* from the menu bar. A POSTFEKO window will open, showing the geometry in the 3D view. To show a graph of the current in the load on the transmission line, select the *Add a currents and charges graph* button on the toolbar above the 3D view. From the configuration panel on the left, the *Use continuous frequency* check box should be selected. The *Tline.load* label should be selected in the *Label* group box. Note that there is only one segment on this label. If multiple segments were present on the label, the target segment would need to be identified in the 3D view. See *Picking* in the POSTFEKO section of the user manual for more information.

Select the *Left axis* button to open a configuration panel to change that axis' setting. Change the scaling to dB.



The steps shown in the second example for plotting of input impedance can be repeated in this example to show the input impedance for the monopole.



5.7 Closing remarks

This example has shown the set up and solution of an EMC coupling problem. The problem description is of a monopole antenna and transmission line on an infinite perfectly electrically conducting ground plane. Coupling of current into the transmission line is shown from 1 MHz to 30 MHz.

This example used a special formulation for the consideration of the infinite ground plane. This formulation is activated from the solution control script.

6 More examples

This ends the getting started examples for FEKO. During installation, a number of examples have been copied to the directory `examples` under the FEKO home directory. These are described in the *Examples Guide*.

You will need to run PREFEKO before you can view the geometry as no `*.fek` files are included in the installation. The FEKO solver will need to be run before any results can be visualised, since no `*.bof` files or `*.out` files are included in the installation.

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