ICHA - interharmonics

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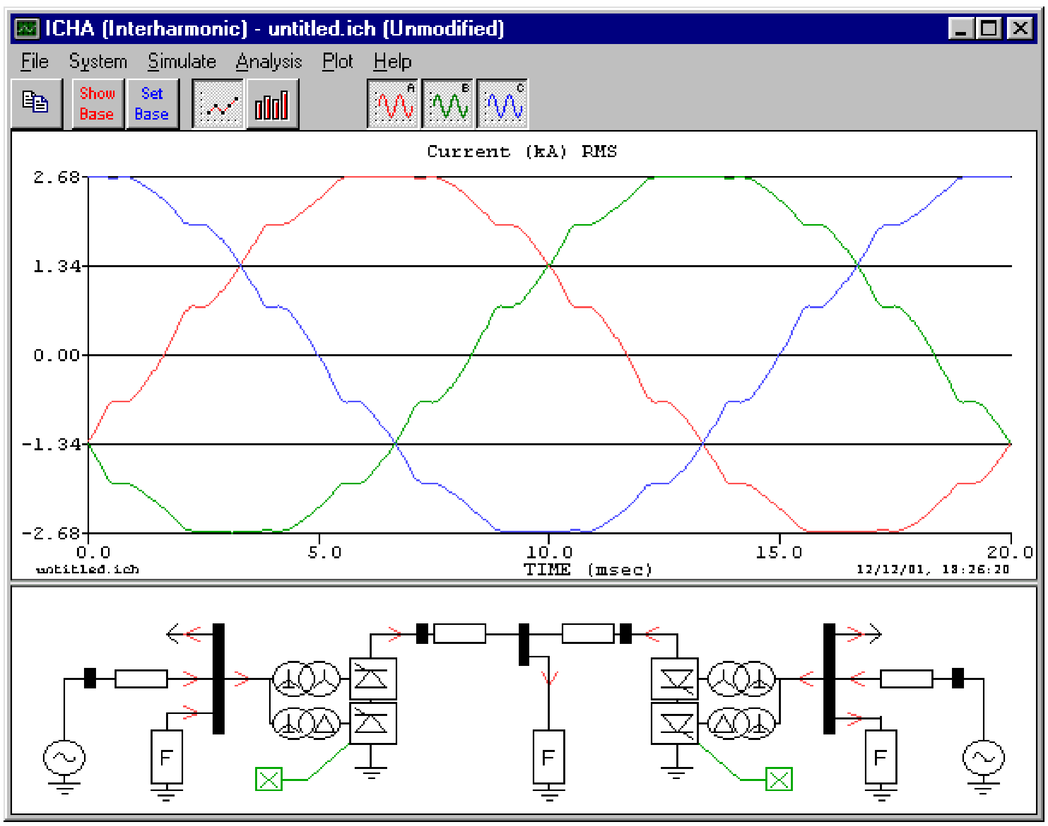

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Note:
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Introduction to ICHA

What is ICHA

ICHA stands for Interactive Converter Harmonic Analysis. The philosophy is to provide a simple real time interface to accurate harmonic solutions of ac-dc converter systems.

The basic converter unit is a 6-pulse three-phase bridge that can be connected with other converter bridges and system components in any particular pre-specified configuration. When the solution solves, it takes all the ac and dc harmonic voltages and currents and combines them into a single unified Newton solution similar to a loadflow.

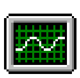
The result is a powerful, fast and very accurate frequency domain method provided in a simple to use interface.

A note on the solution process

The Harmonic Domain solution methodology is probably the most advanced algorithm of its kind. While very powerful it also requires some care in its use as it can in extreme circumstances give incorrect results or will “diverge”. The divergence of a solution does not mean a harmonic instability or that there is no solution even though there have been some who claim this is so. These supposed instabilities have been verified as normal operating points both with time domain solutions and more advanced methods such as these. There are a number of possibilities to improve the convergence of a given system by avoiding dangerous *numerical* oscillations. However to keep the introduction just that these are described in greater detail in later sections, it is just useful to keep this in mind.

The first simulation

Running the simulation

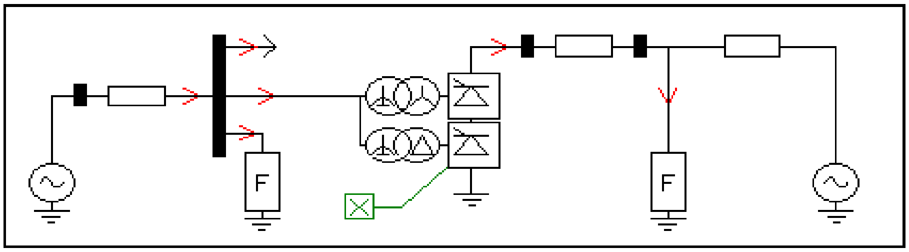


ICHA INT

Start ICHA by double clicking on the start button, which may be a short cut on your desktop, or by double clicking on icha_int.exe.

The initial configuration shows an HVdc rectifier; a 12-pulse converter in parallel on the ac side and in series on the dc side. The dc system has a smoothing reactor, filter and thevenin voltage source. This is a representation of half the CIGRE HVdc benchmark system.

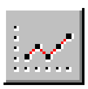
Press the **Simulate** button on the toolbar, a dialog box will appear showing information on the solution process; ignore this for the time being. When the dialog box disappears, the simulation has been completed.



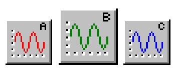
The vertical thick black lines are the ac and dc busbars, left-clicking on these will display the busbar voltages. The red arrows are current measurements and will display the corresponding measurement in the direction shown. Left-clicking on the other components will display dialog boxes with the related simulation data.

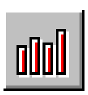
Viewing the simulation results

The simulation results are displayed in three different ways, time domain, frequency domain and summary information. Busbar voltages and branch currents can be displayed by clicking on the current arrows and busbars shown in the system graphic above. Summary information on the loadflow and some harmonic indices (TIF and THD) can be found under the **Analysis** toolbar.

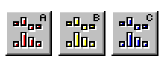


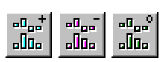
Time Domain

 Time domain information in phase components



Frequency Domain

 Harmonic information in phase components

 Harmonic information in sequence components

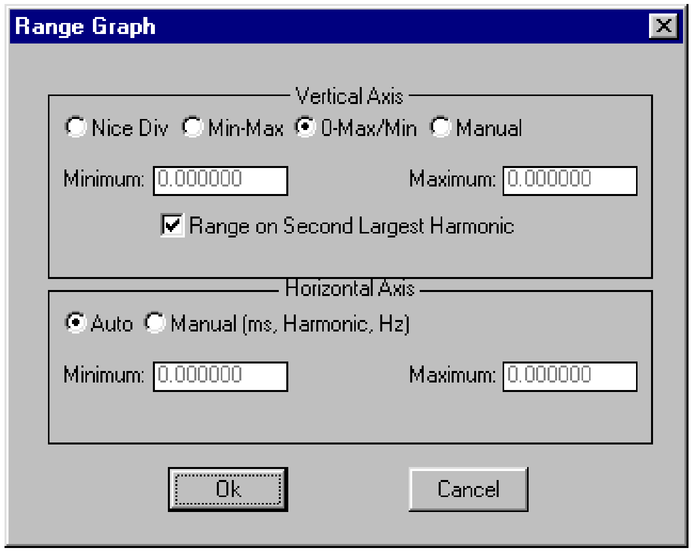
For the frequency domain plots only one quantity can be displayed at one time. For the time domain plots all three phases can be shown at once. Individual phases can be added or removed by clicking the respective phase buttons. The frequency domain style shows the harmonics in polar co-ordinates with the RMS magnitude as the main bottom graph and the angle in degrees as the smaller top graph.

If a harmonic bar is coloured black then its value is greater than then chosen range.

Changing the plot configuration

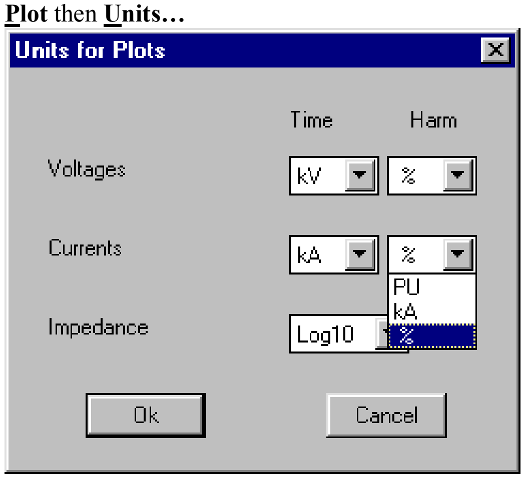
Once a measurement has been selected and displayed the **Plot** menu becomes available on the toolbar. The Y-range of the graphs can be modified as well as the units and additional display information. The options available are shown below with relevant descriptions. First display a measurement by left-clicking on a measurement within the circuit. To change the zoom of the plot:

Plot then **Y Range…**



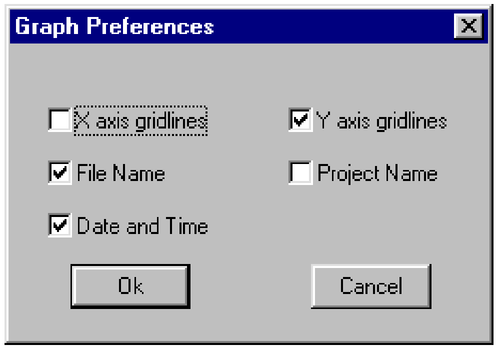
The plots default to automatically ranging between the maximum and minimum values of the displayed information, although for the dc voltage and current this is between zero and the maximum absolute value (0-Max/Min). The Y Range can be manually specified as well. The **Range on Second Largest Harmonic** checkbox is for harmonic bar plots to zoom in on the harmonic frequencies avoiding the power frequency or dc term. It will automatically scale the Y-axis to the second largest harmonic component. This can cause problems for filters or when the largest component is not the power frequency or dc.

Plot then **Units…**



The plots can be shown in different units depending upon what measurement is being shown and in what style. The harmonics are always as RMS phasers and the percentage units are based upon the calculated power frequency component. For sequence component terms this is taken as the positive sequence power term and for dc measurements as the dc term. An impedance plot can have the Y-axis in either linear or base-10 logarithmic.

Plot then **Preferences…**



The **File Name** does not include the full path statement and the **Project Name** is specified the system dialog box by selecting **System** then **General** from the toolbar.

Copying the plot to the clipboard

Once the plot has been modified as desired it can be copied to the Windows clipboard by selecting **Plot** then **Copy**. The picture can then be "pasted" into any Windows package that supports the clipboard functions by Ctrl-V or similar function. The figure will copy exactly as shown in ICHA; no notification shows that the copy has been performed.

Writing the selected data to a file

The simulated data can also be output in a column-wise ASCII format data file. Only the information displayed on the plot will be output including any base case information. To write out a file, select **Plot** and then **Write**. You will be prompted for a file name for the data file and then it will attempt to write the file. If there is another file with the same name it will be over-written. A message will appear indicating whether the file was successfully written or not. The program will automatically append the **.dat** extension unless there is a user specified extension.

The file format is as shown below:

```
% System Title:CIGRE HVdc Benchmark system (Rectifier)
% DATE :-  4 JULY,      2000                TIME :-  7:44 PM
% Measurement=Converter I , Type=Current (kA)
%
   0.00004   -1.20431   -1.28071
   0.00008   -1.16501   -1.23765
   0.00012   -1.12525   -1.19439
   0.00016   -1.08412   -1.15033
   0.00020   -1.04070   -1.10461
```

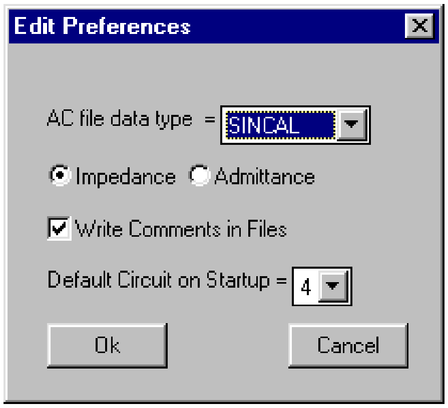
The data columns depend upon the displayed plot and are described in the following. The time domain waveforms consist of 512 points so an FFT can be easily applied in an external program.

Time Waveforms
The first column is always the time reference in seconds. The chosen simulation phases come next in ascending order (A, B, C) and are in the shown units. Finally the base case information (if shown) comes in an identical fashion.

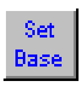
Harmonics
The first column is always the harmonic order. The chosen phase comes next with the RMS magnitude then phase angle in degrees, the base case (if shown) follows in the same format

Impedance curves
The first column is always the frequency in Hz. The chosen impedances come next as magnitudes in ohms. Later updates will also output the phase angle of the impedance or the R-X values.

The file comments in the header can be turned on or off by selecting **File** then **Preferences**. This also is where the input file preferences are for when loading externally calculated frequency dependent ac impedances.



Setting a base case and modifying the case



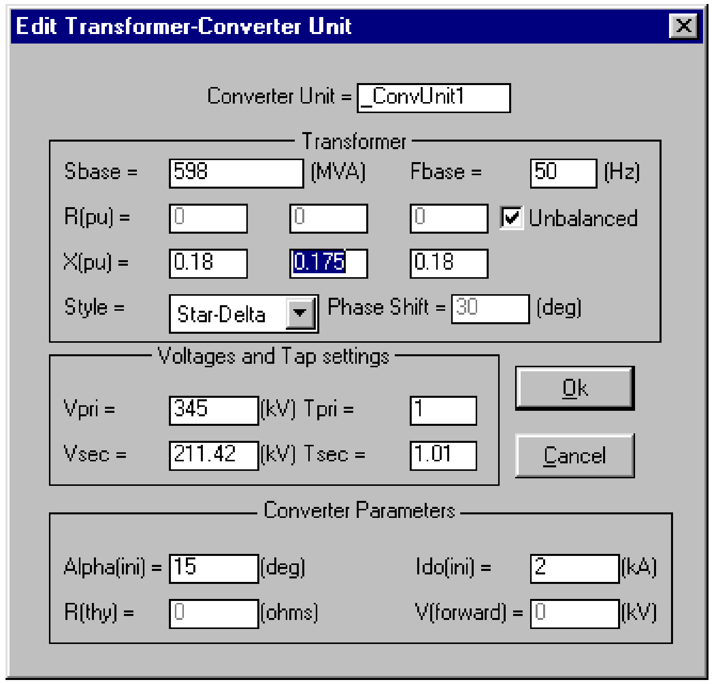
Set Base

Show Base

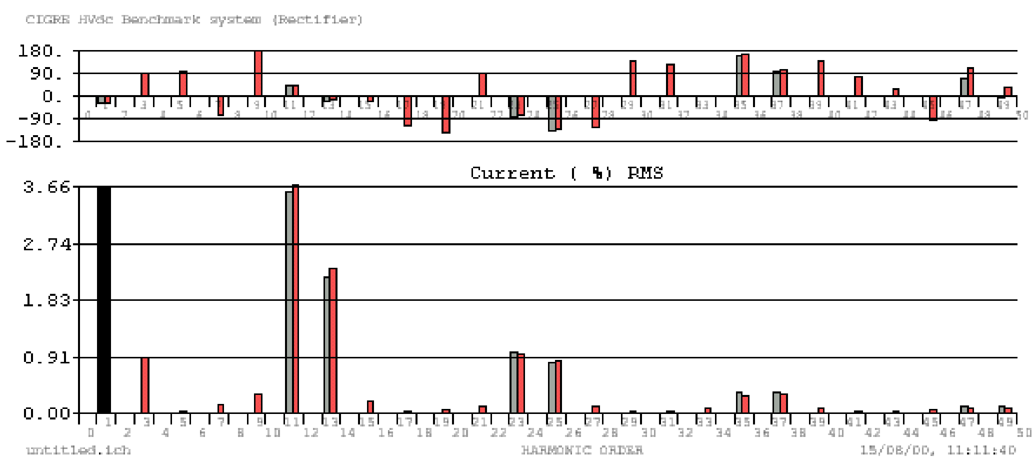
Often it is desirable to see the difference that a particular modification makes to the system under investigation. Simulate the case chosen as base and then press the **Set Base** button to store the results (Note: All results simulated thus far are saved). The **Show Base** button will automatically depress and the base case will be shown along with the current case. To remove the base case press the **Show Base** button again, these results will remain stored until either a new base case is set, a new converter configuration is chosen, or the program is terminated.

Different converter configurations can be obtained by selecting **File** then **New** and then choosing one of the shown cases.

To modify the case displayed, simply click on the component that is to be modified. A dialog box will then appear with the relevant information on the chosen component. An example for a default transformer-converter unit is shown below

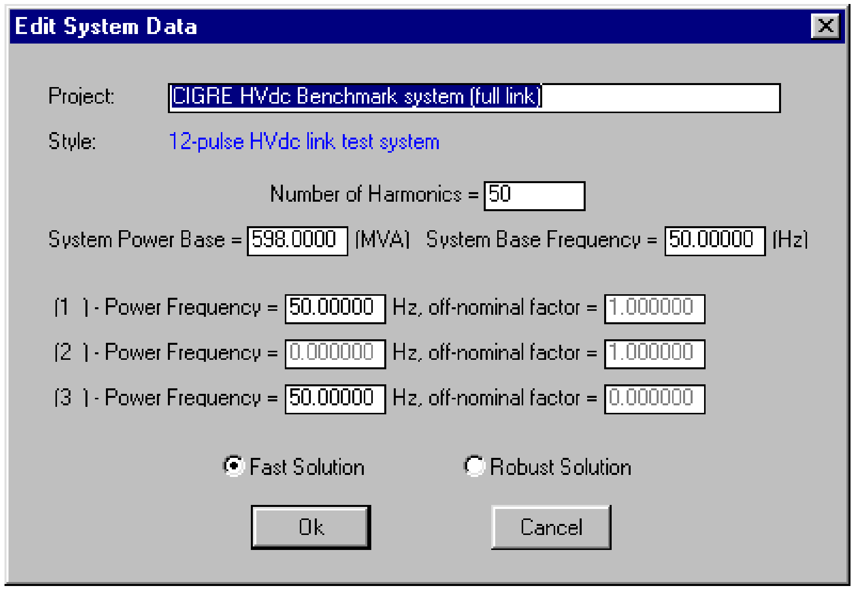


As an example, the standard HVdc rectifier star-delta transformer has been modified as shown above. First the **Unbalanced** box was checked and then the phase B reactance reduced from 0.18 to 0.175 per-unit. The figure below shows the 12-pulse converter currents injected into the PCC with the unmodified balanced base case shown in grey. This figure was created using the previously described **Copy** function.



Set the Project Name and common system information

To set the Project Name select **System** then **General** from the toolbar, this will display the following dialog box.

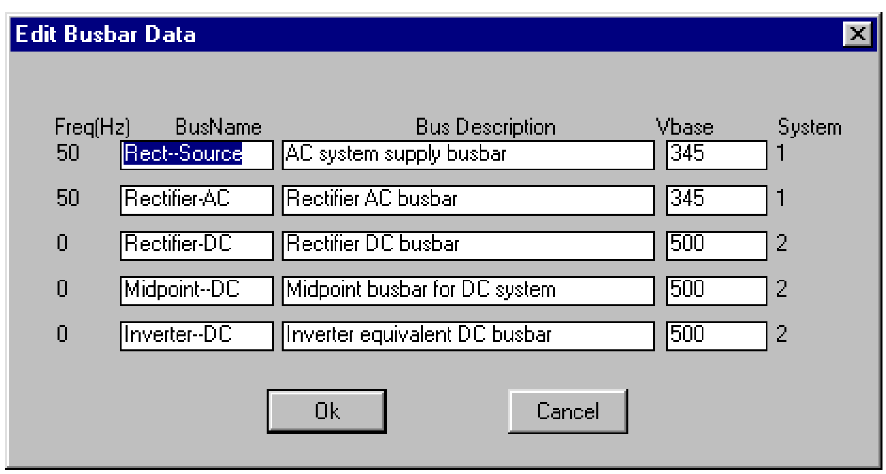


The inter-harmonic solution has been enabled in this release.

At present the number of harmonics is limited to a maximum of 500, specifically for inter-harmonic analysis, and the lowest base frequency is 1Hz. The actual limitation is the ratio between the power frequency and the base frequency; this is limited to 50. The number of harmonics can be set to any desired value but the user should ensure that the dominant harmonics are included in the frequency range for reasonable results.

If a particular case has divergence problems due to suspected high harmonic distortion, the **Robust Solution** should be chosen. This slows the solution method to minimise the risk of numerical oscillation, however this will not always guarantee a solution. The **Expert…** button displays another dialog box with more powerful solution controls; these will be explained in later sections.

Setting Busbar parameters



The ac voltage base is line-to-line voltage base, which is typically the nominal line-to-line RMS voltage. The dc voltage base is the nominal voltage from negative dc rail, or ground, to the positive rail. Both bases are not critical for accurate simulation as they are just for conditioning the numerical solution.

Saving and opening cases

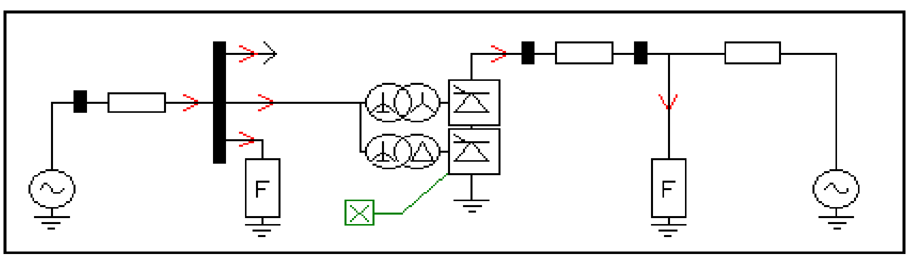
Once a case has been modified it is often desirable to save it for future reference or quality assurance. To do this, select **File** then if a new case **Save As**, you will then be prompted for a file name. The program will automatically append the **.ich** extension unless there is a user specified extension. Once the file name has been specified you will only need to select **File** then **Save** unless a new file name is wanted. To re-load a saved case select **File**, **Open** and then find and choose the desired file.

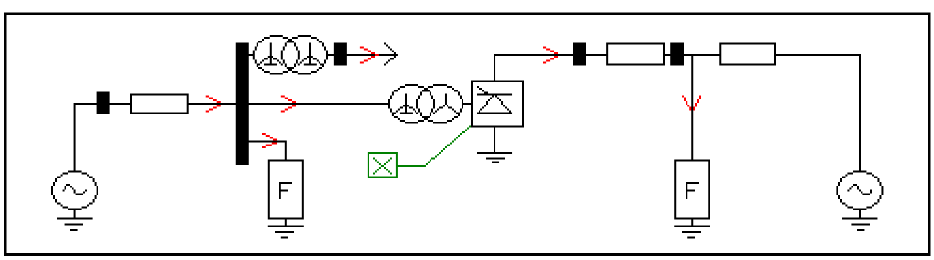
Some of the display parameters do not get saved in this file, but are either initialised to default settings upon program start up or are remembered between program runs. Also, saving a case will only save the system information and not the simulated results, thus it will be necessary to re-solve the case once it is re-opened.

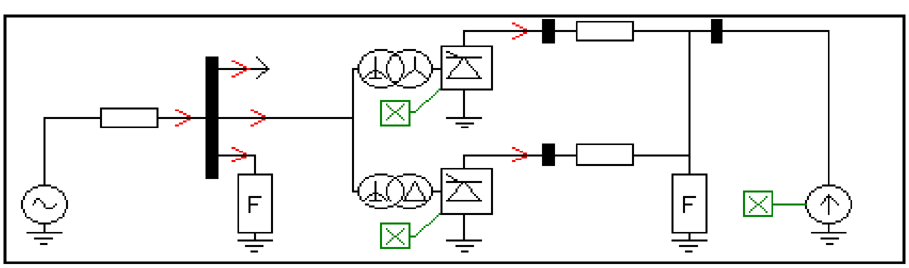
If you have been having problems with a particular simulation and would like assistance with diagnosis, then send this ***.ich** file to the email address shown in **Help** then **About**, and we will try to assist.

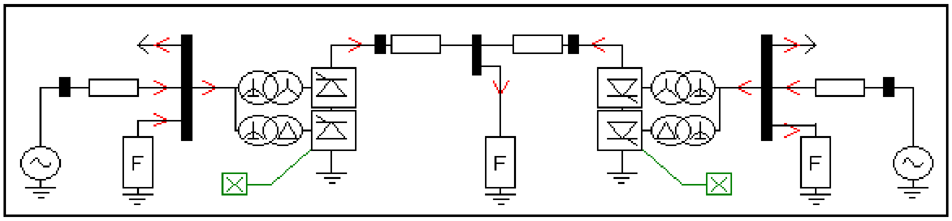
Loading a new simulation style

To setup a new system configuration, select **File** then **New** from the toolbar. This will show a list of the built-in available configurations and an option at the bottom called **External**. This option allows the user to load additional styles from ***.sty** files which are either supplied by the developers or as saved by the user. For example the user can save a predetermined configuration with their own values. This can be done by saving normally but adding the extension **.sty** instead of the automatic **.ich** ending. The standard built in styles are shown below, additional styles can be requested from the developers for little extra cost provided that they are feasible.



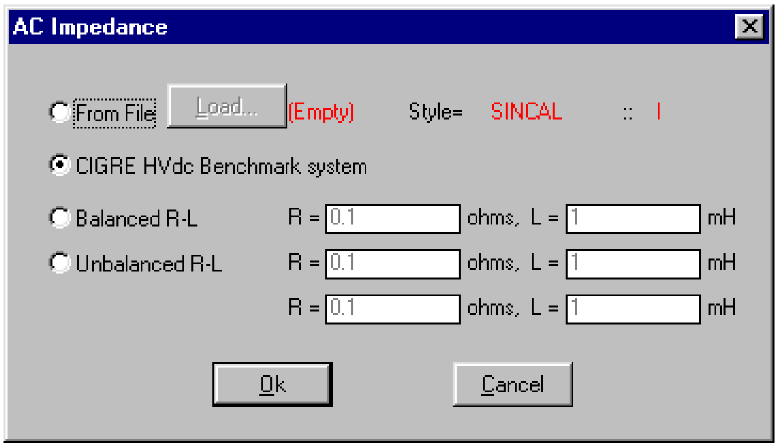






Loading an external ac system datafile

It is possible to load in an externally specified frequency dependent ac system impedance/admittance from a data file. To do this, click on the ac impedance in the system graphic and the following dialog box will be displayed.



Select the **From File** radio button and then press the **Load** button. The external file format presently selected is the **SINCAL** format in impedance form (**I**). This format style is specified in **File**, **Preferences** and will be remembered between program runs.

If the case is saved, then the loaded ac system information will also be saved in the ICHA data file. When the case is re-loaded, the external ac system file will not need to be reloaded.

At present there are only two available input data file formats although if another user specified format is wanted this can be easily arranged. The ac system file can be loaded either as an impedance or and admittance and so this must be specified.

SINCAL data format

- first 10 lines are comments
- solved frequencies: Freq, R, X, Abs(Z), Angle(Z)
- blank line
- summary of series and parallel resonances

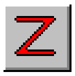
The file load searches for the harmonic frequencies of the power frequency and loads these only. If they are not in the data file or there are not enough data points then an error message will be displayed.

SIMPLE data format

- No header lines
- Solved frequencies: Freq, R, X.
- Blank line

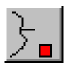
This file load only loads the required harmonic frequencies. This file is usually generated by calculating the terms in a spreadsheet such as Excel and then saving the file as a text file (*.prn).

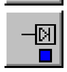
Calculating the harmonic impedance of the converter and system

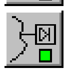


Impedance button

To calculate the effect that the simulated converters have on the ac system, first solve the harmonic system. Then select **Analysis** and then **Impedance**. A dialog box will be displayed showing a number of options, however at present only the displayed case is possible to click on the OK button. A new button will appear on the plotting toolbar, this is the impedance button. A base case can be set, as has been described earlier, which will also now store this impedance information. There are three impedance curves shown which are described below. The Y-range and Units of the graph can be specified in the same fashion as for normal plots although the impedance is available with both linear and Log10 Y-axis.

 - Impedance of ac system, filters and ac load.

 - Impedance of converters by themselves.

 - Impedance of ac system, filters, ac load and converters.

(Note: When saving a base case, it will only save the converter impedance for the base case if an impedance calculation was previously performed)

Errors and other strange occurrences

As the interface between the GUI and the main AHD engine is not fully complete not all of the text error messages from the AHD engine are displayed correctly. Basically, should one of these occurrences happen a white screen will appear on the screen. Do not worry but minimise or close this screen and continue. If the message was only a warning of a potential problem, just check the results carefully and continue. If the message was a fatal error or a solution problem did in fact develop, it is possible that the program will "hang". In this case, please just quit the program, restart it and repeat the simulation. If the problem continues to occur then please send the ".ich" save file to me at: GBathurst@iee.org. I shall then try to find out what the problem is and if it is a solvable case.