MAG2W User's Guide

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MAG2W is a Windows program for designing coils to produce 2D transverse magnetic fields inside circular iron. The program displays the coil configuration graphically and shows the location of the peak field and peak force in the coils. The normal and skew multipoles are listed. It can optionally display the field components on the midplane, force distribution inside the coils, a grid of the magnetic field inside the aperture, magnetic lines of force, or the Fourier components around a reference circle. It also contains a built-in optimizer.

1. Starting the program

The program can be started from a DOS (command) window using the command

C:> mag2w

or

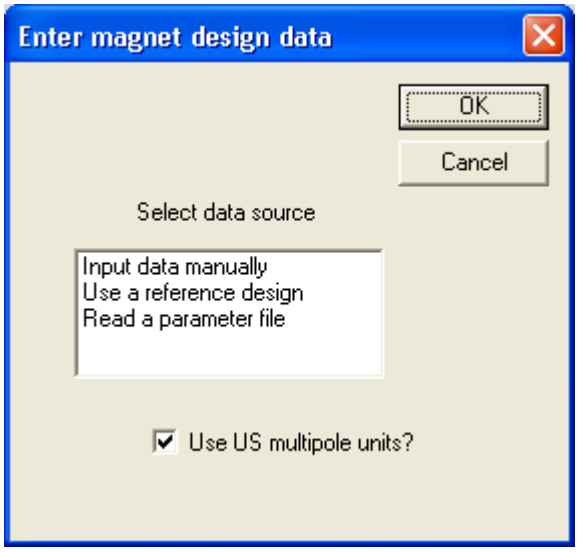
C:> mag2w file.prm

where *file.prm* is the name of an existing parameter file.

The program can also be started by clicking on its Windows icon.

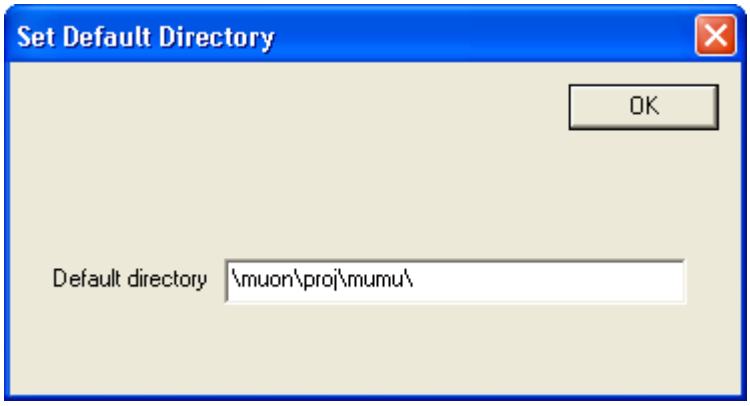
2. Opening screens

The figure shows the opening screen when the program is started without specifying a pre-existing parameter file.



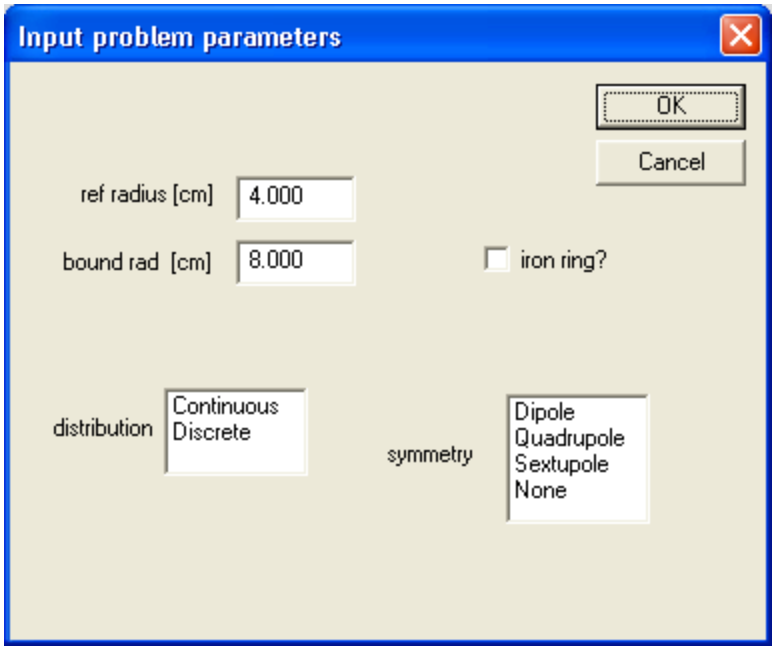
The user can start a problem in three different ways. The user may also choose whether multipoles are labeled in the US or in the European manner (e.g. b_0 is the normal dipole multipole in US units).

The user can set a default directory for reading and writing files by clicking on the File menu and selecting Set Default Directory. This will bring up the following dialog box.



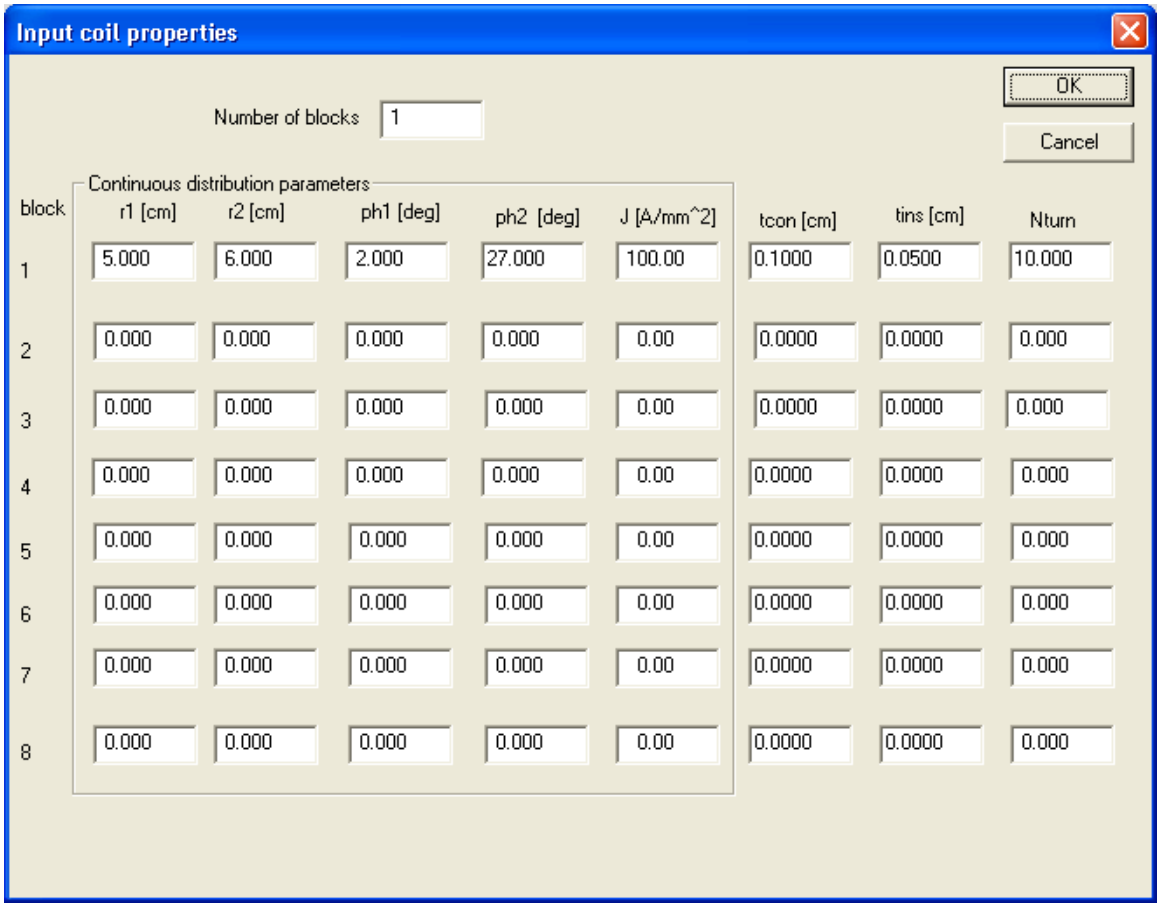
3.1 Entering coil data manually

The first method is to enter the necessary coil data manually. This brings up the window



The reference radius is used for calculating the mutipoles. The boundary radius defines the outer edge of the field grids. It is also the inner radius of the iron if iron is present. The check box on the right determines whether iron is present. The distribution of the current in the coils can either be in continuous blocks or in discrete turns. The symmetry parameter causes duplication of coils defined in the minimum azimuthal sector (e.g. 0-90° for a dipole).

The second input window specifies the actual coil parameters.

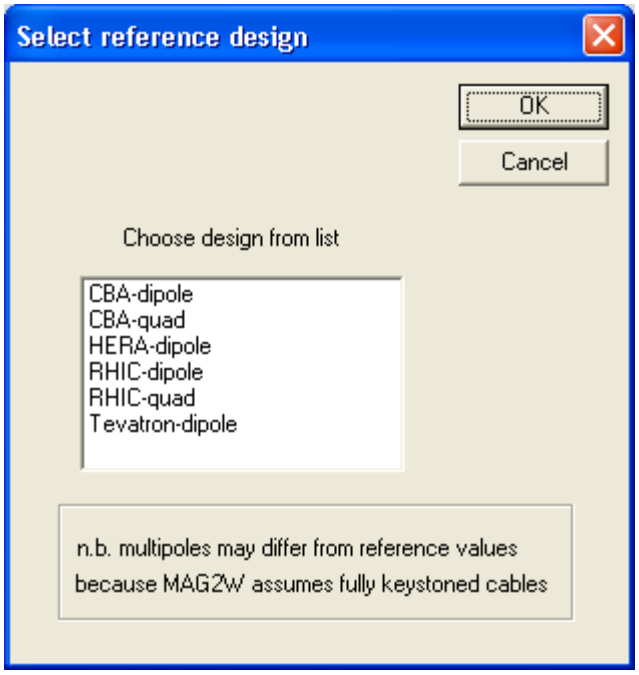


The number of defined coil blocks is given at the top. The user can specify the properties of up to 8 coils using this window. (Up to 16 coils can be defined offline by creating a suitable parameter file.) The first five columns define the quantities needed for continuous current distributions. These are the inner and outer radii, the starting and ending azimuthal angles, and the current density for an annular coil. The last three columns are used for discrete current distributions. These are the thickness of the conductor, the thickness of the insulation, and the number of turns in a coil block.

In discrete mode if all the azimuthal parameters {*ph1*, *ph2*, *tcon*, *tins*, *Nturn*} are given the angle *ph2* may be overwritten if the parameters are not self-consistent. A special tag -999 may be used to specify that a given azimuthal quantity is to be calculated from the other four. Another special tag -990 may be used for the start angle *ph1*of a block to specify that it equal the end angle *ph2* of the previous block.

3.2 Using a reference design

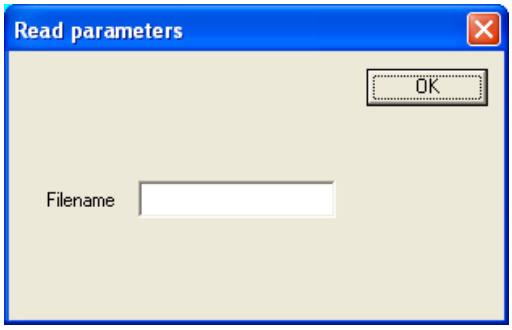
The user may start a design with an existing reference design. This brings up the window



Note that the coil parameters and multipoles that this creates may only be approximate because all of the necessary data is sometimes not readily available and because MAG2W assumes that all coils and are fully keystoned and that all wedges are circular sectors.

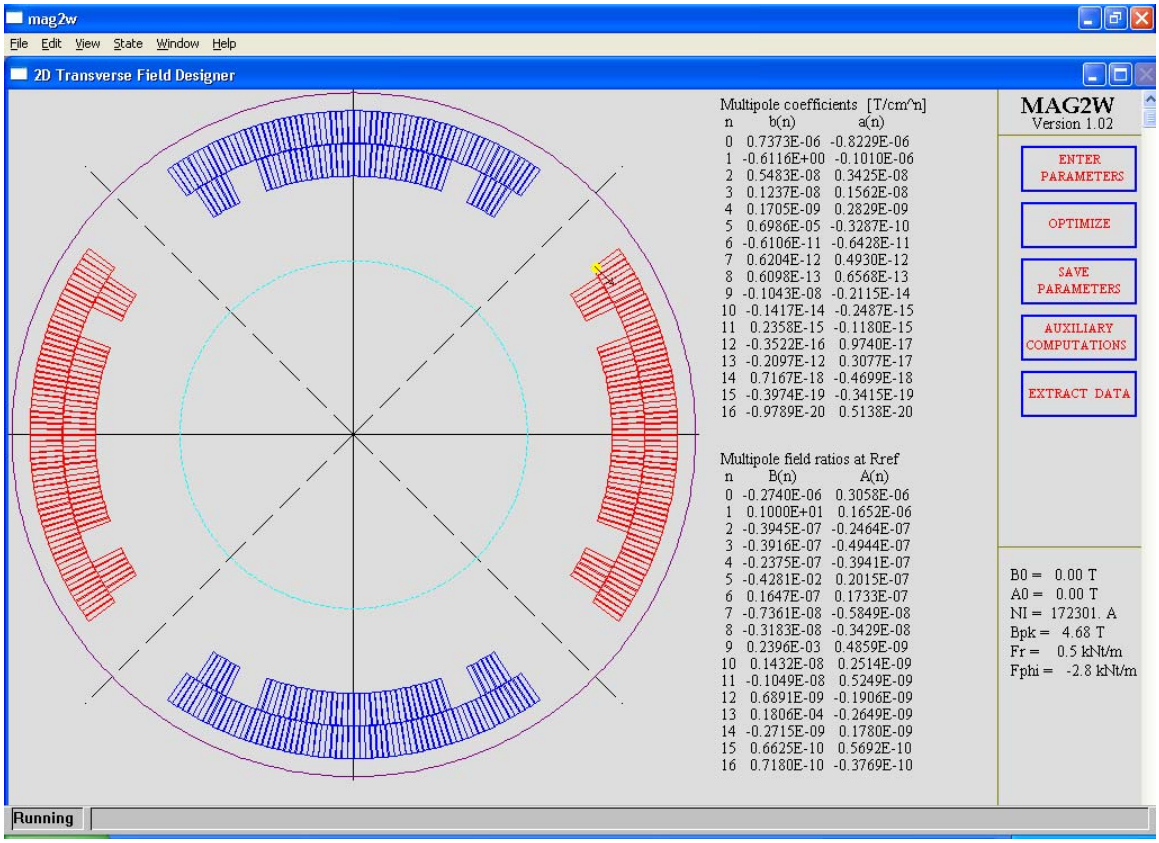
3.3 Reading a parameter file

This command is used to read in a previously saved parameter file.



4. Design screen

After the design has been entered the program displays the magnet design. The large area on the left is used to display the coil geometry, while the multipole information is listed on the right. The area on the lower right is used to display numerical values for some parameters. The buttons on the right side are commands for additional operations.



The graph on the left shows the coil geometry. Coils with positive current are shown in red, while coils with negative current are shown in blue. The purple circle is the boundary, which can indicate the edge of an iron region with infinite permeability. The inner cyan circle is the reference radius. The yellow circle on the coil shows the peak field location. The brown arrow shows the direction and location of the peak force in the coils.

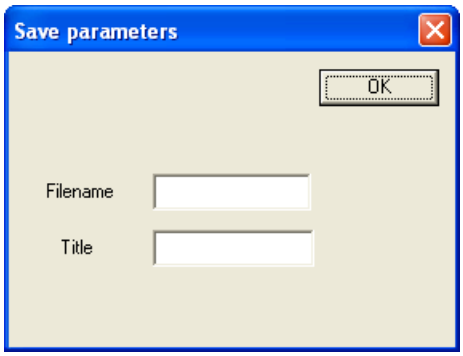
The five buttons on the upper right part of the screen are controlled by clicking with the mouse. ENTER PARAMETERS brings back up the series of windows for the user to change the coil parameters. OPTIMIZE brings up a series of windows for the user to start an optimization study. SAVE PARAMETERS is used to save the parameters for a design to a file. AUXILIARY COMPUTATIONS brings up additional calculations of the midplane field, the magnetic field grid, the force distribution inside the coils, magnetic lines of force, or Fourier components around the reference circle. EXTRACT DATA creates external ascii files of selected information, such as the geometry or field data for a design.

The lower right hand box displays:

B0	normal dipole multipole at the center of the circle
A0	skew dipole multipole at the center of the circle
NI	amp-turns in the minimum symmetry sector (0-90° for a dipole)
Bpk	peak field in coils
Fr	radial component of peak force
Fphi	azimuthal component of peak force

5. Save parameters

This command is used to save the parameters for the current design.



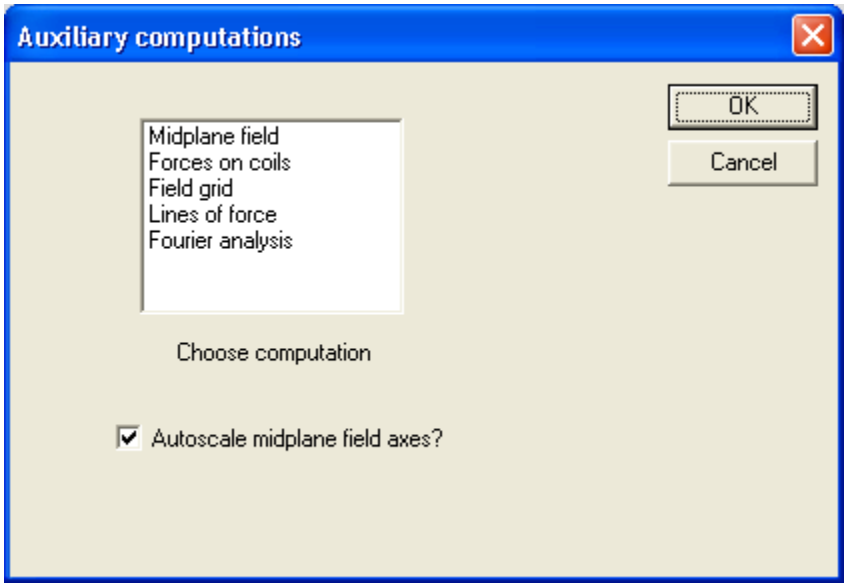
Besides the name of the file the user can enter some descriptive information as the title.

The format of the parameter file is:

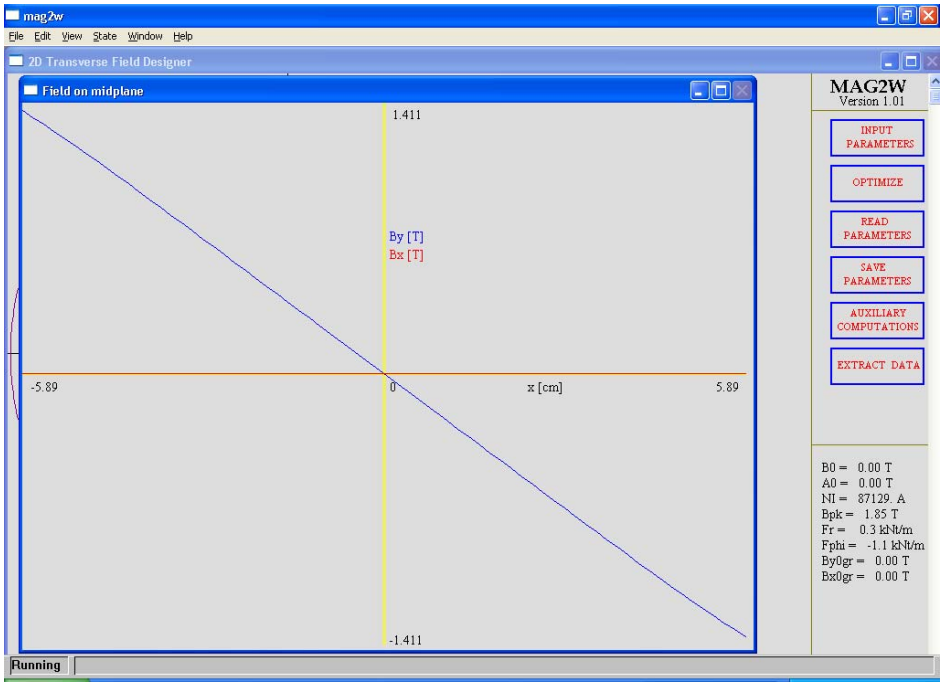
Title	(a80)					
Mode	(I)	1: continuous	2:discrete			
Symm	(I)	1:dipole	2:quad	3:sextupole	4:none	
Iron?	(L)					
Rbnd	(R)					
Rref	(R)					
nblocks	(I)					
For i=1,nblocks						
i	r1(i)	r2(i)	ph1(i)	ph2(i)	J(i)	tc(i)	ti(i)	Nt(i)

6. Auxiliary Computations

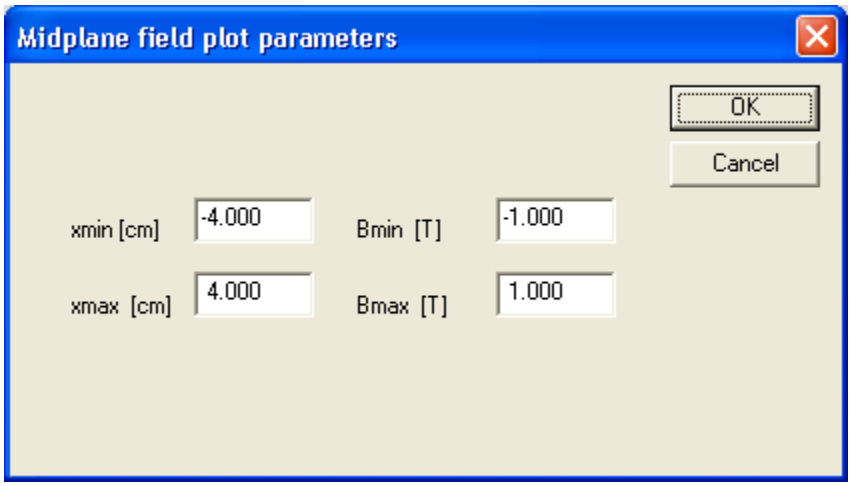
The AUXILIARY COMPUTATIONS button brings up a new window where the user may select additional calculations of the midplane field, the magnetic field grid, the force distribution inside the coils, magnetic lines of force, or Fourier components on the reference circle.



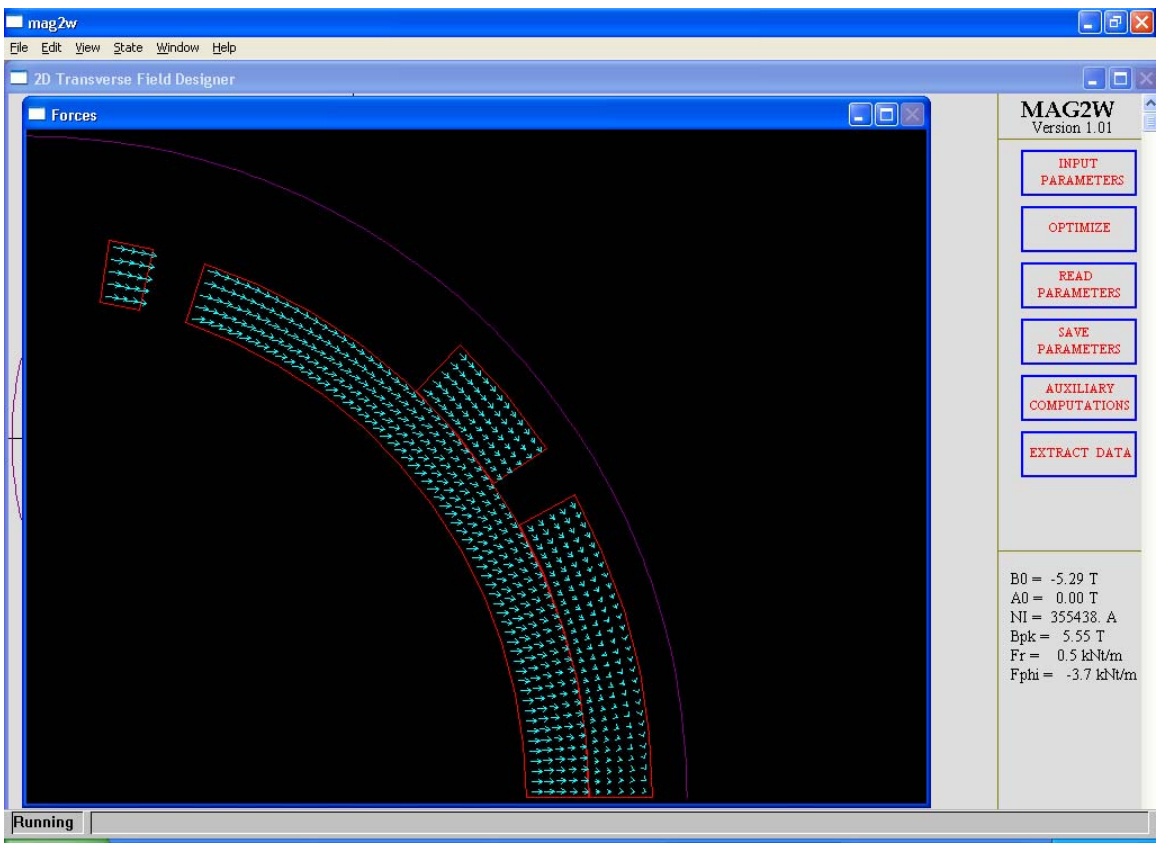
The user must select one of the items in the list and press OK. Here is an example of the midplane field plot for a quadrupole.



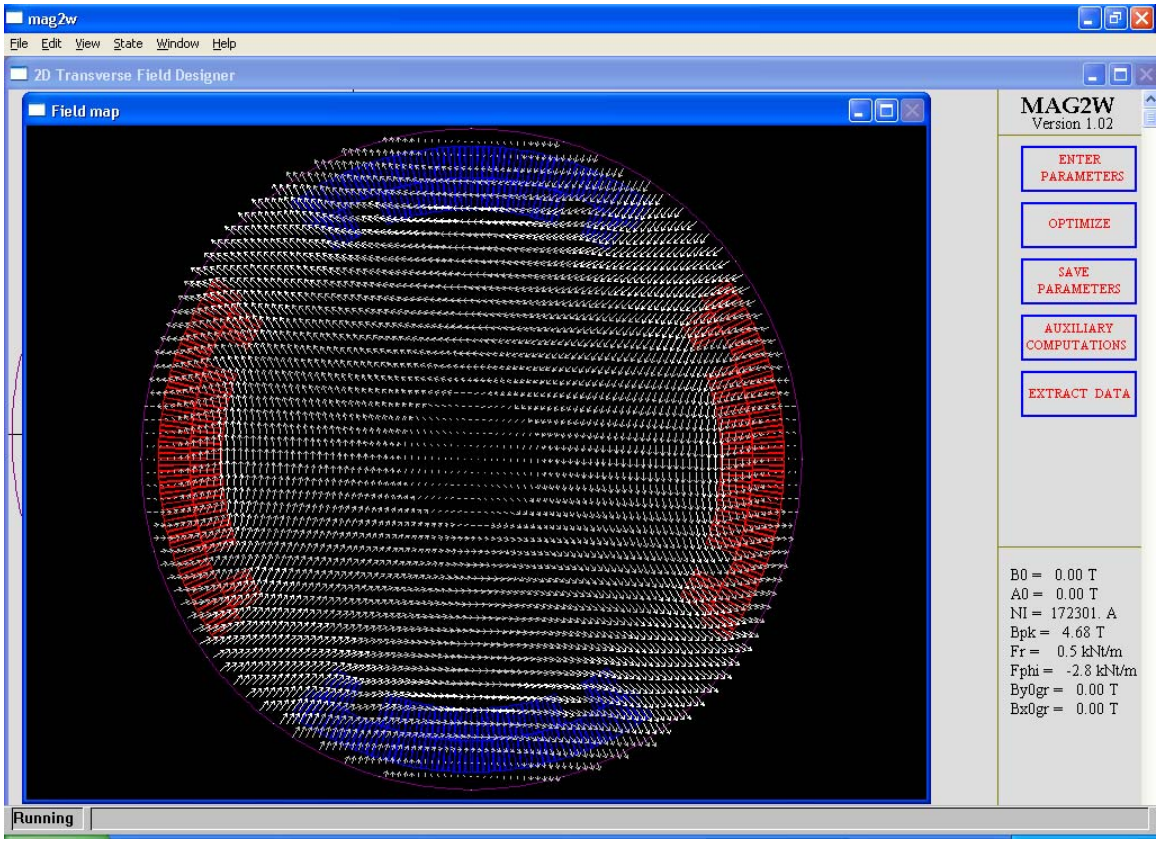
If the Autoscale Midplane box is not checked, a new window appears for the user to enter the axis limits.



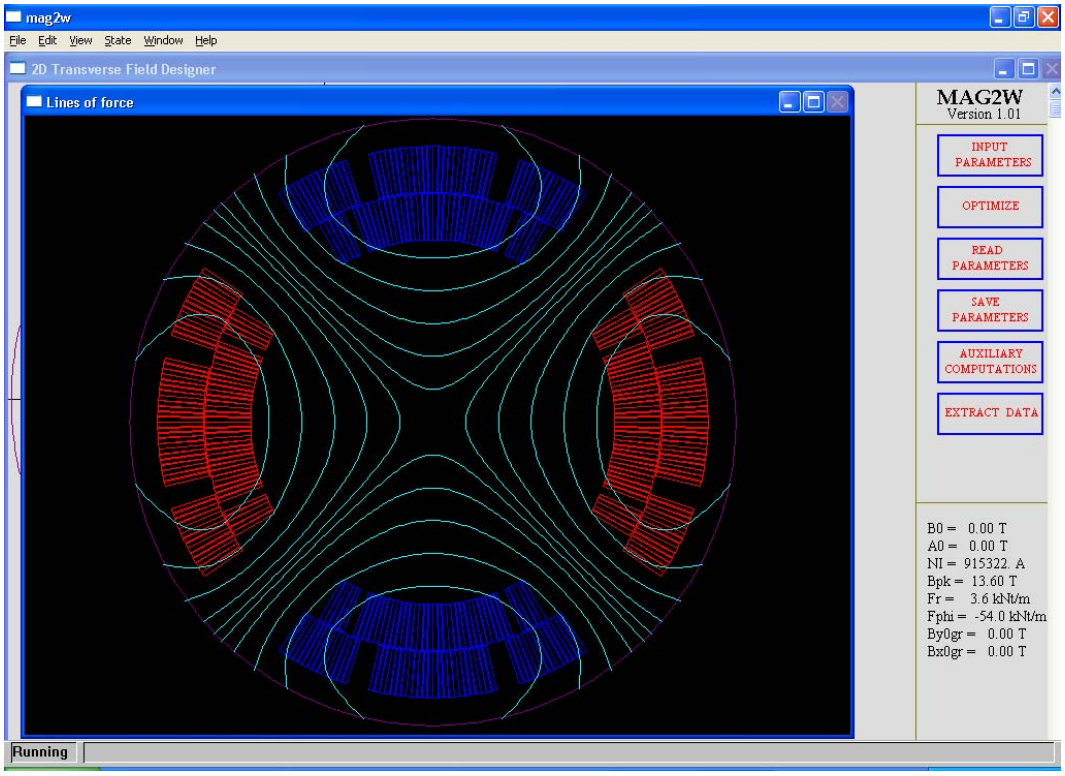
Here is an example of forces on the coil.



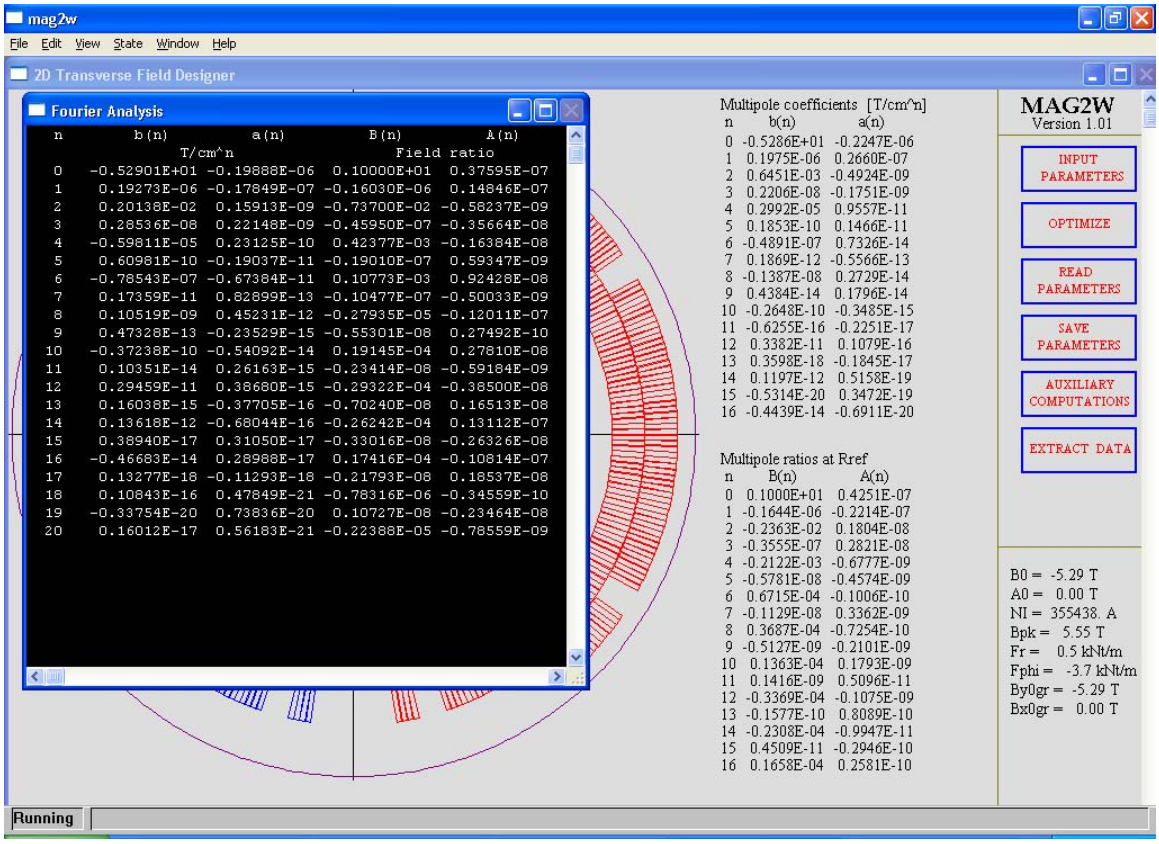
Here is an example of a magnetic field grid plot.



Here is an example of a lines-of-force plot.



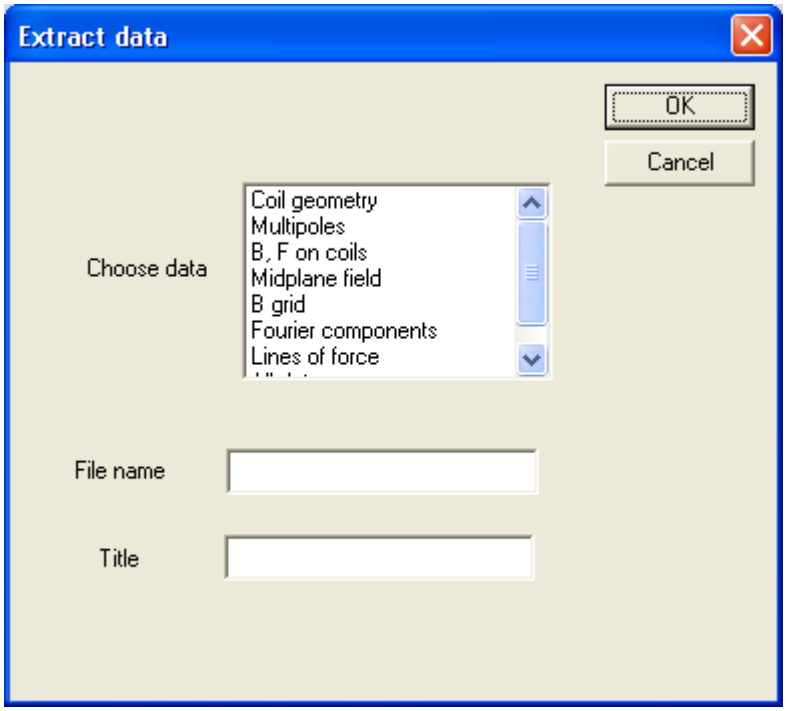
The Fourier analysis on the reference circle produces a table of Fourier coeffcients.



The a_n coefficients are the cosine-like terms, while the b_n coefficients are the sine-like terms.

7. Extract Data

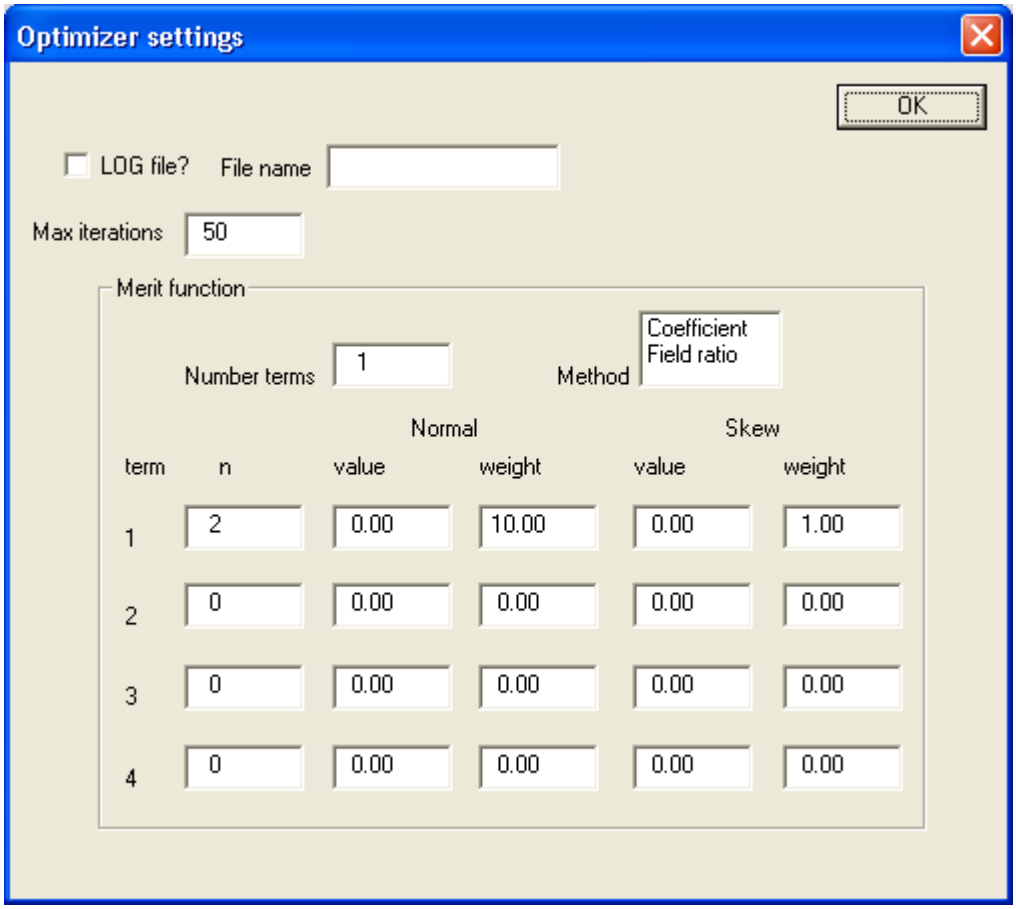
The EXTRACT DATA button can be used write selected information to an external file. This will bring up the following window.



The user can specify the file name where the data is written and can specify up to 80 characters of “title” information at the head of the file. All available information can be written to a single file by choosing All Data.

8. Optimization

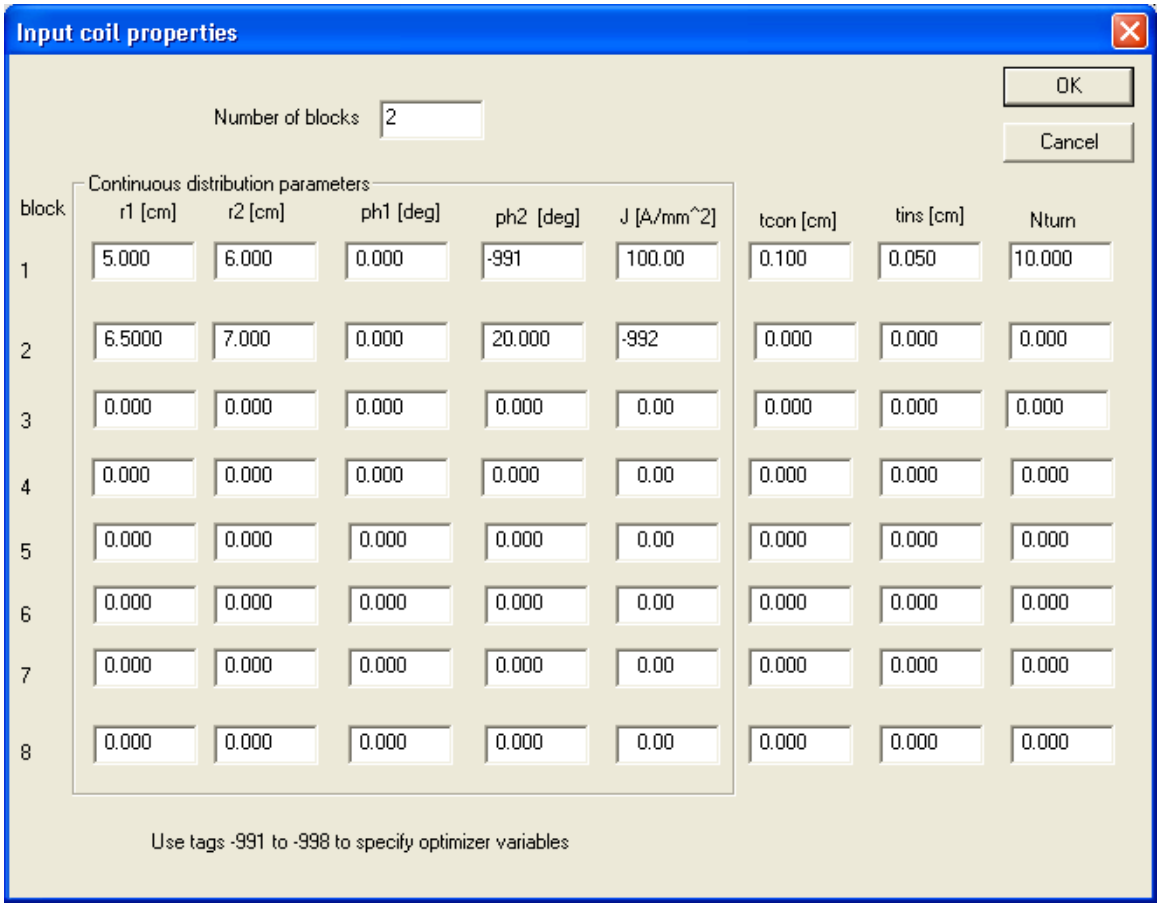
The first optimizer window controls the definition of the merit function and some general properties of the optimizer.



The progress of the optimization can be saved in an ascii log file. The maximum number of iterations roughly controls how long the optimizer will continue. The merit function is determined by the required values of up to four multipole orders *n*. The Method determines whether the value refers to multipole coefficients or to field ratios. The weights determine the relative influence of different orders in computing the merit function. At least one weight must be non-zero.

After this window is closed the coil Input parameters windows appear again.

In the second Input window



Input coil properties

OK

Cancel

Number of blocks 2

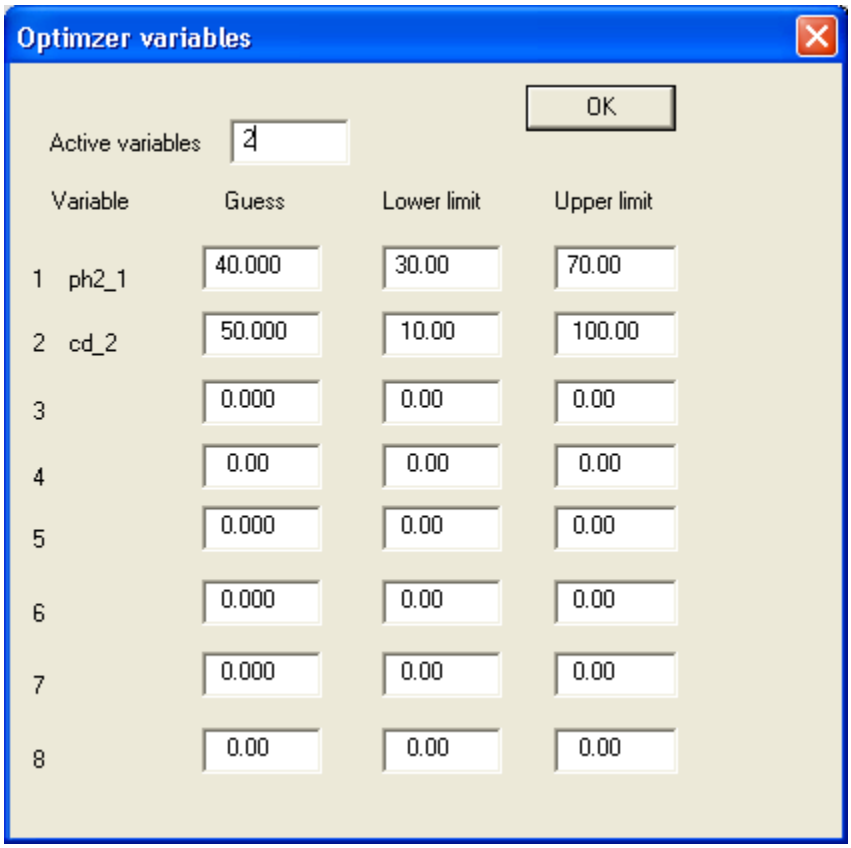
Continuous distribution parameters

block	r1 [cm]	r2 [cm]	ph1 [deg]	ph2 [deg]	J [A/mm^2]	tcon [cm]	tins [cm]	Nturn
1	5.000	6.000	0.000	-991	100.00	0.100	0.050	10.000
2	6.5000	7.000	0.000	20.000	-992	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000

Use tags -991 to -998 to specify optimizer variables

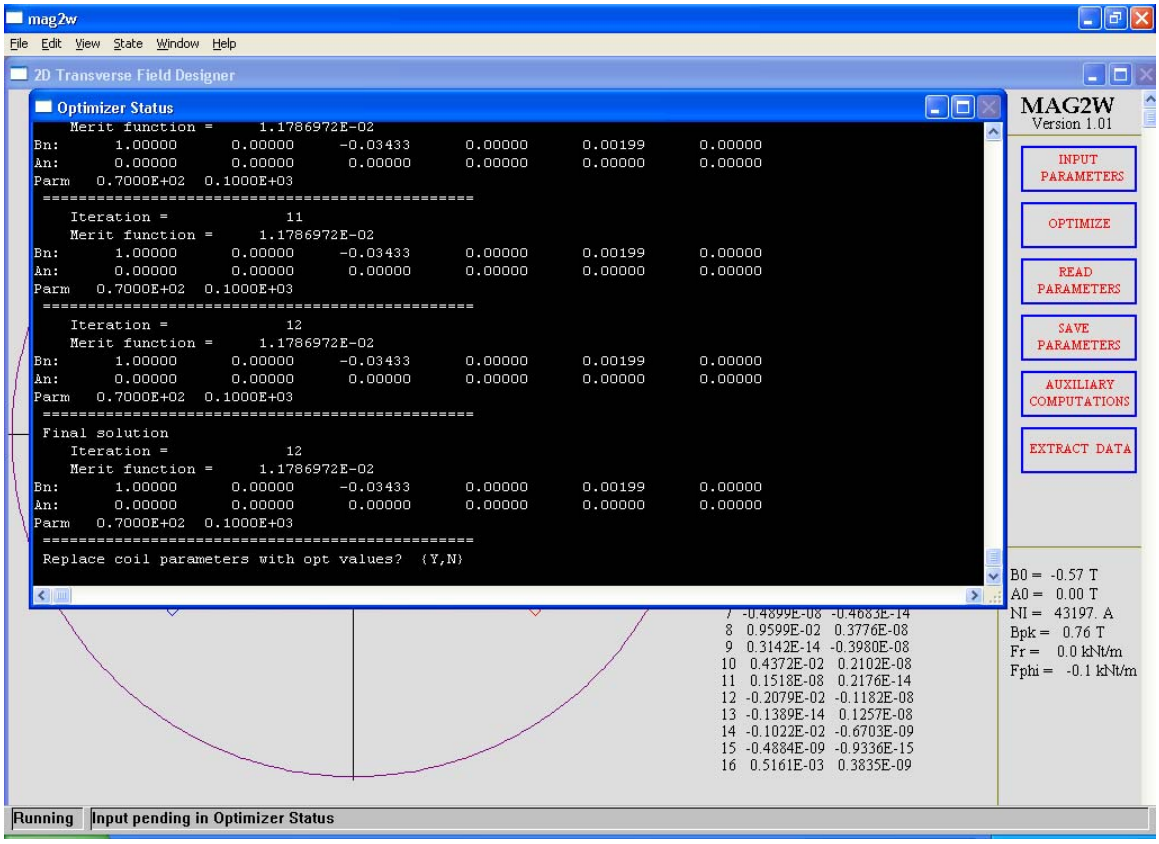
the user enters the tags from -991 to -998 to indicate which parameters to vary in the optimization. The example shows two variables: the end angle of the first block and the current density of the second block.

At this point a second optimizer window appears where the user can specify an initial guess and lower and upper limits for each of the optimizer variables.



One must enter an initial guess and lower and upper limits for each of the active variables.

Once the optimization begins the progress is displayed in another window.



At completion the user must type Y to replace the current solution with the optimizer results, or N to ignore it.