

How do we design a toroidal transformer?

Concerning the mouse and the control buttons

You can use the mouse for everything.

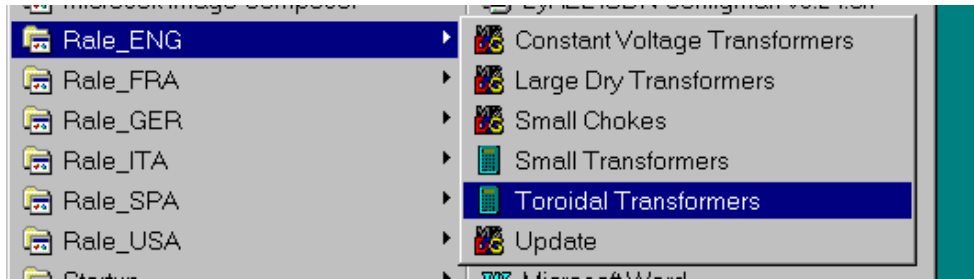
The menu control can also be activated by means of the **Alt** key and the control letter for the menu option (after pressing the **Alt** key, it is normally visible in a different color). Some important menu options can be activated by means of the **F keys**.

Here is a survey of all control keys:

F1	On-line help
F2	It loads your last input file into the input mask in which all of the input data and the results of design are stored
F3	Loads the last input from the user, without any results of the design
F4	Starts design from the input data form
F5	Activates the test mode. This button cannot be pressed until after completion of design
F6	Designs in the test mode
F7	Indicates the loaded or calculated output data
F8	Prints out the loaded or calculated output data
F9	Activates the choice of core family and core with bobbin, and starts manual inputting of core, bobbin and casing
F11	Activates the choice of steel quality
F12	Activates the choice of wire family and wire
Ctrl-F1	Activates help for on-line help
Ctrl-Z	Reverses the last input
Ctrl-X	Stores all input data from a secondary into the internal memory. The cursor should be located in an input field of the secondary to be copied
Ctrl-C	Overwrites the input data of a secondary with the input data from the internal memory in which the cursor is located
Ctrl-V	Joins the input data from a secondary with the input data from the internal memory in which the cursor is located. The input data of the 8th secondary will consequently be lost
Ctrl-D	Deletes the selected secondary winding
PgDn/PgUp	Completes the input for primary voltages or secondary windings. Steps between the Primary , Secondary and Mask input groups
Arrows	Steps between the input fields in the input form and in the test mode
TAB	Steps between the input fields

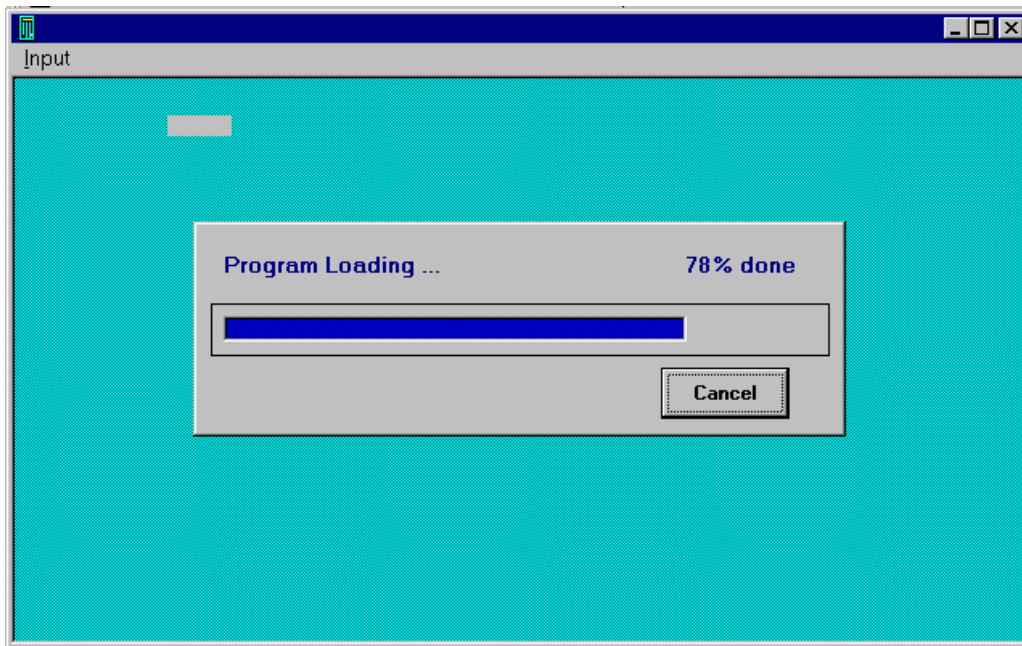
Run RALE DESIGN System for toroidal transformers

After installation of the **RALE Design System** , you see the *Rale Design System* program group on-screen.



Click on the **Toroidal Transformers** bottom

After clicking on the *Toroidal Transformers* bottom, the main menu for the Toroidal Transformers Program will appear on-screen.



This is followed by the input mask on screen with your input data

Input mask

The screenshot shows the 'TOROIDAL TRANSFORMERS/INPUT' window with a menu bar (Input, Material, Run, Output, Edit, Options, Help) and a main input area. The primary and secondary parameters are as follows:

PRIMARY		U (V)	I (A)	SECONDARY	
Circuit	-:1	230		Circuit	:11
Overvolt.*:	1			Voltage	V:230
Wire	-:0			Current	A:1
Ins/L	μ :0			Wire	:0
Ins/E	μ :250			Ins/L	μ :0
Formfactor:	1.11			Ins/E	μ :100
Freque.Hz:	50				
dI/Io	$\%$:100				

The MASK section contains the following parameters:

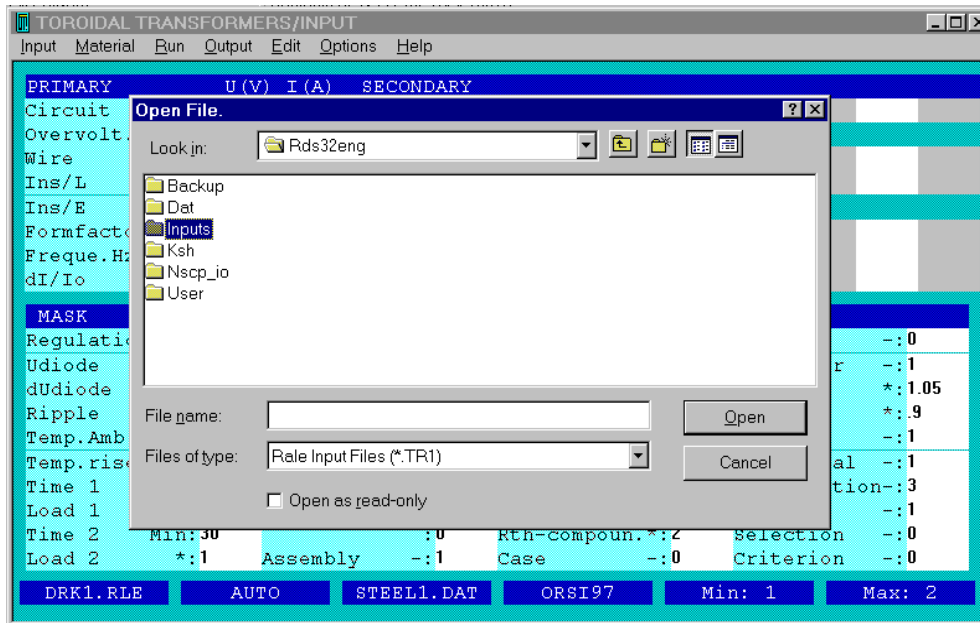
MASK							
Regulation	$\%$:50	Steel	-:2	Cooling	*:1	Sectors	-:0
Udiode	V:0.8	Induction	T:1.65	Force	m/s:0	P/S-Order	-:1
dUdiode	V:.1	Remanence	*:0.35	Hole	-:1	Rac/Rdc	*:1.05
Ripple	$\%$:5.0	W/kg	*:1		-:0	Space	*:9
Temp.Amb.	$^{\circ}$ C:40	VAr/kg	*:1	Chassis	-:1	Vertical	-:1
Temp.rise	*K:75	Gap	*:0		:0	Horizontal	-:1
Time 1	Min:30	Annealed	-:1	Cu-Surface	*:1	Impregnation-	:3
Load 1	*:1	Stacking	*:1	Rth-varnish	*:1	Pitch	-:1
Time 2	Min:30		:0	Rth-compoun.	*:2	Selection	-:0
Load 2	*:1	Assembly	-:1	Case	-:0	Criterion	-:0

At the bottom, there are buttons for 'DRK1.RLE', 'AUTO', 'STEEL1.DAT', 'ORSI97', 'Min: 1', and 'Max: 2'.

(Numerical Characters =>Inputting), (Arrow, PgUp, PgDn, Mouse =>Move)

Your last input file will be loaded into the input mask. Here, you can create your input or incorporate the input data from an input data file and thus achieve drastic acceleration in the procedure for filling-in of the input mask.

This screenshot is identical to the one above, showing the 'TOROIDAL TRANSFORMERS/INPUT' window with the same primary and secondary parameters and the MASK section.



(TAB=>Steps), (Click=>Marks), (Double click=>Selects)

In the installation of the Rale Design System, a RALE library of input data files has also been installed, with the distinction between two groups:

The first group helps in the design of transformers which are designed in accordance with regulation IEC 61558 (VDE 0551), paragraphs 15.3.2 and 15.3.3.

Example: R1532A4.TR1 or R1533E.TR1

Captions:

R	RALE by made
1532	IEC 61558 Paragraph 15.3.2
1533	IEC 61558 Paragraph 15.3.*
A	Insulation class A
E	Insulation class E
B	Insulation class B
F	Insulation class F
H	Insulation class H
4	Current rating of fuse < 4A
10	4> Current rating of fuse < 10A
25	10A > Current rating of fuse < 25A
63	25A > Current rating of fuse < 63A
99	63A > Current rating of fuse < 100A

For all input data files, an ambient temperature of 40°C has been used.

After loading of an input data file from this group, you now only have to enter the value for voltages and currents in the input mask.

The second group of input data files illustrates how it is possible to design certain specific transformers. All of these input data files are extensively discussed in the design examples.

The third group of input data files should be created by yourself in the course of time.

Input

The input mask consists of 5 areas:

1. Menu bar.



2. Input form for primary data.

PRIMARY		U (V)	I (A)
Circuit	-:1	230	
Overvolt.*	:1		
Wire	-:0		
Ins/L	μ:0		
Ins/E	μ:250		
Formfactor	:1.11		
Freque.Hz	:50		
dI/Io	%:100		

3. Input form for secondary data.

I (A)		SECONDARY					
Circuit	:11						
Voltage	V:230						
Current	A:1						
Wire	:0						
Ins/L	μ:0						
Ins/E	μ:100						

4. Input form for general technological parameters.

MASK							
Regulation	%:50	Steel	-:2	Cooling	*:1	Sectors	-:0
Udiode	V:0.8	Induction	T:1.65	Force	m/s:0	P/S-Order	-:1
dUdiode	V:1	Remanence	*:0.35	Hole	-:1	Rac/Rdc	*:1.05
Ripple	%:5.0	W/kg	*:1	Chassis	-:0	Space	*:9
Temp.Amb.	°C:40	VAr/kg	*:1		-:1	Vertical	-:1
Temp.rise	°K:75	Gap	*:0		:0	Horizontal	-:1
Time 1	Min:30	Annealed	-:1	Cu-Surface	*:1	Impregnation	-:3
Load 1	*:1	Stacking	*:1	Rth-varnish	*:1	Pitch	-:1
Time 2	Min:30		:0	Rth-compoun.	*:2	Selection	-:0
Load 2	*:1	Assembly	-:1	Case	-:0	Criterion	-:0

5. Status line

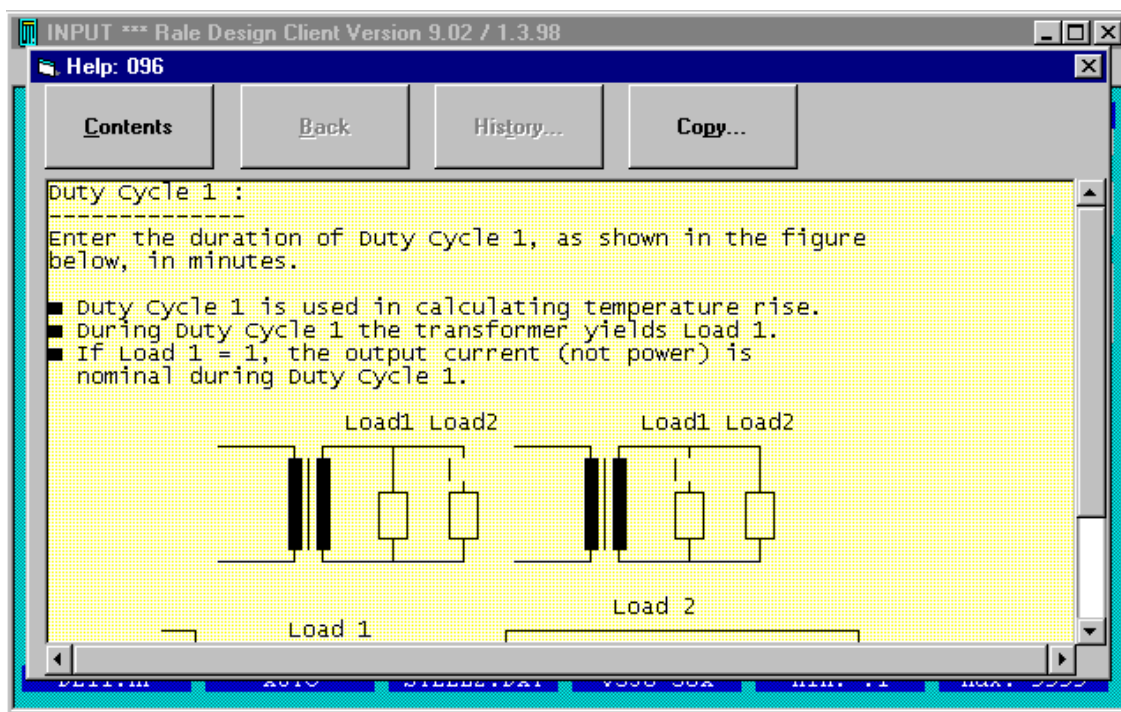


The 6 fields of the status line indicate, in sequence, the core family, the core, the iron quality family, iron quality, and the minimum and maximum values of the current input.

The input process for primary voltages and the secondary windings is concluded by means of the **PgUp** or **PgDn** keys

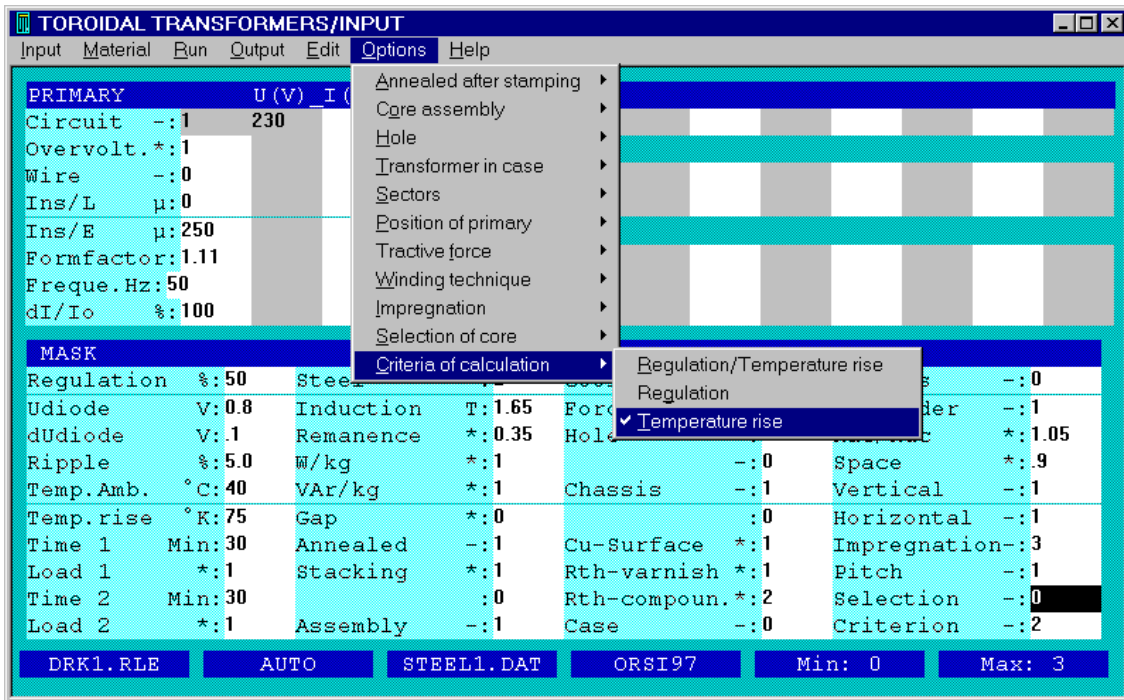
On-line Help

Key **F1** plays an important part at this point, because each input field has a help text. Use **ESC** to quit on-line help.



(Mouse, PgDn, PgUp, Arrow =>Move), (ESC=>Exit)

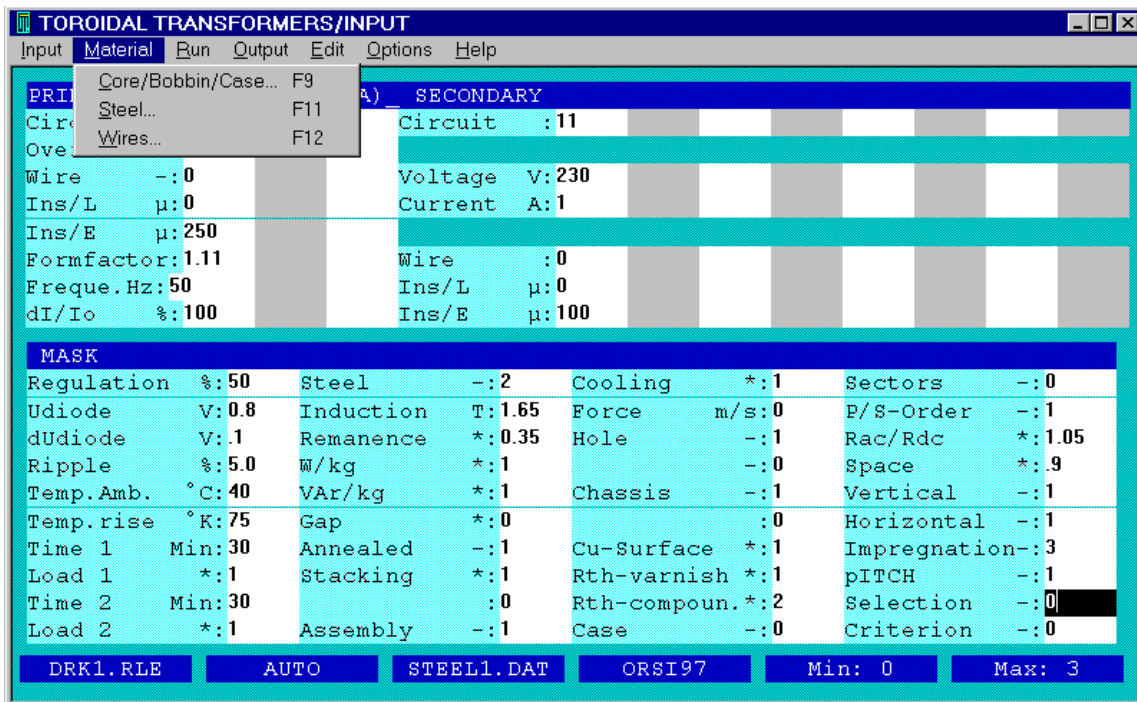
The input fields which are marked * are values with a unit of quantity (V, A, Hz,...) or multiplication factors. The input fields with - are code values. These can be entered or selected via the **Options** menu.



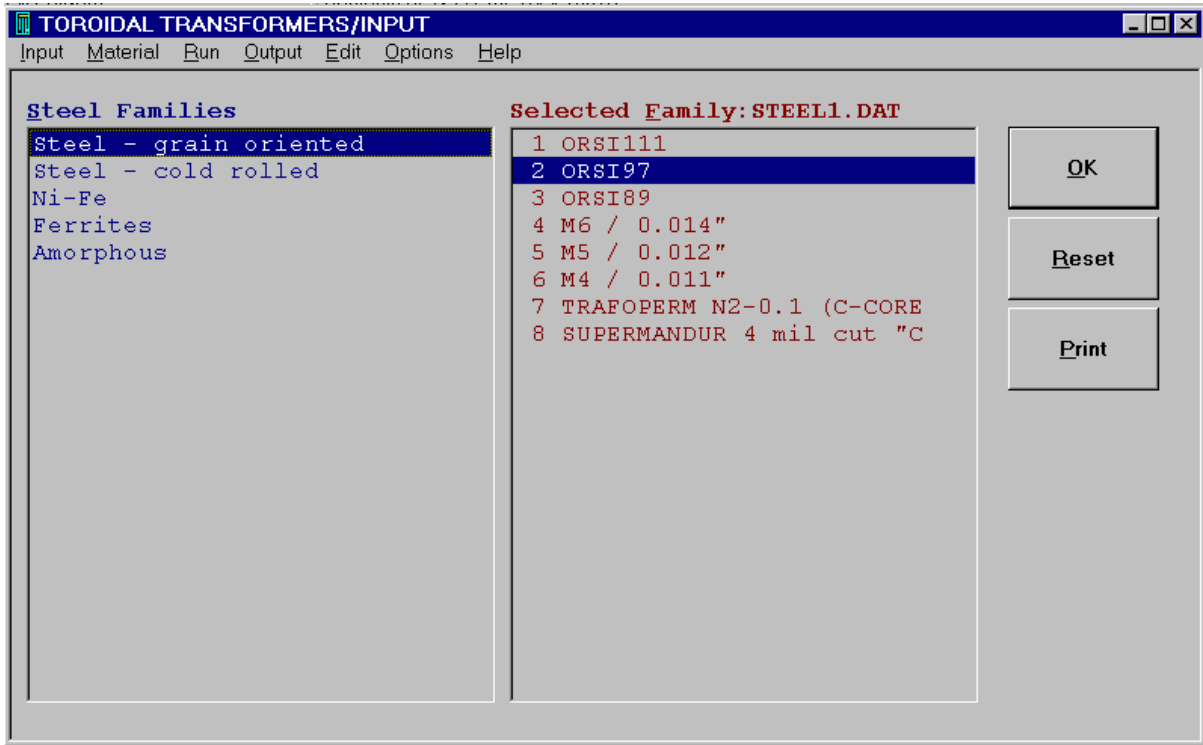
(ESC=>Exit)

Wires and steel

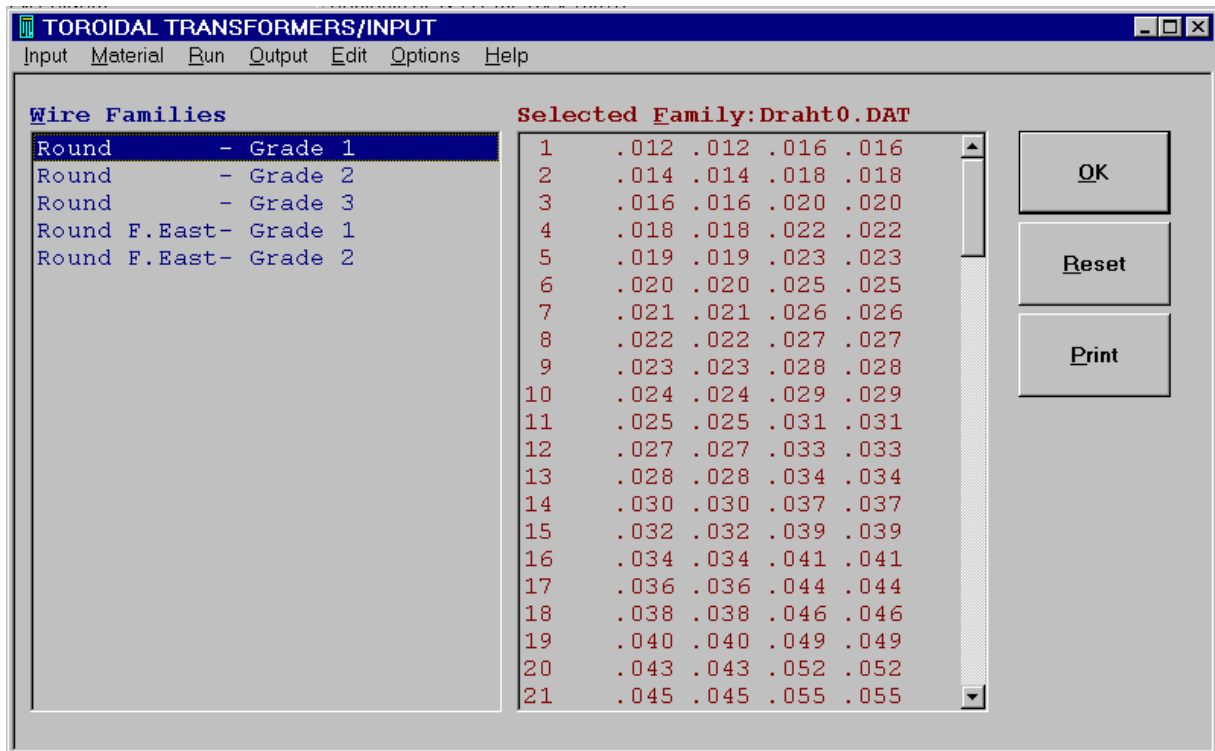
The input fields for **Wire** type (not wire size) and **Steel** are a minor exception in this instance and can be selected in addition to manual input via the **Material/Wires/Fe** menu or selected by means of keys **F11** and **F12**.



(Alt-M and F or F11 only =>Fe-Quality), (Alt-M and W or F12 only =>Wires)



(TAB=>Move), (Click=>Mark), (Double click=>Select)



(TAB=>Move), (Click=>Mark), (Double click=>Select)

Core and bobbin unit

Using the menu option of **Material/Cores** or key **F9**, you can select a core with a given bobbin or set up your own preferred combination.

The distinction is drawn between **4** different approaches for selection of the core and of the bobbin:

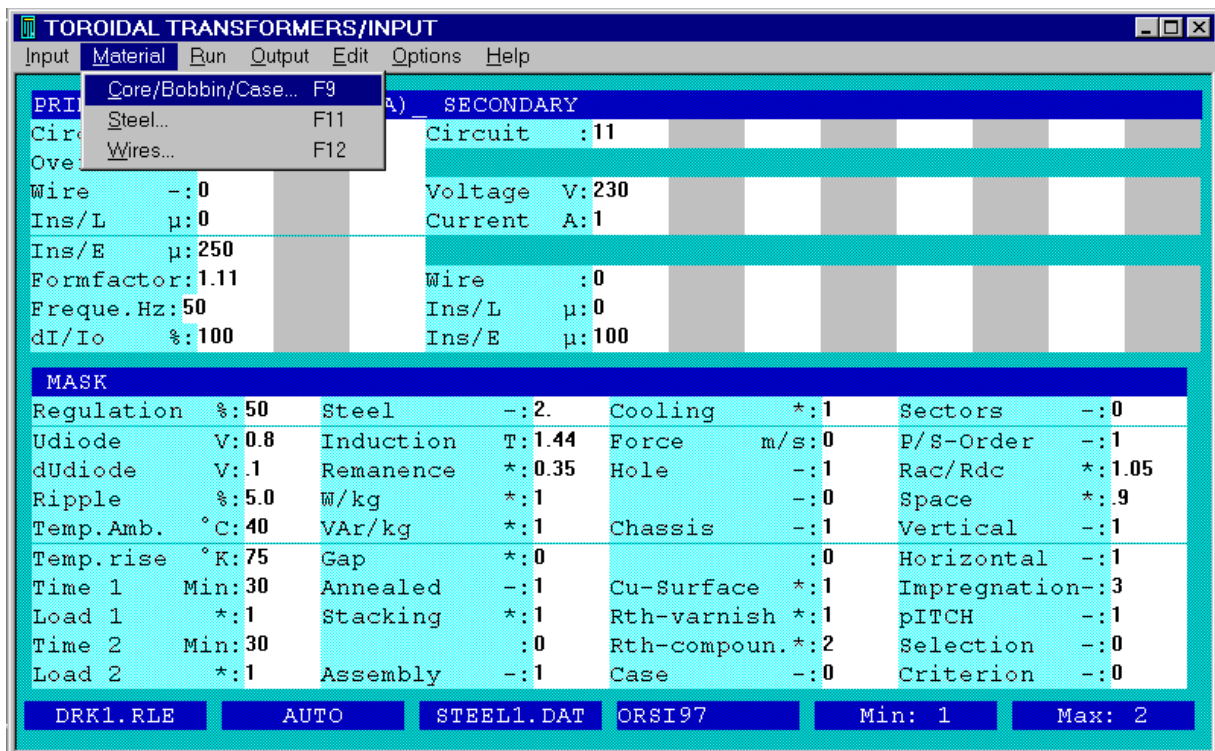
Automatic selection (Selection = 0)

In this mode, you just know the core family for the core and the coil from which you have to choose. But you don't know which core is suitable for your application.

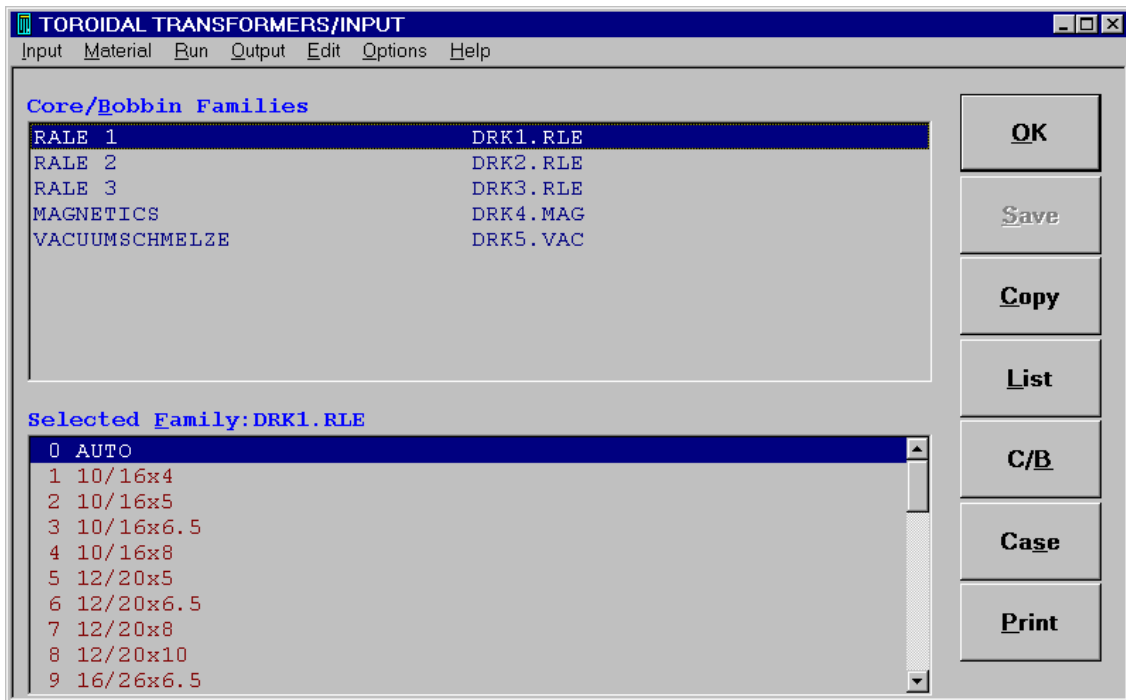
- Enter a **0** in the *Selection* input field.
- The core name in the status line must be **AUTO**.

Core and bobbin are selected (Selection = 1)

You wish to produce your application with a given core and a given bobbin from a given core family.



(Alt-M and C or just F9 =>Cores and Bobbins)

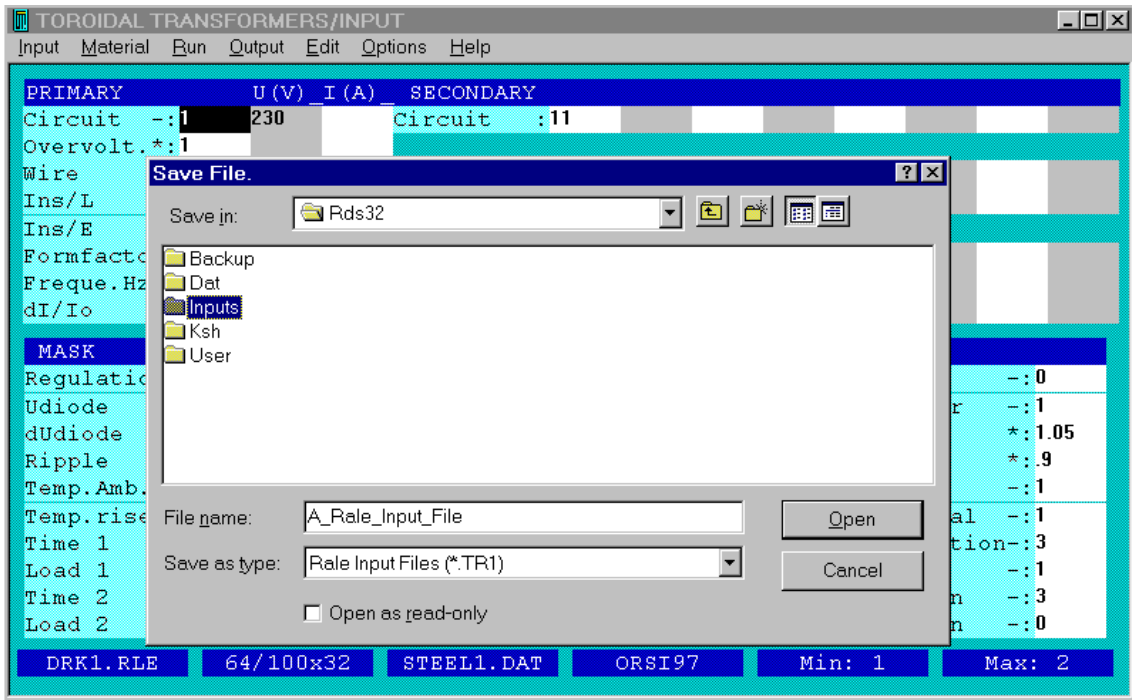


(TAB=>Move), (Click=>Mar), (Double click=>Select)

- Select the **Material/Cores** menu option or press key **F9**.
- Select a core family.
- Use the mouse to click on the core you prefer.
- Click on the **OK** button. The **Selection** input field has automatically acquired the value of **1**.

Core and bobbin are incorporated from a single input data file (Selection = 2)

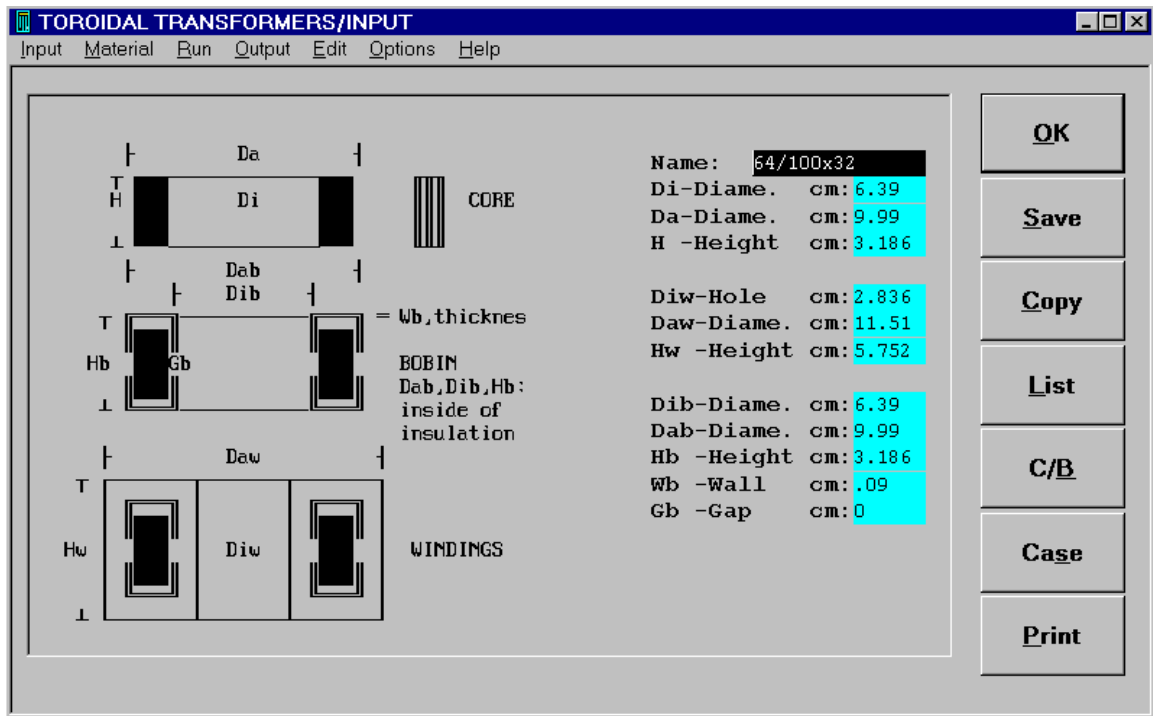
We have already selected an input data file before accessing the input mask, or we have loaded an input data file from the input mask via the **Input/Open** menu option. In this instance, we incorporated the core and coil stored in this input data file. The input field for **Selection** has a value of **2**. Using this procedure, we have no further work to do with regard to core selection **on-line**.



(TAB=>Move), (Click=>Mark), (Double click=>Select)

The core and bobbin are manually entered (Selection = 3)

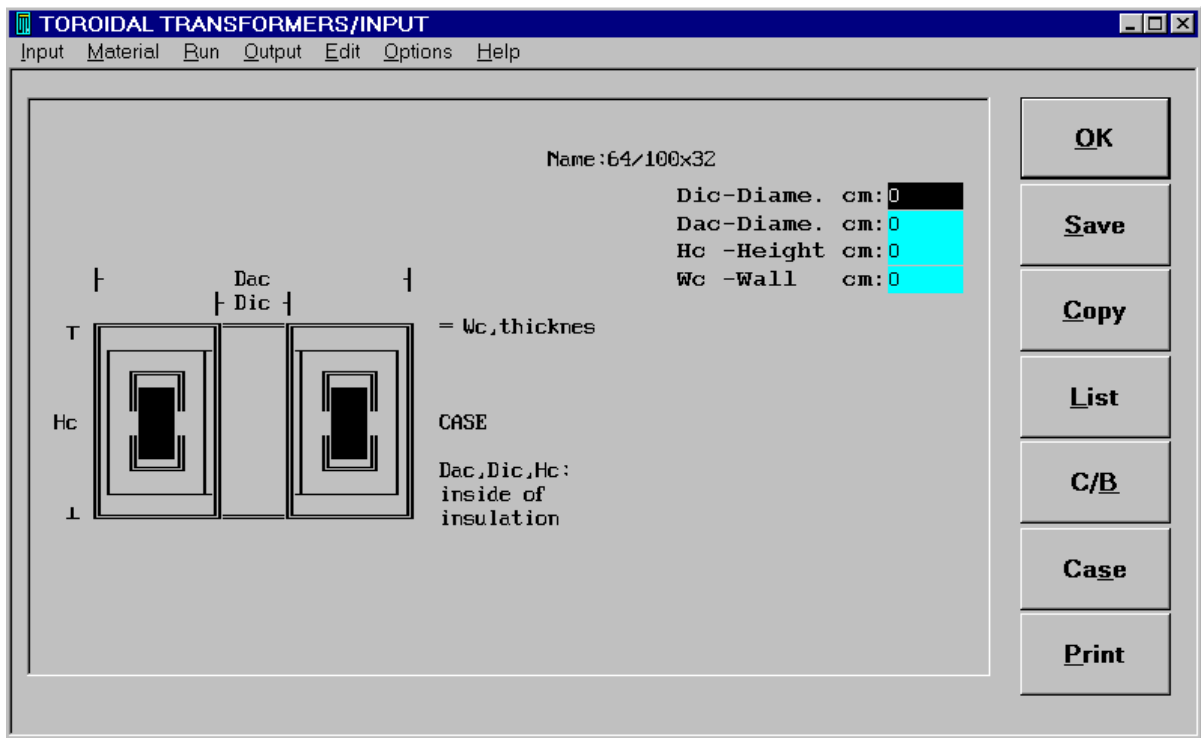
You wish to achieve your application with a given core and a given bobbin, but the core does not exist in any core family.



(Numerical =>Input), (TAB, Mouse =>Move)

Note 1 : If you change the core sizes Di, Da and H the program will show you the maximal, optimal sizes of the transformer Diw, Daw and Hw.

Note 2 : If you change the sizes of the transformer Diw, Daw and Hw the program will show you the minimal, optimal sizes of the core Di, Da and H.



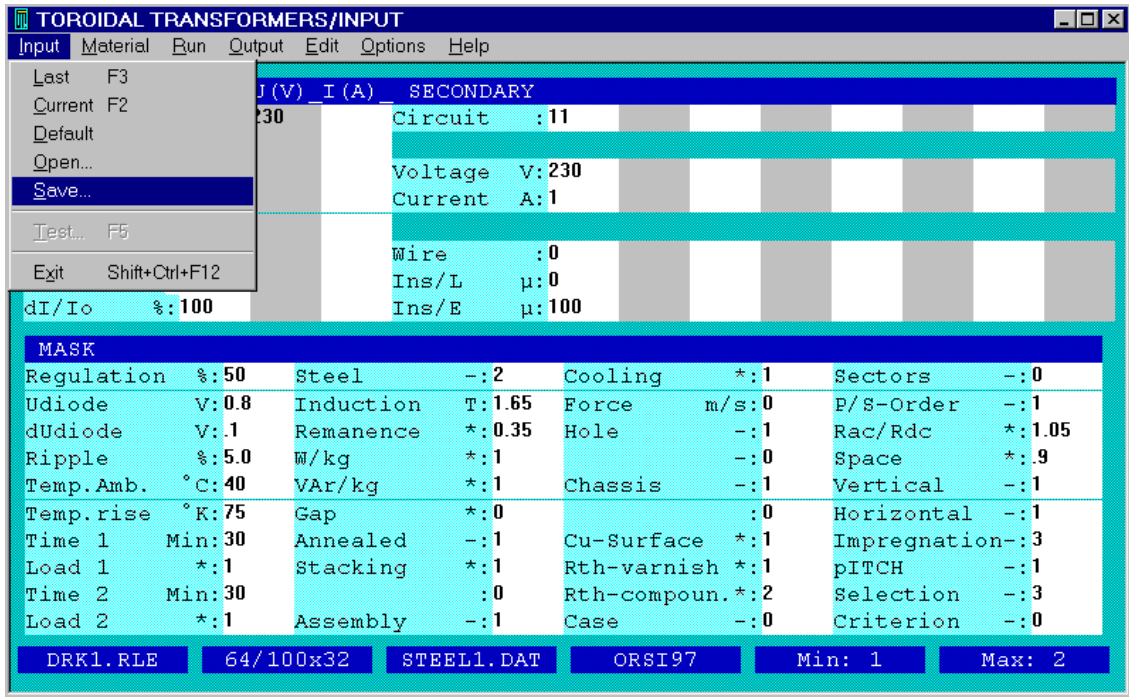
(Numerical=>Input), (TAB, Mouse=>Move)

- Select the **Material/Cores** menu option or press key **F9**.
- Select a core family which could include your core.
- Use the mouse to click on a core which is similar to yours.
- Use the mouse to click on the **Copy** button and then **Yes**.
- Change the core, the bobbin and/or the case.
- Click on the **OK** button. The **Selection** input field has automatically acquired the value of **3**.

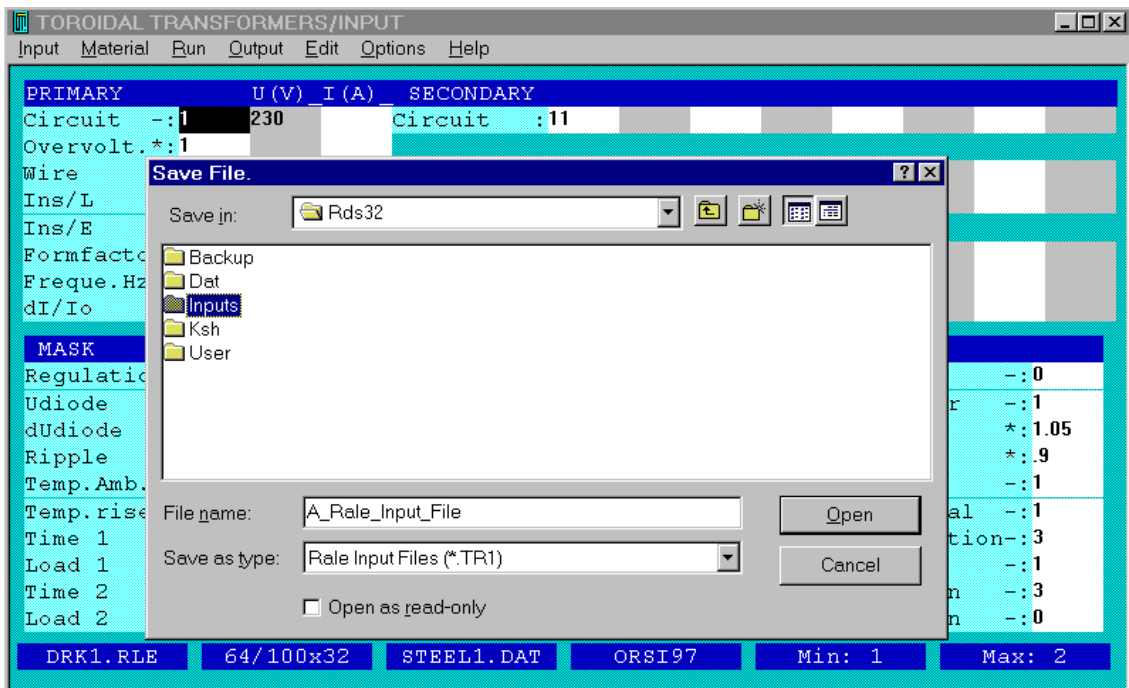
Under this procedure, we have no further work to do **on-line** with regard to core selection.

Saving the input data file

Your input is **COMPLETE!** It is recommended that you save your input data into an input file.



(Alt-I and S)

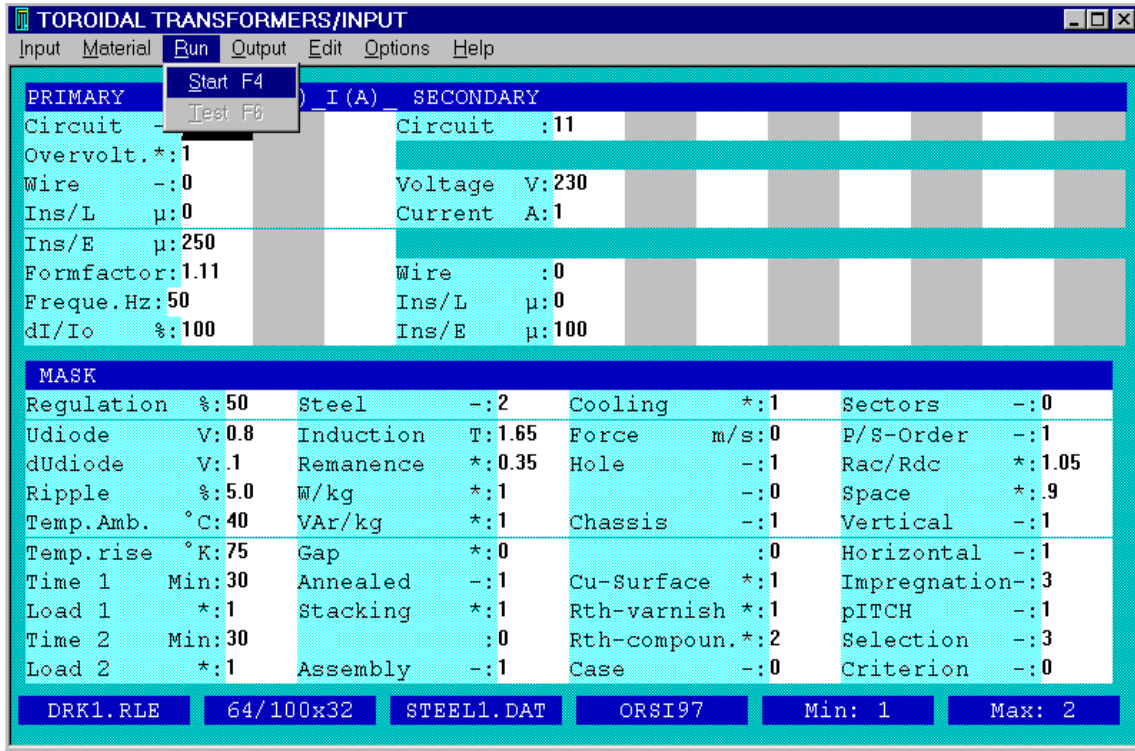


(TAB => Move), (Click => Mark), (Double click => Select)

- Select the **Input/Save** menu option
- Enter the name of your input data file (max. of 8 characters, and the extension **.TKI** cannot be modified).
- Click on the **OK** button.

Run designing

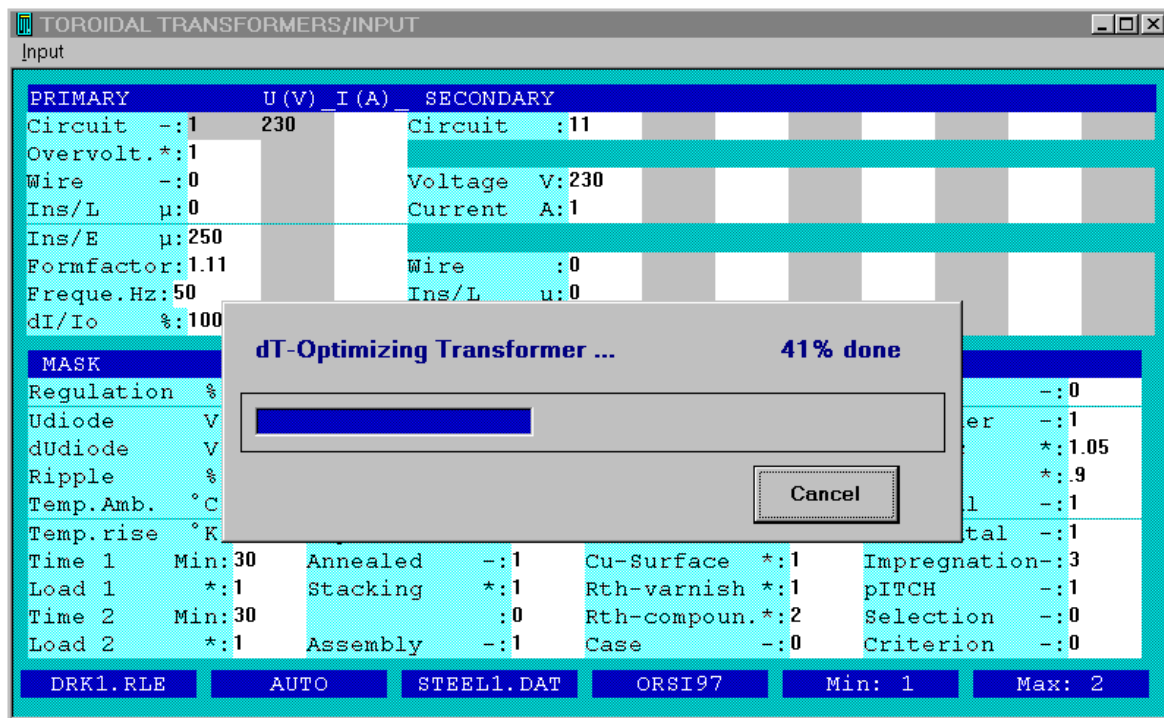
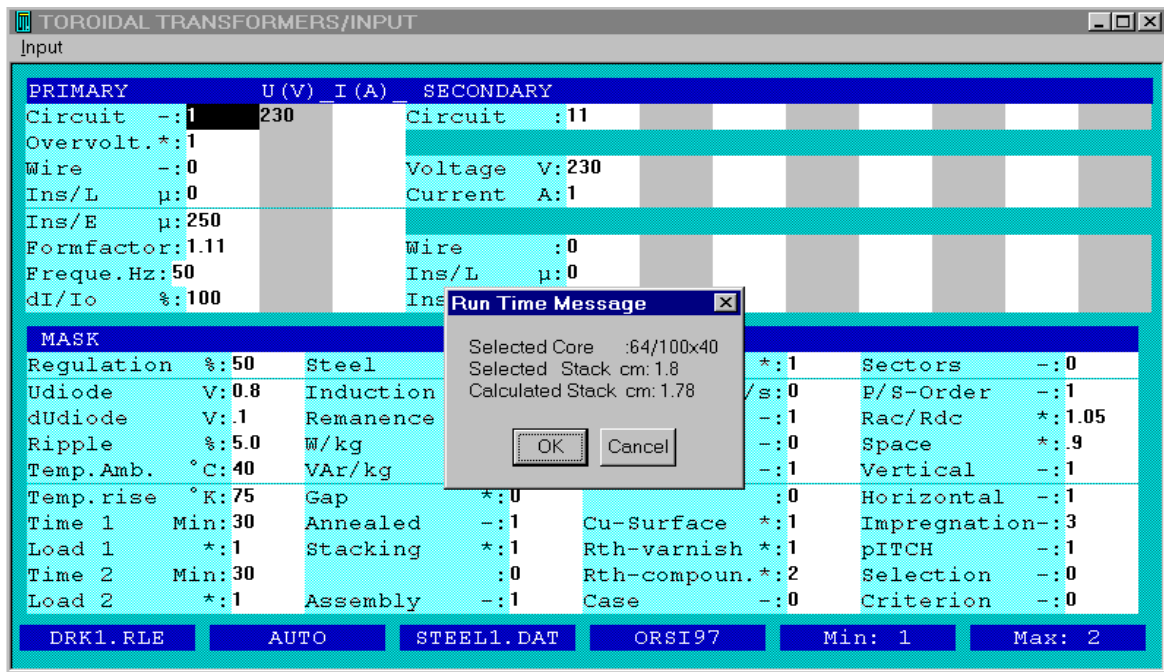
Design is started via the **Run/Start** menu option or with key **F4**.



(Alt-R and S or just F4)

If you have not already selected a core, the program starts automatic search in accordance with one of your requirements from the core size as per your inputting, from the selected core data file.

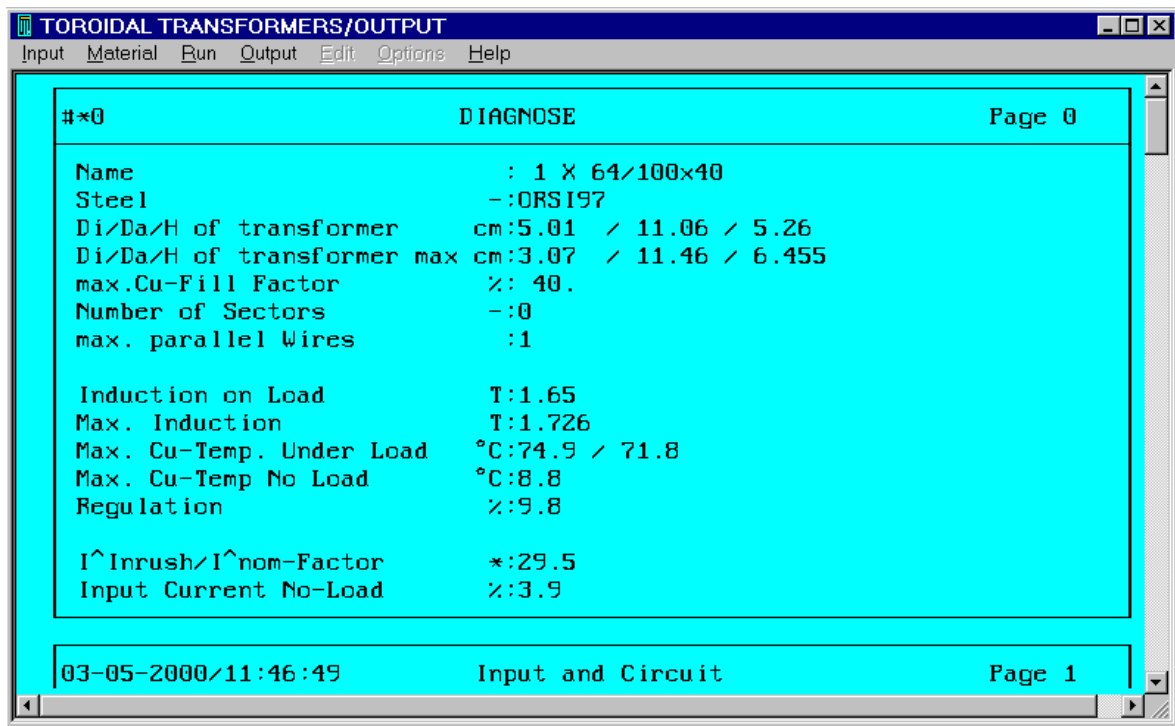
The program starts searching at the first core of the core family and passes through to the last core in the family in sequence. You are invited to approve the first core which is adequately large for your application.



This is followed by the design operation. Note that there are 2 criteria of the optimizing: $dT \Rightarrow$ temperature rise or $dU \Rightarrow$ Regulation

Data page for winding

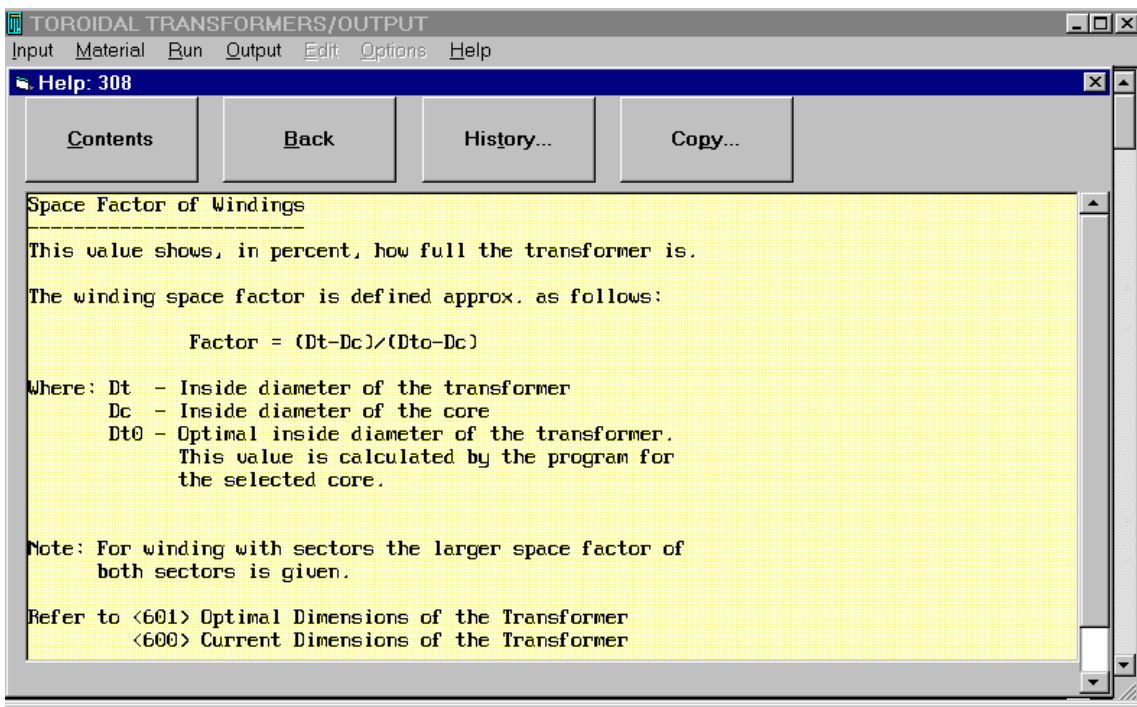
After the design procedure, a summary of the main results will appear on-screen.



(Mouse, control bar, Arrows, PgUp, PgDn=>Move)

The continuation of the above screen illustrates the extensive display of the design results. Each designed value is allocated with an appropriate explanatory text.

If you should need further information, please locate the cursor on the size value and press key **F1**. This activates on-line help.



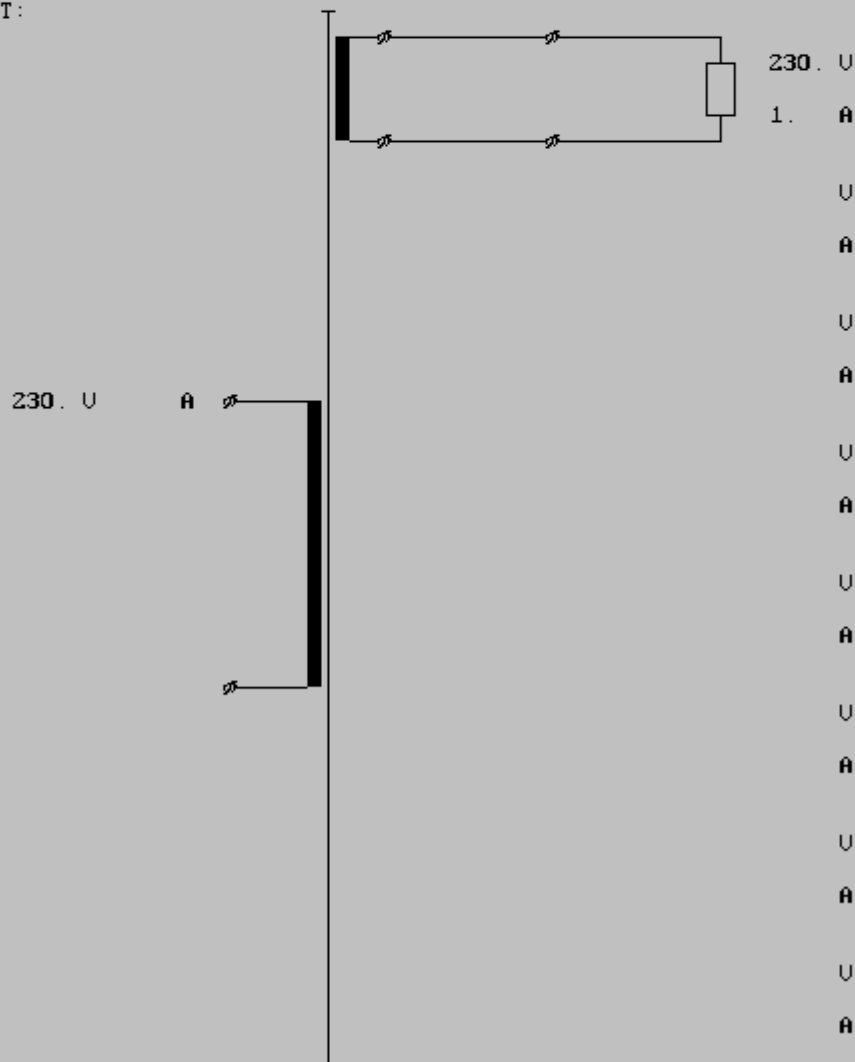
(Mouse, PgDn, PgUp, Arrows=>Move), (ESC=>Exit)

Press Key "1"..."9" to jump to the other screens or press F8 to print the calculated results :

PRIMARY	U(U) I(A)	SECOND.	1--- 2--- 3--- 4--- 5--- 6--- 7--- 8---
Circuit-:1	230.	Circuit-:11	
Overult*:1.00	.	Volta. U:230.	
Wire :0.0	.	Curre. A:1.	
I/L. p:0.	.	Wire :0	
I/E. p:250.	.	I/L p:0.0	
Formfac.:1.11	.	I/E p:100.	
Fre.Hz:50	.		
dI/Io z:100	.		

Regulat. z:50.0	Steel -:2	Cooling *:1.00	Sectors -:0
Udiode U:0.8	Induction T:1.65	Force m/s:0.00	P/S-Order -:1
dUdiode U:1	Remanence *:0.35	Hole -:1	Rac/Rdc *:1.05
Ripple z:5.	W/kg *:1.00	-:0	Space *:0.90
Imp. Amb. °C:40	UAr/kg *:1.00	Chassis -:1.00	Vertical -:1
Imp.rise °K:75	Gap *:0.00	:0	Horizontal -:1
Time 1 Min:30.0	Annealed -:1	Cu-Surface*:1.00	Impregnat. -:3
Load 1 *:1.0	Stacking *:1.00	Rth-urni. *:1.00	Pitch -:1
Time 2 Min:30.0	-:0	Rth-comp. *:2.00	Selection -:0
Load 2 *:1.0	Assembly -:1	Case -:0	Criterion -:0

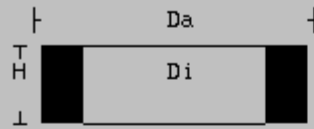
CIRCUIT:



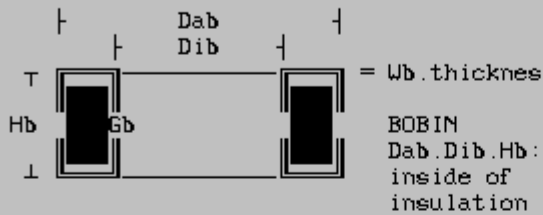
Name : 1X64/100x32
 Steel : ORSI97

/ .3

Weight gr: 1083.6
 Gap total cm: 0.000

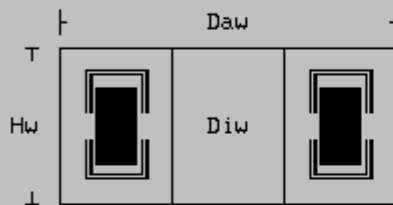


Di-Diameter cm: 6.39
 Da-Diameter cm: 9.99
 H-Height cm: 3.19



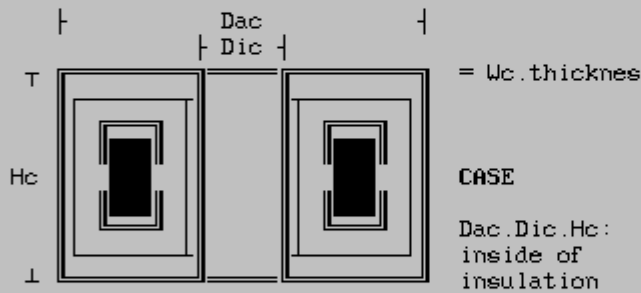
BOBBIN
 Dab, Dib, Hb:
 inside of
 insulation

Dib-Diameter cm: 6.39
 Dab-Diameter cm: 9.99
 Hb-Height cm: 3.19
 Wb-Wall cm: 0.09
 Gb-Gap cm: 0.00



WINDINGS

Diw-min.Dia. cm: 2.84
 Daw-max.Dia. cm: 11.51
 Hw-max.Hei. cm: 5.752
 Diw-is Dia. cm: 4.29
 Daw-is Dia. cm: 11.35
 Hw-is Hei. cm: 4.99



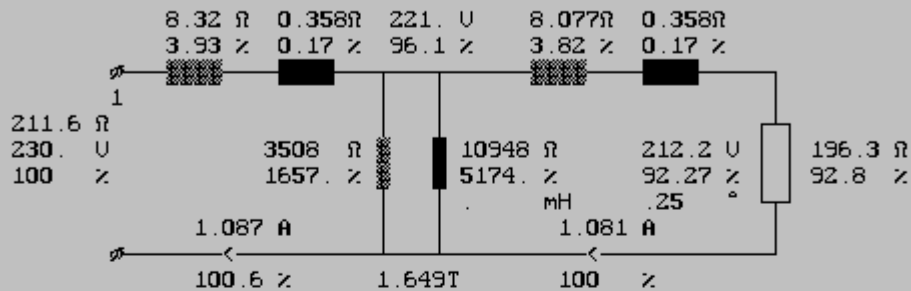
CASE

Dac, Dic, Hc:
 inside of
 insulation

Dic-Diameter cm:
 Dac-Diameter cm:
 Hc-Height cm:
 Wc-Wall cm:
 Compound cm³:

	Typ	Turns	T	WG	Par	W/∅ mm	Feed mm	Lyrs	Lngh m	I/L μ	I/E μ	Weight gr	Diam cm	RWH %
1	1	1036.3	0	75.	1	0.67	0.809	5.	122.8	0.	250	380.58	5.5	23.
2														
3														
4														
5														
6														
7														
8														
1	11	1186.6	0	76.	1	0.71	0.848	7.	160.8	0.	100	559.21	4.3	31.
2														
3														
4														
5														
6														
7														
8														
TOTAL												939.7	58.	

NOMINAL OPERATION at Temperature °C 109.5 and Overvoltage 1.00
 Output Power on Load W:229.3 Output Power of Transform. W:229.3
 Cu Losses W:19.26 Fe-Losses active W:1.3
 Short-Circuit-Volt. cold z:5.77 Regulation z:8.38
 Instantaneous pow. .5/958 W:427.2 Efficiency of Transformer z:91.77
 dT Fe average Surface °K:74.6 dT primary °K:72.5
 dT Surface average °K:67.6 dT secondary °K:66.5



DUTY CYCLE OPERATION at Amb. Temperature °C 40. and Overvoltage 1.00
 dT Fe average Surface °K:74.6 dT primary °K:72.5
 dT Gehäuse au. Surface °K:. dT secondary °K:66.5

NO LOAD OPERATION at Amb. Temperature °C 40. and Overvoltage 1.00
 Losses active W:2.38 Losses reactive VAR:7.05
 Current factor z:2.98 Induction T:1.716
 dT Fe average Surface °K:10.2 dT primary °K:7.7
 dT Gehäuse au. Surface °K:.

SHORT-CIRCUIT OPERATION at Amb. Temperature °C 40. and Overvoltage 1.00
 Losses active W:4324. Losses reactive VAR:254.3
 Current factor cold z:1732. Induction T:.816
 dT Fe average Surface °K:1185. dT primary °K:1185.
 dT Gehäuse au. Surface °K:. dT secondary °K:881.4

PRIMARY (Tap:1) 1---- 2---- 3---- 4---- 5---- 6---- 7---- 8----
 Voltage Input/Output U:230.
 Out. Voltage no load U:
 Current Input/Output A:1.087
 Current in segment A:1.087
 Icc-Current cold A:18.83
 Io -Current A:0.032
 Inrush Current peak ^A:47.23
 Inrush Current rms A:19.47
 Cu-Losses W:9.8
 Resistance cold ohm:6.108
 Reactance ohm:.3582
 Eddy-Current Factor :1.

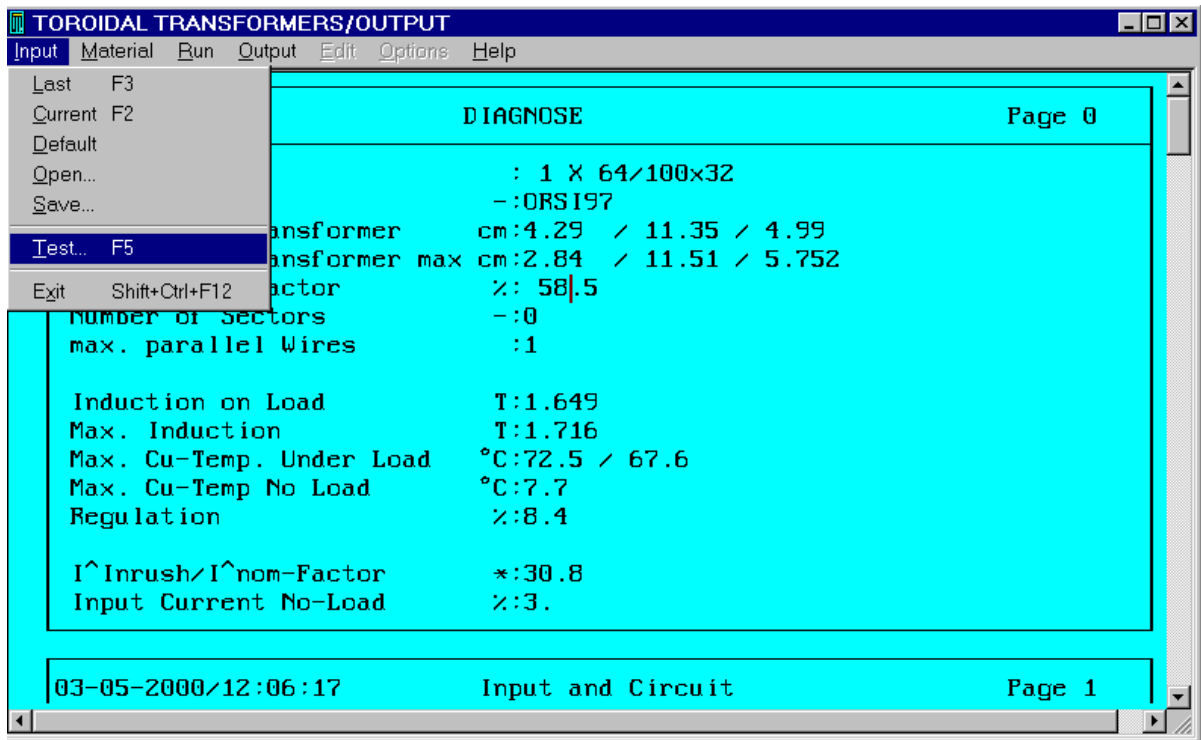
SECONDARY 1---- 2---- 3---- 4---- 5---- 6---- 7---- 8----
 Output Voltage U:229.7
 Output Current A:0.999
 Out. Voltage no load U:248.8
 Sec. Voltage U:229.7
 Sec. Current A:0.999
 Sec. Voltage cold U:234.3
 Sec. Load ohm:230.
 Icc cold A:17.4
 Cu-Losses warm W:9.437
 Resistance cold ohm:7.127
 Reactance ohm:.4196
 Eddy-Current Factor :1.
 Capacitor mF:.

If you are not satisfied with the results of design, you can :

- Return to the input form via the **Input/Current** menu option or by means of key **F2**, and reconfigure the input data on-line
- Or pass to the test mode via the **Input/Test** menu option or with key **F5**.

Activate the **Input/Test** menu option or press key **F5**.

Test mode



(Alt-I and T or F5 only)

In the test mode you can test a designed transformer and manually change its parameters

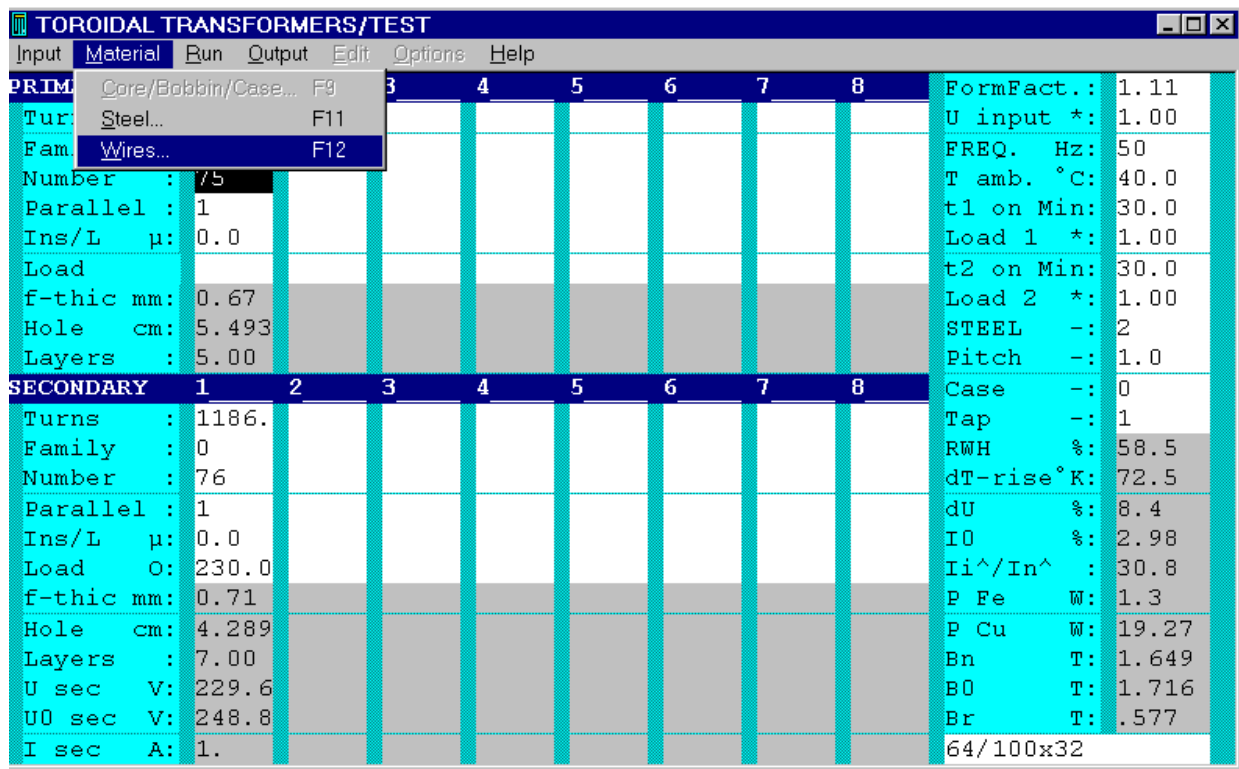
TOROIDAL TRANSFORMERS/TEST									
Input	Material	Run	Output	Edit	Options	Help			
PRIMARY	1	2	3	4	5	6	7	8	FormFact.: 1.11
Turns :	1096.								U input *: 1.00
Family :	0								FREQ. Hz: 50
Number :	75								T amb. °C: 40.0
Parallel :	1								t1 on Min: 30.0
Ins/L μ:	0.0								Load 1 *: 1.00
Load									t2 on Min: 30.0
f-thic mm:	0.67								Load 2 *: 1.00
Hole cm:	5.493								STEEL -: 2
Layers :	5.00								Pitch -: 1.0
SECONDARY	1	2	3	4	5	6	7	8	Case -: 0
Turns :	1186.								Tap -: 1
Family :	0								RWH %: 58.5
Number :	76								dT-rise°K: 72.5
Parallel :	1								dU %: 8.4
Ins/L μ:	0.0								I0 %: 2.98
Load O:	230.0								Ii~/In^ : 30.8
f-thic mm:	0.71								P Fe W: 1.3
Hole cm:	4.289								P Cu W: 19.27
Layers :	7.00								Bn T: 1.649
U sec V:	229.6								B0 T: 1.716
U0 sec V:	248.8								Br T: .577
I sec A:	1.								64/100x32

(Numerical =>Input), (TAB, Arrows, PgUp, PgDn, Mouse=>Moved)

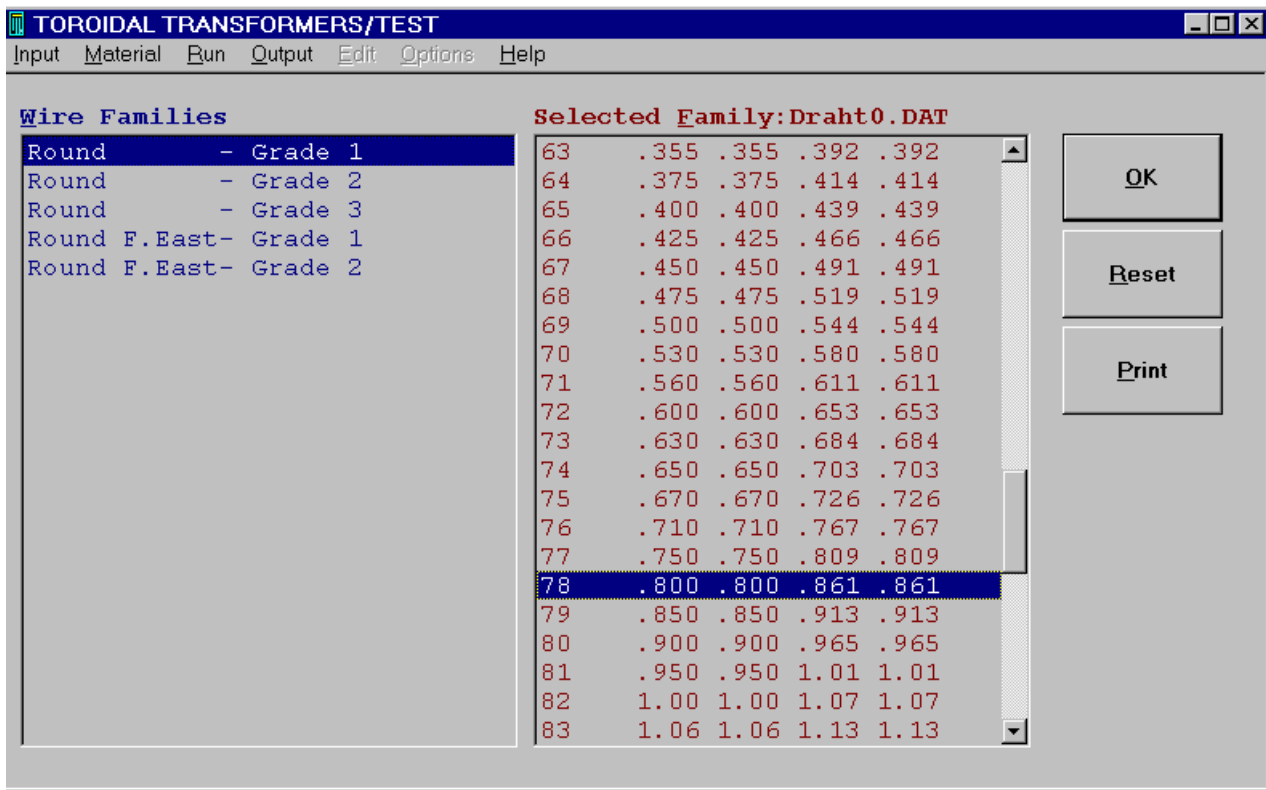
The input fields with the white background can be modified. For instance, if you want to change the wire size you have to move the cursor to the wire number:

TOROIDAL TRANSFORMERS/TEST									
Input	Material	Run	Output	Edit	Options	Help			
PRIMARY	1	2	3	4	5	6	7	8	FormFact.: 1.11
Turns :	1096.								U input *: 1.00
Family :	0								FREQ. Hz: 50
Number :	75								T amb. °C: 40.0
Parallel :	1								t1 on Min: 30.0
Ins/L μ:	0.0								Load 1 *: 1.00
Load									t2 on Min: 30.0
f-thic mm:	0.67								Load 2 *: 1.00
Hole cm:	5.493								STEEL -: 2
Layers :	5.00								Pitch -: 1.0
SECONDARY	1	2	3	4	5	6	7	8	Case -: 0
Turns :	1186.								Tap -: 1
Family :	0								RWH %: 58.5
Number :	76								dT-rise°K: 72.5
Parallel :	1								dU %: 8.4
Ins/L μ:	0.0								I0 %: 2.98
Load O:	230.0								Ii~/In^ : 30.8
f-thic mm:	0.71								P Fe W: 1.3
Hole cm:	4.289								P Cu W: 19.27
Layers :	7.00								Bn T: 1.649
U sec V:	229.6								B0 T: 1.716
U0 sec V:	248.8								Br T: .577
I sec A:	1.								64/100x32

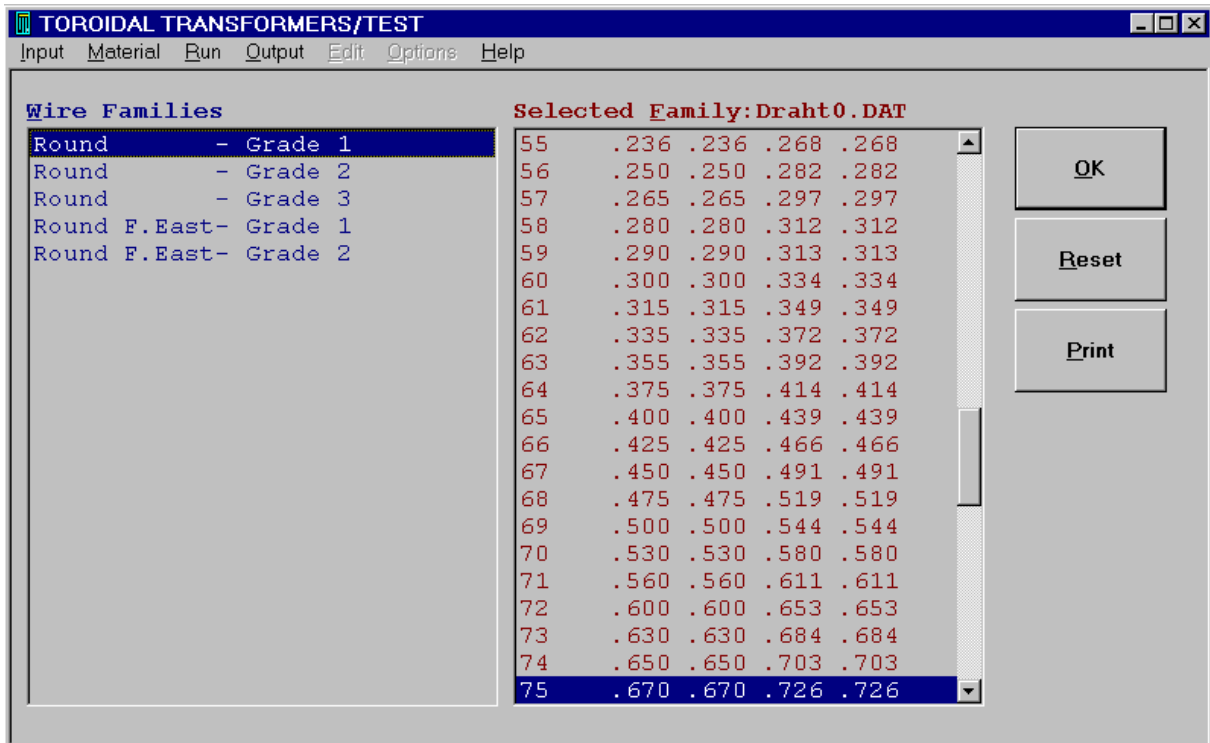
Click the menu option Material/Wires or press F12 to open the list with the wires



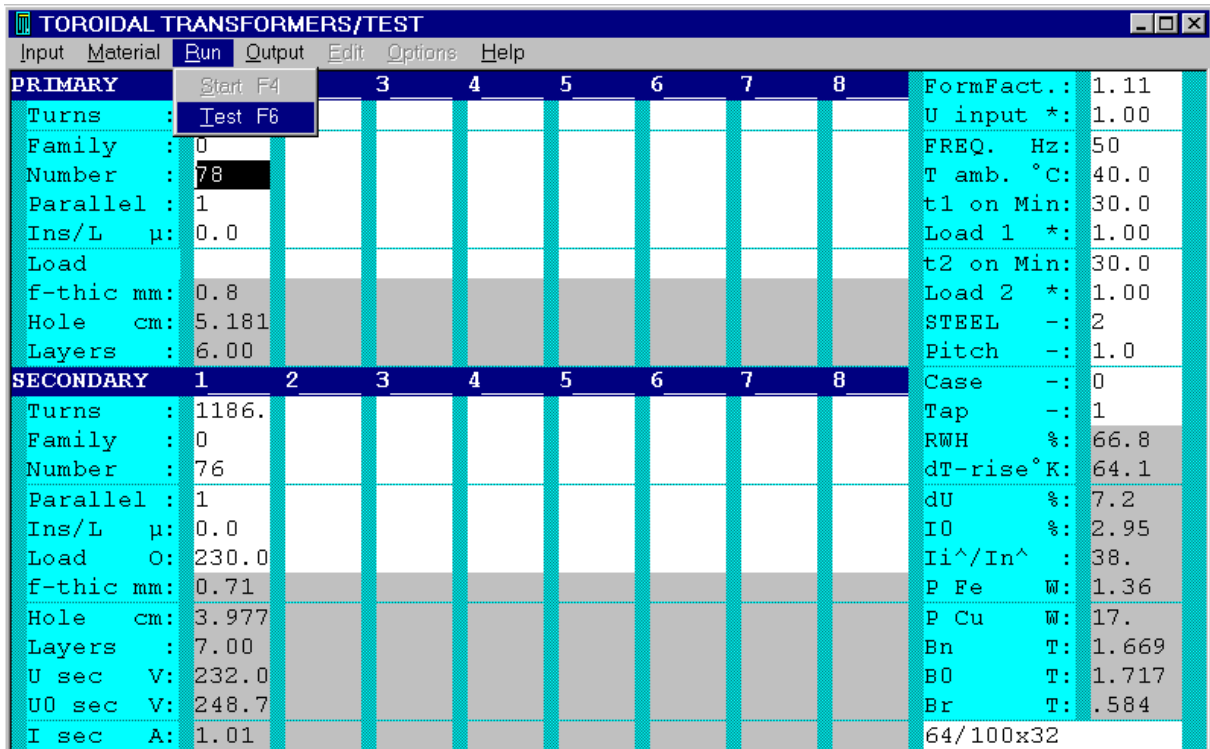
This is the current wire size



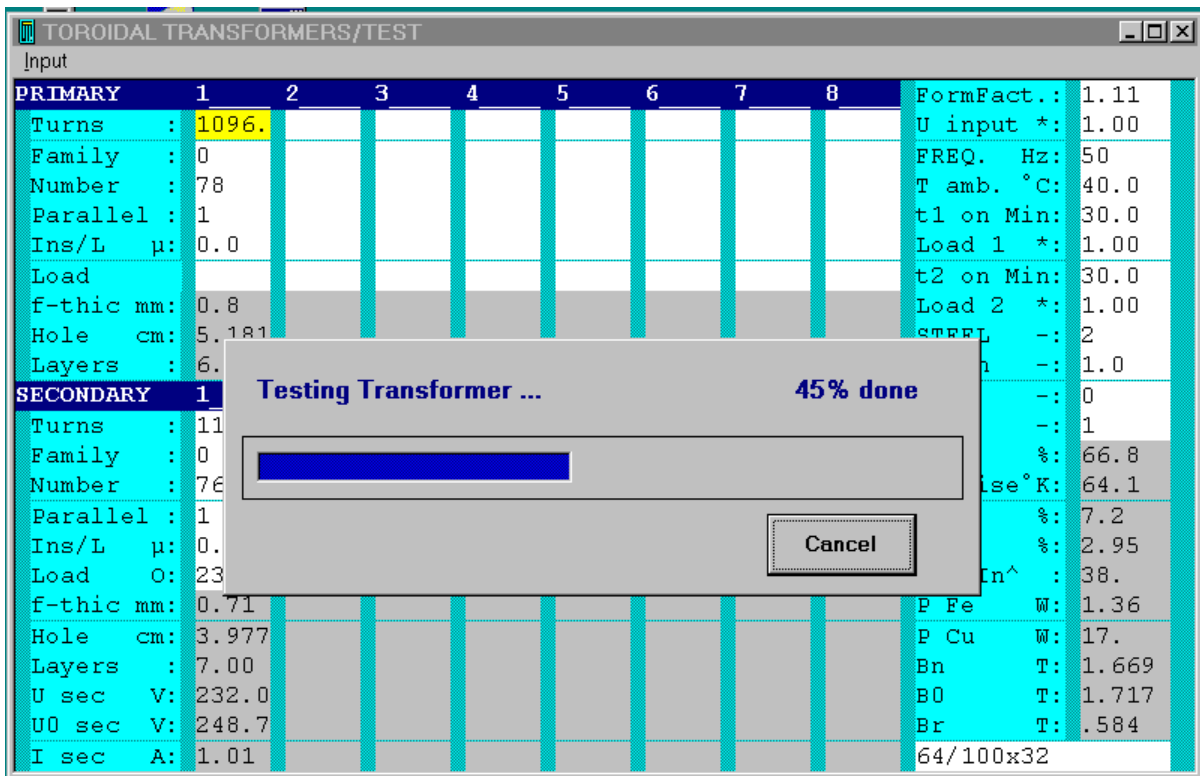
Select the wire size which you want and press **Alt-O** or click **OK**



Re-design in the test mode is activated via the **Run/Test** menu option or by means of key **F6**.

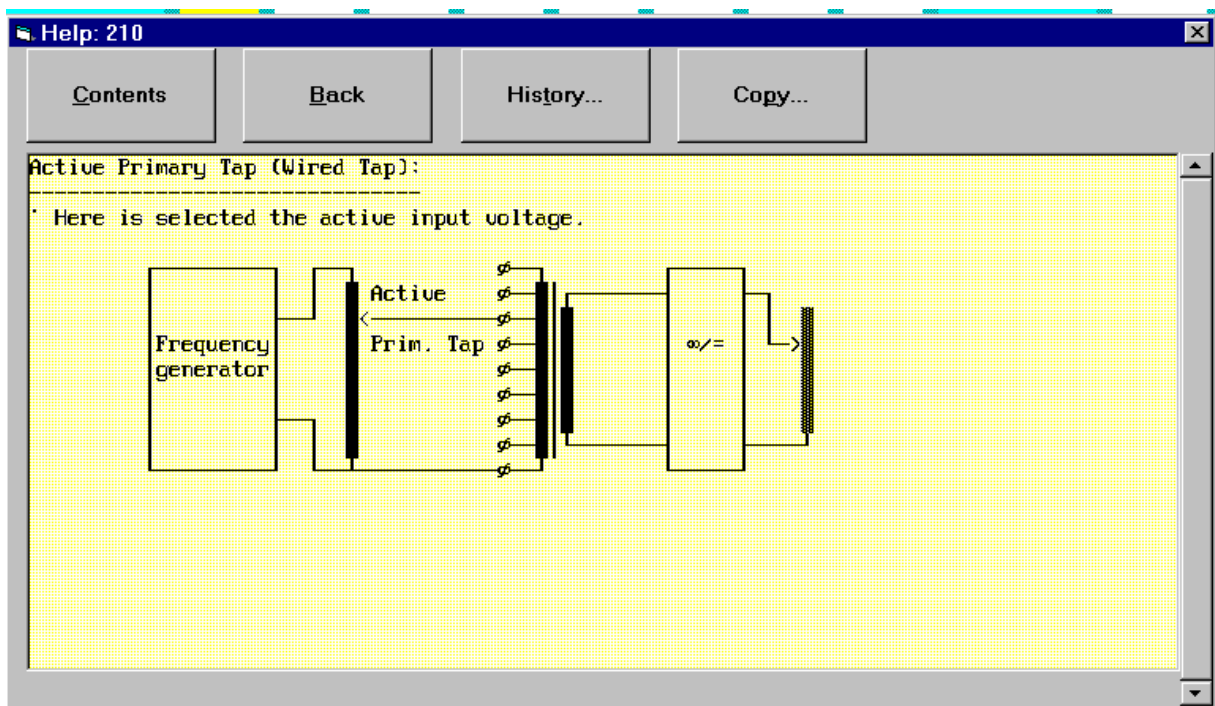


(Alt-R and T or F6 only)



Help in test mode

In order to get on-line help in the test mode place the cursor where you need help and press F1



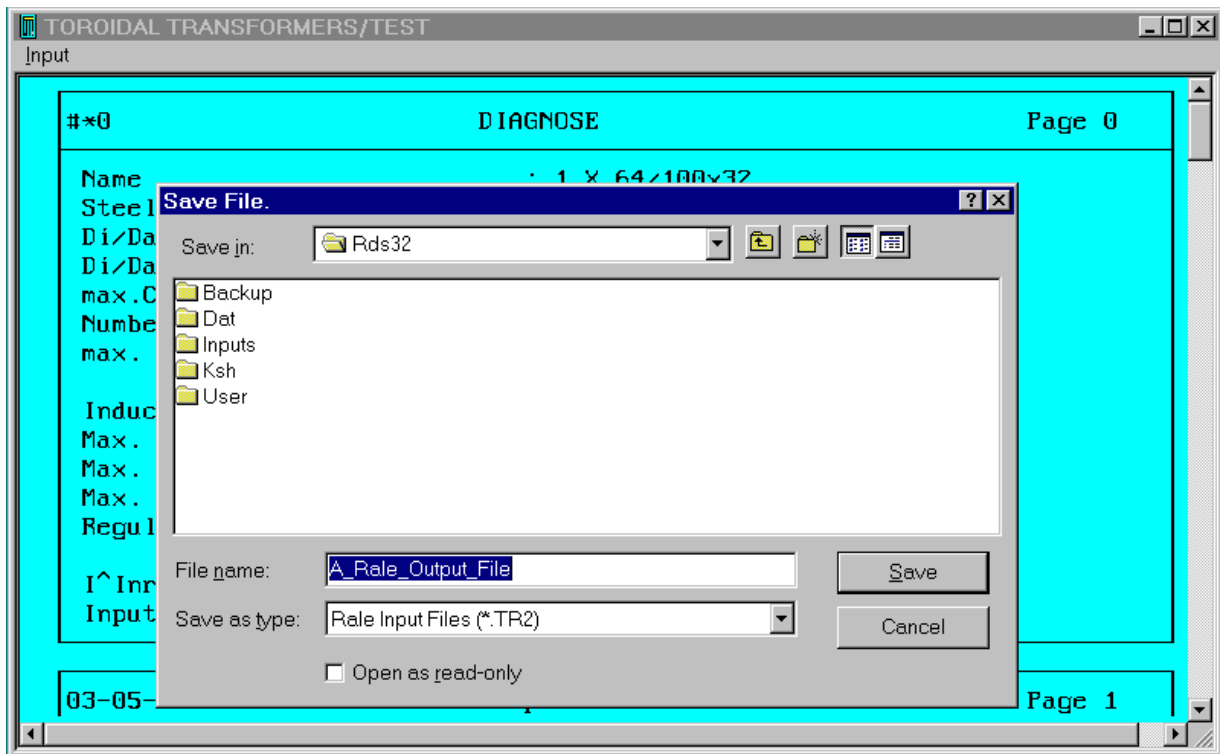
Printing

The printing is performed via the **Output/Print** menu option or by means of key **F8**. After activation of the print process, the data, totalling approx 16kB (3 pages), is printed on your printer. You can too save the results of design on your PC and load them and print out later. The procedure for saving of the designed data looks like this:

Saving of results of design

Saving of the designed data which you can load and print out **later** on the data page for the winding, is activated via the **Output/Save** menu option.

(Alt-A and S)Enter a name for the output file in which the designed data is to be saved.



(TAB=>Move), (Click=>Mark), (Double click=>Select)

Quitting your RALE Design System for toroidal transformers

Select the **Input/exit** menu option or press key **Ctrl-F12** and then click on the **Yes** button.

Important note:

In this context, we have just discussed the procedure for design of the toroidal transformer. There is extensive coverage of the technical aspect of design, within the design examples.

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