Introduction to ATPDraw version 5

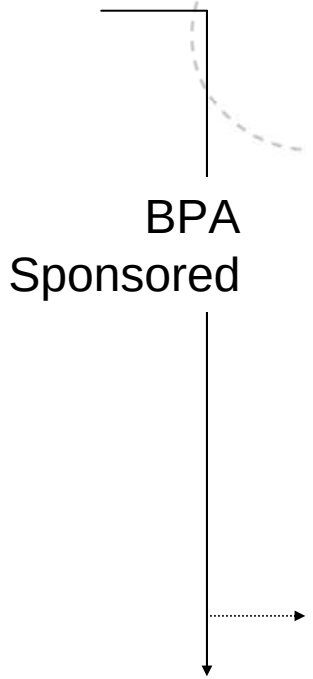
- Introduction to ATPDraw
- Multi-phase circuits
- Vector graphics
- Grouping
- Hybrid transformer
- Machines
- Models
- Lines&Cables

Introduction

- ATPDraw is a graphical, mouse-driven, dynamic preprocessor to ATP on the Windows platform
- Handles node names and creates the ATP input file based on ”what you see is what you get”
- Freeware
- Supports
  - All types of editing operations
  - ~100 standard components
  - ~40 TACS components
  - MODELS
  - $INCLUDE and User Specified Components

Introduction- ATPDraw history

- Simple DOS version
  - Leuven EMTP Centre, fall meeting 1991, 1992
- Extended DOS versions, 1994-95
- Windows version 1.0, July 1997
  - Line/Cable modelling program ATP_LCC
  - User Manual
- Windows version 2.0, Sept. 1999
  - MODELS, more components (UM, SatTrafo ++)
  - Integrated line/cable support (Line Constants + Cable Parameters)



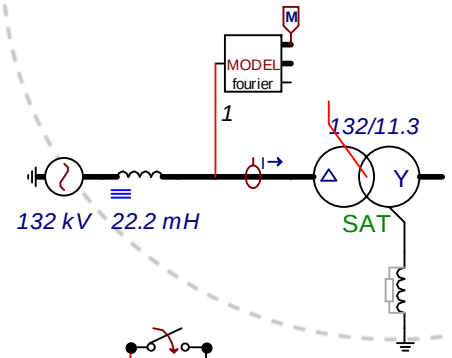
Introduction- ATPDraw history

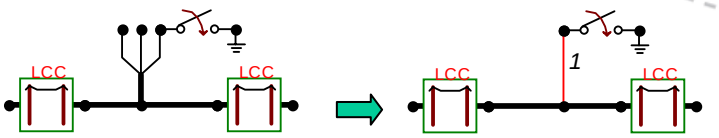
- Windows version 3, Dec. 2001
  - Grouping/Compress
  - Data Variables, $Parameter + PCVP
  - LCC Verify + Cable Constants
  - BCTRAN
  - User Manual @ version 3.5
- Windows version 4, July 2004
  - Line Check
  - Hybrid Transformer model
  - Zigzag Saturable transformer
- Windows version 5, Sept. 2006
  - Vector graphics, multi-phase cirucits, new file handling

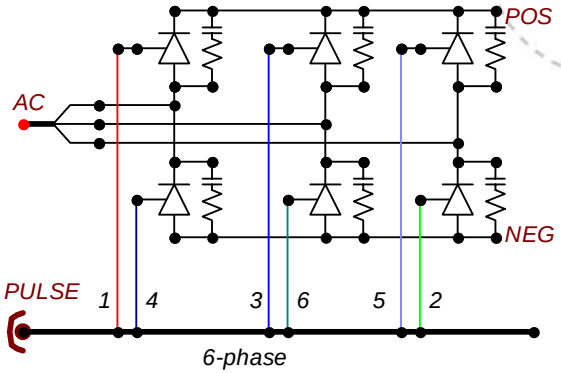
Latest news, Version 5.0 available from October 2006

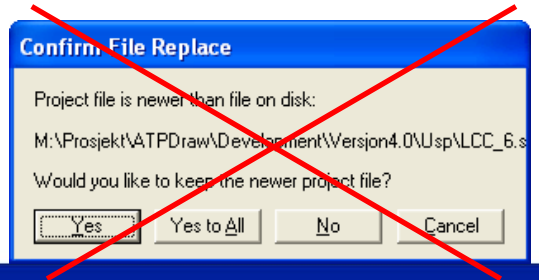
Sponsored by BPA & EEUG

- **Vector graphics**
  - Improved zoom
  - Larger, dynamic icon; RLC, transformer, switch…
  - Individual selection area
- **Multi-phase nodes**
  - 1..26 phases, A..Z extension
  - MODELS input/output X[1..26]
  - Connection between *n*-phase and single phase
  - 21 phases in LCC components
- **New file management**
  - Project file follows the PKZIP 2 format. Improved compression. acp-extension.
  - Sup-file only used when a component is created.
  - External data moved from files to memory.
  - Individual, editable help strings for all components.

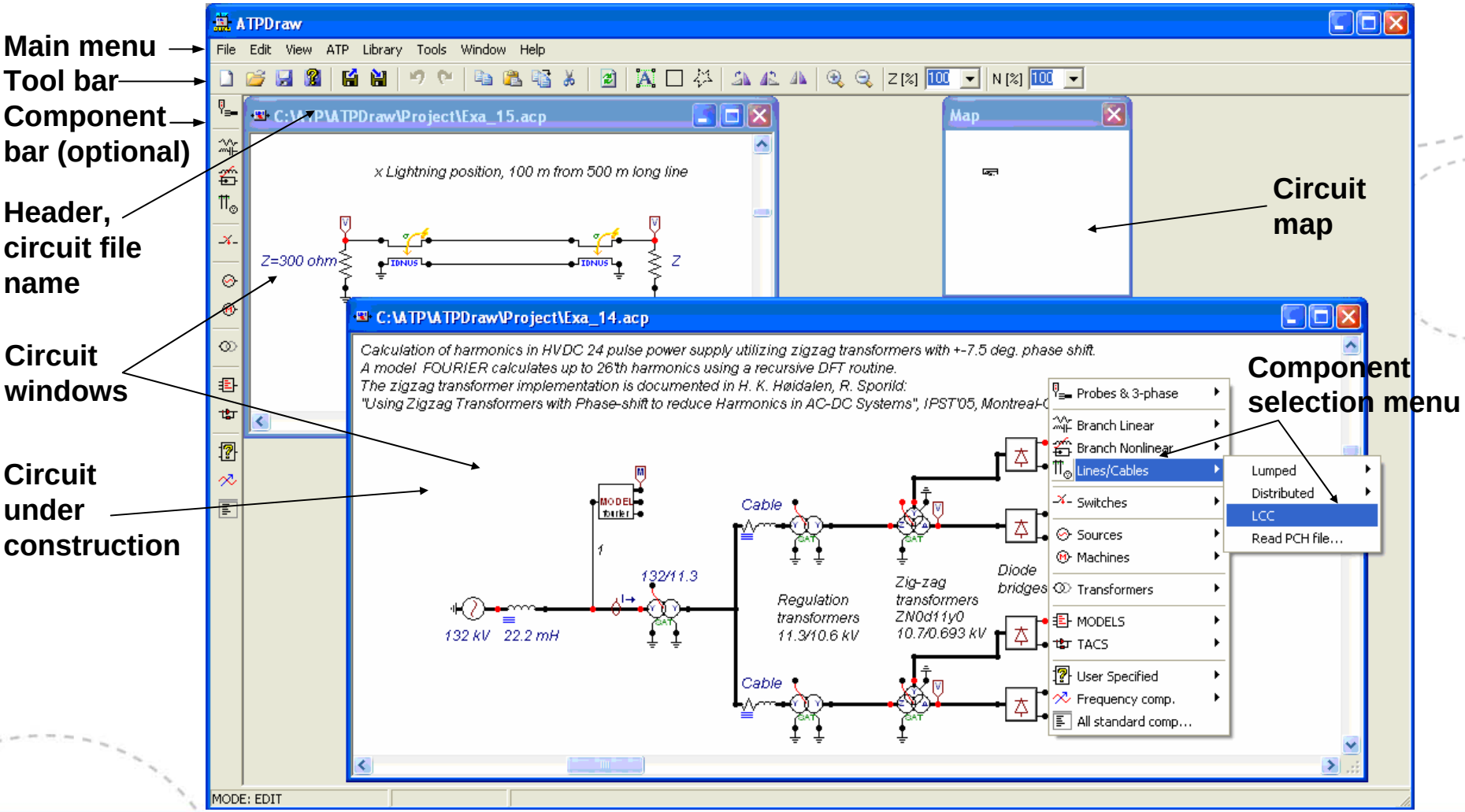




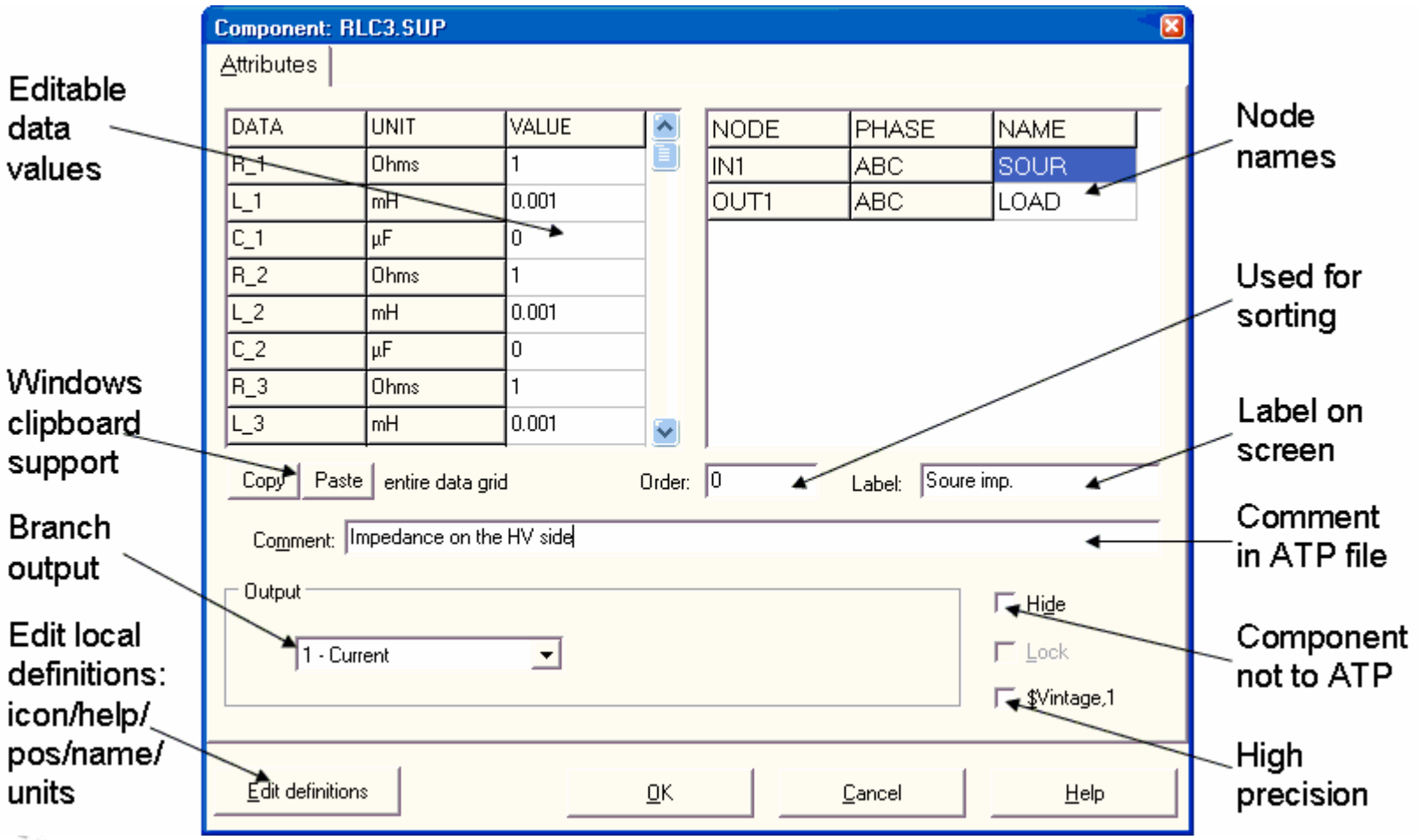




ATPDraw main windows, v5.2



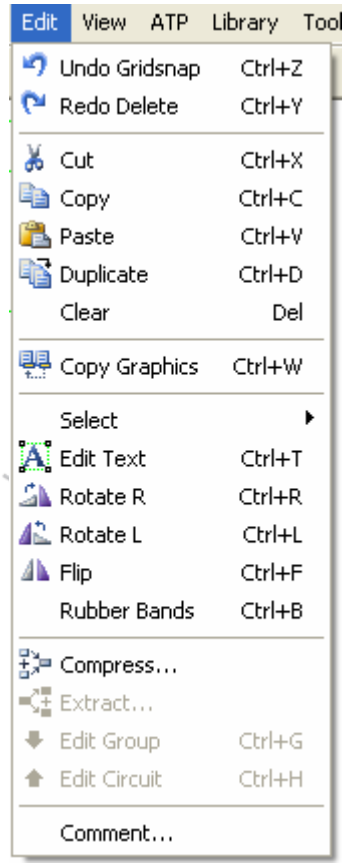
ATPDraw Component dialog



ATPDraw capability

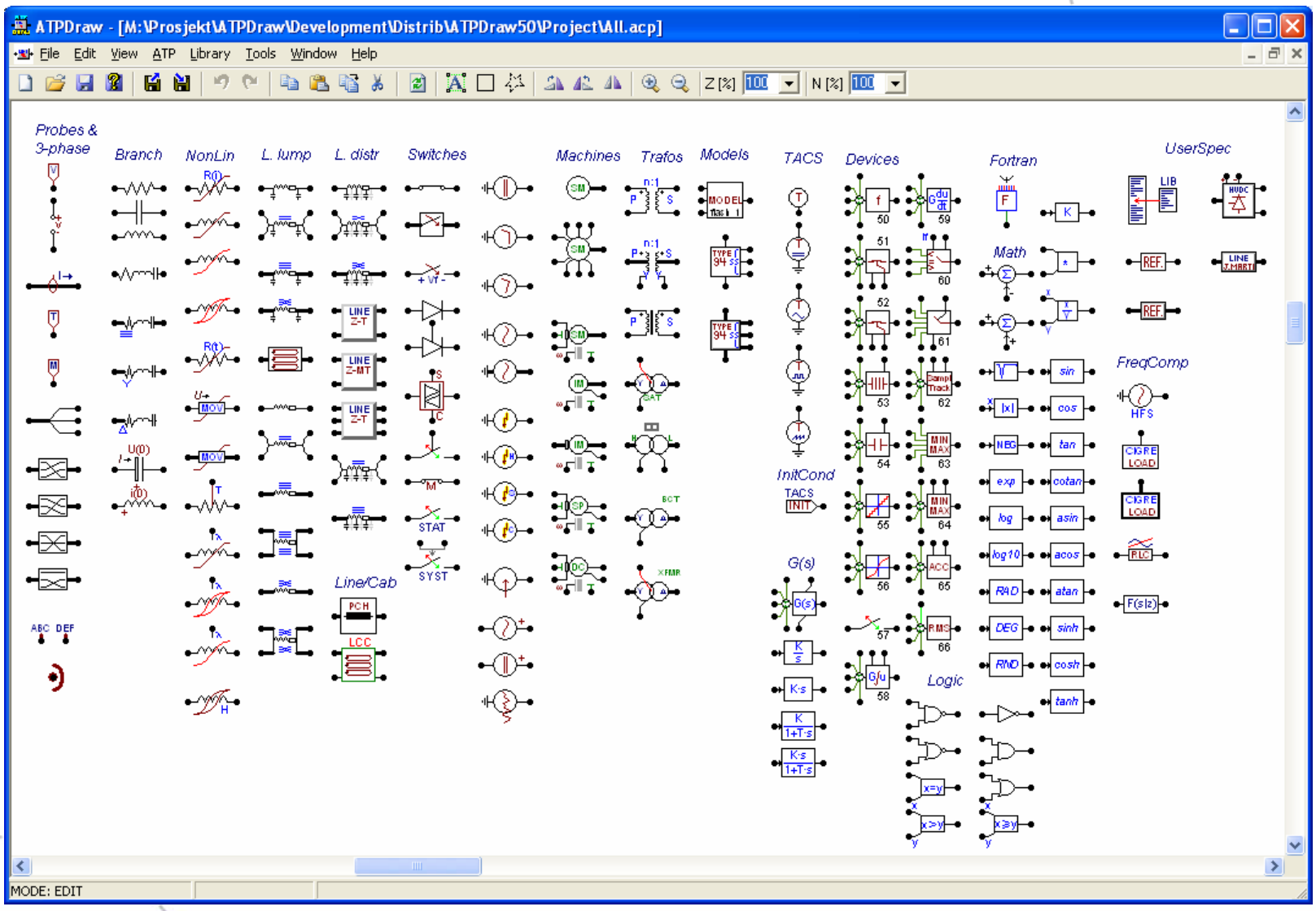
- 30.000 nodes
- 10.000 components
- 10.000 connections
- 1.000 text strings
- Up to 64 data and 32 nodes per component
- Up to 26 phases per node (A..Z extension)
- 21 phases in LCC module
- Circuit world is 10.000x10.000 pixels
- 100 UnDo/ReDo steps

ATPDraw Edit options



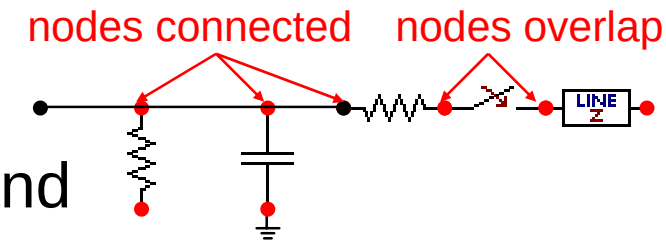
- Multiple documents
  - several circuit windows
  - large circuit windows (map+scroll)
  - grid snapping
- Circuit editing
  - Copy/Paste, Export/Import, Rotate/Flip,
  - Undo/Redo (100), Zoom, Compress/Extract
  - Windows Clipboard: Circuit drawings, icons, text, circuit data
- Text editor
  - Viewing and editing of ATP, LIS, model files, and help files
- Help file system
  - Help on ATPDraw functionality, all components, and MODELS

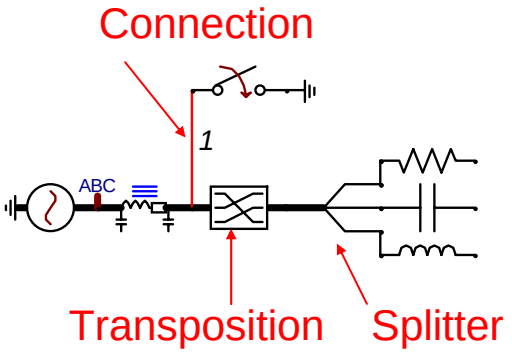
All standard components:



ATPDraw node naming

- "What you see is what you get"
- Connected nodes automatically get the same name
  - Direct node overlap
  - Positioned on connection
- Warnings in case of duplicates and disconnections
- 3-phase and *n*-phase nodes
  - Extensions A..Z added automatically
  - Objects for transposition and splitting
  - Connection between *n*- and single phase



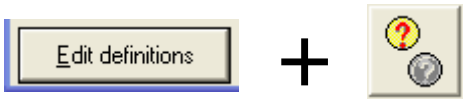


User's manual

- Documents version 3.5 of ATPDraw (246 pages), pdf
- Written by Laszlo Prikler and H. K. Høidalen
- Content
  - Intro: To ATP and ATPDraw + Installation
  - Introductory manual: Mouse+Edit, MyFirstCircuit
  - Reference manual: All menus and components
  - Advanced manual: Grouping/LCC/Models/BCTRAN + create new components
  - Application manual: 9 real examples

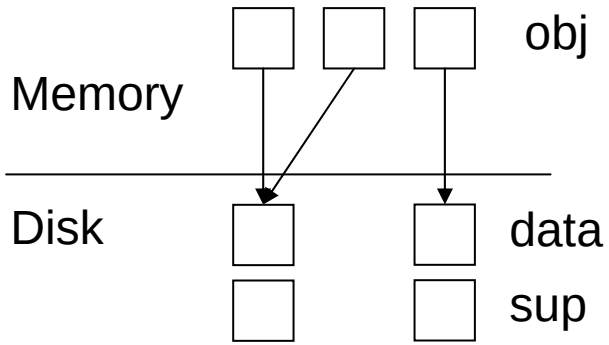
Files in ATPDraw

- Project file (acp): Contains all circuit data.
- Support file (sup): Component definitions. Used only when a component is added to the project.
  - Standard components: ATPDraw.scl
  - User defined components: Optionally in global library
- Data file (alc/bct/xfm): Contain special data
  - Stored internally in data structure
  - Optionally in global library
- Help file (sup/txt): User specified help text
  - Global help stored in sup-file or /HLP directory (txt file)
  - Local help created under *Edit definitions*



Data files in memory

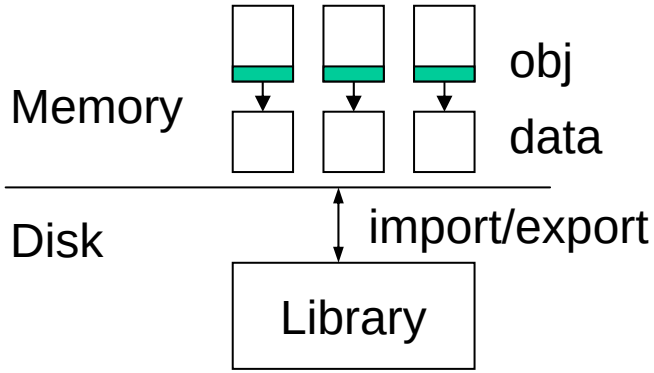
Old:



Problems:

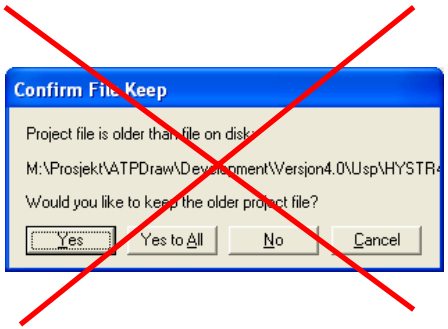
- Where? Lots of files/messy disk
- Conflicts between projects

New:



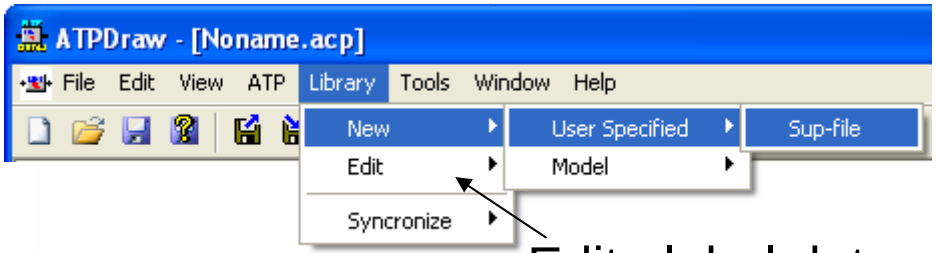
Solutions:

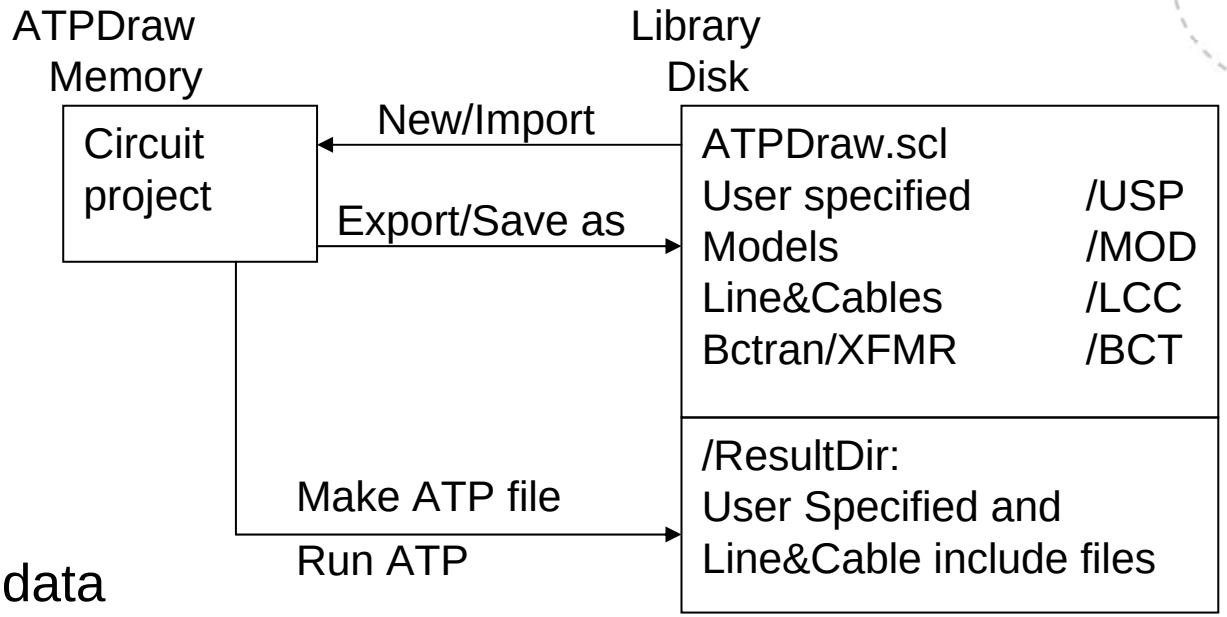
- No files extracted to disk
- Import/Export allowed
- Clear distinction between global library and projects
- No conflicts between projects

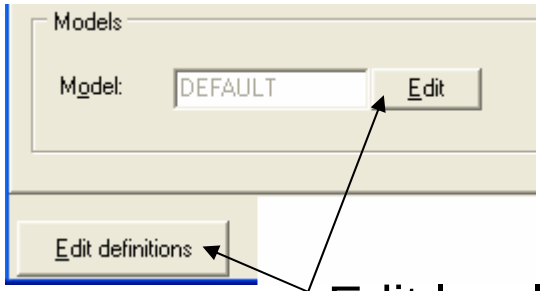


Project vs. Library: Local|Global

- When a new component is added to the project:
- All information copied into the project
- No links to files

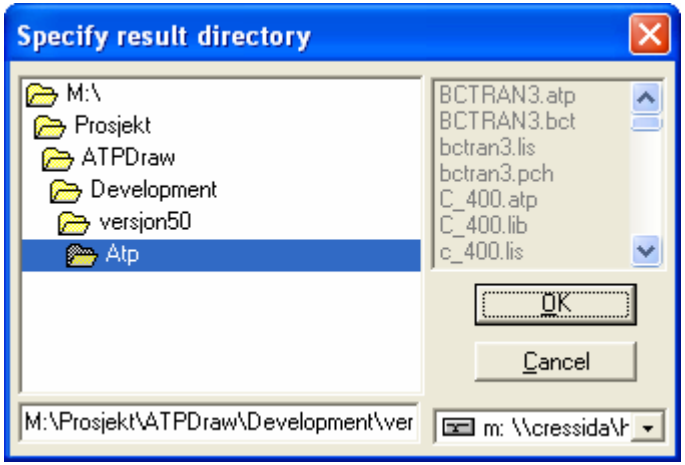






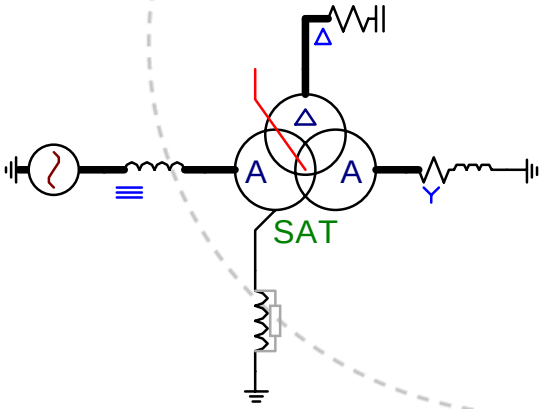
Result Directory

- The user initially specifies where the result should be stored (ATP and $Include files)

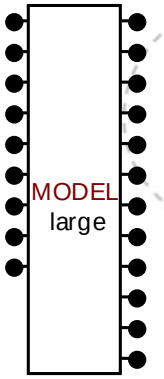


- ATPDraw.ini in APPDATA/ATPDraw

Vector graphics

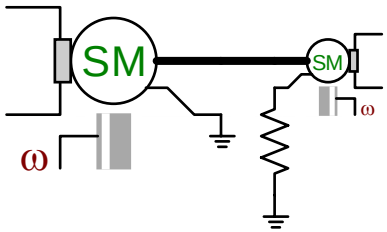


- Sponsored by EEUG (2007)
- Better zooming and dynamics

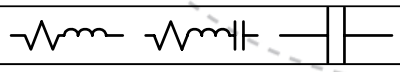
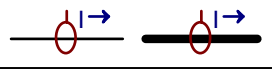
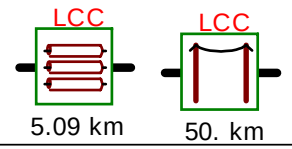
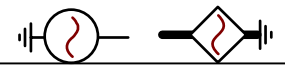
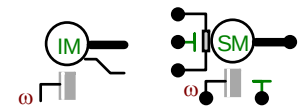
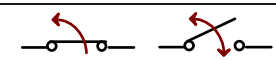
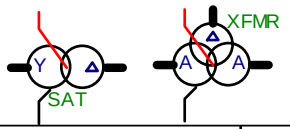
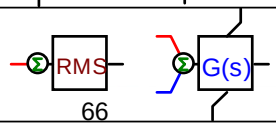


- Increased icon size 255x255 (from 41x41)
- Allow more nodes than 12

- Additional: Flipping & Individual scalable icons



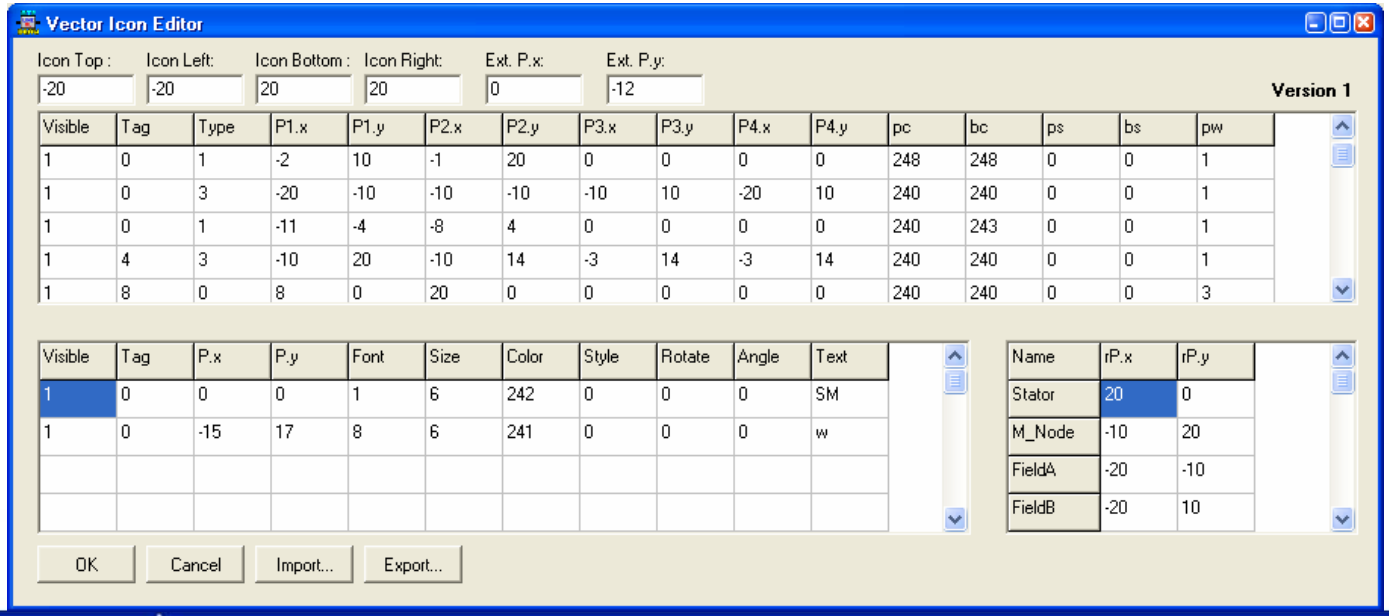
Dynamic icons

RLC, RLC3, RLCD3, RLCY3; R, L, C, RL, RC, LC, RLC appearance.	
PROBE_I (Current probe); Single phase or three phase appearance.	
LCC; Overhead line, single core cable, or enclosing pipe appearance. Length of transmission line optionally added.	
All sources; current (rhomb) or voltage (circle) source appearance.	
Universal machines; manual/automatic initialization, neutral grounding.	
TSWITCH (Time controlled switch); opening/closing indications.	
Transformers; Coupling (Wye, delta, auto, zigzag), two/three windings.	
TACS summation. Positive (red), negative (blue), or disconnected input. Click on the nodes to activate.	

Vector icon editor

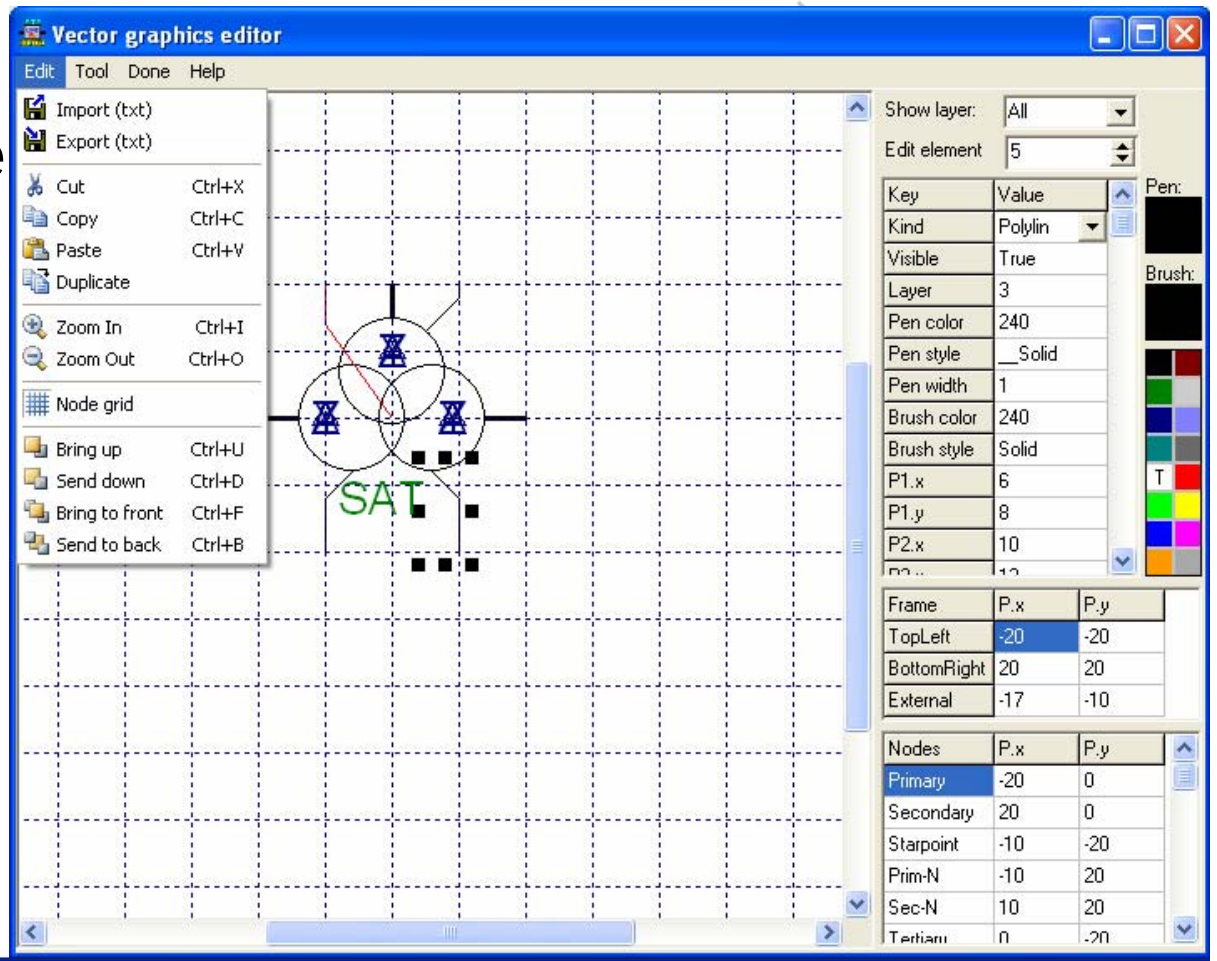
- Difficult for the user to change the default icons
  - Vector elements
  - Node positions
- Vector editor is text based.
  - Shapes and Texts

Shapes:



New vector editor (v.5.2)

- Still text based
- No mouse response
- Visual response
- Color support
- Element ordering



Multi-phase circuits

- EEUG sponsored project
- Why?
  - Problems and bugs related to the Splitter
  - Better support of MODELS input/output arrays
  - Need for multi-phase communication in Groups and Models

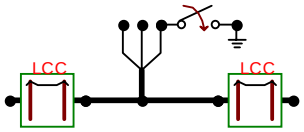
Principles

- Nodes and connections extended to 26-phase (A..Z node name extension)
- Only 3-phase nodes transposed
- Model arrays X[1..26] supported
- Special connection between single phase and *n*-phase node
- Connection properties: Color, label, phase carried
- Extended Probe capabilities
- LCC module capability increased to 21 phases

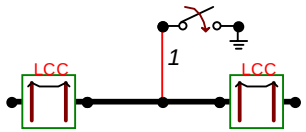
Example 1

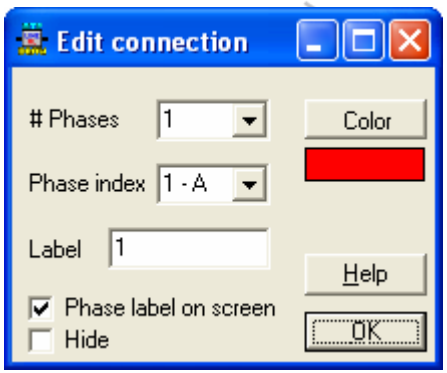
- Single phase to 3-phase connection

Old:



New:

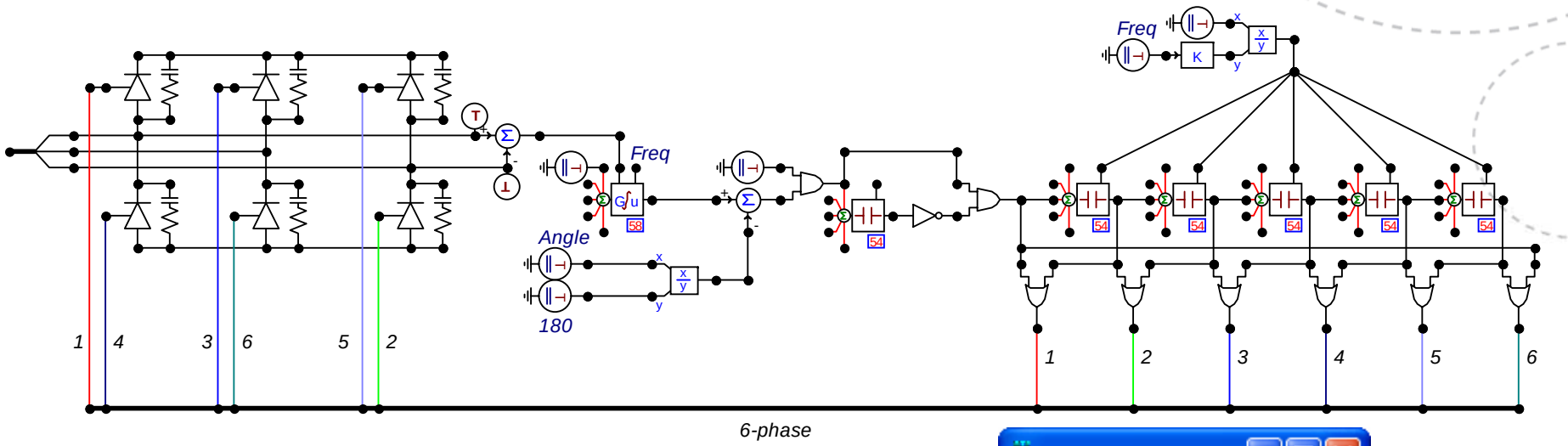




- The Splitter carries Transpositions the single phase connection not.

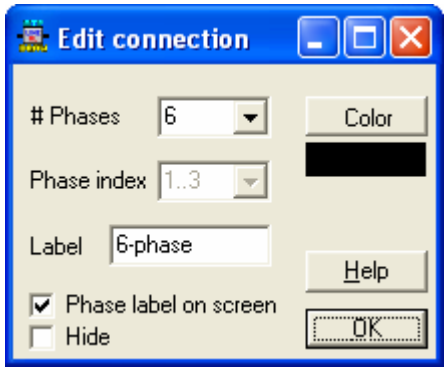
Example 2

- Multi-phase connections



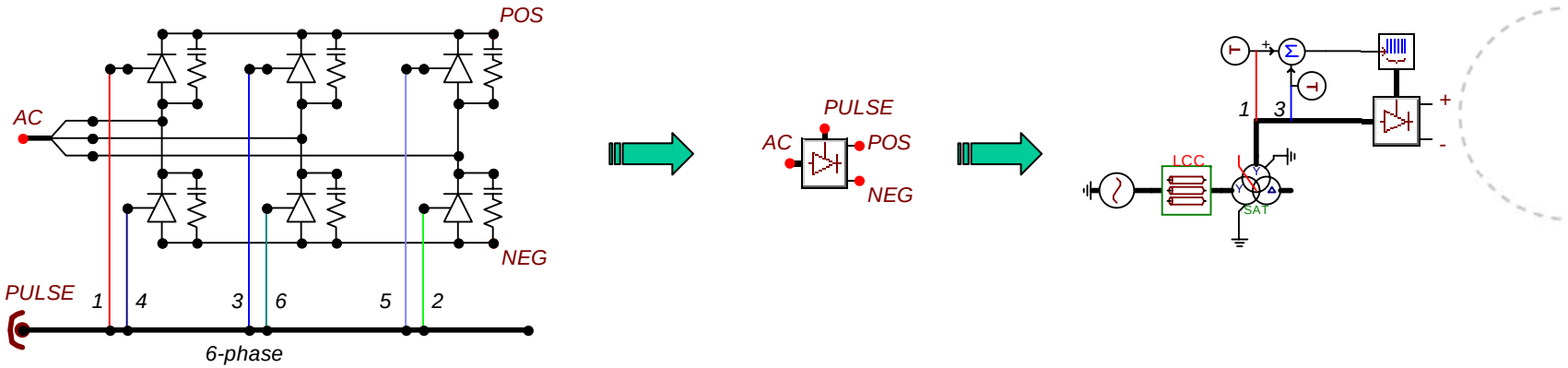
6-phase

- Increased circuit readability



Example 3

- Multi-phase groups



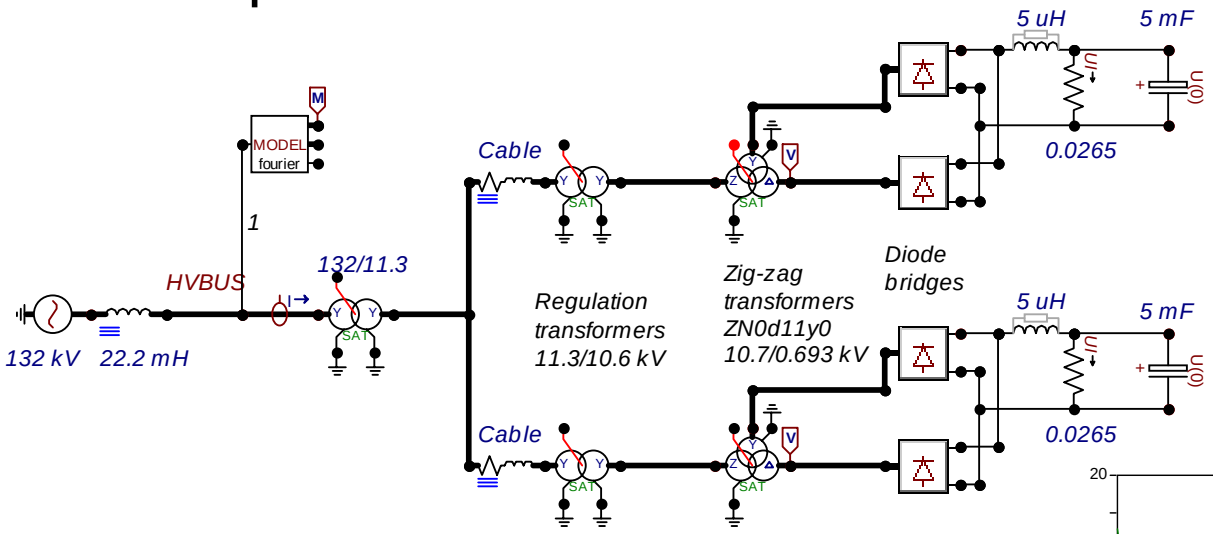
- New component: Collector

Example 4

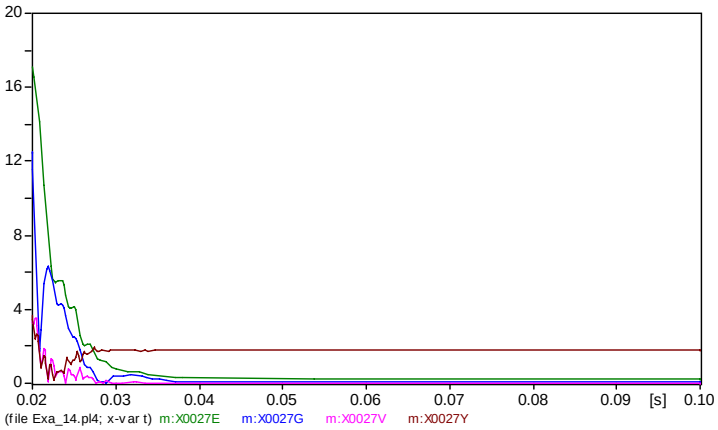
```
MODEL FOURIER
INPUT X               --input signal to be transformed
DATA  FREQ {DFLT:50} --power frequency
      n {DFLT:26}    --number of harmonics to calculate

OUTPUT absF[1..26], angF[1..26],F0 --DFT signals
VAR    absF[1..26], angF[1..26],F0,reF[1..26], imF[1..26],
       i,NSAMPL,OMEGA,D,F1,F2,F3,F4
```

- Multi-phase Models

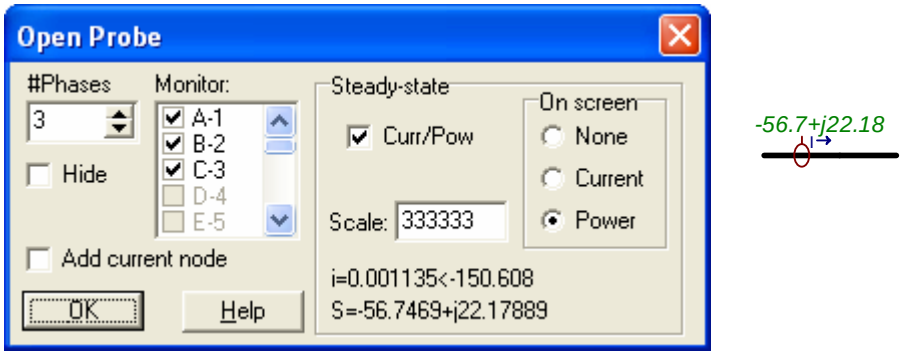


- New Model probe



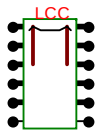
Example 5

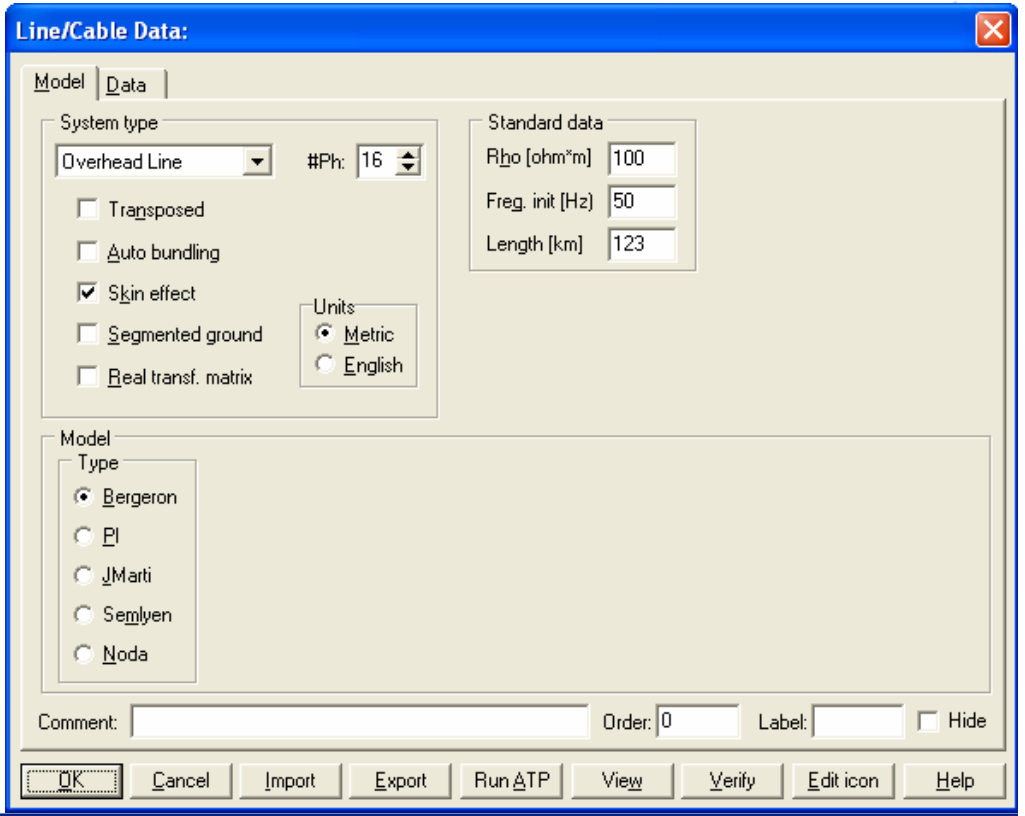
- Extended Probe capabilities
  - Monitor 1-26 phases
  - Read and display steady-state values



Example 6

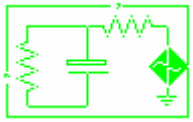
- Increased LCC capability
- 16-phase overhead line:

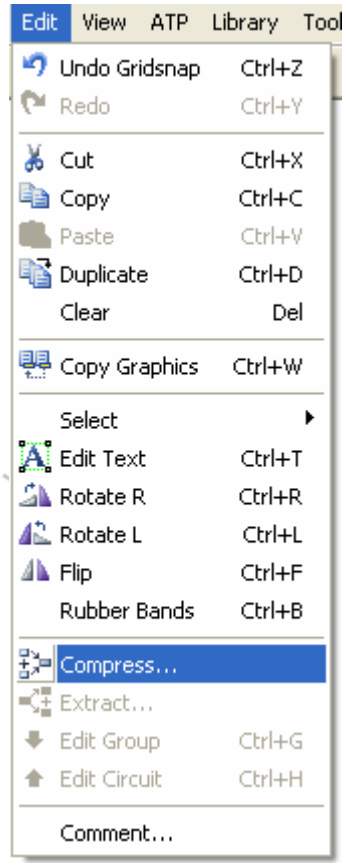


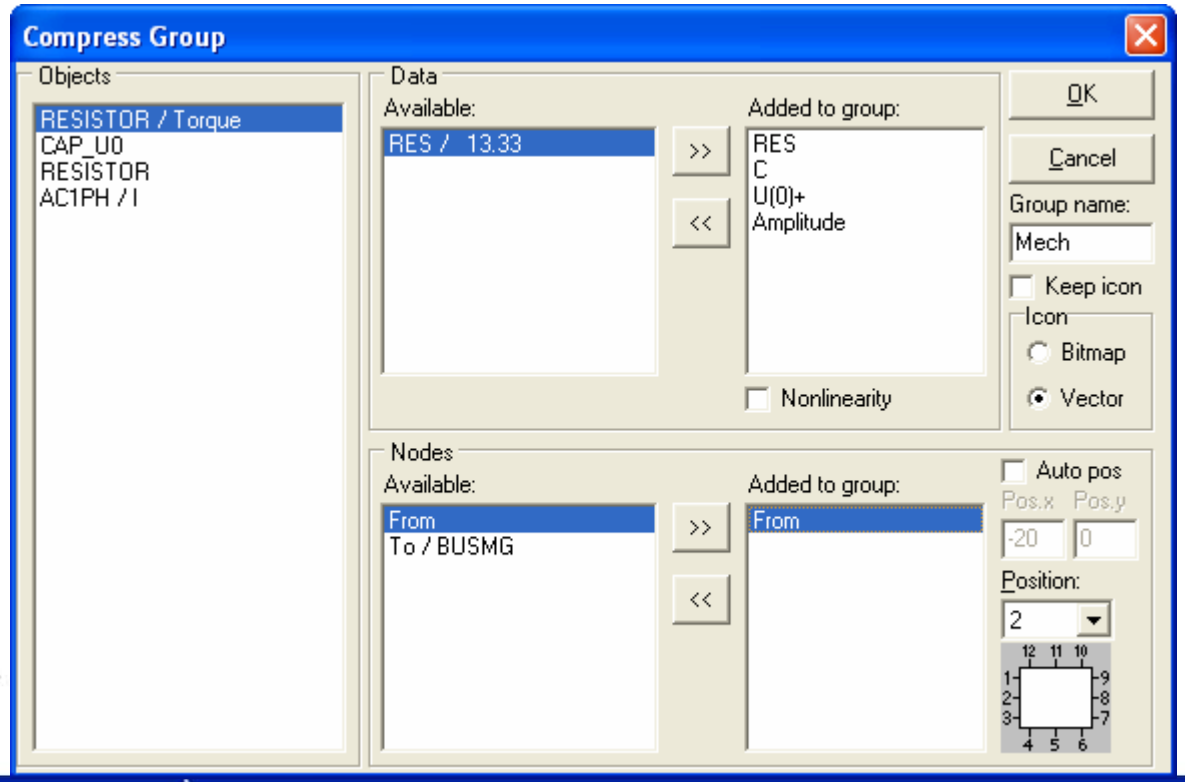


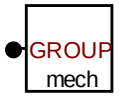
Grouping

- Select a group (components, connections, text)
- Click on Edit|Compress
- Select external data/nodes

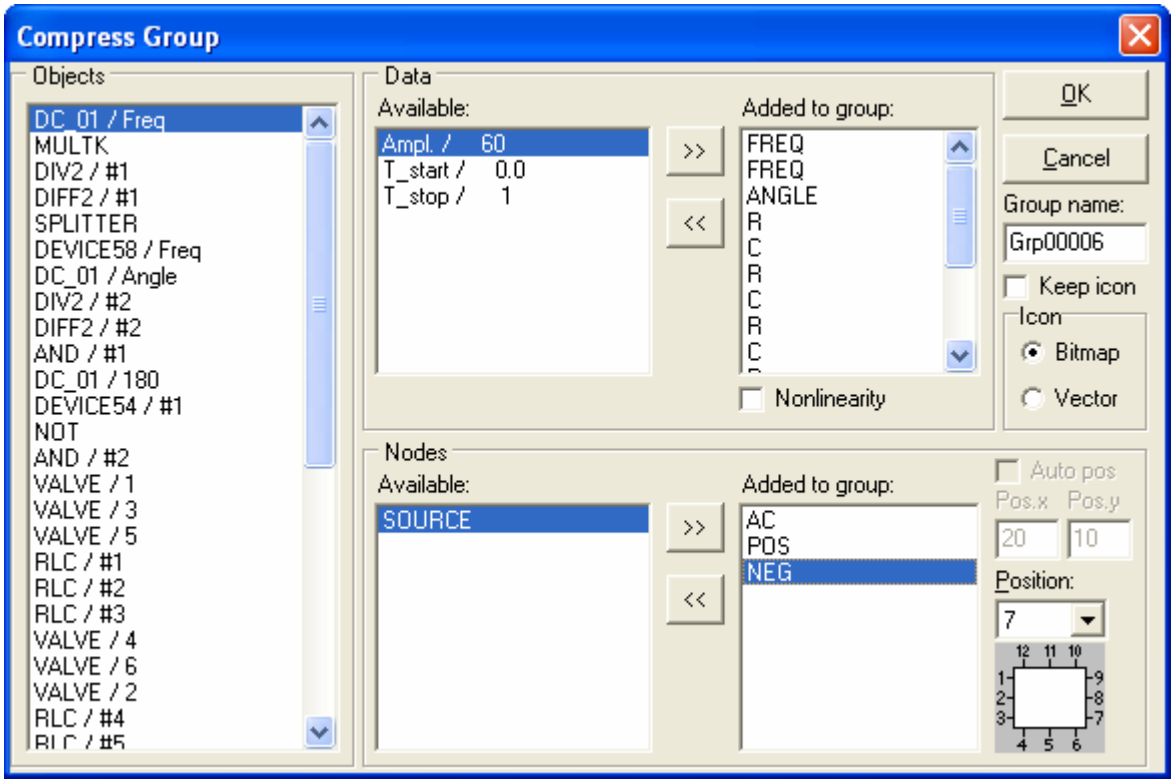








Compress dialog



Note:

Group name: just for icon

Keep icon: in case of recompress

Chose between Bitmap/Vector

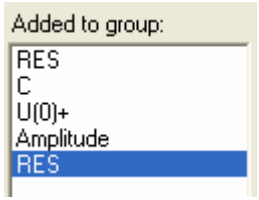
Vector supports automatic node positioning

Old style 1-12 borderpos kept

Specify Position=0 to enable (x, y) pos.

Grouping - special

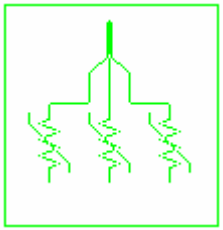
- Data with the same name appear only once in the input dialog
  - Data value copied
  - Double click on name to change

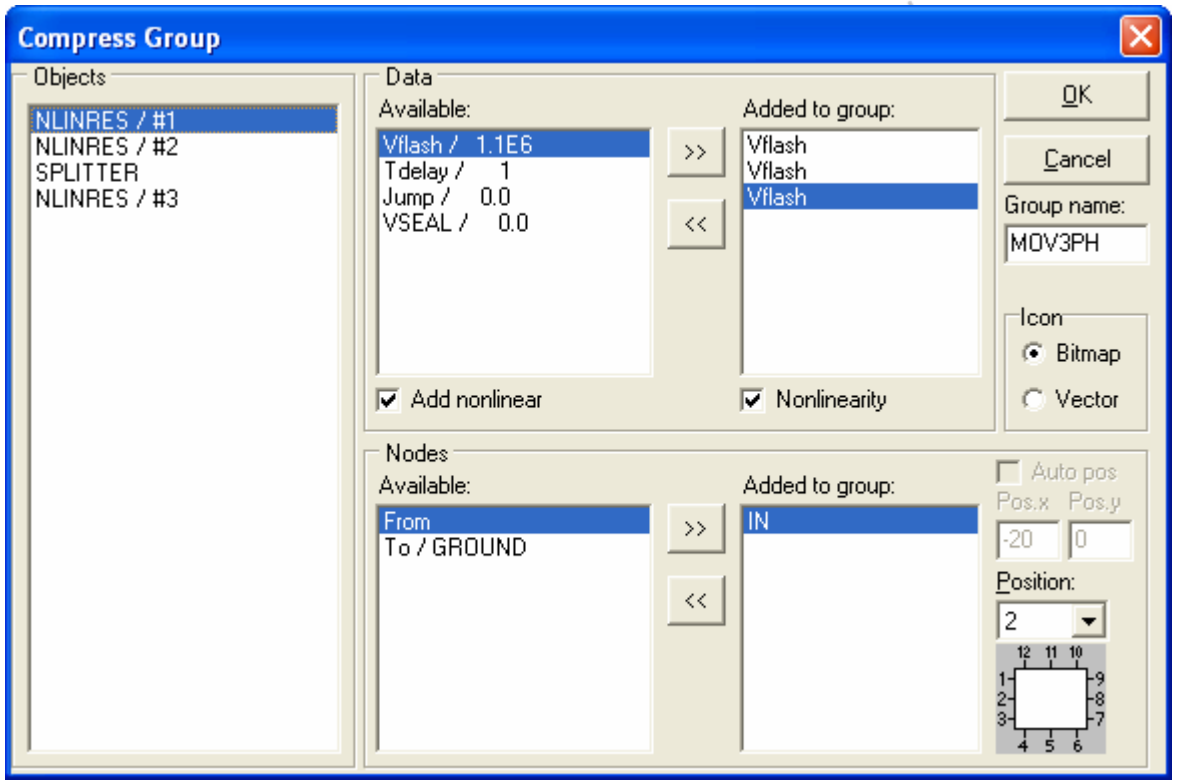


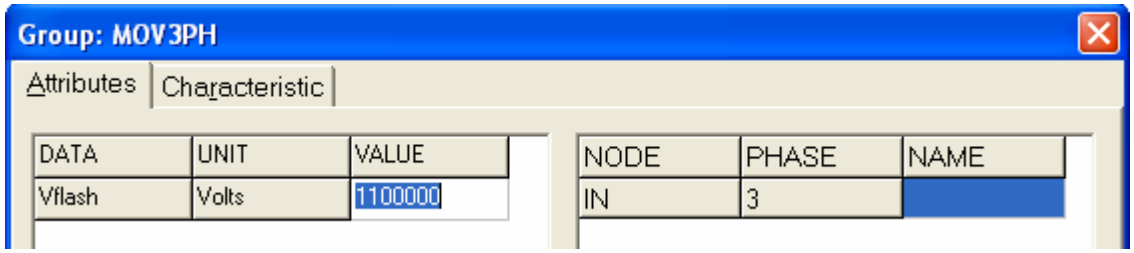
DATA	UNIT	VALUE
RES	Ohms	13.33
C	uF	5000000
U(0)+	Volts	182.840692
Amplitude	Volts/Amps	-374.03889

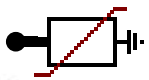
- Nonlinear characteristic supported

Example Create 3-phase MOV



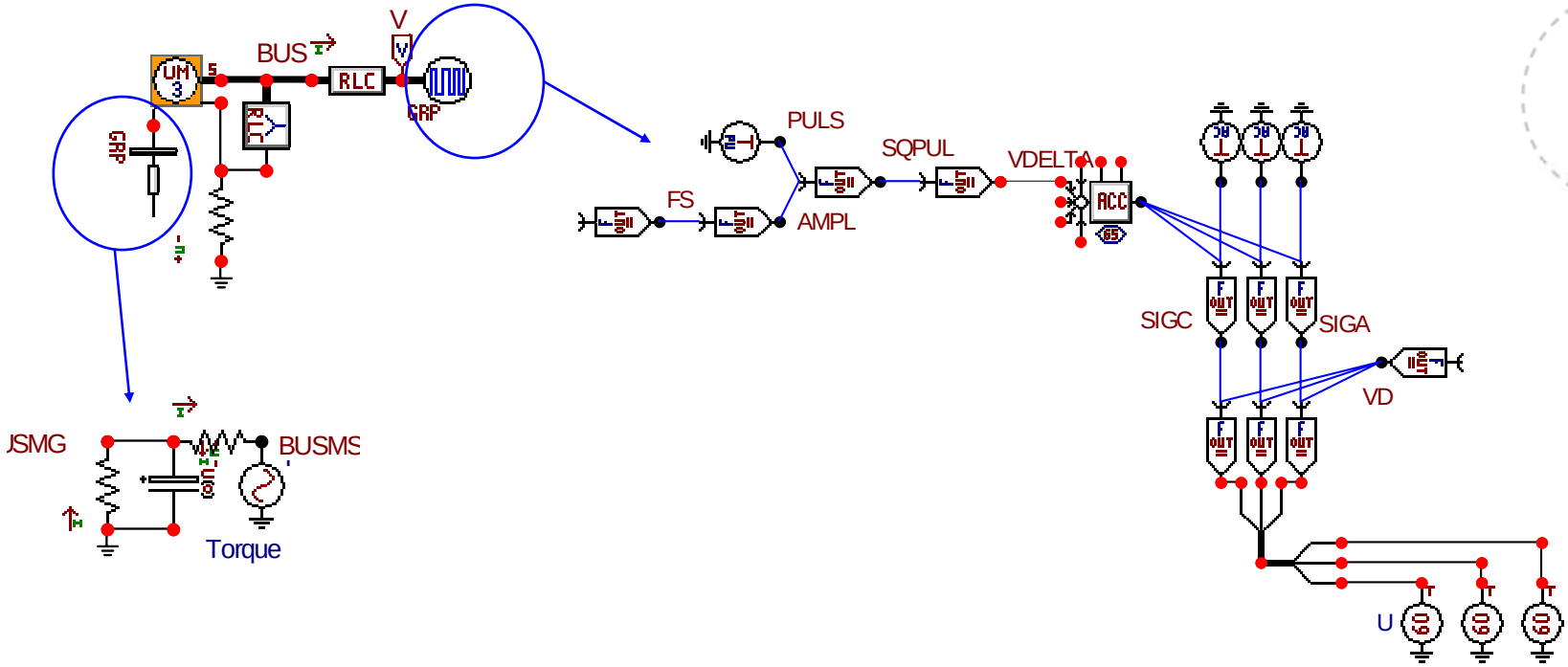






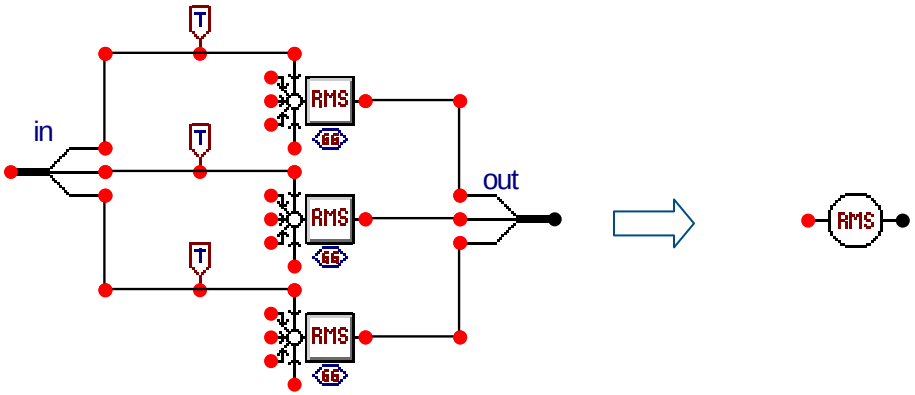
Example – Induction motor

- Induction motor fed by a pulse width modulated voltage source
- External mechanical load

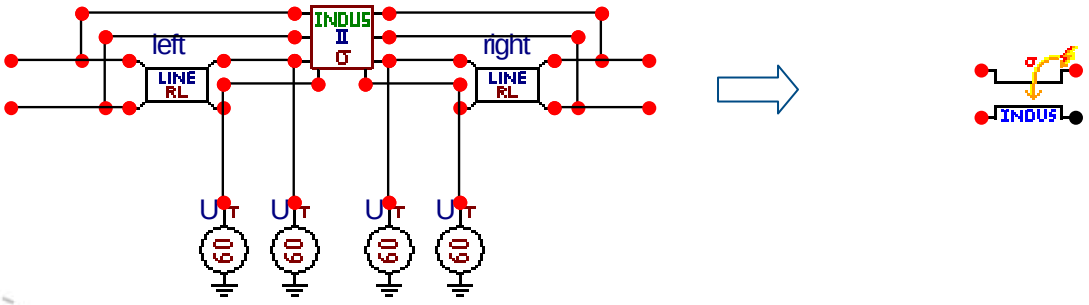


Examples

- 3-phase RMS-meter

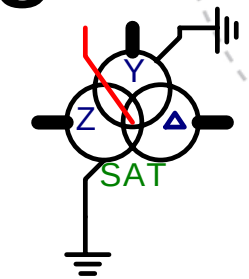


- Lightning-induced voltage in 2-phase overhead line

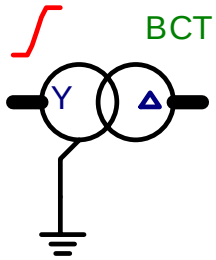


Transformer modeling

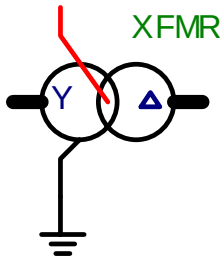
- Saturable Transformer



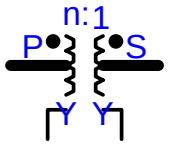
- BCTRAN



- Hybrid Transformer



- Ideal

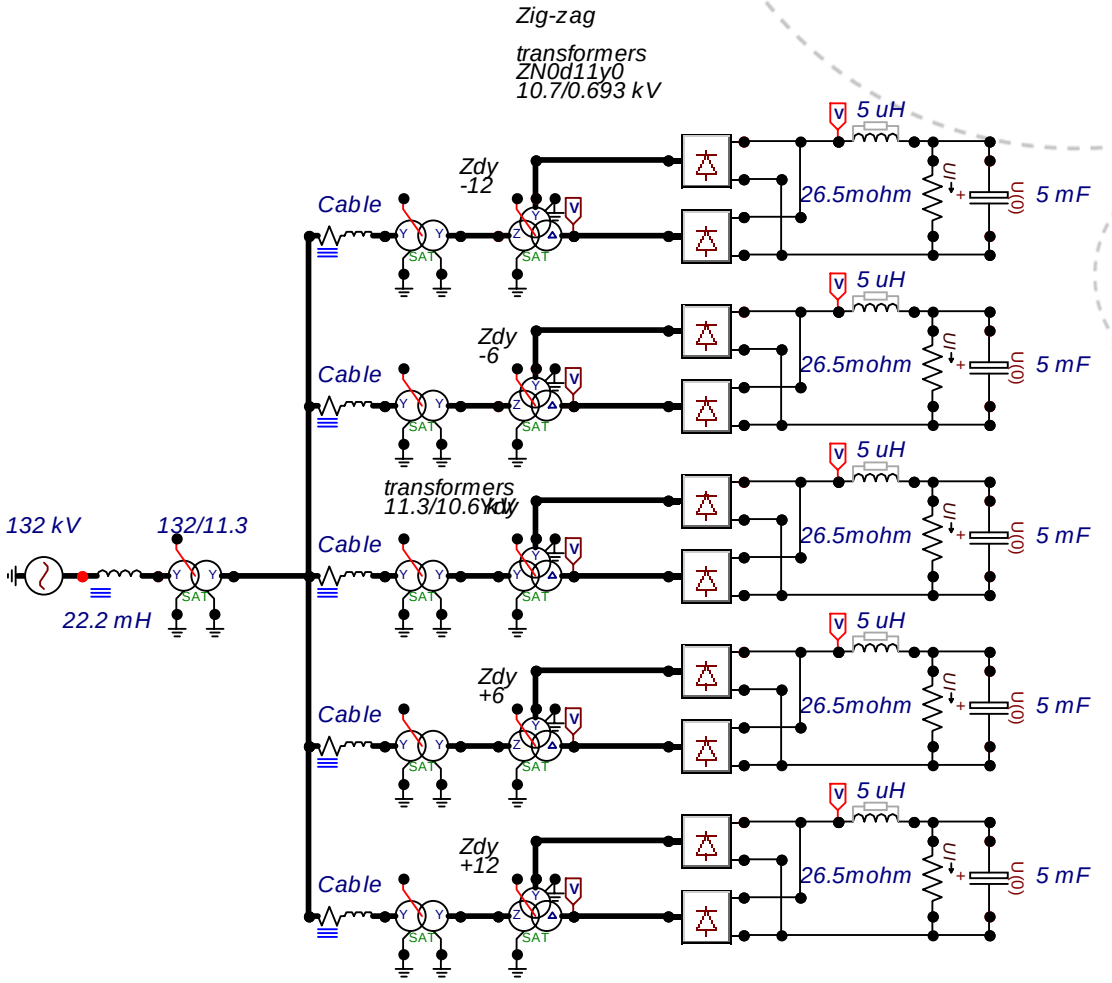


Saturable transformer

- Zigzag supported

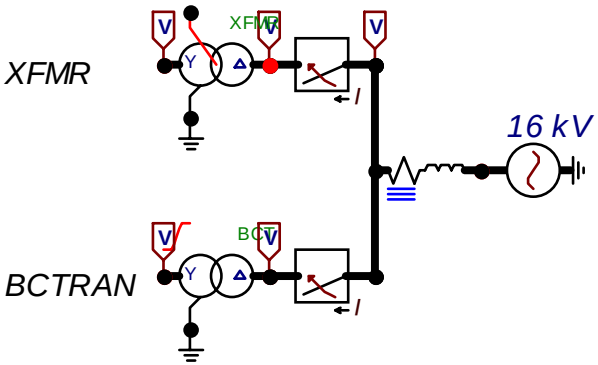
	Prim.	Sec.	Tert.
U [V]	85.92	2.11	1.23
R [ohm]	-0.064193	0.00019	6.6E-5
L [mH,ohm]	1.2260045	0.00973	0.00331
Coupling	Z	D	Y
Phase shift	-12	330	0
I(0)=	0	Rm=	0
F(0)=	0	R0=	1E12

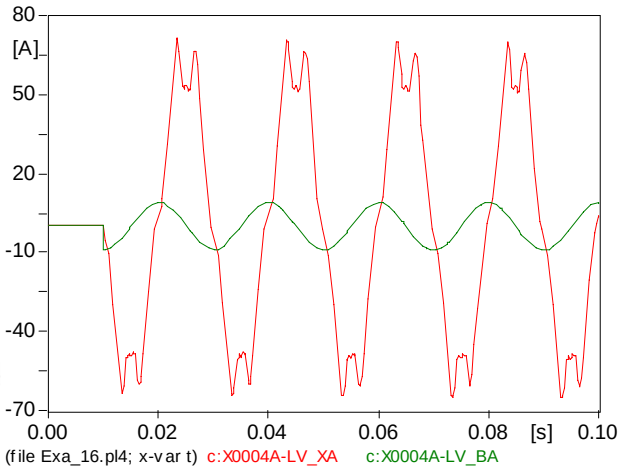
3-leg core
RMS
3-winding

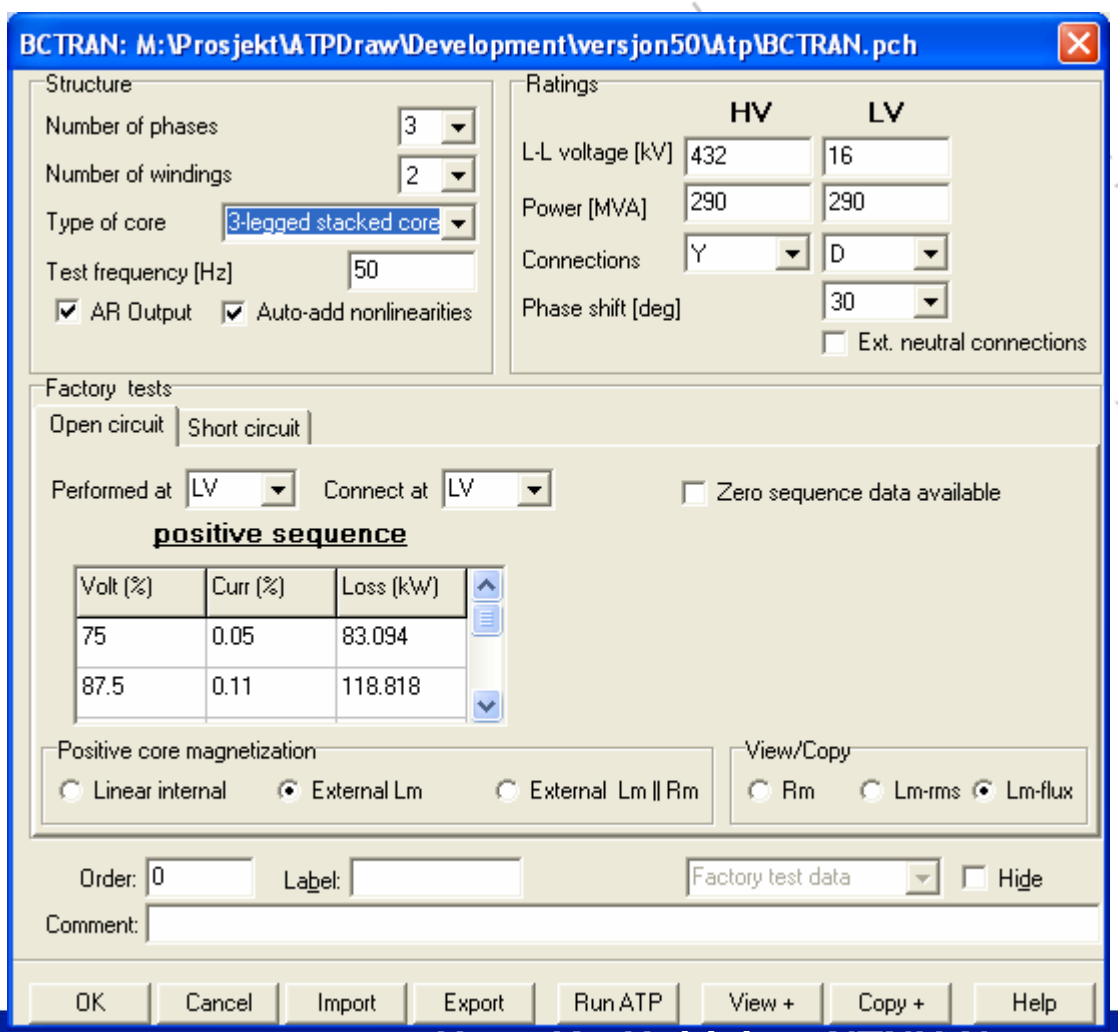


BCTRAN

- Automatic inclusion of external magnetization characteristic



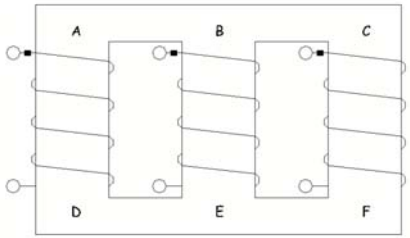




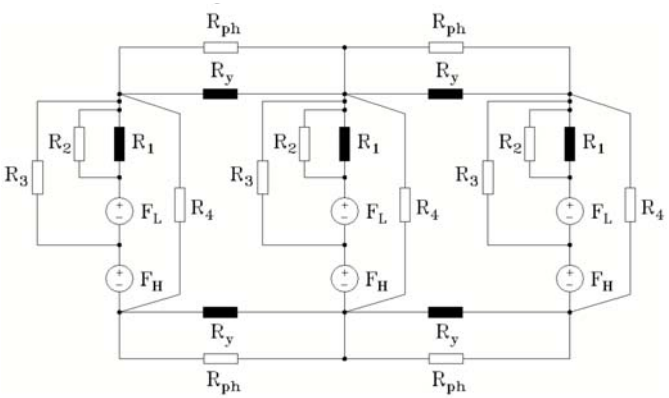
Hybrid Transformer model - XFMR

- The model includes:
  - an inverse inductance matrix for the leakage description,
  - frequency dependent winding resistance,
  - capacitive coupling,
  - and a topologically correct core model with individual saturation and losses in legs and yokes.
- The user can base the transformer model on three sources of data:
  - **Design parameter**: specify geometry and material parameters of the core and windings.
  - **Test report**: standard transformer tests.
  - **Typical values**: typical values based on the voltage and power ratings.

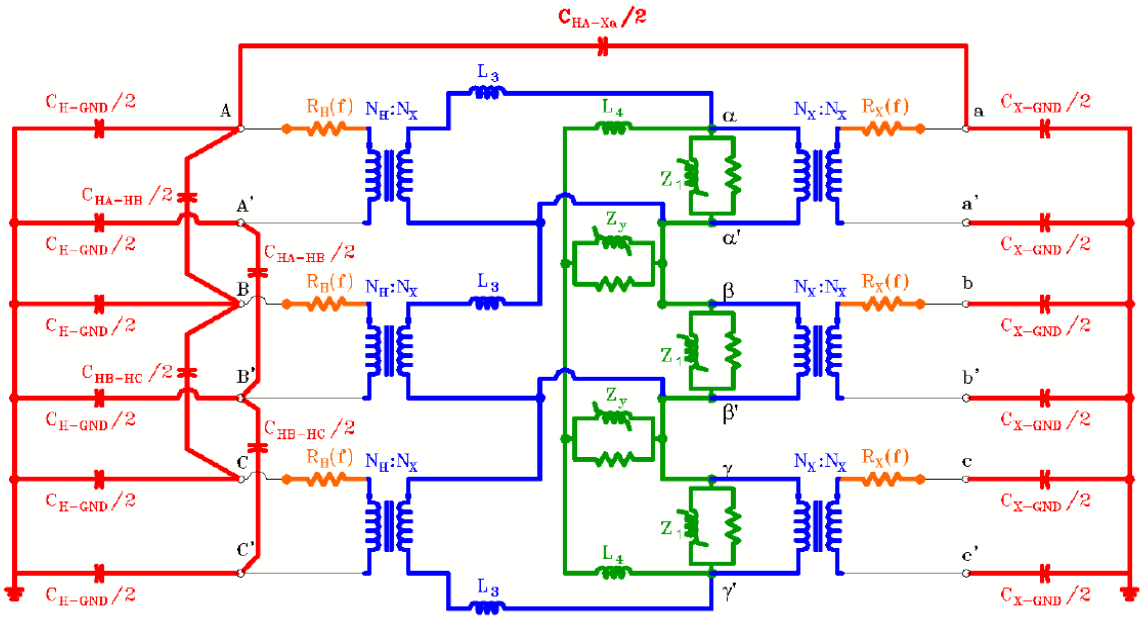
1. Physical Structure

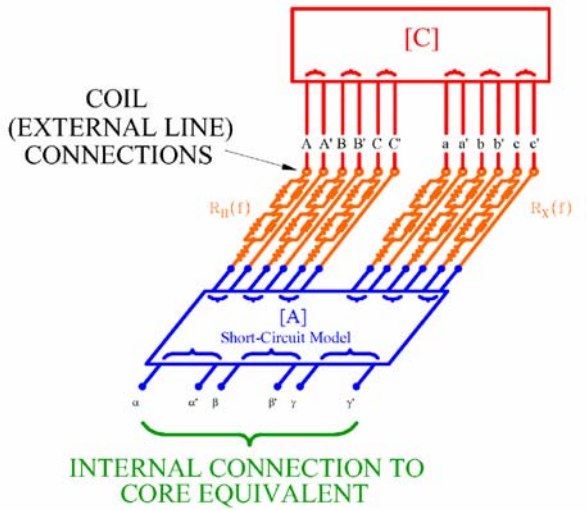


2. Magnetic Circuit



3. Dual Electric Circuit, Hybrid Model



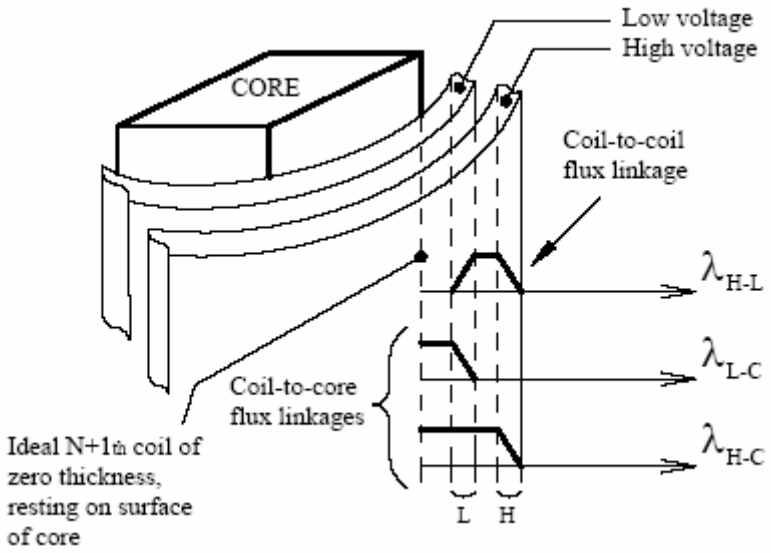


- Core representation
- Leakage representation
- Resistance
- Capacitive effects

– Leakage representation

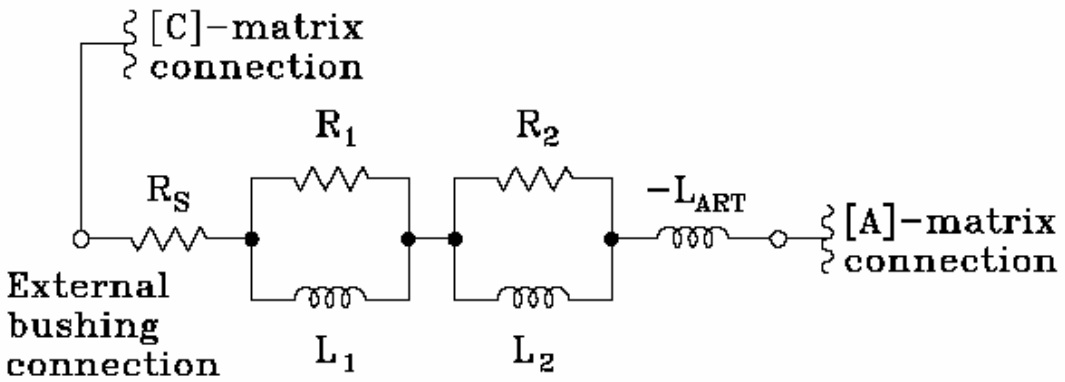
- Corresponds to the [A] = $[L]^{-1}$ matrix
- Takes into account the coils turn ratios
- Introduces artificial N+1th winding at core surface
- No mutual coupling between the phases

equivalent core is attached to
a fictitious N+1th winding

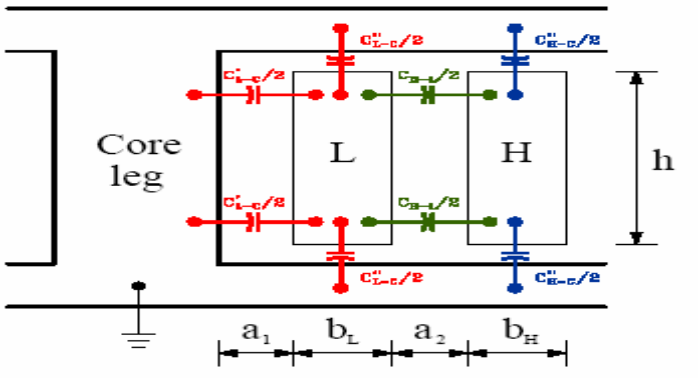


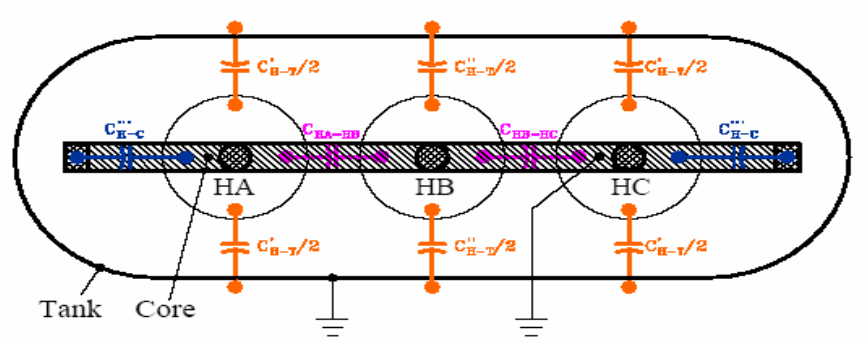
– Resistance (winding)

- Their dependence on the frequency is due to
  - Skin effects
  - Proximity effects
  - Eddy currents
- The frequency-dependency of R is represented using Foster equivalent circuit (two cells)



– Capacitive effects

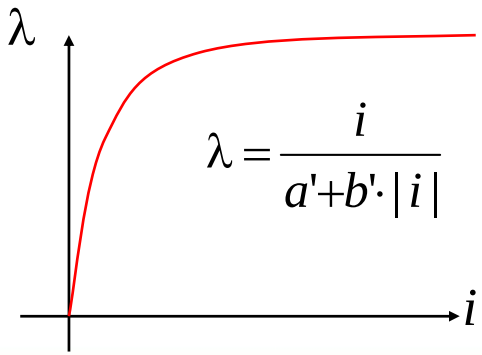


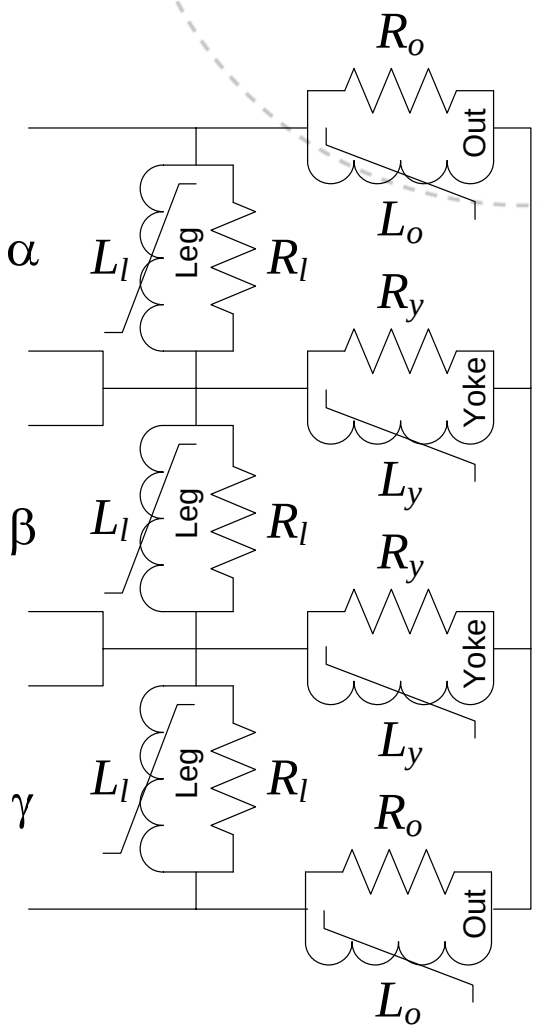


- Capacitances between high and low voltage windings and core
- Capacitance between high voltage phases, outer legs, and grounded elements

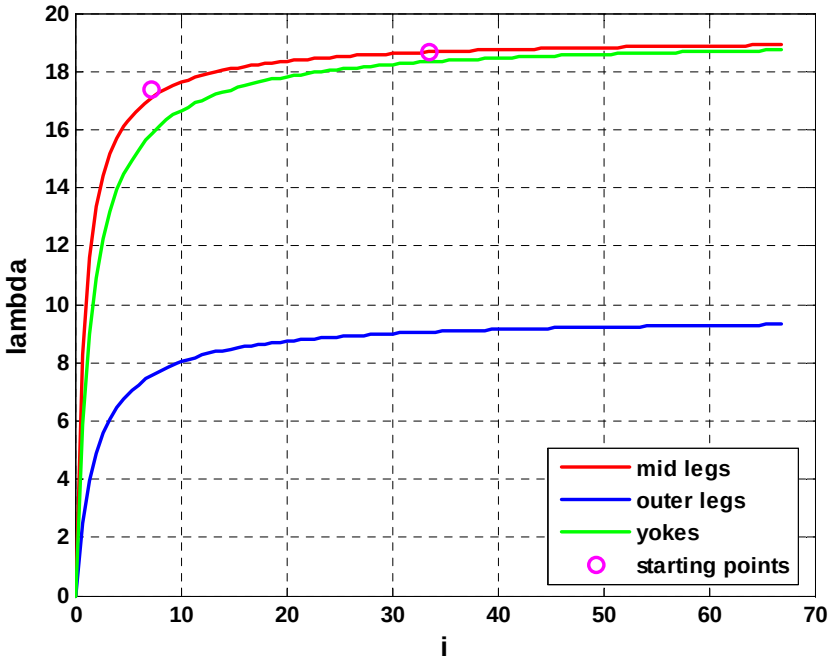
– Core representation

- Attached to the fictitious N+1th winding
- Topologically “correct” core model, with nonlinear inductances representing each leg and limb
  - Triplex
  - 3- and 5-legged core
- Flux linkage-current relation by Frolich equation and relative lengths and areas.
- Fitting to Test Report



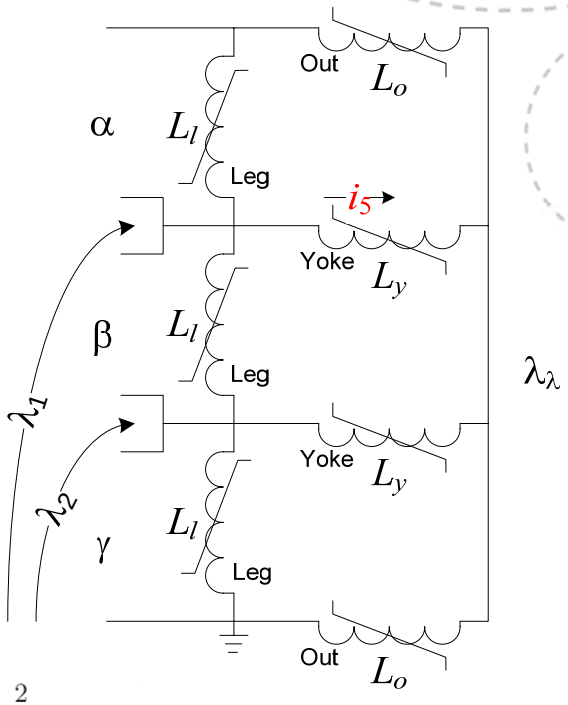


Parameter Estimation, Test Report



Relative areas and lengths

$$i_5 = \frac{l_y \cdot a \cdot (\lambda_1 - \lambda_\lambda)}{A_y - b \cdot |\lambda_1 - \lambda_\lambda|}$$

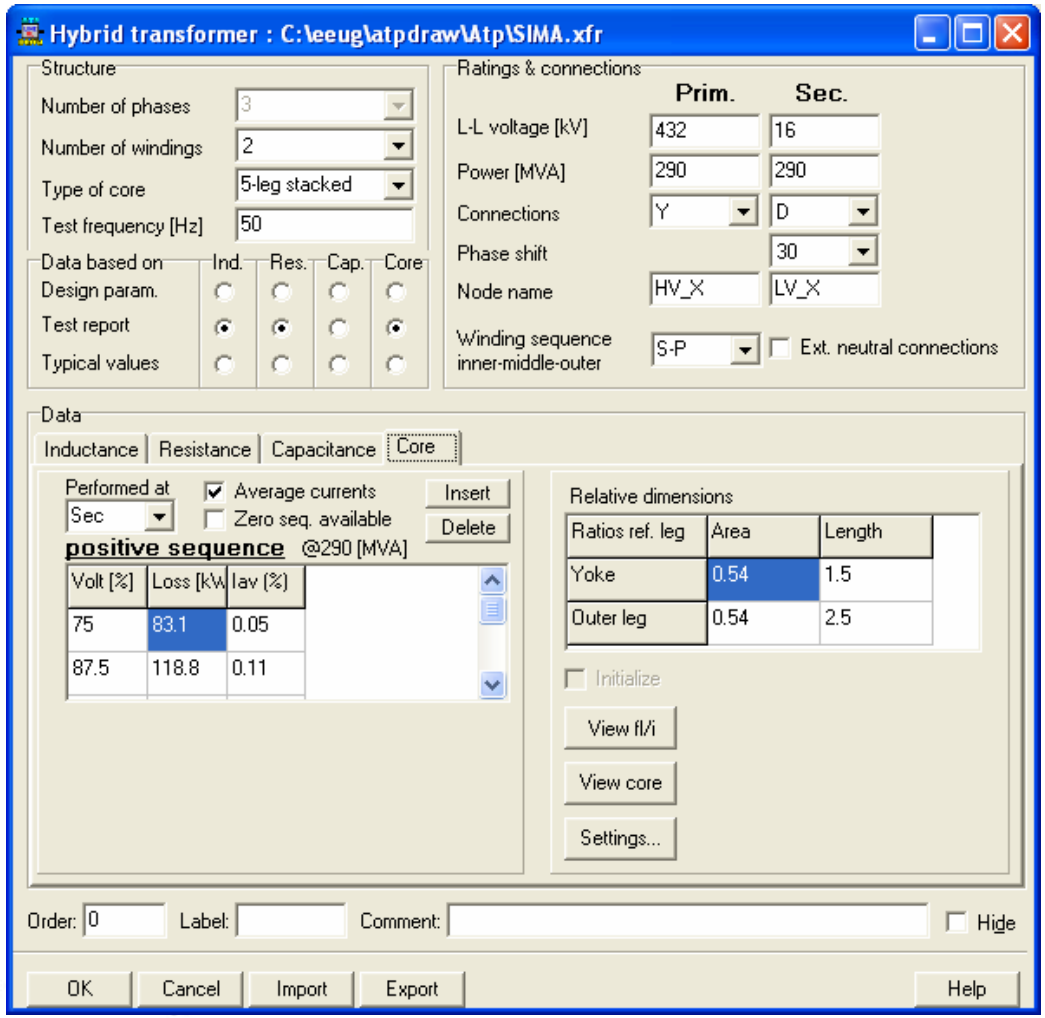


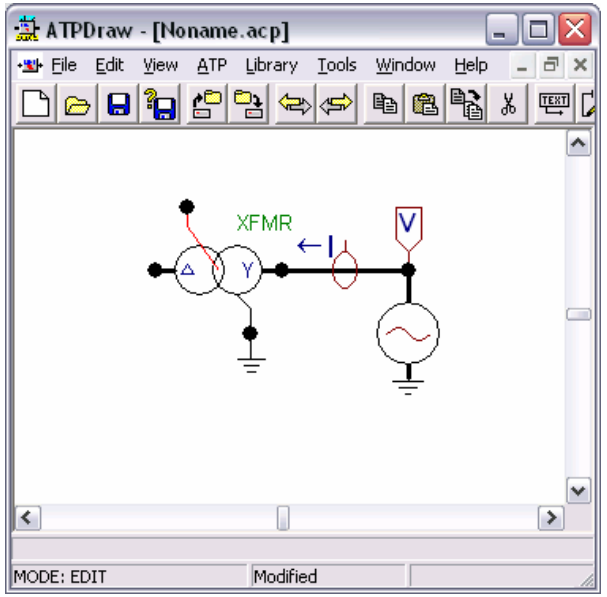
5-legged core

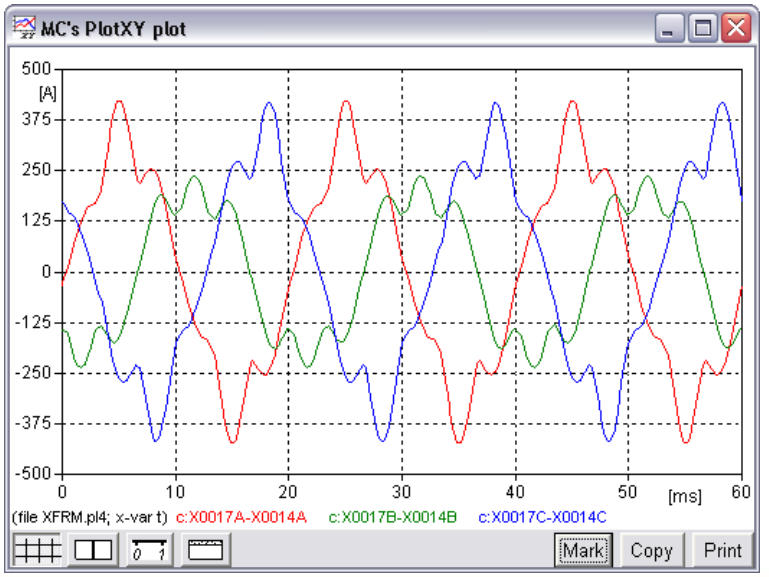
Nonlinear optimization routine, fitting test report

$$MinimizeF(a,b) = \left(\frac{I_{rms,meas}@100\%V - I_{rms,calc}@100\%V}{I_{rms,meas}@100\%V}\right)^2 + \left(\frac{I_{rms,meas}@110\%V - I_{rms,calc}@110\%V}{I_{rms,meas}@110\%V}\right)^2$$

Snapshots

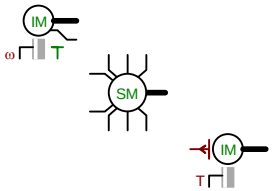

Hybrid transformer : C:\eeug\atpdraw\Atp\SIMA.xfr
Structure
Number of phases
Number of windings
Type of core
Test frequency [Hz]
Data based on
Design param.
Test report
Typical values
Ind.
Res.
Cap.
Core
Ratings & connections
Prim.
Sec.
L-L voltage [kV]
Power [MVA]
Connections
Phase shift
Node name
Winding sequence inner-middle-outer
Ext. neutral connections
Data
Inductance
Resistance
Capacitance
Core
Performed at
Average currents
Zero seq. available
positive sequence
@290 [MVA]
Volt [%]
Loss [kW]
Iav (%)
Insert
Delete
Relative dimensions
Ratios ref. leg
Area
Length
Yoke
Outer leg
Initialize
View fl/i
View core
Settings...
Order:
Label:
Comment:
Hide
OK
Cancel
Import
Export
Help


ATPDraw - [Noname.acp]
File
Edit
View
ATP
Library
Tools
Window
Help
XFMR
MODE: EDIT
Modified


MC's PlotXY plot
500
[A]
375
250
125
0
-125
-250
-375
-500
0
10
20
30
40
50
[ms]
60
(file XFRM.pl4; x-var t) c:X0017A-X0014A c:X0017B-X0014B c:X0017C-X0014C
Mark
Copy
Print

Machines

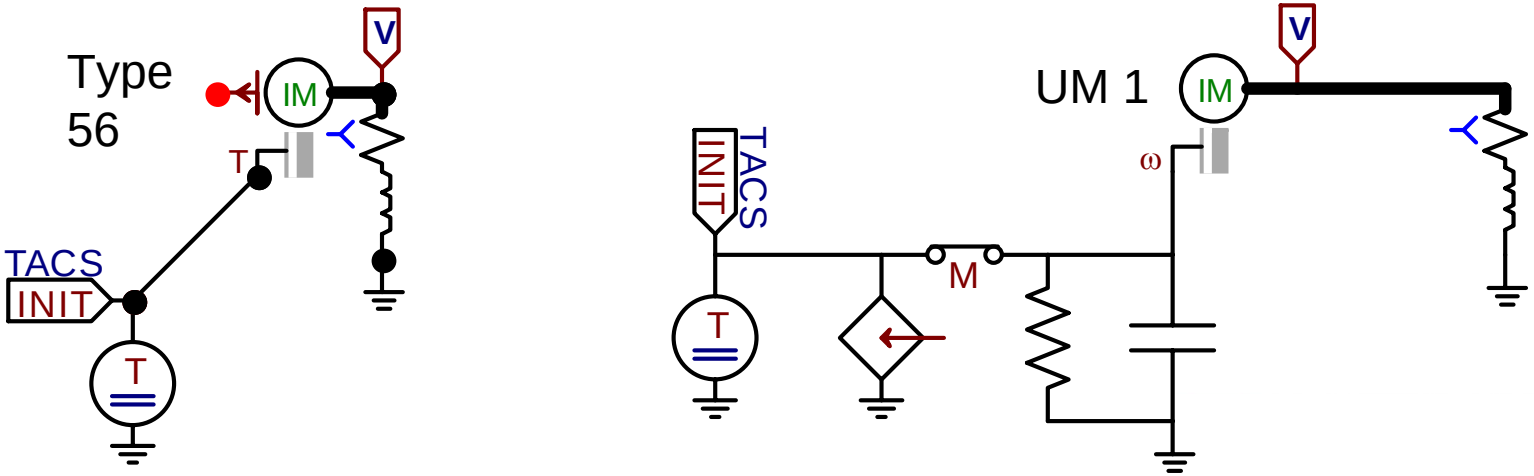
- The following types are supported
  - Universal machine
  - Type 59 synchronous machine
  - Type 56 induction machine



- Probably the weakest part of ATPDraw
  - Control of machines not standardized
  - Several machines (combinations) ?
- Plan for better support of WIndSyn

Type 56 machine

- Initial support in ATPDraw
  - Improvements required (TACS control, combination with UM)
- Brand new versions of ATP and PlotXY required
- More numerically stable (phase domain)
- Limitations on the mechanical side and in rotor coils



Models

- ATPDraw reads the Model text and identifies the circuit components with input/output/data
- Automatic creation of icon
  - User who insists on a special icon should create global Models in Library
- Indexed Nodes and Data supported

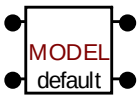
- Create a Model from scratch or load a predified Model

Add a new Model to a circuit

- Select a mod or sup file from the global library

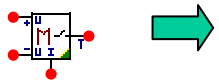
  - If a sup-file does not exist, default data is used and icon automatically created
- Create a new Model

  - Default Model is used (ModelDef.sup from ATPDraw.scl)
  - Icon is automatically created

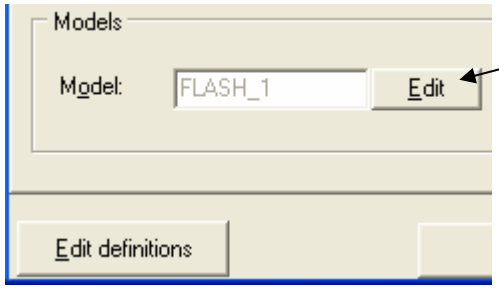


Edit a Model in a circuit

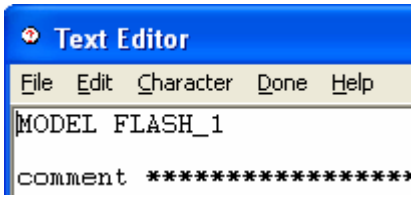
- In the Component dialog box click on Edit



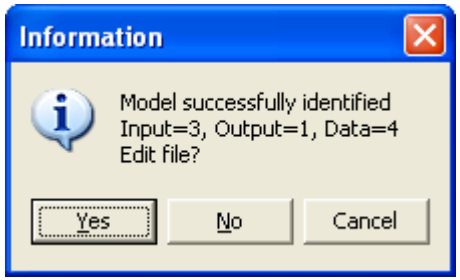
Right click



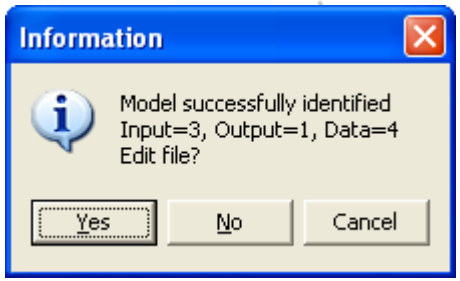
- The built-in text editor appears
  - Edit the text/Import
  - Click on Done



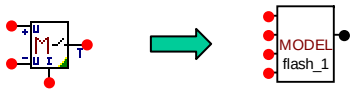
- Respond to the Model identified message



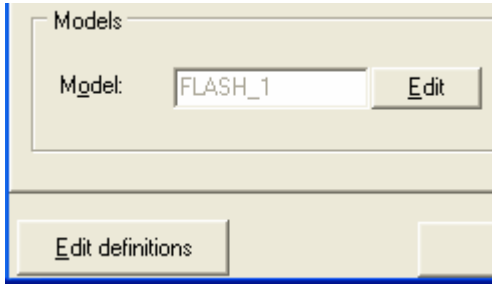
Go to Edit definitions



- Edit during identification
  - Click *Yes:* Go to Edit definitions
  - Click *No*: Accept default icon/node
- If the number of nodes has changed
  - ATPDraw will as default create a new icon in vector graphic style



- Edit definitions later
  - Click *Edit definitions*



Edit definitions

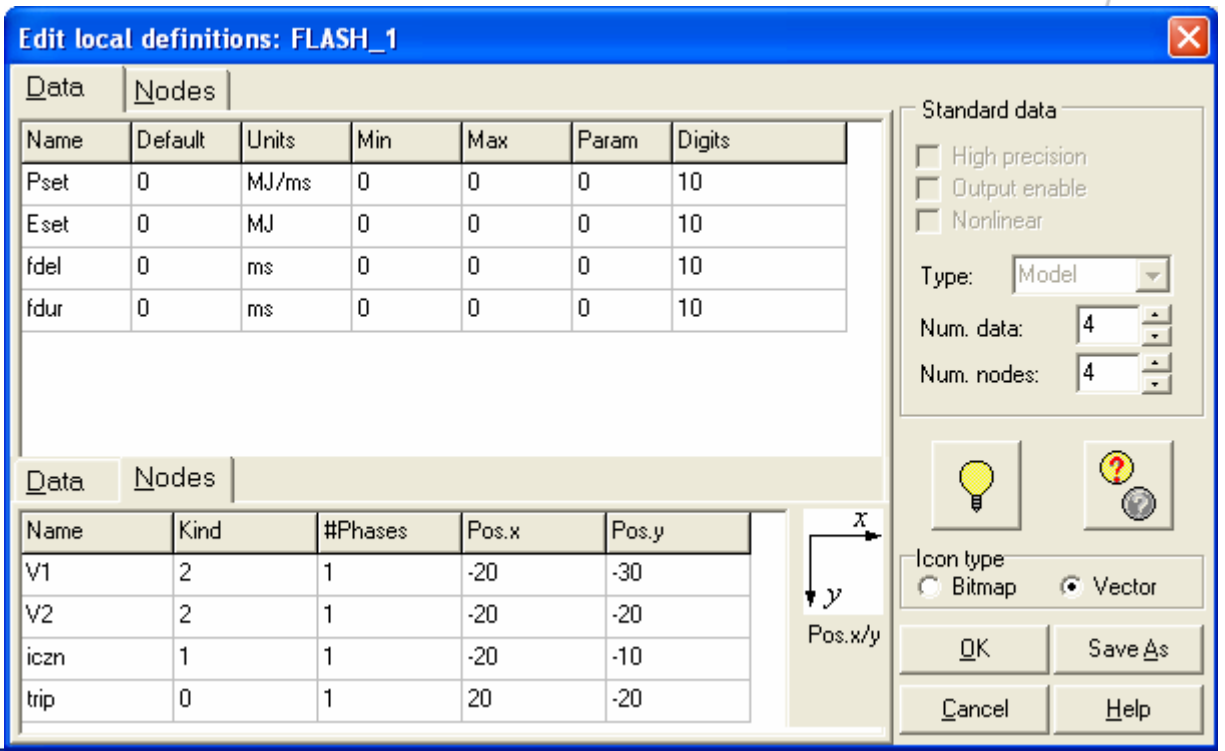
- Local: Component dialog|Edit definitions
- Global: Library|Edit|
- Edit data, nodes, icon, and help

Note:

Node positions changed from iconborder 1-12 to (x, y) positions

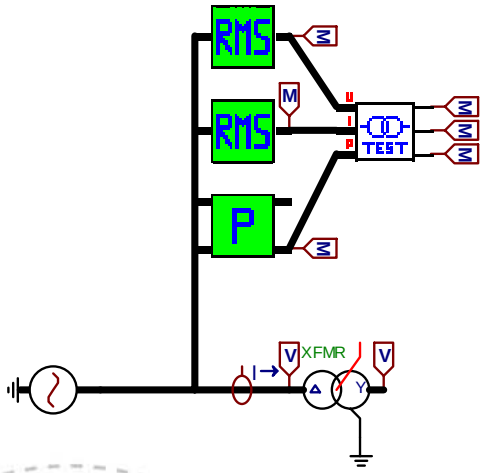
Switch between bitmap/vector

Data|Unit added



Example – Transformer tester

- Pocket calculator
- RMS and Power calculation
- TTester: Averaging, printout



Text Editor

File Edit Character Done Help

```
MODEL TTester
DATA FREQ, np, Us,Is,Ps
INPUT U[1..3],I[1..3],AP[1..3]
OUTPUT Volt, Curr, Pow
VAR Volt, Curr, Pow, Flag
INIT
  Flag:=0
ENDINIT
EXEC
  Volt:=0
  Curr:=0
  Pow:=0
  FOR p:=1 to np DO
    Volt:=Volt+sqrt(3)*U[p]/np/Us
    Curr:=Curr+I[p]/np/Is
    Pow:=Pow+AP[p]/Ps
  ENDFOR
  IF t>=2*recip(FREQ) AND Flag=0 THEN
    Flag:=1
    write1(Volt,' ', Curr,' ', Pow)
  ENDIF
ENDEXEC
ENDMODEL
```

1:1

ATP Settings

Simulation | Output | Switch/UM | Format | Record | Variables

$PARAMETER settings

NAME	VALUE
V	816.5*(13.+KNT)

Number of simulations: 5

Delete

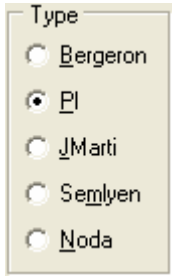
OK Help

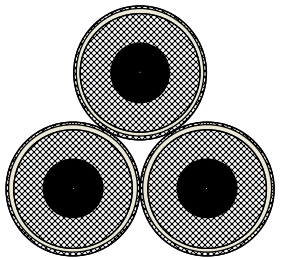
ResultDir\model.1

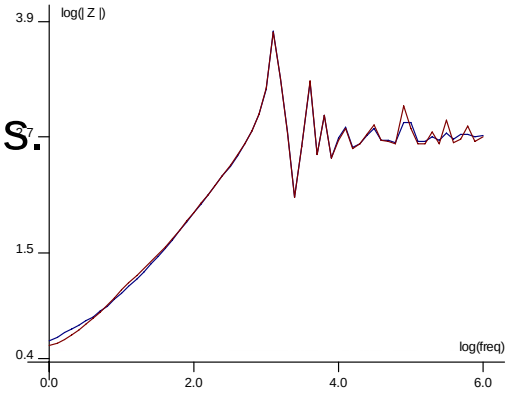
87.5003664 .17121764 131.434758
93.7503926 .220581306 151.751037
100.000419 .35109472 173.603833
106.250445 .743208151 196.896531
112.500471 2.85953651 221.288092

Line/Cable modeling

- Line/Cable Constants, Cable Parameters
  - Bergeron, PI, JMarti, Semlyen, Noda(?)
- View
  - Cross section, grounding
- Verify
  - Frequency response, power frequency params.
- Line Check
  - Power freq. test of line/cable sections

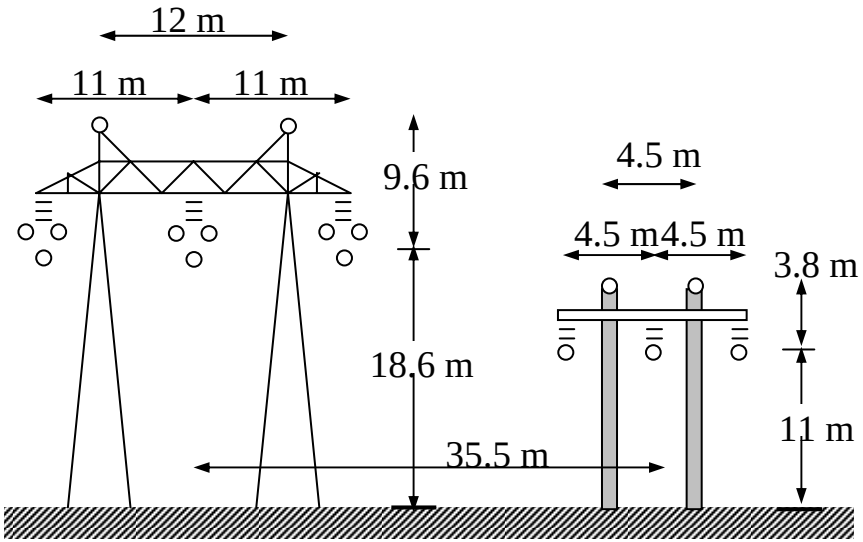






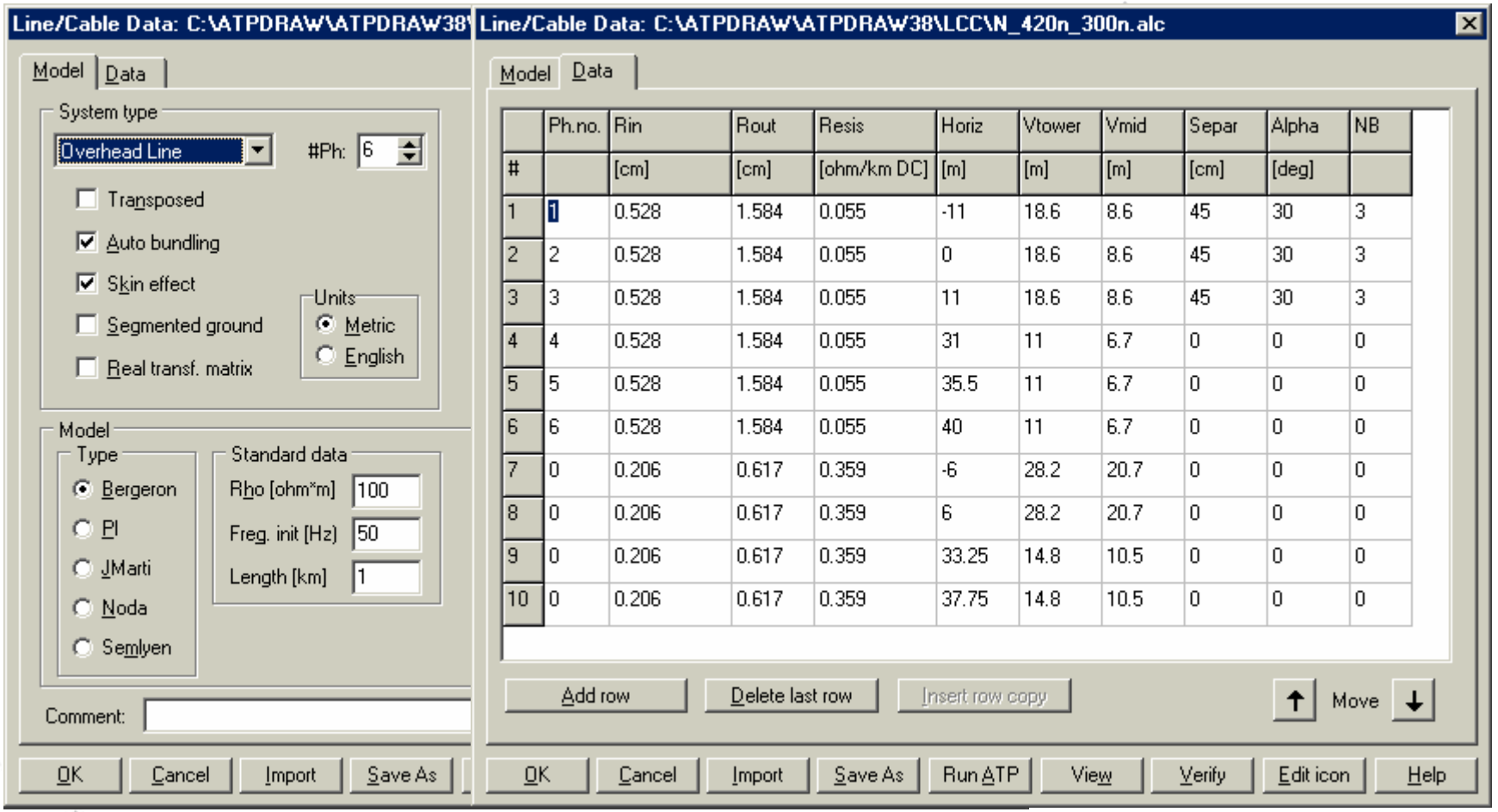
Example

- Double circuit case (420 kV + 145 kV)



Test type	Circuit [kV]	Positive sequence system Z [Ω/km]	C [nF/km]	Zero sequence system Z [Ω/km]	C [nF/km]
Benchmark data 50 Hz, 100 Ωm	420 145	**0.02+j0.29** **0.06+j0.38**	**12.8** **9.7**	**0.19+j0.71** **0.25+j0.80**	**9.3** **6.7**
Individual testing Bergeron model	420 145	0.02+j0.29 0.06+j0.38	12.8 9.7	0.18+j0.71 0.25+j0.80	9.3 6.9

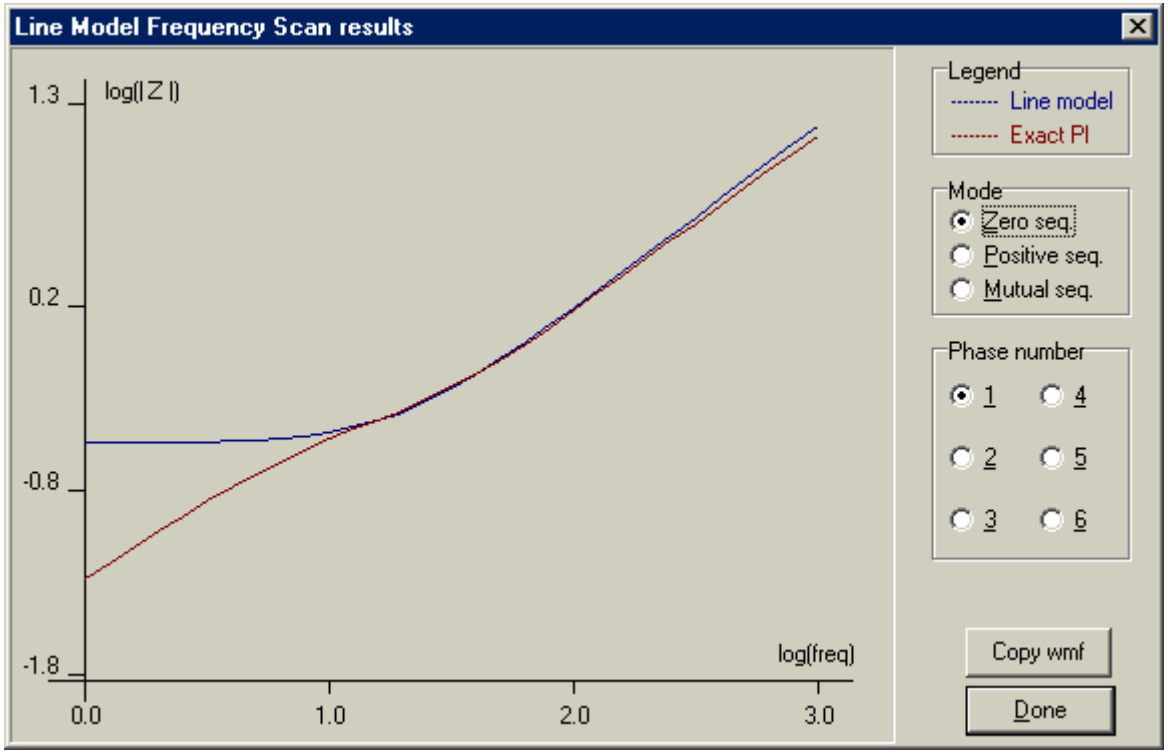
Creating the Bergeron model



#	Ph.no.	Rin [cm]	Rout [cm]	Resis [ohm/km DC]	Horiz [m]	Vtower [m]	Vmid [m]	Separ [cm]	Alpha [deg]	NB
1	1	0.528	1.584	0.055	-11	18.6	8.6	45	30	3
2	2	0.528	1.584	0.055	0	18.6	8.6	45	30	3
3	3	0.528	1.584	0.055	11	18.6	8.6	45	30	3
4	4	0.528	1.584	0.055	31	11	6.7	0	0	0
5	5	0.528	1.584	0.055	35.5	11	6.7	0	0	0
6	6	0.528	1.584	0.055	40	11	6.7	0	0	0
7	0	0.206	0.617	0.359	-6	28.2	20.7	0	0	0
8	0	0.206	0.617	0.359	6	28.2	20.7	0	0	0
9	0	0.206	0.617	0.359	33.25	14.8	10.5	0	0	0
10	0	0.206	0.617	0.359	37.75	14.8	10.5	0	0	0

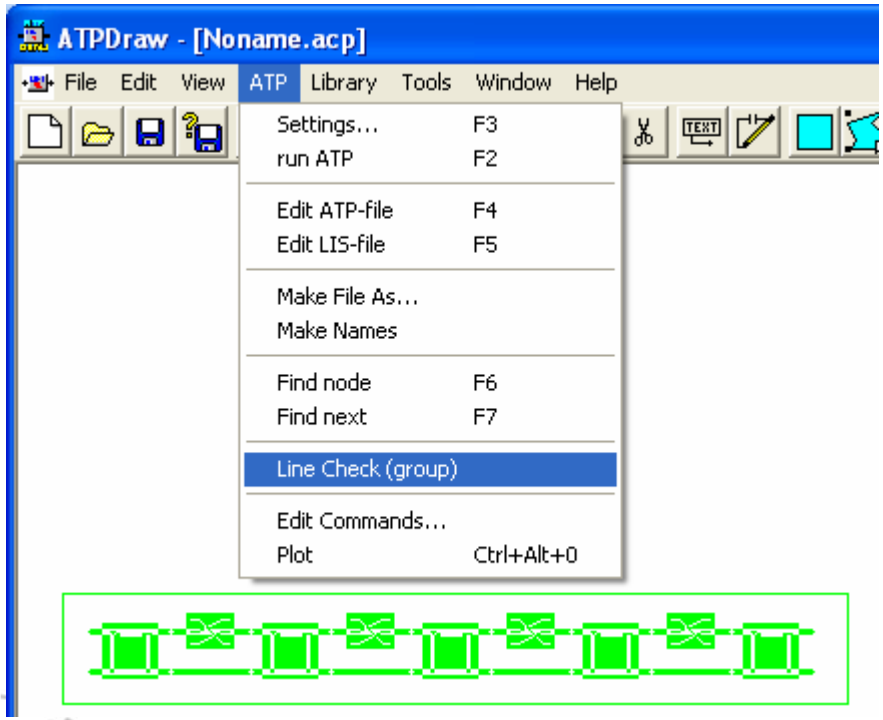
Testing the Bergeron model

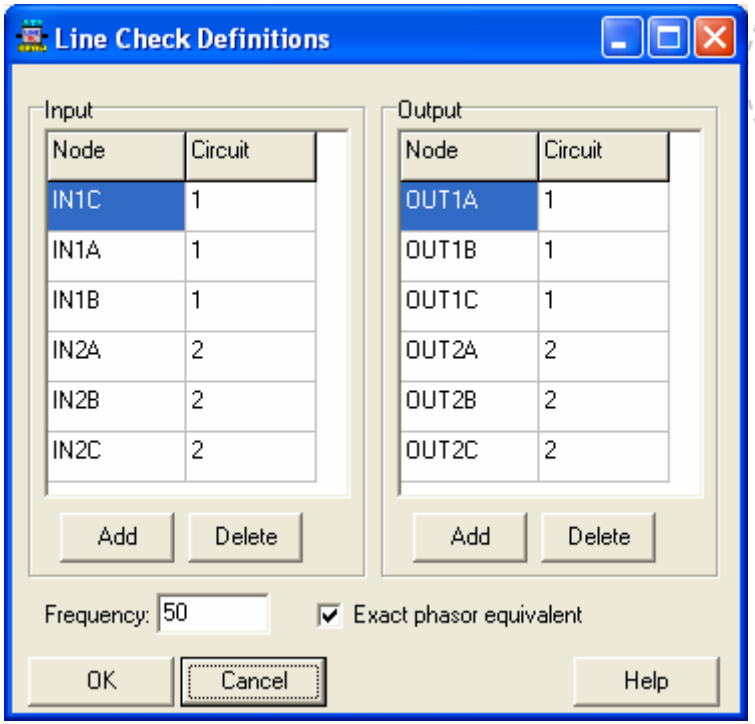
- Line Model Frequency scan. Model OK for 50 Hz.



Line Check

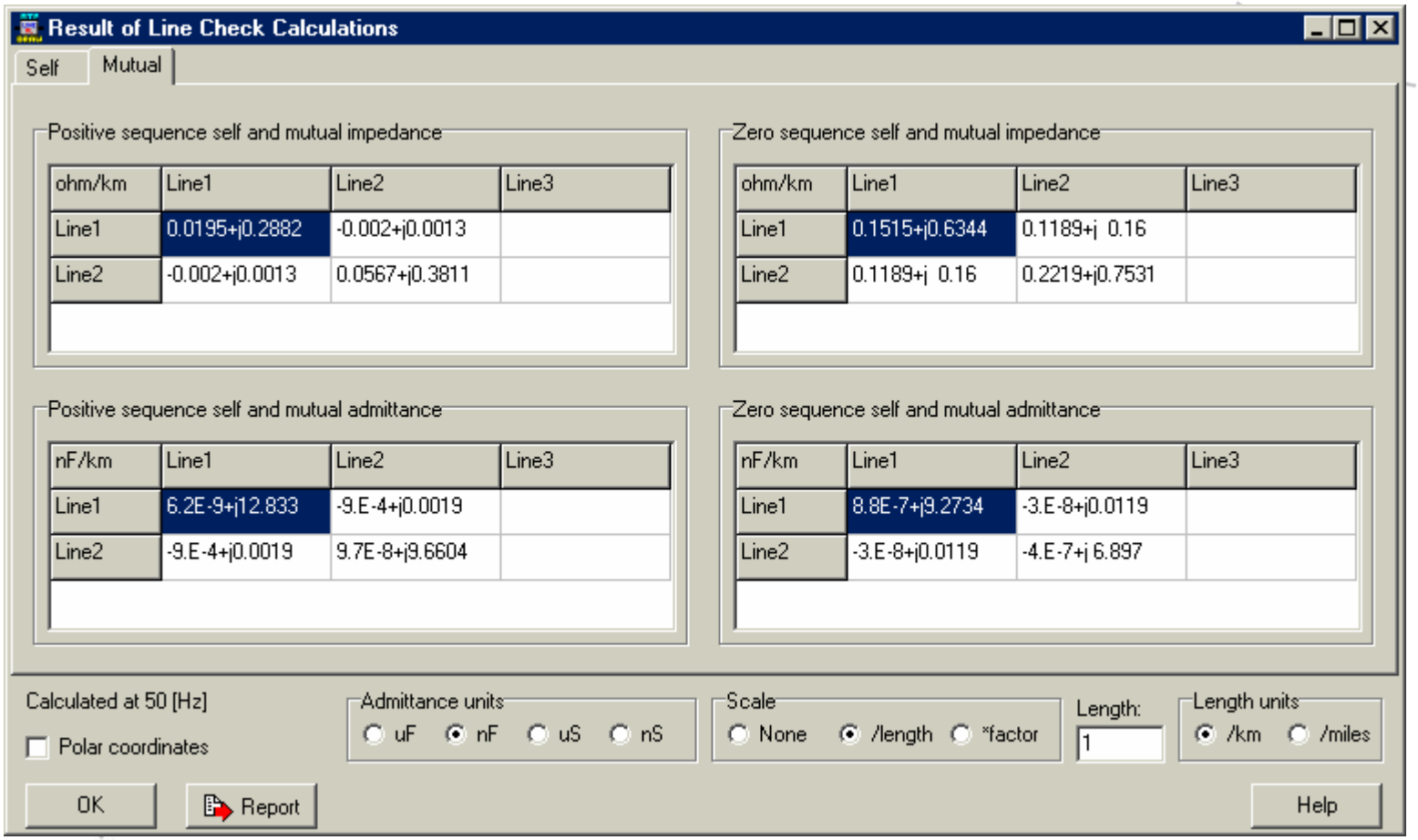
- The user selects a group in the circuit
- ATPDraw identifies the inputs and outputs (user modifiable)





Line Check cont.

- ATPDraw reads the lis-file and calculates the series impedance and shunt admittance



Inrush scanning

- Find the maximum inrush current as a function of switching instant
  - Pocket calculator KNT+MNT
  - Write1 to MODELS.1