U_I Installing ATP:

- Minimum to Download
  - » Mingw version of ATP
  - » ATPDraw -- latest version or latest patch
    - Presently version 6.2
    - PlotXY
- Installation complete set is a little tricky
- Option: ATP Easy Installer
  - » Download from secure sites in Japan

U_I Installing ATPDraw

- Installation is fairly easy
- Default installation path "Program Files"
- The space in the file name can create problems running ATP from ATPDraw
  - » Install it somewhere else. I normally install in "C:\tools\prog\ATPDraw"
- Install program creates shortcut in the start menu, but not very cleanly

---

U_I Running ATP from ATPDraw

- Still need a copy of ATP
- Licensed users can get other versions
- Follow installation directions for yours
- ATPDraw calls ATP
- Passes full path to data file when it calls ATP

U_I Sample Batch File (cont.)

- Second line adds executable to your search path (not needed if set this at boot time)
- The next line calls ATP itself
  - » `tpbig both %1 s -R`
    - "both" tells program to write error messages to screen and to file (useful for debugging)
    - Could also set "disk" to only do disk file or leave blank for no message
    - First "%1" is input data file from ATPDraw
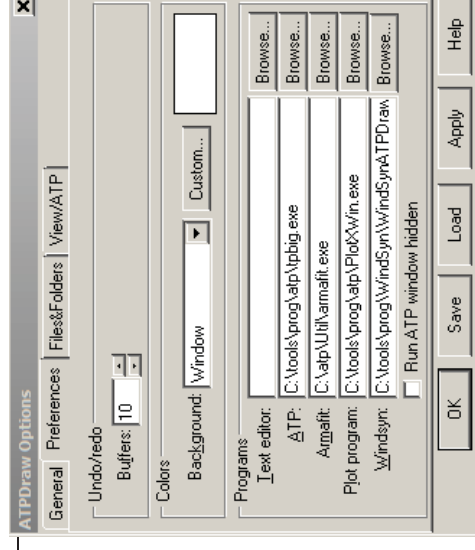
U_I Editing "startup"

- ATP reads a file called "startup"
  - » Resides in same directory as tpbig
  - » Sets variables for the program
- A few suggested changes from default
  - » Change PL4 file format to work with PlotXY
    - – NOBLAN set to 0   {ignore blank lines}
    - – NEWPL4 set to 2   {won't work with Analyzer}

U_I Sample Batch File (cont.)

- – The "s" is to create appropriate output file.
- – "-R" tells ATP overwrite existing output file if one exists
- This bat file will let you run ATP, and all of the support program (line constants etc)

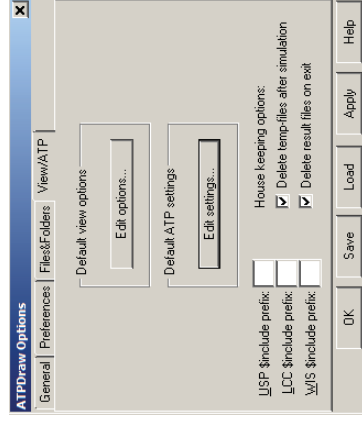# U_I ATPDraw "Preferences"

U_I Setting Up ATPDraw

- Open up ATPDraw
- Select: "Tools" pull down menu
- Select: "Options…"
- Choose "Preferences" tab
  - » You select a text editor, or use Notepad (default)
  - » "ATP" is where you set path to your batch file
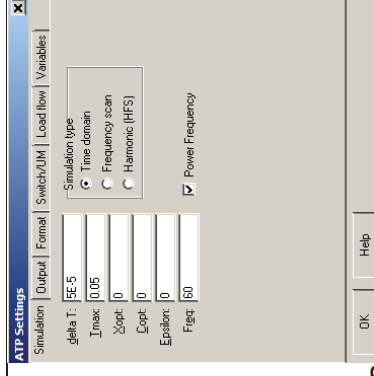- Armafit: which we won't cover in this course

U_I Simulation Settings

- Default time step (deltaT) is very small
- Default run time short
- Xopt and Copt ok
- Select "Power Frequency"
  » Reset to 60 Hz from 50Hz
  » Can mess up some sources

U_I Other Settings

- Switch/UM settings ok for most cases (are for statistical studies only)
- Load flow controls controls how the load flow initialization is run
- Variables: Use can define parameters here and pass them different components
  » Or control them with Pocket Calculator option
  » See help file for more info

U_I Further Settings

- The "Files&Folders" tab settings are ok
- However, you do want changes in the View/ATP tab
  » Select "Edit settings" tab
  » You may want to change some of the default settings. However, you can change any of these for a specific data file

---

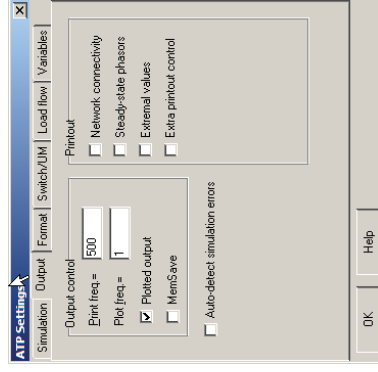# U_I Output Settings

- Probably don't need the selected "Printout" options for most cases
- Slow down the program somewhat
- Plot frequency should be low and odd.

U_I Saving New Settings

- The "Save" or "Apply" buttons aren't sufficient to permanently save change
- Also choose: Tools --> Save Options
- These are all saved into a file called ATPDraw.ini
  - » Typically saved in user's settings
  - » Could put copy in the directory with ATPDraw.exe

U_I Other Settings

- To set other plotting programs or other post processing options you need to open a file
  - » Either select the "File|Open" sequence of click on the icon
  - » Initial default is the Examples directory, after that it is the last directory worked in.
  - » For now, choose example "Exa_1.adp" (*.adp represents the drawing files).

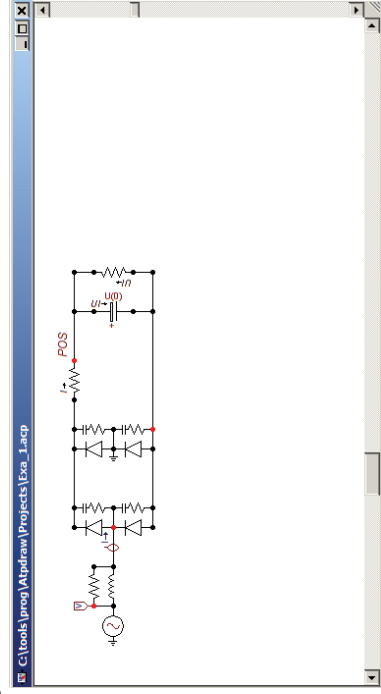# U_I Example 1

- Try to run example case to make sure program installed and set up correctly

---

U_I ATP Menu

- A new pulldown menu is now available at the top of the window, called "ATP"
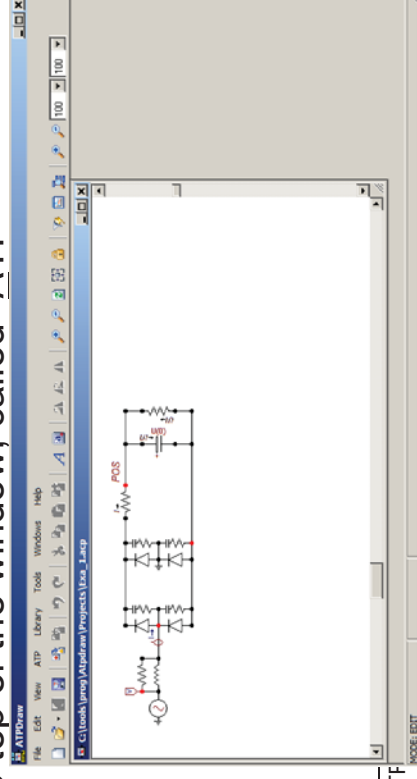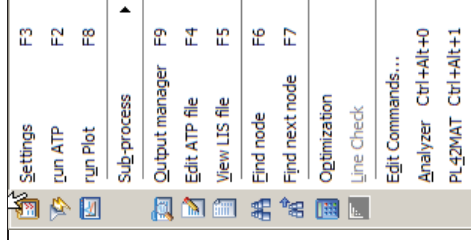
U_I ATP Menu

- <u>S</u>ettings is changes deltaT etc. for a given case
- "<u>M</u>ake File As" generates ATP data file from drawing
- <u>R</u>un ATP calls your bat file
- Each "Edit" calls text editor
- Make <u>N</u>ames, makes node names for drawing

Menu items:

<u>S</u>ettings	F3
r<u>u</u>n ATP	F2
r<u>u</u>n Plot	F8
Sub-process	
<u>O</u>utput manager	F9
<u>E</u>dit ATP file	F4
<u>V</u>iew LIS file	F5
Find node	F6
Find next node	F7
Optimization	
Line Check	
Edit Commands...	
<u>A</u>nalyzer	Ctrl+Alt+0
PL<u>4</u>2MAT	Ctrl+Alt+1

U_I Edit Commands

Edit Commands dialog:
Analyzer
PL42MAT

New
Delete
Help

Parameter
- None
- File
- Current ATP
- Current PL4
- Current circuit

Name:
Analyzer

Command:
C:\tools\prog\Analyzer\ATPAnalyzer.exe
Browse...
Update
Exit

- Allows you to set additional commands
- Run other ATP versions
  » On Current ATP drawing
  » On Selected File
- Run plot programs
  » On Current PL4
- Use "Update" to set
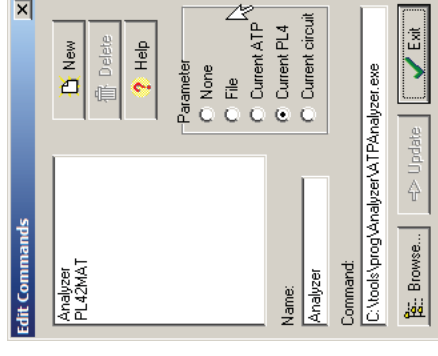
U_I Saving New Settings

- The "Update" buttons isn't sufficient to save for next time
- All choose: Tools --> Save Options

U_I Running an ATP File

- Now we run the example case opened earlier
- Always a multi-step process
  » 1) Make file to create ATP data file from drawing.
    – Must do this every time you change drawing
    – Default is to place this in "ATP" subdirectory under ATPDraw home directory (with extension *.ATP)
    – Can edit this file with "<u>E</u>dit ATP-File" option (not saved to drawing file)
  » 2) Run your case
  » 3) Call plotting program

U_I Running an ATP File

- The drawing file saved separately (save often)
- Remember to save your changes often
- Default is to save this in the "Project" subdirectory under ATPDraw
- Note that if want to save elsewhere, need to select a new home for both ADP and ATP files
  - » PL4 and *.lis (or *.out depending on version) are written to same directory at *.ATP file
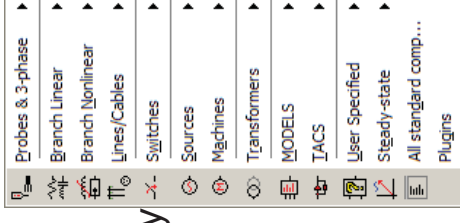 - » Need to cleanup directories periodically

---

U_I Making You Own File

- Open a new drawing (from File menu or from icon)
- Can get the component menu by right clicking mouse in the drawing screen
- Each item lets you select components to create
- More later....

U_I Associated Files

- Input Datafile (text file)
  - » Extension options: *.dat or *.atp (ATPDraw)
  - » Avoid Long File Names
- Plot Datafile (formatted ASCII)
  - » Extension *.PL4
- Text Output File (plain text)
  - » Extension: *.LIS (or *.OUT)
  - » Error Messages in this file

U_I Associated Files (cont)

- ATPDraw Schematic File
  - » Extension: *.acp (or *.adp for older versions)
- Supplement Include File
  - » Use modular programs
  - » Examples: Line constants output, subsystems
  - » Extension options: *.pch, *.pun, *.lib

U_I Creating a File: Text Based

- Use fixed width fonts with your text editor
  - » If use MS-Word or Word-Pad make sure use Courier
- Plain text editor better option
  - » Best if it provides column number
- Older ATP versions do not perform type checking, use all upper case for variables
- Column alignment is very important
- The ATP rule book refers to individual lines as data cards

U_I Sample File

```
C Brian K. Johnson
C Simulation for problem 3.11 in Greenwood
BEGIN NEW DATA CASE
C ..............................................  Miscellaneous data ..........
C DeltaT<----TMax<----XOpt<----COpt<-Epsiln<-TolMat<-TStart
5.0E-5    0.1
C --IOut<---IPlot<-IDoubl<-KSSOut<-MaxOut<----IPun<-MemSav<----ICat<-NEnerg<-IPrSup
        500        1                                                            1
C
C ..............................................  Circuit data .................
C Bus1->Bus2->Bus3->Bus4-><----R<----L<----C
VS    V1            0.149  4.73
BLANK ends circuit data
C
C ..............................................  Switch data ..................
C ***** Close at 160 degrees, or 70 degrees past peak  *********
C Bus-->Bus-><---Tclose<----Topen<------Ie
V1        0.02407    999.                                                        1
BLANK ends switch data
C
```

U_I Sample File (cont.)

```
C ..............Source data .....................................................
C Bus-->< I<Amplitude<Frequency<---T0|Phi0<---0=Phi0      <---Tstart<----Tstop
14VS    28.16913E3   60.    -90.     0.                   -1.    9999.
BLANK ends source data
C
C ..................  Output Request Data ......................................
C Bus-->Bus-->Bus-->Bus-->Bus-->Bus-->Bus-->Bus-->Bus-->Bus-->
   V1   VS
BLANK ends output requests
BLANK ends plot request
BEGIN NEW DATA CASE
BLANK ends all cases
```

U_I Sections of the Datafile

- An ATP datafile must at a minimum have the following sections
  - » Header/Miscellaneous Data Cards
  - » Circuit Data
  - » Switch Data
  - » Source Data
  - » Output request data
  - » Plot request data

U_I Sections of the Datafile

- End of section marked with "BLANK" starting in column 1
  - » Rest of the card is comment
  - » An accidental blank line in data file is treated as end of section – fix in startup file discussed earlier
- Graphical interfaces such as ATPDraw insulate user from needing to work at this level
- Still useful to know what is going on at this level
  - » For Debugging
  - » If someone sends you an older file

U_I Comment Cards

- Good practice to have comments in the file
- Comments start with a "C" in column 1 and a blank in column 2

```
C *****************************
C * This is a sample comment  *
C *****************************
```

- ATP allows "in-line" comments. Place comment between "{ and }"
- Make sure that you don't block useful data fields

U_I Comment Cards (cont.)

- User can also treat a block of code between keywords $DISABLE and $ENABLE

```
$DISABLE
    all lines in between keywords are ignored
$ENABLE
```
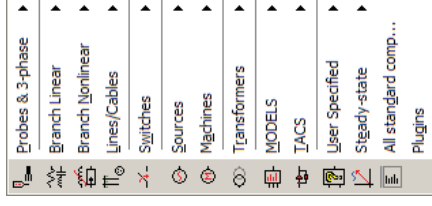

U_I Making You Own File

- **Set deltaT and Tmax!!!**
- Open a new drawing (from File menu or from icon)
- Can get the component menu by right clicking mouse in the drawing screen
- Each item lets you select components to create

Probes & 3-phase
Branch Linear
Branch Nonlinear
Lines/Cables
Switches
Sources
Machines
Transformers
MODELS
TACS
User Specified
Steady-state
All standard comp....
Plugins

U_I Linear Branches

- These are the basic circuit elements
- Single phase and three phase options
- C:U(0) and L:I(0) are capacitor and inductor with voltage/current initial conditions
- Note ATPDraw uses U for voltage

Resistor
Capacitor
Inductor
RLC
RLC 3-ph
RLC-Y 3-ph
RLC-D 3-ph
C: U(0)
L: I(0)

U_I Operating on component

- Once you select a component you can rotate it by single clicking the right mouse button on it.
  » Use to structure your drawing more nicely
  » This also selects polarity for branch outputs
- Double-click left button to open a window to edit values

U_I Resistor Dialog Box

- Set value for resistance in Ohms
- Node names not set
- Can add comment
- $Vintage,1 sets high precision numbers
- Edit definitions: allows model-redefine advanced feature
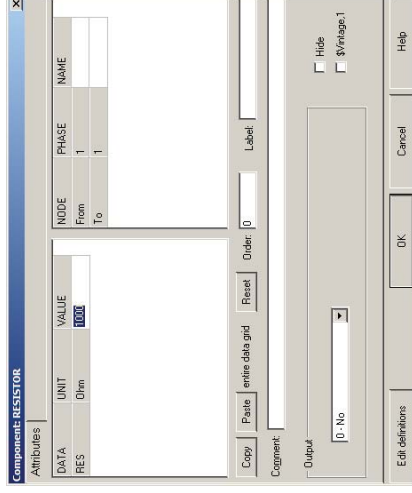
U_I Resistor Dialog Box

- Set branch output:
  0 - No
  1 - Current
  2 - Voltage
  3 - Current&Voltage
  4 - Power&Energy
- Comments
  » For file
  » For drawing

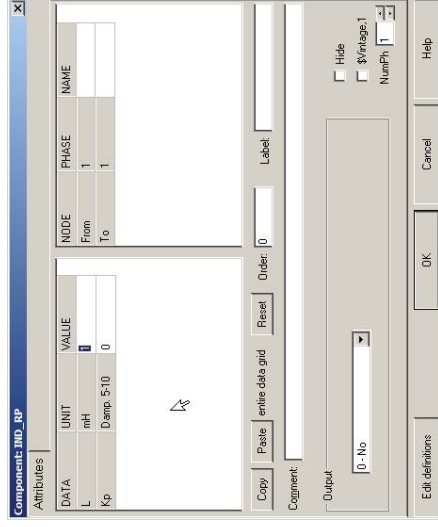# U_I Inductor

- L is in mH unless you have set Xopt to a frequency
- Label creates a label on the drawing next to the component
- Help menus are pretty good
- Kp numerical oscillation damping constant
  » Adds parallel resistor
 » More on that later
- Series RLC

U_I Capacitor

- Capacitance is in microFarads unless Copt set
- Note program sets a default value to prevent errors if you randomly connect nodes
- Ks numerical oscillation damping constant
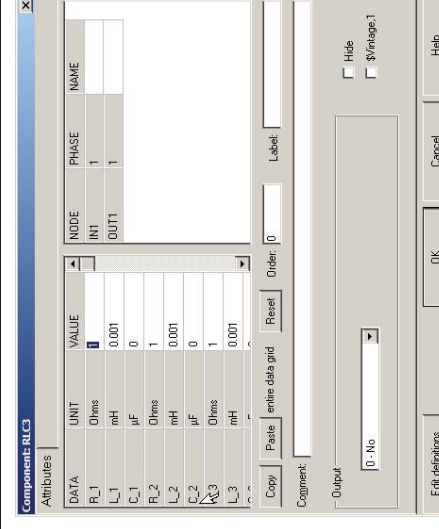 » Adds series resistor
  » More on that later
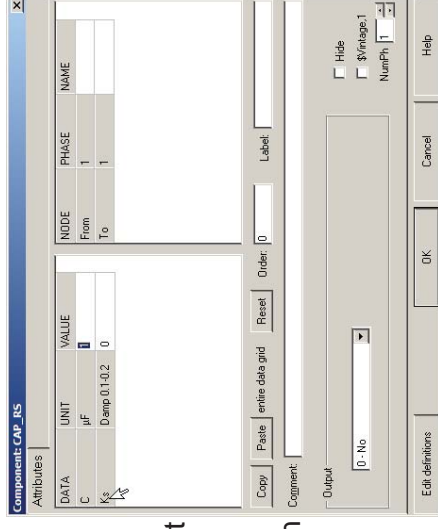
U_I RLC

- RLC lets you set R, L, and C or any combination
- Creates same data card as R, L, or C alone, but lets you do all fields
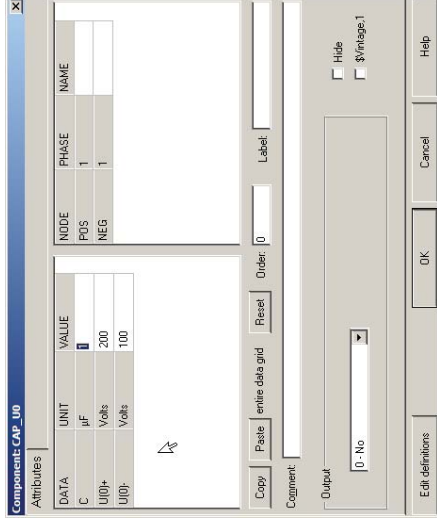- Series RLC
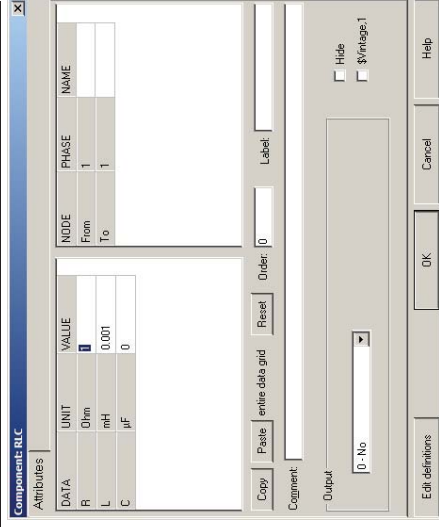
U_I 3 Phase RLC

- Can choose a series 3 phase RLC
- Options include Y connected
- and Delta connected

U_I Capacitor with Initial Voltage Value

Component: CAP_U0

Attributes

DATA	UNIT	VALUE	NODE	PHASE	NAME
C	µF	1			
U(0)+	Volts	200	POS	1	
U(0)-	Volts	100	NEG	1	

Copy Paste entire data grid Reset Order: 0 Label:

Comment:

Output

0 - No

☐ Hide
☐ $Vintage.1

Edit definitions   OK   Cancel   Help

- Still set value for C
- Also set positive and negative voltage relative to ground at T=0
- Will be useful for homework #1

U_I Inductor with Initial Current Value
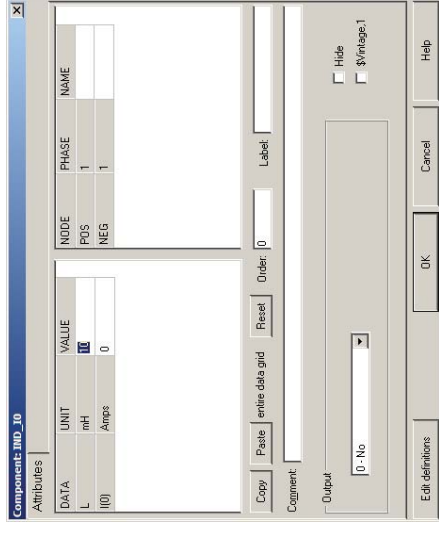
Component: IND_I0

Attributes

DATA	UNIT	VALUE	NODE	PHASE	NAME
L	mH	1	POS	1	
I(0)	Amps	0	NEG	1	

Copy Paste entire data grid Reset Order: 0 Label:

Comment:

Output

0 - No

☐ Hide
☐ $Vintage.1

Edit definitions   OK   Cancel   Help

- Still set value for L
- Plus the current at T=0

U_I Switch Pop Up Menu

Switch time controlled
Switch time 3-ph
Switch voltage contr.
Diode (type 11)
Valve (type 11)
Triac (type 12)
TACS switch (type 13)
Measuring
Statistic switch
Systematic switch
Nonlinear diode

- In most cases you will use a time controlled switch (single or three phase)
- Measuring Switches (always closed)
- TACS controlled switches

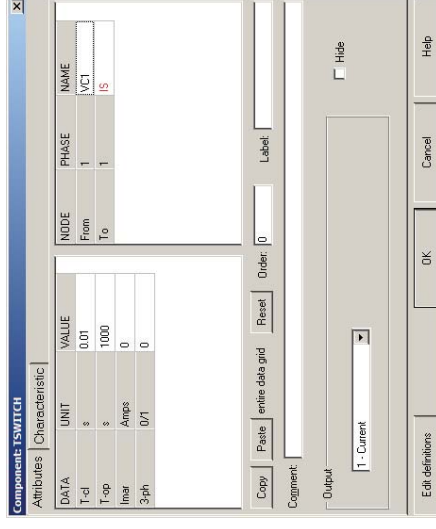# U_I Time Controlled Switch

Component: TSWITCH

Attributes | Characteristic

DATA	UNIT	VALUE	NODE	PHASE	NAME
T-cl	s	0.01	From	1	VC1
T-op	s	1000	To	1	IS
Imar	Amps	0			
3-ph	0/1	0			

Copy Paste entire data grid Reset Order: 0 Label:

Comment:

Output

1 - Current

☐ Hide

Edit definitions   OK   Cancel   Help
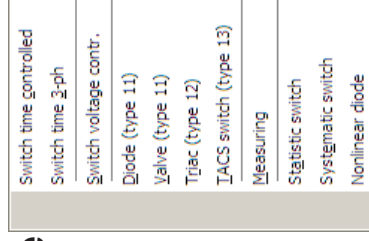
- Set T_close
- Set T_open
  » T_open must be larger than T_close
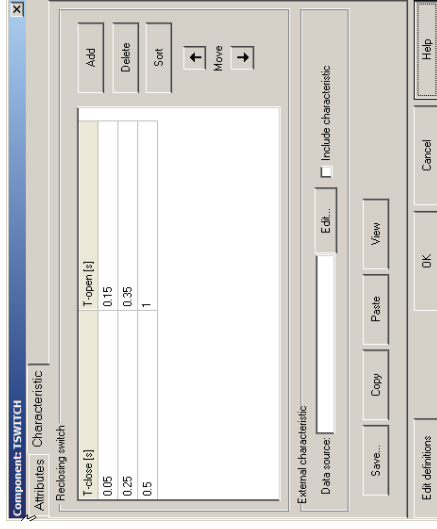- Imar is absolute value of current it will interrupt
- Can select outputs

U_I Time Controlled Switch

- Can also set a time sequence for repeated open/close operations.
- Up to 16

Component: TSWITCH — Attributes | Characteristic | Reclosing switch

T-close [s]	T-open [s]
0.05	0.15
0.25	0.35
0.5	1

Add Delete Sort Move

External characteristic Data source: ☐ Include characteristic Edit...

Save... Copy Paste View

Edit definitions OK Cancel Help

U_I Three Phase Switch

- Individual timing for each phase
- No reclose characteristic

Component: SWIT_3XT — Attributes

DATA	UNIT	VALUE	NODE	PHASE	NAME
T-cl_1	s	1	IN1	1	
T-op_1	s	1000	OUT1	1	
T-cl_2	s	-1			
T-op_2	s	1000			
T-cl_3	s	-1			
T-op_3	s	1000			
Imar	Amps	0			

Copy Paste entire data grid Reset Order: 0 Label: ☐ Hide

Comment: Output 0 - No

Edit definitions OK Cancel Help
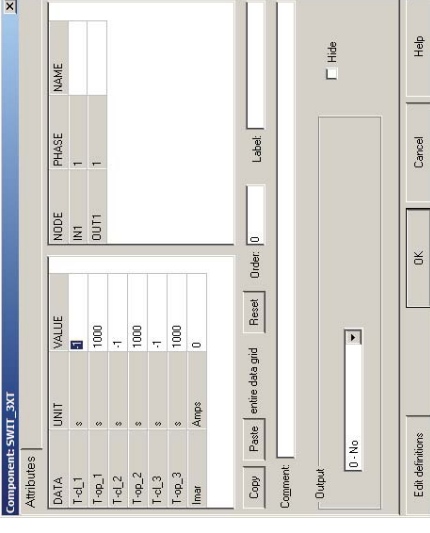
U_I Measuring Switch

- No fields to set, but you must select "Current" output

Component: SWITMEAS — Attributes

NODE	PHASE	NAME
SwF	1	
SwT	1	

Order: 0 Label: ☐ Hide
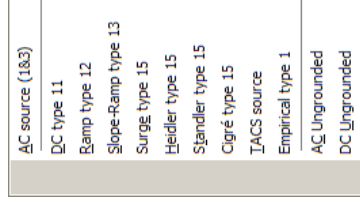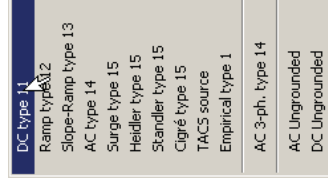
Comment: Output 0 - No NumPh 1

Edit definitions OK Cancel Help
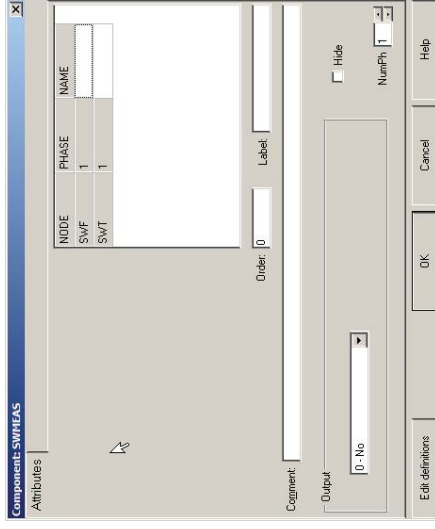
U_I Source Pop Up Menu

- Allows you to create ordinary sources
- Machines and TACS controlled sources on other pop-up menus
- Most of these sources are referenced to ground

ATPDraw 5.5-
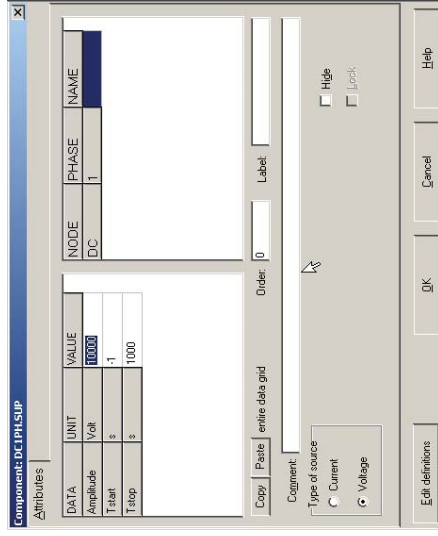
- DC type 11
- Ramp type 12
- Slope-Ramp type 13
- AC type 14
- Surge type 15
- Heidler type 15
- Standler type 15
- Cigré type 15
- TACS source
- Empirical type 1
- AC 3-ph. type 14
- AC Ungrounded
- DC Ungrounded

ATPDraw 5.6+

- AC source (1&3)
- DC type 11
- Ramp type 12
- Slope-Ramp type 13
- Surge type 15
- Heidler type 15
- Standler type 15
- Cigré type 15
- TACS source
- Empirical type 1
- AC Ungrounded
- DC Ungrounded

Slide 49

U_I

Type 11 Source

Component: DC1PH.SUP

Attributes

DATA	UNIT	VALUE
Amplitude	Volt	10000
Tstart	s	-1
Tstop	s	1000

NODE	PHASE	NAME
DC	1	

Order: 0   Label:

Type of source: Current / Voltage

Copy Paste entire data grid

Comment:

Edit definitions   OK   Cancel   Help

□ Hide □ Lock

Slide 50

U_I

Version 5.6+ AC source (1&3 phase)

Component: AC SOURCE

Attributes

DATA	UNIT	VALUE
AmplitudeA	Volt	10000
Frequency	Hz	50
PhaseAngleA	degrees	0
StartA	sec	-1
StopA	sec	100

NODE	PHASE	NAME
AC	1	
ACNEG	1	
Internal	1	

Copy Paste entire data grid Reset Order: 0 Label:

Comment:

Type of source: Current / Voltage
Num phases: Single / 3-phase / 3+1-phase
Angle units: Degrees / Seconds
Amplitude: Peak L-G / RMS L-G / RMS L-L
Grounding: Grounded / Ungrounded □ Hide

Edit definitions   OK   Cancel   Help

1 ph voltage source

3 ph current source

Slide 51
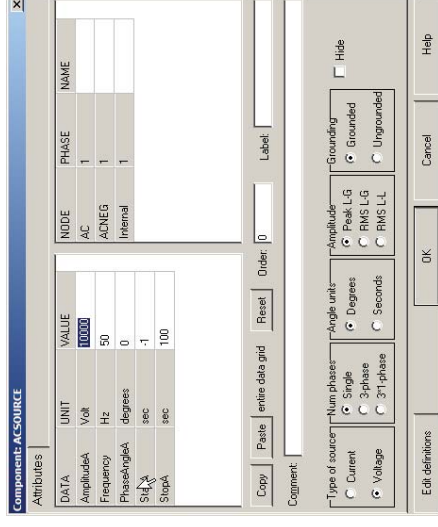
U_I

Single Phase AC Source (ATPDraw 5.5 or earlier)

Component: AC1PH.SUP

Attributes

DATA	UNIT	VALUE
Amplitude	Volt	23180
f	Hz	60
Pha	Deg/Rad	-90
A1		0
TStart	s	-1
TStop	s	1000

NODE	PHASE	NAME
AC	1	VS

Order: 0   Label:

Type of source: Current / Voltage

Copy Paste entire data grid

Comment:

Edit definitions   OK   Cancel   Help

□ Hide □ Lock

Slide 52
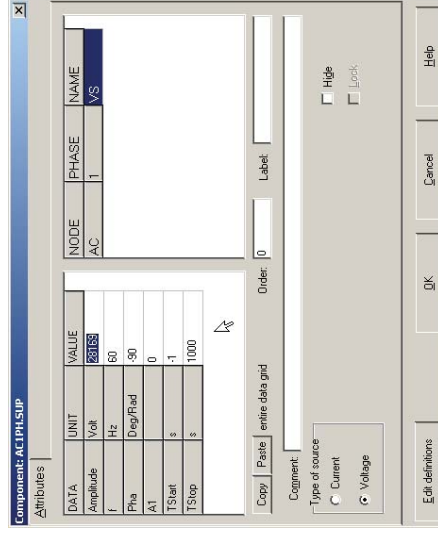
U_I

Three Phase AC Source (ATPDraw 5.5 or earlier)

Component: AC3PH.SUP

Attributes

DATA	UNIT	VALUE
Amplitude	Volt	15000
f	Hz	60
pha	Deg/Rad	0
A1		0
Tstart	s	-1
Tstop	s	1000

NODE	PHASE	NAME
AC3	3	

Order: 0   Label:

Type of source: Current / Voltage

Copy Paste entire data grid

Comment:

Edit definitions   OK   Cancel   Help

□ Hide □ Lock

U_I Creating a Circuit

- Components are highlighted in red until you edit values
- Can connect components together by dragging left mouse button between nodes and then clicking on finishing node
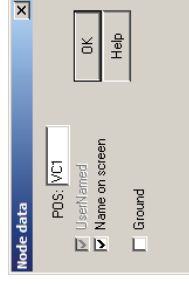- 1 Ph or 3 Ph on context

---

U_I AC or DC Floating Source

- AC source implemented using the Ideal Transformer Component
- Frequency default is 50Hz unless you change default power frequency in settings menu
- Better to use a Norton equivalent to create ungrounded (as dc does)

U_I Selecting Node Names

- Can choose to Display name on the screen
- If you have a connection between nodes, all nodes will get a name you assigned when use "Sub-process > Make Node Names" or "Make ATP File"
  - » ATPDraw assigns names if you don't (XX0001, etc)

U_I Selecting Node Names

- Double click left button to get node data window
- Type node name in SWT
  - » 6 characters max
  - » ALL CAPS or numbers or will have errors
- Can ground the node
  - » Name won't matter
  - » Ground symbol will appear

U_I Building a System

- Can also copy your components
- Remembers output requests and values
- Need to enter new names

U_I Probes and 3 Phase
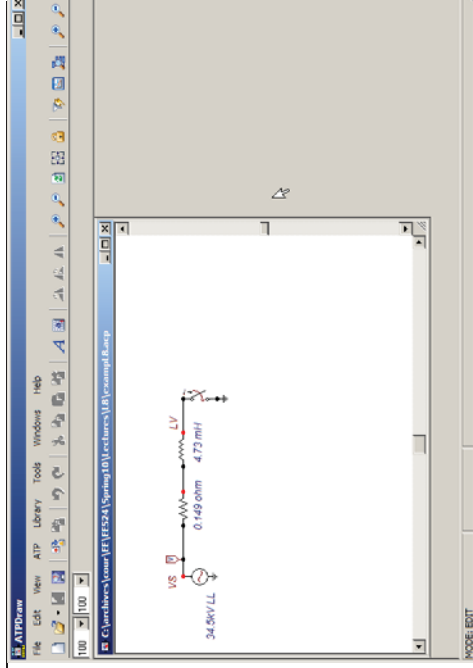
- Menu for voltage and current measurements
- "Probe Volt" is line to ground voltage
- "Probe Branch Volt" "puts in dummy branch as does "probe curr""
- Select 1 or 3 ph

U_I ATPDraw ATP Data File
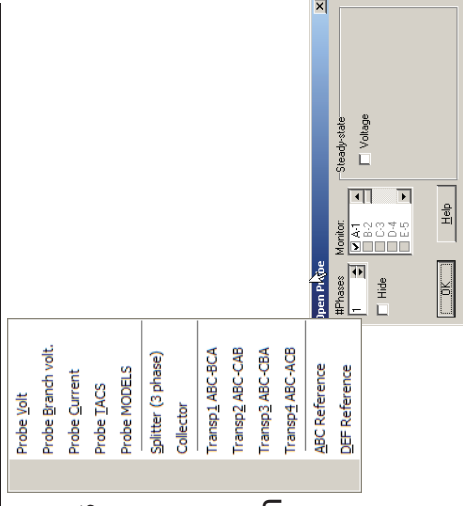
- File itself is less readable:

```
BEGIN NEW DATA CASE
C ------------------------------------------------------------
C Generated by ATPDRAW  January, Wednesday 23, 2008
C A Bonneville Power Administration program
C by H. K. Høidalen at SEfAS/NTNU – NORWAY 1994-2006
C ------------------------------------------------------------
C   dT  >< Tmax >< Xopt >< Copt >
 5.E-5   .1
   500    1     1      1      0       0      1      0
C   1     2     3      4      5       6      7      8
C 345678901234567890123456789012345678901234567890123456789012345678901234567890
/BRANCH
C < n1 >< n2 ><ref1><ref2>< R  >< L  >< C  >
C < n1 >< n2 ><ref1><ref2>< R  >< A  >< B  ><Leng><><>0
  VS   RL               .149
  RL   LV                       4.73
```

U_I ATPDraw ATP Data File

```
/SWITCH
C < n 1>< n 2>< Tclose ><Top/Tde ><      Ie   ><Vf/CLOP ><   type  >
  LV              .02407      1.E3                                       1
/SOURCE
C < n 1><>< Ampl.  >< Freq.  ><Phase/T0><   A1    ><   T1   >< TSTART >< TSTOP  >
14VS    0   28169.      60.      -90.                          -1.    1.E3
/OUTPUT
VS
BLANK BRANCH
BLANK SWITCH
BLANK SOURCE
BLANK OUTPUT
BLANK PLOT
BEGIN NEW DATA CASE
BLANK
```

U_I Lumped Parameter Lines: ATP

- All three model coupled branches
- Can do varying number of phases (up to 6)
- Can do several hundred phases when create by hand

U_I When handing in homework assignments

- Include any hand calculations you did to set up the problem
- Include circuit diagram
- Include text from the *.atp file
- Include simulation plots
  - » Zoom in on key results
  - » Capture key numbers
  - » Interpretation of the results matters!
- See examples in upcoming lectures

U_I Coupled RL: ATP

- Enter using coupled-pi
- Don't enter capacitance values
- Use for network equivalent
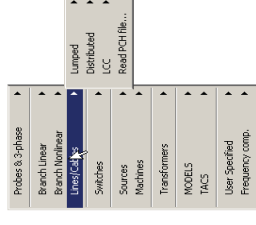
U_I Coupled PI: ATP

- Good for shorted lines or cables
- Often need 10 segments for accurate line model
- Enter the matrix data in the menu
- Notice the scroll bar

U_I Coupled RL-Symmetrical Component Equivalent

- Variation on coupled-RL
- Now do a symmetrical components equivalent
- Positive and zero sequence

U_I Distributed Parameter Lines: ATP

- Transposed or untransposed options
- Transposed options listed here
- Fewer options for the untranposed
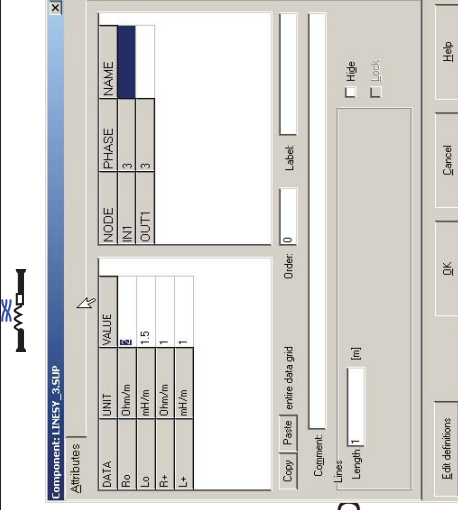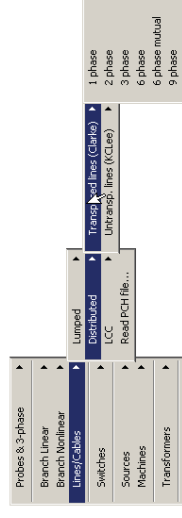
U_I Transposed Line: ATP

- Can enter the valid fields:
  - » Modal resistance per length
  - » Modal L'C' or
  - » Modal Zc and v or
  - » Modal Zc tau

U_I Untranposed Line: ATP

- Can enter the valid fields:
  - » Resistance/length
  - » A, B for modes
  - » Length
  - » ILINE controls A,B
  - » Transformation matrix
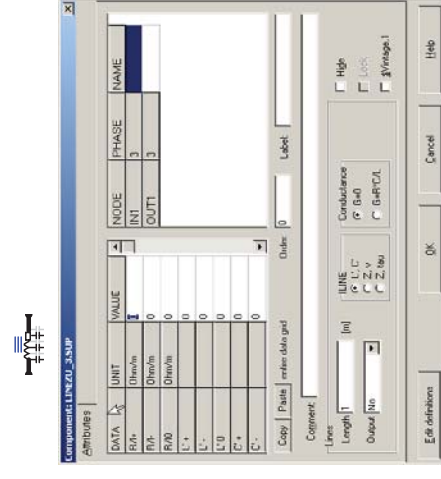
U_I Finding Line Data

- The line constants routine starts out from physical data concerning line
  - » Tower configuration
  - » Conductor sizes
  - » Resistivity of earth
  - » Bundling
  - » Transposition
  - » Set frequency or range for frequency sweep

U_I ATPDraw Line Constants Program

- ATPDraw will let user call the line constants program
- User determines number of phases
- Can do constant frequency parameter and frequency dependent
- Connect line model into circuit schematic

Probes & 3-phase
Branch Linear
Branch Nonlinear
Lines/Cables
Switches
Sources
Machines
Transformers
MODELS
TACS
User Specified
Frequency comp.
Standard Component…

Lumped
Distributed
LCC
Read PCH file…
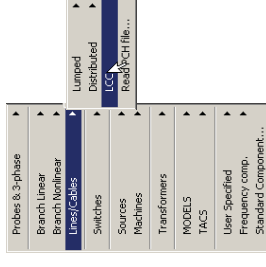
U_I Overhead Line

- If skin effect is check LCC performs computation
  - » Otherwise user provides data
- Segmented ground
- Real transformation better for transients
- Model type
  - » Bergeron and pi for now
- Save as to save line model data
- Can import * .alc file with line data
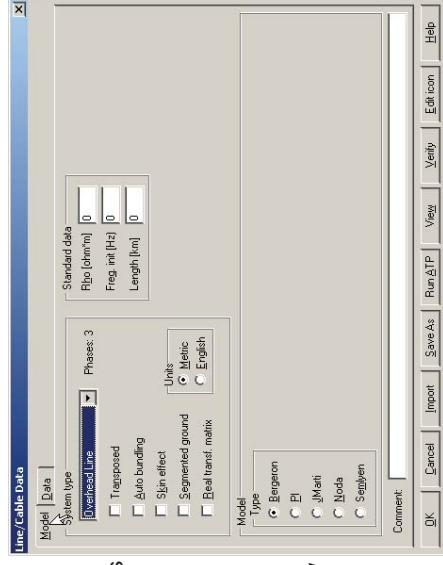
U_I Conductor Data

- Add row to add additional conductors
  - » Phase 0 ground wires
  - » If don't auto bundle will need 2 or 3 per phase
- Run ATP to create data file entry at module
  - » Will run automatically if try to run a case
- View lets you see physical layout
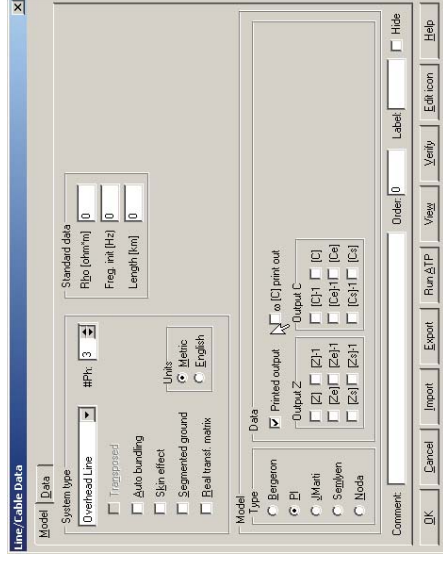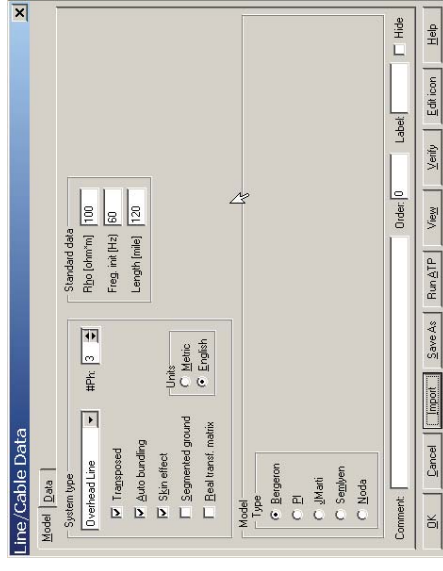- Verify analyzes frequency response of the model
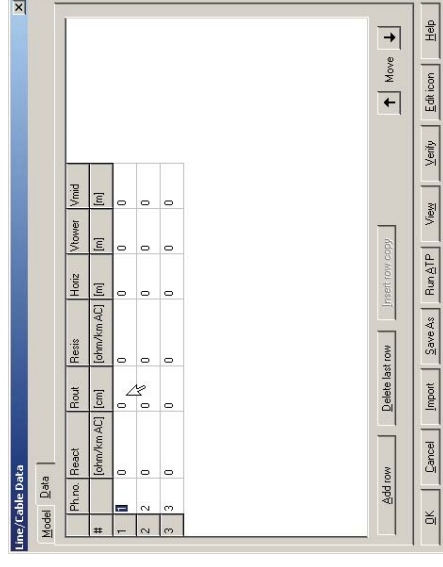
U_I Coupled Pi Output

- Can request printed output to text file
  - » Can use this to collect matrix data to analysis in other programs
  - » Ze is equivalent 3x3
  - » Zs is symmetrical components
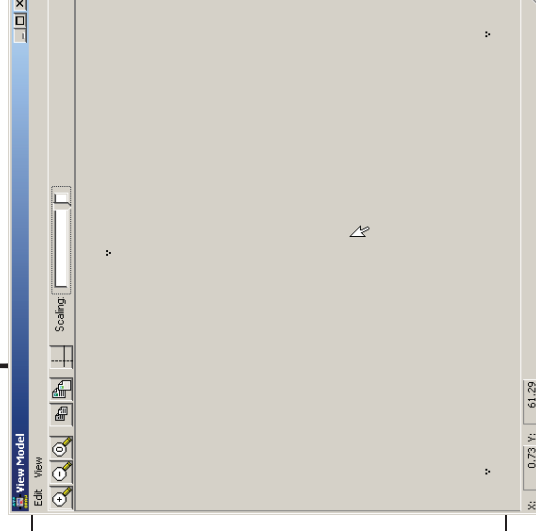 - » Z calculated at initial frequency

U_I Example Case

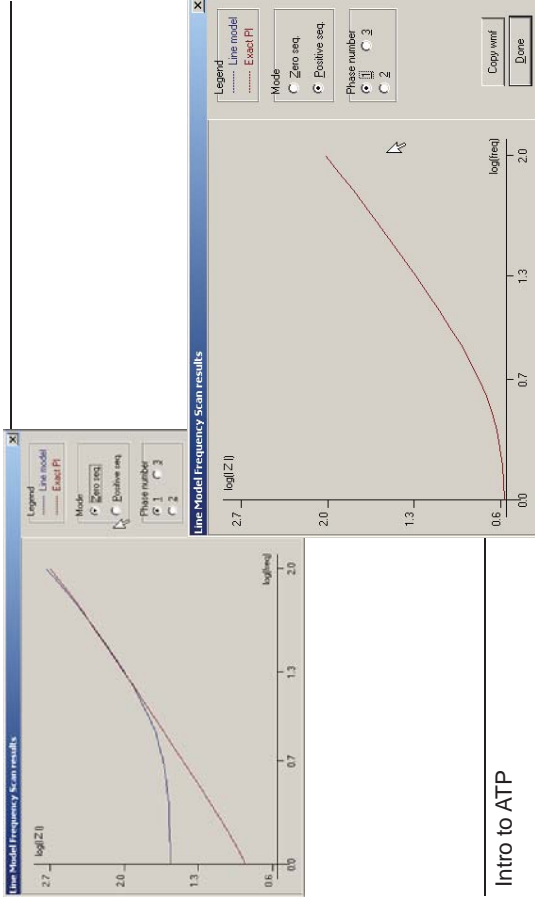- If number of phases is multiple of 3 ATPDraw assumes double or triple circuit line

U_I Example Case

U_I Example Case: View

U_I What is Needed in Transformer Models?

- Amount of detail depends on frequency of desired response
- Power flow stability often just model leakage, perhaps winding resistance
  - » Tap changing
  - » Perhaps wye-delta phase shift

U_I Low Frequency Transients

- Similar modeling info to fault programs
  - » Connection information more important
- Magnetizing branch
  - » Saturation
- Core loss term
- Not using per unit
  - » Need to include turns ratio
  - » Divide leakage L, winding R between windings

U_I Example Case: Verify

U_I What is Needed in Transformer Models?

- Fault studies require more information
  - » Connection info
    - – wye
    - – delta
    - – zig-zag
    - – autotransformer
    - – etc.
  - » Grounding
  - » Possible impact of tertiary

U_I Single Phase Equivalent Circuit

- Winding resistance
- Leakage inductance
- Core loss--total losses
- Non-linear inductor model for magnetizing branch

U_I ATP Options

- Ideal transformer component
- Saturable transformer component
- BCTran -- preprocessor that converts description of transformer to coupled RL
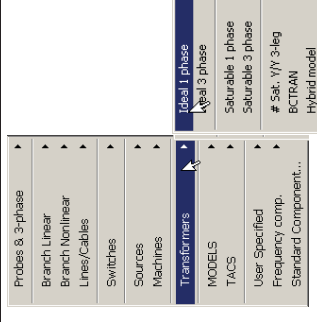- Can also create manually using coupled RL branches

---

U_I Ideal transformer component

- Combines ideal transformer with ideal source
  » Simply enter transformation ratio
  » Can be used to implement floating source too
  » Uses frequency from basic ATPDraw settings
    – Need to make sure this matches system frequency
    – Setting "Branch = 0" forces ATP to use this frequency
    – "Branch = 1" can avoid this (Vm=1E-20)

U_I Accessing Transformer Models

- Note that three phase and single phase options

Probes & 3-phase
Branch Linear
Branch Nonlinear
Lines/Cables
Switches
Sources
Machines
Transformers
MODELS
TACS
User Specified
Frequency comp.
Standard Component...

Ideal 1 phase
Ideal 3 phase
Saturable 1 phase
Saturable 3 phase
Sat. Y/Y 3-leg
BCTRAN
Hybrid model
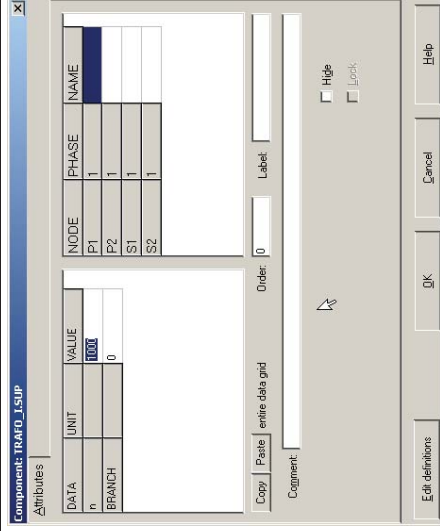
U_I Text Entry

```
C ...........................................Source data ..........................................
C Bus--><I<Amplitude<Frequency<--T0|Phi0<---0=Phi0            <---Tstart<----Tstop
14NodeJ
C NodeL><-|---n----><NodeK<NodeM<NodeX
18
```

- The 18 card need to follow the 14
- Node X can be used for current measurement

---

U_I Limitations

- Limited to two winding transformers
- *It is very easy to create numerical problems in the simulation with the ideal transformer*

U_I Dialog box

U_I Adding R, L Terms

- The balance of the regular transformer model can be created by:
  » Adding external R, L for series terms
  » Shunt resistor for core loss term
  » Saturable inductor component for L_m
- Create winding connections externally
- Can also add capacitance

# U_I Saturable Transformer

- Model has built-in circuit elements
  - » Winding resistance
  - » Leakage inductance (can't enter 0)
  - » Core loss resistance
  - » Magnetizing branch
    - not entered as an L in mH
  - » Can set all except leakage to 0 to simplify
 - » Enter winding to winding ratios

U_I Single Phase Saturable Base Attributes
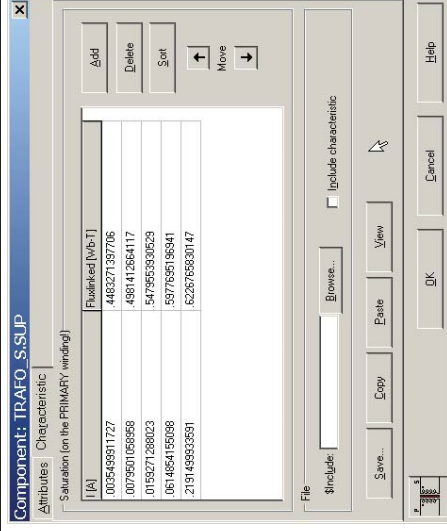
- Io, Fo are steady-state point on saturation characteristic for initial Lm
- RMS = 0 or 1: determines how the saturation characteristic is entered.
- Output is information about mangetization branch
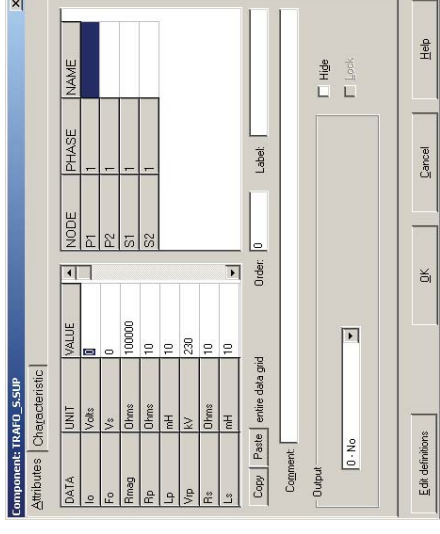
# U_I Saturation Characteristic

- If RMS = 0, this is current versus flux
- If RMS = 1, this is RMS current versus RMS voltage at frequency of first source in the system
- The 0,0 point is assumed by the program
- Up to 10 points can be entered
  - » Better to limit to 3-5

U_I Viewing The Saturation Characteristic

- If RMS = 0, this is current versus flux
- If RMS = 1, this is RMS current versus RMS voltage at frequency of first source in the system
- The 0,0 point is assumed by the program
- Up to 10 points can be entered
  - » Better to limit to 3-5 for better numerical behavior
  - » Does not include hysteresis
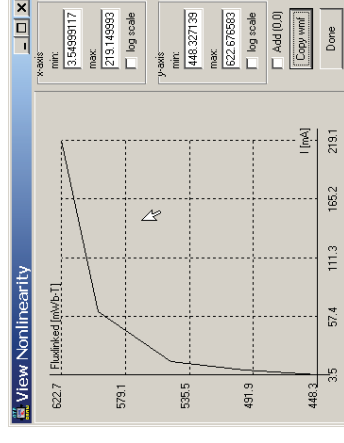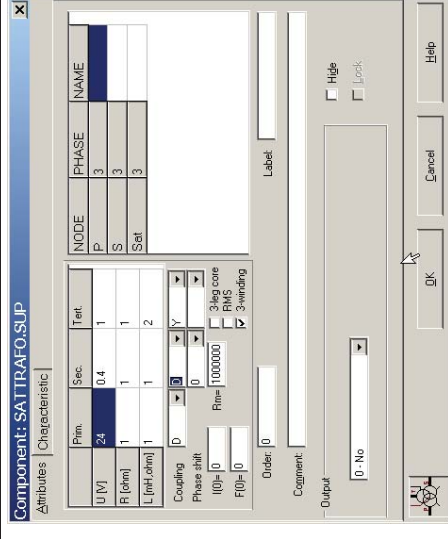
U_I Three Phase Model

- Icon changes with the connection type. Here is three winding with all WYE
- Here is 2 winding with delta-wye
- Note that there is a point to connect to measure magnetizing branch voltage
- Three leg core option

U_I Three Phase Model

Component: SATTRAFO.SUP
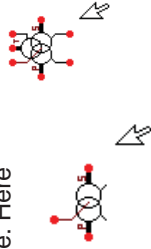
- Enter data for each winding
- Select Y, D, or Zig-zag
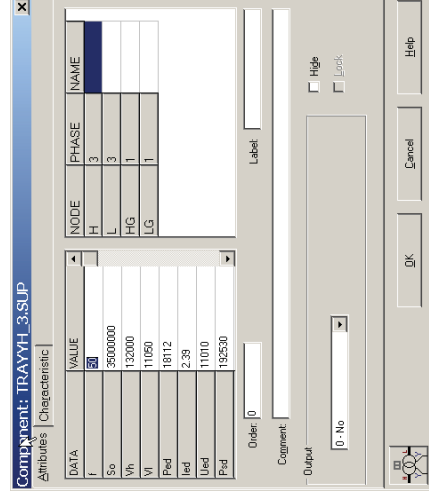- Three leg option here, but better to use specific case from pull-down menu.

U_I Three Phase Model- Three Leg Core

Component: TRAYYH_3.SUP

- Option to model homopolar reluctance
  » Saturable-Three Leg
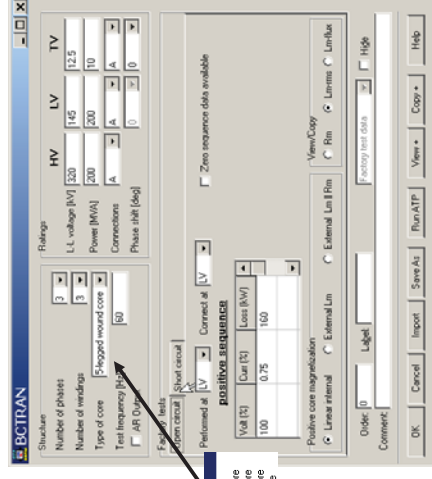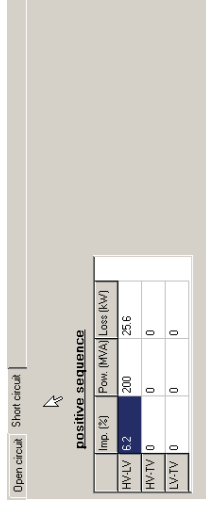- Much additional information needed.
- See help menu.

U_I BCTRAN Interface

- Produces coupled RL model
- Based on SC and OC test data
  » Linear Lm internally
  » Need to add external nonlinear

U_I Additional BC Tran Data

positive sequence		
Imp. [%]	Pow. [MVA]	Loss [kW]
HV-LV 6.2	200	25.6
HV-TV 0	0	0
LV-TV 0	0	0

Open circuit | Short circuit

U_I Nonlinear Devices

- Models for resistors and inductors
  - » Differ model implementation
- The Type 98 and Type 93 inductors do not include hysteresis
  - » Same user data as saturation in saturable xfmr
  - » Set with initial conditions

| R(i) Type 99 |
| R(i) Type 92 |
| R(t) Type 97 |
| R(t) Type 91 |

| L(i) Type 98 |
| L(i) Type 93 |
| L(i) Type 96 |
| L(i) Hevia 98->96 |

| MOV Type 92 |
| MOV Type 3-ph |

| R(TACS) Type 91 |

| L(i) Type 98, init |
| L(i) Type 96, init |
| L(i) Type 93, init |

U_I Type 96 reactor with hysteresis

- Option to enter residual flux along with steady-state

Component: NLIND96.SUP
Attributes | Characteristic

DATA	VALUE
CURR	0
FLUX	0
RESID	0
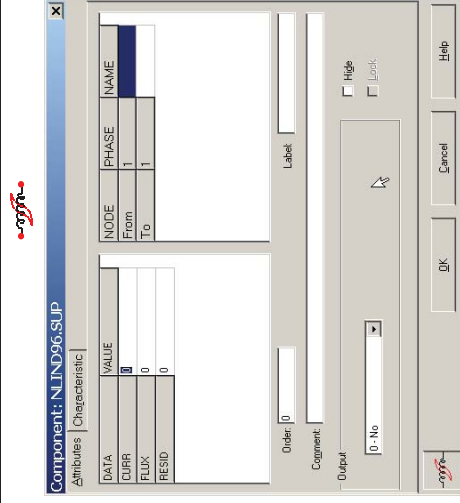
U_I Example

- Transformer with saturation
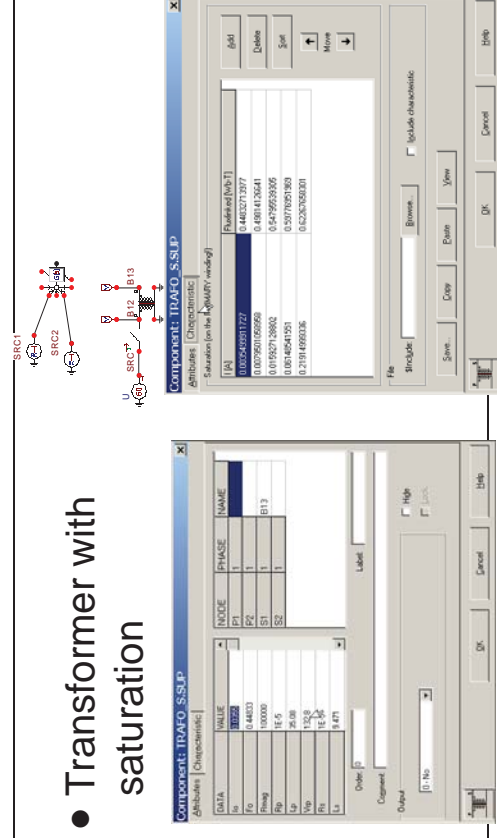
U_I Results from increasing voltage

ECE 525
Lecture 13