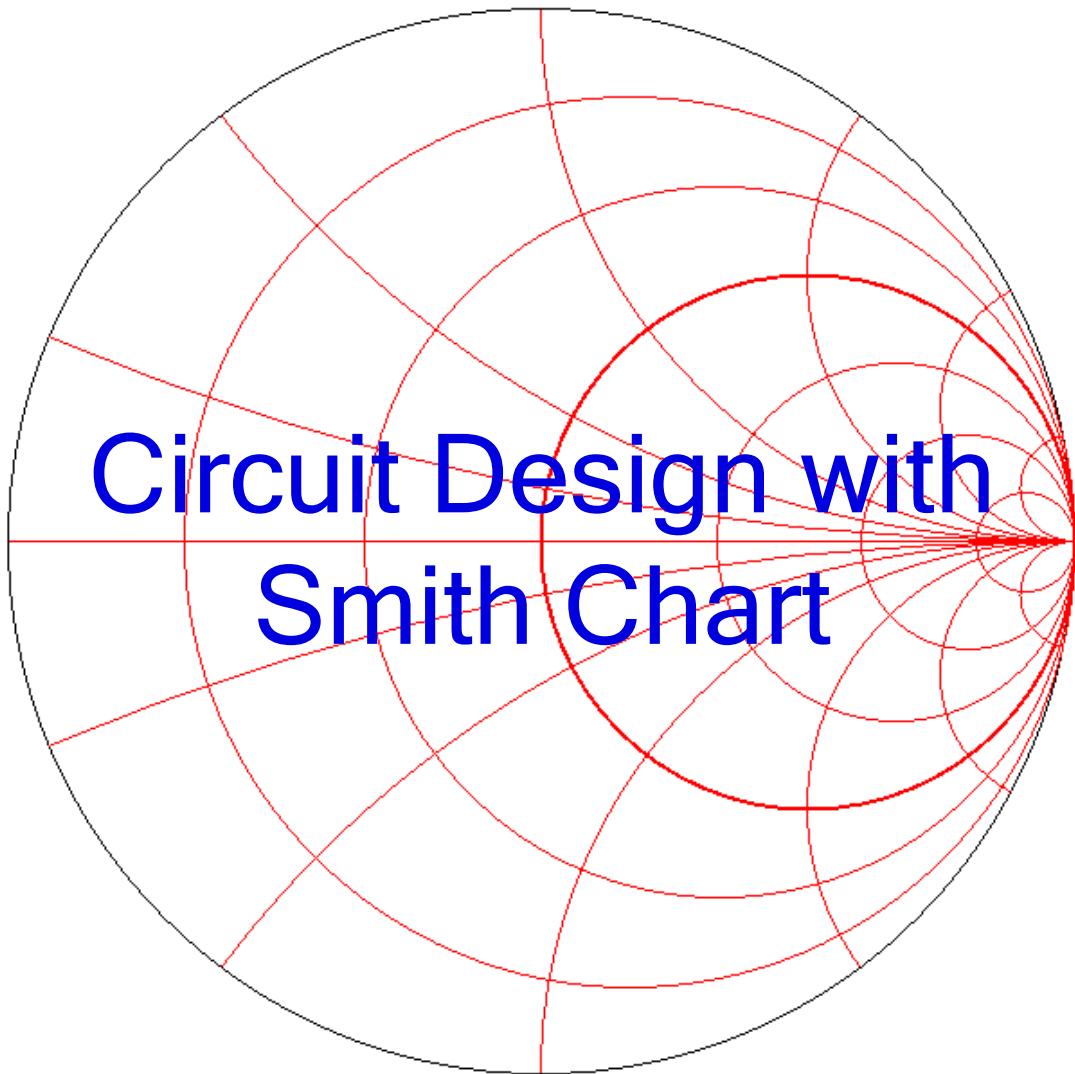


Help for Smith V4.1



www.fritz.dellsperger.net

January 2018

Content

Help for Smith V4.1	1
Overview	1
Smith-Chart	2
Menu and Toolbar	5
Input of Datapoints	7
Input of Circuit Elements for the Network	9
Circuit Elements	11
Edit circuit element values	11
Tune circuit element values, Tuning Cockpit	12
Capacitor (Serial or parallel element)	14
Inductor (Serial or parallel element)	15
Resistor (Serial or parallel element)	16
Physical Transmission Line (Serial element)	17
Open ended Transmission Line, Open Stub (Parallel element)	19
Shorted Transmission Line, Shorted Stub (Parallel element)	21
Transformer (Serial element)	23
R-L-C parallel connected (Serial element)	25
R-L-C serial connected (Parallel element)	26
Edit Datapoints	27
Zoom-Function	27
Undo and Redo	28
Sweeps	28
Circles	31
Constant Q-Circles	31
Constant Gain Circles	33
Constant VSWR Circles	35
Stability-Circles	36
Constant Noise Figure Circles	37
Settings	39
Print the Smith-Chart	41
Copy to Clipboard	42
Shortcuts	42
Save Netlist	43
Export Data	44
S-Plot	45
Export	49
Export H-, Z-, Y- and A-Parameter to File	49
Export CITI to S-Parameter Touchstone File	51
Export S11 or S22 to smith chart	51
Print S-Plot	53
Copy to Clipboard	54
Smith-Chart Basics	55
Smith-Chart Construction	55
Stability Circles	58
Constant Gain Circles	62
Simultaneous Conjugate Match	70
Constant Noise Figure Circles	71
File format info	72
Touchstone®	72
CITI	74
EZNEC	76
References	77
License, Demoversion and Contact	78
It's a long way to a perfect software	79
History	80

Overview

The software is split in two parts: **Smith-Chart** and **S-Plot**

Smith-Chart

Features:

- 👉 Matching ladder networks with capacitors, inductors, resistors, transformers, serial transmission lines and open or shorted stubs
- 👉 Free settable normalization impedance for the Smith-Chart
- 👉 Circles and contours for stability, noise figure, gain, VSWR and Q
- 👉 Edit element values after insertion
- 👉 Tune element values using sliders (Tuning Cockpit) **new in V4.0**
- 👉 Sweep versus frequency or datapoints
- 👉 Serial transmission line with loss
- 👉 Export datapoint and circle info to ASCII-file for post-processing in spreadsheets or math software
- 👉 Import datapoints from S-parameter files (Touchstone, CITI, EZNEC)
- 👉 Undo- and Redo-Function
- 👉 Save and load designs (licensed version only)
- 👉 Print Smith-Chart, schematic, datapoints, circles and S-Plot graphs
- 👉 Copy to clipboard for documentation purposes
- 👉 Settings for color and line widths for all graphs

S-Plot

Features:

- 👉 Read S-Parameter - Files in Touchstone® -, CITI- and EZNEC- Format
- 👉 Graphical display of s_{11} , s_{12} , s_{21} and s_{22}
- 👉 Graphical display and listing of MAG (maximum operating power gain), MSG (maximum stable gain), stability factor k , μ and returnloss.
- 👉 Linear or logarithmic frequency axis.
- 👉 Cursor readout at gain and return loss graphs.
- 👉 Convert and export S-Parameter to normalized or unnormalized H-, Z-, Y- or A- Parameters in Touchstone® - Format files.
- 👉 Export s_{11} or s_{22} to Smith-Chart
- 👉 Print all graphics or listings

System requirements:

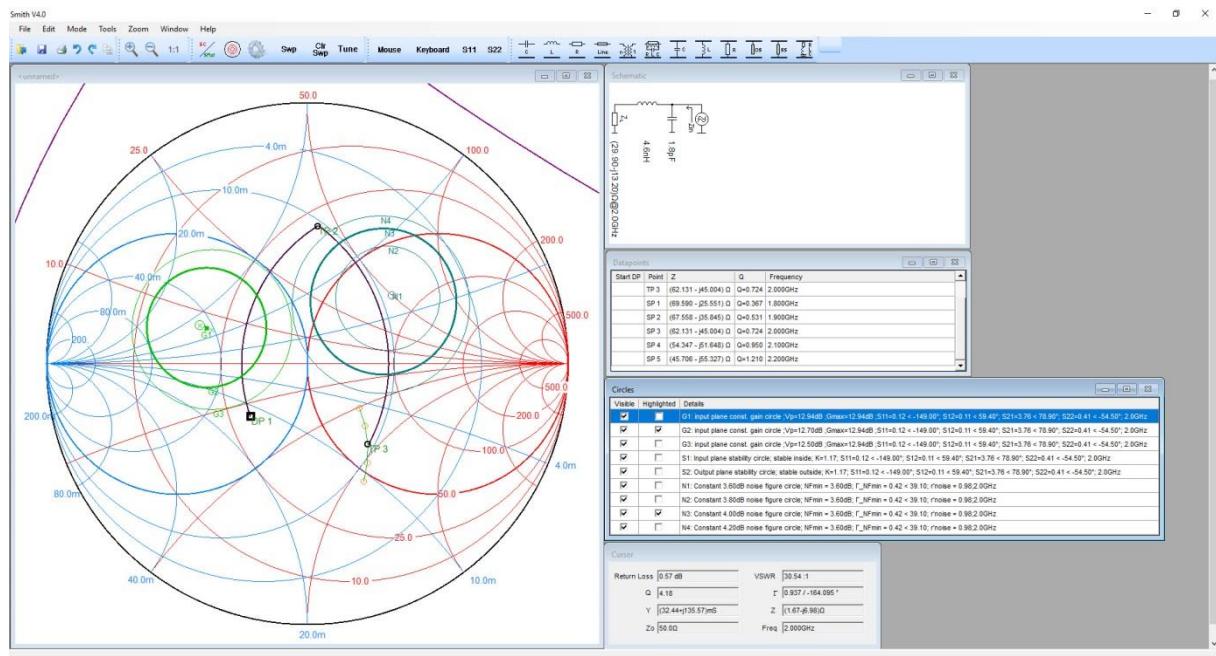
Windows Vista, Windows 7, 8, 10
.NET Framework 4.6.1 or higher

Smith-Chart

Activate Smith-Chart in menu „Mode“

or

toggle between “S-Plot” and “Smith-Chart” with



The display has following features:

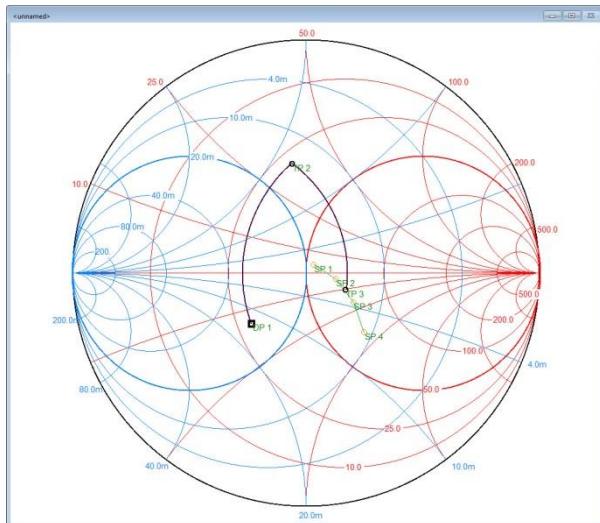
❖ Smith-Chart

Use the Smith-Chart the same way as on paper. Additionally comfortable tools like circles and locus are available. Window can be resized and moved to any position on display. Size and position of windows are saved on exit.

Datapoints input with mouse, keyboard or from S-parameter file are labeled with DPn. n is the number of datapoint, starting with number 1.

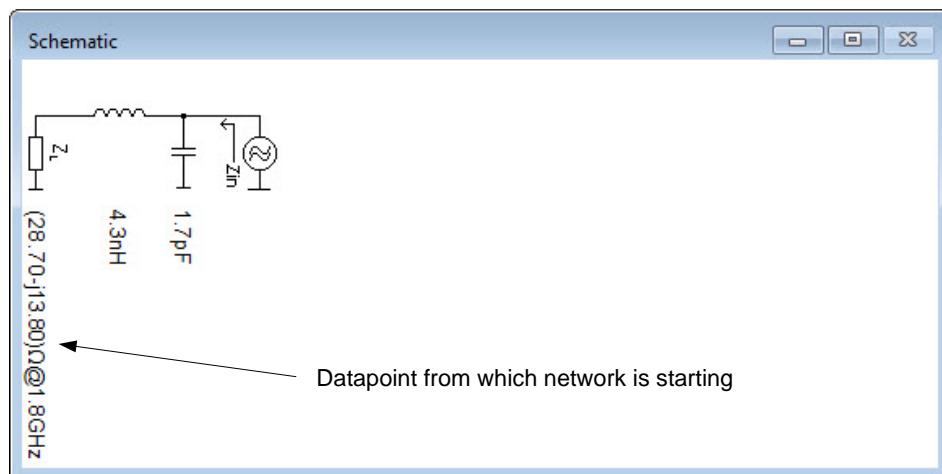
Datapoints transformed by circuit elements are labeled with TPm. m is the number of transformed datapoint, starting with $n_{\max}+1$.

Transformed datapoints resulting from sweeps are labeled with SPp. p is the number of transformed datapoint, starting with 1.

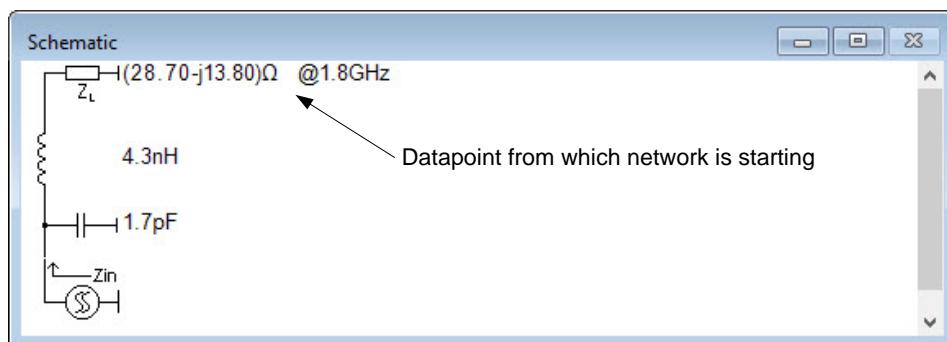


❖ Schematic-window

Networks on Smith-Chart are displayed as schematics. Window can be resized and moved to any position on display. Size and position of windows are saved on exit.



In “Tools - Settings” the schematic can be rotated to vertical.



❖ Datapoints-window

Values for all datapoints are listed here. Window can be resized and moved to any position on display. Size and position of windows are saved on exit.

Datapoints input with mouse, keyboard or from S-parameter file are labeled with DPn. n is the number of datapoint, starting with number 1.

Datapoints transformed by circuit elements are labeled with TPm. m is the number of transformed datapoint, starting with $n_{max}+1$.

Transformed datapoints resulting from sweeps are labeled with SPp. p is the number of transformed datapoint, starting with 1.

Datapoints				
Start DP	Point	Z	Q	Frequency
<input checked="" type="checkbox"/>	DP 1	(28.700 - j13.800) Ω	Q=0.481	1.800GHz
	TP 2	(28.700 + j34.832) Ω	Q=1.214	1.800GHz
	TP 3	(69.465 - j10.239) Ω	Q=0.147	1.800GHz
	SP 1	(53.290 + j3.989) Ω	Q=0.075	1.500GHz
	SP 2	(64.497 - j3.338) Ω	Q=0.052	1.700GHz
	SP 3	(72.618 - j19.372) Ω	Q=0.267	1.900GHz
	SP 4	(69.350 - j40.445) Ω	Q=0.583	2.100GHz

❖ Circles-window

Information of all circles is listed here. Window can be resized and moved to any position on display. Size and position of windows are saved on exit.

Visible	Highlighted	Details
<input checked="" type="checkbox"/>	<input type="checkbox"/>	G1: input plane const. gain circle; Vp=12.94dB ;Gmax=12.94dB ;S11=0.12 < -149.00°; S12=0.11 < 59.40°; S21=3.76 < 78.90°; S22=0.41 < -54.50°; 2.0GHz
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	G2: input plane const. gain circle; Vp=12.70dB ;Gmax=12.94dB ;S11=0.12 < -149.00°; S12=0.11 < 59.40°; S21=3.76 < 78.90°; S22=0.41 < -54.50°; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	G3: input plane const. gain circle; Vp=12.50dB ;Gmax=12.94dB ;S11=0.12 < -149.00°; S12=0.11 < 59.40°; S21=3.76 < 78.90°; S22=0.41 < -54.50°; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S1: Input plane stability circle; stable inside; K=1.17; S11=0.12 < -149.00°; S12=0.11 < 59.40°; S21=3.76 < 78.90°; S22=0.41 < -54.50°; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S2: Output plane stability circle; stable outside; K=1.17; S11=0.12 < -149.00°; S12=0.11 < 59.40°; S21=3.76 < 78.90°; S22=0.41 < -54.50°; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	N1: Constant 3.60dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; rnoise = 0.98; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	N2: Constant 3.80dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; rnoise = 0.98; 2.0GHz
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	N3: Constant 4.00dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; rnoise = 0.98; 2.0GHz
<input checked="" type="checkbox"/>	<input type="checkbox"/>	N4: Constant 4.20dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; rnoise = 0.98; 2.0GHz

Gn = Gain circle number n

Sn = Stability circle number n

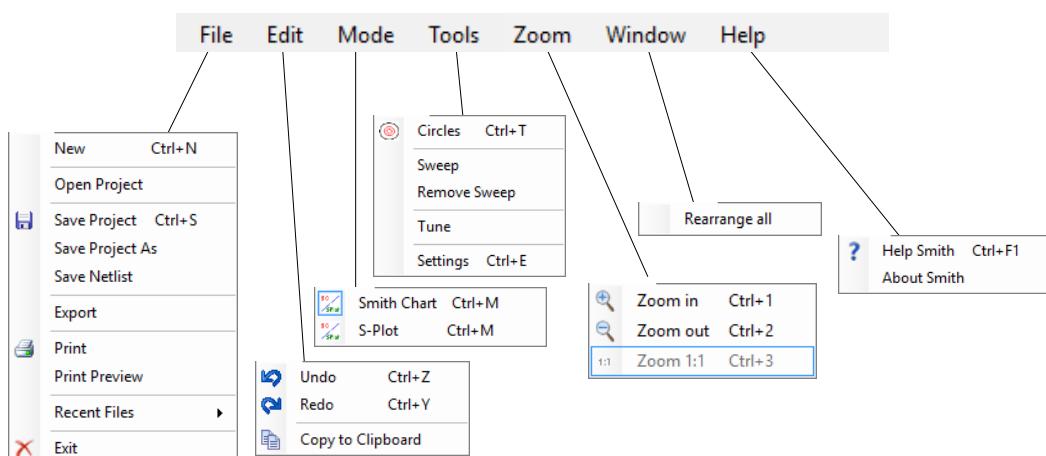
Nn = Noise circle number n

❖ Cursor-window

Display of actual values for the mouse cursor (Return Loss, VSWR, Q, Γ (Gamma), Admittance Y, Impedance Z, normalizing impedance Z_0 and Frequency of datapoint from which network is starting).



Menu and Toolbar



Toolbar:

All toolboxes in the toolbar are docking-toolboxes. They can be placed to any position on screen.
Position of toolboxes and windows are saved on exit.



Toolbox "Standard"



Open project (.xmlsc or .smc for V2.03 and older)

Save project (.xmlsc)

Print

Undo (Circuit elements, Datapoints and Sweeps)

Redo (Circuit elements, Datapoints and Sweeps)

Copy to clipboard

Toolbox "Zoom"



Zoom in

Zoom out

Zoom 1:1

Toolbox “Mode, circles and settings”



Toggle between Smith-Chart and S-Plot
Open Circles Dialogbox
Open Settings
Open Sweep Dialogbox
Clear Sweep
Open Tuning Cockpit

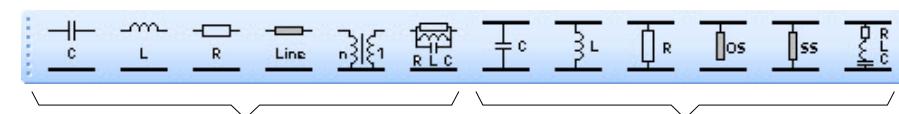
Toolbox “Datapoints”



Input Datapoint

Mouse
Keyboard
 S_{11} from file
 S_{22} from file

Toolbox “Elements”



Insert Serial Element

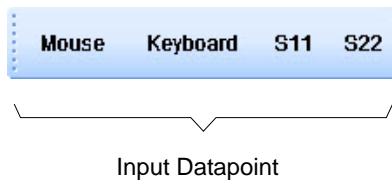
Capacitor
Inductor
Resistor
Transmission Line
Transformer
R-L-C

Insert Parallel Element

Capacitor
Inductor
Resistor
Open Stub
Shorted Stub
R-L-C

Input of Datapoints

There are four options to input datapoints:



- Mouse
Keyboard
 S_{11} from file
 S_{22} from file

Input with mouse:

- Select „Mouse“ in toolbox. This is a toggle-function ON/OFF. The button color turns to green for ON, blue for OFF.
 - Move mouse cursor to desired datapoint in Smith-Chart. Watch window Cursor for actual data values.
 - Left mouse click sets datapoint.
 - Enter frequency in dialogbox.
 - Continue with input of next datapoint.
 - Terminate datapoint input with clicking to “Mouse”-button in toolbox (color turns back to blue)
or
select a circuit-element

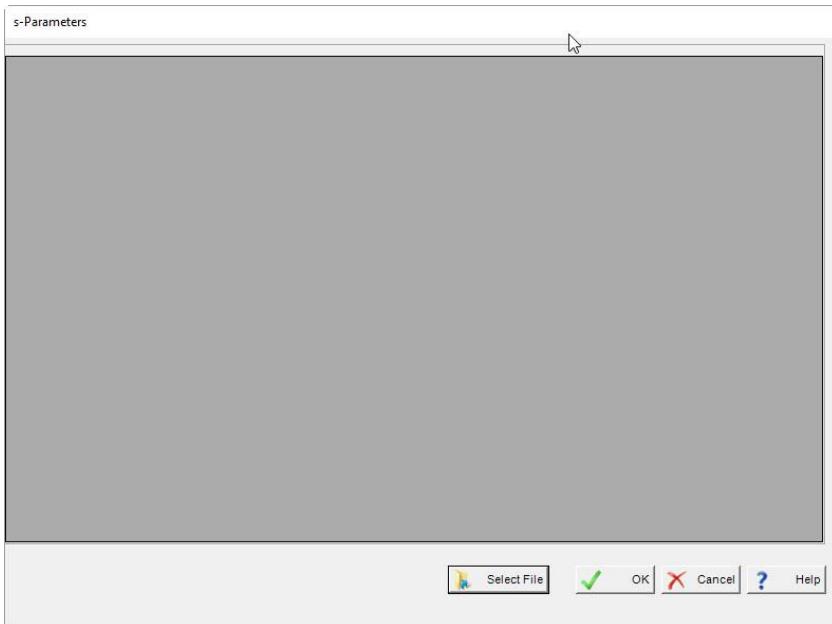
Input with Keyboard:

- Select „Keyboard“
 - Enter values in dialogbox. Data can be input as impedance, admittance or reflection coefficient in cartesian or polar notation.
Enter frequency in dialogbox.

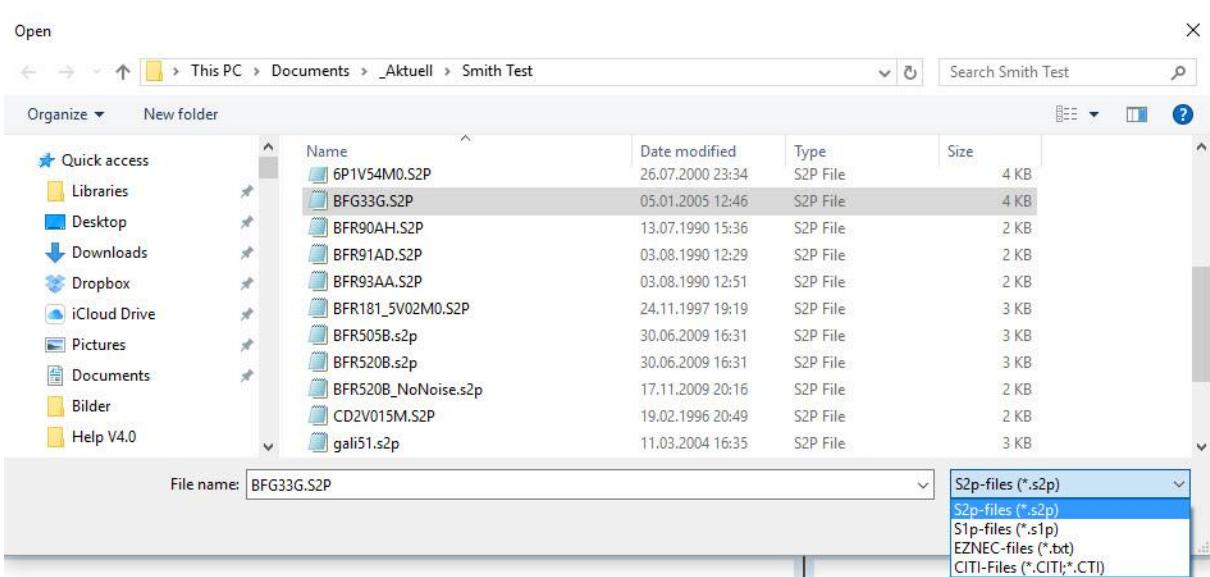
Import from S-Parameter Data File:

Datapoints can be imported from S-Parameter files or exported from S-Plot. See „S-Plot, Export to Smith Chart..“ S-Parameter file can be in Touchstone-, CITI- or EZNEC-format.

-  Click on „S11“ or „S22“.



➤ Select File.



➤ Choose file format:
Touchstone format (*.s1p, *.s2p)
CITI format (*.cti, *.cti)
EZNEC format (*.txt)

s-Parameters								
Frequency [MHz]	S11 Mag	S11 Angle	S21 Mag	S21 Angle	S12 Mag	S12 Angle	S22 Mag	S22 Angle
40.000	0.888	-10.000	14.292	170.500	0.010	84.700	0.977	-5.600
100.000	0.846	-24.300	13.459	158.300	0.024	76.900	0.936	-13.200
200.000	0.737	-44.900	11.641	141.400	0.043	68.100	0.833	-23.000
300.000	0.630	-61.300	9.877	128.800	0.057	63.200	0.732	-29.100
400.000	0.542	-74.500	8.377	119.200	0.067	60.500	0.653	-32.600
500.000	0.473	-84.800	7.179	112.000	0.076	59.600	0.595	-34.700
600.000	0.420	-93.500	6.263	106.300	0.084	59.600	0.554	-35.700
700.000	0.375	-101.200	5.539	101.400	0.092	60.300	0.524	-36.100
800.000	0.337	-107.900	4.952	97.200	0.100	61.000	0.501	-36.100
900.000	0.306	-114.900	4.479	93.300	0.107	61.700	0.484	-36.000
1000.000	0.280	-122.100	4.078	89.800	0.115	62.400	0.469	-35.900
1200.000	0.250	-135.700	3.484	84.100	0.130	63.700	0.444	-36.100
1400.000	0.235	-146.600	3.068	79.100	0.147	64.500	0.427	-37.200
1600.000	0.213	-154.400	2.727	74.500	0.162	65.100	0.421	-37.500
1800.000	0.193	-164.600	2.462	70.600	0.179	66.000	0.417	-38.200
2000.000	0.186	-178.600	2.256	66.600	0.196	66.000	0.405	-38.200
2200.000	0.202	168.900	2.093	63.100	0.214	66.000	0.386	-39.000
2400.000	0.220	163.000	1.977	59.200	0.233	65.600	0.369	-41.700
2600.000	0.221	160.700	1.842	56.100	0.250	65.100	0.361	-45.100

- Select datapoints to import using <shift> and <ctrl> for multiple selection. Terminate with OK.

Input of Circuit Elements for the Network

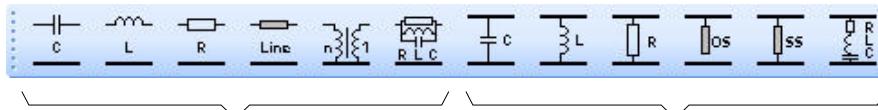
Check setting of reference impedance Z_o . Click menu “Extras-Settings”, Tab “Smith-Chart” and set Z_o to desired value (usually 50 Ohm). Z_o is displayed in Cursor- window.

Before selecting network elements from the toolbox, at least one datapoint must be placed.

If more than one datapoint is placed, select the datapoint from which the network transformation should start by clicking to the desired datapoint or the checkbox in the window “Datapoints”. The selected datapoint is marked with a bold square.

- Click on one of the circuit elements in the toolbox.

From the toolbox following elements can be selected:



Insert Serial Element

- Capacitor
- Inductor
- Resistor
- Transmission Line
- Transformer
- R-L-C

Insert Parallel Element

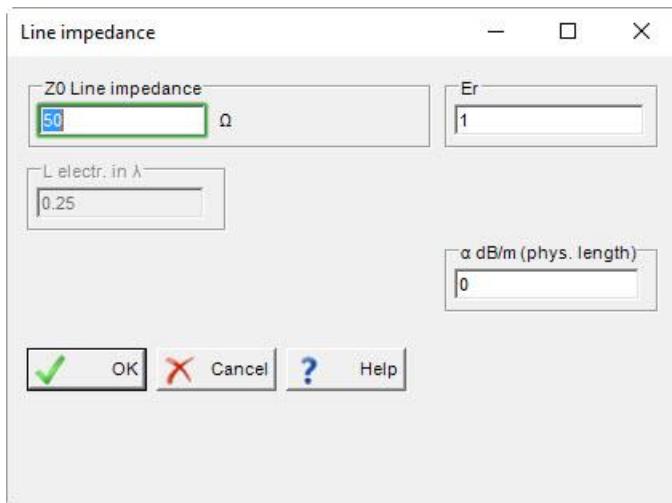
- Capacitor
- Inductor
- Resistor
- Open Stub
- Shorted Stub
- R-L-C

Except for serial or parallel-R-L-C and serial transmission line with loss, a locus for transformation is drawn in Smith-Chart and the element is added to the schematic. Move the cursor along the locus while watching cursor and values in Cursor-window and schematic.

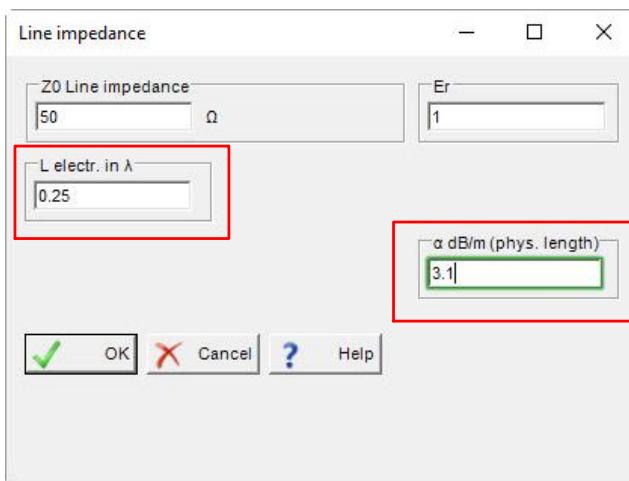
- Click at desired value. This terminates the element insertion.
For RLC, input element values in dialogbox.
- Undo with right mouse button if desired.
- Change element value by double-clicking on element or element-value in Schematic-window.

Serial transmission line:

- If attenuation α is 0 dB/m a locus for transformation is drawn in Smith-Chart and the element is added to the schematic. Move the cursor along the locus while watching cursor and values in Cursor-window and schematic.



- If attenuation α is >0 dB/m the line length in λ must be defined. No locus for cursor moving is drawn on Smith-Chart.

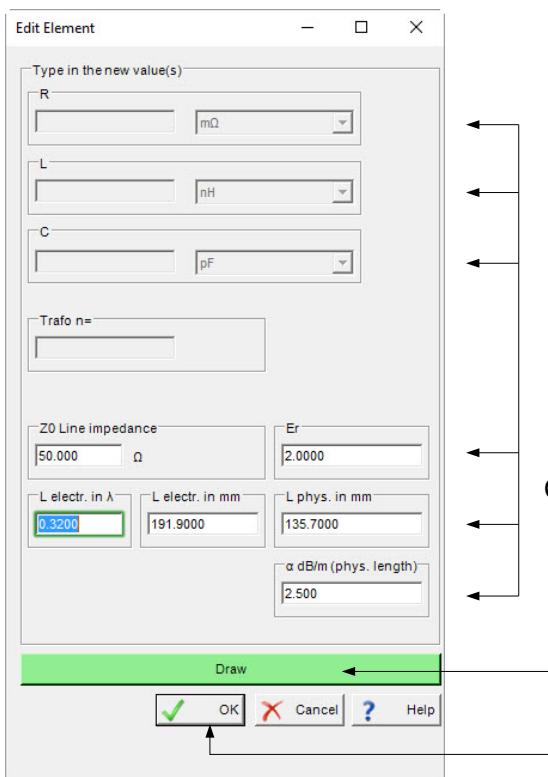


Circuit Elements

Edit circuit element values

To edit circuit element values:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Change values

Click Draw and watch Smith-chart, schematic and window „Datapoints“ how this affect transformation

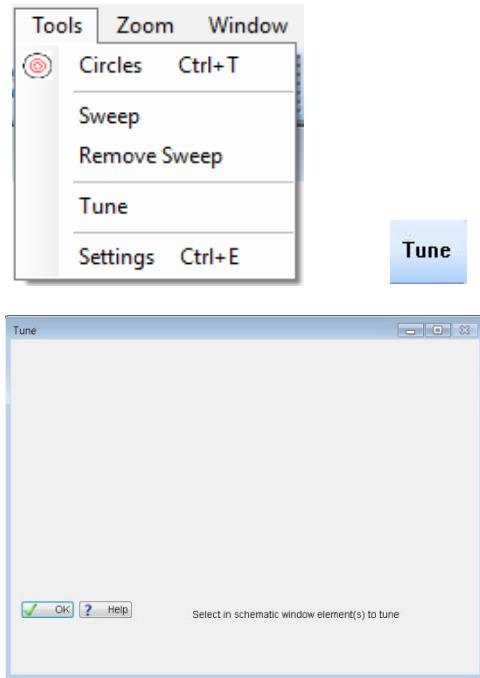
OK when done

Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

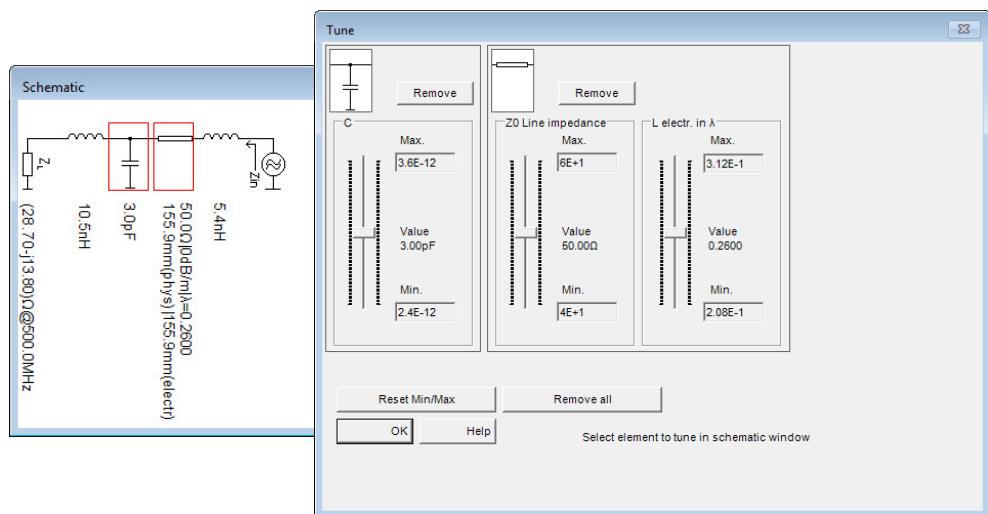
Tune circuit element values, Tuning Cockpit

To tune circuit element values with sliders:

- Use menu “Tools”, “Tune” or button in toolbox to open tuning cockpit



- In schematic point and click to desired element to add it to the tuning cockpit. Selected elements are marked with a red rectangle.

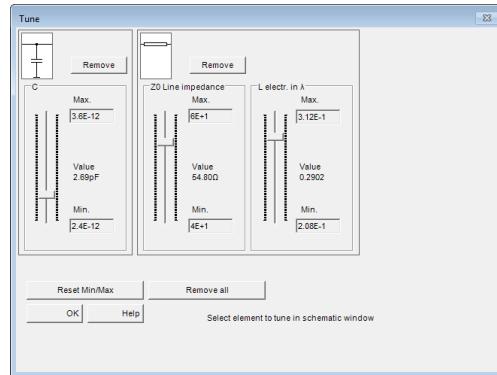


The tuner starts with the element value from schematic for mid position of slider. With the slider the element value can be tuned to maximum of 120% and minimum of 80% of starting value. Maximum and minimum values cannot be changed.

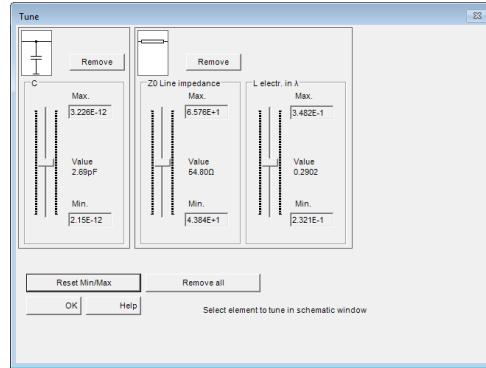
Reset Min/Max

Using “Reset Min/Max” button the actual element value is taken for new mid position of slider. Maximum and minimum values are adjusted to new mid position value.

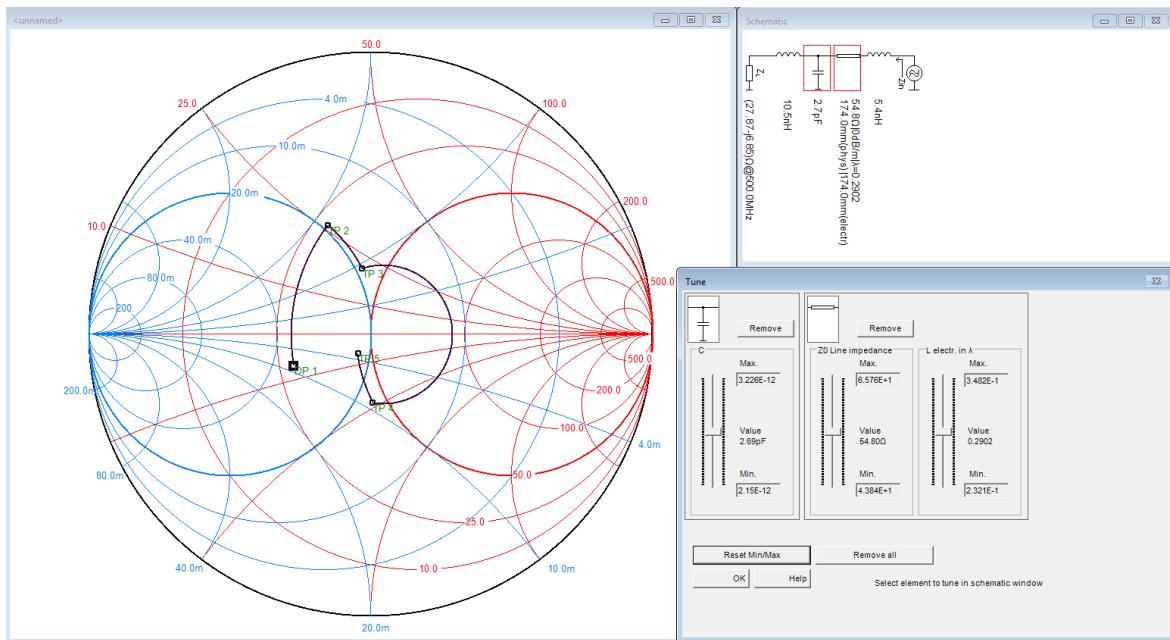
Before "Reset Min/Max"



After "Reset Min/Max"



Move slider and watch Smith-Chart



Remove

Remove element from tuning cockpit with remove button.

Remove all

Remove all elements from tuning cockpit.

For final closing of tuning cockpit and terminate all tuning functions remove all elements in Tune window. The red marking rectangles of the elements in schematic are deleted.

Capacitor (Serial or parallel element)



Model: Ideal capacitor, $Q = \infty$

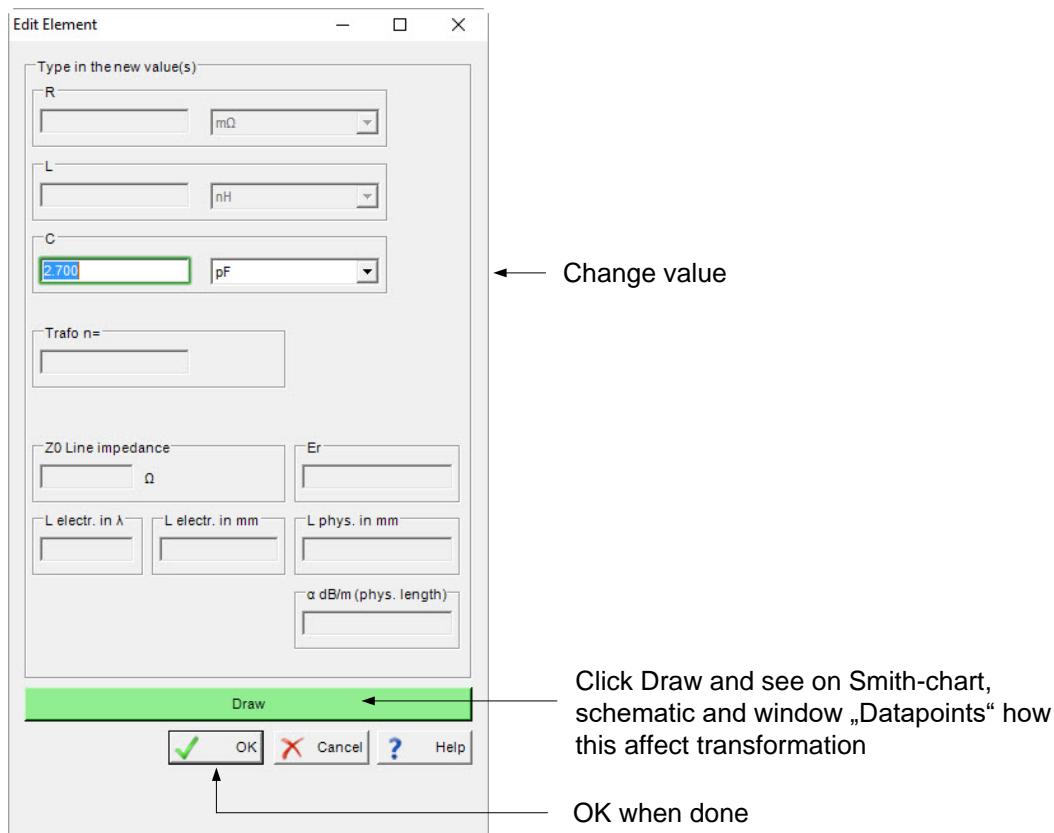
Parameters:

Name	Description	Units
C **	Capacitance	pF, nF, uF

** Value adjustable in tuning cockpit

To edit capacitance value:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

CAP n1 n2 C=capacitance_in_pF

Inductor (Serial or parallel element)

Model: Ideal inductor, Q = infinity



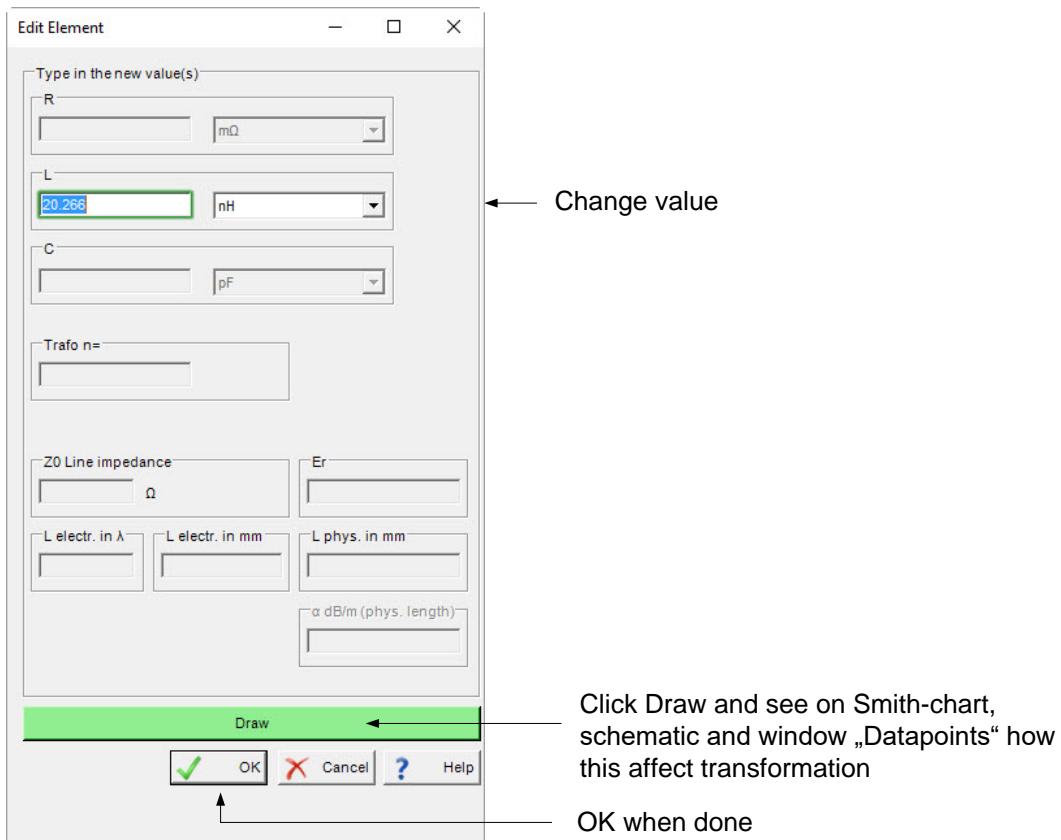
Parameters:

Name	Description	Units
L **	Inductance	pH, nH, uH

** Value adjustable in tuning cockpit

To edit inductance value:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

IND n1 n2 L=inductance_in_nH

Resistor (Serial or parallel element)

Model: Ideal resistor



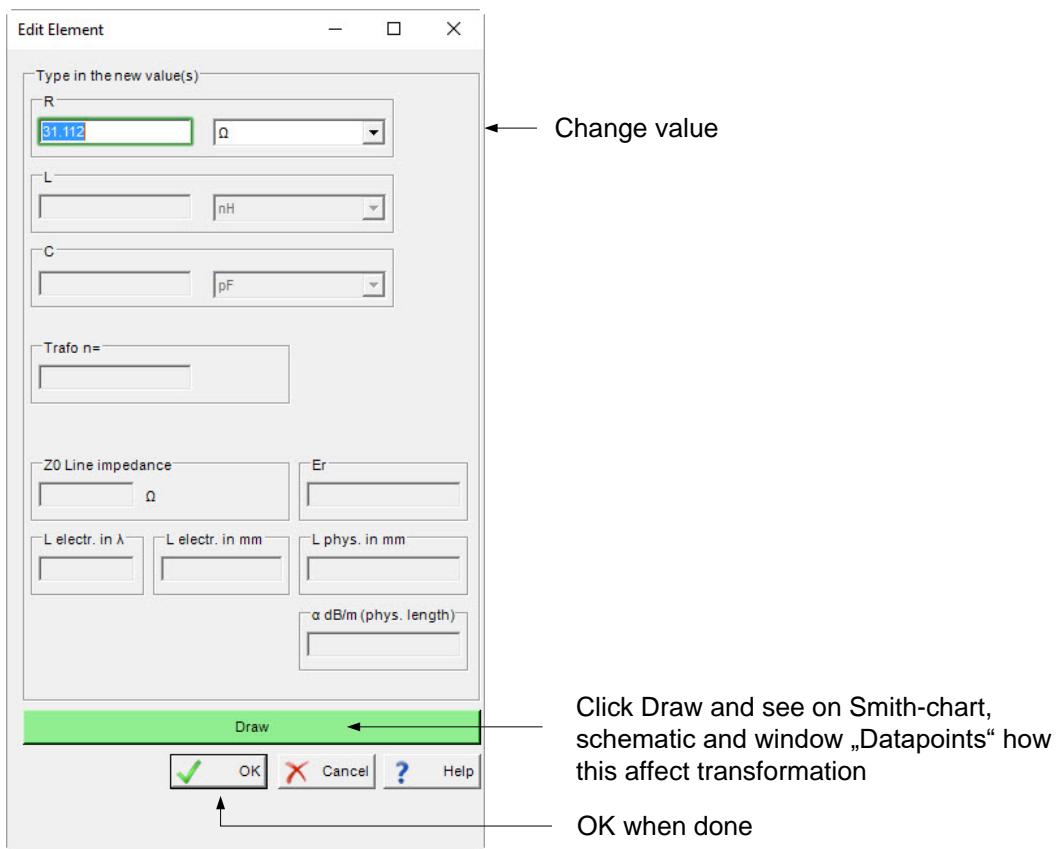
Parameters:

Name	Description	Units
R **	Resistance	mOhm, Ohm, kOhm, MOhm, GOhm

** Value adjustable in tuning cockpit

To edit resistance value:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

RES n1 n2 C=resistance_in_Ohm

Physical Transmission Line (Serial element)



Model: Physical transmission line

Parameters:

Name	Description	Units
Z_0 **	Line impedance	Ohm
ϵ_{re}	Effective relative permittivity	None
$L_{electr.}$ in λ **	Electrical length in wavelength	None
$L_{electr.}$ in mm	Electrical line length	m, mm
$L_{phys.}$ in mm	Physical (mechanical) line length	m, mm
α	Attenuation (frequency dependent)	dB/m physical length

** Value adjustable in tuning cockpit

α is modeling the conductor loss (which is usually dominant) and is frequency scaled by

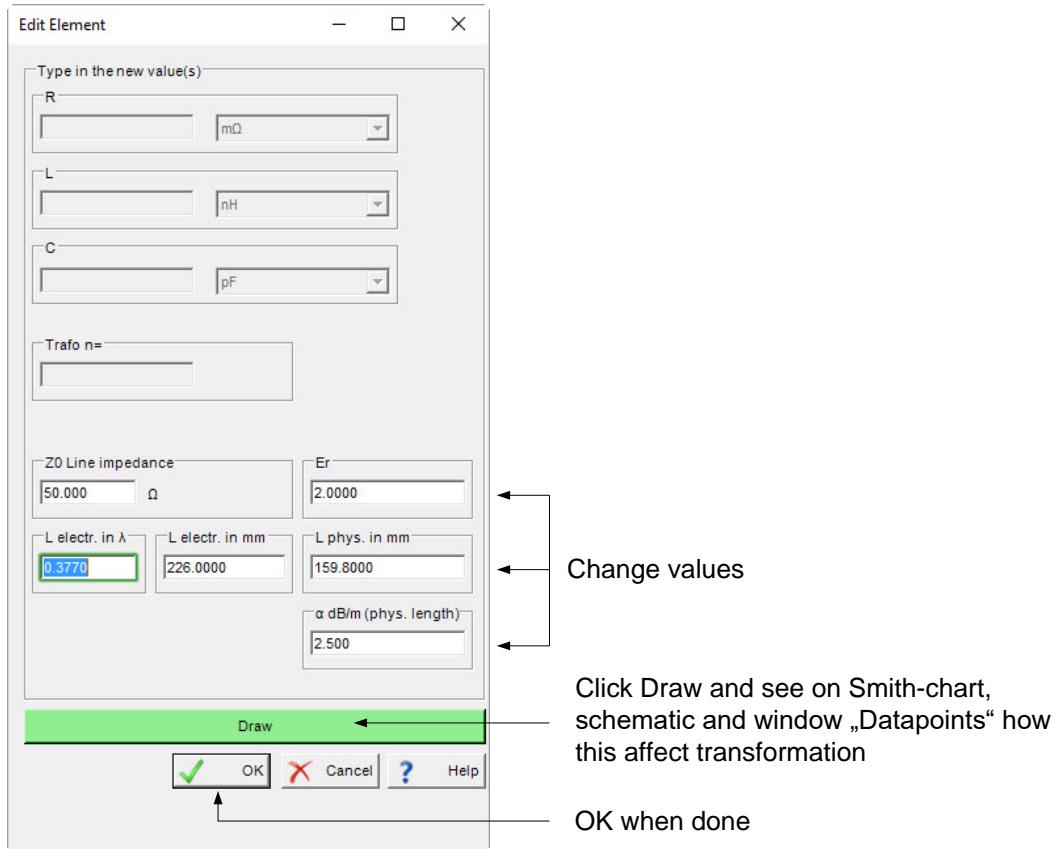
$$\alpha(f) = \alpha \sqrt{\frac{f}{f_{DP}}}$$

f_{DP} = frequency of the datapoint for the network.

The physical line length is $L_{phys} = \frac{L_{electr.}}{\sqrt{\epsilon_{re}}}$

To edit element values:

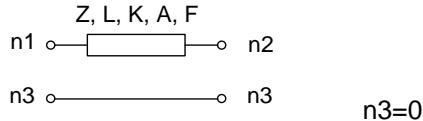
- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

```
TLINP n1 n2 n3 Z=line_imp_in_Ohm L=length_elec_in_mm K=eff_dielectric_const_Ere
A=attenuation_in_dB/m F=0
```



Remark on relative permittivity (relative dielectric constant) ϵ_r using lines:

If the line consist of microstrip, stripline or other planar line, use effective relative permittivity ϵ_{re} .

ϵ_{re} is a function of substrate ϵ_r , W/h, t and frequency.

For microstrip lines it can be approximated by

$$t = 0 \quad f \rightarrow 0$$

$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + 10 \frac{h}{w} \right)^{-0.555} \quad w/h \geq 1$$

Sometime instead of ϵ_r the relative velocity v_r is used.

v_r is related to ϵ_r by

$$v_r = \frac{1}{\sqrt{\epsilon_r}}$$

Open ended Transmission Line, Open Stub (Parallel element)



Model: Ideal transmission line

Parameters:

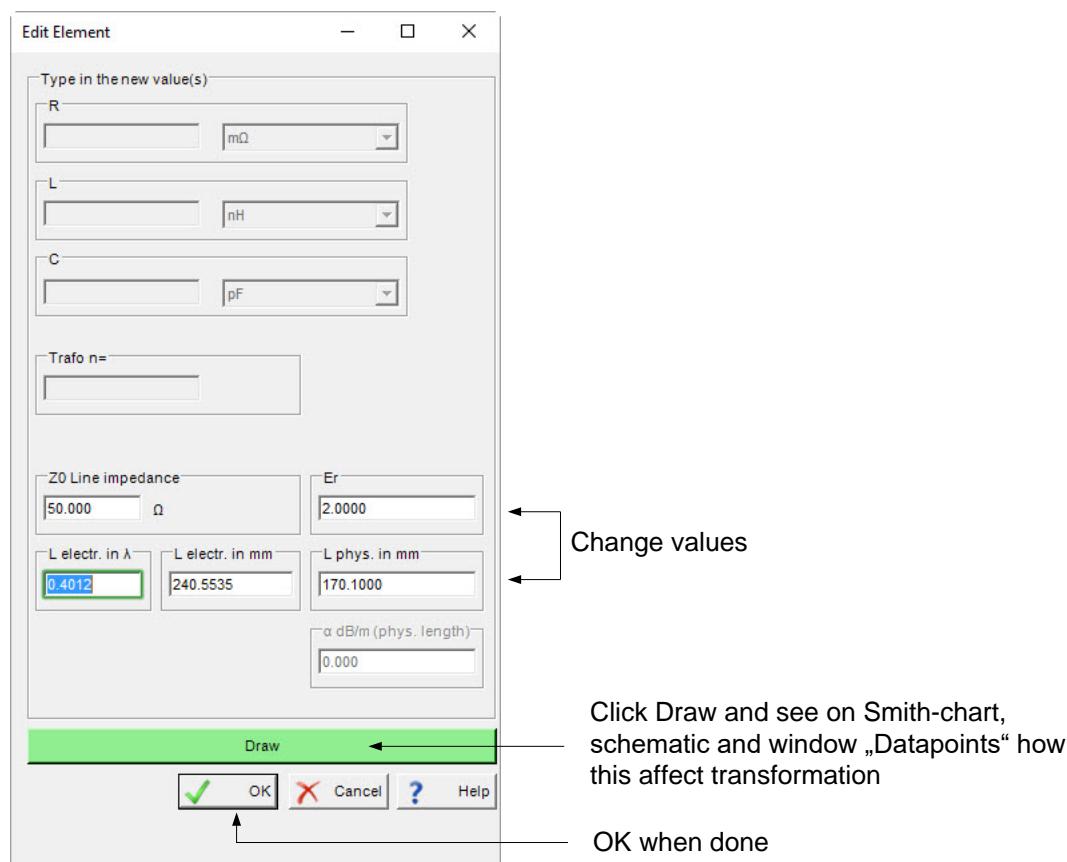
Name	Description	Units
Z_0 **	Line impedance	Ohm
ϵ_r	Effective dielectric constant	None
$L_{\text{electr. in } \lambda}**$	Electrical length in wavelength	None
$L_{\text{electr. in mm}}$	Electrical line length	m, mm
$L_{\text{phys. in mm}}$	Physical (mechanical) line length	m, mm

** Value adjustable in tuning cockpit

$$\text{The physical line length is } L_{\text{phys}} = \frac{L_{\text{electr}}}{\sqrt{\epsilon_r}}$$

To edit element values:

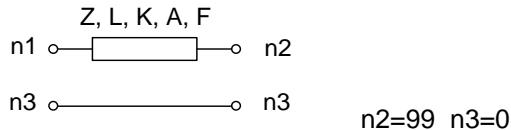
- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

TLINP n1 n2 n3 Z=line_imp_in_Ohm L=length_elec_in_mm K=eff_dielectric_const_Ere A=0 F=0



Remark on relative permittivity (relative dielectric constant) ϵ_r using lines:

If the line consist of microstrip, stripline or other planar line, use effective relative permittivity ϵ_{re} .

ϵ_{re} is a function of substrate ϵ_r , W/h, t and frequency.

For microstrip lines it can be approximated by

$$t = 0 \quad f \rightarrow 0$$
$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + 10 \frac{h}{w} \right)^{-0.555} \quad w/h \geq 1$$

Sometime instead of ϵ_r the relative velocity v_r is used.

v_r is related to ϵ_r by

$$v_r = \frac{1}{\sqrt{\epsilon_r}}$$

Shorted Transmission Line, Shorted Stub (Parallel element)



Model: Ideal transmission line

Parameters:

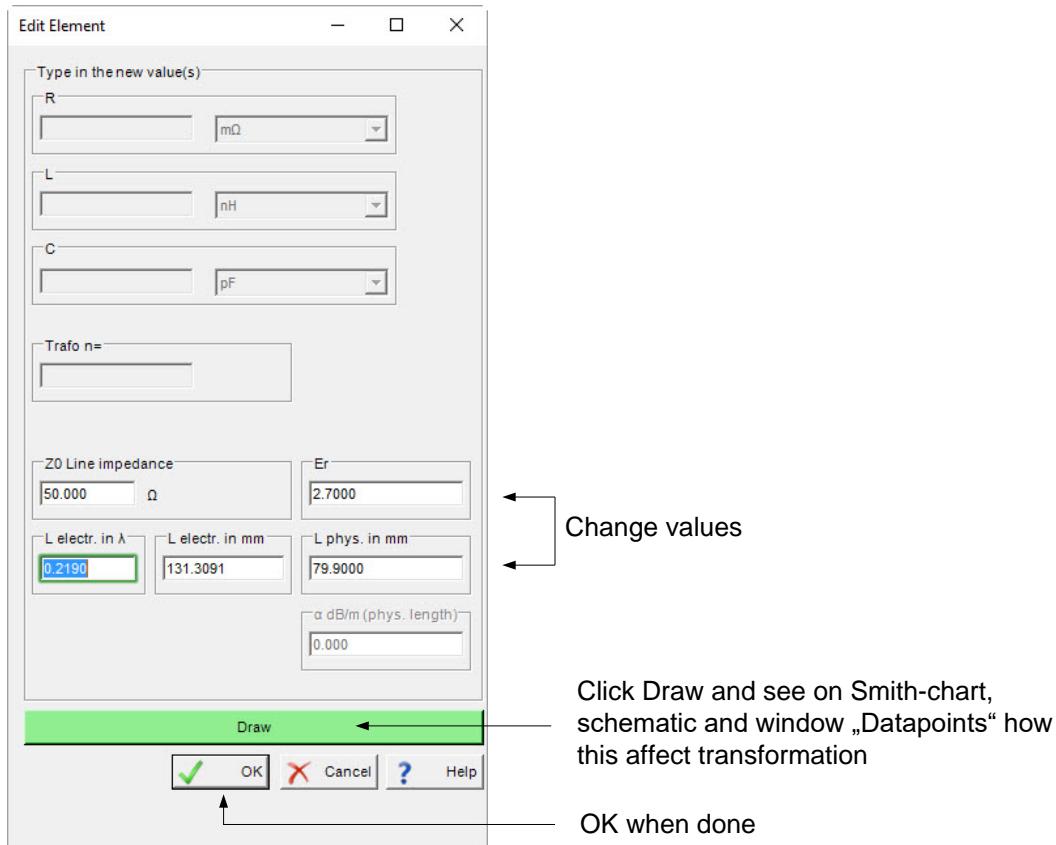
Name	Description	Units
Z_0 **	Line impedance	Ohm
ϵ_r	Effective dielectric constant	None
L electr. in λ **	Electrical length in wavelength	None
L electr. in mm	Electrical line length	m, mm
L phys. in mm	Physical (mechanical) line length	m, mm

** Value adjustable in tuning cockpit

$$\text{The physical line length is } L_{\text{phys}} = \frac{L_{\text{electr}}}{\sqrt{\epsilon_r}}$$

To edit element values:

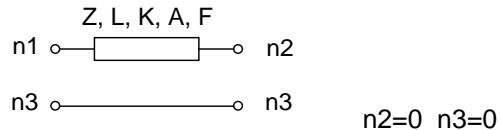
- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

TLINP n1 n2 n3 Z=line_imp_in_Ohm L=length_elec_in_mm K=eff_dielectric_const_Ere A=0 F=0



Remark on relative permittivity (relative dielectric constant) ϵ_r using lines:

If the line consist of microstrip, stripline or other planar line, use effective relative permittivity ϵ_{re} .

ϵ_{re} is a function of substrate ϵ_r , W/h, t and frequency.

For microstrip lines it can be approximated by

$$t = 0 \quad f \rightarrow 0$$
$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + 10 \frac{h}{w} \right)^{-0.555} \quad w/h \geq 1$$

Sometime instead of ϵ_r the relative velocity v_r is used.

v_r is related to ϵ_r by

$$v_r = \frac{1}{\sqrt{\epsilon_r}}$$

Transformer (Serial element)



Model: Ideal transformer

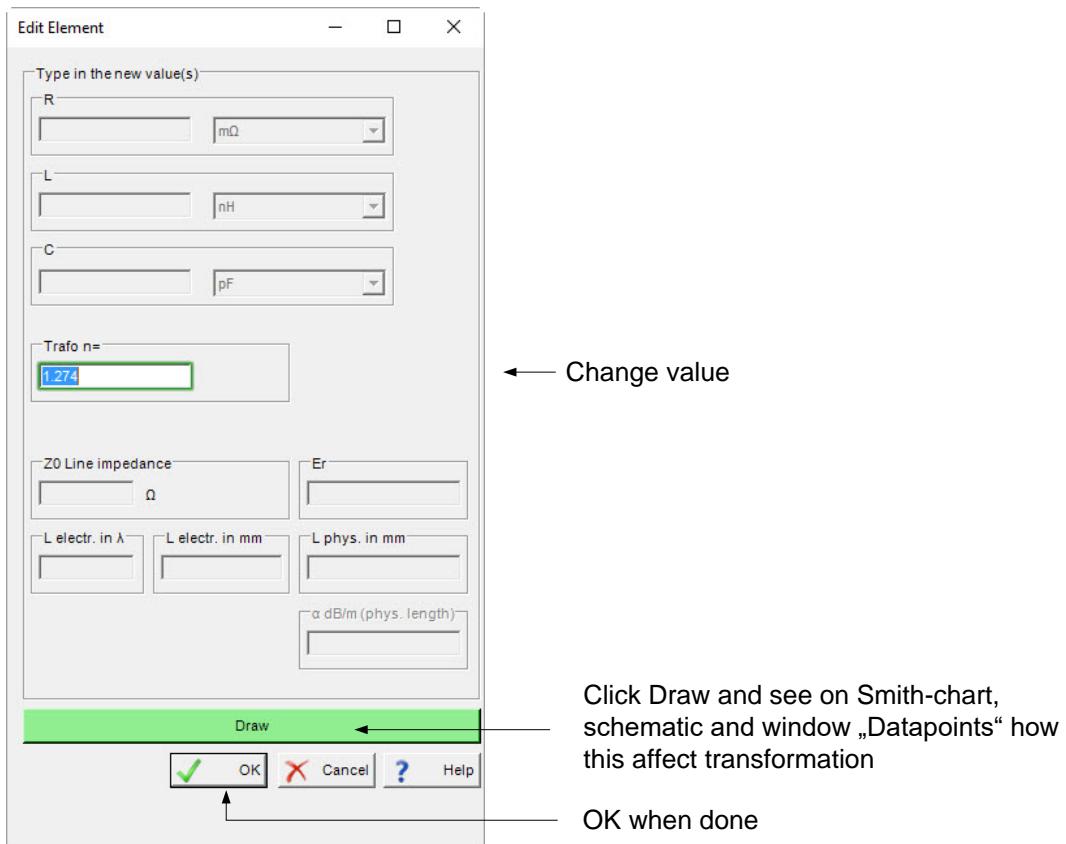
Parameters:

Name	Description	Units
n **	Voltage ratio (number of turn ratio) $0 < n < \infty$	None

** Value adjustable in tuning cockpit

To edit element value:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.

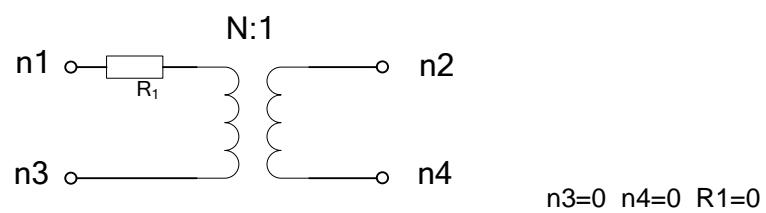


Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Remark: Impedance ratio is n^2

Netlist:

TRF n1 n2 n3 n4 N=turns_ratio R1=0



$n_3=0 \ n_4=0 \ R1=0$

R-L-C parallel connected (Serial element)

Model: Ideal Resistor, Inductor and Capacitor parallel connected



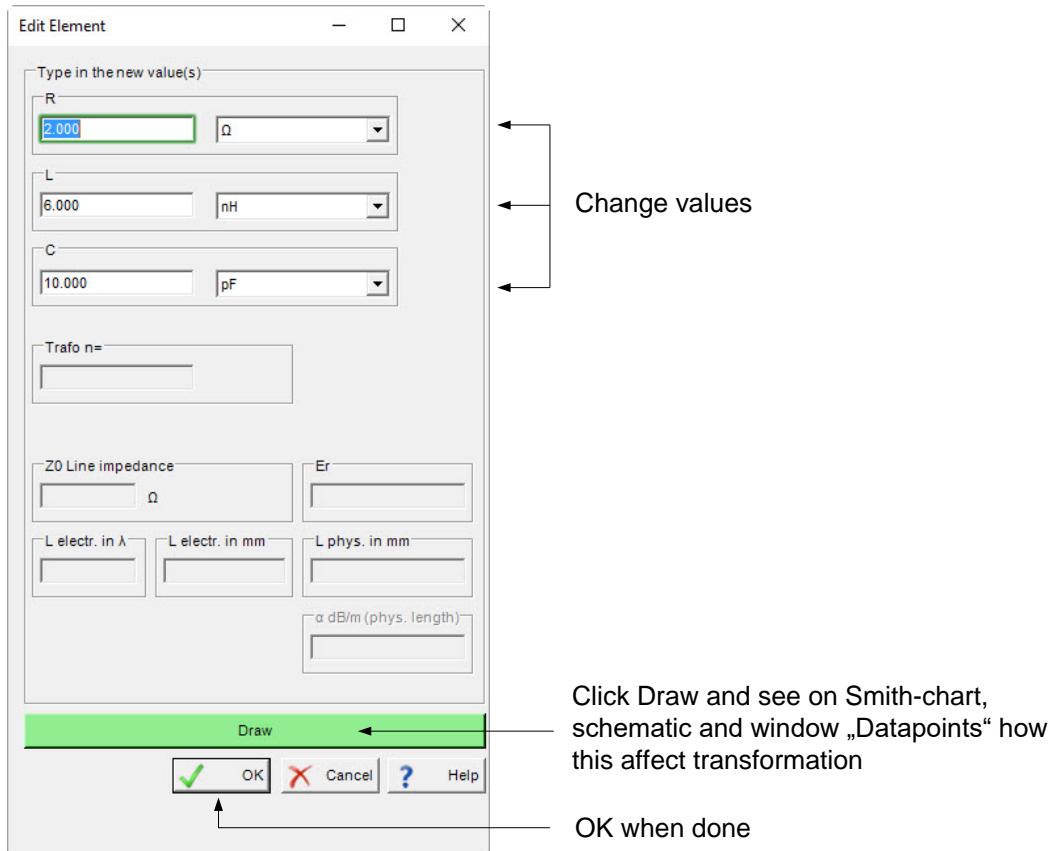
Parameters:

Name	Description	Units
R **	Resistance	Ohm, kOhm, MOhm
L **	Inductance	pH, nH, uH
C **	Capacitance	pF, nF, uF

** Value adjustable in tuning cockpit

To edit element values:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

Netlist:

PRLC n1 n2 R=resistance_in_Ohm L=inductance_in_nH C=capacitance_in_pF

R-L-C serial connected (Parallel element)

Model: Ideal Resistor, Inductor and Capacitor serial connected



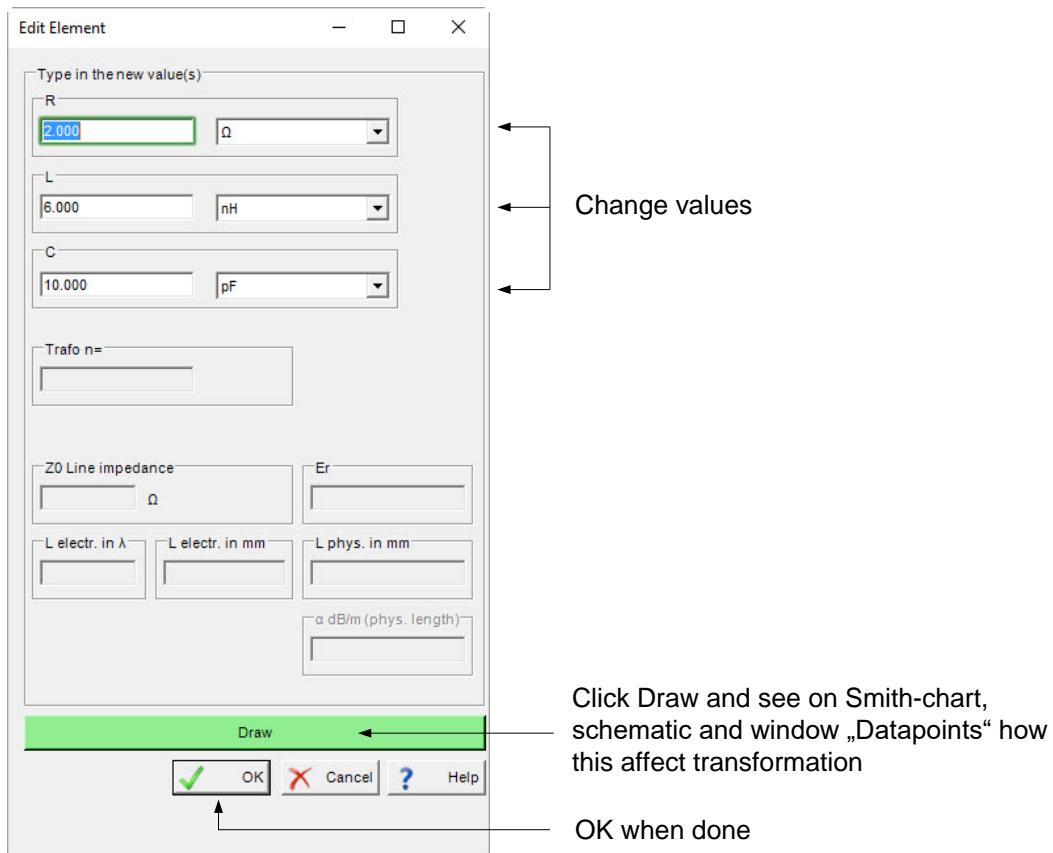
Parameters:

Name	Description	Units
R **	Resistance	Ohm, kOhm, MOhm
L **	Inductance	pH, nH, uH
C **	Capacitance	pF, nF, uF

** Value adjustable in tuning cockpit

To edit element values:

- Double-click on element or element-value in Schematic-window.
- Change value in dialogbox and click "Draw". All calculations are redone and the Smith-Chart is updated.



Do not use values of 0 (zero), instead input a very small value, e.g. 0.000001.
In some special cases a value of 0 can cause an error.

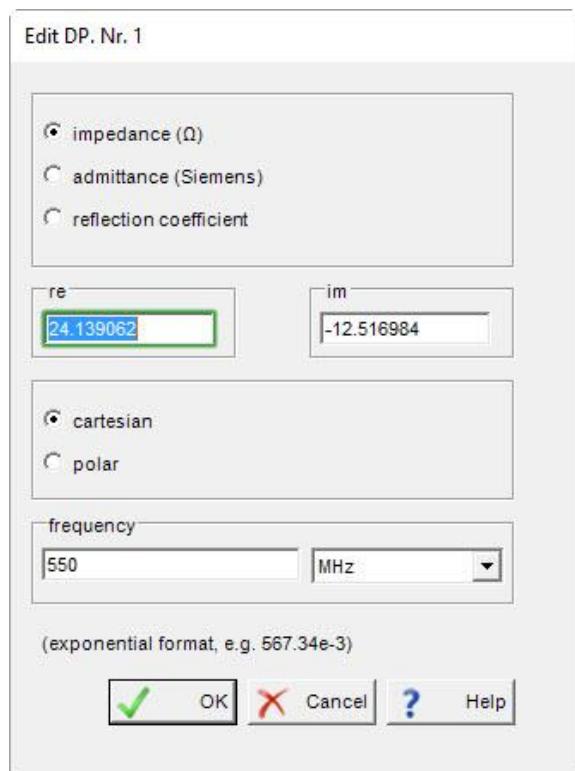
Netlist:

SRLC n1 n2 R=resistance_in_Ohm L=inductance_in_nH C=capacitance_in_pF

n2=0

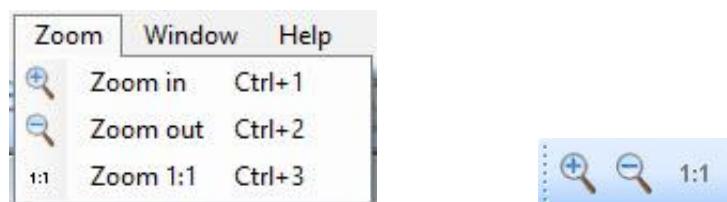
Edit Datapoints

- Double-click on datapoint in Smith-Chart.
- Change values in dialogbox. All calculations are redone and the Smith-Chart updated.



Zoom-Function

Use menu "Zoom" or shortcuts or buttons in toolbox.



There are 3 options for zooming:

- "Zoom in" Shortcut "Ctrl+1"
- "Zoom out" Shortcut "Ctrl+2"
- "Zoom 1:1" Shortcut "Ctrl+3"

The center of zoom is always the center of the Smith-Chart.

Undo and Redo

Undo and Redo works on **circuit elements and datapoints only**, not on circles or other operations.

➤ Undo:

- Right mouse button
- Menu „Edit“
- Button in toolbox 
- Shortcut “Ctrl+Z”

➤ Redo:

- Menu „Edit“
- Button in toolbox 
- Shortcut “Ctrl+Y”



Sweeps

There are two possibilities to sweep a network:

- Frequency sweep
- Datapoint Sweep

Use menu “Tools”, “Sweep” (“Remove Sweep”) or button in toolbox to invoke or clear a sweep.

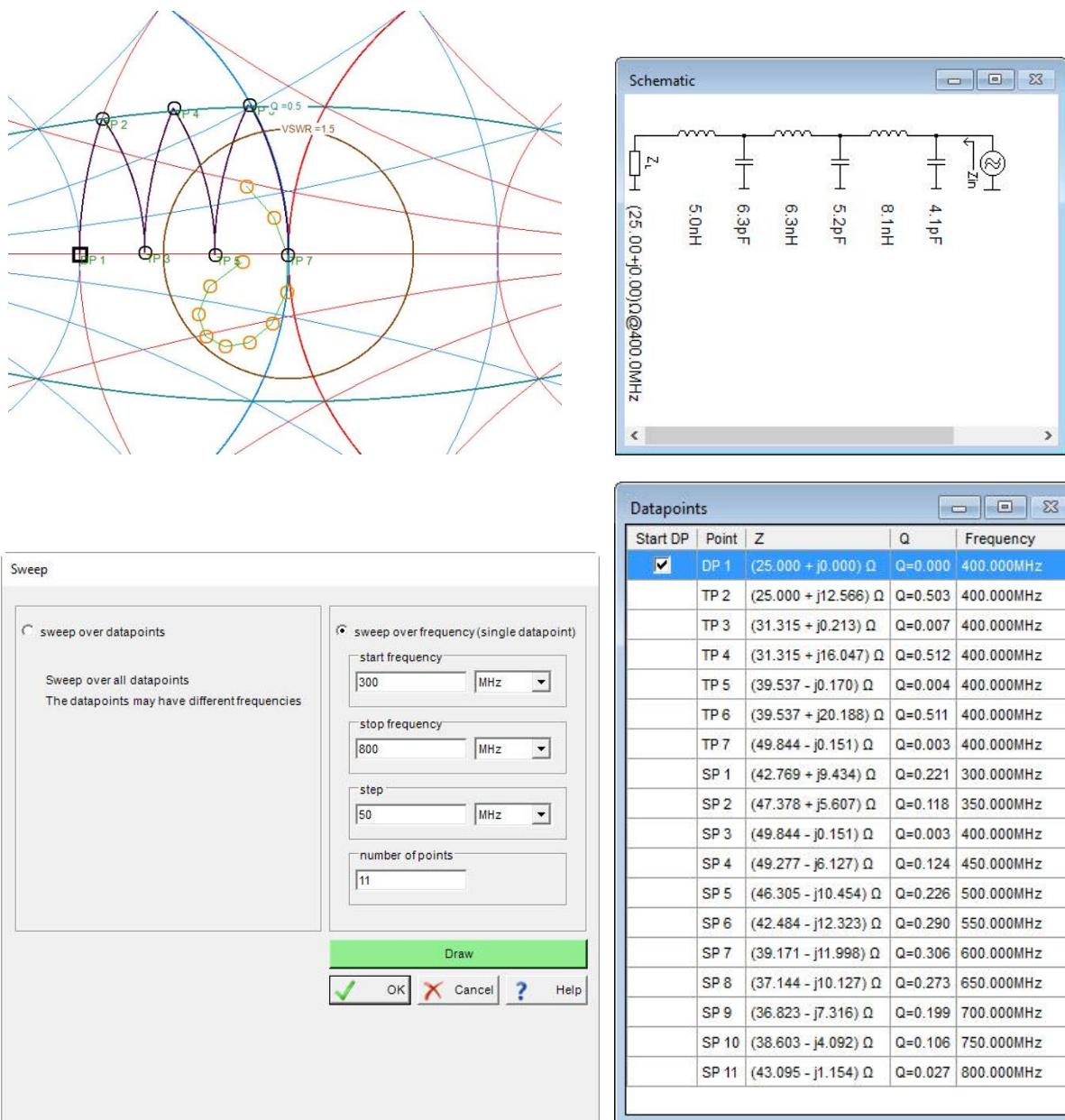


Before doing a sweep design a network starting from one datapoint. For datapoint sweep all datapoints must be input before starting a sweep.

Frequency sweep:

Example:

Match 25 Ohm to 50 Ohm using a 6 element lowpass at 400 MHz. Use a frequency sweep from 300 MHz to 800 MHz to find out the matching performance (VSWR) for this network versus the frequency range from 300 MHz to 800 MHz.

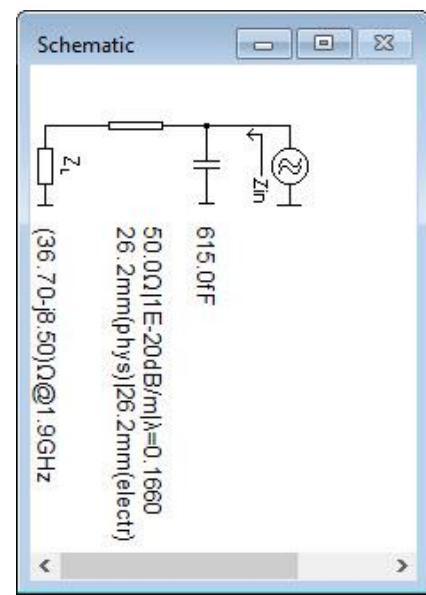
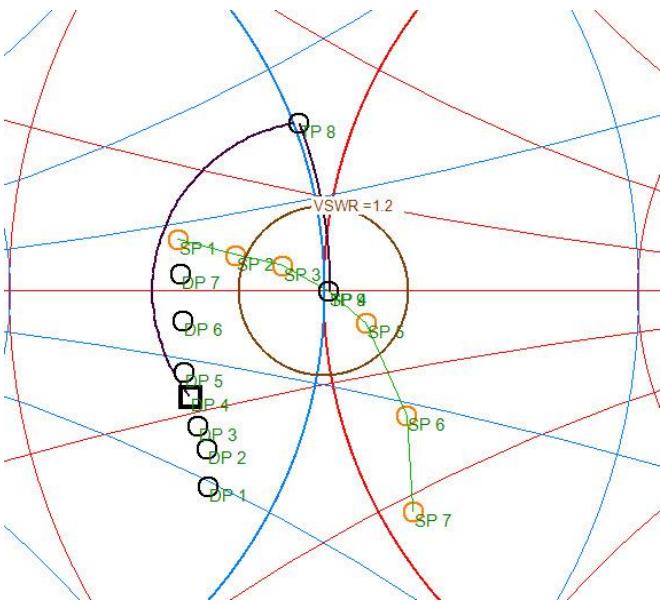


➤ After invoke of a sweep, edit element values to watch changes of swept points.

Datapoint sweep:

Example:

An antenna has different impedances at different frequencies. This datapoints are loaded from a S11-file. Match the antenna at 1.9 GHz to 50 Ohm using a 50 Ohm transmission line and a parallel capacitor. Use a datapoint sweep to find out the matching performance (VSWR) for this network for all datapoints.



Sweep

sweep over datapoints

Sweep over all datapoints
The datapoints may have different frequencies

sweep over frequency (single datapoint)

start frequency: 100 MHz

stop frequency: 500 MHz

step: 50 MHz

number of points: 9

Draw

✓ OK ✘ Cancel ? Help

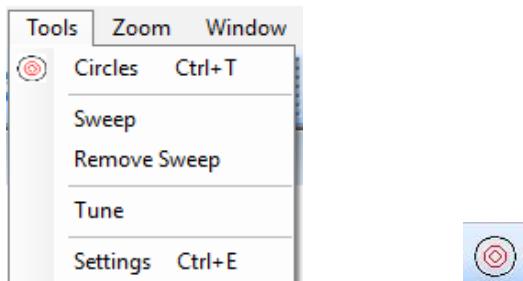
Datapoints

Start DP	Point	Z	Q	Frequency
<input type="checkbox"/>	DP 1	(36.000 - j16.000) Ω	Q=0.444	1.600GHz
<input type="checkbox"/>	DP 2	(37.000 - j13.000) Ω	Q=0.351	1.700GHz
<input type="checkbox"/>	DP 3	(36.800 - j11.000) Ω	Q=0.299	1.800GHz
<input checked="" type="checkbox"/>	DP 4	(36.700 - j8.500) Ω	Q=0.232	1.900GHz
<input type="checkbox"/>	DP 5	(36.500 - j6.500) Ω	Q=0.178	2.000GHz
<input type="checkbox"/>	DP 6	(36.900 - j2.400) Ω	Q=0.065	2.200GHz
<input type="checkbox"/>	DP 7	(36.700 + j1.400) Ω	Q=0.038	2.400GHz
TP 8		(44.472 + j16.472) Ω	Q=0.370	1.900GHz
TP 9		(50.573 - j0.046) Ω	Q=0.001	1.900GHz
SP 1		(36.407 + j4.112) Ω	Q=0.113	1.600GHz
SP 2		(41.298 + j3.227) Ω	Q=0.078	1.700GHz
SP 3		(45.629 + j2.530) Ω	Q=0.055	1.800GHz
SP 4		(50.573 - j0.046) Ω	Q=0.001	1.900GHz
SP 5		(54.609 - j3.814) Ω	Q=0.070	2.000GHz
SP 6		(57.461 - j15.643) Ω	Q=0.272	2.200GHz
SP 7		(53.522 - j26.933) Ω	Q=0.503	2.400GHz

➤ After invoke of a sweep, edit element values to watch changes of swept points.

Circles

Use menu „Tools“, „Circles“ or shortcut “Ctrl+T” or button in toolbox.



There are following options:

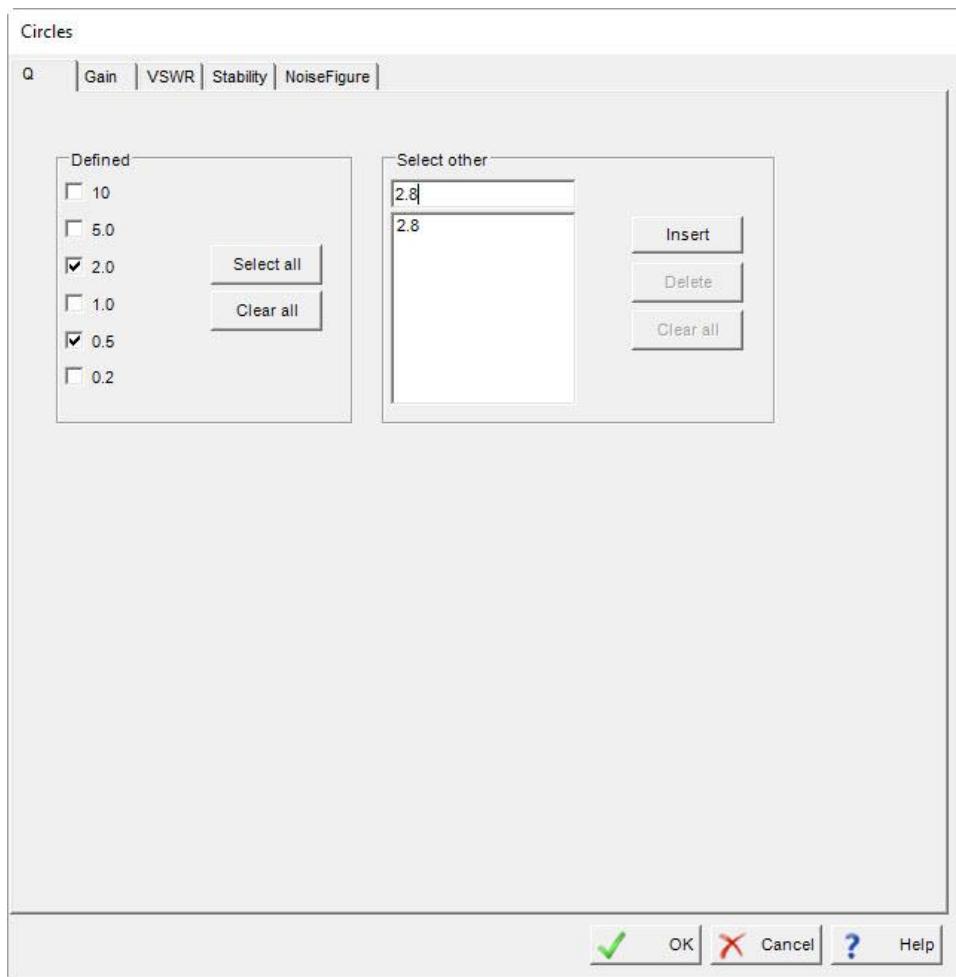
- Q-Circles
- Gain-Circles
- VSWR-Circles
- Stability-Circles
- Noise Figure Circles

Constant Q-Circles

- Select menu „Tools“, „Circles“ or shortcut “Ctrl+T”
- or click button in toolbox  and select tab „Q“
- Enter Q for the locus

This draws the locus (ellipse) of all points for

$$Q = \text{const.} = \frac{\text{Im}(Z)}{\text{Re}(Z)}.$$



Q-circles are not listed in window "Circles".

Constant Gain Circles

- Select menu „Tools“, „Circles“ or shortcut “Ctrl+T”
or click button in toolbox  and select tab „Gain“.
- Select “Available Power Gain”, “Operating Power Gain” or “Unilateral”.

Use “Available Power Gain” for low noise amplifiers.

Use “Operating Power Gain” for amplifiers with maximum output power, best efficiency or lowest intermodulation.

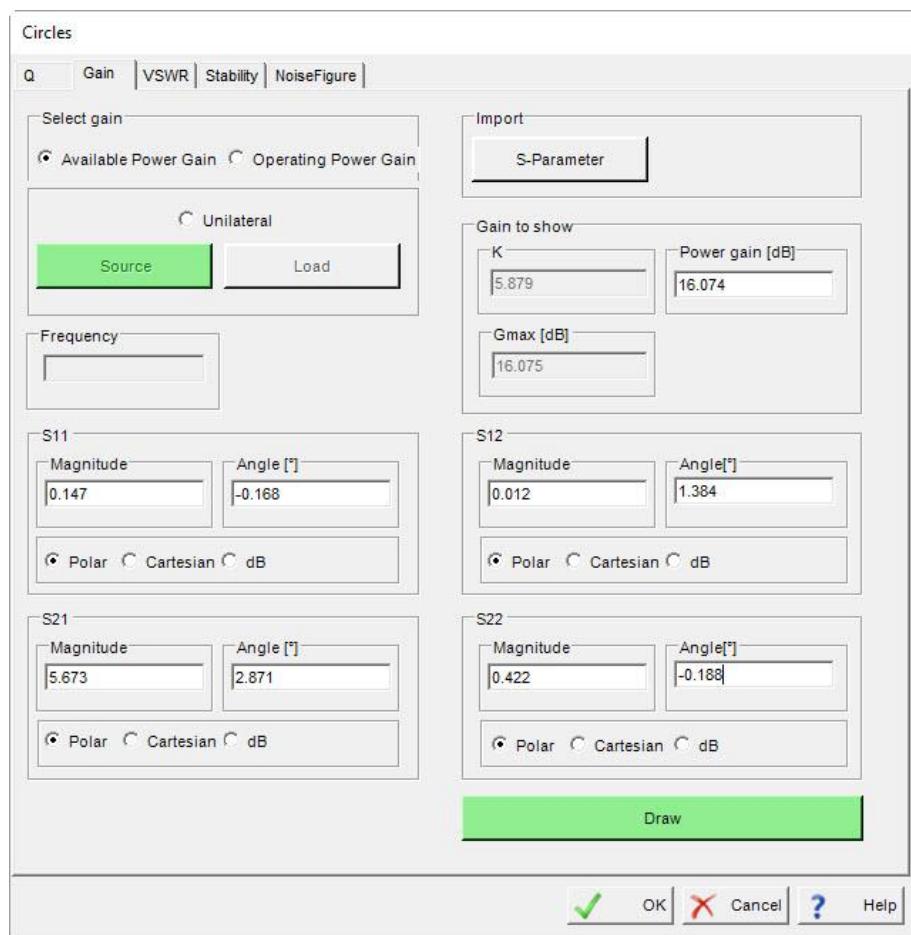
Use “Unilateral” for first approximation of matching network.

- Enter S-parameter or import parameter from a file.
- Enter desired Gain for the circle (must be less than Gmax).

If Stability factor K<1, Available Power Gain and Operating Power Gain are undefined and circles are for conditionally stable twoports. Be careful your amplifier may oscillate. One possibility to avoid oscillation is to stabilize the twoport in advance (serial or parallel resistor at input and/or output, until K>1).

For unilateral devices S12 is assumed to be zero.

- Click “Draw”.
- Continue with entering gain for next circle. Click “Draw”, etc.



Constant Gain circles are labeled with „Gn“. n is the number of the circle, starting with number 1.

Zoom if necessary.

The Constant-Gain-Circle will be described in window “Circles” with following data:

- Gn Gain circle number n
- Input or output plane
- Gain for the circle
- G_{max}
- S-Parameter
- Frequency ¹⁾

Circles		
Visible	Highlighted	Details
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	G3: input plane const. gain circle ;Vp=12.50dB ;Gmax=12.94dB ;S11=0.12...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	G4: input plane const. gain circle ;Vp=12.30dB ;Gmax=12.94dB ;S11=0.12...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S1: Input plane stability circle; stable inside; K=1.17; S11=0.12 < -149.00°;...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S2: Output plane stability circle; stable outside; K=1.17; S11=0.12 < -149.0...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	N1: Constant 3.60dB noise figure circle; NFmin = 3.60dB; $\Gamma_{NFmin} = 0.42 \dots$
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	N2: Constant 3.80dB noise figure circle; NFmin = 3.80dB; $\Gamma_{NFmin} = 0.42 \dots$

With the checkboxes in window “Circles” the visibility and highlight of the circle on Smith-Chart can be switched on and off.

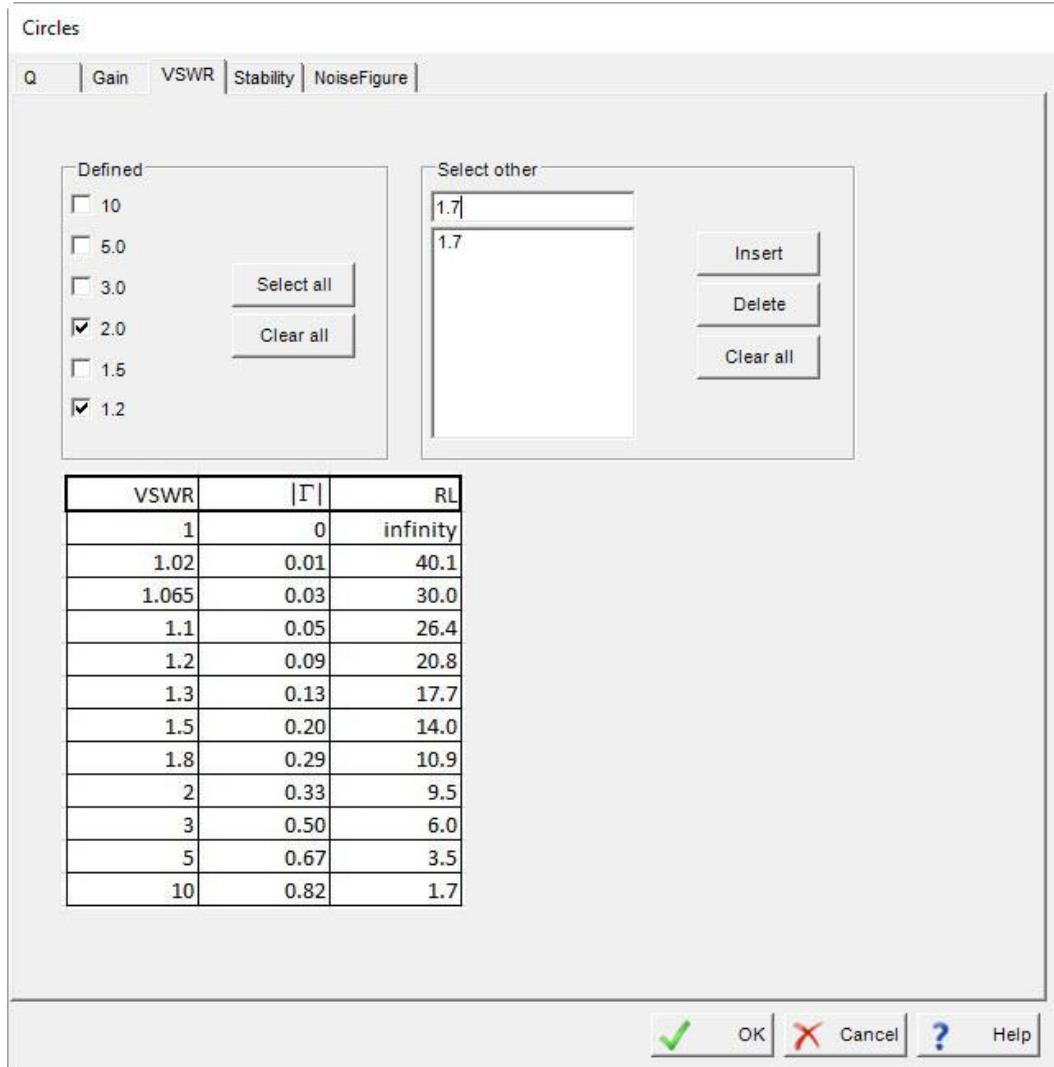
To remove a circle from Smith-Chart highlight appropriate line in window “Circles” and press “Delete”.

¹⁾ Frequency is only assigned to circles if parameters are input from a S-parameter-file. If parameters are input manually or altered, no frequency will be assigned.

Constant VSWR Circles

- Select menu „Tools“, „Circles“ or shortcut “Ctrl+T”
or click button in toolbox  and select tab „VSWR“
- Enter VSWR for the circle

The circles are always centered to the center of the Smith-Chart.

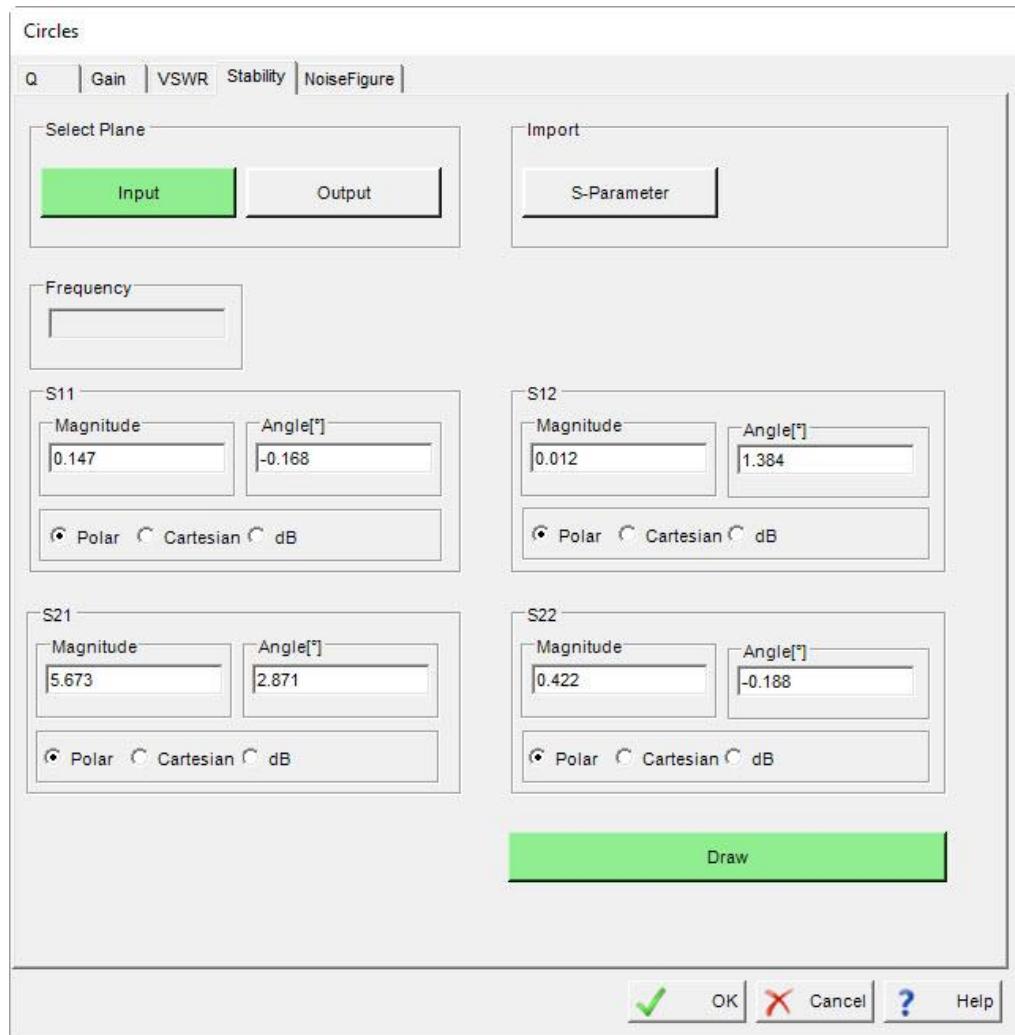


VSWR-circles are not listed in window “Circles”.

Stability-Circles

- Select menu „Tools“, „Circles“ or shortcut “Ctrl+T”
or click button in toolbox  and select tab „Stability“.
- Select Input plane or Output plane.
- Enter S-parameter or import parameter from a file.
- Click “Draw”.
- Continue with entering S-parameter for next circle. Click “Draw”, etc.

Stability circles are labeled with „Sn“. n is the number of the circle, starting with number 1.



If the circle lies outside the Smith-Chart zoom out.

The Stability-Circles are described in window “Circles” with following data:

- Sn Stability circle number n
- Input or output plane
- Stable inside or outside of the circle
- Stability factor K
- S-Parameter

- Frequency ¹⁾

Circles		
Visible	Highlighted	Details
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	G3: input plane const. gain circle ;Vp=12.50dB ;Gmax=12.94dB ;S11=0.12...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	G4: input plane const. gain circle ;Vp=12.30dB ;Gmax=12.94dB ;S11=0.12...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S1: Input plane stability circle; stable inside; K=1.17; S11=0.12 < -149.00°;...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	S2: Output plane stability circle; stable outside; K=1.17; S11=0.12 < -149.0...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	N1: Constant 3.60dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 ...
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	N2: Constant 3.80dB noise figure circle; NFmin = 3.80dB; Γ_NFmin = 0.42 ...

With the checkboxes in window “Circles” the visibility and highlight of the circle on Smith-Chart can be switched on and off.

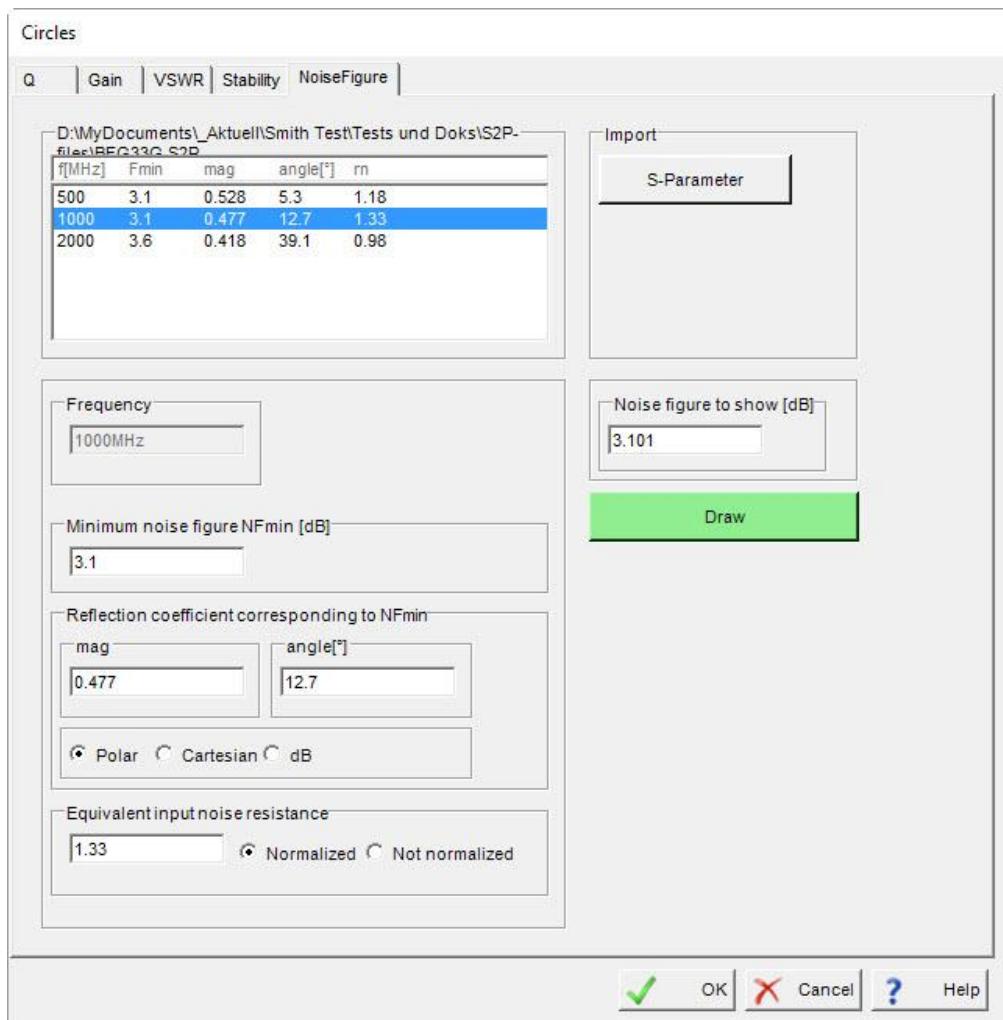
To remove a circle from Smith-Chart highlight appropriate line in window “Circles” and press “Delete”.

- ¹⁾ Frequency is only assigned to circles if parameters are input from a S-parameter-file. If parameters are input manually or altered, no frequency will be assigned.

Constant Noise Figure Circles

- Select menu „Tools“, „Circles“ or shortcut “Ctrl+T”
or click button in toolbox  and select tab „Noise Figure“.
- Enter noise data or import parameter from a file:
 - Minimum noise figure NF_{min} in dB
 - $G_{NF_{min}}$ (reflection coefficient corresponding to NF_{min})
 - Equivalent input noise resistance, normalized or unnormalized
- Enter desired Noise figure NF for the circle in dB ($>NF_{min}$)
- Click “Draw”.
- Continue with entering NF for next circle. Click “Draw”, etc.

Constant Noise Figure Circles are labeled with „Nn“. n is the number of the circle, starting with number 1.



Zoom if necessary.

Remark: Touchstone files have normalized noise resistance info. CDTI-files can have normalized or not normalized noise resistance info. Check appropriate radio button in window above.

The Constant Noise Figure Circle will be described in window "Circles" with following data:

- Nn Noise Figure circle number n
- NF for the circle
- NF_{min}
- $\Gamma_{NF_{min}}$
- Equivalent input noise resistance
- Frequency ¹⁾

Visible	Highlighted	Details
✓	✓	G3: input plane const. gain circle ;Vp=12.50dB ;Gmax=12.94dB ;S11=0.12...
✓	✗	G4: input plane const. gain circle ;Vp=12.30dB ;Gmax=12.94dB ;S11=0.12...
✓	✗	S1: Input plane stability circle; stable inside; K=1.17; S11=0.12 < -149.00°,...
✓	✗	S2: Output plane stability circle; stable outside; K=1.17; S11=0.12 < -149.0...
✓	✗	N1: Constant 3.60dB noise figure circle; NFmin = 3.60dB; $\Gamma_{NF_{min}} = 0.42 ...$
✓	✓	N2: Constant 3.80dB noise figure circle; NFmin = 3.80dB; $\Gamma_{NF_{min}} = 0.42 ...$

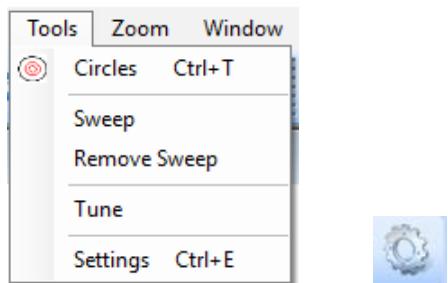
With the checkboxes in window "Circles" the visibility and highlight of the circle on Smith-Chart can be switched on and off.

To remove a circle from Smith-Chart highlight appropriate line in window "Circles" and press "Delete".

- 1) Frequency is only assigned to circles if parameters are input from a S-parameter-file. If parameters are input manually or altered, no frequency will be assigned.

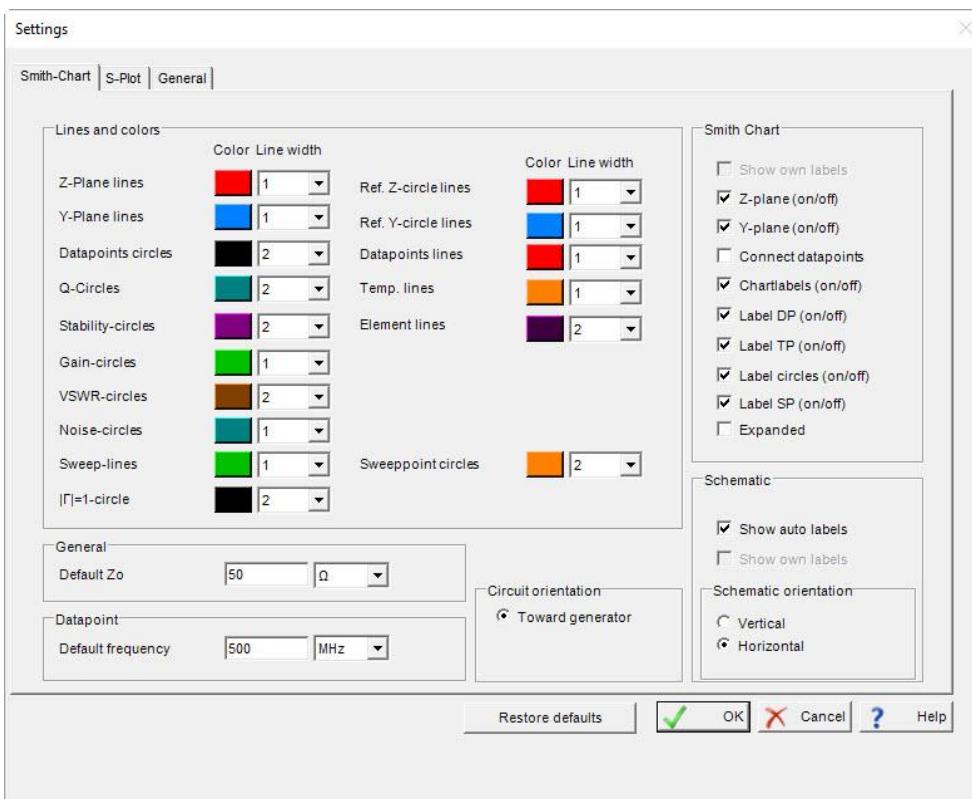
Settings

➤ Select menu „Tools“, „Settings“ or shortcut “Ctrl+E” or click button in toolbox



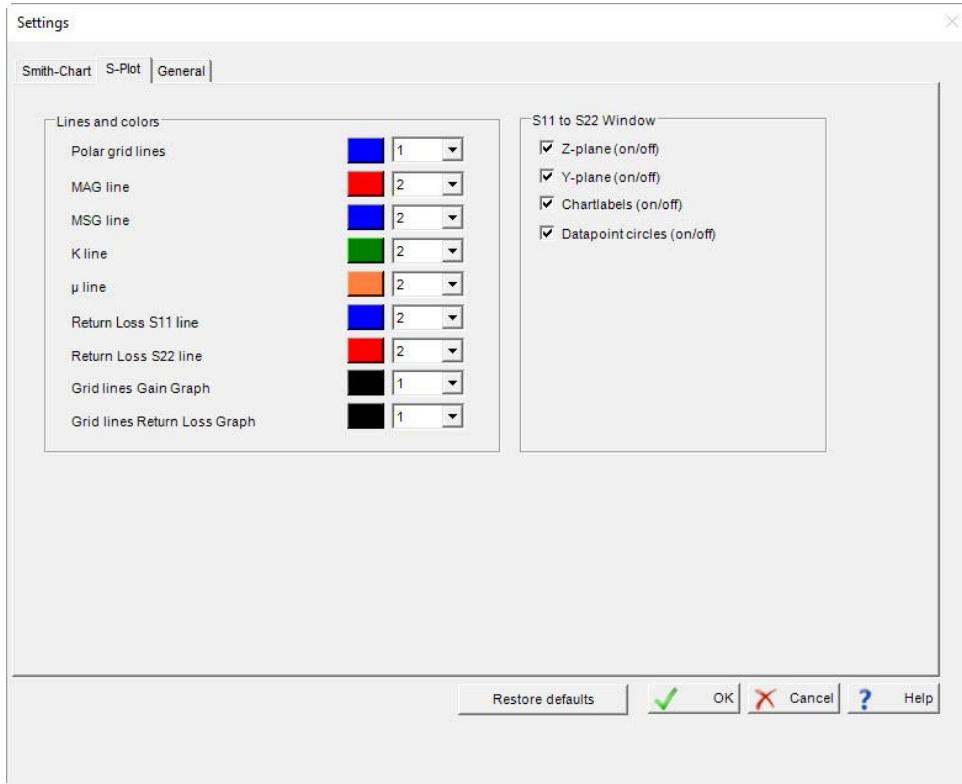
Tab Smith-Chart

- Line width and colors
- Z_0 for Smithchart
- Default frequency for datapoint
- Labels
- Z-plane, Y-plane on/off



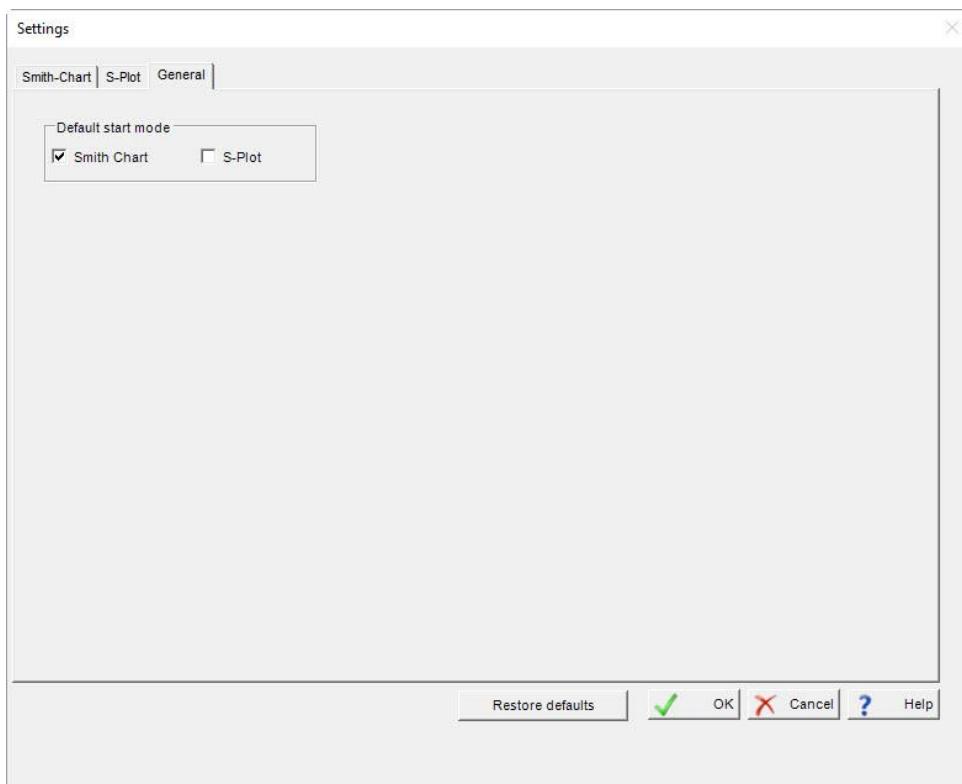
Tab S-Plot

- Line width and colors
- Labels
- Z-plane, Y-plane on/off



Tab General

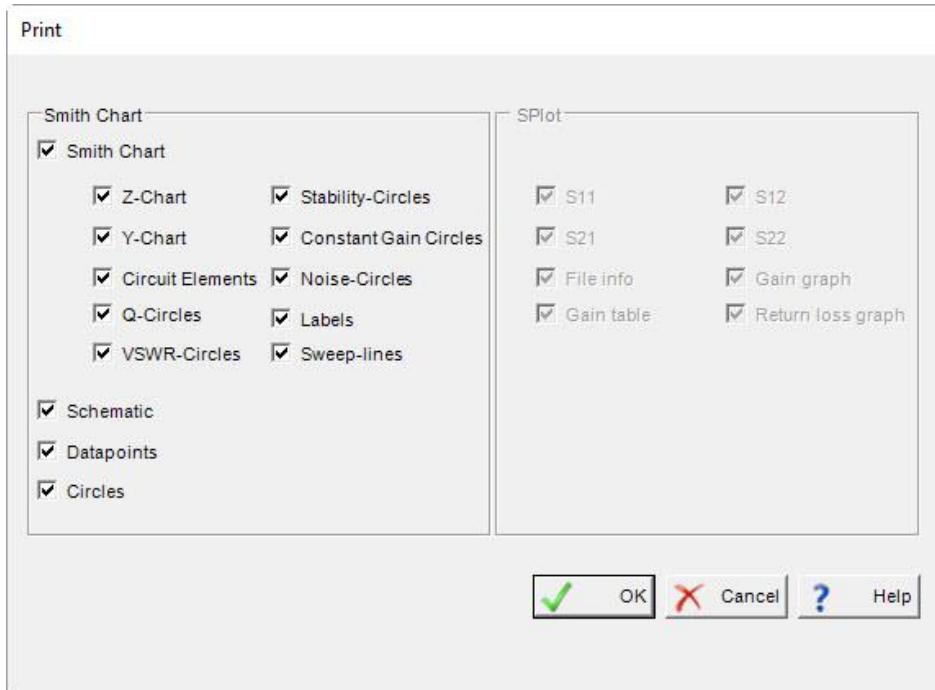
- Default start mode (Smith-Chart or S-Plot)



Print the Smith-Chart



Select “Print“ or “Print Preview” in menu “File“ or click button  in toolbox and select or deselect appropriate items in dialogbox.

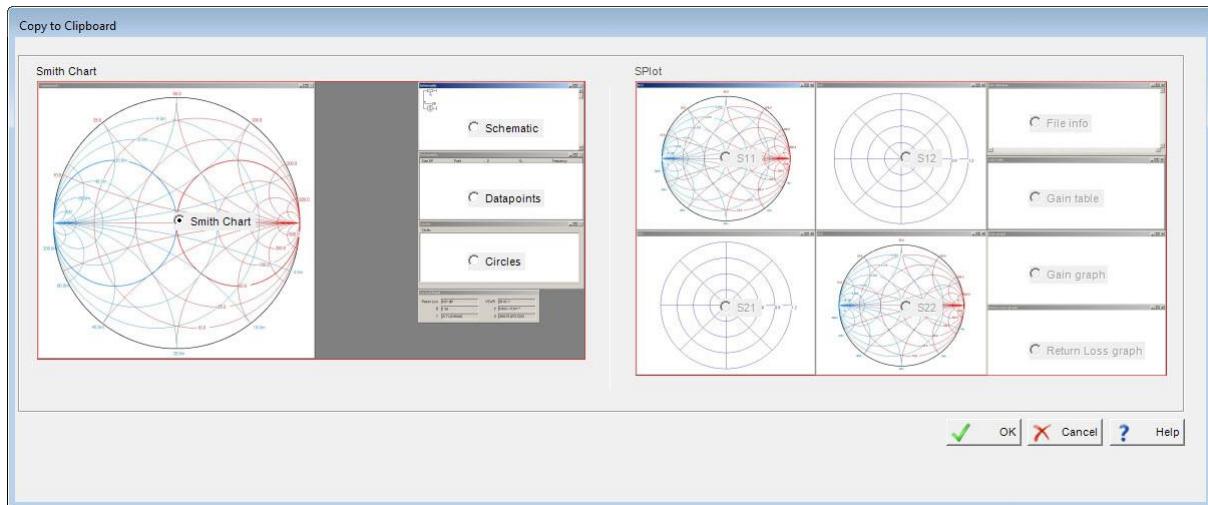


- Smith-Chart: Print Smith-Chart
- Schematic: Print schematic
- Datapoints: Print window “Datapoint”
- Circles: Print window “Circles”

Copy to Clipboard

- Select „Copy to Clipboard“ in menu „Edit“ or click button  in toolbox and select appropriate item.

A copy of the selected item is put to the clipboard for insertion in office applications.



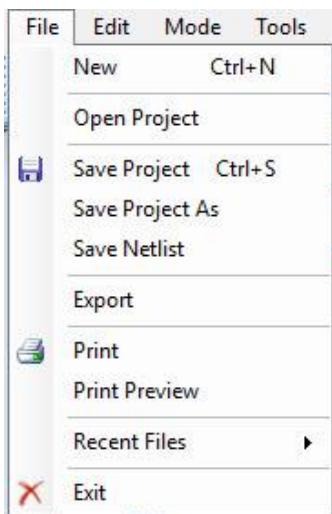
Shortcuts

Following shortcuts can be used for best productivity:

File	New	Ctrl+N
	Open	Ctrl+O
	Save	Ctrl+S
Edit	Undo	Ctrl+Z
	Redo	Ctrl+Y
Mode	Toggle Smith-Chart/S-Plot	Ctrl+M
Tools	Circles	Ctrl+T
Extras	Settings	Ctrl+E
Zoom	Zoom in	Ctrl+1
	Zoom out	Ctrl+2
	Zoom 1:1	Ctrl+3
Help	Help	F1

Save Netlist

➤ Select “Save Netlist” in menu “File”.



Save an ASCII-file in Touchstone netlist format. This format is used by several linear simulators. CKT is standard file extensions.

The generated netlist include:

Comments:

Comments are ignored by the simulators. They can be added anywhere in the file by a preceding exclamation mark (!).

DIM Statement:

The DIM statement set the units.

CKT block:

This block contains the description of the circuit. At the end of this block the statement DEF2P define the network as a 2-port.

FREQ block:

Defines the frequency for analysis.

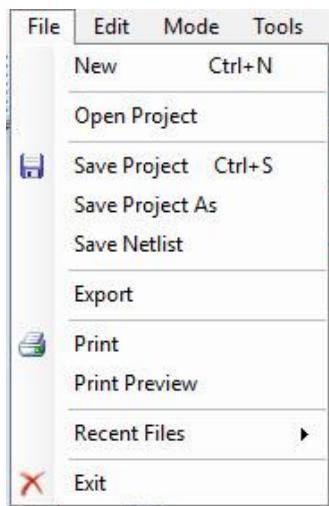
Example:

```
! SMITH-CHART NETLIST GENERATOR VERSION 1.0
! INPUT FILE: Example_netlist.xmlsc
! OUTPUT FILE: Example_netlist.ckt
! GLOBAL
DIM FREQ=1e6 RES=1e0 IND=1e-9 CAP=1e-12 LNG=1e-3 TIME=1e-12 COND=1e-0
!
CKT
SRLC 1 0 R=33 L=22 C=18
TLINP 1 2 0 Z=50 L=37.8 K=1 A=2 F=0
RES 2 3 R=46.08
IND 3 0 L=13.18
CAP 3 4 C=19.4
DEF2P 1 4 A ! A is actual passive Network
!
FREQ
FIXED 500
```

Export Data

➤ Select “Export” in menu “File”.

Export datapoints or circle data to an ASCII-file for post-processing in spreadsheets or math software.
Delimiter format: None, semicolon or comma.



Data file examples:

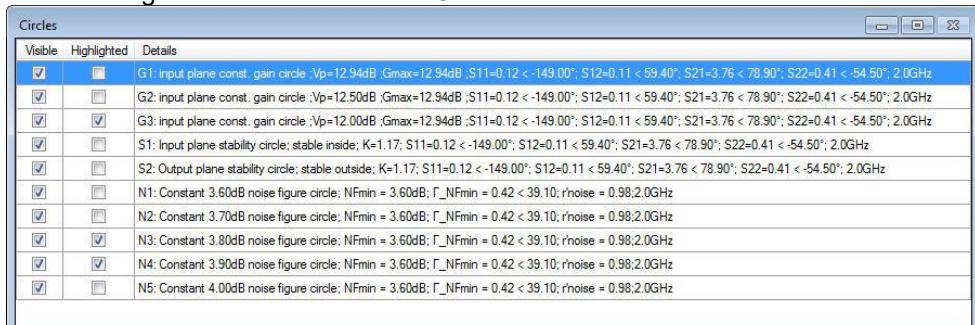
Export datapoints

Start DP	Point	R[Ohm]	X[Ohm]	Q	Frequency[Hz]
true;	1;	20.000;	-12.000;	0.600;	450000000.000
false;	2;	20.000;	12.033;	0.602;	450000000.000
false;	3;	27.180;	1.281;	0.047;	450000000.000
false;	4;	27.180;	16.280;	0.599;	450000000.000
false;	5;	36.855;	1.679;	0.046;	450000000.000
false;	6;	36.855;	21.754;	0.590;	450000000.000
false;	7;	49.695;	0.006;	0.000;	450000000.000

Export circles

```
G1;input plane const. gain circle;12.94;12.94;0.12;-149.00;0.11;59.40;3.76;78.90;0.41;-54.50;2.0GHz;
G2;input plane const. gain circle;12.50;12.94;0.12;-149.00;0.11;59.40;3.76;78.90;0.41;-54.50;2.0GHz;
G3;input plane const. gain circle;12.00;12.94;0.12;-149.00;0.11;59.40;3.76;78.90;0.41;-54.50;2.0GHz;
N1;3.60;3.60;0.42;39.10;0.98;2.0GHz;
N2;3.70;3.60;0.42;39.10;0.98;2.0GHz;
N3;3.80;3.60;0.42;39.10;0.98;2.0GHz;
N4;3.90;3.60;0.42;39.10;0.98;2.0GHz;
N5;4.00;3.60;0.42;39.10;0.98;2.0GHz;
S1;Input plane stability circle;stable outside;1.17;0.12;-149.00;0.11;59.40;3.76;78.90;0.41;-54.50;2.0GHz;
S2;Output plane stability circle;stable outside;1.17;0.12;-149.00;0.11;59.40;3.76;78.90;0.41;-54.50;2.0GHz;
```

For meaning of values see window “Circles”



S-Plot

Export Print S-Plot

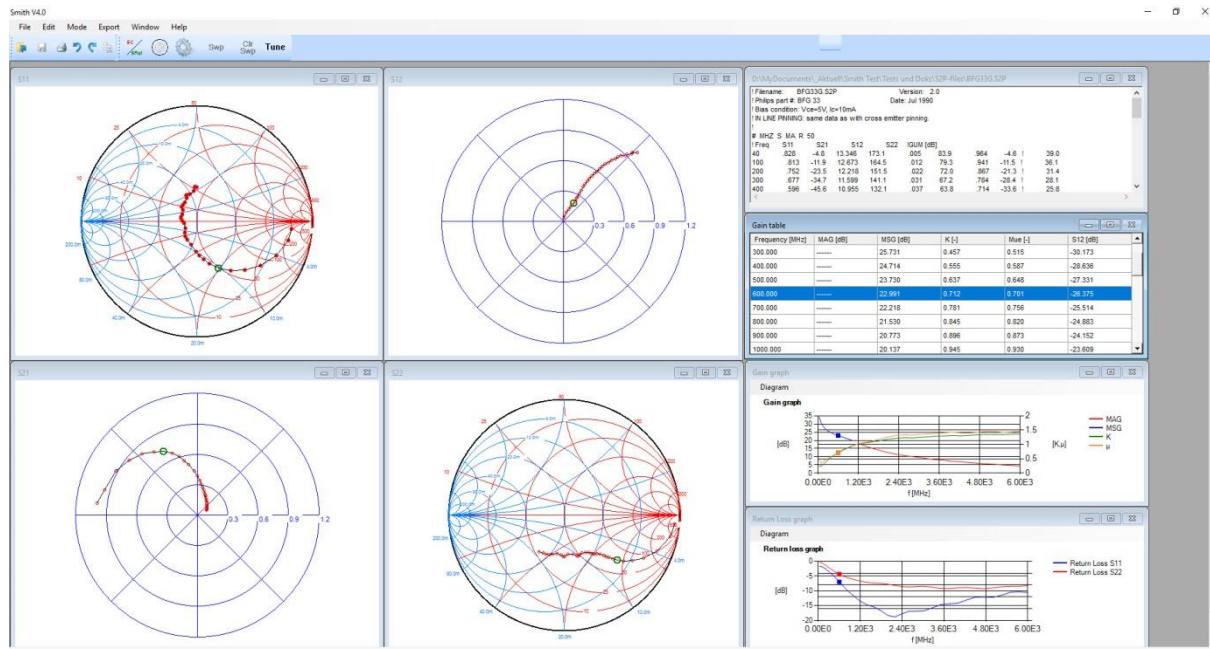
Read S-Parameter - Files in Touchstone® -, CITI- and EZNEC- Format and display the data in different graphs and listings.

Convert and export S-Parameter to normalized or unnormalized H-, Z-, Y- or A-Parameters in Touchstone® - Format files.

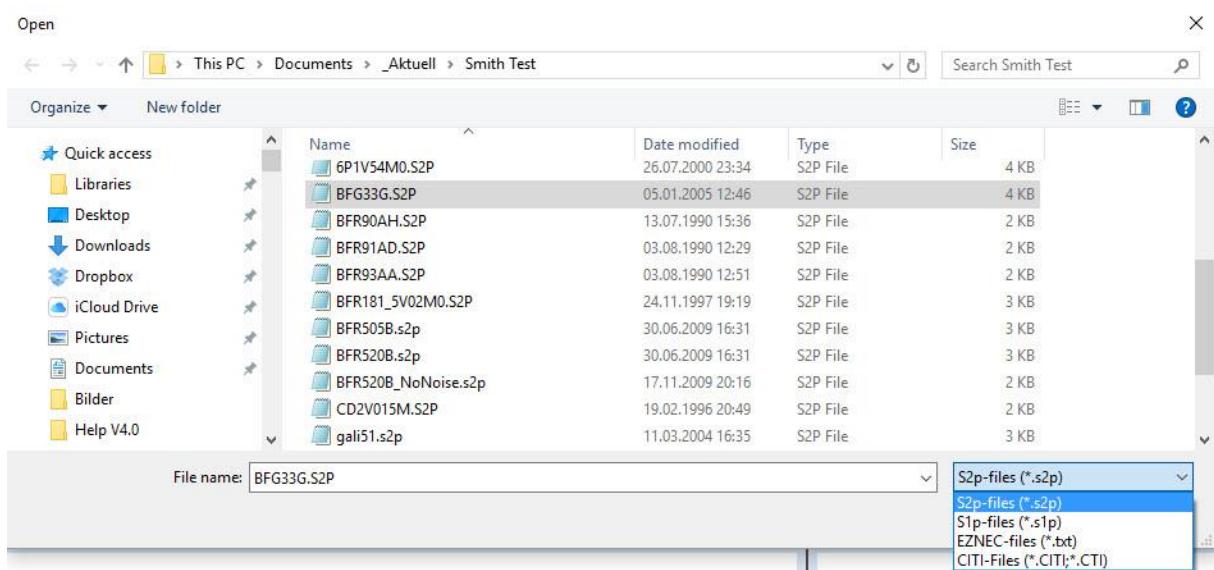
Export s_{11} or s_{22} to Smith-Chart.

Print all graphs or listings.

➤ Select „S-Plot“ in menu „Mode“.



➤ Load S-Parameter file with „Open“ in menu „File“.



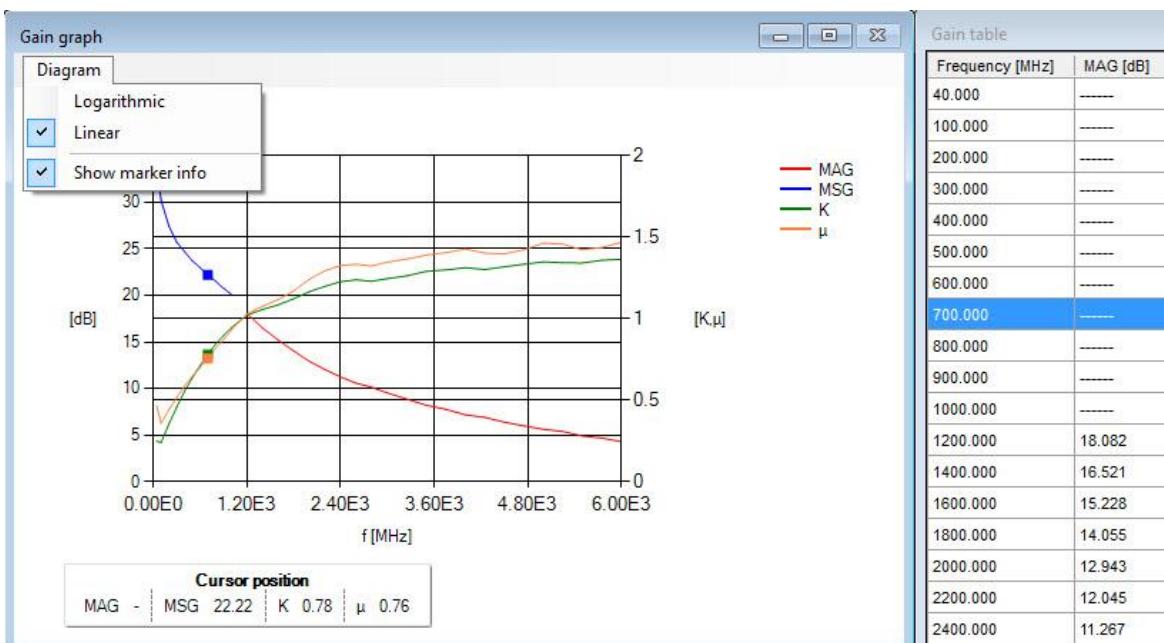
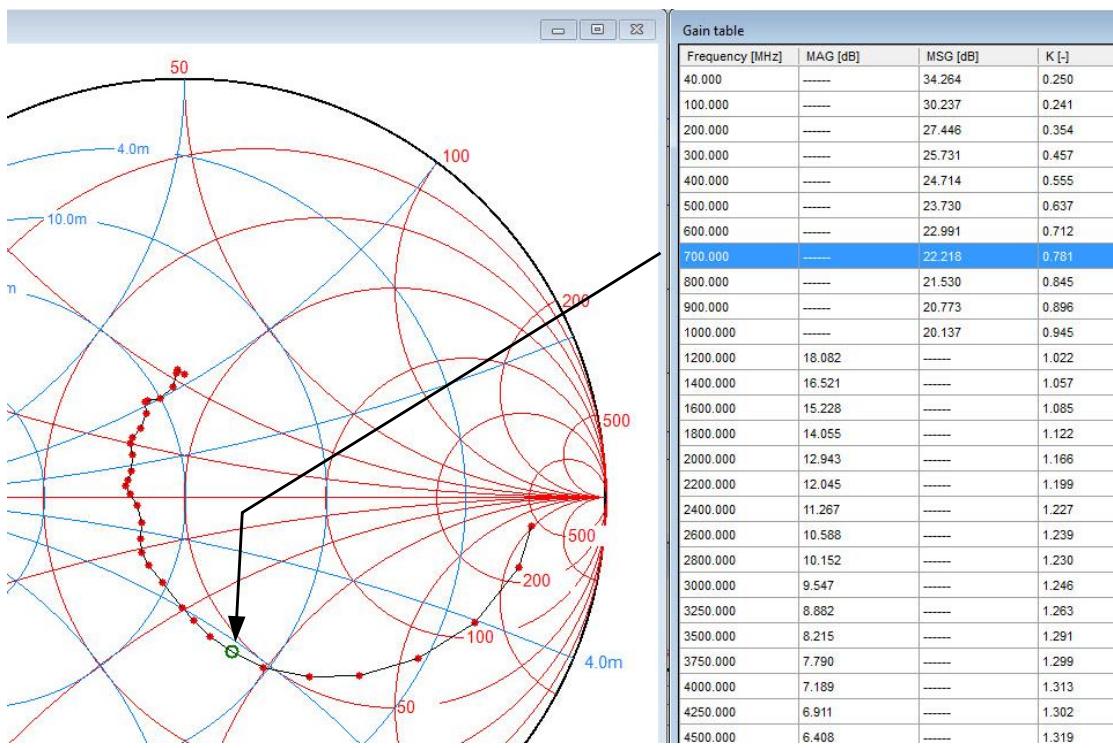
- Choose file format:
 Touchstone format (*.s1p, *.s2p)
 CITI format (*.citi, *.cti)
 EZNEC format (*.txt)

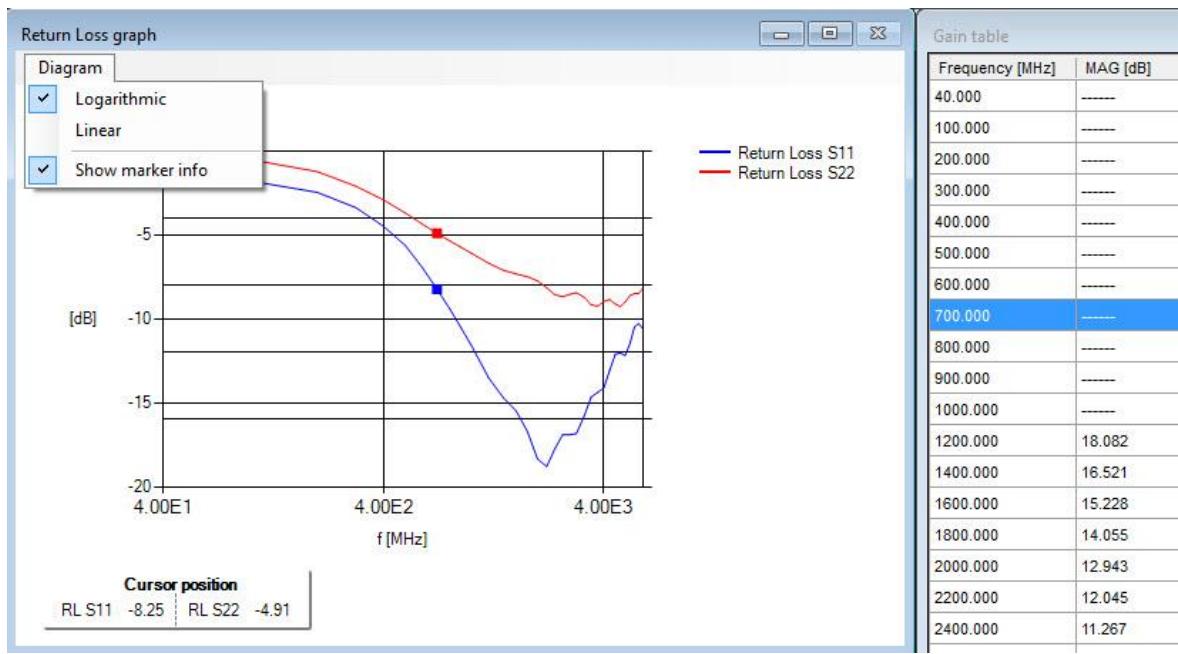
S11 and S22 are plotted to a Smith-Chart, S12 and S21 to a polar plot.

There are additional windows for:

- Source file
- Gain table with listing of MAG[dB] (maximum available operating power gain), MSG[dB] (maximum stable gain), stability factor K, stability factor μ_s (Mue) and S12[dB]
- Gain graph for MAG[dB] (for $K \geq 1$) and MSG[dB] (for $K < 1$), stability factor K and stability factor μ_s (Mue)
- Return Loss graph for S11[dB] and S22[dB]

The selected line in window "Gain table" highlights the corresponding datapoint in all graphs.





Equations:

$$MAG = G_{p_{\max}} = \frac{|S_{21}|}{|S_{12}|} \cdot \left(K - \sqrt{K^2 - 1} \right) ; \quad K \geq 1$$

$$MSG = G_{p_{\max \text{ stabil}}} = \frac{|S_{21}|}{|S_{12}|} ; \quad K < 1$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 \cdot |S_{12} \cdot S_{21}|}$$

$$\Delta = S_{11} \cdot S_{22} - S_{12} \cdot S_{21}$$

$$\mu_s = \frac{1 - |S_{22}|^2}{|S_{11} - \Delta \cdot S_{22}^*| + |S_{21} S_{12}|} > 1$$

$$S11[dB] = 20 \log(|S_{11}|)$$

$$S22[dB] = 20 \log(|S_{22}|)$$

$$S12[dB] = 20 \log(|S_{12}|)$$

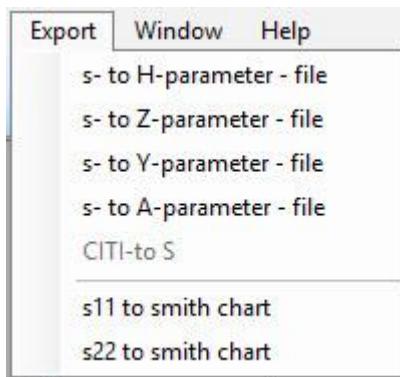
Export

- [Export H-, Z-, Y- and A-Parameter to File](#)
- [Export CITI to S-Parameter Touchstone File](#)
- [Export S11 or S22 to Smith Chart](#)

Export H-, Z-, Y- and A-Parameter to File

After loading an S-Parameter file in S-Plot, the file can be converted to H-, Z-, Y- or A-Parameter (normalized or unnormalized) and saved in a file.
All converted files are in Touchstone® - Format.

➤ Menu „Export“, „s- to x-parameter-file“.



Equations Twoport Parameter Conversion S-, Z-, Y-, H- and A(ABCD)-Parameter:

' (apostrophe) denotes normalized parameter.

$$S_{11} = \frac{(z'_{11}-1)(z'_{22}+1)-z'_{12}z'_{21}}{(z'_{11}+1)(z'_{22}+1)-z'_{12}z'_{21}}$$

$$z'_{11} = \frac{(1+S_{11})(1-S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$$

$$S_{12} = \frac{2z'_{12}}{(z'_{11}+1)(z'_{22}+1)-z'_{12}z'_{21}}$$

$$z'_{12} = \frac{2S_{12}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$$

$$S_{21} = \frac{2z'_{21}}{(z'_{11}+1)(z'_{22}+1)-z'_{12}z'_{21}}$$

$$z'_{21} = \frac{2S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$$

$$S_{22} = \frac{(z'_{11}+1)(z'_{22}-1)-z'_{12}z'_{21}}{(z'_{11}+1)(z'_{22}+1)-z'_{12}z'_{21}}$$

$$z'_{22} = \frac{(1-S_{11})(1+S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$$

$$z'_{11} = \frac{z_{11}}{Z_o} \quad z'_{12} = \frac{z_{12}}{Z_o} \quad z'_{21} = \frac{z_{21}}{Z_o} \quad z'_{22} = \frac{z_{22}}{Z_o}$$

$$S_{11} = \frac{(1-y'_{11})(1+y'_{22}) + y'_{12}y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12}y'_{21}}$$

$$S_{12} = \frac{-2y'_{12}}{(1+y'_{11})(1+y'_{22}) - y'_{12}y'_{21}}$$

$$S_{21} = \frac{-2y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12}y'_{21}}$$

$$S_{22} = \frac{(1+y'_{11})(1-y'_{22}) + y'_{12}y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12}y'_{21}}$$

$$y'_{11} = y_{11}Z_o \quad y'_{12} = y_{12}Z_o \quad y'_{21} = y_{21}Z_o \quad y'_{22} = y_{22}Z_o$$

$$S_{11} = \frac{(h'_{11}-1)(h'_{22}+1)h'_{12}h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$S_{12} = \frac{2h'_{12}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$S_{21} = \frac{-2h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$S_{22} = \frac{(1+h'_{11})(1-h'_{22}) + h'_{12}h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$h'_{11} = \frac{h_{11}}{Z_o} \quad h'_{12} = h_{12} \quad h'_{21} = h_{21} \quad h'_{22} = h_{22}Z_o$$

$$A = \frac{1}{2S_{21}} \begin{bmatrix} (1+s_{11})(1-S_{22}) + S_{12}S_{21} & Z_o \left[(1+S_{11})(1+S_{22}) - S_{12}S_{21} \right] \\ Y_o \left[(1-S_{11})(1-S_{22}) - S_{12}S_{21} \right] & (1-S_{11})(1+S_{22}) + S_{12}S_{21} \end{bmatrix}$$

$$S = \frac{1}{\Delta_1} \begin{bmatrix} A_{11} + A_{12}Y_o - A_{21}Z_o - A_{22} & 2(A_{11}A_{22} - A_{12}A_{21}) \\ 2 & -A_{11} + A_{12}Y_o - A_{21}Z_o + A_{22} \end{bmatrix}$$

$$\Delta_1 = A_{11} + A_{12}Y_o + A_{21}Z_o + A_{22}$$

$$y'_{11} = \frac{(1-S_{11})(1+S_{22}) + S_{12}S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$y'_{12} = \frac{-2S_{12}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

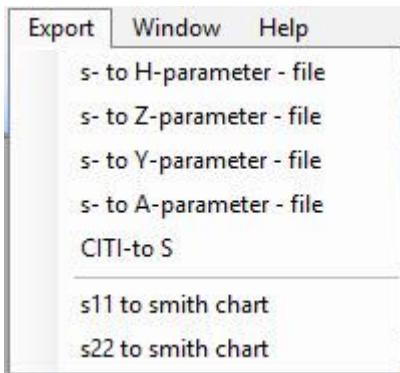
$$y'_{21} = \frac{-2S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$y'_{22} = \frac{(1+S_{11})(1-S_{22}) + S_{12}S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

Export CITI to S-Parameter Touchstone File

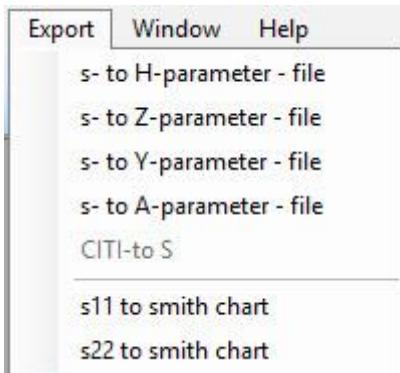
A CITI-file loaded in S-Plot can be saved as S-parameter file in Touchstone format.

- Menu „Export“, „CITI- to S“.



Export S11 or S22 to smith chart

- Menu „Export“, „s11 (or s22) to smith chart“.



s-Parameters								
Frequency [MHz]	S11 Mag	S11 Angle	S21 Mag	S21 Angle	S12 Mag	S12 Angle	S22 Mag	S22 Angle
40.000	0.828	-4.800	13.346	173.100	0.005	83.900	0.964	-4.600
100.000	0.813	-11.900	12.673	164.500	0.012	79.300	0.941	-11.500
200.000	0.752	-23.500	12.218	151.500	0.022	72.000	0.867	-21.300
300.000	0.677	-34.700	11.599	141.100	0.031	67.200	0.784	-28.400
400.000	0.596	-45.600	10.955	132.100	0.037	63.800	0.714	-33.600
500.000	0.524	-55.200	10.150	124.800	0.043	61.800	0.654	-37.700
600.000	0.449	-65.100	9.558	118.100	0.048	61.100	0.605	-40.400
700.000	0.387	-73.000	8.832	112.400	0.053	60.500	0.568	-42.200
800.000	0.338	-79.600	8.108	107.600	0.057	60.400	0.539	-43.500
900.000	0.297	-85.300	7.408	103.700	0.062	60.300	0.516	-44.500
1000.000	0.264	-91.300	6.812	100.300	0.066	60.300	0.496	-45.500
1200.000	0.211	-104.400	5.875	94.600	0.074	60.200	0.463	-47.500
1400.000	0.184	-118.200	5.207	89.700	0.083	60.000	0.441	-49.700
1600.000	0.168	-127.500	4.620	85.500	0.092	59.900	0.430	-52.000
1800.000	0.146	-135.900	4.151	82.400	0.100	59.900	0.422	-53.400
2000.000	0.121	-149.000	3.756	78.900	0.108	59.400	0.410	-54.500
2200.000	0.115	-169.800	3.454	75.800	0.116	58.700	0.391	-56.400
2400.000	0.130	175.800	3.192	72.200	0.123	57.800	0.373	-60.100
2600.000	0.143	168.900	2.955	69.700	0.131	57.100	0.368	-64.900

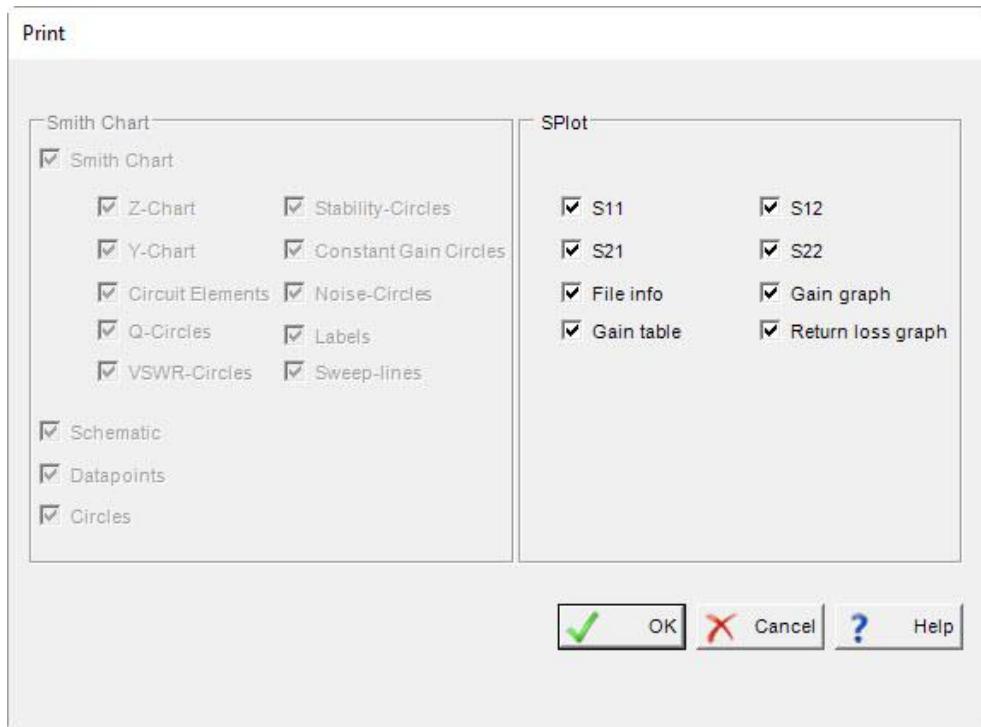
 Select File
  OK
  Cancel
  Help

- Select appropriate parameter lines using <Shift> and <Ctrl> for multiple selection. Terminate with OK.

Print S-Plot



Select “Print“ or “Print Preview” in menu “File“ or click button  in toolbox and select or deselect appropriate items in dialogbox.



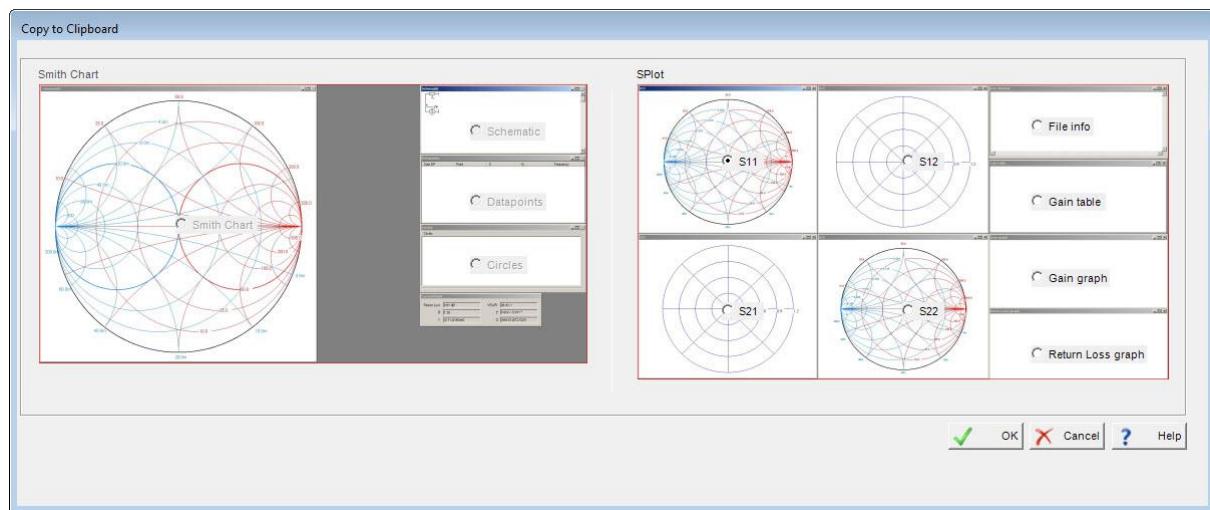
- S11, S12, S21, S22: Print window S11, S12, S21, S22
- Gain table: Print Gain table
- Gain graph: Print Gain graph
- Return loss graph: Print Return loss graph

Copy to Clipboard



Select „Copy to Clipboard“ in menu „Edit“ or click button  in toolbox and select appropriate item.

A copy of the selected item is put to the clipboard for insertion in office applications.



Smith-Chart Basics

[Smith-Chart Construction](#)
[Stability Circles](#)
[Source Stability Circles](#)
[Load Stability Circles](#)
[Constant Gain Circles](#)
[Transducer Power Gain](#)
[Operating Power Gain](#)
[Max Available Gain MAG and Max Stable Gain MSG](#)
[Available Power Gain](#)
[Unilateral Transducer Gain](#)
[Simultaneous Conjugate Match](#)
[Constant Noise Figure Circles](#)

Smith-Chart Construction

The Smith-Chart is a bilinear transformation introduced by Philip Smith in 1940. Still in the Gigahertz-clocked-computer-age the Smith-Chart is the most important visualization tool for transformation networks in the impedance, admittance or reflection coefficient plane. Even the best mathematical software tool cannot beat the graphically based procedure of the Smith-Chart to design matching circuit topology. Of course Math-software is doing the number-crunching much faster and you get more digits in the results. In my opinion we can't miss either.

For my students and for the interested reader, here are some basics for the Smith-Chart construction:

The definition of the reflection coefficient Γ (gamma) is

$$\Gamma = \frac{Z' - 1}{Z' + 1}$$

with normalized impedance

$$Z' = \frac{Z}{Z_0}$$

Solved to Z' and separated to Real- and Imaginary part

$$R' + j \cdot X' = \frac{1 - u^2 - v^2 + j \cdot 2v}{1 + u^2 + v^2 - 2u}$$

with $\Gamma = u + jv$

From

$$R' = \frac{1 - u^2 - v^2}{1 + u^2 + v^2 - 2u} = const.$$

we get, after some algebraic manipulations,

$$\left(u - \frac{R'}{R'+1}\right)^2 + v^2 = \frac{1}{(R'+1)^2}$$

This is the equation of a circle. Thus, constant resistance R (real part of impedance) in the impedance-plane map into a circle in the s-plane.

Similarly, we find by setting $X' = \text{const.}$

$$(u-1)^2 + \left(v - \frac{1}{X'}\right)^2 = \frac{1}{(X')^2}$$

Thus, constant reactance X (imaginary part of impedance) in the impedance-plane maps into a circle in the s-plane.

The same procedure in the admittance-plane results also in circles in the s-plane:

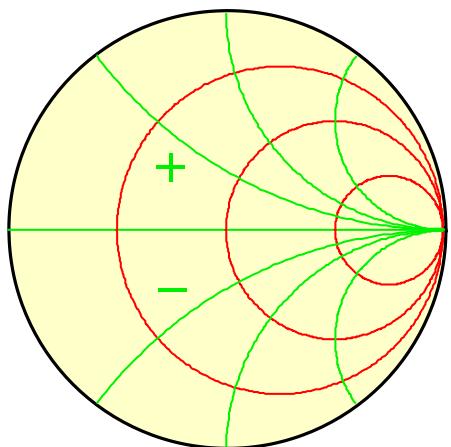
$$Y' = \frac{1}{Z'} = G' + j \cdot B'$$

$$\left(u + \frac{G'}{G'+1}\right)^2 + v^2 = \left(\frac{1}{G'+1}\right)^2$$

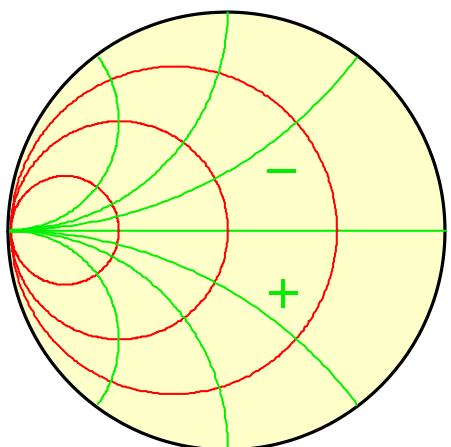
$$(u+1)^2 + \left(v + \frac{1}{B'}\right)^2 = \left(\frac{1}{B'}\right)^2$$

Thus, constant conductance G (real part of admittance) and constant susceptance B (imaginary part of admittance) in the admittance-plane map into a circle in the s-plane.

A graphical representation of this equations results in the Smith-Chart:



Constant Resistance R
Constant Reactance X



Constant Conductance G
Constant Suszeptance B

A Powerpoint presentation referencing this subject can be found on my homepage
www.fritz.dellsperger.net

Stability Circles

Source Stability Circles Load Stability Circles

Stability

Unconditional stable:

$$K = \frac{1 - |S_{22}|^2 - |S_{11}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} > 1 \quad (\text{Rolett stability factor})$$

and

$$|\Delta| < 1$$

$$|\Delta| = |S_{11}S_{22} - S_{12}S_{21}|$$

or

$$K = \frac{1 - |S_{22}|^2 - |S_{11}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} > 1$$

and

$$B = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 > 0$$

or

Graphically defined stability according to Edwards/Sinsky [6]:

Source plane

$$\mu_s = \frac{1 - |S_{22}|^2}{|S_{11} - \Delta \cdot S_{22}^*| + |S_{21}S_{12}|} > 1$$

Load plane

$$\mu_L = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta \cdot S_{11}^*| + |S_{21}S_{12}|} > 1$$

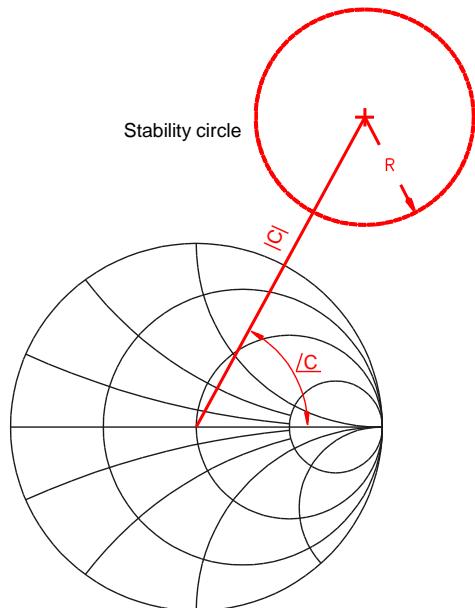
Stability circles:

$$R_{ss} = \left| \frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| \quad \text{Radius source plane}$$

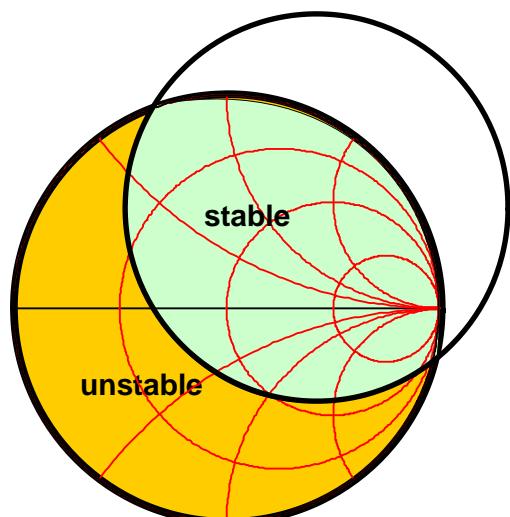
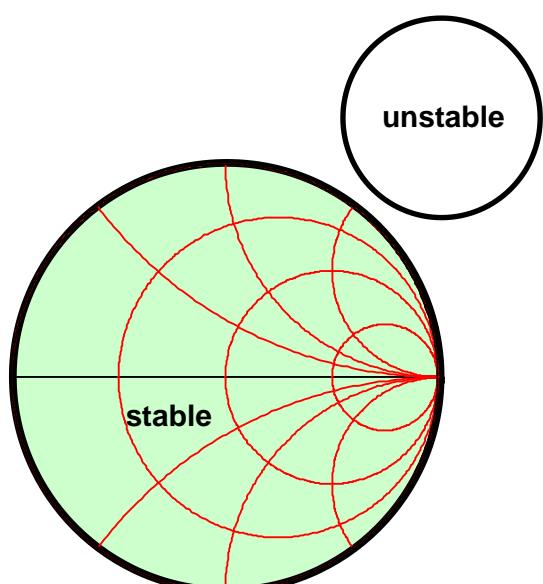
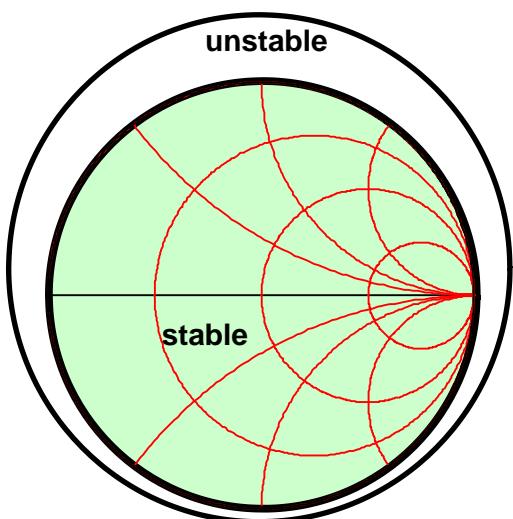
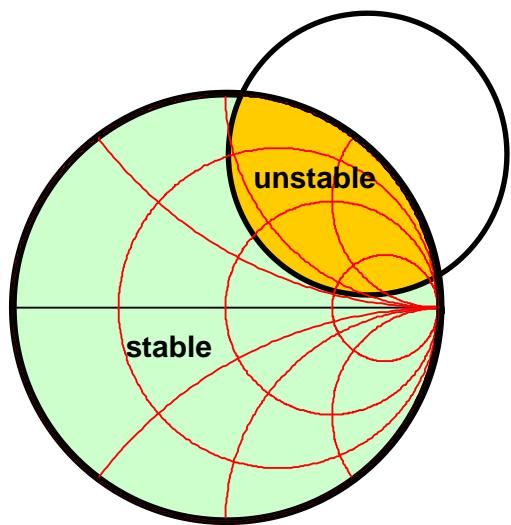
$$C_{ss} = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = \frac{S_{11}^* - \Delta^* S_{22}}{|S_{11}|^2 - |\Delta|^2} \quad \text{Center source plane}$$

$$C_{ls} = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = \frac{S_{22}^* - \Delta^* S_{11}}{|S_{22}|^2 - |\Delta|^2} \quad \text{Center load plane}$$

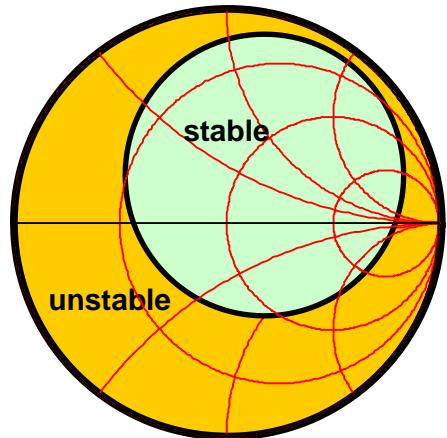
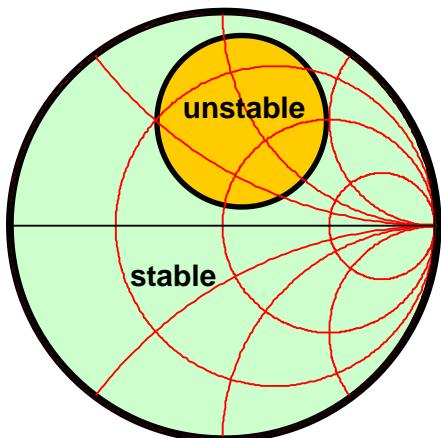
$$R_{ls} = \left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| \quad \text{Radius load plane}$$



The stable region is inside the stability circle when the center of the Smith-Chart is enclosed, and outside if the center is not enclosed. If the circle lies completely outside the Smith-Chart or completely encloses the Smith-Chart the twoport is unconditionally stable.



Unconditionally stable



Source Stability Circles

The Source Stability Circle is the locus of all source impedances for which the magnitude of the output reflection coefficient of the twoport equals 1.

The stable region is inside the stability circle when the center of the Smith-Chart is enclosed, and outside if the center is not enclosed. If the circle lies completely outside the Smith-Chart or completely encloses the Smith-Chart the twoport is unconditionally stable.

Load Stability Circles

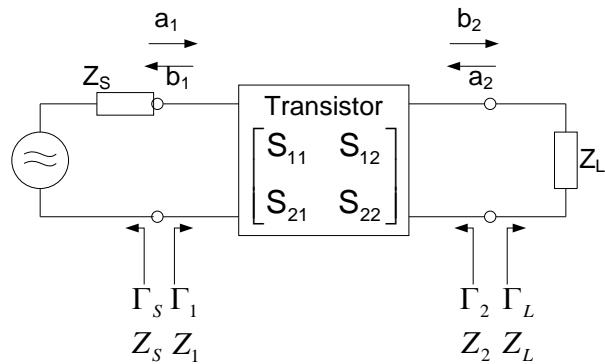
The Load Stability Circle is the locus of all load impedances for which the magnitude of the input reflection coefficient of the twoport equals 1.

The stable region is inside the stability circle when the center of the Smith-Chart is enclosed, and outside if the center is not enclosed. If the circle lies completely outside the Smith-Chart or completely encloses the Smith-Chart the twoport is unconditionally stable.

Constant Gain Circles

Transducer Power Gain
Operating Power Gain
Available Power Gain
Maximum Available Gain MAG and Maximum Stable Gain MSG
Unilateral Transducer Gain
Simultaneous Conjugate Match

Gain Definitions



Transducer Power Gain:

Arbitrary Γ_s and Γ_l

$$G_T = \frac{\text{Power delivered to load}}{\text{Power available from source}} = \frac{P_L}{P_{AvS}}$$

Operating Power Gain:

Independent of Γ_s (arbitrary Γ_l with $\Gamma_s = \Gamma_l^*$)

$$G_p = \frac{\text{Power delivered to load}}{\text{Power input to network}} = \frac{P_L}{P_1}$$

Available Power Gain:

Independent of Γ_l (arbitrary Γ_s with $\Gamma_l = \Gamma_s^*$)

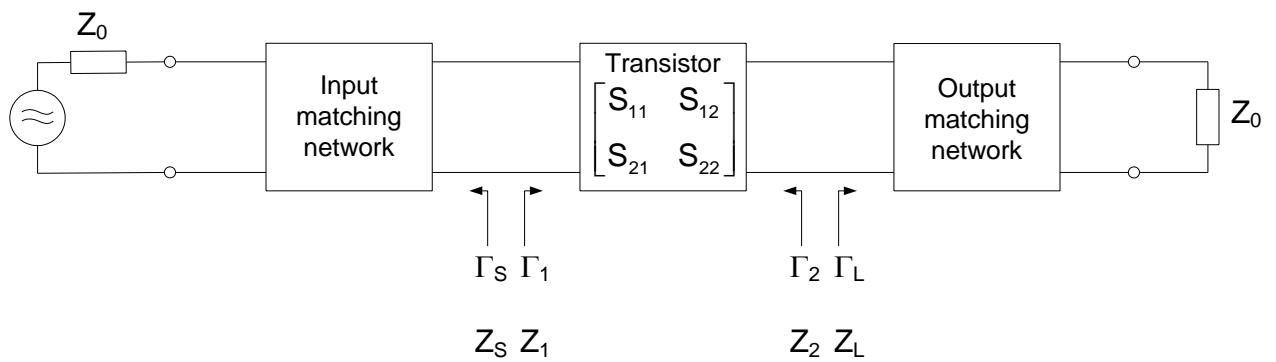
$$G_A = \frac{\text{Power available from network}}{\text{Power available from source}} = \frac{P_{AvL}}{P_{AvS}}$$

Transducer Power Gain

Transducer Power Gain

Arbitrary Γ_s and Γ_L

$$G_T = \frac{\text{Power delivered to load}}{\text{Power available from source}} = \frac{P_L}{P_{AvS}}$$



$$G_T = \frac{(1 - |\Gamma_s|^2) |S_{21}|^2 (1 - |\Gamma_L|^2)}{|(1 - \Gamma_s S_{11})(1 - \Gamma_L S_{22}) - S_{12} S_{21} \Gamma_s \Gamma_L|^2}$$

$$G_T = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s \Gamma_1|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - \Gamma_L \Gamma_2|^2}$$

$$\Gamma_1 = S_{11} + \frac{S_{12} S_{21} \Gamma_L}{1 - S_{22} \Gamma_L}$$

or

$$G_T = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - \Gamma_L \Gamma_2|^2}$$

$$\Gamma_2 = S_{22} + \frac{S_{12} S_{21} \Gamma_s}{1 - S_{11} \Gamma_s}$$

For : $Z_G = Z_0 = Z_L$ ($\Gamma_s = 0, \Gamma_L = 0$)

$$G_{T_{Z_0}} = |S_{21}|^2$$

$$G_{T_{Z_0}} [dB] = 10 \log |S_{21}|^2 = 20 \log |S_{21}|$$

Operating Power Gain

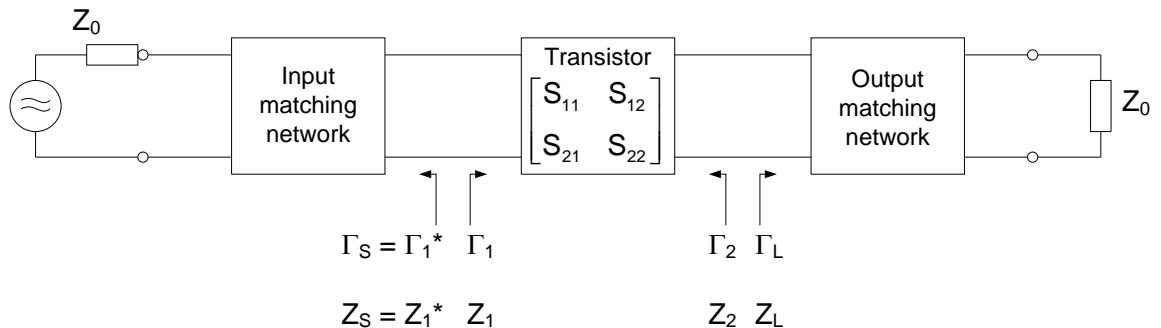
Operating Power Gain

Independent of Γ_s (arbitrary Γ_L with $\Gamma_s = \Gamma_1^*$)

Use “Operating Power Gain” for amplifier design with maximum output power, best efficiency or lowest intermodulation. Choose Γ_L for maximum output power, best efficiency or lowest intermodulation. Match input conjugately to resulting Γ_1 ($\Gamma_s = \Gamma_1^*$).

$$\Gamma_1 = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L}$$

$$G_p = \frac{\text{Power delivered to load}}{\text{Power input to network}} = \frac{P_L}{P_i}$$



$$\begin{aligned}
G_p &= \frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{(1 - |\Gamma_1|^2) |1 - S_{22}\Gamma_L|^2} \\
&= \frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{|1 - S_{22}\Gamma_L|^2 - |S_{11} - \Delta\Gamma_L|^2} \\
&= \frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{\left(1 - \left|\frac{S_{11} - \Delta\Gamma_L}{1 - S_{22}\Gamma_L}\right|^2\right) |1 - S_{22}\Gamma_L|^2} \\
&= \frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{1 - |S_{11}|^2 + |\Gamma_L|^2 (|S_{22}|^2 - |\Delta|^2) - 2 \operatorname{Re}[\Gamma_L (S_{22} - S_{11}^* \Delta)]}
\end{aligned}$$

$$\Delta = S_{11}S_{22} - S_{12}S_{21}$$

Constant Operating Power Gain circles:

The Operating Power Gain Circle is the locus of all load impedances for constant operating power gain. The input is conjugately matched to the resulting input reflection coefficient.

$$R_p = \frac{\sqrt{1 - 2K|S_{12}S_{21}|g_p + |S_{12}S_{21}|^2 g_p^2}}{|1 + g_p (|S_{22}|^2 - |\Delta|^2)|} \quad \text{Radius load plane}$$

$$C_p = \frac{g_p (S_{22} - S_{11}^* \Delta)^*}{1 + g_p (|S_{22}|^2 - |\Delta|^2)} \quad \text{Center load plane}$$

$$g_p = \frac{G_p}{G_{T_{zo}}} = \frac{G_p}{|S_{21}|^2} \quad \text{Gain reduction for circle}$$

G_p : Desired gain

Maximum Available Gain MAG and Maximum Stable Gain MSG

Maximum Available Gain:

$$MAG = G_{p_{\max}} = G_{T_{\max}} = \frac{|S_{21}|}{|S_{12}|} \left(K - \sqrt{K^2 - 1} \right) \quad (K > 1)$$

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 \cdot |S_{12}| \cdot |S_{21}|} \geq 1$$

Maximum Stable Gain:

$$MSG = \frac{|S_{21}|}{|S_{12}|} \quad (K \leq 1)$$

Available Power Gain

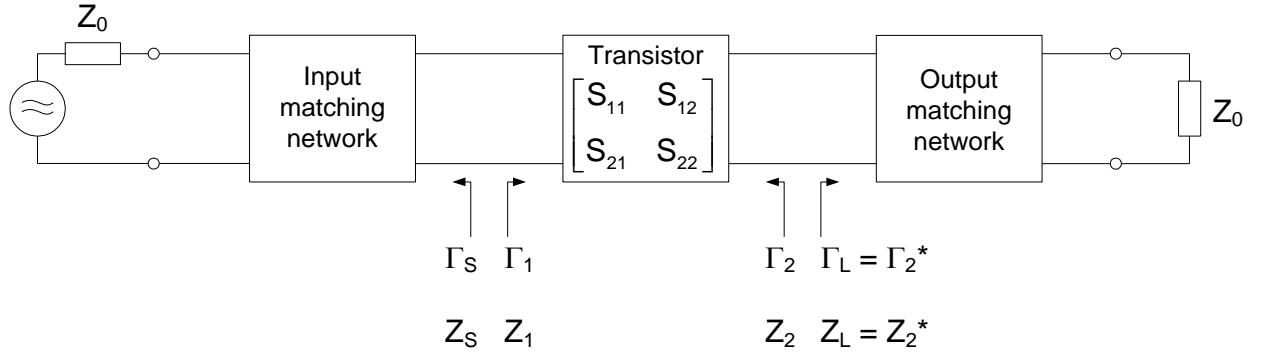
Available Power Gain

Independent of Γ_L (arbitrary Γ_s with $\Gamma_L = \Gamma_2^*$)

Use Available Power Gain for low noise amplifier design. Choose Γ_s for lowest noise figure. Match output conjugately to resulting Γ_2 ($\Gamma_L = \Gamma_2^*$).

$$\Gamma_2 = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s}$$

$$G_A = \frac{\text{Power available from network}}{\text{Power available from source}} = \frac{P_{AvL}}{P_{AvS}}$$



$$\begin{aligned}
 G_A &= \frac{(1 - |\Gamma_s|^2)|S_{21}|^2}{|1 - S_{11}\Gamma_s|^2 (1 - |\Gamma_2|^2)} \\
 &= \frac{(1 - |\Gamma_s|^2)|S_{21}|^2}{1 - |S_{22}|^2 + |\Gamma_s|^2 (|S_{11}|^2 - |\Delta|^2) - 2 \operatorname{Re}[\Gamma_s (S_{11} - S_{22}^* \Delta)]}
 \end{aligned}$$

Constant Available Power Gain circles:

The Available Power Gain Circle is the locus of all source impedances for constant available power gain. The output is conjugately matched to the resulting output reflection coefficient.

$$R_A = \frac{\sqrt{1 - 2K|S_{12}S_{21}|g_A + |S_{12}S_{21}|^2 g_A^2}}{1 + g_A(|S_{11}|^2 - |\Delta|^2)}$$

Radius source plane

$$C_A = \frac{g_A(S_{11} - S_{22}^* \Delta)^*}{1 + g_A(|S_{11}|^2 - |\Delta|^2)}$$

Center source plane

$$g_A = \frac{G_A}{G_{T_{Z_0}}} = \frac{G_A}{|S_{21}|^2}$$

Gain reduction for circle

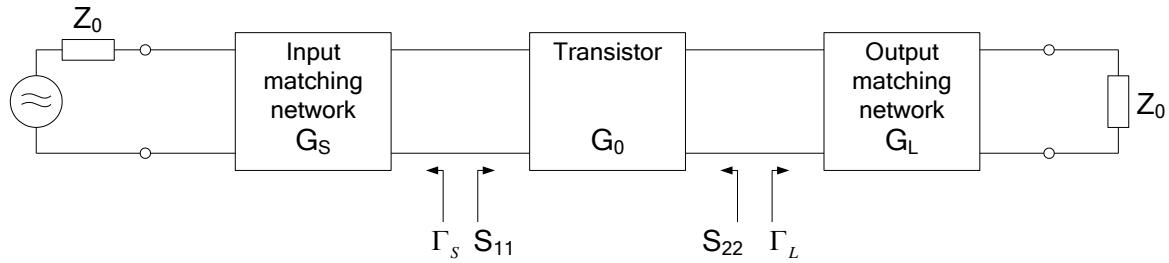
G_A : Desired gain

Unilateral Transducer Gain

Unilateral Transducer Gain

$$S_{12} = 0 \quad \rightarrow \quad \Gamma_1 = S_{11} \quad \Gamma_2 = S_{22}$$

Use Unilateral Transducer Gain for first approximation of matching network.



$$G_{TU} = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - \Gamma_L S_{22}|^2}$$

$$G_{TU} = G_s \cdot G_o \cdot G_L$$

$$G_s = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s S_{11}|^2} \quad G_o = |S_{21}|^2 \quad G_L = \frac{1 - |\Gamma_L|^2}{|1 - \Gamma_L S_{22}|^2}$$

Maximum unilateral gain can be achieved by conjugate match:

$$\Gamma_s = S_{11}^* \quad \text{and} \quad \Gamma_L = S_{22}^*$$

$$G_{s_{\max}} = \frac{1}{1 - |S_{11}|^2} \quad G_{L_{\max}} = \frac{1}{1 - |S_{22}|^2}$$

$$G_{TU_{\max}} = \frac{1}{1 - |S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1}{1 - |S_{22}|^2}$$

„Unilateral Figure of Merit“ U:

$$U = \frac{|S_{12}| |S_{21}| |S_{11}| |S_{22}|}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

Error boundaries:

$$\frac{1}{(1+U)^2} < \frac{G_T}{G_{TU}} < \frac{1}{(1-U)^2} \quad \hat{=} \quad E^+ < E_{eff} < E^-$$

$$10\log\left(\frac{1}{(1+U)^2}\right) < 10\log\left(\frac{G_T}{G_{TU}}\right) < 10\log\left(\frac{1}{(1-U)^2}\right)$$

Maximum error in dB

$$E_{max} [dB] = \left| 10\log\left(\frac{1}{(1+U)^2}\right) \right| + \left| 10\log\left(\frac{1}{(1-U)^2}\right) \right|$$

On error **larger than ±1 dB** ($U>0.1$) unilateral approximation **is not valid**.

Constant unilateral gain circles:

$$R_{SU} = \frac{\sqrt{1-g_{SU}} (1 - |S_{11}|^2)}{|1 + |S_{11}|^2 (g_{SU} - 1)|} \quad \text{Radius source plane}$$

$$C_{SU} = \frac{g_{SU} S_{11}^*}{1 + |S_{11}|^2 (g_{SU} - 1)} \quad \text{Center source plane}$$

$$g_{SU} = \frac{G_S}{G_{S_{max}}} = G_S (1 - |S_{11}|^2) \quad \text{Gain reduction for circle}$$

G_S : Desired gain

$$R_{LU} = \frac{\sqrt{1-g_{LU}} (1 - |S_{22}|^2)}{|1 + |S_{22}|^2 (g_{LU} - 1)|} \quad \text{Radius load plane}$$

$$C_{LU} = \frac{g_{LU} S_{22}^*}{1 + |S_{22}|^2 (g_{LU} - 1)}$$

Center load plane

$$g_{LU} = \frac{G_L}{G_{L_{\max}}} = G_L \left(1 - |S_{22}|^2 \right)$$

Gain reduction for circle

G_L : Desired gain

Simultaneous Conjugate Match

Simultaneous Conjugate Match

$$\Gamma_S = \Gamma_1^* \quad \Gamma_L = \Gamma_2^* \quad K > 1$$

Give maximum gain. Device has to be unconditionally stable ($K > 1$).

$$\Gamma_{SCM} = \Gamma_1^* = \frac{B_1 - \sqrt{B_1^2 - 4|C_1|^2}}{2C_1}$$

Source

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$$

$$C_1 = S_{11} - S_{22}^* \Delta$$

$$\Gamma_{LCM} = \Gamma_2^* = \frac{B_2 - \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

Load

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2$$

$$C_2 = S_{22} - S_{11}^* \Delta$$

Constant Noise Figure Circles

Noise Figure

$$F = F_{\min} + \frac{4 \cdot r_n |\Gamma_s - \Gamma_{Sopt}|^2}{(1 - |\Gamma_s|^2) |1 + \Gamma_{Sopt}|^2}$$

$$F_{\min} = \text{Minimum noise factor} = 10^{\frac{NF_{\min}}{10}}$$

NF_{\min} = Minimum noise figure in dB

$$r_n = \text{equivalent normalized noise resistance} = \frac{R_n}{Z_0}$$

Γ_{Sopt} = source reflection coefficient that produces F_{\min}

Constant noise circle:

$$R_{Fi} = \frac{\sqrt{N_i^2 + N_i (1 - |\Gamma_{Sopt}|^2)}}{1 + N_i} \quad \text{Radius}$$

$$C_{Fi} = \frac{\Gamma_{Sopt}}{1 + N_i} \quad \text{Center}$$

$$N_i = \frac{F_i - F_{\min}}{4r_n} \cdot |1 + \Gamma_{Sopt}|^2$$

F_i = desired noise factor ($> F_{\min}$)

File format info

Touchstone®

Twoport-Parameter - Files (S-, H-, Z-, Y- and ABCD-Parameter) in Touchstone® - Format must follow the rules below:

- ❖ In one line all characters after an exclamation-mark „!“ are comment only. The line terminates with *carriage return* and *line feed*
- ❖ In front of data there must be a parameter-line:
<Frequency unit> <Parameter-designation> <Format> <R n>
 - #: Parameter-line designator
 - <Frequency unit>: „GHz“, „MHz“, „kHz“ or „Hz“
 - <Parameter-Designation>:
„S“ for S-Parameter
„H“ for H-Parameter
„Z“ for Z-Parameter
„Y“ for Y-Parameter.
 - <Format>:
„MA“: magnitude-angle
„DB“: decibel-angle
„RI“: real-imaginary
 - <R n>: n = normalization impedance in Ohm (e.g. R 50)
- ❖ Data:
Each line contains the data for one frequency. The parameters are separated with one space minimum. Data must be in following sequence:
 1. Frequency
 2. Magnitude, decibel or real part of x₁₁
 3. Imaginary part or angle of x₁₁
 4. Magnitude, decibel or real part of x₂₁
 5. Imaginary part or angle of x₂₁
 6. Magnitude, decibel or real part of x₁₂
 7. Imaginary part or angle of x₁₂
 8. Magnitude, decibel or real part of x₂₂
 9. Imaginary part or angle of x₂₂

x = S, H, Z, or Y.
Frequencies must be ascending sequence

At the end of the twoport parameters, noise parameters can be added:

Each line contains the data for one frequency. The parameters are separated with one space minimum. Data must be in following sequence:

1. Frequency
2. Nfmin Minimum Noise Figure in dB

3. Magnitude of reflection coefficient for NFmin
(Gamma_opt)
4. Angle of reflection coefficient for NFmin
(Gamma_opt) in degree
5. Normalized equivalent noise resistor

The lowest noise parameter frequency must be less or equal to the highest S-Parameter frequency.

Example:

```

! SIEMENS Small Signal Semiconductors
! CF750
! GaAs Microwave Monolithic Integrated Circuit in SOT143
! VDGND = 3.8 V ID = 2 mA
! Common Source S-Parameters: April 1992
! Parameters valid for V D-GND between 3.0 and 5.0 VDC
! for Id=1.6mA MAG[S21] is abt. 10% lower
! for Id=2.8mA MAG[S21] is abt. 20% higher
! >>>> Source bypass capacitor must be low inductance!!
# GHz S MA R 50
! f          S11        S21        S12        S22
! GHz    MAG   ANG   MAG   ANG   MAG   ANG   MAG   ANG
  0.010  0.9700 -1.0  1.780  179.0  0.0020  89.0  0.9800 -1.0
  0.100  0.9700 -3.0  1.780  175.0  0.0080  84.0  0.9800 -2.0
  0.250  0.9600 -8.0  1.760  169.0  0.0150  78.0  0.9700 -6.0
  0.500  0.9400 -16.0 1.730  155.0  0.0270  75.0  0.9500 -11.0
  0.750  0.9100 -26.0 1.700  141.0  0.0390  71.0  0.9300 -16.0
  1.000  0.8700 -34.0 1.680  127.0  0.0460  64.0  0.9100 -22.0
  1.250  0.8300 -42.0 1.650  118.0  0.0540  62.0  0.8900 -26.0
  1.500  0.7800 -49.0 1.620  108.0  0.0610  57.0  0.8800 -30.0
  1.750  0.7200 -57.0 1.590  95.0  0.0660  55.0  0.8700 -34.0
  2.000  0.6600 -65.0 1.540  82.0  0.0690  52.0  0.8600 -38.0
  2.250  0.6100 -73.0 1.510  71.0  0.0710  54.0  0.8500 -43.0
  2.500  0.5600 -81.0 1.470  60.0  0.0730  60.0  0.8400 -48.0
  2.750  0.5200 -87.0 1.450  52.0  0.0740  63.0  0.8300 -52.0
  3.000  0.4900 -93.0 1.420  45.0  0.0750  66.0  0.8200 -56.0
!
! NOISE
! f      Fmin  Gammaopt   rn/50
! GHz   dB     MAG     ANG   -
  0.900  1.60   0.63    26    0.98
  1.800  1.90   0.52    51    0.72
!
! SIEMENS AG Semiconductor Group, Munich

```

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CITI

(Text adopted from Agilent)

Overview

CITIfile is a standardized data format that is used for exchanging data between different computers and instruments. CITIfile stands for *Common Instrumentation Transfer and Interchange* file format. CITIfile defines how the data inside an ASCII package is formatted. Since it is not tied to any particular disk or transfer format, it can be used with any operating system, such as DOS or UNIX, with any disk format, such as DOS or HFS, or with any transfer mechanism, such as by disk, LAN, or GPIB. By careful implementation of the standard, instruments and software packages using CITIfile are able to load and work with data created on another instrument or computer. It is possible, for example, for a network analyzer to directly load and display data measured on a scalar analyzer, or for a software package running on a computer to read data measured on the network analyzer.

Data Formats

CITIfile uses the ASCII text format.

The ASCII format is accepted by most text editors. This allows files to be created, examined, and edited easily, making CITIfile easy to test and debug.

CITIfile Definitions

This section defines: *package*, *header*, *data array*, and *keyword*.

Package

A typical CITIfile package is divided into two parts:

- The *header* is made up of keywords and setup information.
- The *data* usually consists of one or more arrays of data.

The following example shows the basic structure of a CITIfile package:

Header	CITIFILE A.01.00 NAME MEMORY VAR FREQ MAG 3 DATA S RI BEGIN -3.54545E-2, -1.38601E-3 0.23491E-3, -1.39883E-3 2.00382E-3, -1.40022E-3 END
Data	

When stored in a file there may be more than one CITIfile package. With the Agilent 8510 network analyzer, for example, storing a *memory all* will save all eight of the memories held in the instrument. This results in a single file that contains eight CITIfile *packages*.

Header

The header section contains information about the data that will follow. It may also include information about the setup of the instrument that measured the data. The CITIfile header shown in the first example has the minimum of information necessary; no instrument setup information was included.

Data Array

An array is numeric data that is arranged with one data element per line. A CITIfile package may contain more than one array of data. Arrays of data start after the BEGIN keyword, and the END keyword follows the last data element in an array.

A CITIfile package does not necessarily need to include data arrays. For instance, CITIfile could be used to store the current state of an instrument. In that case the keywords VAR, BEGIN, and END would not be required.

When accessing arrays via the DAC (DataAccessComponent), the simulator requires array elements to be listed completely and in order.

Example: S[1,1], S[1,2], S[2,1], S[2,2]

Keywords

Keywords are always the first word on a new line. They are always one continuous word without embedded spaces.

CITIfile Example

2-Port S-Parameter Data File

This example shows how a CITIfile can store 2-port S-parameter data. The independent variable name FREQ has two values located in the VAR_LIST_BEGIN section. The four DATA name definitions indicate there are four data arrays in the CITIfile package located in the BEGIN...END sections. The data must be in the correct order to ensure values are assigned to the intended ports. The order in this example results in data assigned to the ports as shown in the table that follows:

```
CITIFILE A.01.00
NAME BAF1
VAR FREQ MAG 2
DATA S[1,1] MAGANGLE
DATA S[1,2] MAGANGLE
DATA S[2,1] MAGANGLE
DATA S[2,2] MAGANGLE
VAR_LIST_BEGIN
1E9
2E9
VAR_LIST_END
BEGIN
0.1, 2
0.2, 3
END
BEGIN
0.3, 4
0.4, 5
END
BEGIN
0.5, 6
0.6, 7
END
BEGIN
0.7, 8
0.8, 9
END
```

DATA	FREQ = 1E9	FREQ = 2E9
s[1,1]	s[0.1,2]	s[0.2,3]
s[1,2]	s[0.3,4]	s[0.4,5]
s[2,1]	s[0.5,6]	s[0.6,7]
s[2,2]	s[0.7,8]	s[0.8,9]

For more information see Keysight/Agilent documentation.

EZNEC

EZNEC is a very powerful antenna simulation tool. It creates a datafile "Lastz.txt". The Lastz.txt file is created when a Frequency Sweep or SWR sweep is run. It contains, in comma-delimited ASCII format, the impedance and SWR at each source and frequency. It remains in the EZNEC program directory after the program ends and can be used for other purposes if desired. Text headers in the first line identify the field contents.

Freq MHz	Frequency in MHz
Src#	Number of source
R	Real part of impedance
X	Imaginary part of impedance
SWR (50 ohms)	VSWR referenced to 50 Ohms
SWR (alt Z0)	VSWR referenced to other specified resistance

Example:

```
"EZNEC+ ver. 5.0"
"Vert13m h=2,5m 4xRad6m Hut4x7m", "10.09.2008 12:48:36"
"Alt Z0: ",75
"Freq MHz", "Src #", "R", "X", "SWR (50 ohms)", "SWR (alt. Z0)"
3.4,1,30.0344,-104.4704,9.427082,7.611355
3.45,1,31.09572,-87.45639,7.006533,5.937705
3.5,1,32.19752,-70.44454,5.082611,4.596093
3.55,1,33.35558,-53.0484,3.573638,3.53528
3.6,1,34.53947,-35.95722,2.484591,2.770061
3.65,1,35.77891,-18.79243,1.733638,2.262968
3.7,1,37.08047,-1.231948,1.350235,2.02335
3.75,1,38.42399,16.13573,1.567183,2.071931
3.8,1,39.82835,33.66065,2.157393,2.371814
3.85,1,41.2804,51.10541,2.964938,2.861347
3.9,1,42.81051,68.93056,3.993486,3.518317
```

For more information see EZNEC documentation.

References

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www.ez nec.com

License, Demoversion and Contact

The unlicensed Demoversion allows 5 elements and 5 datapoints only. Save project and save netlist are disabled.

If you are interested in a licensed version with full capabilities send an e-mail to

fritz@dellsperger.net

Commercial licenses are priced to US\$ 120

Licenses for universities, students and Ham's with callsign are priced to US\$ 80

Demoversion and additional documents related to the Smith-Chart can be downloaded at

www.fritz.dellsperger.net

It's a long way to a perfect software...

If this ever exists...

While using our Smith software you may find bugs or new features to implement.

Send me a mail.

For next version we will fix the bugs and maybe put a few new ones.
We will also think about new features...

We're working hard...

Prof. Fritz Dellsperger
Dipl. Ing. Michel Baud

October 2016

May 2010

January 2010

October 2009

September 2005

November 2004

Former team members at
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April 2004

March 2004

July 2002

July 2000

February 1998

August 1995

History

Version 4.0 to Version 4.1, January 2018

- Fixed bug in labels of circles (VSWR, Q)
- Solved Problems with multiple datapoints and editing or tuning serial line
- Solved Problems with multiple datapoints, datapoint sweep and tuning serial line length
- Corrected text for Operating Power Gain Circles in circle window
- Fixed bug with input for "number of points" in frequency sweep
- Corrected CITI file load problems in S-Plot
- Corrected S21 and S12 swapping in s2p file from "Export > CITI-to S" in S-Plot
- Fixed different labels and minor bugs in "Smith" and "S-Plot"

Version 3.01 to Version 4.0, October 2016

- Added Tuning Cockpit to tune element values with sliders
- Fixed bugs in element definitions, frequency sweeps and other subjects
- Solved problems with Decimal Symbol in window settings
- Corrected file load problems in S-Plot
- Minor changes in menu and dialog boxes

Version 3.01 to Version 3.10, May 2010

- Added Frequency and Datapoint Sweep
- Serial transmission line with loss (attenuation)
- Export datapoint and circle info to ASCII-file for post-processing in spreadsheets or math software
- Linear or logarithmic frequency axis in S-Plot graphs
- Cursor readout in S-Plot graphs
- Minor changes in toolboxes and settings

Version 3.0 to Version 3.01, January 2010

- Fixed problem with key-files including "Umlauts" and other vowel mutations
- Allow delete of manually defined VSWR-circles
- Solved problems with gain-, noise- and stability-circle dialogbox
- Automatic update of values in schematic on selecting active datapoint and insert circuit elements
- Fixed bug for line length units in schematic
- Last input of Er on line elements will be default value for next line insertion
- Replaced "Ohm" with greek Ω in some dialogboxes
- Removed unused checkboxes in window "Datapoints"
- Correct frequency assignment from datapoints to circuit elements

Version 2.03 to Version 3.0, October 2009

- Complete redesign

Version 2.02 to Version 2.03, September 2005

Version 2.01 to Version 2.02, November 2004

Version 2.00 to Version 2.01, April 2004

Version 1.92 to Version 2.0, March 2004

Version 1.91 to Version 1.92, July 2002

Version 1.90 to Version 1.91, July 2000

Version 1.82 to Version 1.90, June 2000

Version 1.71 to Version 1.82, February 1998

Version 1.0, August 1995