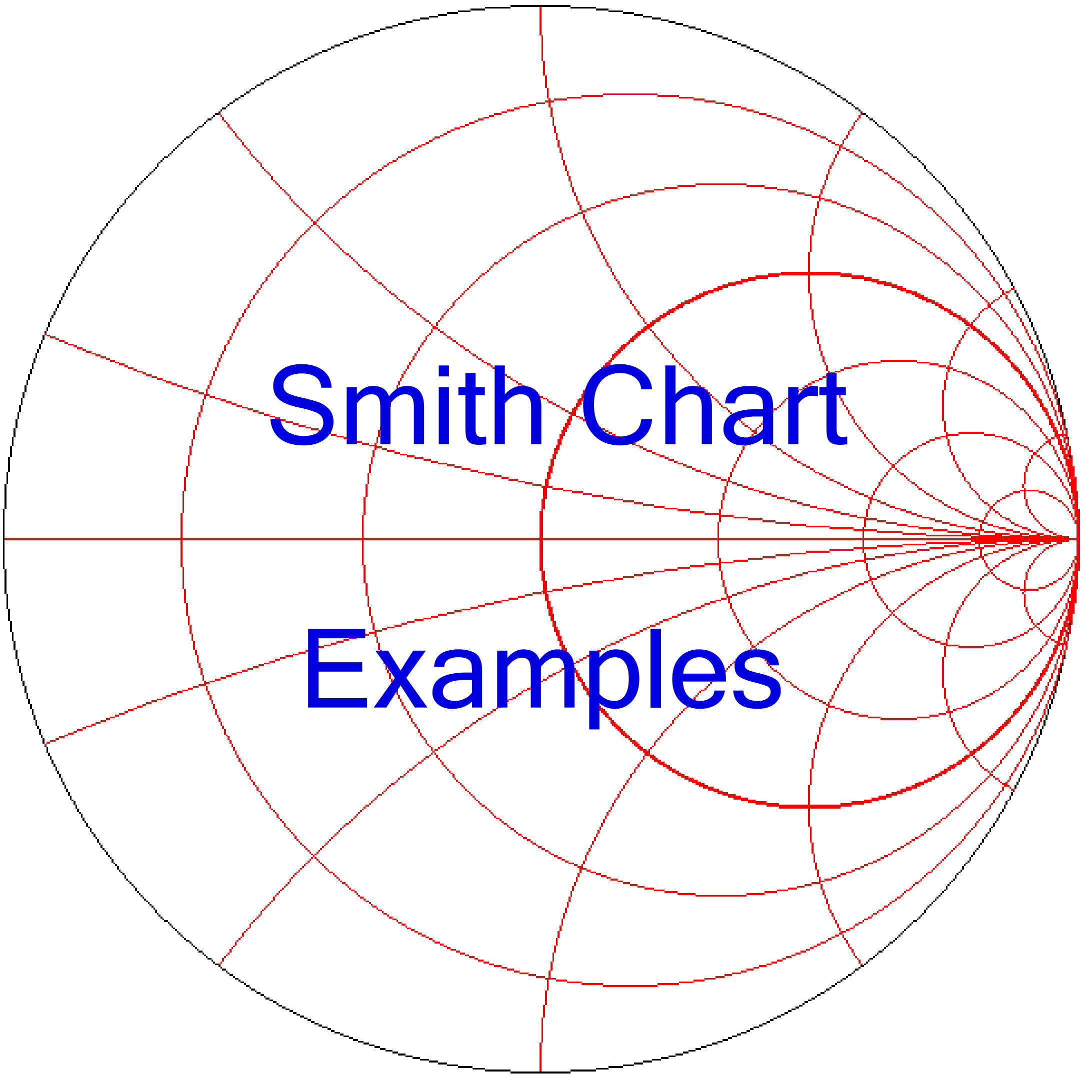
Bern University of Applied Sciences
Engineering and Information Technology

Division of Electrical and Communication Technology

Smith Chart Examples



Smith V4.1

Fritz Dellsperger 5.2010 / 10.2016 / 1.2018

Content

Impedance Matching

Impedance, Admittance, Reflection Coefficient, VSWR and Return Loss

Impedance: $Z = R + jX$ R: Resistance X: Reactance

$$Z = Z_0 \frac{1+\Gamma}{1-\Gamma}$$

Admittance: $Y = G + jB$ G: Conductance B: Susceptance

$$Z = \frac{1}{Y} \qquad Y = \frac{1}{Z}$$

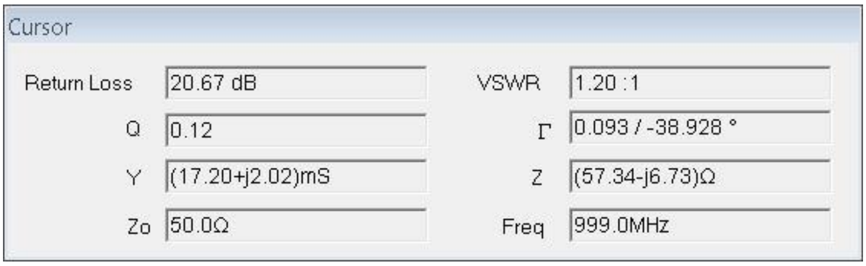
Reflection Coefficient: $\Gamma = \frac{Z - Z_0}{Z + Z_0} = \frac{Y_0 - Y}{Y_0 + Y} = |\Gamma| \angle \varphi$ Z_0 : Reference Impedance

$$|\Gamma| = \frac{VSWR - 1}{VSWR + 1} = 10^{-\frac{RL}{20}} = \frac{|Z - Z_0|}{|Z + Z_0|}$$

Voltage Standing Wave Ratio: $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+10^{-\frac{RL}{20}}}{1-10^{-\frac{RL}{20}}} = \left.\frac{|Z_0|}{|Z|}\right|_{Z<Z_0} = \left.\frac{|Z|}{|Z_0|}\right|_{Z>Z_0}$

Return Loss: $RL = -20 \cdot \log|\Gamma| = -20 \cdot \log \frac{VSWR - 1}{VSWR + 1} = -20 \cdot \log \frac{|Z - Z_0|}{|Z + Z_0|}$

All values for cursor position in Smith-Chart are displayed in window “Cursor”.

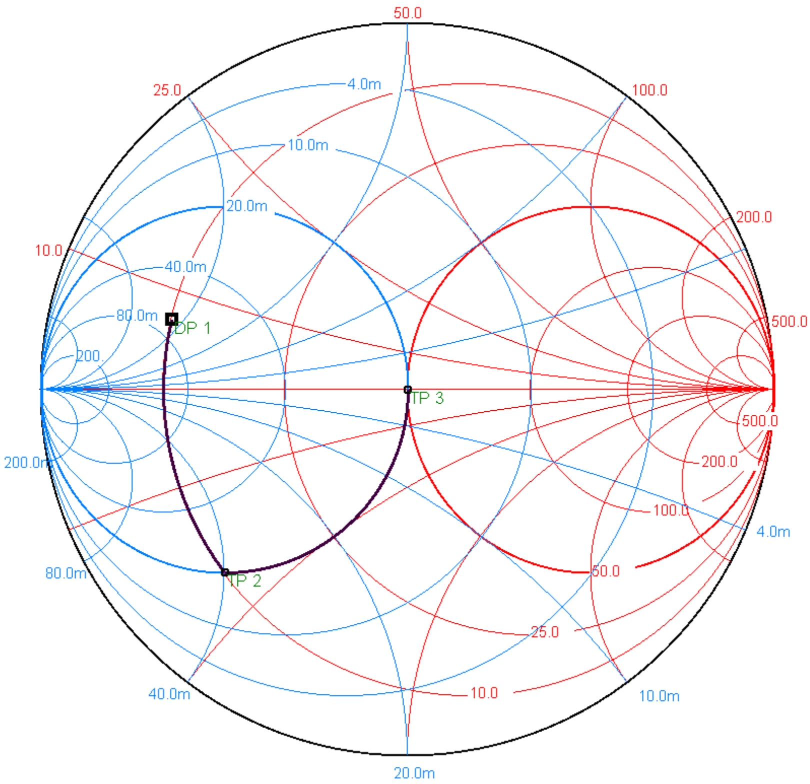


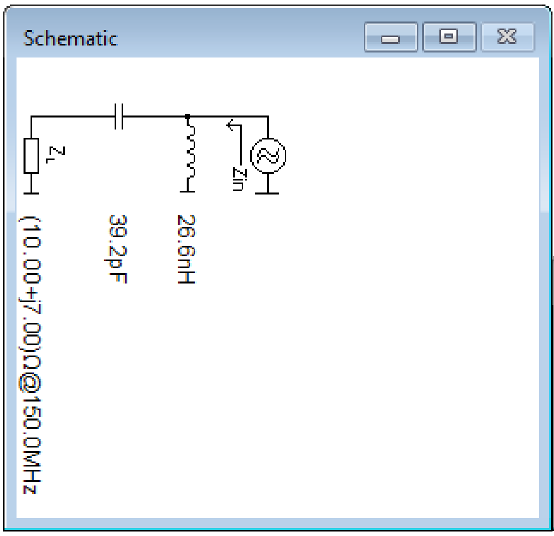
Matching arbitrary impedances to 50 Ohm

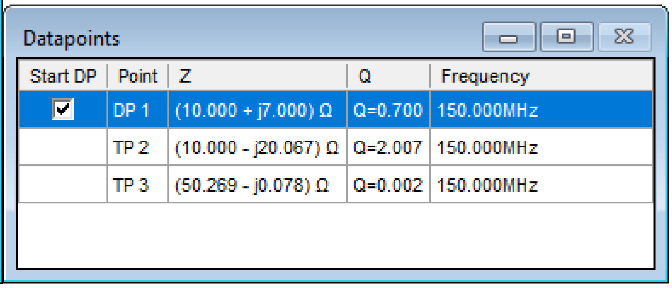
Example 1: Use 2 reactance elements, Highpass

Problem: Match an impedance of $(10+j7)\Omega$ to $50\,\Omega$. Use 2 reactance (L,C) in a circuit topology with highpass characteristic. Frequency: 150 MHz.

Smith project file: Example1.xmlsc





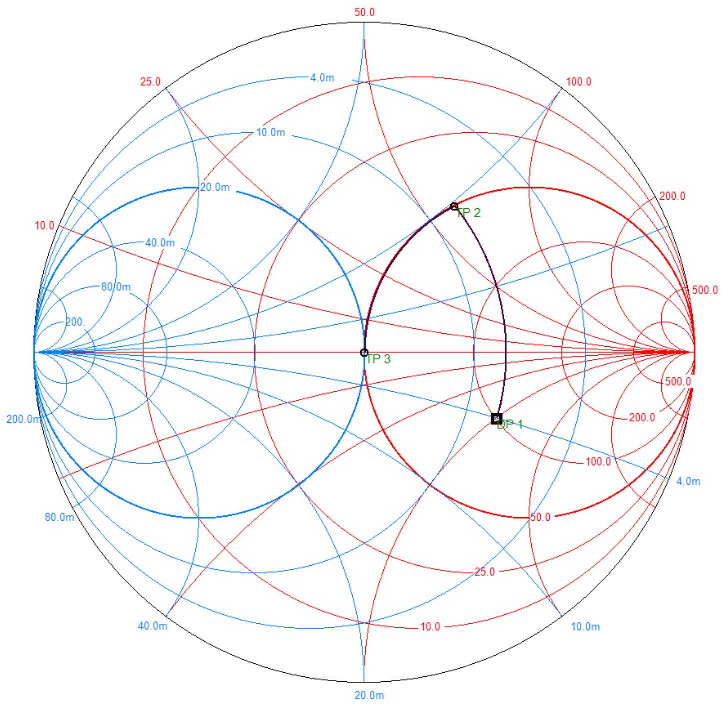


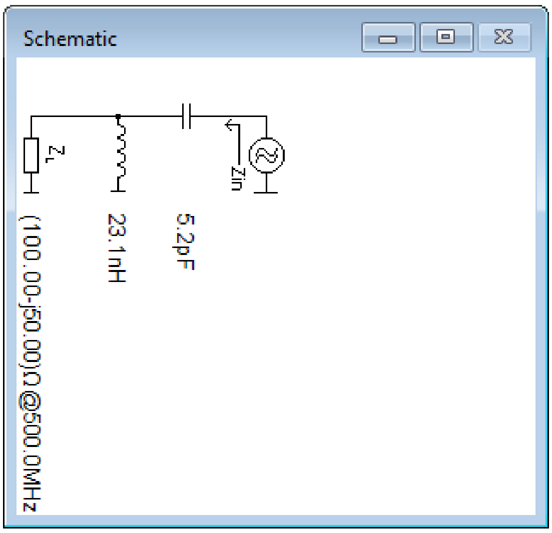
Start DP	Point	Z	Q	Frequency
✔	DP 1	(10.000 + j7.000) Ω	Q=0.700	150.000MHz
	TP 2	(10.000 - j20.067) Ω	Q=2.007	150.000MHz
	TP 3	(50.269 - j0.078) Ω	Q=0.002	150.000MHz

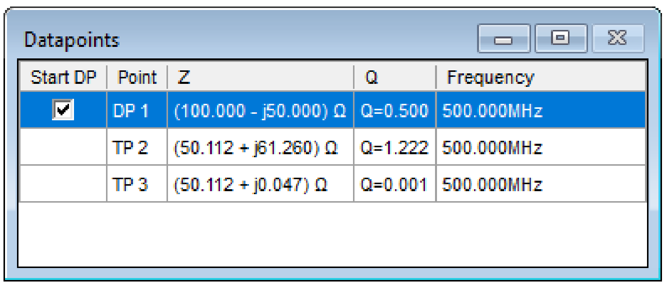
Example 2: Use 2 reactance elements, Highpass

Problem: Match an impedance of $(100 - j50)\Omega$ to 50Ω. Use 2 reactance (L,C) in a circuit topology with highpass characteristic. Frequency: 500 MHz.

Smith project file: Example2.xmlsc





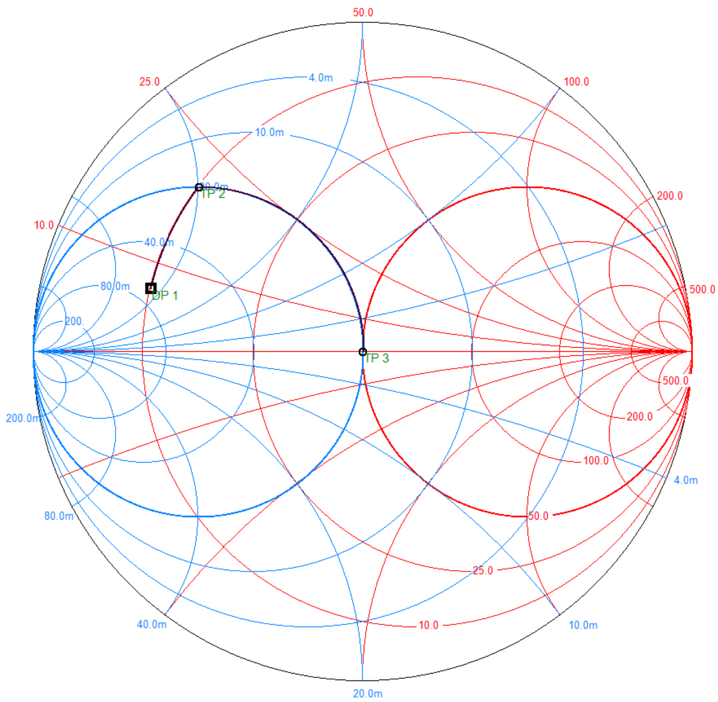

Datapoints

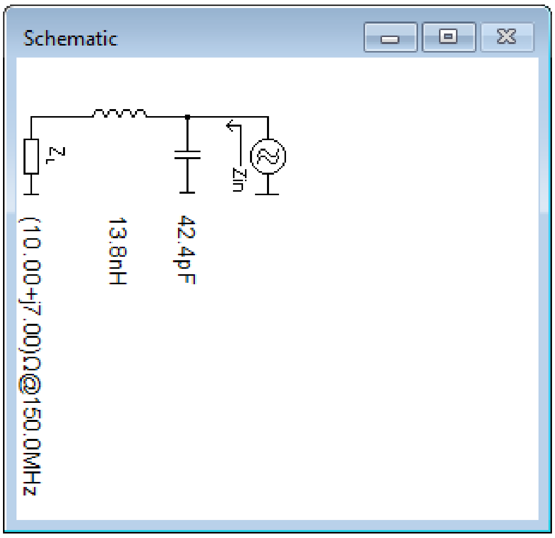
Start DP	Point	Z	Q	Frequency
☑	DP 1	(100.000 - j50.000) Ω	Q=0.500	500.000MHz
	TP 2	(50.112 + j61.260) Ω	Q=1.222	500.000MHz
	TP 3	(50.112 + j0.047) Ω	Q=0.001	500.000MHz

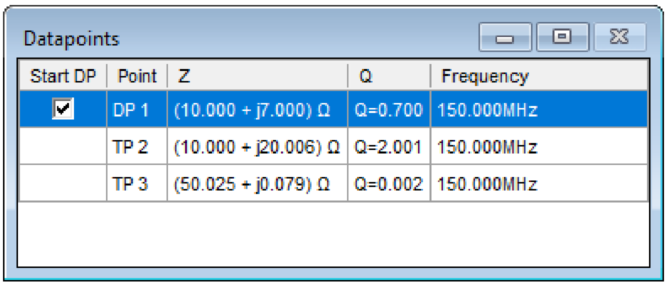
Example 3: Use 2 reactance elements, Lowpass

Problem: Match an impedance of $(10+j7)\Omega$ to 50Ω. Use 2 reactance (L,C) in a circuit topology with lowpass characteristic. Frequency: 150 MHz.

Smith project file: Example3.xmlsc







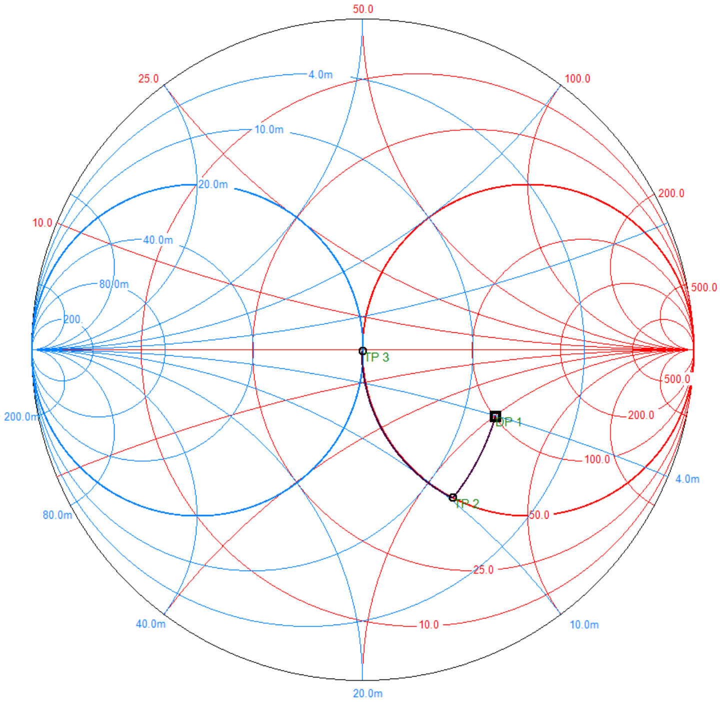
Datapoints

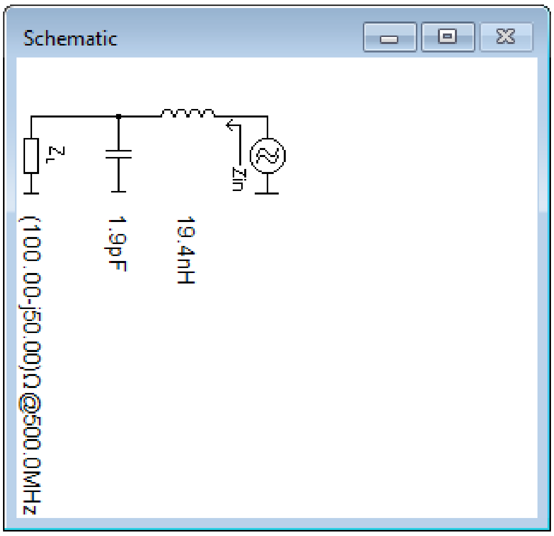
Start DP	Point	Z	Q	Frequency
☑	DP 1	(10.000 + j7.000) Ω	Q=0.700	150.000MHz
	TP 2	(10.000 + j20.006) Ω	Q=2.001	150.000MHz
	TP 3	(50.025 + j0.079) Ω	Q=0.002	150.000MHz

Example 4: Use 2 reactance elements, Lowpass

Problem: Match an impedance of $(100 - j50)\Omega$ to 50Ω. Use 2 reactance (L,C) in a circuit topology with lowpass characteristic. Frequency: 500 MHz.

Smith project file: Example4.xmlsc





Datapoints

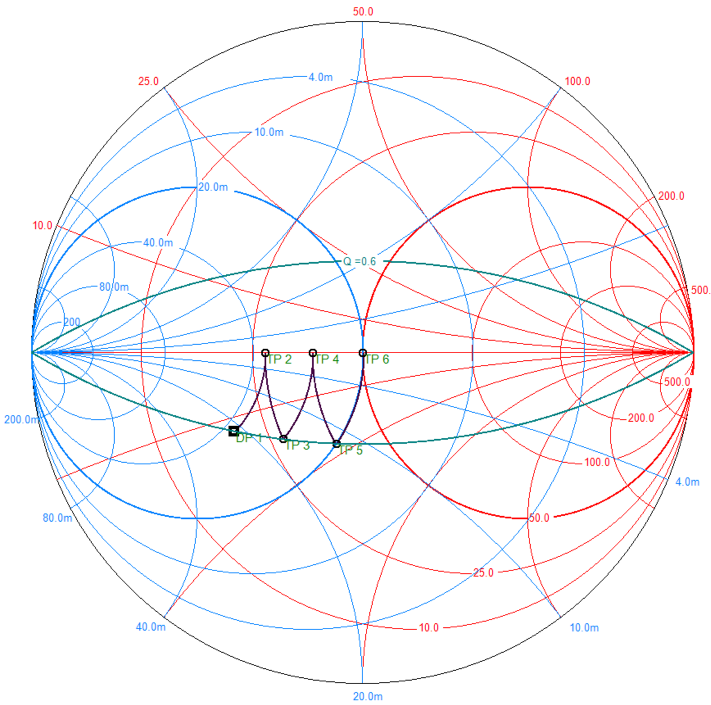
Start DP	Point	Z	Q	Frequency
☑	DP 1	(100.000 - j50.000) Ω	Q=0.500	500.000MHz
	TP 2	(49.914 - j61.220) Ω	Q=1.226	500.000MHz
	TP 3	(49.914 - j0.273) Ω	Q=0.005	500.000MHz

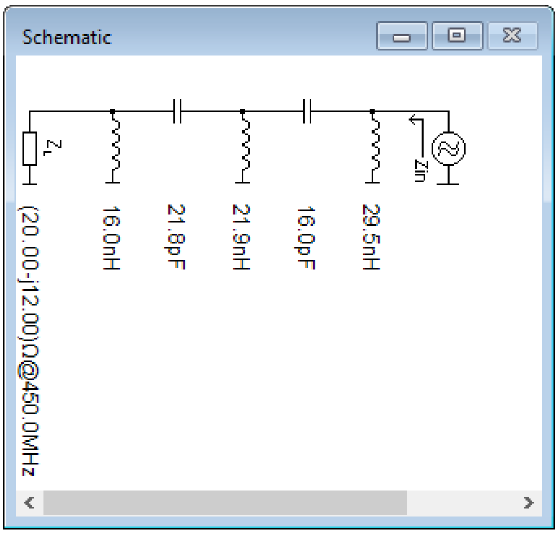
Example 5: Antenna Match with 3 or more reactance elements, Low Q, Highpass

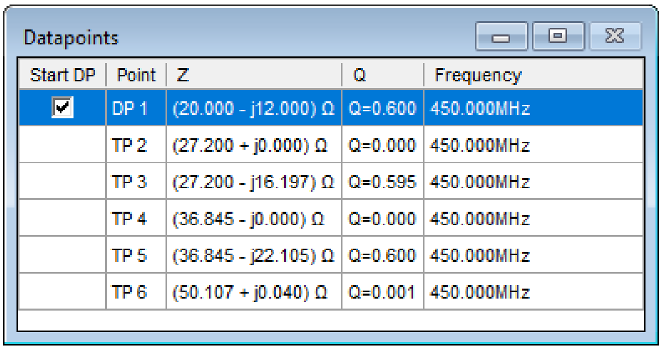
Problem: Match an antenna impedance of $(20 - j12)\Omega$ to 50Ω. Use L and C in a circuit topology with highpass characteristic and do not exceed a $Q_{max} = \frac{X}{R} = \frac{12}{20} = 0.6$ (for maximum bandwidth).

Frequency: 450 MHz.

Smith project file: Example5.xmlsc







Datapoints

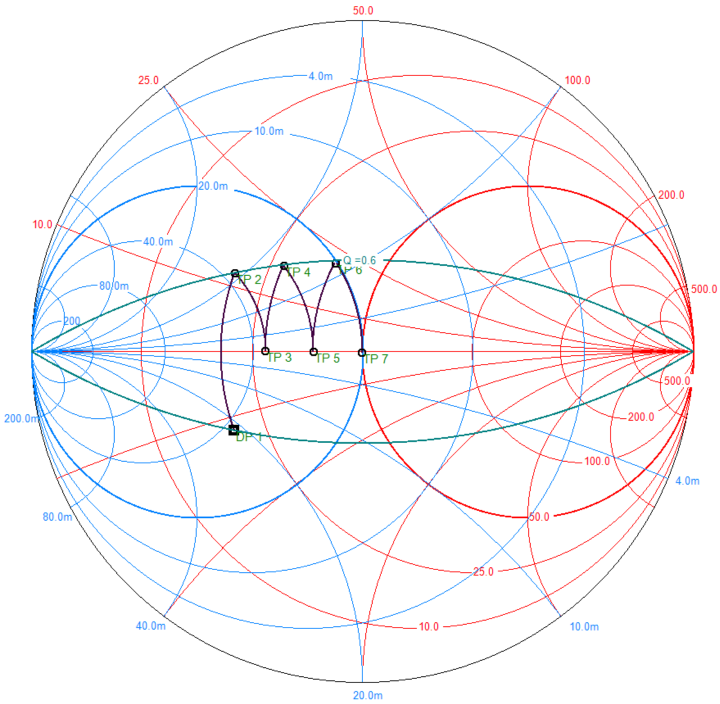
Start DP	Point	Z	Q	Frequency
✔	DP 1	(20.000 - j12.000) Ω	Q=0.600	450.000MHz
	TP 2	(27.200 + j0.000) Ω	Q=0.000	450.000MHz
	TP 3	(27.200 - j16.197) Ω	Q=0.595	450.000MHz
	TP 4	(36.845 - j0.000) Ω	Q=0.000	450.000MHz
	TP 5	(36.845 - j22.105) Ω	Q=0.600	450.000MHz
	TP 6	(50.107 + j0.040) Ω	Q=0.001	450.000MHz

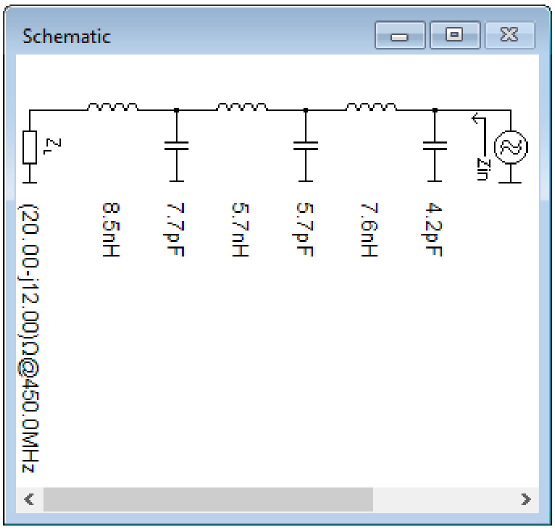
Example 6: Antenna Match with 3 or more reactance elements, Low Q, Lowpass

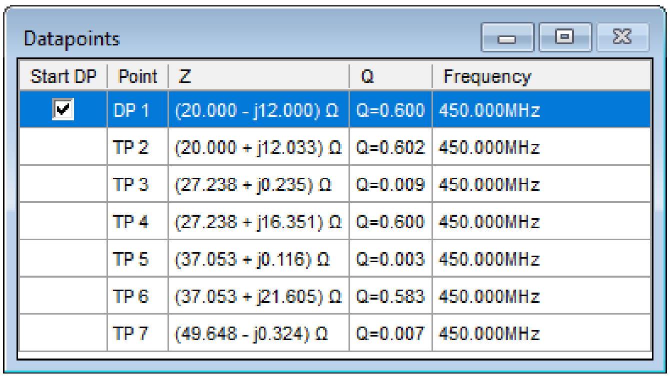
Problem: Match an antenna impedance of $(20 - j12)\Omega$ to 50Ω. Use L and C in a circuit topology with lowpass characteristic and do not exceed a $Q_{max} = \frac{X}{R} = \frac{12}{20} = 0.6$ (for maximum bandwidth).

Frequency: 450 MHz.

Smith project file: Example6.xmlsc





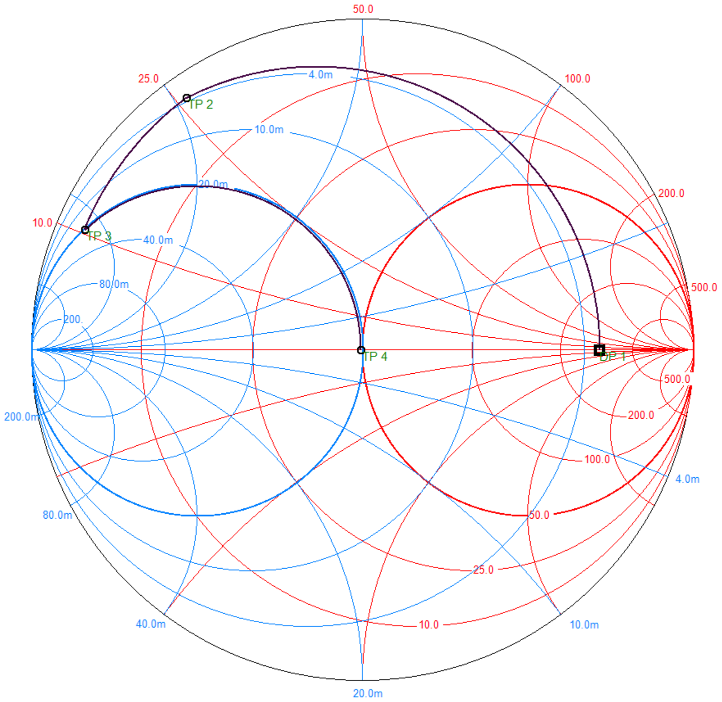

Datapoints

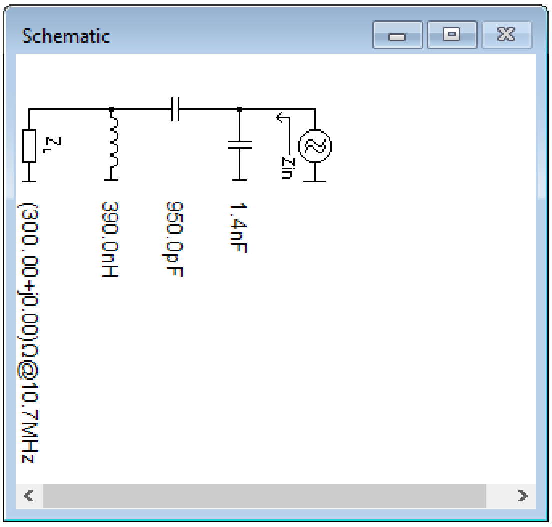
Start DP	Point	Z	Q	Frequency
☑	DP 1	(20.000 - j12.000) Ω	Q=0.600	450.000MHz
	TP 2	(20.000 + j12.033) Ω	Q=0.602	450.000MHz
	TP 3	(27.238 + j0.235) Ω	Q=0.009	450.000MHz
	TP 4	(27.238 + j16.351) Ω	Q=0.600	450.000MHz
	TP 5	(37.053 + j0.116) Ω	Q=0.003	450.000MHz
	TP 6	(37.053 + j21.605) Ω	Q=0.583	450.000MHz
	TP 7	(49.648 - j0.324) Ω	Q=0.007	450.000MHz

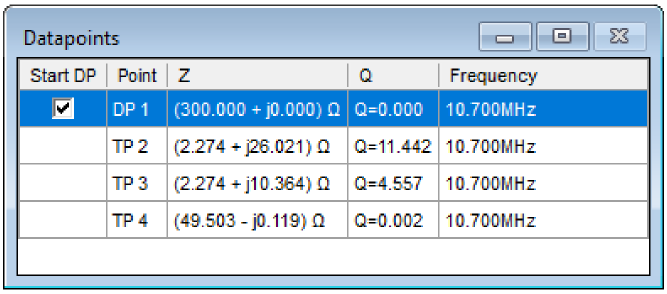
Example 7: Match Ceramic Filter to 50 Ohm

Problem: For measurement purposes match a 10.7 MHz 300 Ohm Ceramic filter to 50 Ohm using a parallel resonance circuit with capacitive voltage divider and L = 330 nH.
Frequency: 10.7 MHz.

Smith project file: Example7.xmlsc



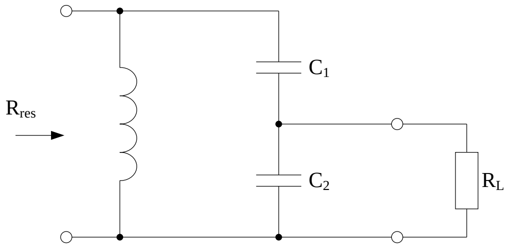




Start DP	Point	Z	Q	Frequency
☑	DP 1	(300.000 + j0.000) Ω	Q=0.000	10.700MHz
	TP 2	(2.274 + j26.021) Ω	Q=11.442	10.700MHz
	TP 3	(2.274 + j10.364) Ω	Q=4.557	10.700MHz
	TP 4	(49.503 - j0.119) Ω	Q=0.002	10.700MHz

$f_0 := 10.7 \cdot \mathrm{MHz} \quad R_1 := 300 \cdot \Omega \qquad L := 390 \cdot \mathrm{nH}$

$$B := \frac{2 \cdot \pi \cdot L \cdot f_0^{\,2}}{R_1} = 791.298 \cdot \mathrm{kHz}$$



For Q ≥ 10 following approximations can be used:

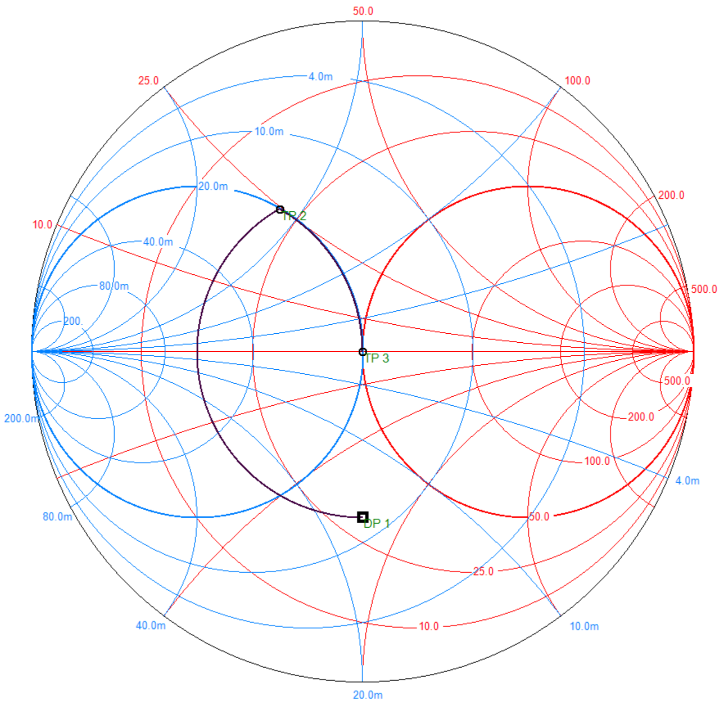
$$Q \approx \frac{f_o}{B} \qquad C \approx \frac{1}{2\pi B R_{res}} \qquad L \approx \frac{1}{\omega_o^{\,2}\, C} \qquad N = \sqrt{\frac{R_{res}}{R_L}}$$

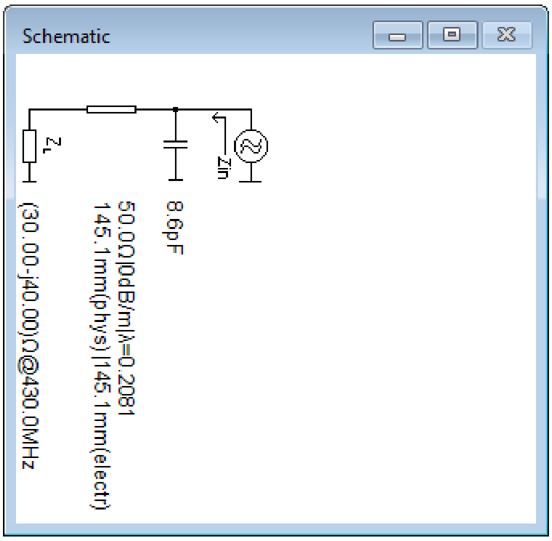
$$Q_p \approx \frac{Q}{N} \qquad C_1 \approx \frac{C_2}{N-1} \qquad C_2 \approx NC$$

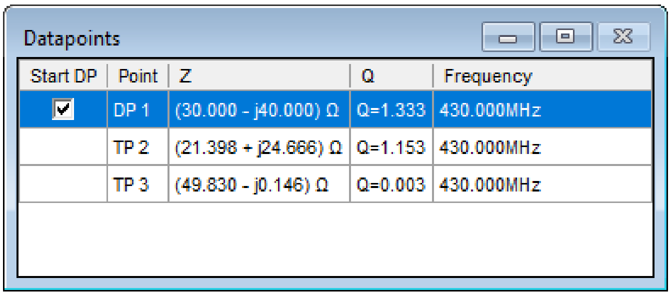
Example 8: Antenna match using reactance and serie line element

Problem: Match an antenna impedance of $(30 - j40)\Omega$ to 50Ω. Use one reactance and one serie line. Frequency: 430 MHz.

Smith project file: Example8.xmlsc







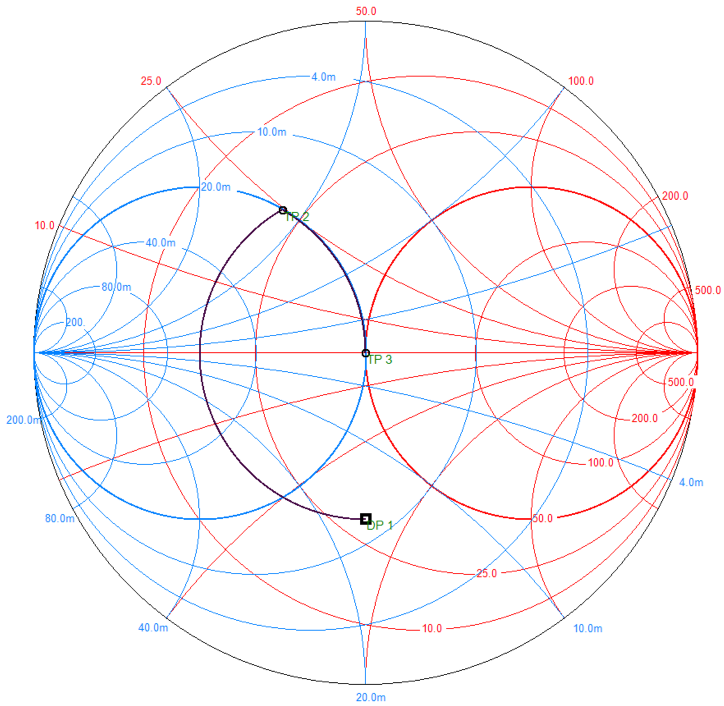
Datapoints

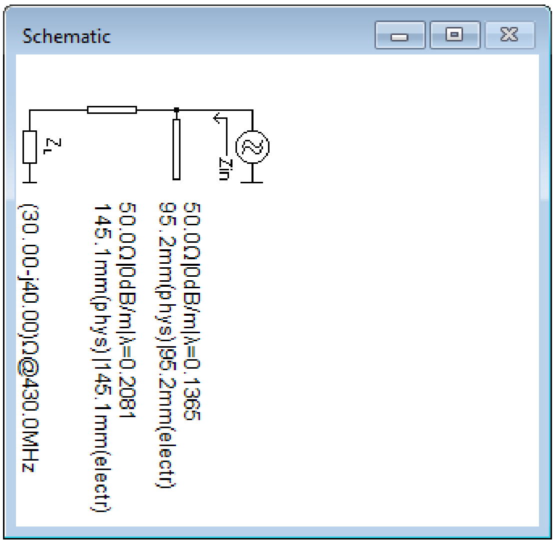
Start DP	Point	Z	Q	Frequency
☑	DP 1	(30.000 - j40.000) Ω	Q=1.333	430.000MHz
	TP 2	(21.398 + j24.666) Ω	Q=1.153	430.000MHz
	TP 3	(49.830 - j0.146) Ω	Q=0.003	430.000MHz

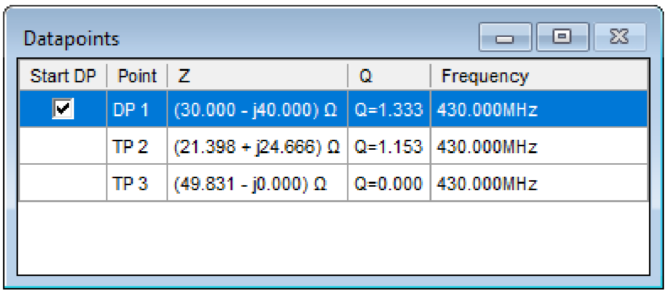
Example 9: Antenna match using serie line and open stub

Problem: Match an antenna impedance of $(30 - j40)\Omega$ to 50Ω. Use one serie line and an open stub. Frequency: 430 MHz.

Smith project file: Example9.xmlsc





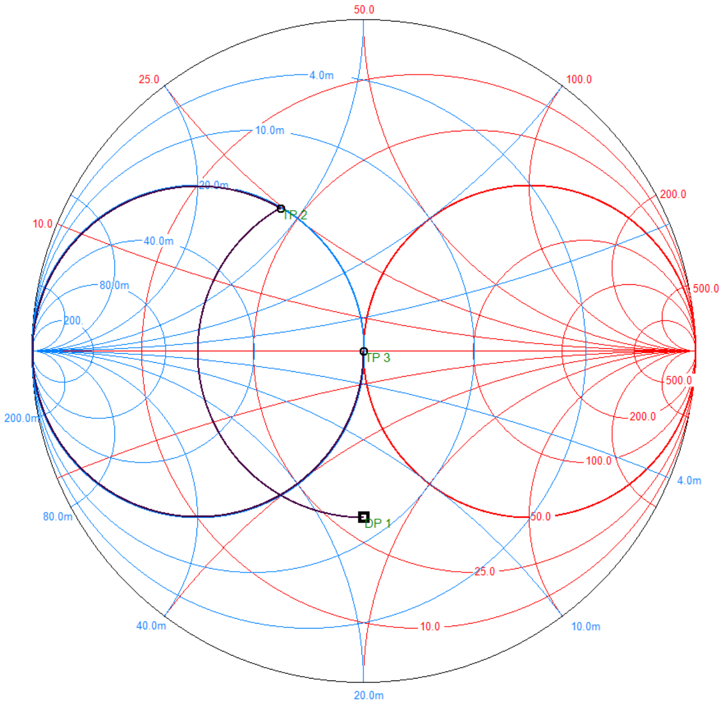


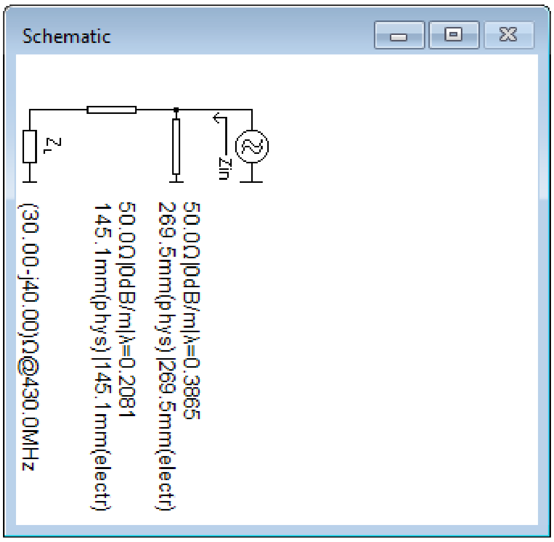
Start DP	Point	Z	Q	Frequency
☑	DP 1	(30.000 - j40.000) Ω	Q=1.333	430.000MHz
	TP 2	(21.398 + j24.666) Ω	Q=1.153	430.000MHz
	TP 3	(49.831 - j0.000) Ω	Q=0.000	430.000MHz

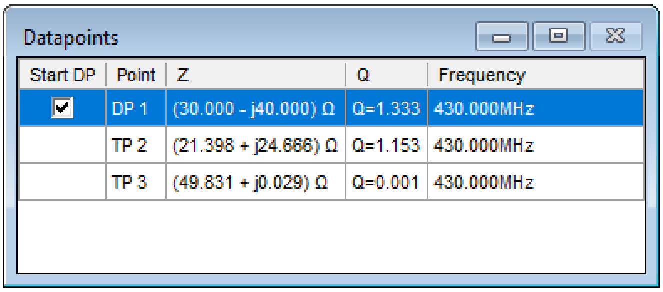
Example 10: Antenna match using serie line and shorted stub

Problem: Match an antenna impedance of $(30 - j40)\Omega$ to 50Ω. Use one serie line and a shorted stub. Frequency: 430 MHz.

Smith project file: Example10.xmlsc







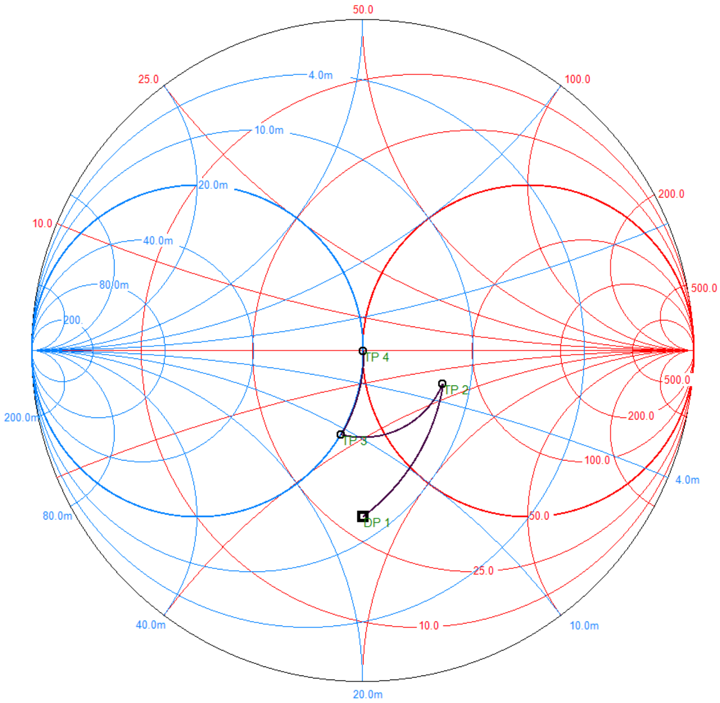
Datapoints

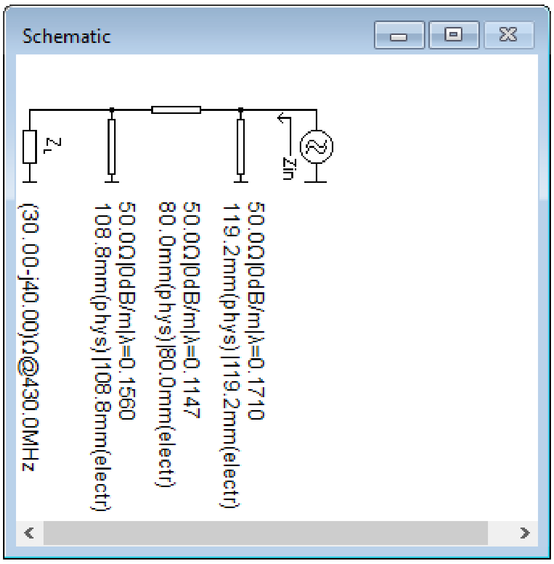
Start DP	Point	Z	Q	Frequency
☑	DP 1	(30.000 - j40.000) Ω	Q=1.333	430.000MHz
	TP 2	(21.398 + j24.666) Ω	Q=1.153	430.000MHz
	TP 3	(49.831 + j0.029) Ω	Q=0.001	430.000MHz

Example 11: Antenna match using double stub tuner

Problem: Match an antenna impedance of $(30-j40)\Omega$ to 50Ω. Use a double stub tuner with serie line length of 80 mm with $\varepsilon_r = 1$ and Frequency: 430 MHz.

Smith project file: Example11.xmlsc

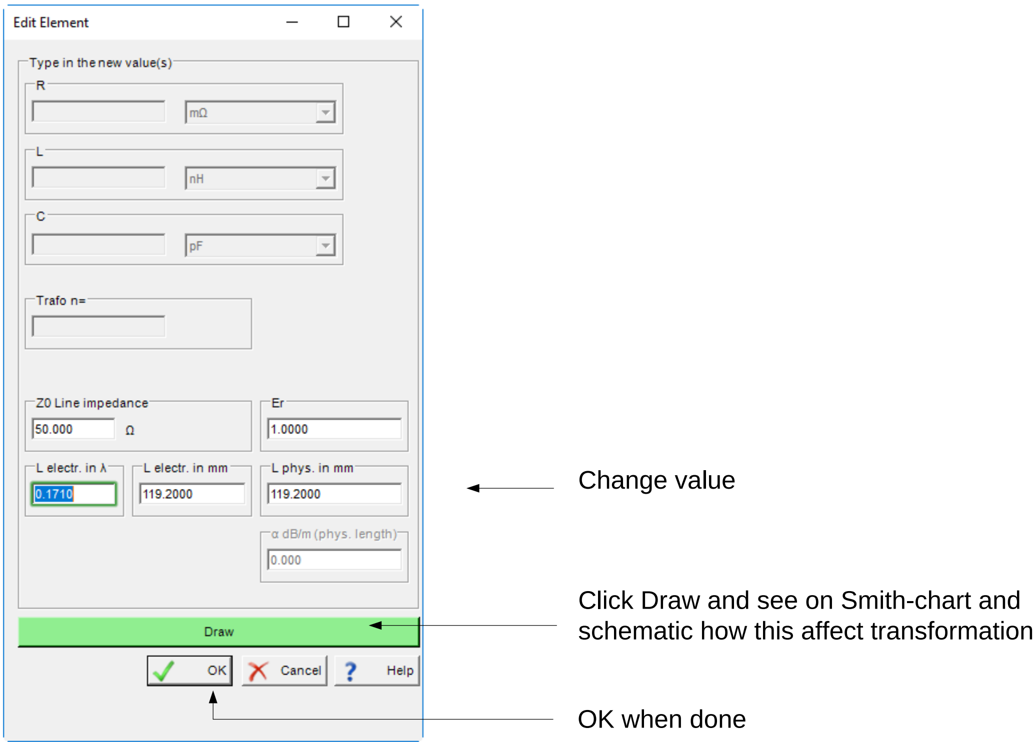




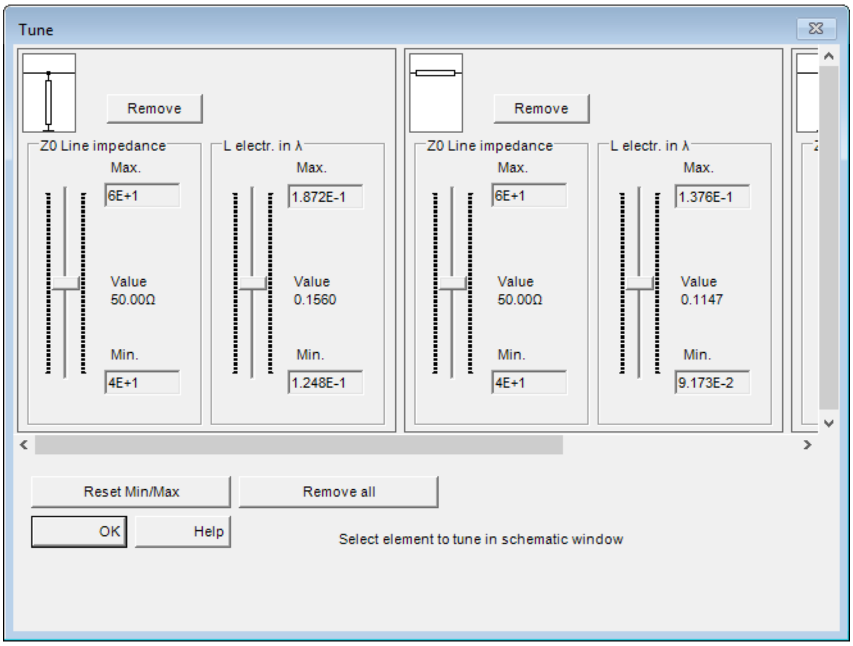
Datapoints

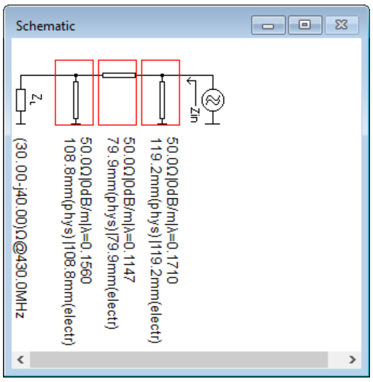
Start DP	Point	Z	Q	Frequency
☑	DP 1	(30.000 - j40.000) Ω	Q=1.333	430.000MHz
	TP 2	(79.622 - j17.191) Ω	Q=0.216	430.000MHz
	TP 3	(38.628 - j20.970) Ω	Q=0.543	430.000MHz
	TP 4	(50.012 - j0.057) Ω	Q=0.001	430.000MHz

Use Edit Element (doubleclick on element in schematic) to adjust for desired line length.



Or use tuning cockpit (Tune) to adjust for desired line length.

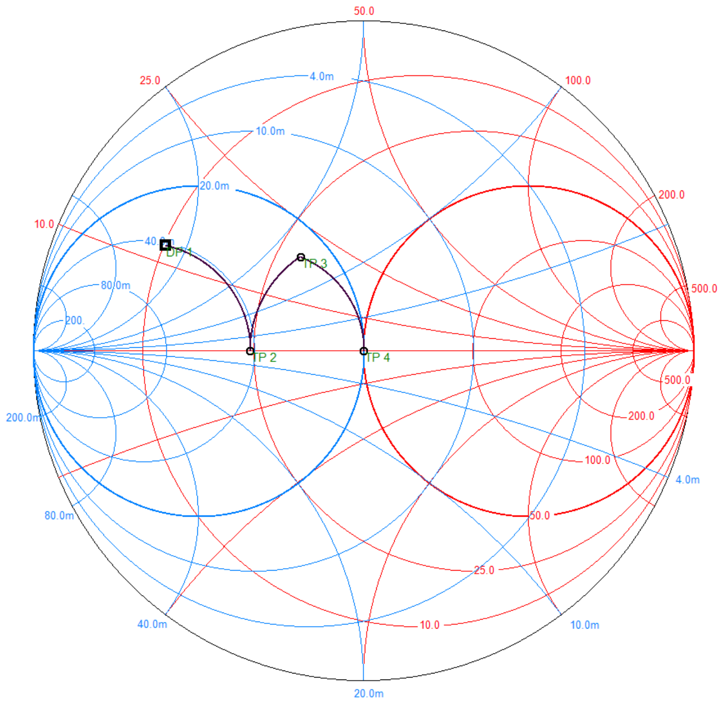


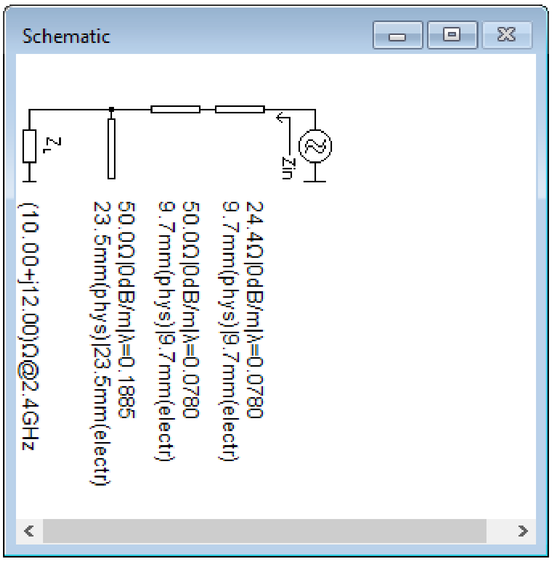


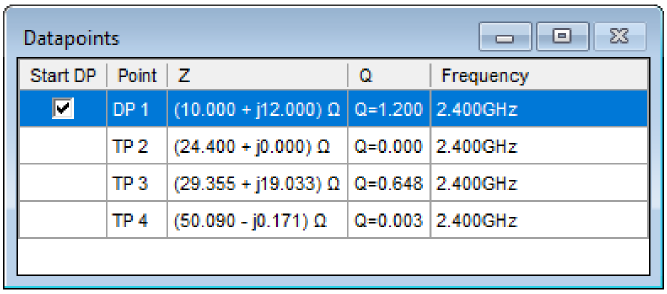
Example 12: Nonsynchronous Transformer

Problem: Match an impedance of $(10+j12)\Omega$ to 50Ω. Use an open stub and a nonsynchronous transformer. Frequency: 2.4 GHz.

Smith project file: Example12.xmlsc

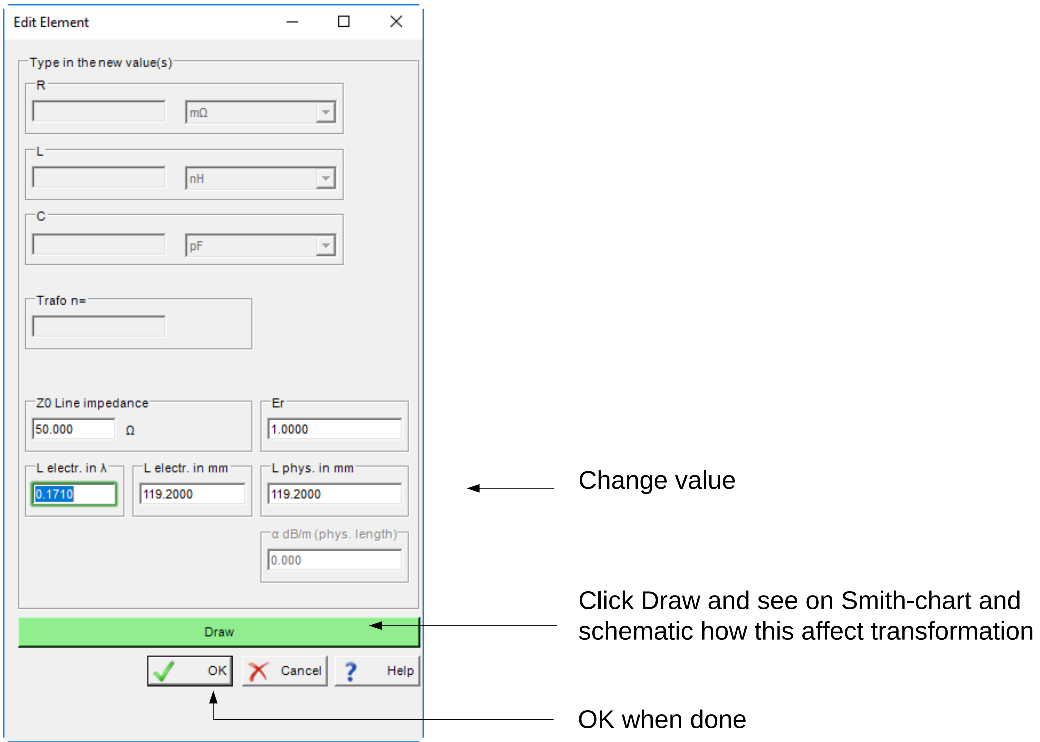




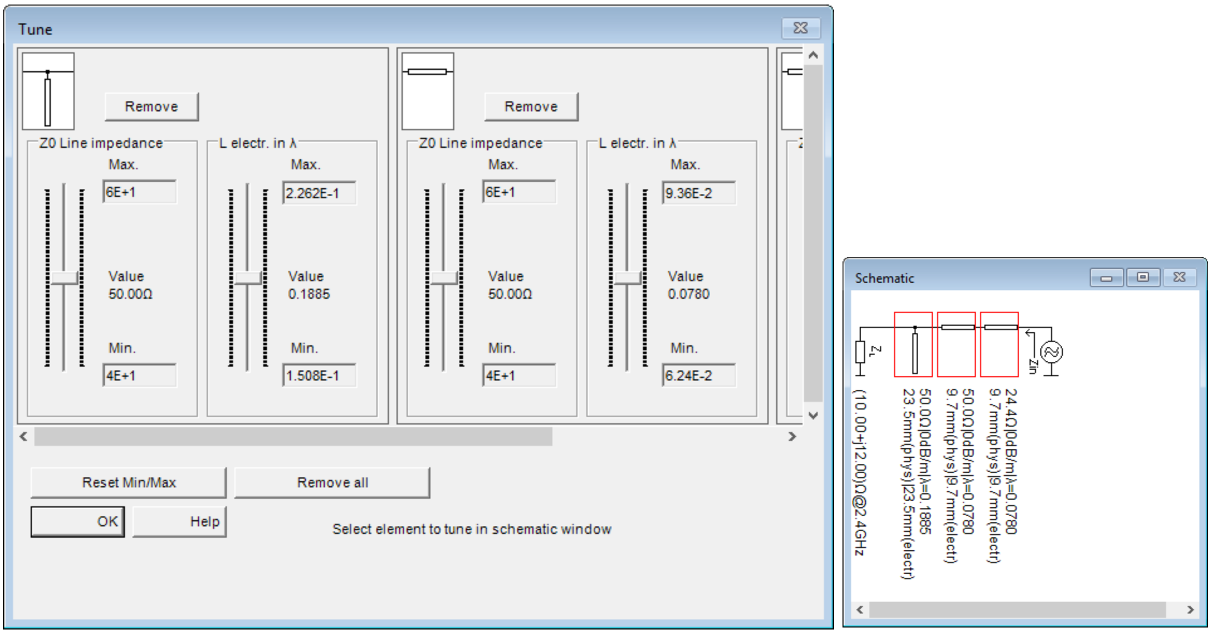


Start DP	Point	Z	Q	Frequency
☑	DP 1	(10.000 + j12.000) Ω	Q=1.200	2.400GHz
	TP 2	(24.400 + j0.000) Ω	Q=0.000	2.400GHz
	TP 3	(29.355 + j19.033) Ω	Q=0.648	2.400GHz
	TP 4	(50.090 - j0.171) Ω	Q=0.003	2.400GHz

Use Edit Element (doubleclick on element in schematic) to adjust for desired line length.

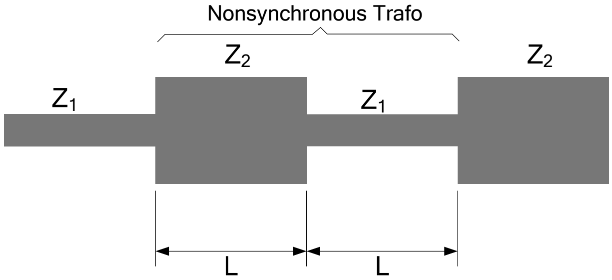


Or use tuning cockpit (Tune) to adjust for desired line length.



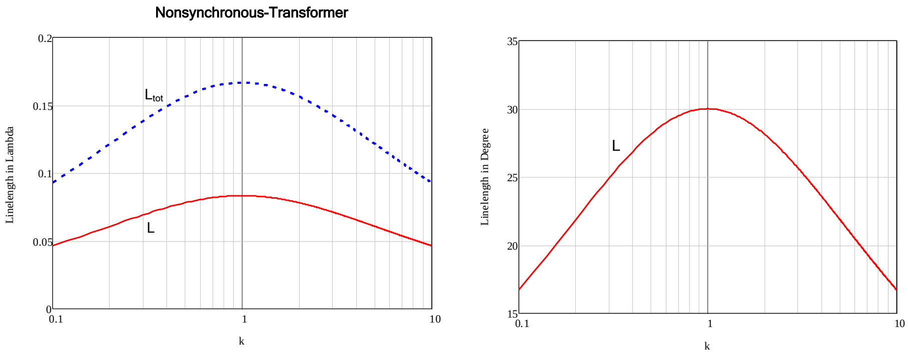
Properties of Nonsynchronous Trafo:

It uses two pieces of line with the same length. One line must have the line impedance of the source and the other line the impedance of the load. The total length depends on impedance ratio and is much shorter than $\lambda / 4$.



L = Length of one line section

$$k = Z_1 / Z_2 \qquad L = \frac{\lambda}{2\pi\sqrt{\varepsilon_r}} \operatorname{atan}\left(\frac{1}{\sqrt{k + \frac{1}{k} + 1}} \right)$$



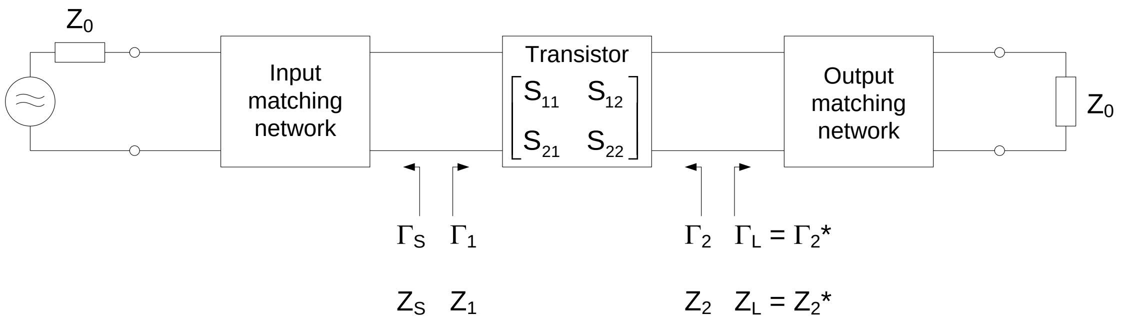
Line length as function of impedance ratio k

Low Noise Amplifier Design

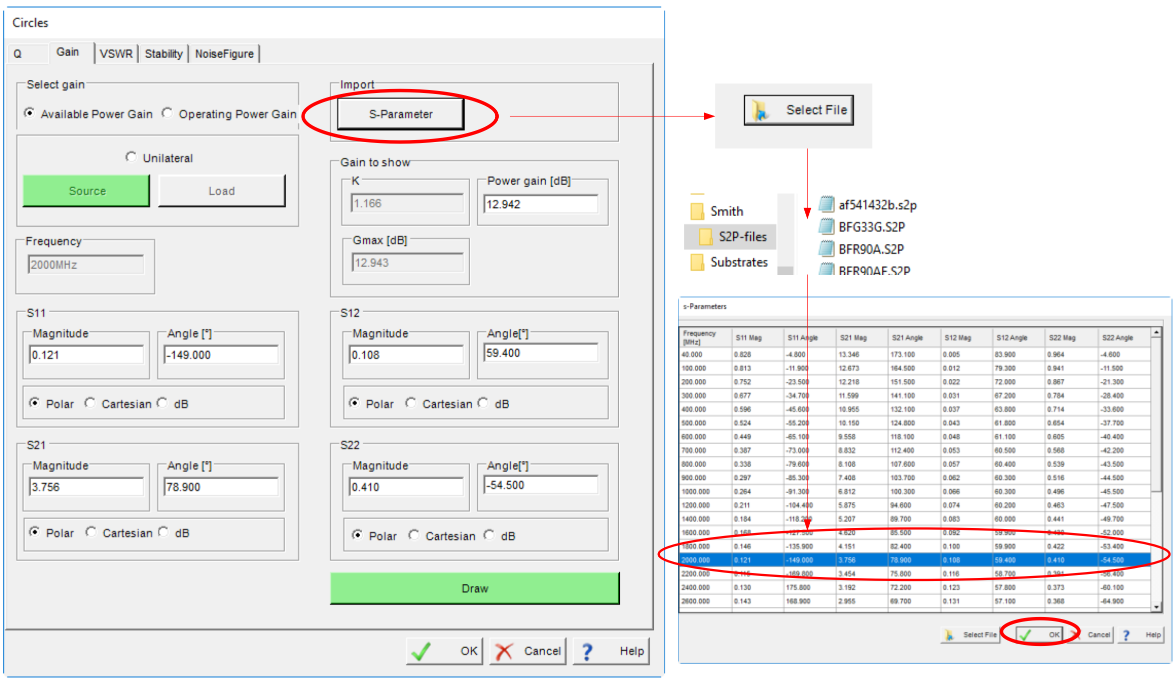
Example 13: Low Noise Amplifier, 2.0 GHz

Problem: Design input and output matching network for a LNA using BFG33G.
Frequency: 2 GHz

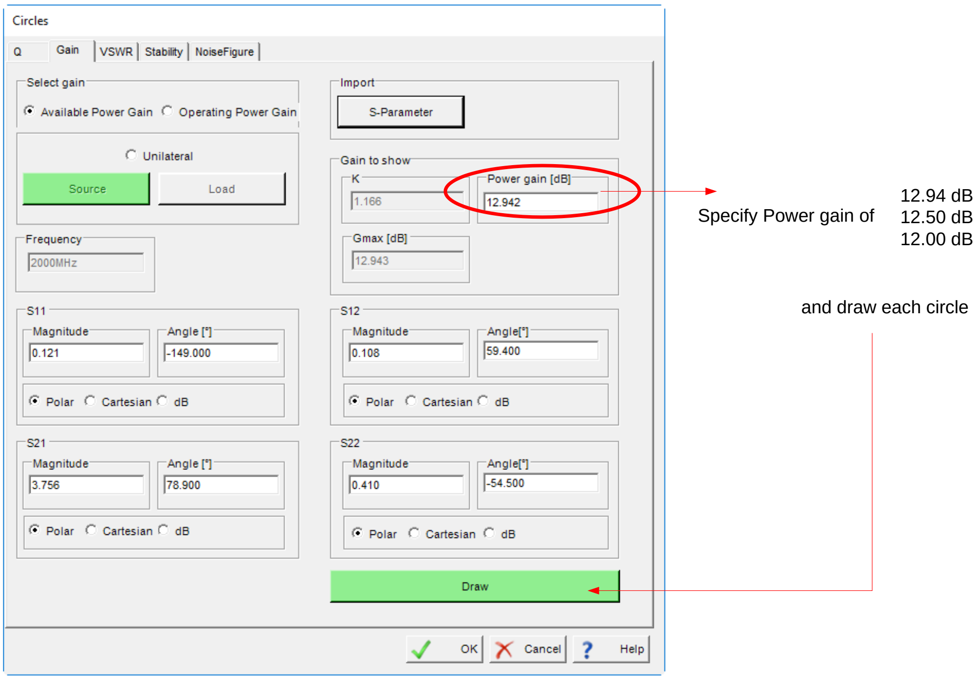
Smith project file: Example13-input.xmlsc



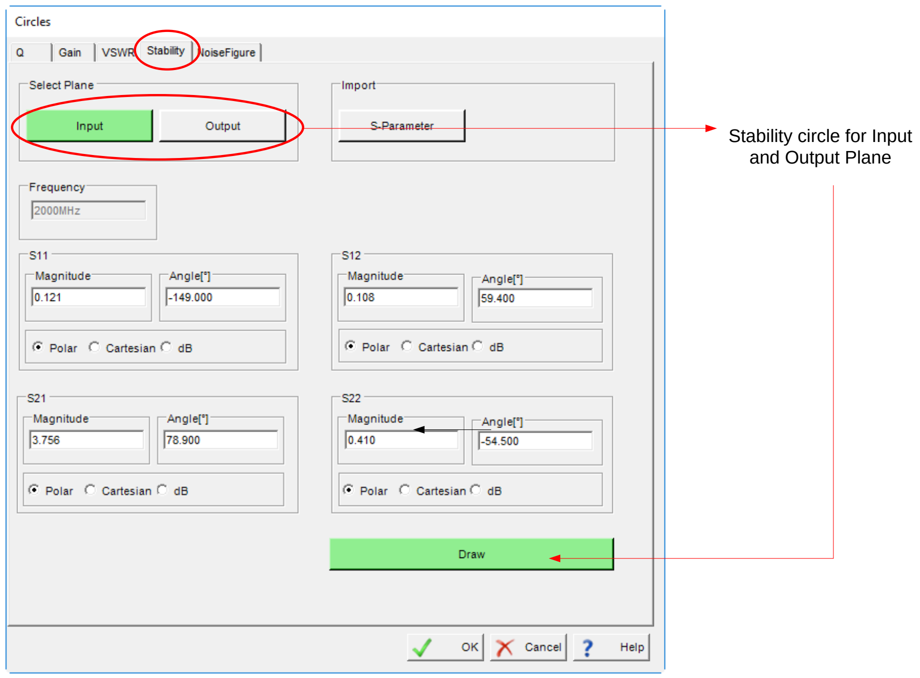
Import S-Parameters for device BFG33G at 2.0 GHz.



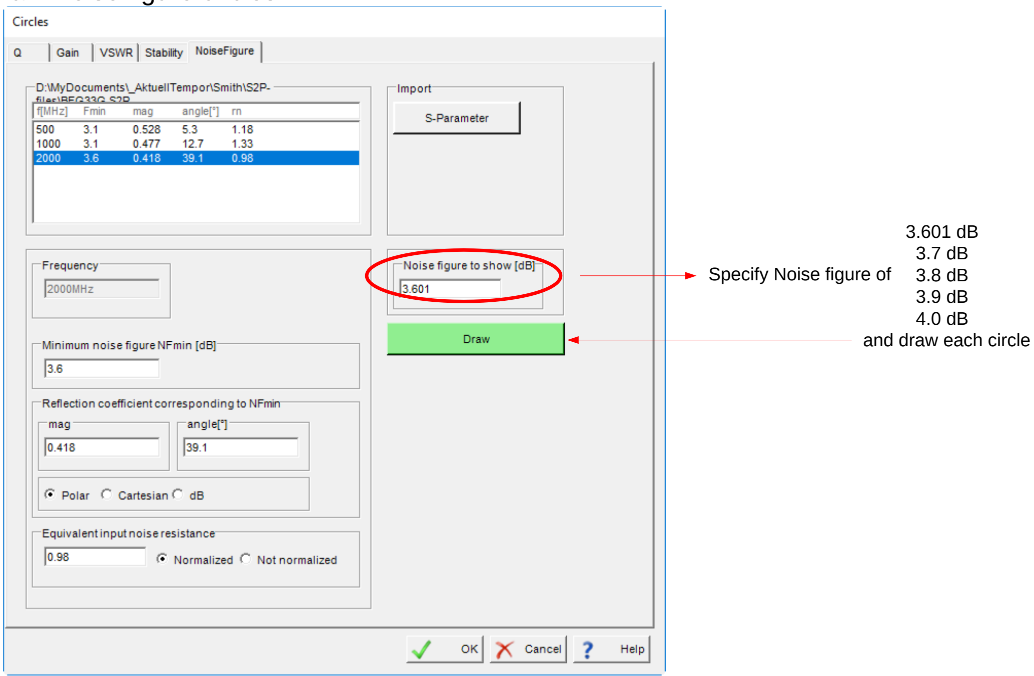
Draw circles for gain:



Draw stability circles:

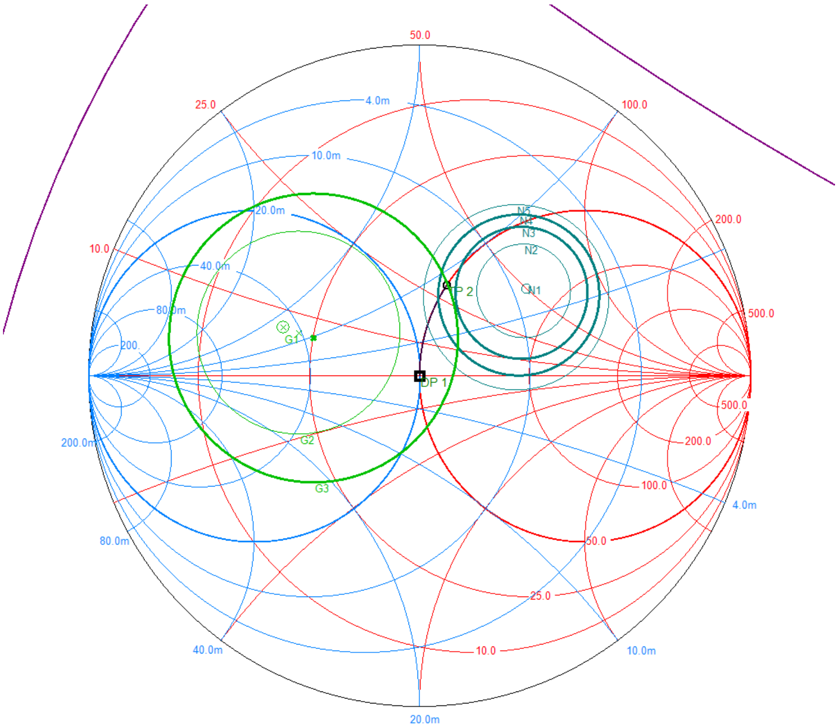


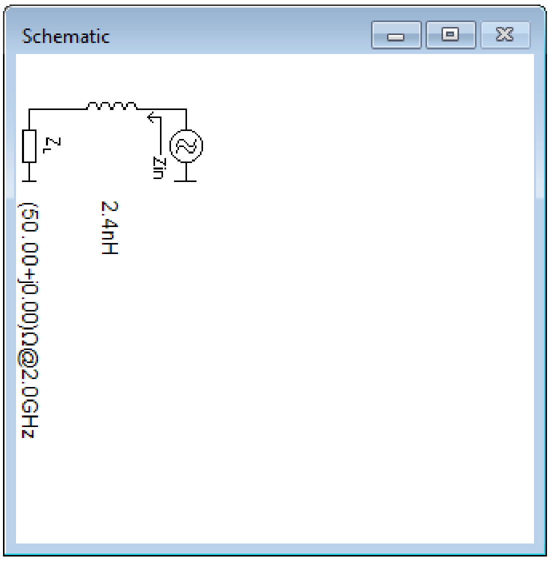
Draw Noise figure circles:

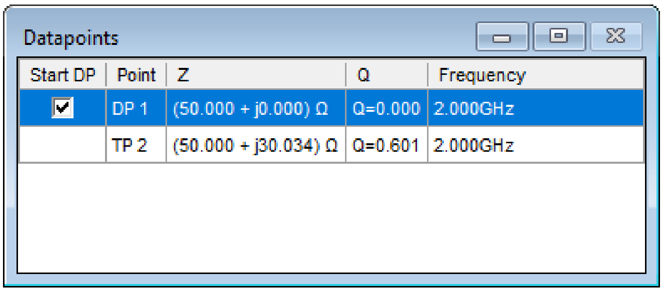


Input matching network:

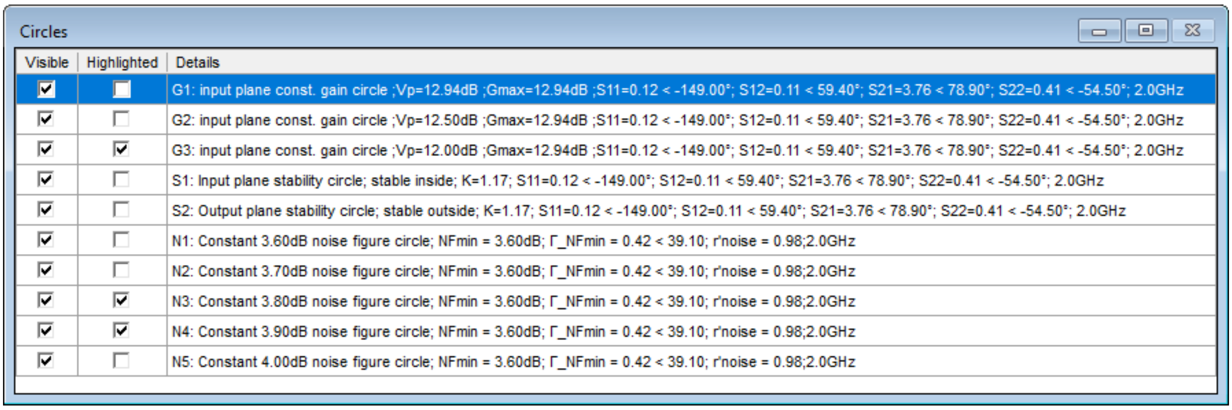
If we choose a source impedance of Z_S = (50+j30)Ohm we get a gain of approx. 12 dB and a NF of approx. 3.85 dB with only a serie inductor as input matching network.






Datapoints

Start DP	Point	Z	Q	Frequency
☑	DP 1	(50.000 + j0.000) Ω	Q=0.000	2.000GHz
	TP 2	(50.000 + j30.034) Ω	Q=0.601	2.000GHz


Circles

Visible	Highlighted	Details
☑	☐	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
☑	☐	G2: 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
☑	☑	G3: input plane const. gain circle ;Vp=12.00dB ;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
☑	☐	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
☑	☐	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
☑	☐	N1: Constant 3.60dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; r'noise = 0.98;2.0GHz
☑	☐	N2: Constant 3.70dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; r'noise = 0.98;2.0GHz
☑	☑	N3: Constant 3.80dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; r'noise = 0.98;2.0GHz
☑	☑	N4: Constant 3.90dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; r'noise = 0.98;2.0GHz
☑	☐	N5: Constant 4.00dB noise figure circle; NFmin = 3.60dB; Γ_NFmin = 0.42 < 39.10; r'noise = 0.98;2.0GHz

With a few calculations we get:

S-parameters at 2000 MHz:

$$S := \begin{pmatrix} 0.121 \cdot e^{j \cdot -149 \cdot deg} & 0.108 \cdot e^{j \cdot 59.4 \cdot deg} \\ 3.756 \cdot e^{j \cdot 78.9 \cdot deg} & 0.41 \cdot e^{j \cdot -54.5 \cdot deg} \end{pmatrix}$$

Source impedance at 2000 MHz

$$Z_S := (50 + j \cdot 30) \cdot \Omega$$

$$Z_0 := 50 \cdot \Omega$$

$$\Gamma_S := \frac{Z_S - Z_0}{Z_S + Z_0} = 0.083 + 0.275j$$

$$|\Gamma_S| = 0.287$$

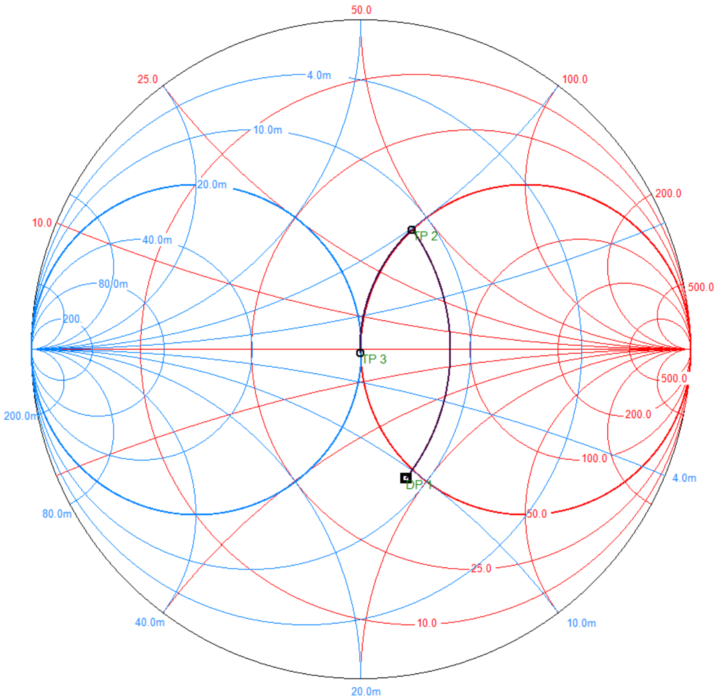
$$\arg(\Gamma_S) = 73.301 deg$$

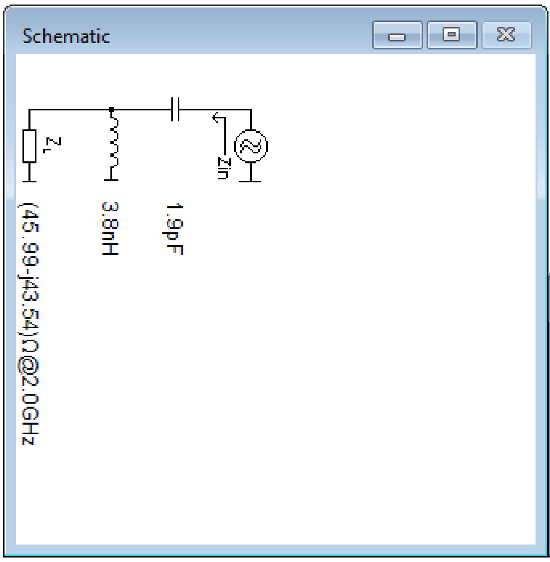
$$\Gamma_2 := S_{2,2} + \frac{S_{1,2} \cdot S_{2,1} \cdot \Gamma_S}{1 - S_{1,1} \cdot \Gamma_S} = 0.136 - 0.392j$$

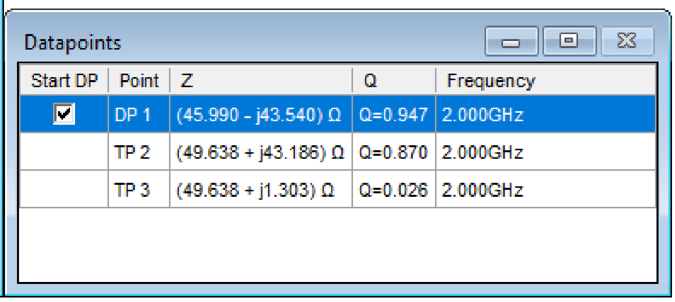
$$Z_2 := Z_0 \cdot \frac{1 + \Gamma_2}{1 - \Gamma_2} = (45.987 - 43.54j)\,\Omega$$

For the output network we conjugately match Z_2 (or Γ_2) to 50 Ohm.
There are several possibilities to realize the output matching network.

Problem: Output matching network 1
Smith project file: Example13-output1.xmlsc



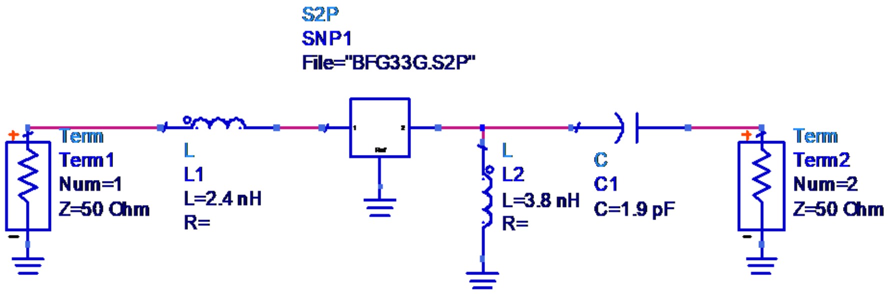


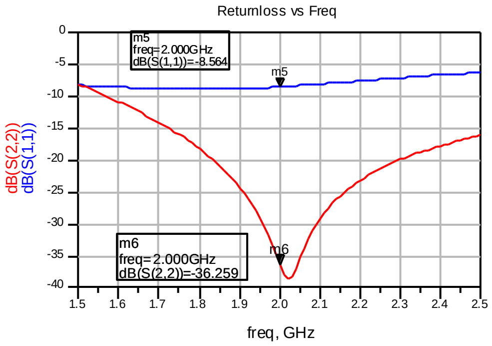


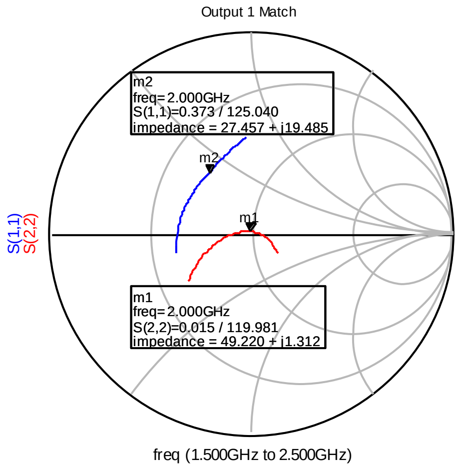
Datapoints

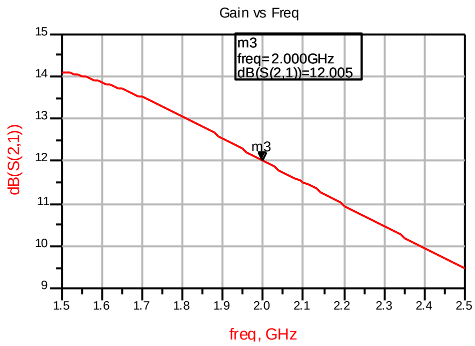
Start DP	Point	Z	Q	Frequency
☑	DP 1	(45.990 - j43.540) Ω	Q=0.947	2.000GHz
	TP 2	(49.638 + j43.186) Ω	Q=0.870	2.000GHz
	TP 3	(49.638 + j1.303) Ω	Q=0.026	2.000GHz

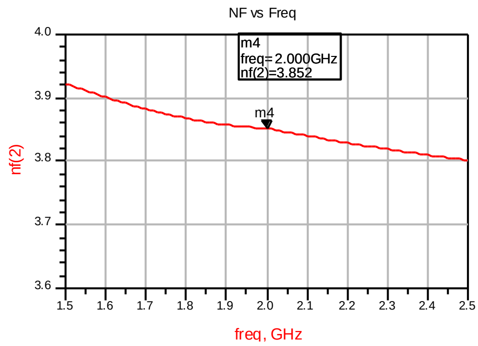
Simulation of LNA with Output matching network 1 versus Frequency in Agilent ADS:



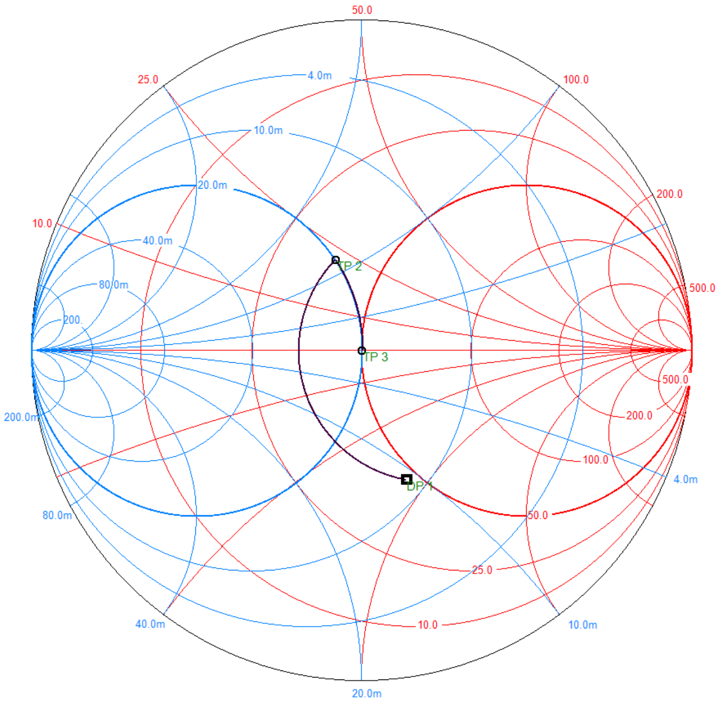


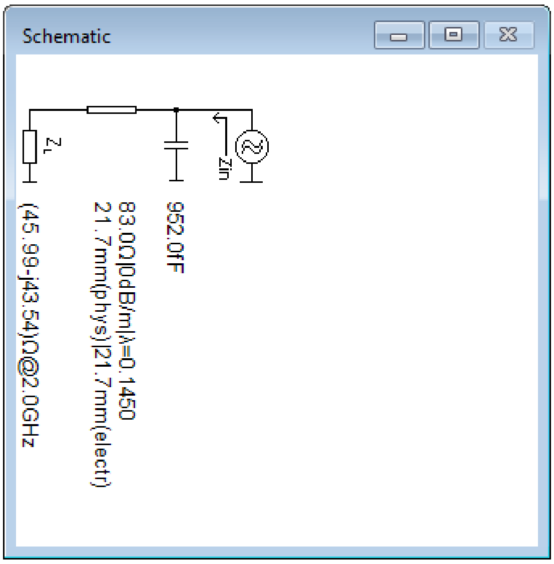


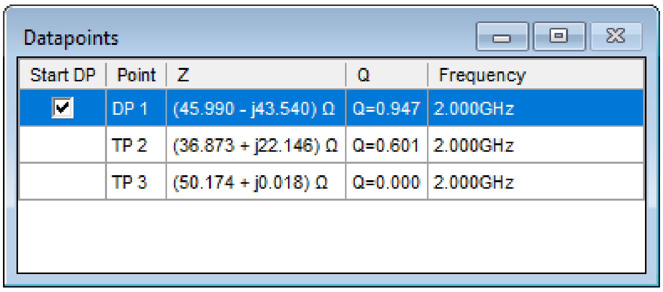




Problem: Output matching network 2
Smith project file: Example13-output2.xmlsc

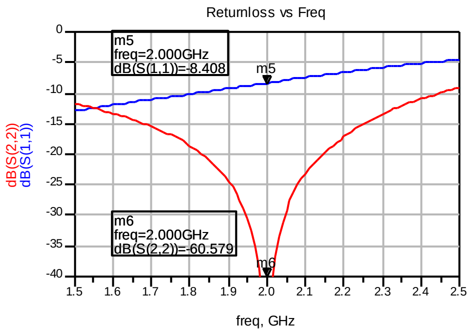


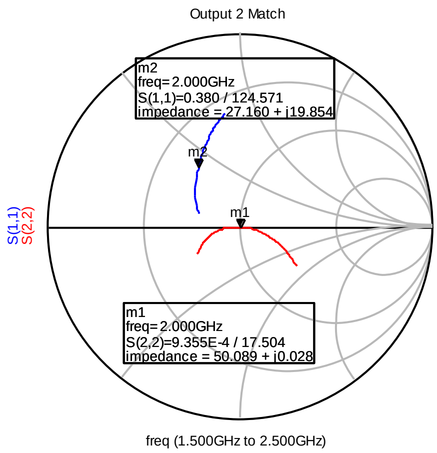


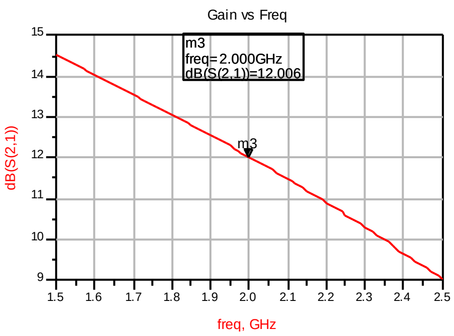


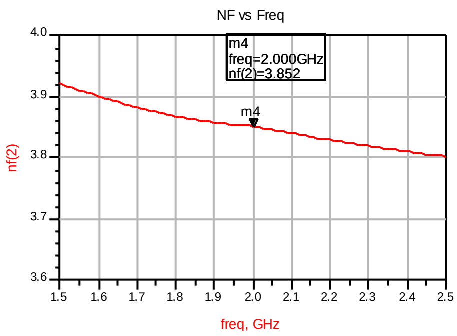
Start DP	Point	Z	Q	Frequency
☑	DP 1	(45.990 - j43.540) Ω	Q=0.947	2.000GHz
	TP 2	(36.873 + j22.146) Ω	Q=0.601	2.000GHz
	TP 3	(50.174 + j0.018) Ω	Q=0.000	2.000GHz

Simulation of LNA with Output matching network 2 versus Frequency in Agilent ADS:

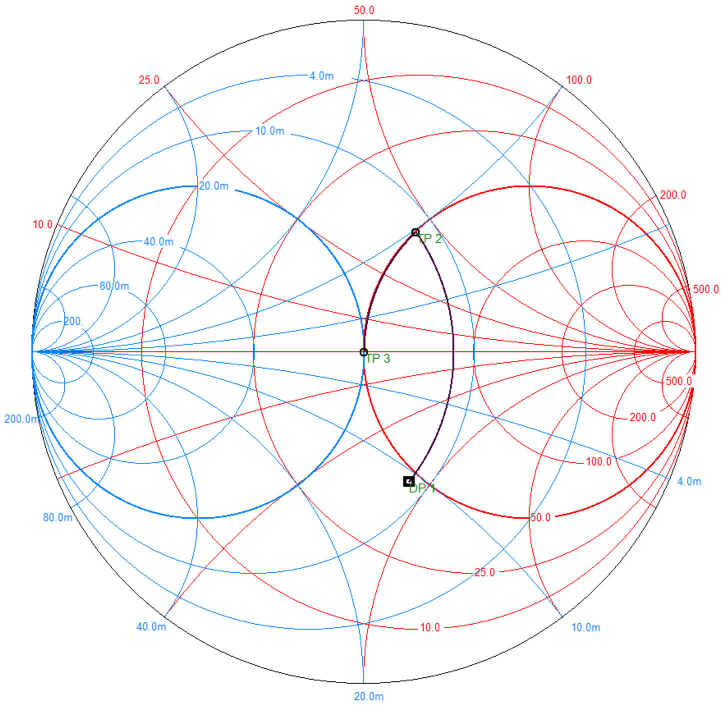


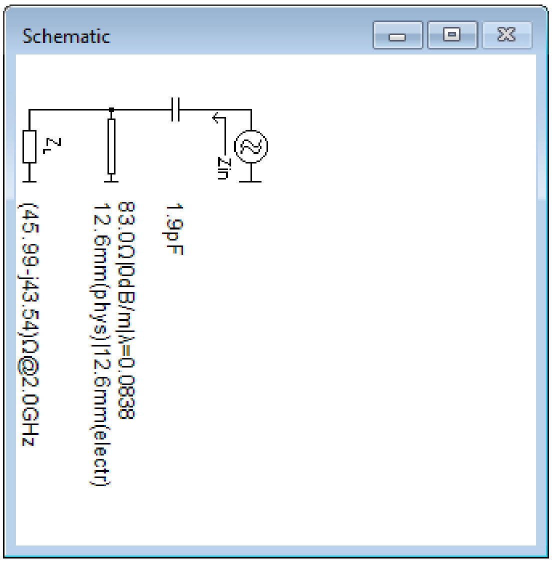






Problem: Output matching network 3
Smith project file: Example13-output3.xmlsc

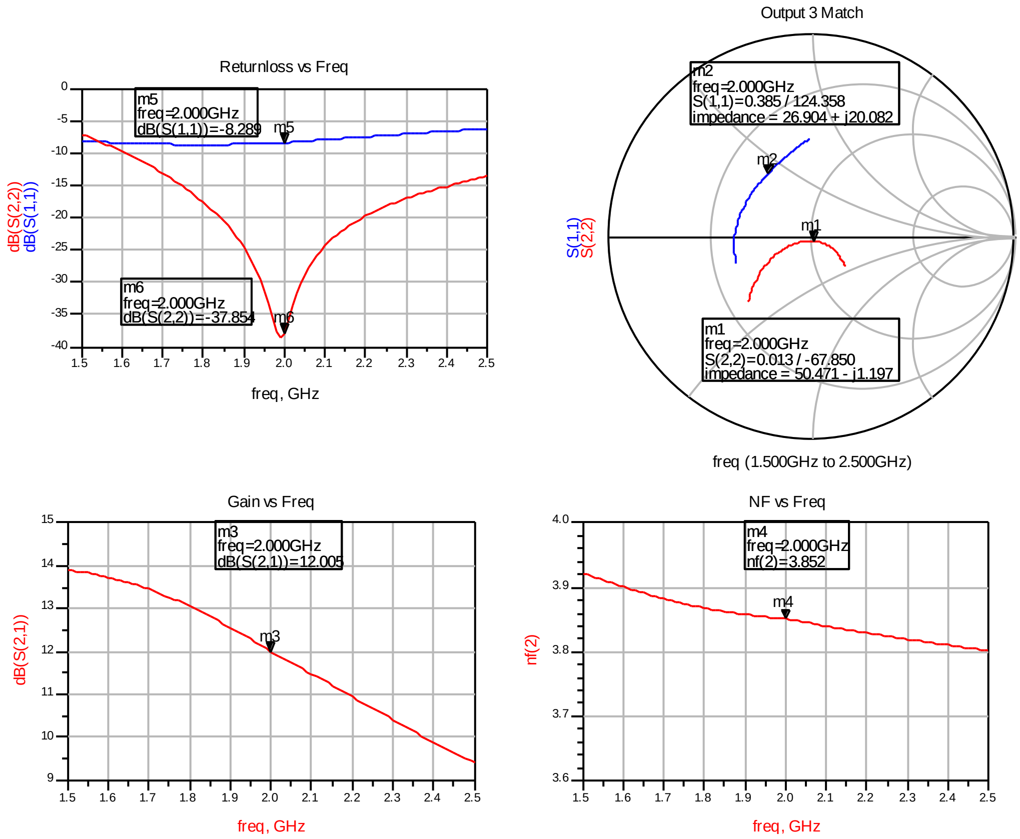




Datapoints

Start DP	Point	Z	Q	Frequency
☑	DP 1	(45.990 - j43.540) Ω	Q=0.947	2.000GHz
	TP 2	(50.087 + j43.121) Ω	Q=0.861	2.000GHz
	TP 3	(50.087 + j0.106) Ω	Q=0.002	2.000GHz

Simulation of LNA with Output matching network 3 versus Frequency in Agilent ADS:



Conjugate Matching

Example 14: Conjugate Match

Problem: Conjugately match impedance Z_1 (or Gamma Γ_1) to 50 Ohm.

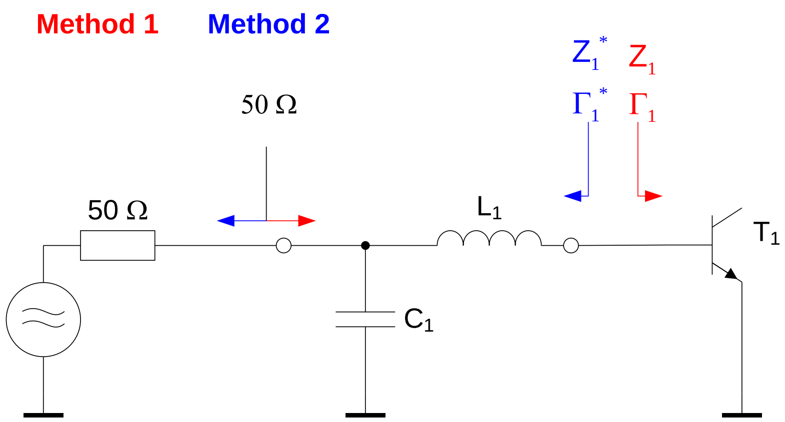
Method 1: Start at Z_1 and transform with network to 50 Ohm.

In this case Z_1 is used as load impedance for the network and after transformation we would like to see 50 Ohm at the input of the network.

Method 2: Start at 50 Ohm and transform with network to Z_1^* = conjugate Z_1

In this case 50 Ohm is used as load impedance for the network and after transformation we would like to see Z_1^* into the input of the network.

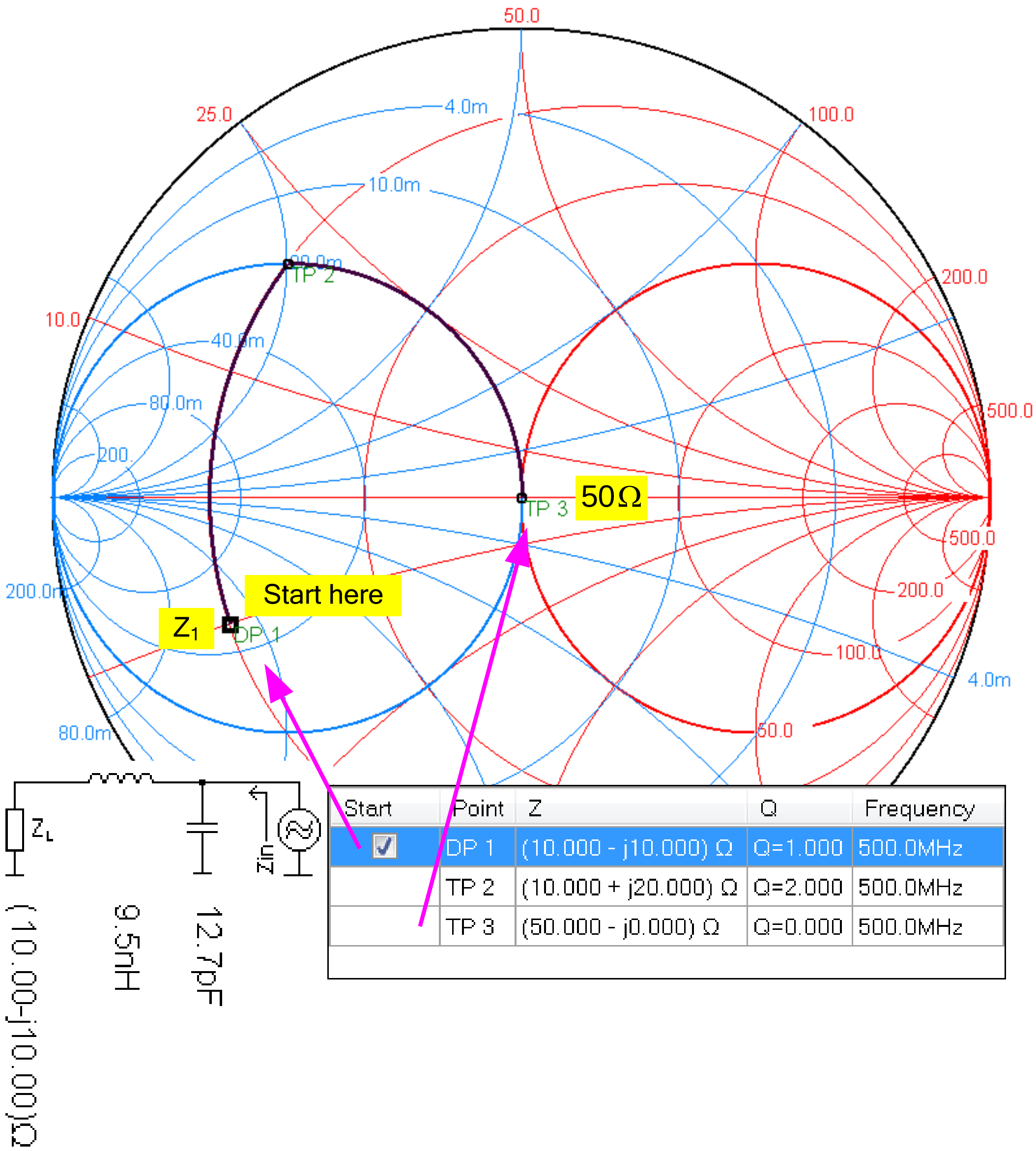
Both method result in the same network.



Example: $Z_1 = (10 - j10)\Omega$

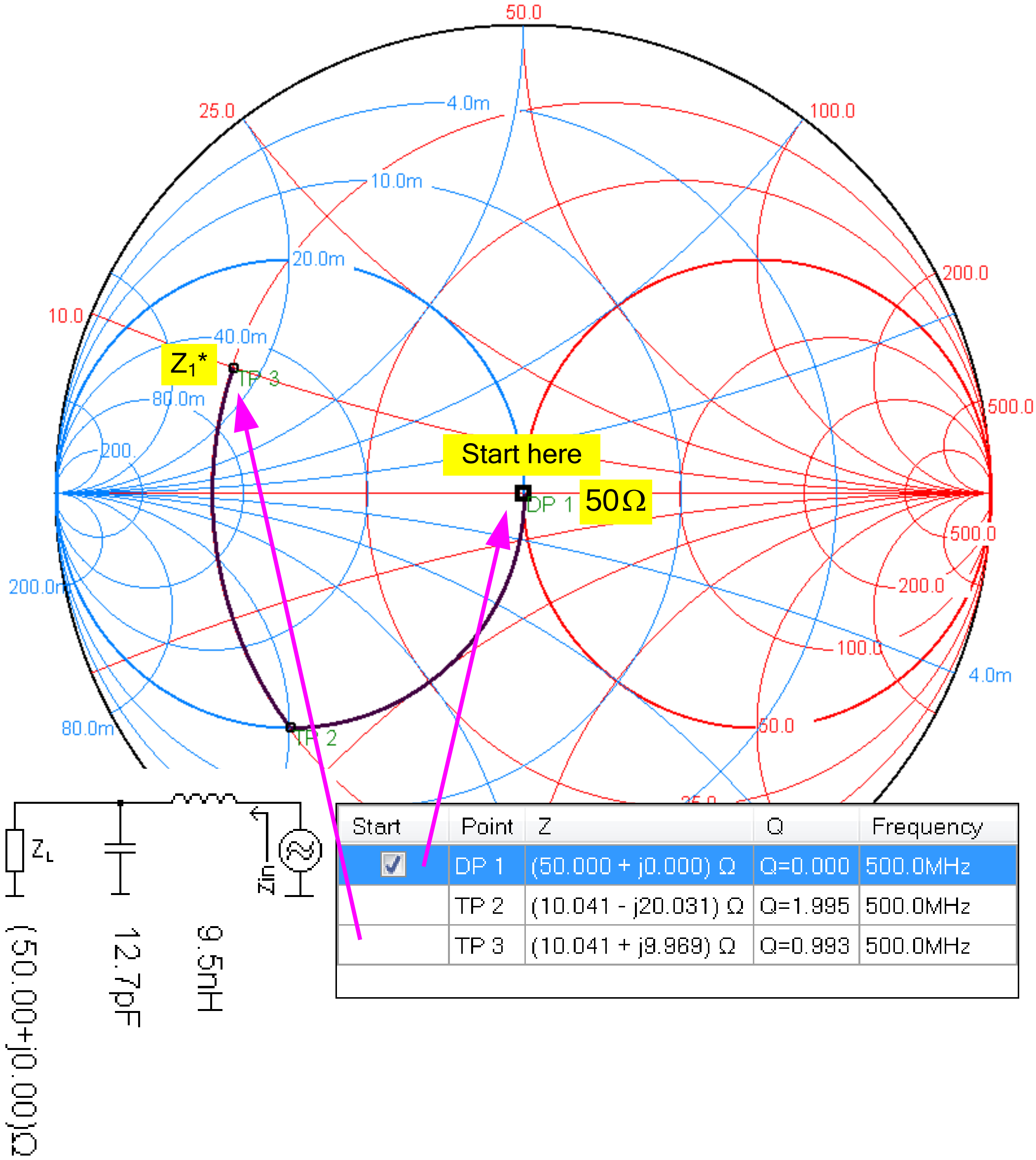
Method 1:

Smith project file: Example14-1.xmlsc



Start	Point	Z	Q	Frequency
☑	DP 1	(10.000 - j10.000) Ω	Q=1.000	500.0MHz
	TP 2	(10.000 + j20.000) Ω	Q=2.000	500.0MHz
	TP 3	(50.000 - j0.000) Ω	Q=0.000	500.0MHz

Method 2:
Smith project file: Example14-2.xmlsc



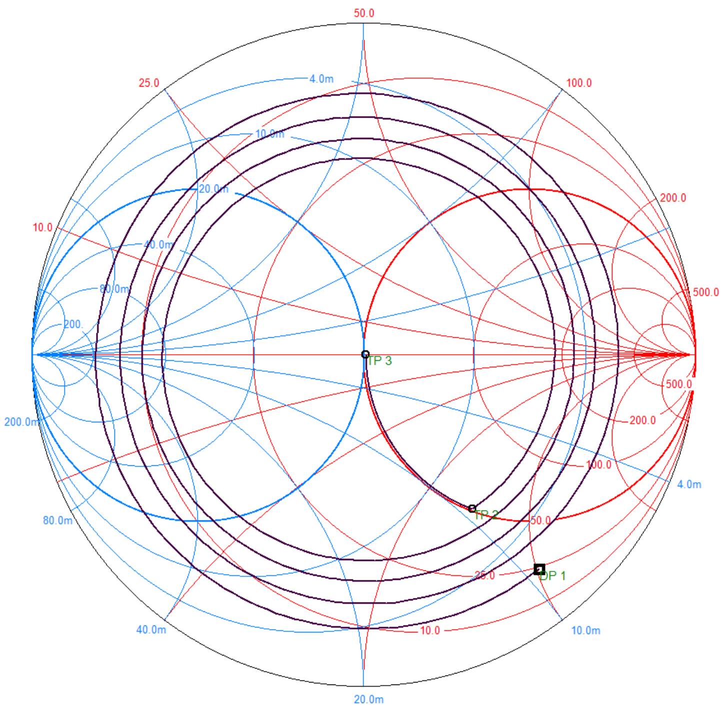
Start	Point	Z	Q	Frequency
☑	DP 1	(50.000 + j0.000) Ω	Q=0.000	500.0MHz
	TP 2	(10.041 - j20.031) Ω	Q=1.995	500.0MHz
	TP 3	(10.041 + j9.969) Ω	Q=0.993	500.0MHz

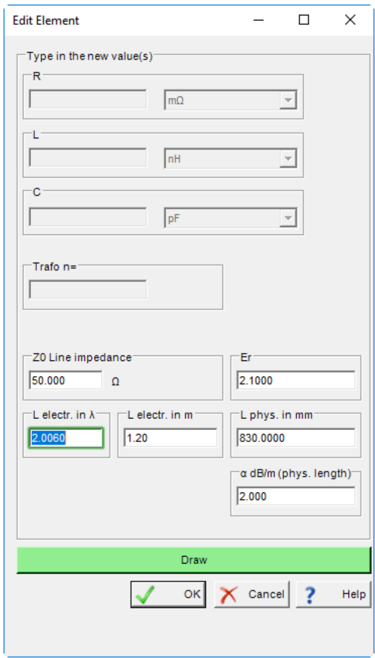
Serial Transmission Line with Attenuation

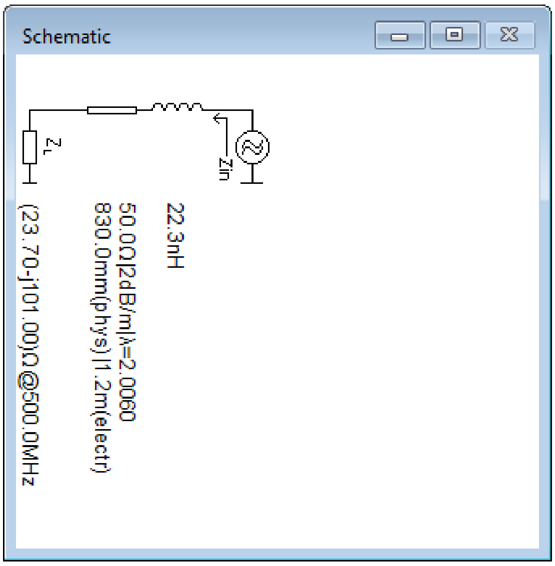
Example 15: Match using transmission line with loss

Problem: Match an impedance of (23.7 + j 101) Ohm to 50 Ohm using a lossy transmission line with an electrical length of about 2 wavelength, attenuation of 2 dB/m and a serial reactance.
Frequency: 500 MHz

Smith project file: Example15.xmlsc







Datapoints

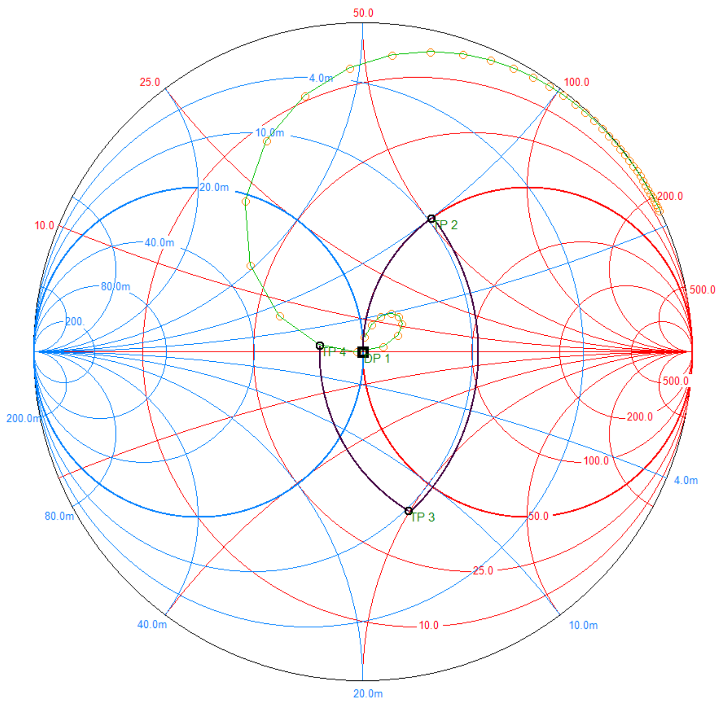
Start DP	Point	Z	Q	Frequency
☑	DP 1	(23.700 - j101.000) Ω	Q=4.262	500.000MHz
	TP 2	(50.687 - j69.776) Ω	Q=1.377	500.000MHz
	TP 3	(50.687 + j0.281) Ω	Q=0.006	500.000MHz

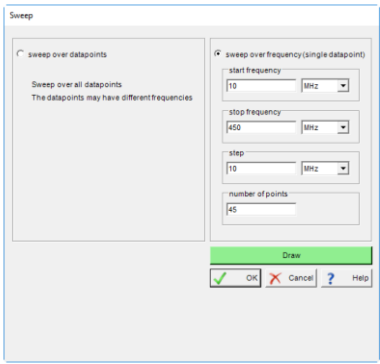
Sweeps

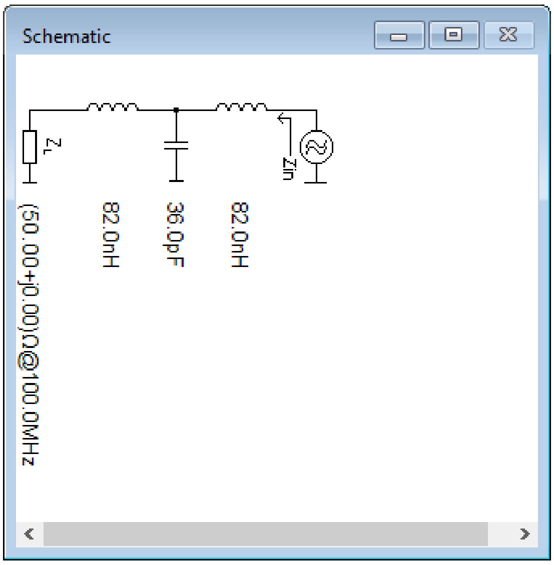
Example 16: Input impedance of a Chebyshev lowpass filter

Problem: Plot input impedance of a 50 Ohm Chebyshev lowpass filter with n = 3, Ripple = 0.1 dB and cut-off frequency = 100 MHz
Frequency: 10 MHz to 450 MHz

Smith project file: Example16.xmlsc







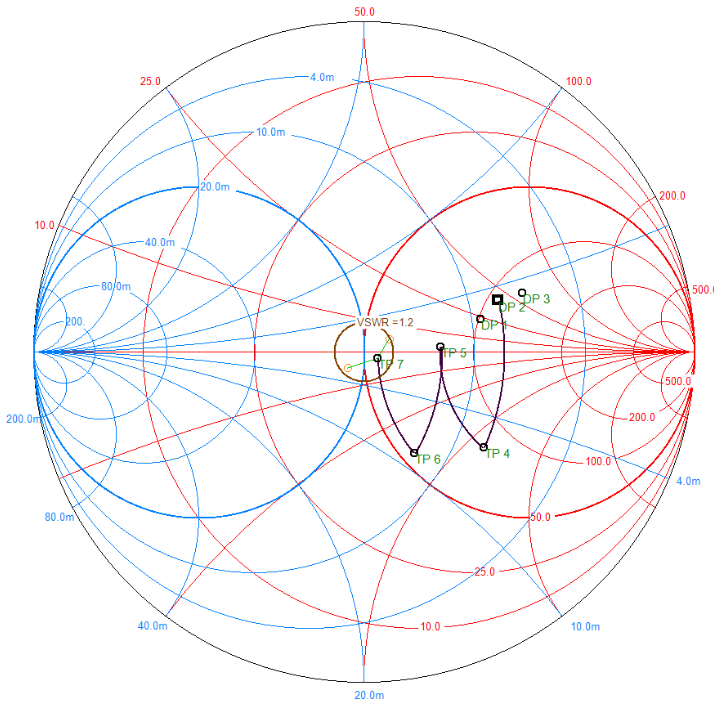
Datapoints

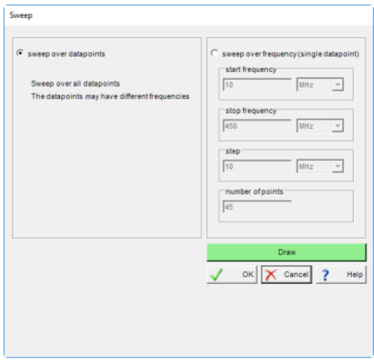
Start DP	Point	Z	Q	Frequency
☑	DP 1	(50.000 + j0.000) Ω	Q=0.000	100.000MHz
	TP 2	(50.000 + j51.522) Ω	Q=1.030	100.000MHz
	TP 3	(38.271 - j49.807) Ω	Q=1.301	100.000MHz
	TP 4	(38.271 + j1.715) Ω	Q=0.045	100.000MHz
	SP 1	(50.525 + j4.584) Ω	Q=0.091	10.000MHz
	SP 2	(52.078 + j8.757) Ω	Q=0.168	20.000MHz
	SP 3	(54.564 + j12.042) Ω	Q=0.221	30.000MHz
	SP 4	(57.704 + j13.854) Ω	Q=0.240	40.000MHz
	SP 5	(60.830 + j13.572) Ω	Q=0.223	50.000MHz
	SP 6	(62.703 + j10.866) Ω	Q=0.173	60.000MHz
	SP 7	(61.671 + j6.323) Ω	Q=0.103	70.000MHz
	SP 8	(56.612 + j1.857) Ω	Q=0.033	80.000MHz
	SP 9	(48.113 - j0.104) Ω	Q=0.002	90.000MHz
	SP 10	(38.271 + j1.715) Ω	Q=0.045	100.000MHz
	SP 11	(29.139 + j6.877) Ω	Q=0.236	110.000MHz
	SP 12	(21.722 + j14.131) Ω	Q=0.651	120.000MHz
	SP 13	(16.120 + j22.341) Ω	Q=1.386	130.000MHz

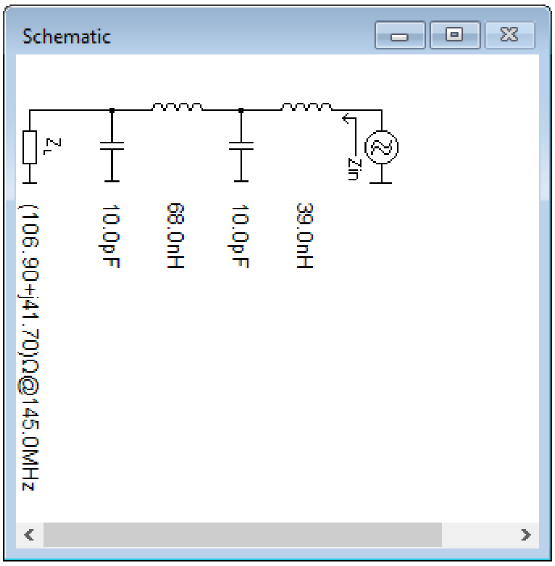
Example 17: Broadband load match

Problem: Given: Load impedance = (100.8+j24.2) Ohm @ 140 MHz, (106.9+j41.7) Ohm @ 145 MHz, (121.2+j60) Ohm @ 150 MHz
Find LC-lowpass network to match within VSWR of 1.2. Use standard component values as possible.
Frequency: 140 MHz to 150 MHz

Smith project file: Example17.xmlsc







Datapoints

Start DP	Point	Z	Q	Frequency
☐	DP 1	(100.800 + j24.200) Ω	Q=0.240	140.000MHz
☑	DP 2	(106.900 + j41.700) Ω	Q=0.390	145.000MHz
☐	DP 3	(121.200 + j60.000) Ω	Q=0.495	150.000MHz
	TP 4	(80.193 - j58.704) Ω	Q=0.732	145.000MHz
	TP 5	(80.193 + j3.248) Ω	Q=0.041	145.000MHz
	TP 6	(54.350 - j37.572) Ω	Q=0.691	145.000MHz
	TP 7	(54.350 - j2.041) Ω	Q=0.038	145.000MHz
	SP 1	(58.151 + j4.882) Ω	Q=0.084	140.000MHz
	SP 2	(54.350 - j2.041) Ω	Q=0.038	145.000MHz
	SP 3	(44.930 - j4.426) Ω	Q=0.099	150.000MHz

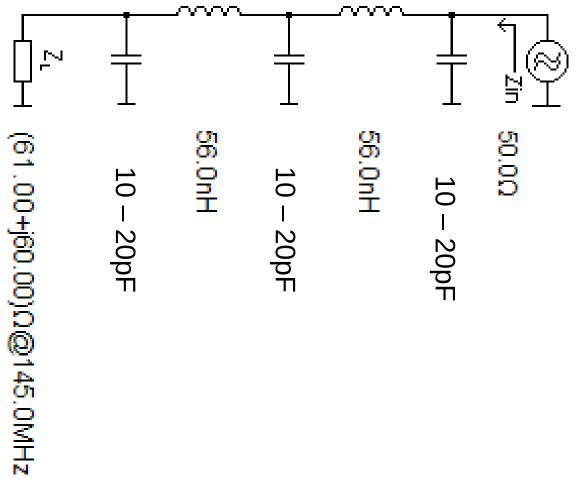
Tune element values

Example 18: Match an Antenna with Lowpass network and fixed L-values

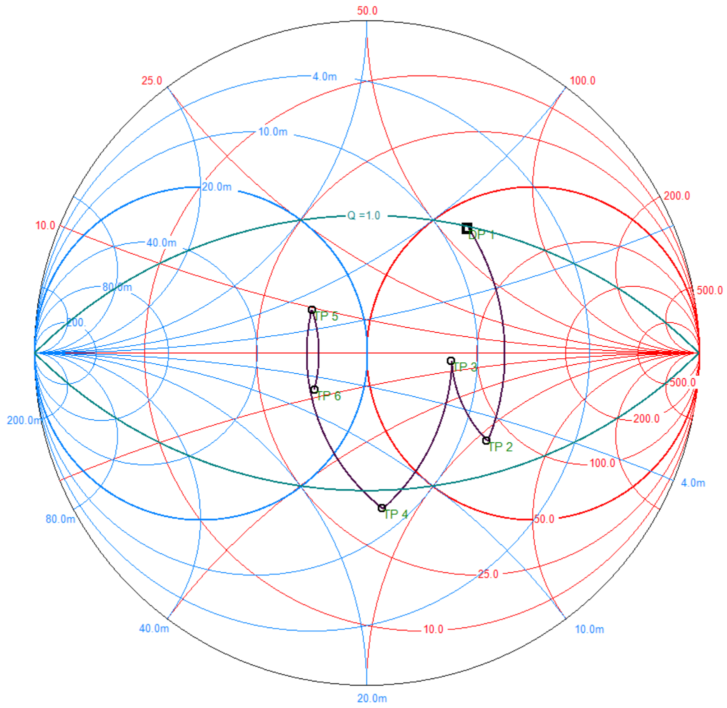
Problem: Match an antenna impedance of $(61 + j57)\Omega$ to 50Ω. Use L and C in a circuit topology as shown below. Inductors are fixed to a value of 56 nH and capacitors should have a value between 10 and 20 pF. Do not exceed a $Q_{max} = \frac{X}{R} = \frac{60}{61} \approx 1$.

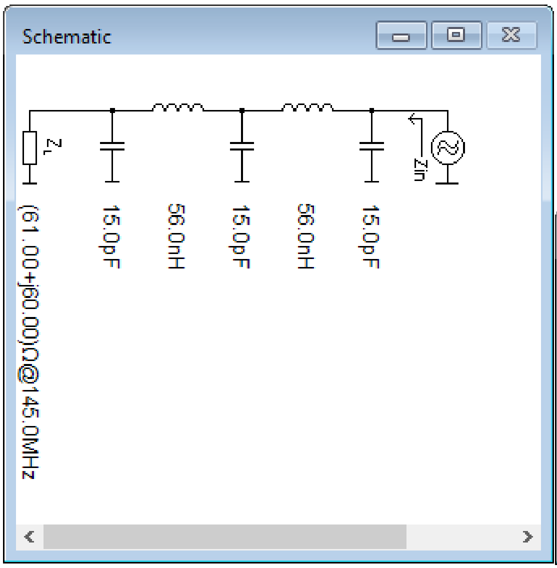
Frequency: 145 MHz.

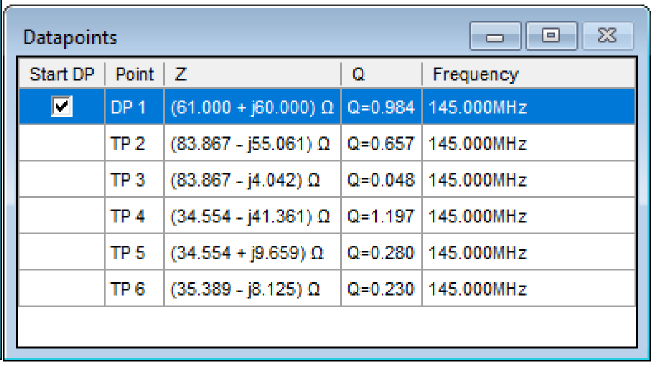
Smith project file: Example18.xmlsc



Start with all capacitors 15pF. Tune capacitors to find a solution.

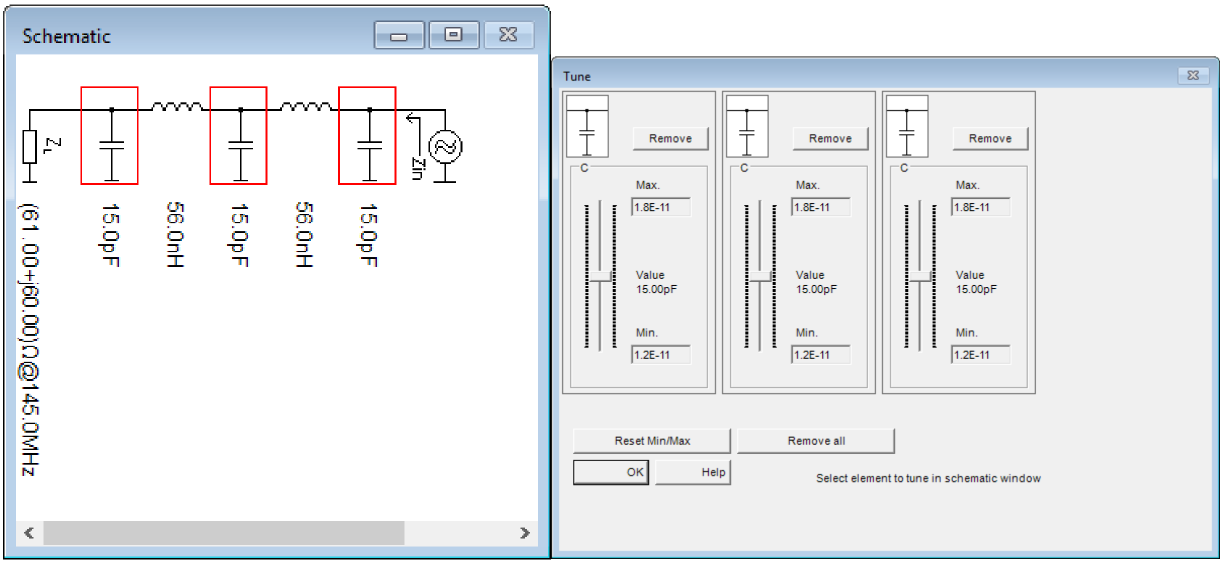


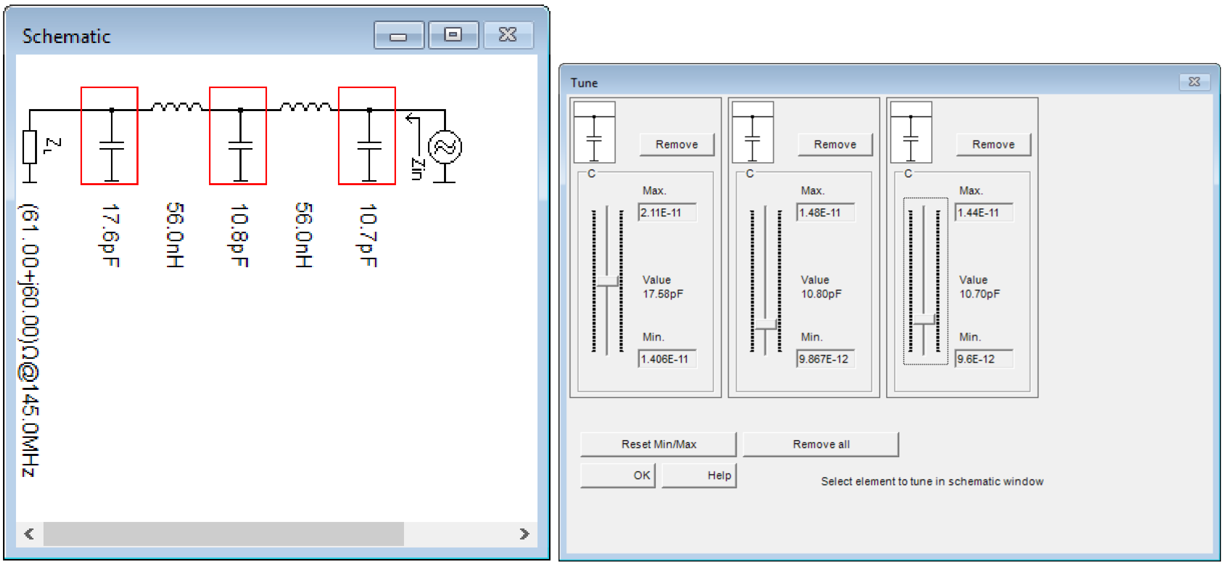


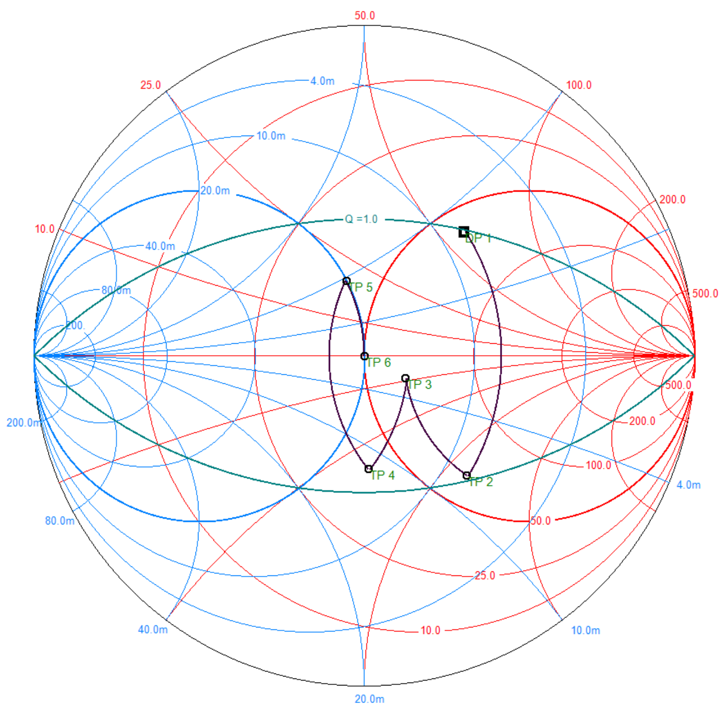


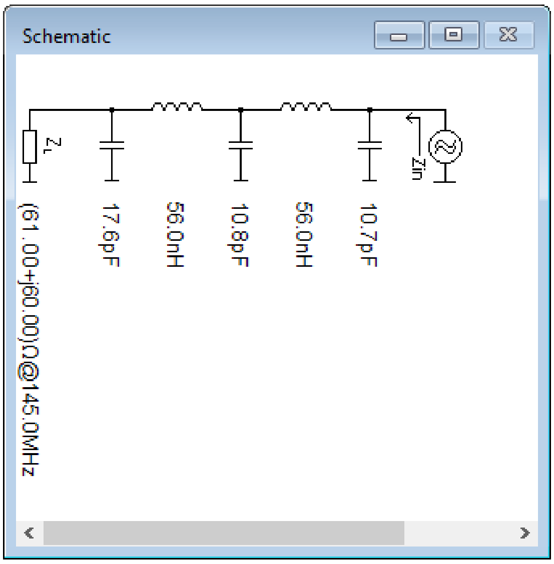
Start DP	Point	Z	Q	Frequency
☑	DP 1	(61.000 + j60.000) Ω	Q=0.984	145.000MHz
	TP 2	(83.867 - j55.061) Ω	Q=0.657	145.000MHz
	TP 3	(83.867 - j4.042) Ω	Q=0.048	145.000MHz
	TP 4	(34.554 - j41.361) Ω	Q=1.197	145.000MHz
	TP 5	(34.554 + j9.659) Ω	Q=0.280	145.000MHz
	TP 6	(35.389 - j8.125) Ω	Q=0.230	145.000MHz

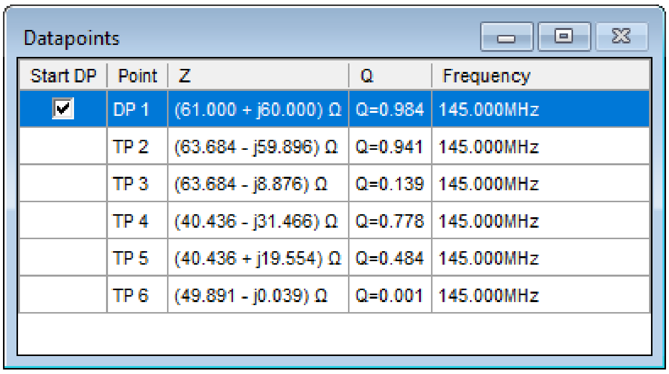
Tune capacitors to find a solution.










Datapoints

Start DP	Point	Z	Q	Frequency
☑	DP 1	(61.000 + j60.000) Ω	Q=0.984	145.000MHz
	TP 2	(63.684 - j59.896) Ω	Q=0.941	145.000MHz
	TP 3	(63.684 - j8.876) Ω	Q=0.139	145.000MHz
	TP 4	(40.436 - j31.466) Ω	Q=0.778	145.000MHz
	TP 5	(40.436 + j19.554) Ω	Q=0.484	145.000MHz
	TP 6	(49.891 - j0.039) Ω	Q=0.001	145.000MHz

Many other solutions are possible.