5XTC0, Components in wireless technologies

Lab 1: Computer-aided circuit simulation tool QUCS

Student number	
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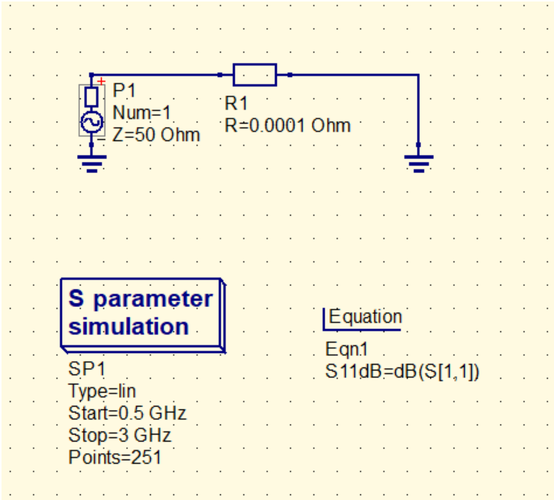
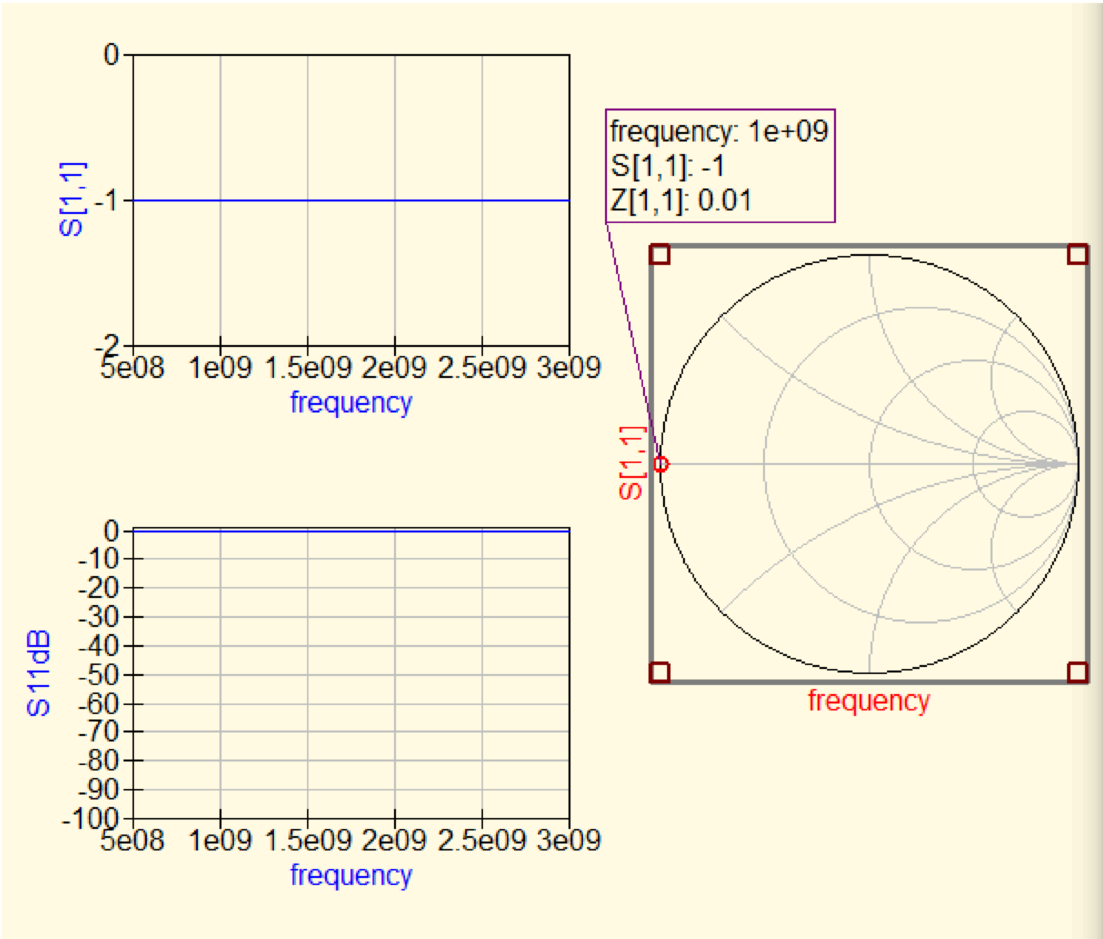
Exercise 1a - Short-circuit load (Z_0 = 50Ω)

Circuit diagram:



Simulation results:

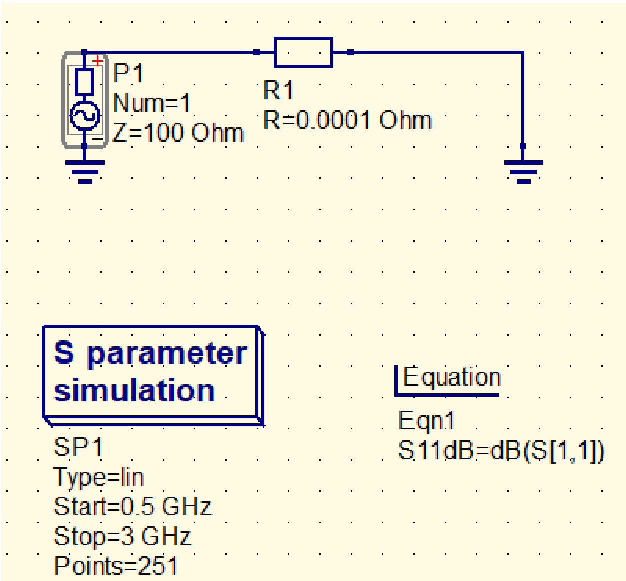


Explanation:

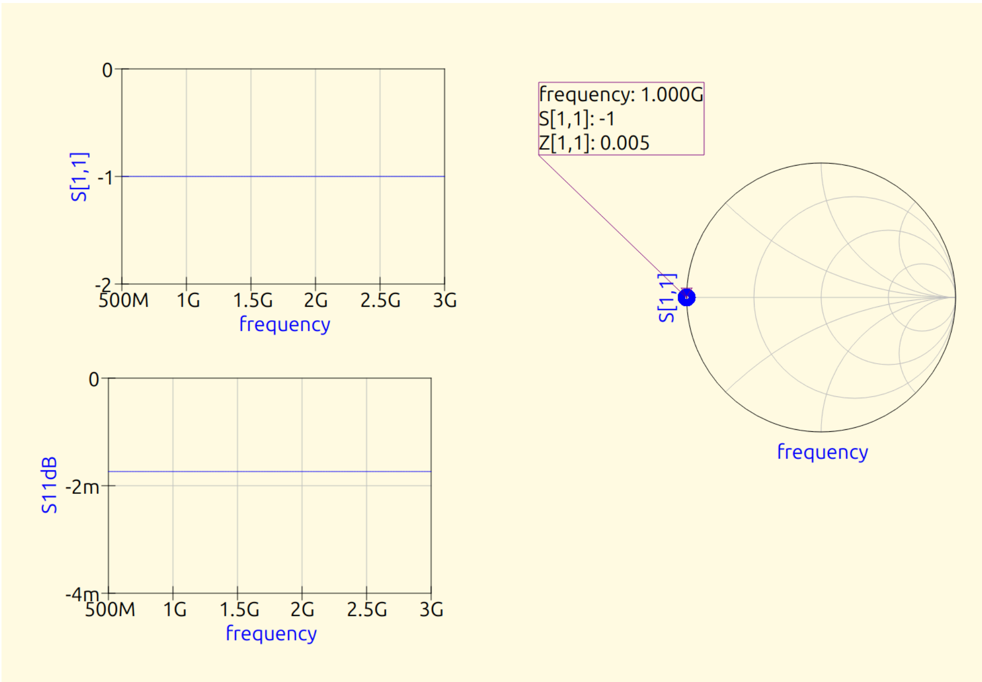
All power from the power source is reflected back but opposite phase. $\Gamma = Z_l - Z_0 / Z_l + Z_0$ = (0-50) / (0+50) =
-50/50 = -1.

Exercise 1b - Short-circuit load (Z_0 = 100Ω)

Circuit diagram:



Simulation results:

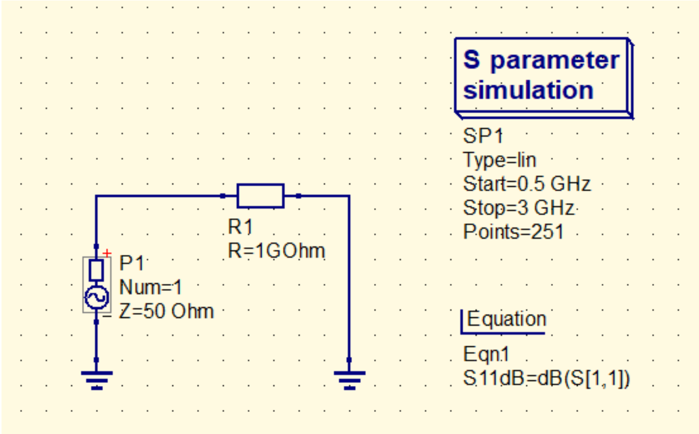


Explanation:

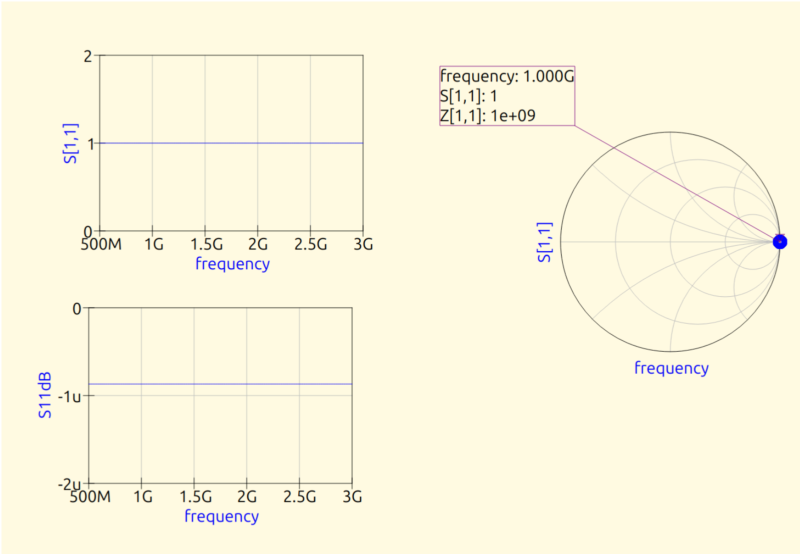
All power from the power source is reflected back but opposite phase. $\Gamma = Z_l - Z_0 / Z_l + Z_0 =$ (0-100) / (0+100) =
-100/100 = -1.

Exercise 1c - Open-circuit load (Z_0 = 50Ω)

Circuit diagram:



Simulation results:

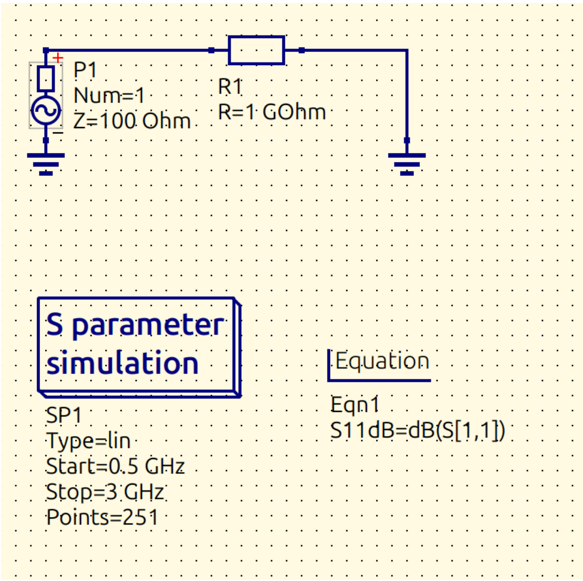


Explanation:

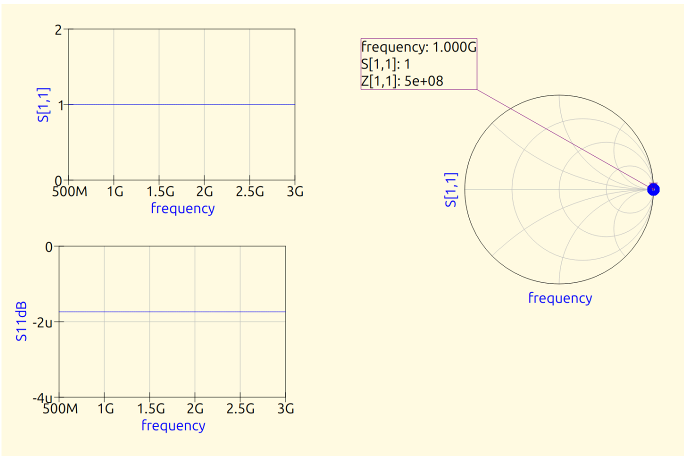
All power from the power source is reflected back with same phase and amplitude, Z_l = infinity. Γ = Z_l-Z_0 / Z_l + Z_0 = (0-50) / (0+50) =
infty/infty = 1.

Exercise 1d - Open-circuit load (Z_0 = 100Ω)

Circuit diagram:



Simulation results:

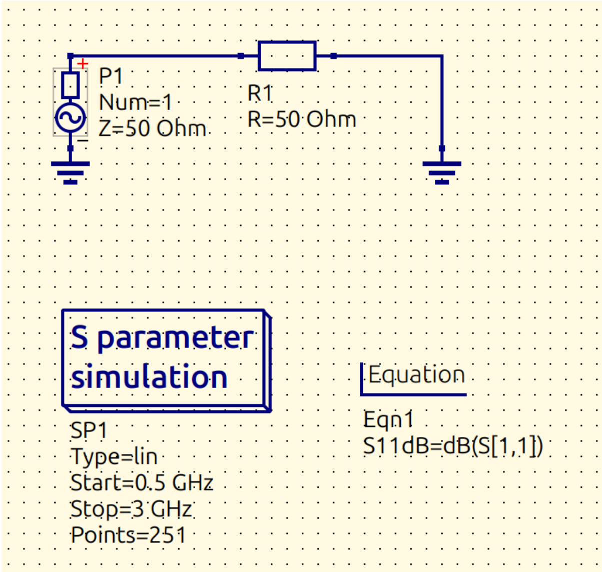


Explanation:

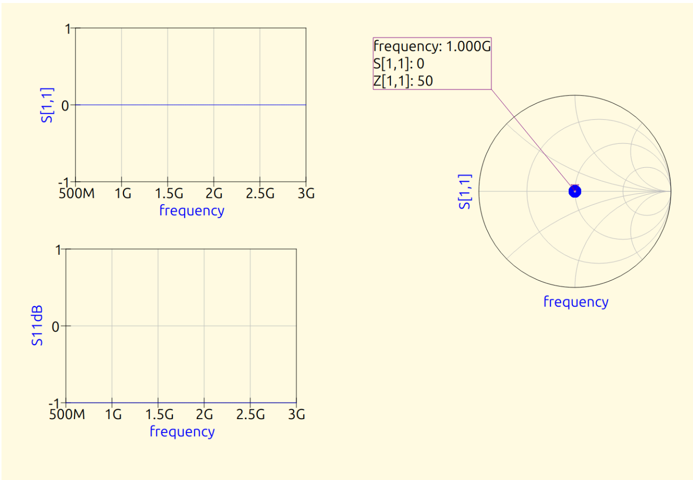
All power from the power source is reflected back with same phase and amplitude, Z_l = infinity. $\Gamma = Z_l - Z_0 / Z_l + Z_0$ = (0-100) / (0+100) =
infty/infty = 1.

Exercise 1e - Matched load ($Z_0 = 50\Omega$)

Circuit diagram:



Simulation results:

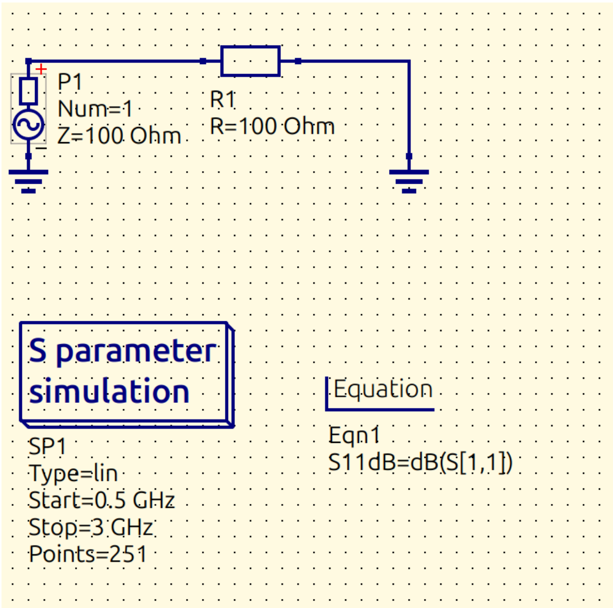


Explanation:

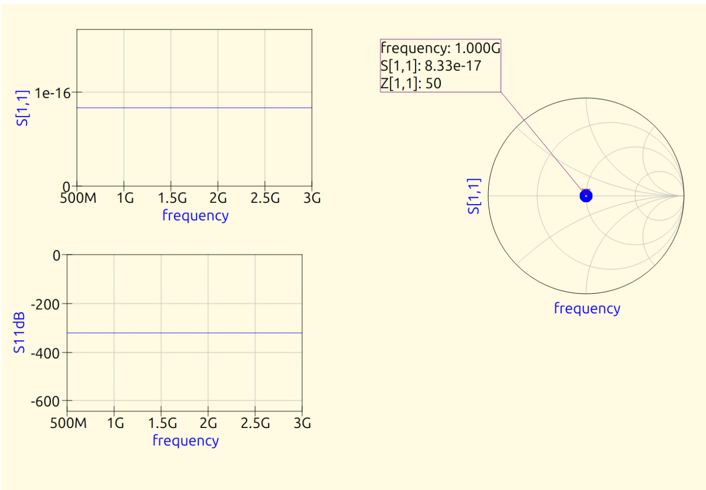
Z_L = Z_0 Γ = 0, with a matched filter there is 0 reflection coefficient perfect matching, no reflections.

Exercise 1f - Matched load (Z_0 = 100Ω)

Circuit diagram:



Simulation results:

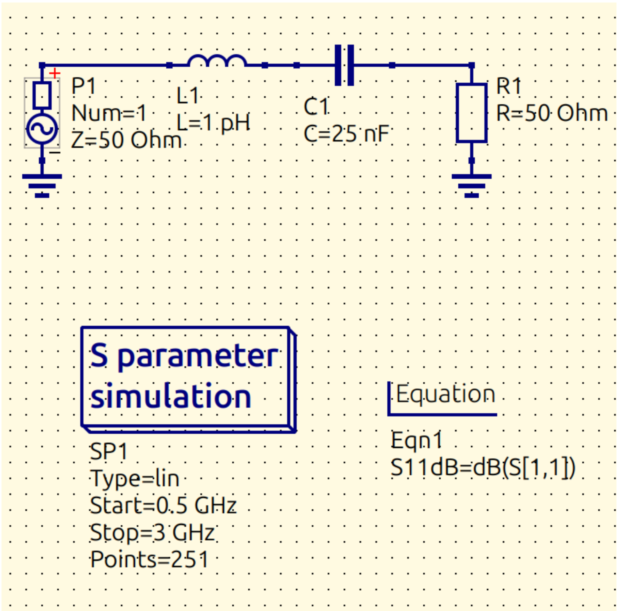


Explanation:

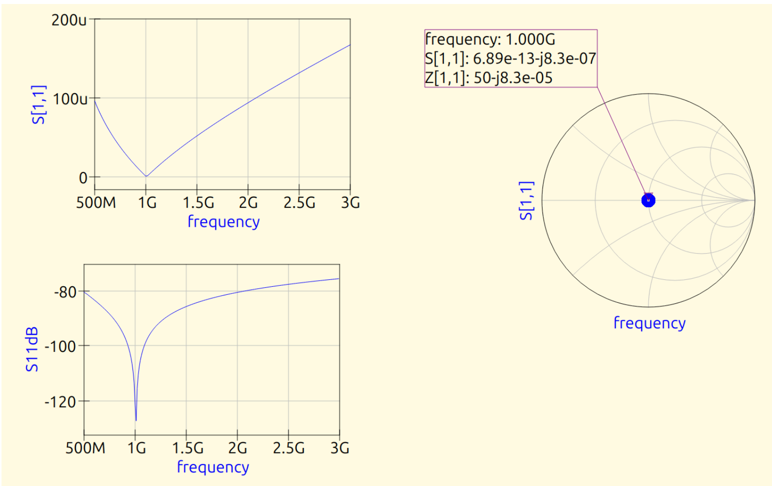
Z_L = Z_0 Γ = 0, with a matched filter there is 0 reflection coefficient perfect matching, no reflections. (In this case very minimal insignificant reflection).

Exercise 1g - LC lumped element (resonator) as load (Z_0 = 50Ω)

Circuit diagram:



Simulation results:



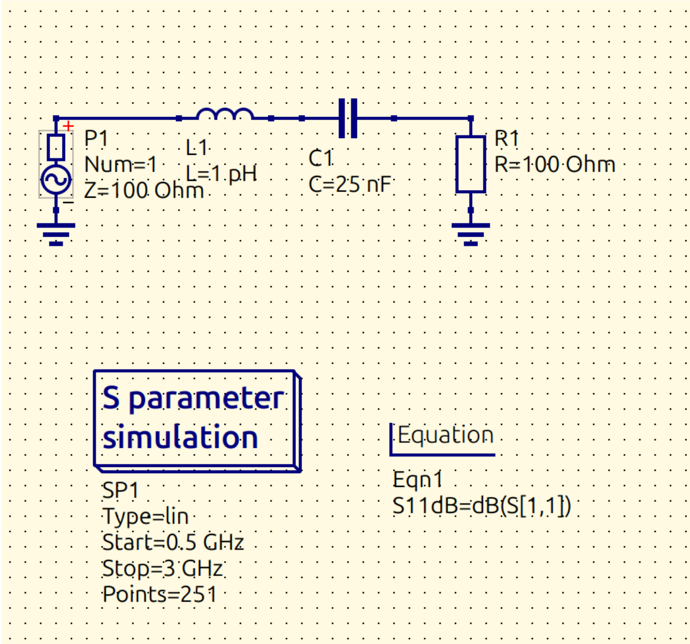
Explanation:

f=1/2pi*sqrt(LC) ⇒ LC=2.5*10^-20=25*10^-21 so we can use L= 1*10^-12 = 1pico and C = 25*10^-9 = 25 nano

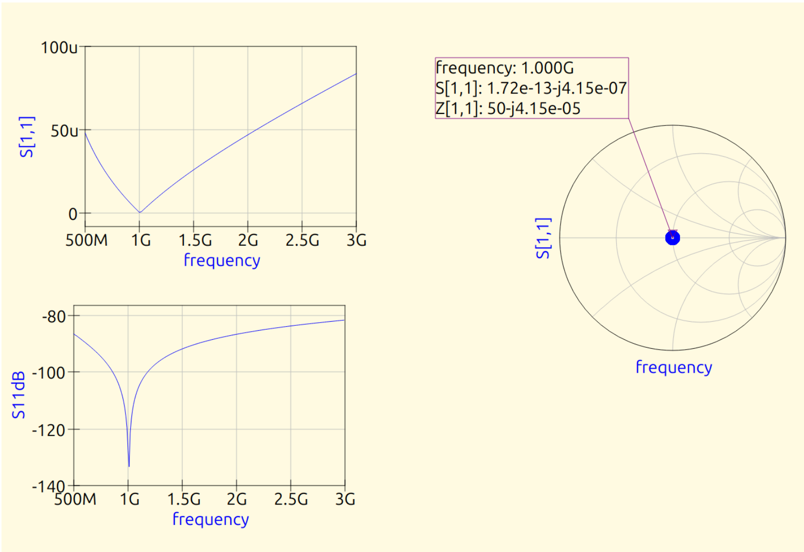
Z_LC= jwL + 1/jwC = j6.27, Z_total = Z_LC || 50, Γ = (Z_total - Z_0) / (Z_total + Z_0) = 6.89 * 10^-13 - j8.3 * 10^-7 is the obtained reflection coefficient.

Exercise 1g - LC lumped element (resonator) as load (Z_0 = 100Ω)

Circuit diagram:



Simulation results:

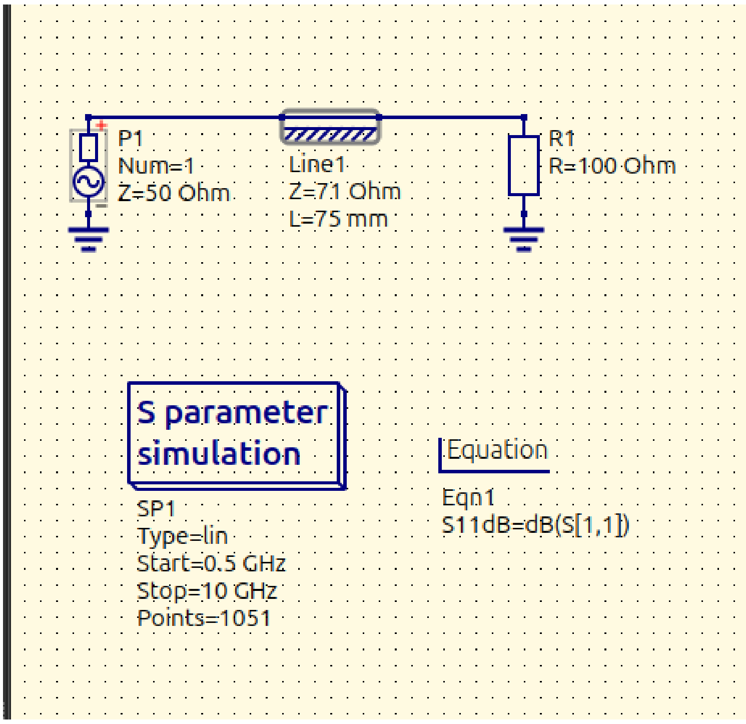


Explanation:

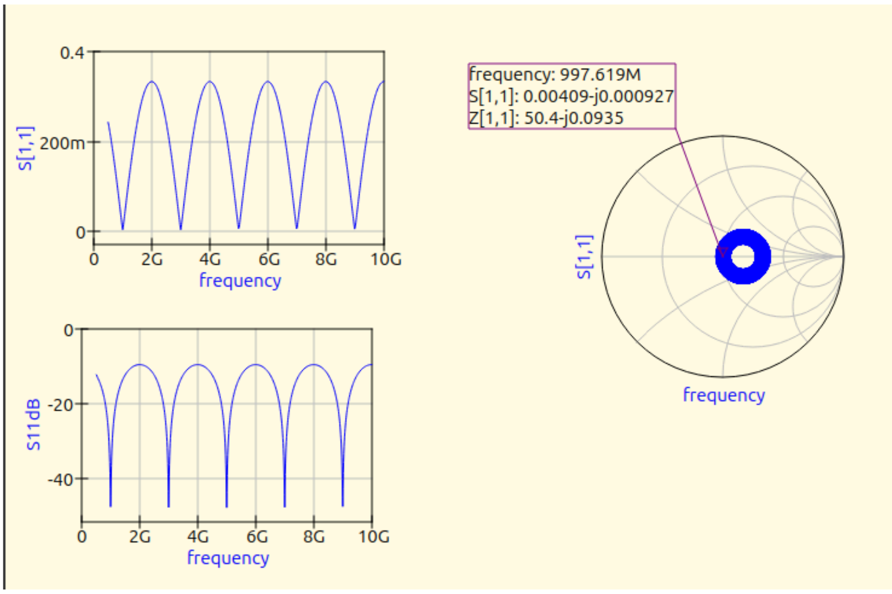
The exact same steps as in 1g just for Z_0 = 100

Exercise 2 - Quarter-wave transformer

Circuit diagram:



Simulation results:



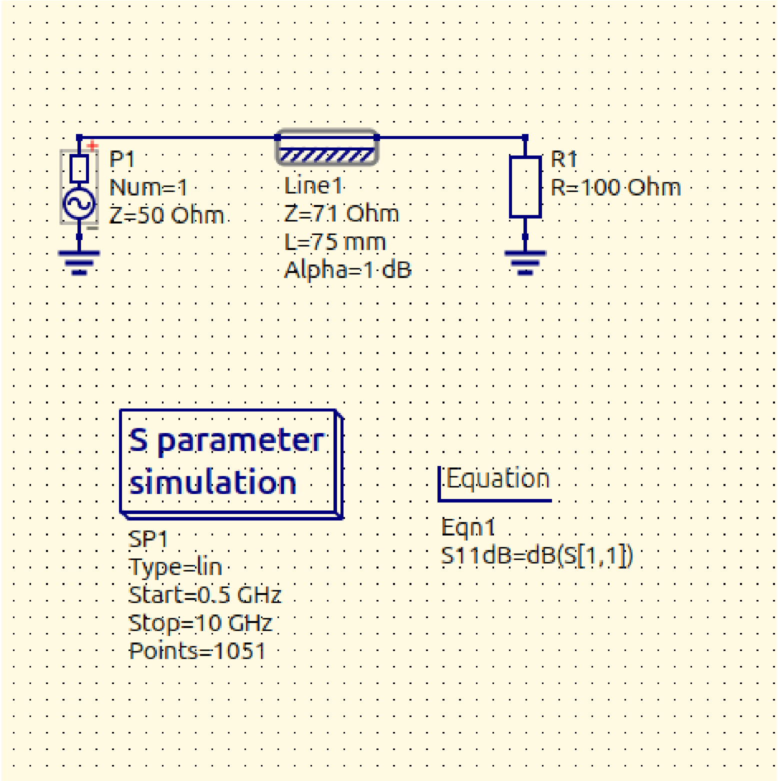
Explanation:

Z1 = sqrt(Z_0 * R_L)=sqrt(50 * 100) = 71 Ohm, lambda = c/f = 3* 10 ^8 / 1*10^9 = 0.3m and then L = lambda/4 = 75 mm.

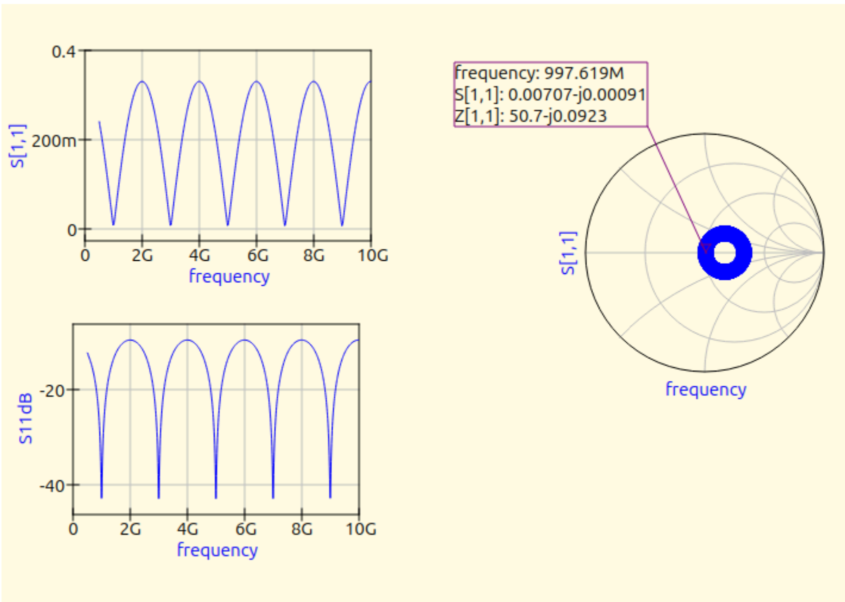
Γ = Z_in - Z_0 / Z_in + Z_0 -> Z_in = Z1^2/R_L where Z1 = sqrt(Z_0 * R_L) so Z_in=Z_0 so Γ = 0 in our case it is close to 0 so no reflection.

Exercise 3a – Lossy Quarter-wave transformer (1 dB/m)

Circuit diagram:



Simulation results:

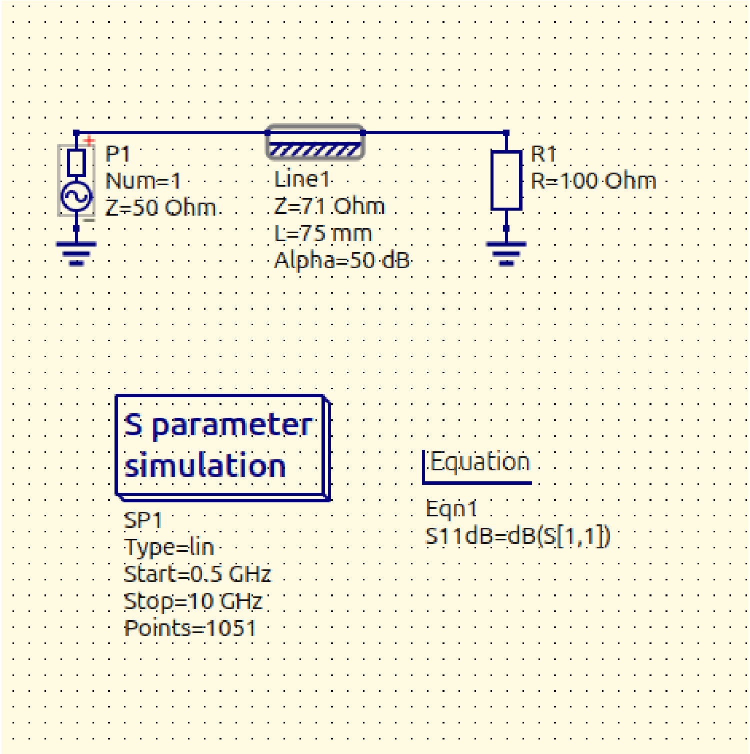


Explanation:

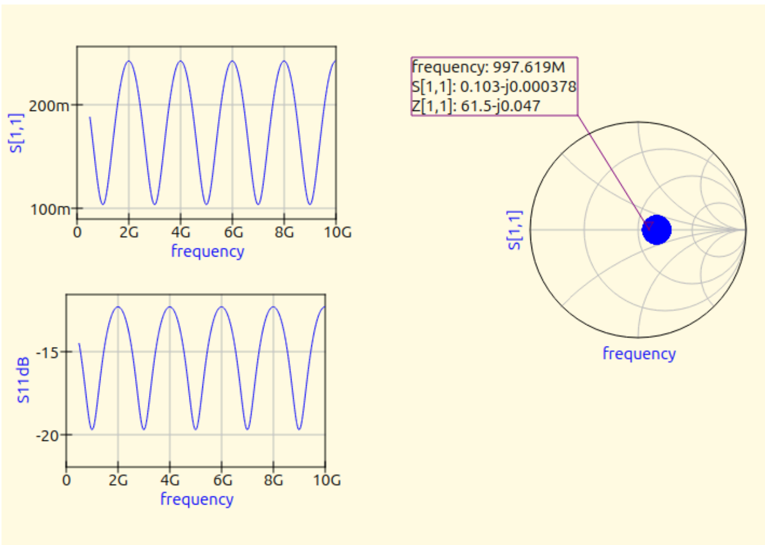
attenuation for 75mm = aL = 1dB/m * 0.075 = 0.075 dB, exponential loss factor = e^{-2aL}=0.983, Z_in != Z_0 since we have real world attenuation, Z_in = Z_1^2/R_L * e^{-2aL} = 50 * 0.983 = 49.15 so the Γ ! = 0 so reflects more.

Exercise 3b – Lossy Quarter-wave transformer (50 dB/m)

Circuit diagram:



Simulation results:

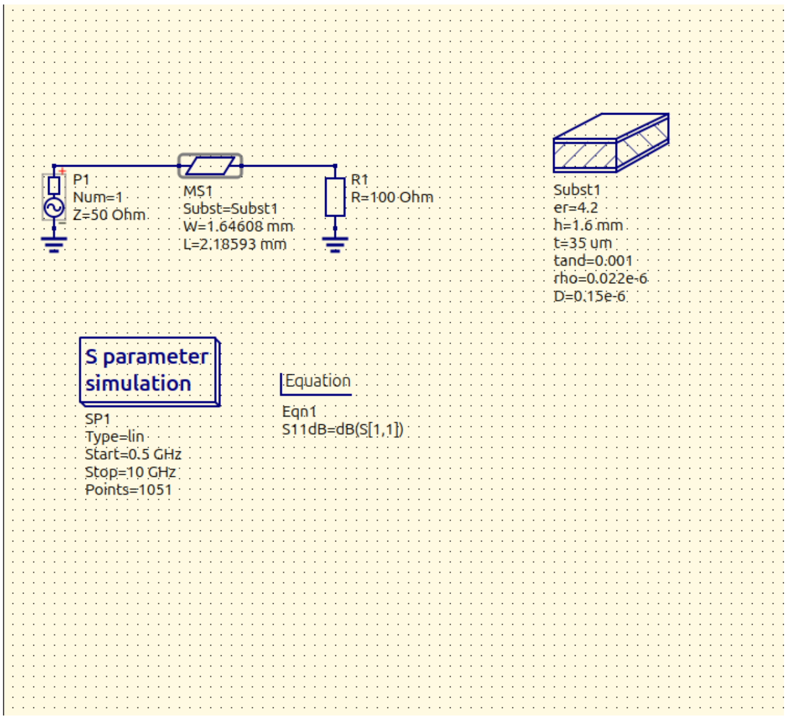


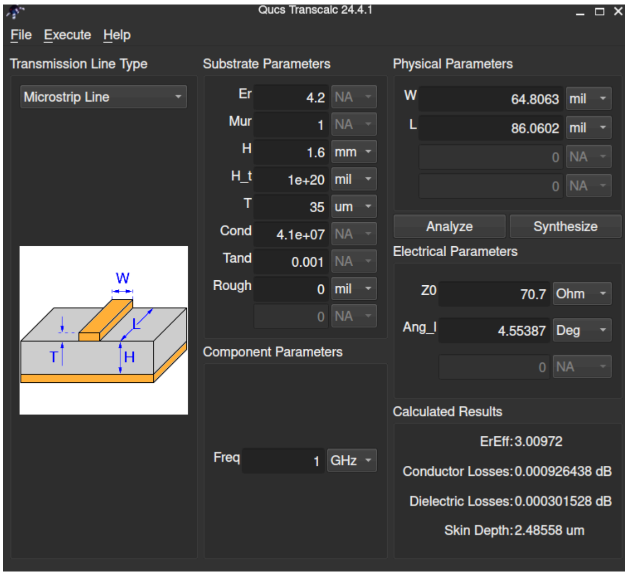
Explanation:

Same operation as last question but due to higher attenuation more reflection as a higher reflection coefficient in the range of 0.1.

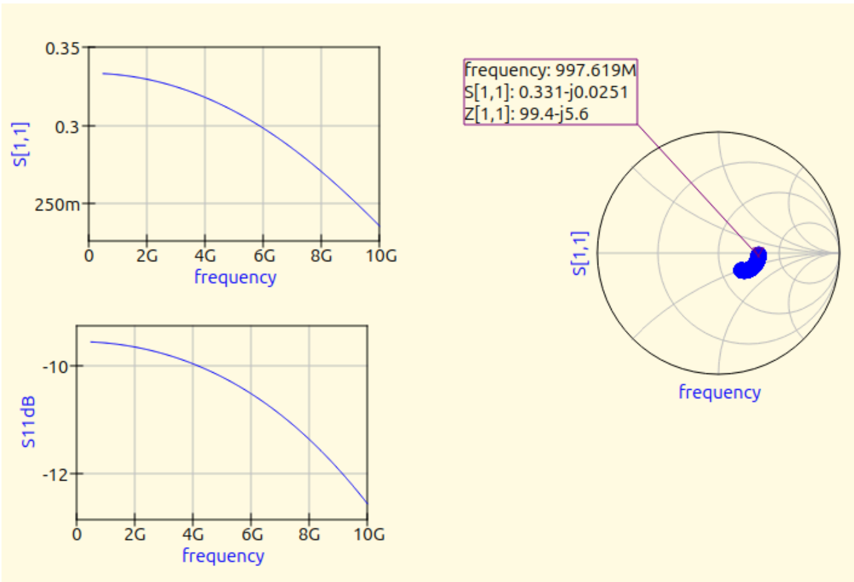
Exercise 4 – microstrip Quarter-wave transformer

Circuit diagram:





Simulation results:

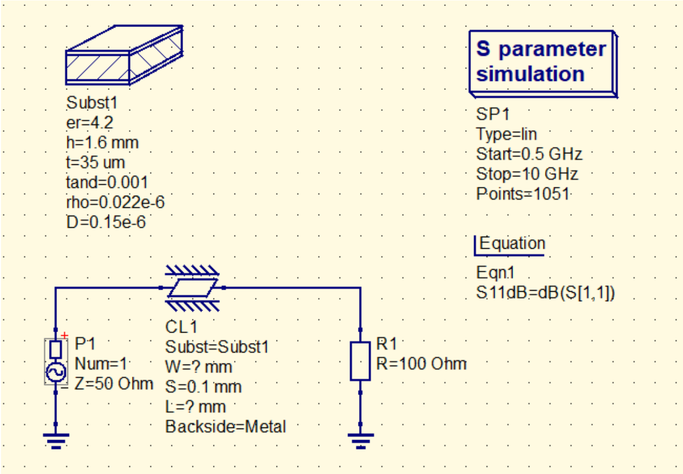


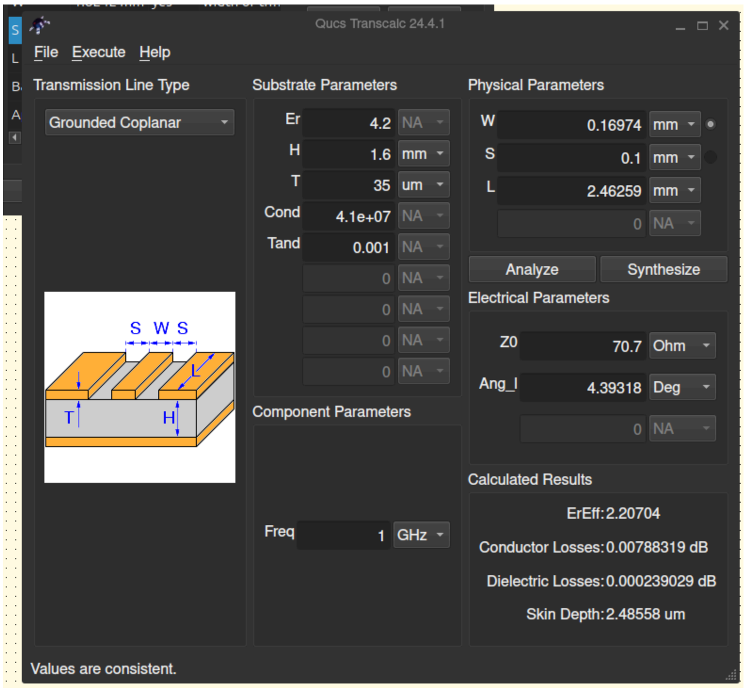
Why is L shorter as compared to the ideal Transmission line case?

The length L is shorter in the microstrip case compared to an ideal transmission line because the effective permittivity (εeff=2.49) of the microstrip is lower than the substrate permittivity (εr=4.2), causing the guided wavelength (λ_g) to be shorter than the free-space wavelength (λ0).

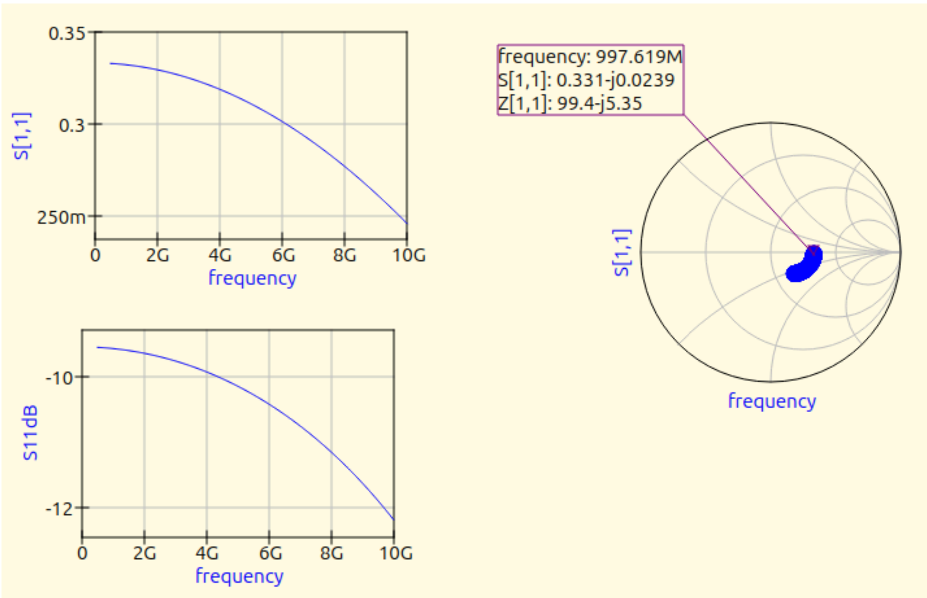
Exercise 5 – Grounded co-planar line Quarter-wave transformer

Circuit diagram:





Simulation results:



Which line is less lossy? The microstrip line of exercise 4, or this grounded coplanar line?

Microstrip Line (Exercise 4) Losses:

- **Conductor Losses** = **0.0058358 dB**
- **Dielectric Losses** = **0 dB**

Grounded Coplanar Line (Exercise 5) Losses:

- **Conductor Losses** = **0.00788319 dB**
- **Dielectric Losses** = **0.000239029 dB** (small but nonzero)

Comparison:

- The **Grounded Coplanar Line** has slightly **higher conductor losses** (0.00788 dB vs. 0.00583 dB).
- The **Dielectric Losses** in the grounded coplanar line are **slightly nonzero**, while they were effectively **0 dB** in the microstrip line.

Conclusion:

The **Microstrip Lineis less lossy** compared to the **Grounded Coplanar Line** due to **lower conductor and dielectric losses**. This is generally expected because in a grounded coplanar waveguide (GCPW), more of the current is concentrated along the edges, increasing conductor losses due to surface resistance effects.