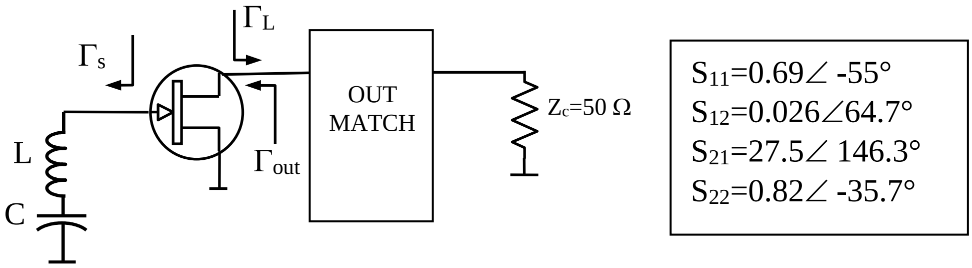
<u>Exercise 010217</u>

The following scheme refers to an oscillator working at f_{osc}=425 MHz. The S parameters of the transistor are also reported on the figure.



The resonant circuit resonates at f_{res}=400 MHz, where it can be replaced with a short circuit.

1) Imposing $|\Gamma_{out}|$=1.3 compute the values of Γ_S and Γ_L determining the start of oscillation
2) Verify that for Z_s=0 (short circuit) the start of oscillation is not possible. This happens at the resonance frequency f_{res} of the resonator.
3) Evaluate the values of L and C determining the requested value of Γ_S at f_{osc}=425 MHz and the resonance at f_{res}=400 MHz (Hint: the reactance of the series resonator is given by $X_s=\omega L-1/\omega C$ with $\omega=2\pi f$. The resonance frequency is given by $f_{res}=\dfrac{1}{2\pi\sqrt{LC}}$
4) Chose a topology and design the output network

<u>Soluzione</u>

Inserting the scattering parameter into the S.C. we discover the device potentially instable and the suitable for an oscillator.

1) Draw the mapping circle for |Γout|=1.3 and select one of the intersection with the unit circle: Γs=1∠132.31°. The corresponding reactance results Xs=0.442·50=22.1 Ω. Evaluate Γout=1.3∠-10.4 → Zout=-5.21-j3.53. The assign Z_L=1.7+j3.52. Using the S.C. we enter this value as current point and compute |Γin|=1.79, so the oscillation start up is guaranteed.

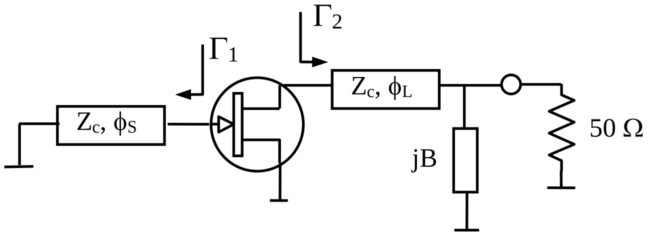
2) Assigning Γ_s=-1 (short circuit) as current point we compute |Γout|=0.957 so the oscillation cannot start.

3) We have at fosc=425 MHz: $X_s=\omega_{osc}L-\dfrac{1}{\omega_{osc}C}=\omega_{osc}L-\dfrac{\omega_{res}^2 L}{\omega_{osc}}=22.1$. Replacing ω_{osc}=2π·425 MHz and ω_{res}=2π·400 MHz we get L=72.48 nH. Then $C=\dfrac{1}{\omega_{res}^2 L}=2.18\ \text{pF}$.

4) Using a single stub network: Φ=58.75°, b=-2.73.

Exercise 260916

The following figure represents a microwave oscillator operating at f_0=10 GHz. Using the reported scattering parameters of the active device and the components values, evaluate the reflection coefficients Γ_1 and Γ_2 and verify that the start condition of oscillations is satisfied.

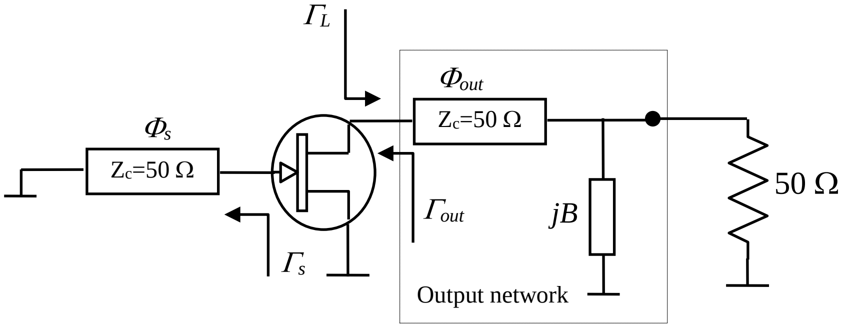


$S_{11}=0.521\angle-52.6°$
$S_{12}=0.069\angle 42.7°$
$S_{21}=14.44\angle 121.7°$
$S_{22}=0.844\angle -62.3°$
$Z_c=50\ \Omega$
$\phi_L=22.27°$, $\phi_S=78.5°$
$B\cdot Z_c=4.273$

Solution:
With the electronic Smith Chart (and using the circuit parameters) we obtain the values of Γ_1 and Γ_2:
$\Gamma_1=1\angle 23°$, $\Gamma_2=0.906\angle 160.54°$
In order the starting oscillations condition is verified we must obtain $|\Gamma_{in}|>1$ and $|\Gamma_{out}|>1$. In fact, using the Smith chart, we get:
$\Gamma_{out}=1.202\angle-168.31°$, $\Gamma_{in}=1.075\angle-23.16°$

Exercise 060716

We want design the oscillator in the following figure, operating at 5 GHz:



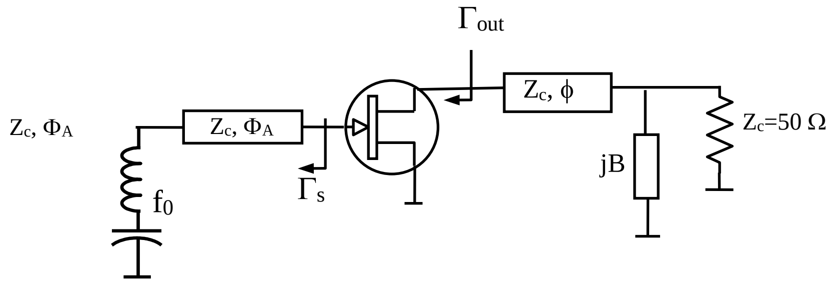
The scattering parameters of the transistor are given by:

$S_{11}=0.844\angle-62.3°$, $S_{21}=5.273\angle 121.7°$, $S_{12}=0.069\angle 42.7°$, $S_{22}=0.521\angle-52.6°$

a) Select a value for Γ_s and evaluate the electrical length Φ_s of the first line. (Hint: set $|\Gamma_{out}|=1.2$ and select the Γ_s which determines the minimum value of Φ_s)
b) Design the output network, once the required value of Γ_L has been computed

<u>Exercise 220914</u>

The following scheme refers to an oscillator working at 24 GHz. The S parameters of the transistor are also reported on the figure.



$S_{11}=0.772\angle 6.17°$
$S_{12}=0.2\angle -82.08°$
$S_{21}=2.224\angle -137.15°$
$S_{22}=0.508\angle 37.07°$

The resonant circuit resonates at the oscillation frequency, where can be replaced with a short circuit. At all the other frequencies it can be approximated with an open circuit.

1) Select a suitable value for ϕ_A (use the mapping circles of Γ_s for obtaining $|\Gamma_{out}|\geq 1.5$)
2) Evaluate the parameters of the output network (ϕ, jB) to ensure the start of oscillation and the transfer of the output power to the external load (50 Ω).
3) Is it possible to get oscillation at 24.1 GHz with the designed circuit? (assume the S parameters unchanged and the resonator replaced with an open circuit)

<u>Solution</u>

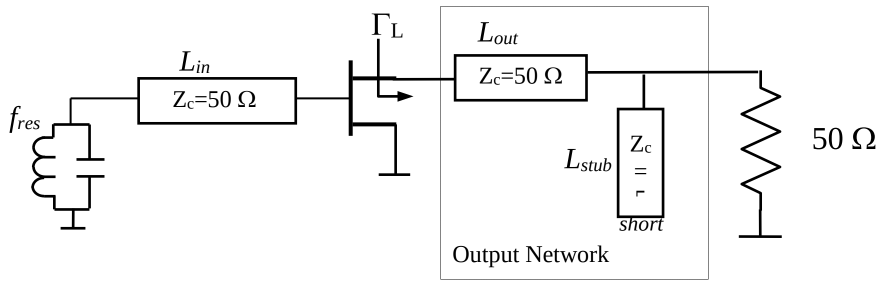
Draw on the electronic S.C. the source mapping circle with $|\Gamma_{out}|=1.5$. We must select a point inside this circle on the boundary of the chart ($|\Gamma_S|=1$). A suitable point is the open circuit ($\Gamma_S=1$), for which: $\Gamma_{out}=1.569\angle 144.53$, $y_{out}=-1.613-2.01i$. In order to get $\Gamma_S=1$ with a short circuited stub (the resonator is assumed shorted), we need a length $\Phi_A=90°$.
The load to be presented at the transistor output is represented by an admittance y_L given by:

$$y_L=-\frac{1}{3}\mathrm{Re}\left(y_{out}\right)-\mathrm{Im}\left(y_{out}\right)=0.54+j2.01$$

This load determine $|\Gamma_{in}|=1.091$ so the start of oscillation is guaranteed also at input side.
The single stub matching network at output is designed starting from yL and moving toward load on the circle at constant $|\Gamma|$ until the circle g=1 is crossed (first intersection at $\phi=137.08°$). The imaginary part of the normalized admittance at this point represents the susceptance b=-2.806 (then B=-2.806·0.02=0.05612).
At f=24.1 GHz, considering the resonator an open circuit, the normalized impedance z_S determined by the stub with length $\Phi'=\Phi\cdot(24.1/24)=90.375°$ is given by $z_S=1/j\tan(\Phi')=j0.006545$. Inserting this value into the S.C. the output reflection coefficient can be obtained: $\Gamma_{out}=0.607\angle 13.046$. Being $|\Gamma_{out}|<1$ the oscillation cannot start.

Exercise 230215

We want to design the oscillator in the figure operating at 2 GHz:



The S parameters of the active device at 2 GHz are given in the following table as function of the bias current:

Ibias	S11	S12	S21	S22
10 mA	0.745 ∠ -162.9°	0.063∠-7.1°	1.875∠25.1°	0.602∠-119.6°
20 mA	0.76∠-145°	0.06∠-1.2°	1.92∠43.6°	0.603∠-105.3°
30 mA	0.864∠-93.4°	0.064∠27.4°	2.545∠93.8°	0.627∠-64.2°

1) Select the bias current (imposing the necessary oscillation condition)
2) Assign a suitable value to the resonant frequency f_{res}
3) Assuming the relative dielectric constant of the lines ε_r=2.2, evaluate the length L_{in} of the input line
4) Evaluate the reflection coefficient Γ_L to be presented at the transistor output and design the output network (i.e. evaluate the lengths L_{out} and L_{stub})

Solution

Using the electronic Smith Chart it can be observed that the active device is potentially instable (k<1) only with Ibias=30 mA.
The resonant frequency of the resonator is assigned equal to the oscillation frequency. The input line is then an open stub with $b_s=\tan(\beta \cdot L_{in})$. For choosing bs the mapping circle of the source is drawn with $|\Gamma_{out}|=1.2$. The chosen point must be also on the outer circle (two choices); we have selected bs=-1.39. The electrical length of the input stub is then given by:
$(\beta \cdot L_{in})=\tan^{-1}(-1.2)=129.8°$
It has:
$Z_{out}=-0.27-j1.386 \rightarrow Z_L=0.09+j1.386$.
The single-stub matching network transforms Z_L into 50 Ohm. We get:
$(\beta \cdot L_{out})=44.4°$, $b_{stub}=-5.55 \rightarrow (\beta \cdot L_{stub})=\tan^{-1}(1/5.55)=10.21°$

Lengths computations:

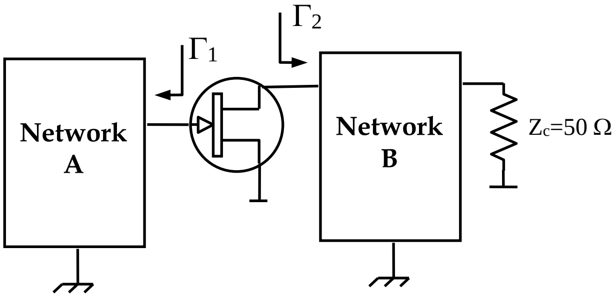
$$\lambda = \frac{300}{f_0\sqrt{\varepsilon_r}} = 101.13 \text{ mm}, \qquad \beta = \frac{360}{\lambda} = 3.56 \text{ °/mm}$$

$L_{in}=129.8/\beta=36.46$ mm, $L_{out}=44.4/\beta=12.47$ mm, $L_{stub}=10.21/\beta=2.87$ mm

Exercise 3

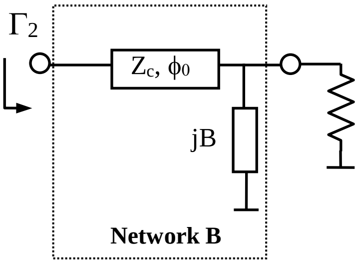
The following figure represents the general configuration of a microwave oscillator. Using the reported scattering parameters of the active device, evaluate the reflection coefficients Γ_1 and Γ_2 which ensure the start of oscillation (the magnitude of Γ_1 must be imposed equal to 1).

Hint: draw the mapping circle of the source with $|\Gamma_{out}|=1.2$ for determining Γ_1. For evaluating Γ_2 determine the value of Z_{out} corresponding to the selected Γ_1 and assign $Z_2=|R_{out}/3|-jX_{out}$.



$S_{11}=0.521\angle{-52.6°}$
$S_{12}=0.069\angle{42.7°}$
$S_{21}=14.44\angle{121.7°}$
$S_{22}=0.844\angle{-62.3°}$

Then design the network B, using the scheme in the following figure (assume Z_c=50 Ohm and evaluate the electrical length ϕ_0 and the susceptance B):



Solution

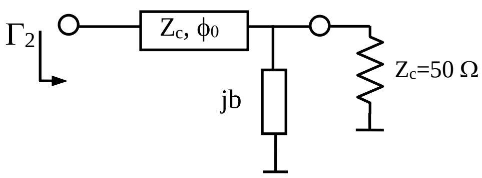
The assigned transistor is potentially instable (k=0.53), so it can be used for realizing an oscillator. Using the electronic Smith Chart, the mapping circle with $|\Gamma_{out}|=1.2$ is drawn. The two intersections with the outer circle are: $\Gamma_{1a}=1\angle 23°$ and $\Gamma_{1b}=1\angle{-161.5°}$

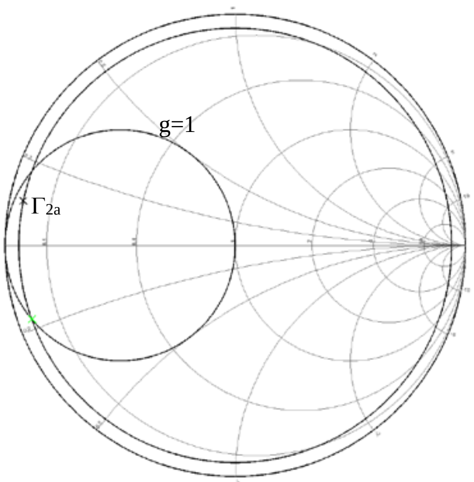
Selecting "S Param." → "Gamma OUT" the reflection coefficient at port 2 is obtained: $\Gamma_{out,a}=1.2\angle{-168°}$ ($\Gamma_{out,a}=1.2\angle{-28.7°}$) The S. chart reports also the normalized impedance $Z_{out,a}=-0.092-j0.103$ ($Z_{out,b}=-1.31-j3.44$).

Imposing the condition suggested in the text, the values of Z_2 and Γ_2 are then obtained:

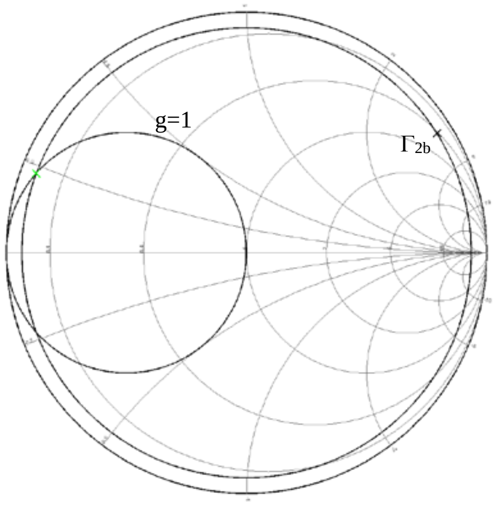
$Z_{2a} = 0.03+j0.103 \rightarrow \Gamma_{2a} = 0.94\angle 168.2°$ ($Z_{2b} = 0.44+j3.44 \rightarrow \Gamma_{2b} = 0.935\angle 32°$)

The matching network is designed according the well-known procedure:





ϕ_0=15.85°, b=5.5



ϕ_0=63.7°, b=−5