Simulation: *Input Impedance of a Transmission Line as a Function the Frequency*

Homework to train the concepts of input impedance of lossy and lossless transmission lines terminated in a load made up of concentrated elements.

Please: Install the RF Toolbox; annotate **each figure adequately by using legends, axis labels and titles**.

The script intends to simulate measurements carried out with the VNA: the line has a fixed length and is measured as function of the frequency.

Input data:

- Line length (air dielectric) l: *User input*
- Line characteristic impedance Z_0': *User input*
- Maximum frequency f_{max} : *User input*
- Attenuation constant: $\alpha=k\sqrt{f_{MHz}}$(*k is a user input: suggestion k= 0.015 dB/m and then convert to Np/m)*
- Load impedance Z_L preferred to be given as lumped components for a more realistic simulation:
  - Read load lumped inductance L (nH) or capacitance C (pF)
  - Read load resistance RL (Ω)
  - Read if the lumped elements are to be considered in series or parallel.

Problem solving steps

1. Read all the input data;
2. Generate a vector of frequencies up to fmax;
3. Compute the vector of wavelength λ;
4. Compute the load impedance as a function of the frequency;
5. Compute the load coefficient ρ_L in the transmission line with characteristic impedance Z_0';
6. Compute the propagation constant γ;
7. Compute the line input impedance;
8. Compute the reflection coefficient in a 50 Ω characteristic impedance line (as the VNA impedance)
9. Plot the reflection coefficient using:
   a. Polar plot
   b. Impedance Smith Chart
   c. Admittance Smith Chart
10. Plot in the same figure, as a function of the frequency:
    a. The input resistance of the line
    b. The input reactance of the line
11. Plot as a function of the frequency in the same new figure, for Vinc=1 V and $Z_0' = 50\ \Omega$:
    a. The power delivered to the line;
    b. The power dissipated in the line;
    c. The power delivered to the load.
12. Try the matching networks discussed in TP classes in a Z_0=50Ω lossless line:
    a. Compute the matching network elements -stub based and lumped element based matching systems for example- for a chosen matching frequency

b. Simulate the input impedance of the system and check it is matched at the matching frequency.

Suggestion: Simulate with choosen combinations among …

1. Simulate with $Z_0^{'}$ from 20 to 100Ω
2. Simulate with short circuit (SC) and open circuit (OC)
3. Simulate up to 2 GHz for the length of line 0.2 m (like the microstrip boards in the 1st labwork)
4. Simulate with resistances ($Z_L = R_L + j0$)
5. Simulate with R and C in series and in parallel (chose appropriated nominal values)
6. Simulate with R and L in series and in parallel (chose appropriated nominal values)

Home work

1. Study carefully all the subjects addressed in this simulation.

Some useful MatLab functions: atan2(y,x); abs(); angle(); plot(x,y,'b'); axis([x1 x2 y1 y2]), polar(θ, r); grid on; axis square; polarplot(); hold on; linspace; xlim(); ylim();real(); imag(); figure(); legend(); xlabel(); ylabel(); title(); ylim(); xlim(); title(); smithplot(). Latex use is possible: Z_{in} looks like Z_{in} (in labels, legends, etc)

Note: Use "." "./" and ".^2" instead of "*" "/" "^" to make operation point by point.*