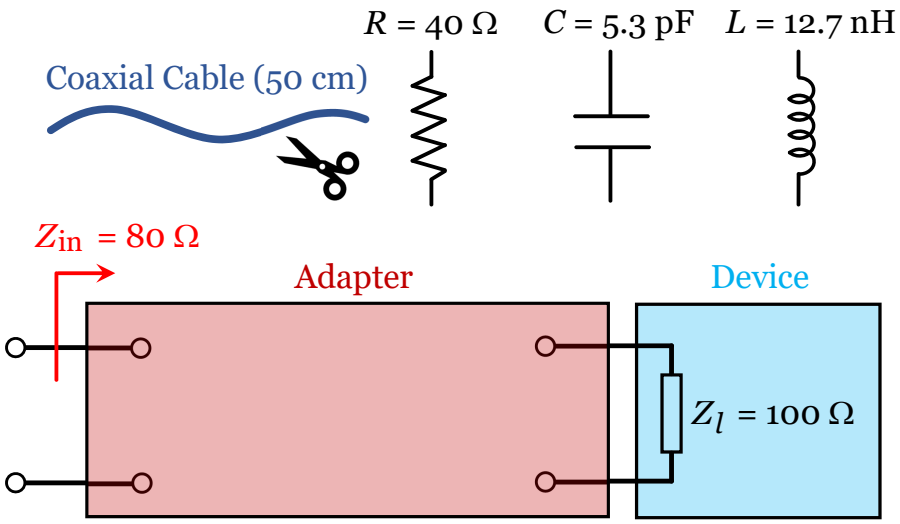
2020-2021, EE303 – HW9

Question 1 (1 pts)



In this questions, you are asked to design an adapter, which reduces the input impedance of a device from 100 Ω to 80 Ω. The operating frequency is given as 1 GHz. To construct the system, you have the following items:

- 50 cm coaxial cable (lossless), which may be **cut** into two or more pieces if necessary, with $L_c = 62.5$ nH/m inductance and $C_c = 25$ pF/m capacitance per length
- Single 40 Ω resistor, single 5.3 pF capacitor ($5.3 \approx 1/(0.06\pi)$), and single 12.7 nH inductor ($12.7 \approx 40/\pi$)

All or some of these items may be used. **No** extra item can be used.

- Find Z_0, β, and λ for the coaxial cable. Note that these are necessary parameters you need before your design. Also find the impedances corresponding to the lumped components, i.e., $C = 5.3$ pF and $L = 127$ μm.
- Design your system. Clearly and visually describe all details (fill in the box above); show how you combine coaxial or coaxial parts with lumped elements to reach 80 Ω on the right-hand side. Since there are multiple solutions, you must show your own design procedures and approach in detail.

Question 2 (1 pts)

A series combination of a 10 Ω resistor and a 4.77 nH inductor ($4.77 \approx 15/\pi$) is connected to a lossless transmission line as a load at 1 GHz. The characteristic impedance of the line is $Z_0 = 20$ Ω.

- Find the reflection coefficient at the load (Γ_l) and VSWR.
- In the following, assume that the incident voltage is unity ($V^+ = 1$). Write the expression for the voltage (in phasor domain) with respect to position, i.e., $V(z')$ where z' is measured from the load.
- Find the positions for the first maximum $z'_{\text{max,first}}$ and the first minimum $z'_{\text{min,first}}$ of the voltage pattern $|V(z')|$ in terms of the wavelength λ.
- Plot the voltage pattern $|V(z')|$ with respect to position z' in the range from 0 to 2λ. This can be done in many ways, e.g., using MATLAB, Excel, Mathematica, or even manually by using a calculator. In any case, make sure that you clearly label the critical points.
- Find the expression for the voltage in time domain, i.e., $V(z', t)$ where z' is measured from the load. Your expression should be in terms of z', t, and β or λ. Inserting the value of ω is optional.
- Plot the instant value of the voltage $|V(z', t)|$ at $t = \pi/(3\omega)$ seconds with respect to position z' in the range from 0 to 2λ. If you use a plotter, it may be interesting to put this plot onto the plot of the voltage pattern $|V(z')|$.
- Compare the values of $|V(z' = z'_{\text{max,first}}, t = \pi/(3\omega))|$ and $|V(z' = z'_{\text{min,first}}, t = \pi/(3\omega))|$, visually or numerically (or both). Which one is larger? Comment on your result.

Question 3 (0.5 pts)
Consider a rectangular waveguide with $a = 50$ cm and $b = 30$ cm dimensions filled with vacuum. Create a table that lists the following data for all propagating modes at 1.5 GHz.

- Mode numbers (m, n)
- Phase constant (β_{mn})
- Wavelength (λ_{mn})
- Phase velocity (v_{mn})

Course Ethics: In all activities (homeworks, quizzes, exams, attendance questionnaire) of the course, students should not receive any unauthorized help from other students or persons. All submissions must be students' own work. Students are assumed to understand what constitutes plagiarism, cheating, and other unethical activities.

Note: If you have any questions regarding the problems in this homework assignment, please ask to Özgür Ergül by e-mail (ozergul@metu.edu.tr) with e-mail subject as "EE303-HW9, Question by Your Name Surname"