HA # 4 , 5 and 6

- In these assignments you will design three matching networks using:
  - A quarter wave transformer.
  - A 4-section binomial transformer
  - A 4-section Chebyshev transformer

Assignment Scope

- Attempt to match a real load of $R_L = 20\Omega$ to a transmission line with a 50Ω characteristic impedance at a frequency of 6.0 GHz.
- The **bandwidth** of the 4-section transformers is defined by $\Gamma_m = 0.1$.
- Assume TEM wave propagation in the transmission lines, and the transmission line dielectric constant is $\varepsilon_r = 9.0$.

Assignment Tasks

1) Design each of the three matching networks, determining both the characteristic impedance and physical length (in cm) of each section.
2) Use the design equations in your slides/book to determine the expected bandwidth for each design.

3) Implement each design on ADS software. Analyze the circuit by evaluating $\Gamma_{in}(\omega)$ from 0 to 12 GHz. Display the results as (make sure you use enough frequency points—at least 100—in the analysis!):

   a) a Smith Chart plot of $\Gamma_{in}(\omega)$. Note this is a parametric plot of reflection coefficient Γ_{in} as a function of frequency—not as a function position (i.e., not $\Gamma(z)$!).
   b) a Cartesian plot of $\Gamma_{in}(\omega)$ (i.e., linear scale) versus frequency, with a vertical scale from 0 to 1.0.

Questions on 3rd Task

Q1: Do the plots indicate that your designs are correct? **Explain why** you think so. **Give** specific **numerical** examples!

Q2: **Observe** the parametric plot $\Gamma_{in}(\omega)$ on the Smith Chart. Use the adjustable markers to **determine** at what **frequencies** the curve is **far** from the center of the chart, and at what **frequencies** the curve is **near** the center. Use your knowledge of the Smith Chart and matching networks to **explain why** this result makes sense.

Q3: Likewise **precisely determine** the **specific frequencies** at which the parametric Smith Chart plot of $\Gamma_{in}(\omega)$ is **precisely** at the center of the chart (i.e., the curve intersects the center point). **Explain why** this result makes sense. **Locate** these **same** specific frequencies on the **Cartesian** plot. **What** is the **values** of $\Gamma_{in}(\omega)$ at these frequencies? **Explain why** this result makes sense.

Assignment Tasks (contd.)

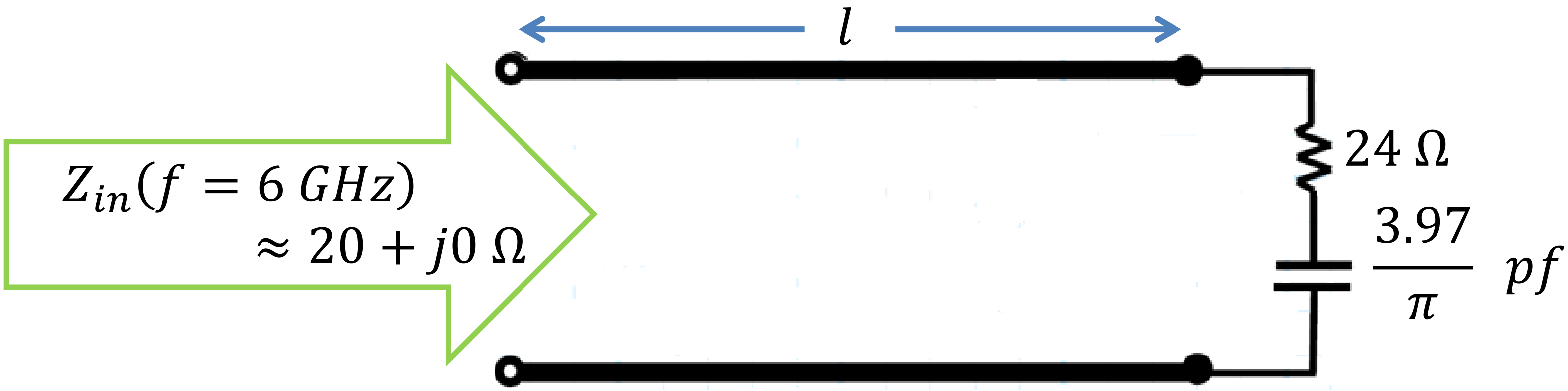
4) Use the adjustable markers on the plots to determine the bandwidth of each design, using the criterion $\Gamma_m = 0.1$.

Question on 4th Task

Q4: You will find that the bandwidths of your design will **not be exactly** the bandwidths predicted by the design equations. **Explain why** that is.
Hint: It is **not** because "ADS has errors"!

Assignment Tasks (contd.)

5) You will find that at $f = 6\,GHz$, the following device has an input impedance of approximately $Z_{in} = 20 + j0\ \Omega$ if the length l is properly determined:



6) Determine the proper value for line length l. Now replace the 20Ω resistor with this 20Ω "load" shown above, and reanalyze (with ADS) each matching transformer design.

7) Display the results of this new load on the same two plots (with the same scale!) as described in step 3.

Question on 5th to 7th Task

Q5: Compare and **contrast** these results with the 20 Ohm resistor plots. **How** are the results different? **Determine** the **specific** frequencies where the value of $\Gamma_{in}(\omega)$ is **precisely** the same for the two cases. **Explain why** this is true.

Assignment Report

- You basically should view the HA report as a **lab report**. **Show how** and why the design parameters were determined. “Construct” the circuits in ADS, and then “measure” the circuits in ADS. Provide the results of these “measurements” in report. **Discuss** your results, and include the answers to the questions posed earlier (put particular emphasis on the answers to questions with the word “**why”**!).
- Assume your audience is a **knowledgeable microwave engineer** (i.e., **me**!) Thus, you do not need to provide a long (or even short) discussion about what matching networks are, or why they are so great, or what their general characteristics are, or a multiple reflection analysis of them, etc. I assume you know the material that has been presented in class. What I don’t know is if you can take that material and: 1) **design** a matching network that works and; 2) explain the behavior of that design when analyzed on ADS.
- Thus, I am looking for **quality** over quantity. I do not want this to be a massive report requiring tons of writing. Make the points that you want to make in a clear and complete manner, and then **stop** writing! However, do not confuse the word “**why**” with the word **“what**”. I have frequently asked you to explain **why** an observation is true, or **why** something happened, or **why** an observation makes sense. Students often instead just tell me **what** is observed, or **what** happened when something was changed—do **not** do this!

Assignment Report (contd.)

- You must describe the synthesis process you used to design the matching networks. I require that your **computations** be presented in your report. I must be able to see **where** the error was made if your results or design are erroneous. I want to see all the **general equations** used, and then the **values** used for the **variables** in the equations, and **then** the numeric results of the equation.
  - You may put **detailed computations** in one or more **organized appendices**. These appendices can be **handwritten**. However, do not destroy the flow or organization of your report by providing **fundamental** information in the appendix **only**. In other words, I do not want to have to search through the appendix to find fundamental design parameters (e.g., the characteristic impedances, bandwidth, etc.)—the appendix is for computation **details**.
- Moreover, the report should flow from one section to another as one continuous document. Often I receive a set of independent pieces, stacked together and called a report—do not do this! To this end, figures, tables, and appendices should be labeled, number, and titled and referred to in the report. For example, “Figure 2 provides the parametric plot of $\Gamma_{in}(\omega)$ for…”, or “The details of the computation can be found on page 3 of Appendix 2”.