Design Project #1: *Matching Transformers*

In this project you will design and test **three** matching networks:

a) A Quarter-wave transformer
b) A 4-section Binomial transformer
c) A 4-section Chebychev transformer

Project Scope

In this design, we will 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 $\varepsilon_r = 9.0$.

Project 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 notes/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.

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

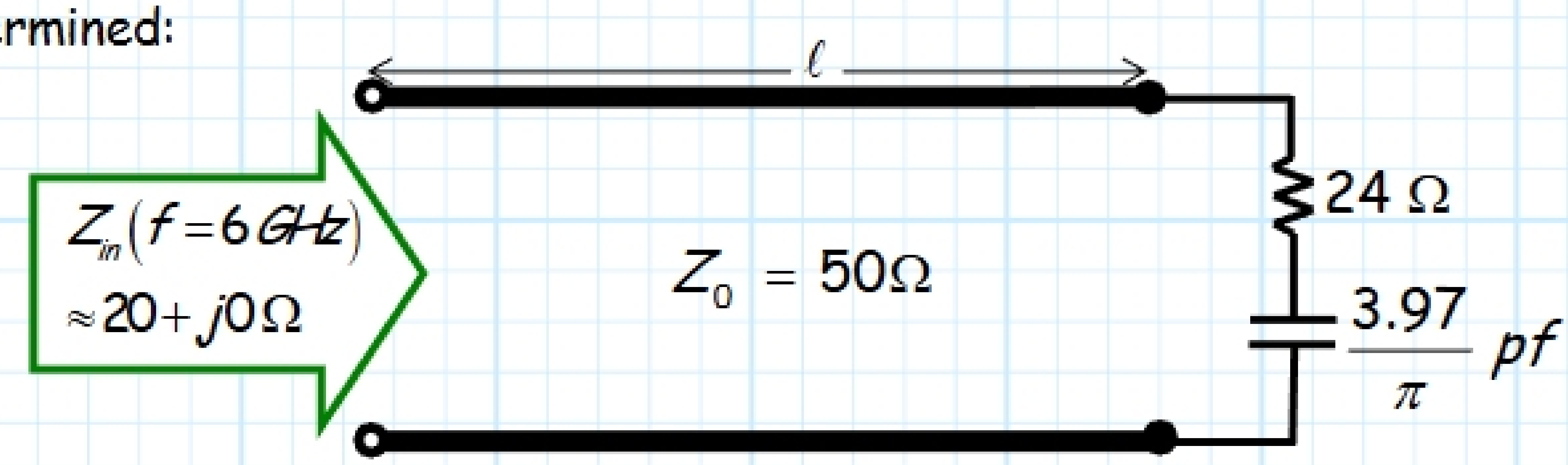
Q2: ***Observe** the parametric plot $\Gamma_{in}(\omega)$ on the Smith Chart. Use the adjustable markers to **determine** at what **frequencies** the curve is **far** from the center of the chart, and at what **frequencies** the curve is **near** the center. Use your knowledge of the Smith Chart and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

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

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"!*

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



6) Determine the proper value for line length ℓ. Now **replace** the 20 Ω resistor with this 20 Ω "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.

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.*

Project Report

1. You basically should view the project 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**"!).

2. 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.

3. 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