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 $R_L = 120\Omega$ to a transmission line with a 50Ω characteristic impedance at a frequency of 4.0 GHz.

The **bandwidth** of the 4-section transformers is defined by $\Gamma_m = 0.2$.

Assume TEM wave propagation in the transmission lines, and the transmission line dielectric constant is $\varepsilon_r = 16.0$.

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 8 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 $|\Gamma_{in}(\omega)|$ versus frequency (i.e., **linear** scale).

c) a Cartesian plot of $10\log_{10}|\Gamma_{in}(\omega)|^2$ versus frequency (i.e., **dB** scale). Make sure that you use a **log scale** that **makes sense** (e.g., 50 dB from top to bottom).

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

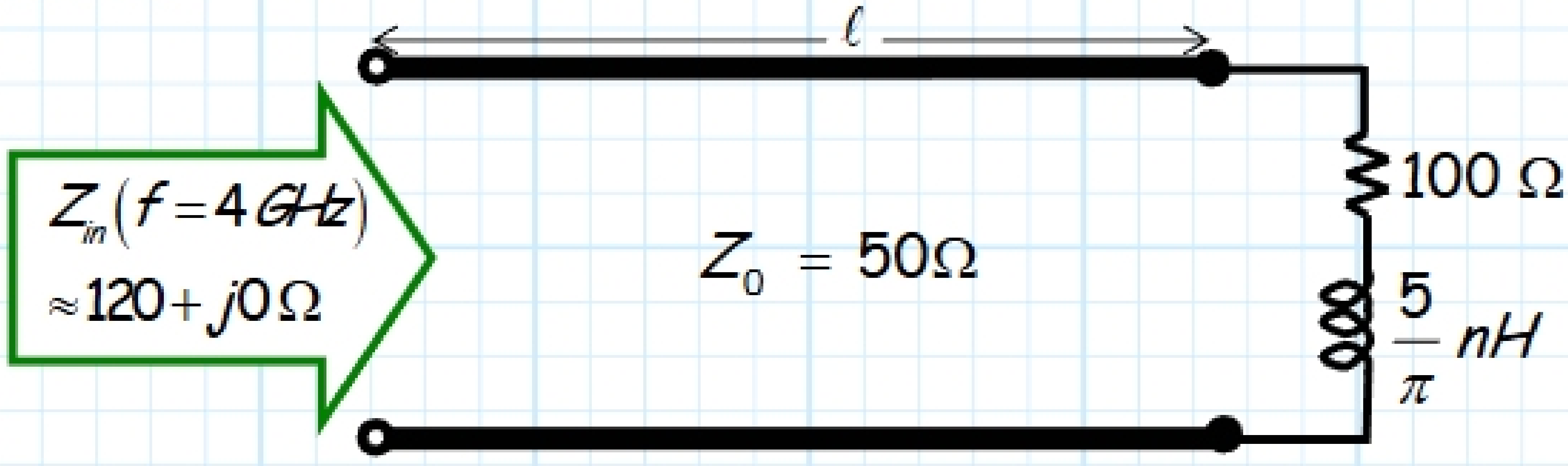
Q2: ***Observe*** *the parametric plot* $\Gamma_{in}(\omega)$ *on the Smith Chart. Use the adjustable markers to* ***determine*** *at what* ***frequencies*** *the curve is* ***far*** *from the center of the chart, and at what* ***frequencies*** *the curve is* ***near*** *the center.* ***Explain why***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

Q3: *Likewise* ***determine*** *the* ***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*** *frequencies on the* ***Cartesian*** *plots.* ***What*** *are the* ***values*** *of* $|\Gamma_{in}(\omega)|$ *and* $10\log_{10}|\Gamma_{in}(\omega)|^2$ *at these frequencies?* ***Explain why*** *this result makes sense.*

4) Use the adjustable **markers** on the plots to **determine** the **bandwidth** of each design.

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 $f = 4$ GHz, the following device has an input impedance of approximately $Z_{in} \approx 120 + j0\ \Omega$ if the length ℓ is properly determined:



6) Determine the proper value for line length ℓ. Now **replace** the 120 Ω resistor with this 120 Ω "load" shown above, and **reanalyze** (with ADS) each matching transformer design.

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

Q5: ***Compare*** *and* ***contrast*** *these results with the 120 Ohm resistor plots.* ***How*** *are the results different?* ***Determine*** *the frequencies where the value of $\Gamma_{in}(\omega)$ is* ***precisely*** *the same for the two cases.* ***Explain why*** *is this 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