HA # 7

Assignment Scope

Design a **low-pass filter** with the following specifications:

Order: 3
Cutoff Frequency: 2.0 GHz
Source and Load Impedance: 50Ω
Port Impedance: 50Ω
Filter Type: Chebyshev (0.5dB ripple)

Design this filter using **3 methods**:

a) With lumped elements, using two series inductors and one shunt capacitor
b) With shunt stubs (i.e., Richard's Transformation and Kuroda's Identities).
c) Using stepped impedance transmission lines, with Z0l = 15Ω and Z0h = 200Ω.

Assignment Tasks

1) Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each design. Specify transmission line lengths assuming TEM propagation and $\varepsilon_r = 4.0$.

2) For each method, plot $|S_{21}|$ in linear scale and $|S_{21}|^2$ in log scale, from 0GHz to 10GHz.

Q1: Do these results indicate that your designs are correct? Explain **why** you think so.

3) From these plots, determine the insertion loss of each filter design at 1, 3, 4 and 7 GHz.

Q2: Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain **why** this is so.

4) For each design, plot S_{11} on a **Smith Chart** over the same frequencies of 0 to 10 GHz.

Q3: For what frequencies is the curve on the Smith chart nearest the center? Explain **why** this is so.

5) For each method, plot the **phase** of S_{21} from 0 GHz to 10 GHz.

Q4: Do these filters appear to be linear phase filters? Explain **why** you think they are or are not.

6) Change the impedance of the "TERM" element to 100 Ω for the input (port 1) element, and change the impedance of "TERM" element to 25 Ω for the output (port 2) element.
Now replot $|S_{21}|$ in linear and $|S_{21}|^2$ in log scale from 0 GHz to 10 GHz.

Q5: Compare these plots to the results of task 2. Explain **why** they are not the same.

Assignment Report (Hard Copy – No email)

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 coupled-line couplers 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 coupled-line coupler 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 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!
4. You must describe the synthesis process you used to design the coupled-line coupler. 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.
5. 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.