EE 481/581 Microwave Engineering (Fall 2025)
Homework 11
Wednesday, December 3, 2025

1) a) For a 50 Ω system, design a 5th-order, lumped-element, 0.5 dB ripple, Chebyshev low-pass filter with a cut-off frequency of 2.4 GHz using the architecture of Fig. 8.25a. b) Draw a labeled sketch of the scaled filter with component values. c) Assuming that Z_ℓ = 20 Ω and Z_h = 120 Ω, find the required electrical lengths of each section for a stepped-impedance implementation of the low-pass filter.

2) Next, use MWI program to design a microstrip implementation of the stepped-impedance low-pass filter designed in 1) on Rogers RO4003C with 1 oz. copper and 1.524 mm board thickness using 'z-axis Bulk Dk values'. a) Find width w_{20} (mm), phase velocity v_{20}, wavelength λ_{20} (mm), and length ℓ_{20} of 20 Ω sections. b) Find width w_{120} (mm), phase velocity v_{120}, wavelength λ_{120} (mm), and length ℓ_{120} of 120 Ω sections. c) Find width w_{50} (mm), phase velocity v_{50}, and wavelength λ_{50} (mm) for 50 Ω microstrip. d) Draw a fully-labeled top view sketch of design with 50 Ω microstrip traces (indefinite length) at input and output. For legibility, the sketch may be scaled.

3) **EE 581 only**: Plot $|S_{21}|$ (dB) for the lumped-element and stepped-impedance implementations of the low-pass filter with a horizontal dashed line at -0.5 dB and a vertical dashed line at 2.4 GHz for $0 \le f \le 5$ GHz and -25 dB $\le |S_{21}| \le 0$.

4) a) Design a 4th-order, lumped-element, linear phase low-pass filter prototype using the architecture of Fig. 8.25b with a Thevenin equivalent source and draw a fully-labeled sketch. b) Use Richards' Transformation to implement low-pass filter prototype using stubs and draw fully-labeled sketch of resulting circuit. c) Add unit element to the lefthand (LH) side, sketch resulting circuit, apply a Kuroda identity to convert the LH series stub to a shunt stub, & sketch resulting circuit. d) Add a unit element to the righthand (RH) side by load, sketch resulting circuit, apply a Kuroda identity to convert the RH shunt stub to a series stub, & sketch resulting circuit. e) Add a unit element to the RH side by load (again), sketch resulting circuit, apply a Kuroda identity to each of the two short-circuit series stub & unit element combinations to convert them to shunt stubs, and sketch resulting circuit. [Note: Normalized design should now only have shunt open-circuit stubs.] f) Scale all impedances to a 50 Ω system and draw a fully-labeled sketch of the final design [add 50 Ω sections (no specified length) at both ends for connectivity]. For all steps, the lengths ℓ may be left in terms of λ at f_c.

Due Monday, December 8, 2025 by 4 pm at office or EECS mail box.

- For plots, you can use MathCAD or Matlab. Include either worksheet (MathCAD) or m-file & plots (Matlab) with each solution.
- Include any design figures/tables used.