# Simulation Methods for Electronic Circuits
# Assignment on Contents 5 and 6

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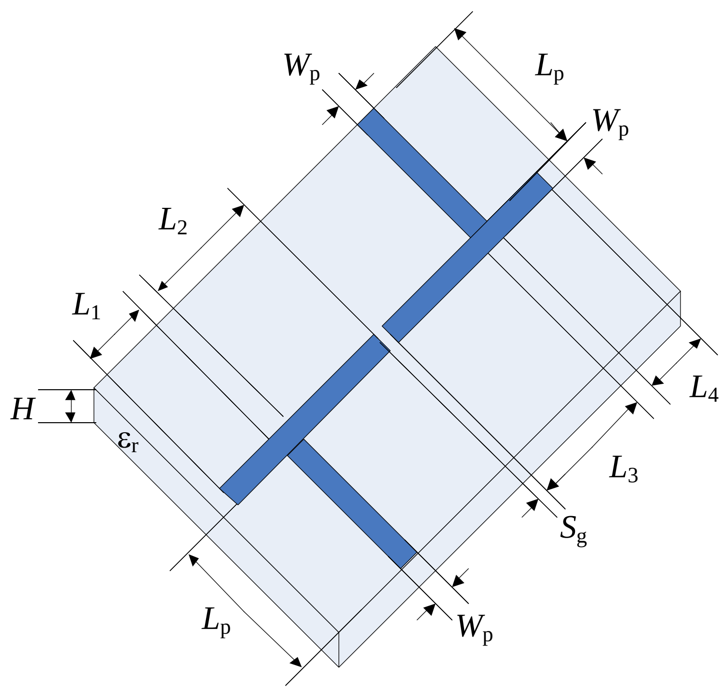
The following microstrip band pass filter is reported in [1], [2] and [3], with some small variations. The dielectric substrate is made of Alumina with a relative dielectric constant $\varepsilon_r = 9$, a substrate height $H = 0.66$ mm, and a negligible loss tangent. All microstrip lines used in the filter have the same width $W_p = 0.7$ mm. The feeding microstrip lines have a length $L_p = 10W_p$. Main resonators have lengths $L_1$, $L_2$, $L_3$, and $L_4$, with a separating gap $S_g$. Filter design parameters have the following dimensions: $\boldsymbol{x} = [L_1 \;\; L_2 \;\; L_3 \;\; L_4 \;\; S_g]^T = [6.6096 \;\; 4.6042 \;\; 6.2821 \;\; 4.8314 \;\; 0.1241]$ (mm). Both metallic and dielectric losses can be neglected. The metallic strips and ground plane can be considered infinitesimally thin. Both ports use a reference impedance of 50 Ω.




1. Implement the filter in a high-frequency circuit simulator such as APLAC, ADS (Keysight) or Qucs. This filter can be simulated with the student version of APLAC if the microstrip T-junctions are neglected. If APLAC is employed, try using different model levels for the dielectric substrate (`LEVEL = 0, 1`, etc., in `Msub` component).
2. Implement the filter in a full-wave EM simulator such as Sonnet, Momentum (Keysight), HFSS, EM-Pro (Keysight), CST or COMSOL. This filter can be simulated with Sonnet Lite if the resolution is properly selected.
3. In both cases, show the plot of $|S_{11}|$ and $|S_{21}|$ (in linear scale and in dB) from 4.5 GHz to 5.5 GHz in



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linear scale for the frequency.

4. Using only the circuital simulation (Step 1 above), vary the length of the input/output lines, $L_p$, and plot again $|S_{11}|$ and $|S_{21}|$. What effects has $L_p$ on the filter responses?

Submission deadline: May 18, 2020.

**References**

[1] A. Hennings, E. Semouchkina, A. Baker, and G. Semouchkin, "Design optimization and implementation of bandpass filters with normally fed microstrip resonators loaded by high-permittivity dielectric," *IEEE Trans. Microwave Theory Tech*., vol. 54, no. 3, pp. 1253–1261, Mar. 2006.

[2] S. Koziel, J. W. Bandler and K. Madsen, "A space-mapping framework for engineering optimization - theory and implementation," *IEEE Trans. Microwave Theory Tech*., vol. 54, pp. 3721-3730, Oct. 2006.

[3] V. Gutiérrez-Ayala and J. E. Rayas-Sánchez, "Neural input space mapping optimization based on nonlinear two-layer perceptrons with optimized nonlinearity," *Int. J. RF and Microwave CAE*, vol. 20, pp. 512-526, Sep. 2010.



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