Local stability analysis of microwave circuits

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Abstract

Frequency domain simulation methods have become very popular in modern simulators for RF and microwave electronic circuits. These methods, like Harmonic Balance or DC, constrain the frequency grid of the circuit solution. This constraint can lead the simulator to find unstable solutions of the electronic circuit's differential equations. A stability analysis is therefore required once the solution has been found.

To test the stability of these steady-state solutions, the circuit is linearised around the solution and several non-parametric frequency response functions of the linearised circuit are determined. The stability analysis therefore boils down to determining whether a given non-parametric frequency response of a linear system is stable or not. Microwave circuits contain distributed elements (transmission lines), which causes the frequency responses to be non-rational.

Our approach to analyse the stability of a frequency response ($\in L_2$) is to split it into a stable and unstable part. The stable part is a function in the Hardy space H_2 while the unstable part lies in its orthogonal complement $\overline{H_2} = L_2 \ominus \overline{H_2}$. The stable and unstable parts are obtained by projecting the frequency response onto the bases of H_2 and $\overline{H_2}$ respectively. With this non-parametric approach, we can easily determine whether a given frequency response has poles in the right half-plane or not.

In this presentation, we will discuss the details and limitations of this functional approach. We will also explain how the unstable poles in the circuit can be estimated once the unstable part of the frequency response is obtained.