A functional approach to stability analysis of linear systems

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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. The high-frequency circuits under study contain distributed elements, which causes the frequency responses to be non-rational.

The presented approach to analyse the stability of a frequency response ($\in \mathcal{L}_2$) is to split it into a stable and unstable part. The stable part is a function in the Hardy space $\mathcal{H}_2$ while the unstable part lies in its orthogonal complement $\overline{\mathcal{H}}_2 = \mathcal{L}_2 \ominus \mathcal{H}_2$. The stable and unstable parts are obtained by projecting the frequency response onto the bases of $\mathcal{H}_2$ and $\overline{\mathcal{H}}_2$ respectively. With this non-parametric approach, we can easily determine whether a given frequency response has poles in the right half-plane or not.