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A feedback system dynamic response analysis by root-locus method using Excel spreadsheet and XNumbers add-in package

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Abstract The Microsoft® Excel spreadsheet is a formidable educational tool but lacks native functions that would allow easy working with complex numbers and polynomials, so preventing its widespread use in most electrical engineering courses. Such limitations could be overcome using the open source XNumbers add-in package, bringing to Excel new numerical capabilities which have been available to students only in high-end scientific packages, such as Matlab® or Scilab. Here, we present an application of those features in control engineering courses, treating the specific case of a second-order feedback system with dynamic response by the root-locus method.

Keywords computing; control engineering; control systems; linear feedback; spreadsheet

The application developed here is useful in control systems undergraduate courses, where the students generally struggle with the mathematics and the concepts of system dynamics. Students could follow two alternative paths in those classes: get deep into the mathematics of control systems analysis, or focus on a simulation package. In the first case, they get familiar with maths tricks but lack experience with real systems, while in the last case, they lack a deep understanding of the physical phenomena. The proposal presented here is a balanced approach, where students are encouraged to develop and understand the maths underlying control systems analysis, but not in a deep algebraic procedure. Instead, they rely on a spreadsheet, with its unparalleled interface and advanced complex number and polynomial functions to develop a root-locus graphic and analyse the dynamic response of a second-order system. Over the last few years, this strategy has been implemented in the Automation and Control classes for students majoring in electrical and mechanical engineering. The feedback from students has been very positive, especially when comparing the level of understanding and interest generated among them in comparison with a procedure using other simulation packages.

In systems and control engineering undergraduate courses, the analysis of an electronic circuit in the time domain is often very inconvenient, such that it is generally performed in the Laplace domain. In the time domain, the input $r(t)$ and output $c(t)$ signals are associated with each other by a convolution

$$c(t) = g(t) * r(t), \tag{1}$$