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A New Framework for Numerical Analysis of Nonlinear Systems: the Significance of the Stahl's Theory and Analytic Continuation via Padé Approximants

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An appropriate embedding of polynomial systems of equations into the extended complex plane renders the variables as functions of a single complex variable. The relatively recent developments in the theory of approximation of multivalued functions in the extended complex plane give rise to a new framework for numerical analysis of these systems that has certain unique features and important industrial applications. In electricity networks the states of the underlying nonlinear AC circuits can be expressed as multi-valued algebraic functions of a single complex variable. The accurate and reliable determination of these states is imperative for control and thus for efficient and stable operation of the electricity networks. The Padé approximation is a powerful tool to solve and analyze this class of problems. This is especially important since conventional numerical methods such as Newton's method that are prevalent in industry may converge to non-physical solutions or fail to converge at all.

The underlying concepts of this new framework, namely the algebraic curves, quadratic differentials and the Stahl's theory are presented along with a critical application of Padé approximants and their zero-pole distribution in the voltage collapse study of the electricity networks.