

Fractional slope on the log-log Bode plot has long been observed in characterizing a wide range of natural processes which have been called fractal systems. This non-integer power behavior often causes certain mathematical difficulties in the study of fractal systems.

Fractional power poles (FPP) have been suggested for representation of fractal systems in frequency domain. To study their behavior two methods have been used. The first emphasizes the approximation of fractal system by a singularity function, a pole-zero structure, from which the discrete distribution of relaxation times can be obtained and an analog circuit model of the Foster type can be synthesized. The second deals with direct time domain representation by a set of linear time-varying differential equation whose finite order depends on the next highest integer of the fractal dimensions. A complete investigation of this time domain representation has been made in terms of existence, uniqueness, boundness, and asymptotic stability behavior of its solutions, as well as analytical derivation and performance characteristics of these solutions so that fractal system dynamical behavior can be analyzed and understood.