Part I
Projector based approach

Part I describes the core of the projector based DAE analysis, the construction of admissible matrix function sequences and the notions of regular points and regularity regions of general DAEs

$$f((d(x(t),t))',x(t),t) = 0$$

in a hierarchical manner starting with constant coefficient linear DAEs, then turning to linear DAEs with variable coefficients, and, finally, considering fully implicit DAEs.

Chapter 1 deals with constant coefficient DAEs and matrix pencils. We reconsider algebraic features and introduce them into the projector framework. This shows how the structure of the Weierstraß–Kronecker form of a regular matrix pencil can be depicted by means of admissible projectors.

The extensive Chapter 2 on linear DAEs with variable coefficients characterizes regular DAEs by means of admissible matrix function sequences and associated projectors and provides constructive projector based decouplings of regular linear DAEs.

Then, with this background, a comprehensive linear theory of regular DAEs is developed, including qualitative flow properties and a rigorous description of admissible excitations. Moreover, relations to several canonical forms and other index notions are addressed.

Chapter 3 contains the main constructions and assertions concerning general regular nonlinear DAEs, in particular the regularity regions and the practically important theorem concerning linearizations. Also local solvability assertions and perturbation results are proved.

We emphasize the hierarchical organization of the approach. The admissible matrix function sequences built for the nonlinear DAE (0.10) generalize those for the linear DAE (0.14) with variable coefficients, which, in turn, represent a generalization of the matrix sequences made for constant coefficient DAEs (0.15). Part IV continues the hierarchy with respect to different views.