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DC-DC power converters modeling: from averaging to hybrid systems

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The theory of pulse DC converters for a long time was based on the average values of the variables. Cornerstones of the work in this area are published by R.D.Middlebrook (California Institute of Technology, Pasadena) and Professor B.P. Soustin (Krasnoyarsk Polytechnic Institute), that were caused by quite practical needs provide power spacecraft based on solar energy. Since then, the urgency of the task of converting solar energy into electricity has increased many times and gained worldwide significance both in terms of application and geography spread.

In addition, the DC- DC converters have significantly expanded the range of applications due to the need for energy conversion of fuel cells, mainly due to the massive use of electrified vehicles, including electric vehicles of various classes (hybrid, autonomous), where required frequent exchange of energy in the source drive-to-consumer (electric motor). Application of the theory of averaging with Pulse Withdraw Modulation (PWM) which are more rigorous investigation of the dynamics of DC- DC systems. PWM of the controllers are nonlinear and time-invariant system.

Control system operating in the switching mode in which predetermined structure and dynamic properties respectively, are called hybrid dynamical systems (HDS) that attract attention of many researchers. Continuous operation of HDS are usually described by a system of differential and (or) the difference equations, while the discrete behavior of these systems seems logical expressions or by discrete state machines.

If the whole system is a hybrid dynamic system of its continuous and discrete properties need to integrate at the same time. Therefore HDS have the opportunity to represent many of the systems in a single model without division into separate components, continuous and discrete models.

A large class of power electronics systems can also be classified as HDS, as they demonstrate continuous and discrete behaviors. The continuous nature of the current and voltage signals (for passive components such as inductors, resistors, capacitors) at the same time accompanied by the state of the switching elements (transistors and diodes) that have a status of 0 or 1, which demonstrates their discrete properties.

In hybrid systems, changes of continuous states and changes of discrete states are often connected to each other via inequalities. Fuzzy logic control could be introduced here, since fuzzy systems are typically based on a combination of different operating regimes.