ABSTRACT

Modeling Non-linear Electrical Devices Using Artificial Neural Networks

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Modeling of electrical devices such as semiconductors, electrical transformers and machines presents some difficulty because of their non-linear behavior.

With the increased power of personal computers, a wide range of software is commercially available for simulation. Some are like MATLAB, basically a program for solving problems in mathematics, used in electrical engineering and increasingly adapted for it. Others are like PSpice, a popular commercial version of SPICE, specifically designed for simulating integrated circuits and the world standard for computer simulation of analog circuits.

SPICE has no models for the three-phase transformer and electrical machines; MATLAB has within the last decade with the advent of what is now called the Power System Blockset, introduced limited models for electrical transformers and machines. SPICE was created to simulate microcircuits, which are prone to physical effects that are of little consequence in circuits consisting of individual discrete components, and not much effort was placed on modeling components such as electrical transformers and machines. For high-power semiconductor devices of large dimensions and large values of operating current, the small-signal models lose their accuracy.

In SPICE, the operating temperatures of a device can be set, but in-situ variation of operating temperature with loading is absent, even though operating

temperature varies with loading, and in a semiconductor device the current through the pn junction has a non-linear temperature-dependent relationship with the voltage across it.

Because of these limitations novel artificial neural networks models, which incorporate operating temperature variation due to changes in loading, were created to accurately represent analog semiconductor devices, electrical transformers and machines in simulators such as MATLAB and PSpice which are based on numerical integration.

By acquiring data representative of these devices and training the artificial neural networks, these devices can be accurately represented in these simulation programs. From evaluating the models of the electrical machines as motor-generator sets, it is projected that prime movers such as steam, gas or water turbines, and internal combustion engines may be similarly modeled.

Keywords: John Joseph; John D. C. Joseph; J. D. C. Joseph; transformers; electrical machines; synchronous machines; dc machines; ac machines; induction machines; electrical drives; power electronics; semiconductor, pn junction, diode, transistor, BJT, FET, MOSFET, IGBT, SCR, thyristor, GTO, simulation; MATLAB; SIMULINK, PSpice; soft computing; artificial neural networks.