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Editorial

Diagnosis in Analog Electronic Circuits, Electrical Power Systems and Smart Grids

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Diagnosis, in its most general meaning, is the process aimed at identifying the causes that have produced a behavior, normally anomalous, in a system of either biological or artificial nature. In medicine, the term has long been commonly used and describes the aim of identifying a disease producing certain symptoms. The concept of diagnosis can easily be extended to a more generic biological context, and has eventually been applied also to technology. In fact, in terms of a machine, it is important tracing back to the causes that have produced an anomaly, typically a fault, or possibly a design error; in any case something that, once identified, must be corrected. For simple systems, a diagnosis can be achieved manually by an expert operator. However, as the system complexity increases, fault identification becomes more and more difficult and taking advantage of automatized tools becomes necessary. An additional advantage of an automated diagnosis system is its inherent rapidity, an extremely important feature when the consequences of a fault involve many users simultaneously, as, for example, in the case of electrical power distribution, or when they can create safety critical conditions. In such cases, an even more desirable feature is the ability to prevent the malfunctions by recognizing the symptoms that precede the fault, typically associated with gradual performance degradation or anomalous variations in some key parameters, produced by aging or alterations associated with chemical, mechanical and wear phenomena.

Electrical and electronic systems certainly belong to a category where the need for automated diagnosis is extremely important, due to their inherent complexity and ubiquitous presence. It is also important to keep in mind that, despite the fact that more than 80% of electronic circuits are digital, around 80% of faults occur mainly in the analog parts [1]. If automatic diagnosis tools are common in the digital world, in the analog field, dominated by more complex phenomena, the same level of automation has not yet been reached and the development of this kind of tools is still an open research subject, on which researchers and industrial engineers are intensively working [2].

In this Special Issue, we focus on five papers covering aspects of different kinds of systems.

Two papers, produced by long-term experts in the field [3,4], cover the problem of faults in circuits containing Distributed Parameter Multiconductor Transmission Lines (DPMTL) and lumped elements, which terminate the end of a circuit. The first paper [3] aims at developing a method for diagnosing short and open faults with an approach based on a measurement test performed in AC with the associated diagnostic equations belonging to the frequency domain. The obtained nonlinear complex equations are solved by a specifically developed numerical method. The procedure is applied to the possible soft shorts and is adapted to the detection and location of open faults in DPMTL. The second paper [4] proposes instead a parametric fault diagnosis of analog circuits operating at a very high frequency and consisting of a Distributed Parameter Transmission Line (DPTL), terminated at both ends by lumped one-ports. The method takes into account all aspects of parametric fault diagnosis: detection of the faulty area, location of the fault inside this

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area, and estimation of its value. It can be extended to a broader class of circuits containing several transmission lines. Several numerical examples are also presented.

An approach based on machine learning is applied to the parametric fault diagnosis of analog circuits in [5]. The technique is based on three sequential steps: the first one is the calculation of testability and ambiguity groups of the circuit under test; the second one is the location of the failure and its correct fault class via multi-frequency measurements; the third step is the estimation of the value of the faulty component, taking into account the fabrication tolerances of the components. The study combines machine learning techniques, used for classification and approximation, with testability analysis procedures for analog circuits. Again carrying out the testability evaluation, the paper in [6] proposes a new graphical method specifically dedicated to the fault diagnosis of DC–DC converters, executed via Complex Valued Neural Networks (CVNNs), based on Multi-Layer Multi-Valued Neurons (MLMVN). In order to effectively design the network, the testability analysis is exploited in a special graphic environment proposed by the authors.

In paper [7], the diagnosis of particle-induced failures in harsh environments, such as space and high-energy physics experiments, is discussed. To address these effects, simulation-before-test and simulation-after-test are used by the authors as key points in choosing which Radiation Hardening By Design (RHBD) techniques can be implemented to mitigate or prevent failures. The effects that space and high-energy environments have on two different architectures for high-radiation and high-frequency data transmission are reported, and the efficiency of the mitigation techniques is exploited.

The papers presented in this Special Issue testify the heterogeneous and transversal aspects of studies and applications in the field of fault diagnosis. However, the topics of the Special Issue included other subjects, such as maintenance, fault prevention, fault resolution, fault-tolerant approaches and non-intrusive monitoring techniques of smart grids, not covered by the five papers. This is due to the relatively recent interest of the scientific community in smart grids. The absence of material on these topics must encourage scholars to continue research in the field of diagnosis.

We would like to take this opportunity to thank all authors for submitting papers to this Special Issue. We also hope that readers will find new and useful information on diagnosis in analog electronic and electrical circuits.

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