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Neuro-Fuzzy fault detection method for photovoltaic systems

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Abstract

In this work we present a faults detection method for photovoltaic systems (PVS). This method is based on the calculation of sets of parameters of a PV module in different operating conditions, by means of a Neuro-Fuzzy approach. The PV system status is determined by evaluation and comparison of norms based on the aforementioned parameters, with threshold values. This intelligent system developed in Matlab&Simulink environment, consists on the study of the crucial information that the six parameters in normal and faulty condition contain. They are calculated using the I-V curves and synthesized by "hybrid" models. Results show that the diagnosis system is able to discern between normal and faulty operation conditions and with the same defective existence of noise and disturbances.

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Keywords: Photovoltaic system; Fault diagnosis ; Neuro-Fuzzy model; I-V characteristic analysis; Norm-test

1. Introduction

With the growth of world energy consumption and the concerns about environmental effects of fossil fuels, human society is in desperate need of renewable energy sources (e.g., solar, wind, geothermal). They are clean and eco-friendly. Among this renewable energy sources, photovoltaic (PV) energy draws a significant attention since solar energy is accessible and abundant [1].

The problem is that, differently from traditional power sources, the photovoltaic (PV) energy may have undetectable and unlearned faults in current and in voltage during the utilization in conventional overcurrent (OCPD) and in overvoltage (OVPD) protection devices.

The faults in PV plants do not only affect the performances and services of the plant but may also lead to critical and detrimental situations. In fact, without proper fault detection, the presence of faults in PV arrays not only causes power losses, but also can cause a probable fire hazard for the whole system [2]. Having considered these problems, it is of paramount importance to check the PV system status (normal

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or off-normal condition).

Accordingly, numerous PV monitoring and fault detection methods related to a definite PV model have been studied in the literature. Firstly, the traditional modeling approaches based on long-term energy yield and power losses (V-I measurement and Flash test) have been proposed [3, 4].

An extension of method using correlation function and the matter-element model was suggested to identify specific the fault types of a PV system (PVS) [5]. Furthermore, a decision tree model has been proposed for the detection and classification of defects in PV systems [6]. Additionally, the capacitance measurement (ECM) and the time domain reflectometry (TDR) for fault detection in PV array were introduced [7].

Finally, intelligent system (based on neural network, Fuzzy systems or Neuro-Fuzzy network) for automatic detection of faults in PV fields were proposed [8-10]. Interpreting I-V curve characteristic by applying flash test to determined fault type [11, 12] and using signal processing to detect online fault in PV system [13, 14]. However, none of the previous works have presented a complete algorithm and methodology for faults detection and classification that is able to represent the real system effectively.

After reviewing relevant works in PV systems diagnosis area, this paper presents an intelligent faults diagnosis system, based on "Norm-test"of the six attributes of I-V curves.

The detection system initially uses an I-V curves estimation by the ANFIS PV model simulator. Secondly it uses a Norm-test to generate the difference among sets of parameters calculated in different conditions at operating conditions. The diagnostic method can detect the fault and classify the specific fault type and it deals with noises and disturbances. The models of the PV system and the whole diagnostic procedure has been developed on Matlab&Simulink environment.

This intelligent procedure of fault detection has been tested for a a-Si:H triple layer amorphous module (Uni-Solar ES-62T), that is installed at the MIS laboratory renewable energy platform at the University of Picardie Jules Verne, Amiens (France).

2. Photovoltaic module modeling in ANFIS