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Nonlinear Systems Estimation in Renewable Energies

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Abstract

In this paper, an approach estimation of nonlinear systems in renewable energies is studied. The system can be structured by blocks-oriented. The proposed solution is more general and can be easy to implement.

Keywords: Nonlinear systems; Renewable energies; Oriented blocks; Harmonics analysis

Introduction

In this work, nonlinear system used in renewable energies is dealt. These nonlinear systems can be described by blocks-oriented. Lately, these types of models are increasingly used practically [1-4]. Nonlinear systems estimation parameters are a necessary step in control [5-7]. The nonlinear element can be in input of system (Figure 1) or in output of system (Figure 2). If the two blocks are parametric, the determination of parameters nonlinear system can be done using quite a few solutions e.g. [1-4]. When both parts are parametric, the identification problem has been dealt with using several methods e.g. [1,8-10]. Two-stage nonlinear parameters estimation solutions, involving two stages, have been established in e.g. [1,8-10]. Presently, a solution nonlinear parameters estimation is dealt. The considered nonlinear system has a nonlinear element in output of system (Figure 2).

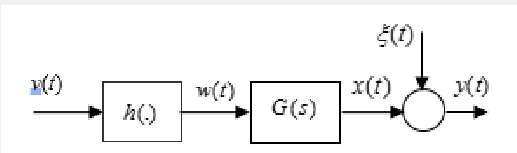

Figure 1: Hammerstein nonlinear systems.

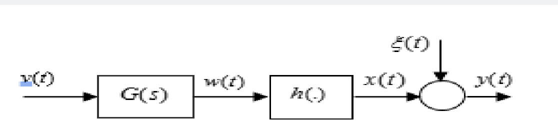

Figure 2: Wiener nonlinear systems.

These nonlinear models can describe several industrial systems [11]. These models have been much more useful to represent nonlinear systems. In this paper, an estimation approach is developed to determine the nonlinear and linear elements parameters (i.e. G(s) and f(.)). The paper is organized as follows: a brief description of the considered nonlinear system is presented in Section 2; the nonlinear system parameters (of nonlinear and linear elements) determination is formulated in Section 3; This paper will be concluded by a conclusion in Section 4.

Presently, the proposed nonlinear models consist of a linear element followed in series by a nonlinear function $h(.)$ (Figure 1). This nonlinear system is analytically defined by the following equations:

$$w(t) = g(t) * v(t) \quad \text{.............................} \quad (1)$$

$$x(t) = h(w(t)) \quad \text{.................................} \quad (2)$$

$$y(t) = h(w(t)) + \xi(t) \quad \text{.....................} \quad (3)$$

Note that the difficulty of this problem comes from the fact that, only the input of nonlinear system v(t) and the output signal y(t) are measurable.

The equation error ξ(t) is a stochastic sequence of independent random variables. This signal describes the external noise. The linear dynamic block is characterized by the amplitude $|G(j\omega)|$ and the phase $\varphi(\omega)$. The system n onlinearity h(.) is parametric, e.g. polynomial function of order p. The output of nonlinear block can be expressed as:

$$x(t) = h(w(t)) = \sum_{k=0}^{p} \lambda_k w(t)^k \quad \text{..................} \quad (4)$$

where, are the parameters of nonlinear function h(.).

In this work, the objective is to develop a solution letting the estimation of parameters of the above nonlinear system (Figure 2) using uniquely the input signal v(t) and the output system y(t).

Nonlinear System Parameters Determination

This problem has several solutions (see please [7] and [11]). Without loss of generalities, a very effective solution can be taken by choosing: .

First stage

Then, applying the following signal to the nonlinear system:

$$v(t) \in \{U_l\,;\, l = 0 \,\dots\, p+1\} \quad \text{(5)}$$

where $U_l,\, l = 0 \dots p+1$, are constant values. Accordingly, using the chosen solution, the signal w(t) keeps the set of values:

$$x(t) \in \{U_l\,;\, l = 0 \,\dots\, p+1\} \quad \text{(6)}$$

Then, the parameters estimation of nonlinear function can be easily done using uniquely the set of input signal (5) and the measured output signal y(t). Specifically, we have $p+1$ unknown parameters corresponding to f(.), using the set of $p+1$ measured points these unknowns can be covered.

First stage

At this point, the unknowns of the system that remain are the linear element parameters ($|G(j\omega)|$ and $\varphi(\omega)$). For convenience, using the input signal:

$$v(t) = V \sin(\omega t) \quad \text{(7)}$$

where V is arbitrarily chosen. Accordingly, using Equation (1), the signal can be written according to the following expression:

$$w(t) = V\,|G(j\omega)|\sin(\omega t + \varphi(\omega)) \quad \text{(8)}$$

Furthermore, it is readily seen using the Equations (4) and (8) that, the signal can expressed as:

$$\begin{aligned} x(t) &= \sum_{k=0}^{p} \lambda_k w(t)^k \\ &= \sum_{k=0}^{p} \lambda_k V^k |G(j\omega)|^k (\sin(\omega t + \varphi(\omega)))^k \end{aligned} \quad \text{(9)}$$

Recall that, the unknowns parameters in (9) are $|G(j\omega)|$ and $\varphi(\omega)$ (the parameters of nonlinear block h(.) $\lambda_k,\, k = 0 \dots p$, are determined in the first stage).

It readily follows from (9) that, the measure of one component (harmonic), the amplitude and the phase, is sufficient to estimate the parameters of linear block G(s).

Conclusion

In this work, a determination parameters approach is proposed to estimate the parameters of nonlinear systems. The considered nonlinear system is characterized by a nonlinear element in output of system. In the suggested solution, two independent stages. In the first, the nonlinear function parameters are estimated using an easy input sequence. In the second stage, the parameters of linear block can be covered using sine signal.

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