Chapter 21
Artificial Neural Network for PWM Rectifier Direct Power Control and DC Voltage Control

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ABSTRACT

In this chapter, a new technique has been proposed for reducing the harmonic content of a three-phase PWM rectifier connected to the networks with a unit power factor and also providing decoupled control of the active and reactive instantaneous power. This technique called direct power control (DPC) is based on artificial neural network (ANN) controller, without line voltage sensors. The control technique is based on well-known direct torque control (DTC) ideas for the induction motor, which is applied to eliminate the harmonic of the line current and compensate for the reactive power. The main idea of this control is based on active and reactive power control loops. The DC voltage capacitor is regulated by the ANN controller to keep it constant and also provides a stable active power exchange. The simulation results are very satisfactory in the terms of stability and total harmonic distortion (THD) of the line current and the unit power factor.

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1. INTRODUCTION

Recently, different control approaches have been proposed for designing nonlinear systems for many practical applications, such as optimal control, nonlinear feedback control, adaptive control, sliding mode control, nonlinear dynamics, chaos control, chaos synchronization control, fuzzy logic control, fuzzy adaptive control, fractional order control, and robust control and their integrations (Azar & Vaidyanathan, 2015a,b,c, 2016; Azar & Zhu, 2015; Azar & Serrano, 2015a,b,c,d, 2016a,b, 2017; Boulkroune et al, 2016a,b; Ghoudelbourk et al., 2016; Meghni et al, 2017a,b,c; Azar et al., 2017a,b,c,d; Azar 2010a,b, 2012; Mekki et al., 2015; Vaidyanathan & Azar, 2015a,b,c,d, 2016a,b,c,d,e,f,g, 2017a,b,c; Zhu & Azar, 2015; Grassi et al., 2017; Ouannas et al., 2016a,b, 2017a,b,c,d,e,f,g,h,I,j; Singh et al., 2017; Vaidyanathan et al, 2015a,b,c; Wang et al., 2017; Soliman et al., 2017; Tolba et al., 2017).

The increasing use of electronically powered and controllable systems in the industrial sector, motivated by improved performance, has led to a proliferation of static converters. Today, the number of these devices connected to electricity grids is constantly increasing. The switching operation of the semiconductor components constituting these converters is the reason why their behavior with respect to the power source is non-linear. Indeed, they take non-sinusoidal currents and for the most part consume reactive power, which poses serious problems for electrical networks. Static converters have become the most important sources of harmonics on the network. The uncontrolled diode and controlled thyristor rectifier is the most polluting and widespread static converter in both industry and domestic appliances. Under certain operating conditions, it can introduce a harmonic distortion rate (THDi) of current greater than 30%. For this reason, some recent adapted international standards, such as IEEE Standard 519, IEC 61000 and EN 50160, impose limits on the THD of currents and voltages within the supply network (5% for currents and 3% for voltages). In view of this state of affairs, and in order to limit the harmonic disturbance caused by the power electronics systems connected to the network, it is necessary to develop curative devices such as active filtering on one side and the other to design preventive actions such as non-polluting converters, equipped with a control device making the current drawn on the network as sinusoidal as possible.

In this context and over the past few years, high-power static converters have started to appear on the market mainly concerning AC / DC conversion. Indeed, changes have been made on conventional bridge rectifiers modifying their structure or their control system in order to reduce their injection of harmonic currents into the network. These new AC / DC converters are distinguished by their structure and how to handle the currents absorbed. They can be divided into three classes: diode rectifier with power factor correction (PFC), rectifier with current injection and PWM-rectifier with voltage or current structure. Among these most popular and attractive structures are the voltage PWM-rectifier. It is characterized by a quasi-resistive behavior with respect to the supply network. In addition to its ability to control the currents absorbed and to operate with a power factor close to one unit, the voltage Pulse Width Modulation (PWM) rectifier can also operate in two modes: rectification and regeneration. Thus, it controls the flow of active and reactive power in both directions. This advantage enables it to be used in a wide range of applications, particularly in regeneration mode and bidirectional power flow control (variable speed drives). This converter currently a key research theme for specialists in the field. The research is carried out mainly on so-called advanced strategies (predictive, fuzzy, Neurons, etc.) as well as on the selection and sizing of the input filter. To solve this problem, several research works have been done on PWM rectifiers due to some of their important advantage such as power regeneration capabilities, control of DC-bus voltage, low harmonic distortion of input currents, and high-power factor (Bouafia