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Hybrid Control of the Single-Phase Induction Machine without Capacitor Using Artificial Intelligence Techniques

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Abstract

The hybrid controls are the controls combining several techniques. Their purpose is to benefit from performance of each of these techniques. The control proposed in this paper is based on this hybrid approach; combining the performances of the controls which are based on the tools of the artificial intelligence (artificial neural networks and fuzzy logic) applied to control the single-phase induction machine without capacitor supplied by voltage source inverter. The application of this approach to the single-phase induction machine is a contribution to the study of this machine. Indeed, this type of machine has not yet taken its whole share from various works present until now, compared to the three-phase induction machine. The simulation results show the feasibility and good performance obtained by the proposed control.

Keywords: Single-phase induction machine without capacitor (SPIMWC) ; hybrid control ; artificial neural networks ; fuzzy logic ; static converter.

1. Introduction

Single-phase machines are widely used in commercial and industrial applications where energy conversion efficiency and cost are key topics. They are traditionally used in constant speed home appliances, usually in locations where only single-phase energy supply is available without any type of control strategy. They are found in washers, air conditioners and many other applications.

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Now, variable speed controls of electric motors are necessary in industrial applications. In addition, the cost reduction and high efficiency of power electronic and micro-electronics devices are motivating to implement a single-phase machine drives in both industrial and domestic applications. These years, research laboratories focus on variable speed drives, especially for SPIM, and major improvements are underway for achievement [1-4].

The selection criteria of controls depends on several factors, such as the response time, the robustness towards external disturbances or parameter changes, simplicity of implementation, the computing time. One of the current directions of research is to use the tools of the artificial intelligence; such as: fuzzy logic and artificial neural networks; to solve problems encountered in control system or just improve their operation [5-7].The works on these two topics are the subject of great passion. However, they are opposite to each other: The first has a character very explicit; it bases the synthesis of controllers on the expertise and declarative representation, from which an approximate reasoning is developed. The second follows a blind approach in the sense that it appeals to notions of learning and is based only on data collected. In general, in control system, fuzzy controllers are known for their robustness and neural networks are known for their rapidity of response [8].

The hybrid controls are the controls combining several techniques. Their purpose is to benefit from performance of each of these techniques. The control proposed in this paper combines these two techniques. It results from a study which compares the performances of two controls; one based on the artificial neural networks and the other on fuzzy logic; detailed in [8].

The application of this approach to the single-phase induction machine is a contribution to the study of this machine. Indeed, this type of machine, less known than the three-phase induction machine, has not yet taken its whole share from various works present until now. What enabled us to propose a new decoupling approach for this type of machine, detailed in [7] ; and by the means of this paper, a structure of hybrid control combined the performances of the controls based on artificial neural networks and fuzzy logic for rapid and robust control of single phase induction motor.

Nomenclature

s, r	Stator and rotor index.	V_r	Rectified voltage, V.	ω_{s1}	Slip frequency, rad/s.	$T_r = L_r/R_r$	Rotor time constant, s.
n	Rated value index.	V_n	Rated voltage, V.	θ	Angle, rad $\theta = \int \omega \, dt$.	SPIM	Single-Phase Induction Machine
ref, sp , c	Reference value, speed and current index.	I	Current, A.	f	Viscose friction coefficient, Nm.s/rad.	SPIMWC	Single-Phase Induction Machine Without Capacitor
α, β	Rotor reference frame.	Ω_r	Mechanical speed, rad/s.	P J	Pole pair number. Moment of inertia, Kg.m^2.	N C; F C; C C	Neural ; fuzzy & conventional controller.
m, a	Stator reference frame (main and auxiliary)	Ψ	Flux Wb.	σ	Leakage coefficient $= 1 - L_M^2 / L_s L_r$.	N Csp	Neural speed controller.
d, q	Synchronously rotating reference frame.	T_{em}	Electromagnetic torque, N.m.	R_s, R_r	Stator, rotor resistance, Ω.	F Ccd, cq	Fuzzy current I_{ds} & I_{qs} controller.
V	Voltage, V.	ω_s, ω_r	Stator, rotor angular frequency rad/s.	L_s, L_r, L_M	Stator, rotor and mutual inductance, H.	PWM	Pulse-Width Modulation.
V_{s1}, V_{s2}	Phase Inverter-Fed voltage, V.			$T_s = L_s/R_s$	Stator time constant, s.	VSI	Voltage Source Inverter.