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Introduction of Doubly Fed Induction Machine in an Electric Vehicle

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Abstract

This work is aiming to study and control of drive train of an electric vehicle based on doubly fed induction machine (DFIM), the power structure of this machine and the control strategy applied allow operating over a wide range of speed variation, for both applications: engine and recovery. Therefore the power of the machine can reach twice its rated power. After modeling different parts of the drive train a numerical simulation in MATLAB / Simulink is carried out. The results show the good performance of the vector control, and the structure of power applied to the DFIM.

Key words: DFIM, PWM Converters, Battery, Gearbox, control of vehicles drive train.

1. Introduction

Industrial applications of variable speed drives require increasingly important performance and a maximum reliability and minimum cost. Indeed, currently the use of AC machines is becoming more common as these machines are characterized by their robustness and longevity compared to commutator machines [1-2].

Literature shows the great interest shown in the double-fed induction machine (DFIM) for various applications: as a generator for wind energy and for certain industrial applications, such as rolling and traction or propulsion maritime. Indeed, most work on this machine have been the subject of the study of the structure where the stator is directly connected to the network and the rotor powered by a power electronics converter. The advantage of this solution is that the converter is sized at 30% of the rated power of the system and therefore the variation of speed limit near the speed of synchronization [3-4].

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However, the objective of this work is to operate the DFIM in a wide range of speed variation, for application in a drive train of an electric vehicle; for this the machine is connected through two power converters with pulse wide modulation control (PWM), these converters are both powered by a battery, which is a key element for development of electrical vehicles, namely the energy density is low and the charge time very long [4]. In the drive train we use only one machine (DFIM) for the motorization of the vehicle, and for recovering energy during braking. The advantage of the power structure chosen is not only to operate the machine in a wide range of speed variation, but also to give to the machine the capacity to operate up to twice its rated power. So the power density is improved. Figure (1) illustrates the schematic diagram of the drive train:

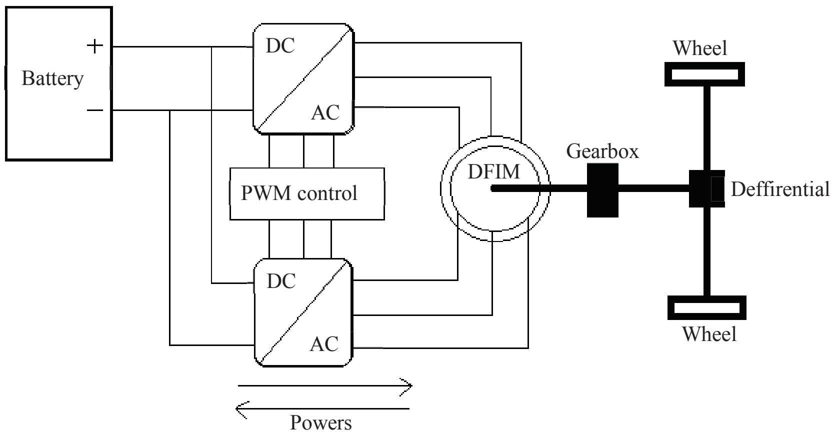

Fig (1): Representative diagram of the electric vehicle drive train

The ability of the DFIM to start with high torque makes possible the elimination of clutch and gearbox. The torque is the size dimensioning; therefore the machine must be heavier and bulky, so more expensive. The use of fixed ratio gearbox overcome these problems and allows to have a simple machine that can provide the required torque.

The power electronic converters used for power transfer between the battery and the DFIM are sized at 100% of rated power of the machine, those are bidirectional converters with PWM control, they absorb power from the battery when the machine operates as a motor and they provide to it when the machine operates as a generator (braking).

Semiconductors used depends on power level passing converters; for low powers are used IGBT. For high power converters based on IGCT or GTO semiconductors can be used. Variable-speed drives with a rated power up to 40MW (IGCT) or 100MW (GTO) have been installed. A disadvantage of these semiconductor types is their lower switching frequency, compared with IGBT's [5].

2. DFIM model

Two-phase equivalent model of the DFIM represented in the reference (dq) linked to the rotating field is given as follows [6-7]: