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Vector control techniques for traction drive with induction machines - comparison

Ľuboš Struhárňanský\textsuperscript{a,b,*}, Ján Vittek\textsuperscript{a}, Pavol Makýš\textsuperscript{a}, Jaroslav Ilončiak\textsuperscript{b}

\textsuperscript{a}Department of Power Electrical Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 1, Žilina
\textsuperscript{b}EVPÚ a.s., Trenčianska 19, Nová Dubnica 01851, Slovak Republic

Abstract

Nowadays trends in railway transportation are improvement of passengers comfort, safety, speed and reliability of transportation. This paper deals with improvement of aforementioned performances from the traction drive view. The most often exploited drives system is the induction motor supplied from inverter therefore strategy of its control has direct influence on reliability. Control techniques exploited in traction drives are ‘field oriented control’ (FOC) and ‘direct torque control’ (DTC). For investigation of the drive performances controlled with these two techniques the parameters of 152 kW induction motor are used. The comparison can be done on various criteria, but in this paper comparison will be focused on influence of key parameters including magnetizing inductance $L_m$, rotor inductance $L_r$ and rotor resistance $R_r$. The study is done by simulation using the Simulink. The simulation and evaluation of both control strategies are performed using actual parameters of induction machine fed by an IGBT PWM inverter.

Keywords: FOC; DTC; VC; Induction motor

* Corresponding author. Tel.: +421908730599; 
E-mail address: lubos.struharnansky@fel.uniza.sk
1. Introduction

Due to their numerical advantages induction machines (IM) have attracted increasing interest in recent years for traction drive applications. The low maintenance cost, high steady state torque density and simple controller of the IM motor drives make them a suitable alternative in certain applications.

The most often exploited control strategies for IM are field-oriented control (FOC) and direct torque control (DTC). They have been invented in the 70’s and in the 80’s respectively. These control strategies differ on the operation principles but objectives of control are the same. The aim of both is to effectively control the motor torque and flux in order to force the motor to track accurately the prescribed state-variables command regardless of the machine and load parameter variation or external disturbances. Both control strategies have been successfully implemented in industrial and traction applications.

The supporters of field-oriented control and direct torque control claim the superiority of their strategy versus the other. Up to now, this question has not been clearly answered. The purpose of this paper is to present a comparative study of these two control strategies in order to clarify the “truth”. The comparison can be done on various criteria, but in this paper the comparison will be focused on influence of key parameters such as magnetizing inductance, $L_m$, rotor inductance, $L_r$, and rotor resistance $R_r$.

2. Induction Motor Measurements (IM)

To obtain realistic parameters and their subsequent exploitation in simulation it was necessary to measure the IM parameters. The conventional measurement methods prescribed by STN standard were used namely:

- no-load condition,
- locked rotor,
- loaded IM.

![Figure 1](image_url)

From the measured values the equivalent circuit parameters of ASM were calculated under rated conditions that were used also for simulations. The accuracy of the equivalent circuit parameters of ASM has been verified for a no-load state and for rated load and simulation results corresponded to the results of measurements. Measured and calculated parameters of equivalent circuit ASM are: $R_s = 0.03758[\Omega]$, $R_r = 0.038382[\Omega]$, $L_m = 0.0254[mH]$, $L_{ds} = L_{dr} = 0.99032[mH]$. 
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