Transient Management Solution for the Reconfiguration of Tandem Inverter Fed Induction Motor

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Abstract: The paper focuses on the reconfiguration process of vector control systems of the induction motor supplied from the tandem (hybrid) static-frequency converter. Reconfigurable control structure ensures different strategies for operating modes with non-failed and partial-failed converter. The reconfiguration process introduces perturbations in the vector controlled AC drives. The paper tries to give some solutions for the transient management. Problems related to hardware and software implementation of the transition from a control structure to another are discussed.

Key words: Converter control, Field-oriented control, Real time processing, Vector control, Run-time reconfiguration, Transient management.

1. Introduction

The term "*tandem converter"* denotes a solution of DC link Static Frequency Converters (SFC), used in medium- and high-power AC drives 0. It combines the advantages of the two component inverters, with different source character (current and voltage) and different modulation method 0 Trzynadlowski 1999].

The most sensitive situation for the tandem converter is when the VSI (Voltage Source Inverter) fails, because the control structure looses its voltage-source character 0. In such a situation, the motor is fed only by the CSI (Current Source Inverter) and the current control concept will be applied. Under these circumstances the control structure does not correspond any more for the new demands and this justifies the need for reconfiguration 0.

The reconfiguration process introduces perturbations, which were treated in 0. While the transients generated in the control system are low power transients, the perturbations, which appear in the induction motor and converter, have high power character.

2. PERTURBATION MANAGMENT

In Figure 1 can be observed the perturbations introduced in the stator currents (t=0.5s). The transient effects on the AC drive – while the stator current waveforms became sinusoidal again - are observed for 0.1s.

The reconfiguration transients for the AC drive act as disturbances and reduce the quality of the drive performances. For this reason it is important to reduce the reconfiguration transients.

The transients amplitude and durations also depends on the controlled character of the state in which it will be reconfigured the tandem converter. There are four reconfigurable control structure possibilities as shown in the Table 1.

To manage the transients then, one may observe that are very few IP cores of the control structure (i.e. modules presented in 0), where the transient filtering can be solved. There are the PI controllers of flux, torque, and speed, and there is the DC link PI controller.

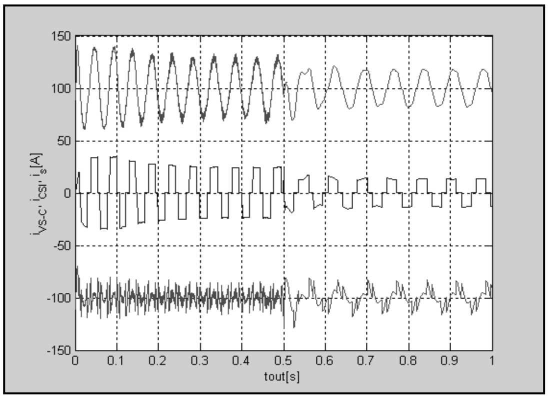

Figure 1. Current waveforms before and after reconfiguration.

Table 1. Reconfiguration variants of the tandem converter

Tandem converter-fed motor		**CSI-fed motor**	**Observations**
Orientation Flux	**PWM Method**	**Orientation Flux**	
Ψr	Space Vector Modulation (SVM)	Ψr	0, 0
Ψs	Space Vector Modulation (SVM)	Ψr	0, 0, 0
Ψr	Current Feedback Modulation ("bang-bang")	Ψr	0

One may found that if the DC link Controller will have PID character there is possible to filter the transients, but this influence the controller actions on the controlled reference flux and speed. So the transient management should act in concordance with the stability of the control system but the action have to be done in all the controllers.

This means that the entire controller functions (for example the flux one) one should show function continuity at the reconfiguration time t_r, which means:

$$u(t)=\begin{cases} k_{p1}e(t)+k_{i1}\int e(t)dt \ \text{for} t \le t_r; \\ k_{p2}e(t)+k_{i2}\int e(t)dt \ \text{for} t > t_t; \end{cases} \qquad (1)$$

The transient filtering it would be successful, when the controlled *d or q* component stator/rotor current (or voltage) function is continue at t_c. This means:

$$\begin{aligned} \underrightarrow{lim}\, i_{sd\lambda r}^{Ref}(t \to t_r - 0) &= \underrightarrow{\lim}\, i_{sd\lambda r}^{Ref}(t \to t_r + 0); \\ \underrightarrow{lim}\, i_{sq\lambda r}^{Ref}(t \to t_r - 0) &= \underrightarrow{\lim}\, i_{sq\lambda r}^{Ref}(t \to t_r + 0); \end{aligned} \qquad (2)$$

These conditions have to be implemented in reconfigurable hardware and they impose implementation conditions for the variable transfer at the reconfiguration moment t_r .

3. Simulation results

MATLAB-Simulink simulation was performed for the presented vector-control-system structures. The rated data of the motor are: 5.5 *kW*, 720 *rpm*, 50 *Hz*, 220/380 V^{rms}, 24.3/14 A^{rms}, cos φ = 0.735. There are simulated the behaviour of the system for the following operation modes: the starting (at negative speed reference) with speed-dependent load torque, first in tandem-fed mode and after 1.3 *sec* a speed reversal was performed, then at 1.9 *sec* it was followed by the reconfiguration of the vector-control structure corresponding to the CSI-fed mode. The following figures presents the transients on the flux and voltages space diagram.

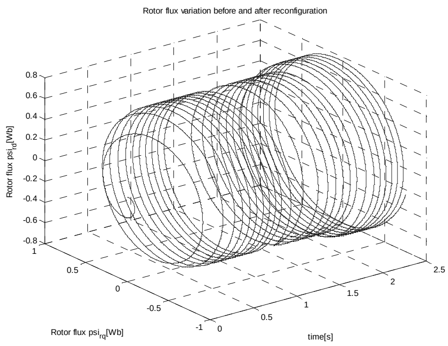

Figure 2. Rotor flux space phasor

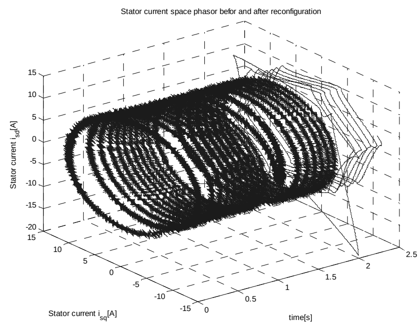

Figure 3. Stator current scpace phasor

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