PREDICTIVE CURRENT CONTROL OF VOLTAGE SOURCE INVERTERS

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Abstract: A new current controller for a voltage source inverter based on calculation of an electromotive force is presented in this paper. Practical aspects of realizing the new controller in a system with a signal processor are considered. Delays introduced by measurements are taken into consideration. An improved algorithm with one period prediction of current is presented. Controller was realized in an experimental system with floating point signal processor and with Field Programmable Gate Arrays (FPGA). Results of the simulations and experiments are presented.

SUMMARY

The calculations for current controller and the reading of new time instants to the counters should be realized between the instant (k-1) and (k). Current controller has information about current value at instant (k-1) and earlier and about voltage value at instant (k-1) and earlier instants. A task of current controller is a voltage calculation for instant (k) such that at instant (k+1) a current error will be reduced to zero. For a realization of the controller it is desirable to determine a current at instant (k). For this we can replace the current derivation by a current increment in time $T_{imp}$.

It is considered that for small switching period the ohmic drop and the back emf stay constant, which causes the voltage drop in above to be together with back emf and noted as $e$. The back emf in step (k-3) and (k-2) of controller operation could be identified:

$$e_{\alpha}(k-3) = \frac{u_{\alpha}(k-3) - u_{\alpha}(k-2) - i_{\alpha}(k-3)L_\sigma}{T_{imp}}$$
$$e_{\beta}(k-3) = \frac{u_{\beta}(k-3) - u_{\beta}(k-2) - i_{\beta}(k-3)L_\sigma}{T_{imp}}$$

and

$$e_{\alpha}(k-2) = \frac{u_{\alpha}(k-2) - i_{\alpha}(k-1) - i_{\alpha}(k-2)L_\sigma}{T_{imp}}$$
$$e_{\beta}(k-2) = \frac{u_{\beta}(k-2) - i_{\beta}(k-1) - i_{\beta}(k-2)L_\sigma}{T_{imp}}$$

The emf for the period from (k-1) to (k) may be predicted by an increment of the back emf position by $\Delta\phi_e$.

$$\begin{bmatrix} e_{\alpha}(k-1) \\ e_{\beta}(k-1) \end{bmatrix} = \begin{bmatrix} \cos(\Delta\phi_e) & \sin(\Delta\phi_e) \\ -\sin(\Delta\phi_e) & \cos(\Delta\phi_e) \end{bmatrix} \begin{bmatrix} e_{\alpha}(k-2) \\ e_{\beta}(k-2) \end{bmatrix}$$

The current at instant (k) is:

$$\begin{bmatrix} i_{\alpha}(k) \\ i_{\beta}(k) \end{bmatrix} = \begin{bmatrix} i_{\alpha}(k-1) + \frac{(u_{\alpha}(k-1) - e_{\alpha}(k-1))}{L_\sigma}T_{imp} \\ i_{\beta}(k-1) + \frac{(u_{\beta}(k-1) - e_{\beta}(k-1))}{L_\sigma}T_{imp} \end{bmatrix}$$

The identified currents from above relation are provided as the measured currents at instant (k) for the calculation of current controller algorithm.

![Fig. 1 Step change response of commanded current frequency from $f_i=10$ Hz to $f_i=20$ Hz when $I_s=2.2$ A, $T_{imp}=150$ $\mu$s.](image)

In this work, attention is given to the restriction faced during the realization of the current controller in a discretized control system with A/D converter and a modification method of the controller algorithm is presented. A comparison between the controller function before and after providing a proposed modification is presented. Simulation and experimental results using DSP and FPGA are shown.