A NEW CONTROL STRATEGY FOR HYBRID-EXCITED SWITCHED-FLUX PERMANENT MAGNET MACHINES

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Background
Since hybrid-excited permanent magnet machines utilise the coordinated operation between the permanent magnet (PM) and field excitation flux, which is generated via field winding, such machines are capable of adjusting the flux-linkage in both enhancing and weakening operations. In order to enhance the effectiveness of field excitation flux adjusting capability, iron flux bridges are applied to hybrid-excited switched-flux PM machine (HESFPMM). In this topology, the flux produced by the PMs can be inherently short-circuited via the iron flux-bridges, and the phase flux-linkage can be adjusted as a bipolar quantity following to the direction of field excitation current. However, since both of the field excitation current and d-axis current can be used to weaken the flux-linkage, the operation in both flux-enhancing and flux-weakening regions needs to be verified especially in terms of the operating speed range and efficiency.

Proposed Control Strategy
The maximum field excitation current ($\Delta$) is initially employed to enhance the torque in the flux-enhancing mode, and it is modified when operating between points B and C due to voltage constrain. In the flux-weakening operation, the field excitation current is controlled toward zero, while the d-axis current is modified to extend the speed range. The modification current ($\Delta I_e$) determined by utilising the difference voltages without the influence of machine parameters variation.

Experimental Results
The proposed method is compared with the method that utilises only the field excitation current in all operating regions. Both methods can achieve the same torque in the constant-torque region due to the same field excitation current, while the proposed method exhibits further speed range and higher efficiency in flux-enhancing region since the copper loss of field winding can be totally eliminated due to zero field excitation current. The experimental results are verified under both steady-state and transient conditions as follows:

Steady-state performance

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