A New PM-Assisted Synchronous Reluctance Machine with a Non-conventional Fractional Slot per Pole Combination

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Abstract

Fractional-slot concentrated-winding permanent magnet (PM) machines are appreciated for their ease of manufacturing and short end connections, modular construction can increase the slot filling factor resulting in very high torque density figures [1]. However, it has also been noticed that salient IPM rotors associated to fractional slot windings do not retain the expected reluctance torque contribution.

In the literature is very rare that the Synchronous Reluctance (SyR) and the PM-assisted SyR (PM-SyR) machines have been realized with fractional-slot windings, because of such reluctance-killing effect of fractional slot configurations.

This paper proposes a new PM-SyR machine with a non conventional 24 slot/10 pole fractional configuration. The 24/10 combination ($q = 4/5$) was recently proposed for SPM motors application [2]. It is derived from the popular 12 slot/10 pole combination ($q = 2/5$), aiming at reducing the harmonic content of the magneto-motive force (MMF) distribution. The 12/10 combination was chosen in [2] and here as the starting point because it is very popular in the literature, but similar transformations could be applied to other concentrated-winding configurations.

The proof of principle presented here shows that the 24/10 PM-SyR machine preserves the most of the reluctance torque of the salient rotor, in Fig 2 is reported the comparison with distributed winding $q=3$ and $q=2/5$ motor. This open the stage to a new class of fractional-slot SyR and PM-SyR solutions. The 24/10 PM-SyR machine retains most of the ease of manufacturing of fractional slots together with the advantages of PM-SyR rotor topologies, such as PM cost reduction [3], uncontrolled generator voltage reduction.

Fig. 1 Cross sections of the three PM-SyR machines under analysis: a) $q=3$, distributed windings; b) $q=2/5$, concentrated windings; c) proposed $q=4/5$ solution with mildly overlapping windings. The end turns are also evidenced.

Fig. 2 Reluctance torque, a) Comparison between distributed $q=3$ and $q=2/5$, b) comparison between $q=3$ and $q=4/5$

References

