

# Opportunities of Advanced Multi-phase Concentrated Windings

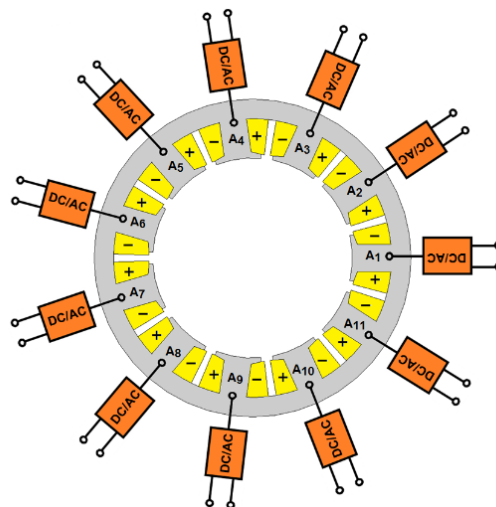
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*Abstract* - In addition to reliability and fault tolerant capability, the new multi-phase FSCW concept considered in this paper gives further novel capabilities for electric machines, such as, variable- and multi pole-pair operation modes, controlling their amplitude and frequency separately, compensation of parasitic effects, and so on. During the following work, the new features of this winding type have been investigated and proved in different machine types. The multi pole-pairs control strategy was implemented for the PMSMs to compensate the critical radial forces responsible for the machine noises. For the CESMs, the MMF harmonic injection mode was applied for brushless rotor excitation already at zero speed. However, the switching pole method was used for ASMs to drive this machine type with higher power density and efficiency over a high speed range.

**Keywords**— Fractional slot concentrated winding, multiphase winding, permanent magnet machine, current excited synchronous machine, asynchronous machine, noise and vibrations, efficiency, brushless excitation



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