

**DESIGN STUDIES ON A NEW OUTER-ROTOR  
PERMANENT MAGNET FLUX SWITCHING  
MACHINE WITH HYBRID EXCITATION FLUX FOR  
IN-WHEEL DRIVE EV APPLICATIONS**

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**Abstract**

Recently, in-wheel motors are among the attractive research topics on pure electric vehicles (EVs) propulsion systems. This because of they offer great controllability for each independent wheel as well as provide more cabin space due to elimination of mechanical transmission and differential gears. Moreover, more series batteries can be installed to increase the driving range percharge. Since the motors are attached directly to wheel, it is required to have high torque density and efficiency. Thus, this paper presents design study on a new structure of outer-rotor permanent magnet flux switching synchronous machine (PMFSM) with hybrid excitation flux for in-wheel EV propulsion system. The proposed machine consists of 12 slots of stator poles, 10 rotor poles, and all the active parts are located on the stator. In addition, it has a robust rotor structure which only comprises a single piece of rotor and has the ability of a wide range flux control. Under some design restrictions and specifications for the target EV drive applications, the initial performances of the proposed machine in terms of flux-linkage, cogging torque, back-emf voltages, and magnetic flux density distribution are evaluated based on 2-D finite element analysis (FEA). The predicted performances show that the proposed machine has viability to be applied for in-wheel drive applications however design refinement is required to achieve the target specifications.